BEHAVIOUR OF *Anastrepha fraterculus*

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Abstract

BEHAVIOUR OF *Anastrepha fraterculus.*
A number of experiments and observations on the behaviour, host associations, attractants for adults and pupation of the South American fruit fly *Anastrepha fraterculus* (Wiedemann), conducted under field or semi-natural conditions are presented here.

1. INTRODUCTION

This paper presents a summary of experiments on *Anastrepha fraterculus* (henceforth AF) conducted under field or seminatural conditions.

In southern Brasil between parallels 23 and 32, a region with a subtropical climate, AF is the totally dominant species, comprising as high as 95-97% of all *Anastrepha* trapped/captured, and it is the only fruit fly species of economic importance, that is, a pest.

In this region there are many and various fruit crop species available (in space and time) throughout the year. The Mediterranean fruit fly, *Ceratitis capitata*, is present in this region, but only as an "urban" resident. In the cities, both species (AF and *C. capitata*) coexist and infest common fruit species. Fruits of guava and peach, for example, are infested by both species in a single fruit. However, *C. capitata* does not live in the rural areas. Peach and orange orchards in suburban areas are infested by *C. capitata*, but when they are located around 10-15 km from the urban areas, only AF is found infesting these fruits.

In São Paulo state, both species coexist in many fruit species orchards (e.g., orange, coffee). Intra- and interspecific competition occur at the larval stage, and factors such as temperature may be determinants for their relative frequency in nature. It was suggested that temperature is a factor that would confer an adaptative advantage to one or the other species and determine a better rate of survival. Temperatures in the vicinity of 16°C would confer an advantage for *Ceratitis* over AF. The threshold temperature favoring AF would be around 22°C, above which, AF develops better than *Ceratitis*.

In Argentina (Bella Vista, Corrientes), *C. capitata* and AF coexist in citrus orchards (small populations of both species), but cultivars of early and middle maturation are more infested by AF and later cultivars are infested by *C. capitata*. *C. capitata* is considered the most damaging species.

In southern Brasil, *C. capitata* does not attack citrus in rural areas, but only in urban backyards. AF only sporadically infests citrus in the rural areas, despite a large number of varieties and acreage of these fruits.

Behavior of AF as a potential pest species is still far from understood.

2. ADULT BEHAVIOR

Studies on adult behavior and activity were conducted in Pelotas, Brasil, lat.31 S, long. 52 W, altitude from 7 to 100m). Adults of AF emerged during all months in the fall and winter, indicating that this species has no winter diapause or quiescence in this region. In the fall (April and May), the pupal period (until emergence of adult) takes from 31 to 47 days and, in winter (June, July and August), it takes 31 to 167 days.

From pupae formed under guava trees, adult emergence takes 27 to 41 days, but the highest number emerged at 34 days after pupation (April 30). Males emerged first, but at the end of the day, an equal number of males and females had emerged. Adults (females and males) show flight activity throughout the year. During the winter months (June, July, August), normally very few are captured, and increased capture is associated with a day or days of abnormally higher temperatures. This tells us that adults flies are alive and in the environment during the winter time, although we do not know where they are located, if they are isolated or agregated, if there is migration, etc.

In September, the adult population starts to increase, peaking in November through December and drastically decreasing in January and February (summer months). Highest captures of AF occurred during November and December.

In peach orchards, two peaks are typical. The first is during the last week of October and the first-second week of November, when growers generally spray. The second peak occurs after harvesting, in the third-fourth week of December and the first-second of January. This temporal variation depends on the cultivar composition of the orchard.

There is no relation between time of maturation or harvesting and adult capture (harvesting of peach occurs in December and January). In peach, AF only infest fruits during the "swelling" period or stage, i.e. 25-20 days prior to the harvest maturation point. In peach, AF has only one generation per cultivar. Considering alternative hosts, AF (in Pelotas) has full conditions to develop 5 to 7 generations per year. Highest capture of adults occurred in the period between 11:30 to 19:00 hours. Lowest captures occurred during morning and nocturnal periods. No capture occurred on rainy or windy days or, at least, in days with afternoons under these circumstances. In general, AF uses the morning hours for reproduction, afternoon hours for locomotion and night hours for resting. AF was captured from 1,5 to 10 m above the ground. A vertical differentiated capture occurred at 4 and 6m, with highest values at these heights.

Fruits were equally infested at 2, 4, 6, 8 and 10m above ground level and no difference occurred among these heights. This suggests that AF adults display full activity - flying and infesting fruits - from 2 to 10m above ground level.

