Influence of Weather and Time of Day on Plum Curculio (Coleoptera: Curculionidae) Tree Canopy Entry Behaviors and Evaluation of Traps for Predicting Fruit Injury[1]

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Abstract In the spring of 1997, tree canopy entry behaviors of adult plum curculios, *Conotrachelus nenuphar* (Herbst), were estimated by three types of traps examined five times each day from 24 May (bloom) until 15 June in an unmanaged apple orchard. In addition, presence of plum curculios in the canopy, ovipositional injury to fruit, and local weather conditions (temperature, barometric pressure, relative humidity, and wind speed) were monitored. The principal means of entry into apple trees by plum curculios appeared to be direct flights from outside the canopy into the canopy. However, the major means of tree entry on days when large amounts of oviposition occurred appeared to be crawling up or flying onto the trunk. Ovipositional injury to fruit was correlated with high temperature and low barometric pressure. The greatest amount of tree entry occurred between 1800 and 2100h. The strongest correlation found between daily trap captures and daily occurrence of injury was between captures by flight interception traps placed just outside the canopy and injury occurring the following day. Based on this, captures by flight interception traps just outside the canopies of fruit trees may have potential for predicting episodes of plum curculio damage to fruit.

Key Words *Conotrachelus nenuphar,* plum curculio, tree entry behavior, insect traps, weather, apple.

The plum curculio, *Conotrachelus nenuphar* (Herbst), is a native insect pest of stone and pome fruits in eastern North America. Adult plum curculios overwinter in woods and hedge rows surrounding orchards and migrate into orchards in the spring around blossom time (Racette et al. 1992). Plum curculios feed and mate in the orchard for several days before the onset of oviposition, the primary means of crop damage. During this time, curculios move between the canopy and the ground under trees as well as between trees (Chouinard et al. 1994). It is likely that the effectiveness of sprays to control this pest could be improved, and possibly the number of sprays minimized, by the development of a trap for monitoring plum curculio activity (Yonce et al. 1995, Prokopy and Wright 1998).

Several studies of plum curculio movement and activities in apple orchards in the spring have been conducted previously either by direct observation of plum curculios (Owens et al. 1982) or by the location of radioactively labeled curculios released at a known location (Lafleur and Hill 1987). Using the latter technique, Chouinard et al.

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(1993) observed three means of plum curculio movement: crawling, flying, and dropping. Plum curculio activity has been correlated with weather conditions, including temperature and humidity (Racette et al. 1991, Chouinard et al. 1994, Prokopy and Wright, unpubl. data), and air saturation deficit (Chouinard et al. 1993). Racette et al. (1991) reported that plum curculio activity in tree canopies was greater from late afternoon (1600h) until the following morning (0500h) than from 0500h to 1600h, when adults could be found resting on the ground under tree canopies.

Here, three different types of traps were used to gain information on how plum curculios enter apple trees: entry by flight from outside the canopy into the canopy; entry by flight from the ground beneath the canopy onto the trunk; or entry by crawling from the ground beneath the canopy onto the trunk. Correlation analyses were used to determine the degree of relationship between trap captures and the presence of plum curculios in canopies (measured by tapping branches over a cloth) and the extent of ovipositional injury to fruit. Influence of time of day and weather conditions (temperature, relative humidity, wind speed, and barometric pressure) on plum curculio captures by traps and branch tapping and on seasonal progression of fruit injury were also studied.

Materials and Methods

Experimental orchard. The study was conducted in the spring of 1997 in a 0.68-ha apple orchard near the center of the Hampshire College campus in Amherst, MA. The orchard consisted of 27 standard "Baldwin", "Red Delicious", and "Golden Delicious" apple trees and had not been sprayed with pesticide for at least a decade. Of the 27 trees, 18 bore fruit in 1997 and were used in this study. Mixed deciduous forest bordered the orchard 5 m to the south. The orchard was surrounded on the other three sides by paved driveways and then mixed deciduous forest 32 m to the east, a lawn with a row of pine trees and a planting of unsprayed apples trees 101 m to the north, and a classroom building 5 m to the west. The trees had an average height of 5.6 m, canopy diam of 7.6 m, and trunk circumference of 119 cm. The average distance between neighboring apple trees was 13.1 m. The trees were unpruned for the last 10 seasons, and the only management was the mowing of groundcover.

Trap descriptions. Movements of plum curculios into tree canopies were estimated by three types of traps designed to detect different types of entry behaviors. Flights into the tree canopy from outside the canopy were measured by vertical clear Plexiglass® (Elder Lumber, South Deerfield, MA) panels (termed interception traps) coated on one side with a thin layer of Tangletrap® sticky compound (OESCO, Inc., Conway, MA). Four 0.6 × 0.6 m panels were mounted on wooden poles 0.3 m outside of the canopy of each of six trees, with the sticky surface of each panel facing away from the tree. One high panel (upper edge 2.6 m above the ground) and one low panel (upper edge 1.8 m above the ground) were mounted on the same pole. One pole was placed outside the eastern half and another outside the western half of each tree.

Flights from the ground beneath a tree onto the trunk were measured by a pyramidal wooden trap (Tedders and Wood 1994, Prokopy and Wright 1998) located next to the trunk of each of six trees different from those having interception traps. Pyramid traps were painted black to visually mimic the appearance of tree trunks. Each trap was 111 cm in height and 55 cm wide at the base, with a boll weevil trap top at the apex to collect curculios crawling up. Each trap was coated with a 2 cm wide band of

Tangletrap 11 cm above ground to prevent adult access by crawling. The ground cover immediately surrounding each trap was kept trimmed close to the ground so that no vegetation within 20 cm of a trap base ever grew to the height of the sticky barrier. This was done to prevent short flights of curculios from high blades of grass onto parts of a pyramid above the sticky barrier. These traps are henceforth referred to as sticky pyramid traps.

Pyramidal traps like those just described, except without a sticky barrier, were used to obtain a combined measure of adults arriving on tree trunks by flying and by crawling. These traps (termed pyramid traps) were located next to the same six tree trunks as the sticky pyramid traps but on the opposite side of the trunk.

Other sampling methods. Plum curculio presence in the canopy was sampled by tapping abruptly in a downward direction all medium-sized and small branches which could be reached by a padded pole (2.3 m long) and inspecting a 1.5 × 2 m white sheet on the ground beneath tapped branches for fallen curculios. Tapping was done at two prescribed locations toward outer parts of the canopies and on approximately opposite sides of each of six trees which were not used as trap locations.

The percentage of fruit damaged by plum curculio oviposition scars was sampled daily by inspecting 11 fruits per tree on each of the 18 fruiting trees involved in the study (total 192 fruit per day). Scarred fruit were not removed from the tree after sampling.

Experimental design. The 18 trees were divided into six replicated blocks of three trees each. Trees within a replicate were located near each other. Within each block, one tree was randomly assigned to have tapping sites, one to have interception traps, and one to have both pyramid and sticky pyramid traps.

Percent fruit injury was sampled daily at approximately 1500 h. Traps were checked and tapping was done each day at five times of day: 0600, 1000, 1400, 1800, and 2100 h. About 1 h was required to complete sampling at each time of day, with a flashlight used after darkness. Data collection began when the daily total of plum curculio captures in the orchard by all methods combined first exceeded ten. This occurred during bloom on 24 May. Sampling for fruit damage began at 85% petal fall on 28 May. Data collection ended on 15 June to give a set of 23 consecutive days of data. All plum curculios captured by traps or tapping were removed from the orchard.

Weather data. Temperature at a tree trunk in the shade and wind speed 50 cm above ground were measured by a maximum-minimum thermometer and a continuously recording anemometer, respectively, which were checked at the same five times of day that the traps were checked. The minimum and maximum temperature during the interval of time preceding the sampling period were averaged to give the mean temperature for that interval. The mean temperature and the mean hourly wind speed for each of the five daily intervals were weighted according to the length of interval. Subsequently, they were averaged to give the daily mean temperature and daily mean wind speed.

Hourly relative humidity and hourly barometric pressure data were obtained and averaged from three weather stations 12, 22, and 40 km away. Mean relative humidity and mean barometric pressure were calculated for each time interval and each day as above.