No study of horizontal flight distance or dispersion capacity (± migration patterns) of AF was conducted. Colonization and dispersion of adults of AF in peach and apple orchards had different patterns. In peach, fruit presence (especially close to ripening) had a positive correlation with occurrence and distribution. In apple, no effect of fruit or/and its condition was observed. In peach orchards, adults seem to be "residents" in the area but, in the apple orchard, they are "in transit," probably living in surrounding vegetation (especially in forests). Presence of native forest had a detrimental effect on the colonization and distribution of adults in apple orchards, but not in peach orchards. In apple, adults began to occupy the orchard in areas adjacent to forest and concentrated their presence in forests and surrounding areas. In peach, flies were massively captured within the orchard, but not in the forest or nearby.

Apple is a new host for AF (approximately 20 years). It is possible to speculate that this fruit fly species is in a coevolutionary process and is adapting to explore and use apple as a host. Observations of the diel pattern and location of activities of AF on host trees, with and without fruit, and non host trees without fruit, revealed: at dawn (6:00h) both sexes were at rest on the bottom surface of leaves near the top of nonhost or host trees. Sexual activity (male calling) began at 7:00h and ceased before 11:00 h. It occurred on nonhost as well as hosts, with all observed copulation initiation and mating occurring only near the top of a tall nonhost tree (Malavasi et al 1983). In guava and peach trees, copulation movements and mating were observed (Salles, L.A.B., personal observation). Flies were most abundant on major host trees that had fruits. Feeding and oviposition began at 8:00 h, peaked from midmorning to midafternoon and ended before 18:00 h. Flies observed at dusk (18:00 h) and afterward were either at rest on the bottom surface of leaves near the tops of trees or were in flight toward tree tops. Adults seem to have a pattern of movements on the tree according to time of day, either going up and downward.

Diurnal courtship, activity and mating system of AF was studied in caged trees, in Pelotas, Brasil (Lima, I. & Salles, L.A.B.). A brief summary is presented: Flies are feeding and grooming throughout the light period and ceased with the onset of darkness. Locomotory activity was also almost exclusively diurnal. There was a peak in locomotion (mainly walking) at the beginning of the dusk period. Most of the flies remained still or moved very little in the dark.

Sexual maturation of male flies began at the age of 5 days. Males younger than 5 days showed no courtship behavior. At dawn, mature males repeatedly rotated their bodies through 360°, while rapidly fanning their wings. However, they did not try to copulate and did not approach other males or females. This is part of a calling display which ceases after one hour of full light conditions. The duration of male calling activity was increased to nearly four hours when they reach 8-9 days old. Males were seen calling either in isolation or in small groups of 3-4, usually at the top of the cage. During the dawn period, calling activity was observed in 60% of the males in the cage. It increased to nearly 100% at the beginning of the period of high light intensity, when most mating initiation occurred and calling males had selected a position in the cage, either isolated or in leks. Calling remained at a high level during the next two hours.

Most of the mating observed occurred during the dawn period and continued through two hours of full light conditions. All recorded mating took place within the first two hours of light. Copulation duration time was 60-80 minutes.

Female flies reached sexual maturity at 11 days old. Females younger than this were not seen copulating. Feeding occurrence was mainly during the period between 4 and 8 hours of light conditions. Mated females were not observed ovipositing during the dawn period but immediately after the beginning of full light conditions. However, oviposition occurred throughout the day and was observed even during the dusk period. The relationship between fruit phenology and infestation by AF was studied only for two fruit species, peach and apple. In peach (5 cultivars), infestation occurs only at and during the fruit ripening (swelling) stage. This stage, for the studied cultivars, occurs close to 25-20 days before the first harvest time.

It is concluded that AF infests peach only during a short period of time. Obviously, this fact must be strictly considered in any pest management program, and it makes it much easier to establish control measures, especially timing insecticide use for larval control. In apple (Gala cultivar) infestation with live, developed larva (II, III instars) is extremely rare. We assumed that very high mortality occurs during the first larval stage.

Females are usually strong and intensively oviposit (=puncture) into apple fruits. Fruits 1-2 cm in diameter are already punctured and damaged by females. This damage is irreversible, producing a skin deformation with a consequent market value depreciation. When small fruits are punctured they may drop, reducing future production. Larval development of AF is observed extremely rarely in apple. It occurs only in overipe fruits, usually fruit that have dropped to the ground. (Salles, L.A.B., personal observation: in ten years of surveys, I have never found a fruit infested with mature (III instar) larvae in commercial orchards).

External damage on fruits is very severe due to numerous punctures per fruit. Fruits had an external appearance resembling the figure of a "moon surface." Internal damage occurs just under and around a puncture site. This damage became like a corked tissue, similar to the damage or symptom of the bitter pit disease. This situation, due to actual behavior of females of AF on apples, makes it difficult to take actions for its control. A long time period of control actions (> 90 days) is required.