Data analysis. Data on numbers of plum curculios captured by traps and by tapping were summed across 24-h periods extending from 1400 to 1359 h and compared graphically and by linear regression to the daily rise in percent fruit injury measured at 1500 h for all dates beginning on 28 May (85% petal fall). Numbers of plum curculios caught by each type of trap were compared with numbers tapped from tree canopies for all individual time intervals (beginning on 24 May) as well as for daily sums by linear regression. Weather data summed daily were compared to daily rise in percent fruit injury graphically and by linear regression. Weather data were compared with numbers of adults tapped from tree canopies and trap captures daily as well as at each of the five sampling times by stepwise multiple regression. Times of day of capture of plum curculios by traps and by tapping were compared by analysis of variance, followed by a least significant difference test at the 0.05 level.

Results

Relation of fruit injury to tree entry behaviors and presence in the canopy. A significant positive correlation was observed between daily captures by pyramid traps and increase in fruit injury on the same day ($r^2 = 0.24$, $P = 0.033$) (Table 1). A significant positive correlation also was observed between daily interception trap captures and increase in fruit injury on the following day ($r^2 = 0.28$, $P = 0.019$) (Table 1). No other significant correlations occurred between captures by traps or by tapping and daily fruit injury. Interception trap captures one day were also strongly correlated with pyramid trap captures the following day ($r^2 = 0.63$, $P = 0.000$). Daily trap captures and daily branch tapping data are depicted with daily increase in fruit injury across the period of study in Fig. 1.

Relation of presence in the canopy to tree entry behaviors. Significant positive correlations were observed between daily captures by interception traps ($r^2 = 0.54$, P

Table 1. R-squared values* (and *P* values) of linear regression relationships between fruit injury and captures of plum curculios by tapping of apple tree branches or by traps (28 May-15 June) and between captures by tapping and by traps (24 May-15 June). Amherst, MA, 1997

	Adult captures by			
	Tapping	Interception traps	Pyramid traps	Sticky pyramid traps
Injury same day	0.00(+)	0.05(+)	0.24(+)	0.04(+)
	(0.775)	(0.365)	(0.033)	(0.420)
Injury next day	0.14(+)	0.28(+)	0.01(−)	0.02(+)
	(0.116)	(0.019)	(0.650)	(0.597)
Tapping same day	—	0.54(+)	0.00(+)	0.29(+)
	—	(0.000)	(0.742)	(0.006)
Tapping next day	—	0.02(+)	0.01(−)	0.06(+)
	—	(0.530)	(0.698)	(0.260)
Tapping same time interval	—	0.52(+)	0.21(+)	0.34(+)
	—	(0.000)	(0.000)	(0.000)

* (+) or (−) following r-squared value refers to the directionality of the relationship.

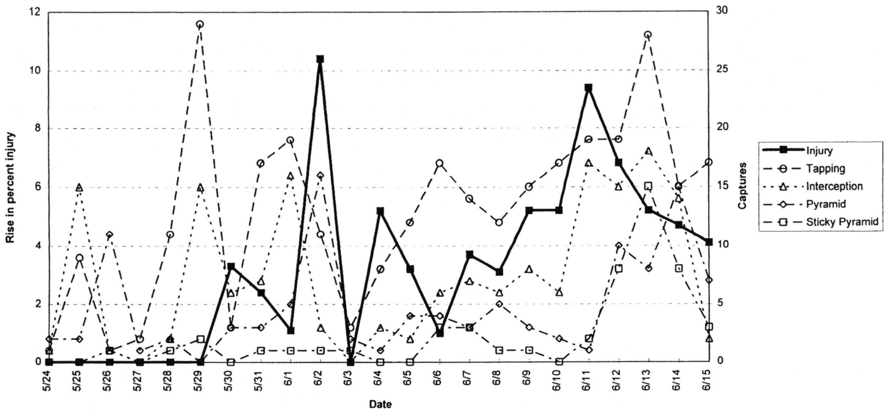

Fig. 1. Daily rise in percent fruit injury and daily total numbers of plum curculios captured by each method across the period of study: 24 May (late bloom)-15 June. Fruit injury data collection began 28 May (85% petal fall). Amherst, MA, 1997. (Note: On 2 June at 1800 h the orchard was mowed with a tractor resulting in very low plum curculio captures and injury that evening and night. Because each day's data were grouped from 1400 to 1400 h, this appears in Fig. 1 as very low captures on 3 June.)

= 0.000) and by sticky pyramid traps (r^2 = 0.29, P = 0.006) and numbers of adults tapped from the canopy on the same day (Table 1). There was no significant relationship between captures by pyramid traps and by tapping on the same day or between captures by any trap type and following day captures by tapping (Table 1). When data from each sampling interval (rather than daily sums) were used, positive correlations were found between numbers tapped from the canopy and captures by each type of trap (Table 1). Relationship was strongest in the case of the interception traps (r^2 = 0.52, P = 0.000) and least in the case of the pyramid traps (r^2 = 0.21, P = 0.000) (Table 1).

Relation of weather to injury. Daily average temperature was found to correlate positively with injury on the same day (r^2 = 0.27, P = 0.024) and injury on the following day (r^2 = 0.33, P = 0.010) (Table 2). A significant negative correlation was observed between average daily barometric pressure and injury occurring on the same day (r^2 = 0.40, P = 0.012) though not the following day (Table 2). Neither relative humidity nor wind speed correlated significantly with fruit injury. Data on weather parameters and fruit injury are depicted in Fig. 2.

Relation of weather to tree entry behaviors and presence in the canopy. Weather data and captures were compared by multiple regression in two ways: first with all data averaged daily, and second for each sampling interval separately.

When data were averaged daily (Table 3), temperature was the most significant factor correlating (positively) with captures by tapping (r^2 = 0.38) and by interception traps (r^2 = 0.70). Barometric pressure was the most significant factor correlating (negatively) with captures by pyramid traps (r^2 = 0.68) and by sticky pyramid traps (r^2 = 0.49). A secondary factor significantly correlating (negatively) with tapping and

Table 2. R-squared values* (and *P* values) of linear regression relationships between fruit injury and weather conditions (24 May-15 June). Amherst, MA, 1997

	Relative humidity	Barometric pressure	Temperature	Wind speed
Injury same day	0.15(–)	0.40(–)	0.27(+)	0.04(+)
	(0.122)	(0.012)	(0.024)	(0.415)
Injury next day	0.01(+)	0.13(–)	0.33(+)	0.10(–)
	(0.677)	(0.188)	(0.010)	(0.192)

* (+) or (–) following r-squared value refers to the directionality of the relationship.

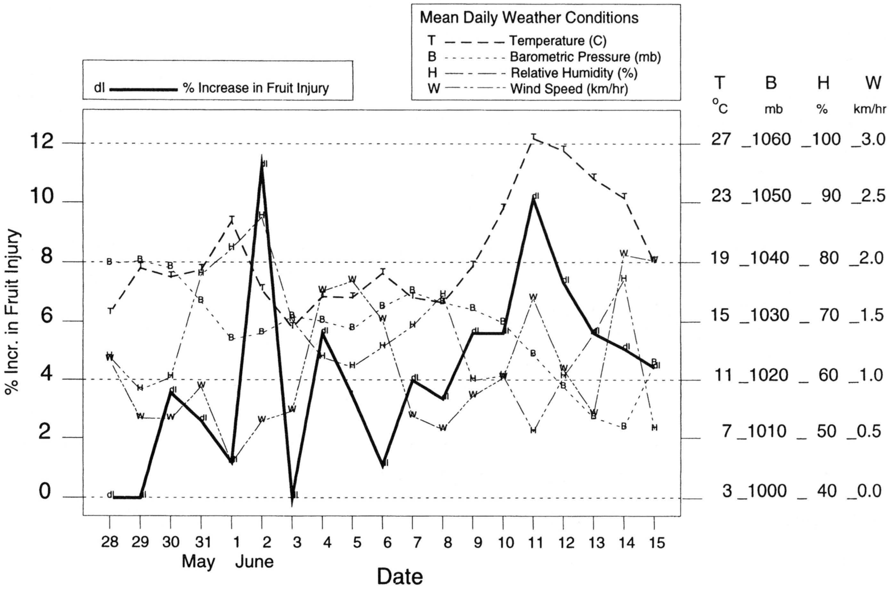

Fig. 2. Daily rise in percent fruit injury and daily mean weather conditions across the period of study: 28 May (85% petal fall)-15 June. Amherst, MA, 1997.

captures by interception traps and by sticky pyramid traps was wind speed. A secondary factor significantly correlating (positively) with captures by pyramid traps was relative humidity.