3. HOSTS

In southern Brasil, 83 fruiting tree species were evaluated to establish their status as hosts for AF. Among these, 59 species were not infested by AF and 24 were infested. Of the infested species, 9 were classified as heavily infested and are considered to be alternative hosts. Despite this classification, AF has a considerable number of hosts, and they are distributed throughout the year: Plum, blackberry, araca (*Psidium* sp), wild cherry, guava, feijoa, guabiroba (*Campomanesia xanthocarpa*), jaboticaba (*Myrcia jaboticaba*), sour orange, common orange, laranja de umbigo (*Citrus* sp), kinkan, lima (*Citrus linetoides*), lemon, apple, maria preta (*Diateropteryx sorbifolia*), mata olho (*Chrysophyllum gonocarpum*), strawberry, loquat, pear, peach, wild peach, and pitanga (*Eugenia uniflora*).

It is interesting that several mentioned "traditional" hosts for AF were not infested in southern Brasil, including avocado, coffee, kaki, fig, papaya, mango, passion fruit, quince, pecan, grapefruit, grape and uvaia. As already studied and proposed, AF may have differentiated host patterns, probably due to the existence of biological races or biotypes, adapted to local conditions. Larval and pupal development of AF was evaluated on different hosts. The average number of pupae per fruit varied from 0.7 to 9.9. Hosts that produced more pupae were feijoa, loquat, peach, and plum. Bigger and heavier pupae were obtained from wild cherry, brazilian cherry, guava, plum, and peach. In general, those hosts that produced a larger number of pupae were not those that produced bigger and heavier ones. Another study stated that the average number of larvae per fruit was between 1-5 in large fruits (guava, peach and loquat) and it was <1 in small fruits (Surinam cherry).

4. ATTRACTANTS FOR ADULTS.

Some studies were developed to determine the efficiency of different attractants for adult AF. Most studies were concentrated on food attractants. Most studies of attractants for adults had monitoring as the main goal. No visual responses occurred to colors, forms and their combination. Yellow rectangles were more attractive for capture of AF. Spheres seem to be much more attractive to females than males. Traps using color and format are not used for monitoring AF.

No acoustical attractant trap was tested for AF and no information on this aspect is available. Lures based on pheromone (or any semiochemical) are not available to capture adults of AF. Pheromone studies of AF have been initiated in Southampton University (Dr. Philip Howse, Ivanildo Lima), but the current stage of their development and advances have not been reported. Adult attractants (food) already used were vinegars, protein in hydrolyzed proteins, molasses and several fruit juices. Fruit juices seems to be the best attractants.

The most common juices (probably efficient) are peach, grape, orange, feijoa, and guava.

The ideal attractant for adult AF is still to be discovered and/or to be indicated. Probably there is no one best or ideal, but local conditions (e.g., cost, ease of preparation) could determine their use and advantage. Hydrolyzed protein was recommended as a "universal" food attractant for fruit flies, including AF, but in southern Brasil, for example, is much easier and cheaper to use peach or orange juices instead. Traps used for AF capture are the traditional McPhail glass trap, modified McPhail plastic trap and several homemade traps, especially those made with disposable plastic containers. Again, cost and ease of preparation suggested which trap should be selected, of course, among those evaluated.

5. PUPATION

Pupation behavior of AF was studied in the laboratory and field. Larvae complete their development in a single host fruit and leave it a few hours (1-2 hours) before pupation. Larvae do not come to the soil by any part of the tree but by "jumping" out of the fruit and falling on the soil surface, however high the fruit is. We have measured that larva have "jumped" onto the soil and entered it in few minutes (2-5 minutes) from fruits as high as 11 meters high on the tree (loquat tree).

The time spent by larvae to enter the soil for pupation also depends on the soil characteristics, such as humidity and compactation level. Larvae spend time crawling and "looking for" a suitable place to get into the soil. When the fruit are on the soil, the larva leaves and crawls away from the fruit at least about 5 cm to pupate. This is a critical time for larvl predation. In areas with fire ants, heavy predation occurrs. Under a loquat tree canopy, for example, the number of fire ant nests increases when fruits begin to fall on the ground and larvae are emerging.

Under the guava tree canopy (natural compaction conditions), all puparium were found in the first 6 cm of the soil, but most of them were located in the first 4 cm. When soil was cultivated at 10cm of depth, puparium were found this deep, but between rows, with compacted soil, they were localized only up to 4 cm deep. In the laboratory, puparium formation was related to the depth of the soil layer and its level of compaction. In soft soil (no compaction) puparium were found at 18 cm, but most were concentrated in the first 10 cm. When soil was artificially compacted, most puparia were found in the first 4 cm. There was a direct response of the depth of pupation to the level of soil compaction. Level of soil compaction did not influence time to emergence and number of adults emerged.