When data were analyzed with the five sampling intervals as separate entities: (a) no significant correlations were found between numbers tapped from the canopy and weather conditions, (b) captures by interception traps correlated positively with temperature and negatively with wind speed (combined $r^2 = 0.31$), and (c) captures by pyramid traps and by sticky pyramid traps correlated negatively with barometric pressure ($r^2 = 0.21$ and 0.24, respectively) (Table 4).

Table 3. Stepwise multiple regressions of weather conditions in relation to daily captures of plum curculios by branch tapping and by traps (24 May-15 June). Amherst, MA, 1997

Capture method	Weather condition as predictor*	df	t**	r^{2***}
Tapping	Temperature	17	3.12	0.38
	Wind speed	16	−2.04	0.51
Interception traps	Temperature	17	6.11	0.70
	Wind speed	16	−2.42	0.78
Pyramid traps	Barometric pressure	17	−5.84	0.68
	Relative humidity	16	2.51	0.77
Sticky pyramid traps	Barometric pressure	17	−3.89	0.49
	Wind speed	16	−3.68	0.73

* All weather conditions listed are statistically significant with an $F > 4.0$.
** The sign of each t-value indicates the direction of the correlation.
*** R-squared value given for step two of each analysis is cumulative.

Table 4. Stepwise multiple regressions of weather conditions in relation to plum curculio captures per hour by branch tapping and by traps at all time intervals (24 May-15 June). Amherst, MA, 1997

Capture method	Weather condition as predictor*	df	t**	r^{2***}
Tapping	No significant predictors			
Interception traps	Temperature	78	2.96	0.10
	Wind speed	77	−4.73	0.31
Pyramid traps	Barometric pressure	78	−4.51	0.21
Sticky pyramid traps	Barometric pressure	78	−4.88	0.24

* All weather conditions listed are statistically significant with an $F > 4.0$.
** The sign of each t-value indicates the direction of the correlation.
*** R-squared value given for step two of each analysis is cumulative.

Hourly variations. Mean numbers of adults captured per hour by each trap type at each data collection time are shown in Table 5. Analysis of variance indicated significant variation in captures according to trap type (F = 21.48, df = 3,88, P = 0.000), time (F = 6.88, df = 4,110, P = 0.000), and trap type by time interaction (F = 3.85, df = 12,440, P = 0.000). Mean captures per hour at each data collection time

Table 5. Mean numbers (and standard error) of adult plum curculios captured per hour by branch tapping and by each of the three types of traps at each data collection time (24 May-15 June). Amherst, MA, 1997

Hour	Tapping*	Interception Traps	Pyramid Traps	Sticky pyramid Traps	*F* value**	*P* value**
0600	0.43aB	0.26abB	0.17bcB	0.05cA	5.87	0.001
	(0.09)	(0.07)	(0.06)	(0.02)		
1000	0.56aB	0.21bB	0.09bB	0.06bA	9.99	0.000
	(0.11)	(0.07)	(0.04)	(0.02)		
1400	0.40aB	0.12bB	0.27abB	0.16bA	3.26	0.025
	(0.08)	(0.06)	(0.05)	(0.08)		
1800	1.00aA	0.30bB	0.12bB	0.12bA	18.95	0.000
	(0.16)	(0.08)	(0.04)	(0.04)		
2100	0.51abB	0.83aA	0.49abA	0.20bA	3.01	0.035
	(0.16)	(0.21)	(0.13)	(0.09)		
F value***	4.02	6.12	5.03	1.15		
P value***	0.004	0.000	0.001	0.337		

* Means followed by the same letter are not significantly different at the 0.05 level according to the LSD test criterion. Small letters refer to differences between the four capture methods within each time of day. Capital letters refer to differences between the five times of day within each capture method.

** *F* value (df = 3,88 and P value refer to differences between the four capture methods within each time of day.

*** *F* value (df = 4,11) and P value refer to differences between the five times of day within each capture method.

varied significantly according to trap type. Mean captures per hour by each trap type varied significantly across the five data collection times in all cases except sticky pyramid traps. Of the three trap types, interception traps caught numerically (though rarely significantly) the most plum curculios at all times except 1400 h, when pyramid traps captured numerically the most. Captures by tapping were numerically (and sometimes significantly) greater than captures by any of the traps at all times except 2100 h, when interception trap captures exceeded tapping captures. Captures by each of the three trap types were numerically greatest at 2100 h. Captures by tapping were numerically greatest at 1800 h.

Discussion

The strong correlation between plum curculio captures by interception traps and numbers tapped from the canopy coupled with the much weaker correlation between captures by pyramid traps and numbers tapped from the canopy suggest that adult appearance in the tree canopy is determined more by flight directly into the canopy than by flight onto or crawling up the tree trunk. Curculios captured by interception traps may have been immigrating from outside the orchard or dispersing from elsewhere in the orchard. The lack of significant correlation between numbers tapped from the canopy and occurrence of fruit injury suggests that most of the curculios in the canopy of an apple tree at any given time are engaged in behaviors other than egg laying, such as feeding, mating, crawling, or resting.

Based on the significant positive correlations observed between pyramid trap captures and injury occurring on the same day, interception trap captures and injury occurring on the following day, and interception trap captures one day and pyramid captures the next day, it would seem that the major method of plum curculio entry into the canopy to lay eggs is by crawling or flying onto the trunk, and that this tends to occur at least one day after plum curculios have immigrated into the tree from some more distant point. This lag time between entry into the tree canopy and injury may be due to a physiological need to feed and mate before commencing egg laying (McGiffin and Meyer 1986).

Trials involving unbaited pyramid traps in commercial orchards (Prokopy et al. 1999) have not shown a significant positive relationship (either in time or space) between pyramid trap captures and fruit injury. Instead, it has been observed that captures by pyramid traps decrease sharply after the first insecticide application and remain close to zero for the rest of the season, while injury remains very low for a week or so after insecticide application but then increases as the insecticide loses residual effectiveness. Fruit injury begins to occur again but without corresponding trap captures. This pattern was observed even when traps were protected by plastic bags during spraying.

According to Blanchet (1987), most curculios immigrating into apple orchards do so by high elevation (2 to 3 m above ground) lateral flight. The data collected here suggest that in an unsprayed orchard, flight directly into apple tree canopies is followed the next day by dropping to the ground and then crawling or flying onto tree trunks, with subsequent crawling up tree trunks into tree canopies to oviposit. However, after an insecticide spray, it appears that curculios do not crawl up tree trunks before ovipositing, as evidenced by the lack of pyramid trap captures following insecticide treatment (Prokopy et al. 1999). One can envision three possible scenarios for this decline in pyramid trap captures after an insecticide application: (1) curculios on the ground fly directly back into tree canopies rather than crawling up tree trunks, (2) curculios immigrating into tree canopies by flight do not drop to the ground but stay in the canopy, and (3) curculios that drop to the ground die as a result of a possible longer residual effect of insecticide on the ground than in the canopy.

Prokopy et al. (1999) hypothesized that the reason for the dramatic decline in pyramid trap captures following insecticide sprays is an increasing tendency for curculios on the ground to fly directly into tree canopies (rather than crawling or flying onto tree trunks and crawling up) as a result of warmer temperatures as the season progresses. However, such a hypothesis is not strongly supported by the data collected here. If the decline in pyramid trap captures were due solely to the effect of increasing temperature on curculio behavior, then one would have expected to see a decline in pyramid trap captures in the unsprayed orchard studied here similar to that observed in sprayed orchards. This did not occur. Instead, pyramid trap captures came in three distinct waves, two early in the curculio season and the largest one late in the season (Fig. 1). According to multiple regression analyses, temperature was not a significant predictor of pyramid trap captures.

An alternative hypothesis is that after an insecticide spray has initially killed essentially all curculios within a tree canopy but has lost residual effectiveness a week or so after application, new curculios become established within the canopy via direct flight from locales outside the canopy and remain there for several days or more without dropping to the ground (or if they drop to the ground they are killed by greater residual amounts of insecticide beneath than within the canopy). Such flight would be most likely to occur under high temperatures and such curculios would not be captured by pyramid traps adjacent to the tree trunk.

The causes of curculio dropping behavior are not well understood. Owens et al. (1982) observed that plum curculios drop to the ground in response to disturbance. It may be that the dropping behavior of curculios in an unsprayed orchard is a response to disturbance by organisms (perhaps other insects or birds) which are few in number in orchards receiving insecticide sprays. Chouinard et al. (1993) suggest that dropping may be part of the mechanism by which curculios disperse from tree to tree. It may be that after an insecticide spray curculios immigrating into the orchard have little impetus to disperse from tree to tree due to high availability of food and oviposition sites. It is also possible that residual amounts of insecticide in tree canopies could have sublethal effects on curculio behavior such as a reduction in dropping.

Based on the correlations observed here between weather conditions and trap captures, it appears that flights directly into tree canopies (as estimated by interception trap captures) are facilitated by high temperature and calm air, that flights onto tree trunks (as estimated by sticky pyramid trap captures) are facilitated by low barometric pressure and calm air, and that combined flights onto tree trunks and crawling up tree trunks (as estimated by pyramid trap captures) are facilitated by low barometric pressure and high relative humidity. Adult presence in tree canopies is facilitated by warm temperature and calm air. Oviposition is most likely to occur on days having high temperature and low barometric pressure and especially on days following a high temperature day.

Our conclusion that plum curculios have a greater tendency to fly and to be present in tree canopies at warmer temperatures is in agreement with conclusions of previous studies (Chouinard et al. 1993, Chouinard et al. 1994, Prokopy and Wright 1999, Prokopy et al., unpubl. data). However, the effect of humidity on plum curculio behavior is unclear. Previous studies report that high relative humidities are associated with greater total activity (Chouinard 1993, Smith and Flessel 1968), greater presence in tree canopies (Chouinard 1994, Smith and Flessel 1968), and less tendency to fly (Prokopy et al., unpubl. data). In contrast, Racette (1988) found no relationship between relative humidity and plum curculio activity. In the present study, relative humidity was related (positively) only to captures by pyramid traps. It may be that at high relative humidity, curculios have less tendency to fly and more tendency to crawl up tree trunks.

The time of day of greatest entry by plum curculios into apple tree canopies as measured by captures by all trap types was the interval between 1800 and 2100 h. This agrees with the finding of Racette et al. (1991) that curculio activity is greatest in the late afternoon and evening. However, in the present study, the time interval of greatest presence in the canopy as measured by tapping was between 1400 and 1800 h. This is in conflict with the finding of Chouinard et al. (1994) that the average number of curculios present in tree canopies is greatest between 1800 and 0000 h. This difference may be due to sampling error associated with finding tapped curculios after darkness, the earlier time of sunset in the present study, or plum curculios dropping out of the canopy prior to the 2100 h sampling time. Racette et al. (1990)

reported a high level of dropping behavior just after sunset during the part of the season before fruit set but not during and after fruit set. Chouinard et al. (1992) reported that during bloom plum curculio presence in trees cycles according to time of day in only a minority of individuals. Future research on plum curculio dropping behavior may shed more light on this issue.

Based on the results here, simpler versions of the flight interception traps used here might have greater potential as monitoring devices for predicting ovipositional injury to fruit by plum curculios in commercial apple orchards than currently used black pyramid traps. Rises in captures by interception type traps, which tend to occur one day prior to rises in fruit injury, would give growers advanced warning before the onset of oviposition. Further research should be conducted to determine the best color, size, shape, position, orientation, and design for such a trap and its effectiveness in sprayed orchards.

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