

and a chalcidid parasite of this species, the latter being secondary on the former.

In addition to the parasites which destroy this species, blackbirds are said to eat the larvæ before they go into shelter.

#### CONTROL

A spray of arsenate of lead, Paris green or other arsenical could be used in the destruction of the young larvæ before they penetrate the interior of buds, seed capsules, stems, and the like. Where they are found at work in these shelters, however, about the only recourse would be to pick the affected portions by hand and burn them. The collection and destruction, also by burning, of the stalks in which the insects are found late in the season, is also advisable. In the occurrence of the insect on Lotus all parts of the plant containing the insect above the water line should be cut away as soon as this can be conveniently done.

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### ANASTREPHA FRATERCULUS WIED. (TRYPETIDAE)—A SEVERE MENACE TO THE SOUTHERN UNITED STATES

By E. W. RUST, *Entomologist of the Tucumán Experiment Station,  
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In almost all tropic or sub-tropic lands fruit-growing is subject to severe losses occasioned by insect pests, and among the latter one of the most damaging is almost sure to be some one of the fruit-flies of the family *Trypetidæ*.

In the northern part of the Argentine Republic, where the writer is stationed, the particular scourge of the fruit-grower is *Anastrepha fraterculus* Wied., and during the past two years it has been the subject of more or less constant observation. During that time we have noted with surprise that so little is known, and even less published, about an insect which is such a menace to the fruit-growing interests of the semi-tropic portions of the United States. The Mediterranean fruit-fly is known by name and dreaded by a great number of fruit- and vegetable-growers, thanks to the wide-spread publication of the most excellent work done by the United States Bureau of Entomology. The melon fly (*Bactrocera cucurbitæ*) and the Mexican fruit-fly (*Anastrepha ludens* Loew) have also come in for some share of popular attention, but it appears that comparatively few people realize what a scourge *Anastrepha fraterculus* might become if once it gained entrance to the Southern portion of the United States.

## DISTRIBUTION

*Anastrepha fraterculus* might well be called the South American fruit-fly, as it is indigenous to, and well distributed over the warmer portions of South and Central America, and the West Indies, where it is regarded as only less destructive than the Mediterranean fruit-fly. Moreover, it occurs as an extremely destructive agent in many sections where the latter has not as yet gained entrance. So far, we have authentic records of its occurrence in Brazil, Argentina, Peru, Colombia, Yucatan (Mexico), Cuba and Porto Rico. Beyond a doubt it is found in most of the other islands of the West Indies, but has not been definitively reported as yet. Northern Chile, Ecuador and the various Central American States will doubtless be added to the list also, as soon as anyone is in a position to search these regions, as it seems certain that this fly has penetrated to all the warmer portions of South and Central America where fruit is grown. In some sections it is as yet only a menace, while in others it has assumed almost the proportions of a calamity.

## DAMAGE DONE

In the Province of Tucumán (Northern Argentina) *Anastrepha fraterculus* is variously known as "la mosca de la fruta" (the fruit-fly), "el gusano de la fruta" (the fruit-worm), "la mosca del naranjo" (the orange fly), and "el gusano del naranjo" (the orange worm). It is definitively known to have been present at least twenty years, and in conversation with old residents, the writer has learned that as long ago as the natives can remember, thin-skinned fruits, such as peaches and chirimoyas, have been regularly destroyed by a maggot, which is described as identical to that found in all kinds of fruits today. After a thorough canvass of the situation, there seems little reason to doubt that the fly is indigenous to this section, or has at least been present for several decades.

During this period it had been noted that the pest caused more damage during certain years than others, and this fact was attributed to combinations of climatic factors not completely understood. However, it appeared certain that the maximum amount of sound fruit was obtained following seasons during which climatic extremes of one kind or another had occurred. But even after such periods unfavorable to the fly a large percentage of the local peaches and apricots were apt to be wormy; in bad years practically all soft or thin-skinned fruits were destroyed, and in recent years even the various species of citrus have been, in their turn, badly infested. This latter condition is, however, of only recent date, for it is only within the last three or four years that any infestation of citrus fruits has been noticed; but during

this period the condition has become more and more wide-spread and the percentage of infested oranges has increased until during the autumn of the present year (March-April and May, 1918) a loss was experienced of nearly 50 per cent. of the oranges in some sections; and one grower reports the dropping of at least three-fourths of his crop of pomelos through the agency of this insect.

Conditions at present are worst in the Province of Tucumán, and it is in the central and southern portions of this province only that oranges are severely damaged. On the other hand, almost all thin-skinned fruits are more or less subject to infestation in most parts of Northern Argentina. In the Province of Salta and the majority of the Province of Jujuy peaches and apricots are generally almost a total loss, due to the rot engendered by these maggots, and chirimoyas or "custard apples," plums, etc., are regarded with suspicion until after a thorough examination. Although very excellent oranges have been produced in that section (notably at Orán, Salta) for more than one hundred years, the fruit-fly does not seem to have adapted itself to that host to any great extent, as yet, in the two provinces named, but indications point to a heavier infestation in the future. The writer saw evidences of oviposition in nearly every orchard visited in those provinces during May of the present year, and ventures that before the lapse of many years even the wild oranges in the forests around Orán will be the regular hosts of this fruit-fly, which seems to be gradually extending its ravages to fruits heretofore considered immune. Conditions which will bring about a serious infestation of these oranges will be a season when many flies have emerged, followed by a sudden diminishing in the usual quantity of thin-skinned fruits of late summer or autumn, which will force large numbers of flies to oviposit in the oranges.

#### DESCRIPTION OF THE FLY

The adult of the maggot which makes all this havoc might be said to resemble, in a general way, the common house-fly, except that the former is yellowish-brown in color and of somewhat larger size. In this matter of size, some latitude should be allowed, for individuals of both sexes vary greatly in this particular, in accordance with the conditions under which they developed. The writer has seen a statement to the effect that the female measured about 12 mm. in length (exclusive of the ovipositor) by slightly more than 25 mm. across the extended wings. The foregoing is, however, a trifle large, as an average, for the flies which occur in the region under discussion. Data obtained from the examination of large series of individuals show the following characters:

Length of average female (exclusive of ovipositor), 8 to 9 mm.; length of ovipositor, 2 mm.; wing expanse, 18 to 20 mm. Length of average male, 7 to 8 mm.; wing expanse, 15 to 16 mm. Eyes conspicuous, of living or recently killed specimens, beautifully iridescent but gradually turning dark brown to blackish. Body yellowish-brown to almost castaneous, except ventral side of thorax which is very light brown to straw-colored; thorax with three sulphur colored, longitudinal stripes on dorsum and another on each side reaching from wing base to head; scutellum sulphur-yellow, abdominal segments edged with light yellow, giving appearance of three well-defined transverse stripes. Wings comparatively large and relatively more slender than those of *Ceratitis*; hyaline, stained in places with a distinctive pattern of yellowish-brown which involves the base of the wing and extends (with one slight interruption) in a broad stripe along the anterior margin to the tip; the interruption alluded to leaving a small notch-like, clear spot near the center of the anterior wing-margin, and from the lower angle of this spot another band curves downward and backward to the basal angle of the wing; on the distal half of the wing is another streak, like an inverted V, one prolonged arm of which rests upon the posterior wing-margin, while the apex almost (and in certain cases, quite) joins the aforementioned stripe along the anterior margin, at a point just distad of the clear spot. Wings iridescent in certain lights. In freshly emerged individuals the eyes are unusually conspicuous and flash combinations of red and blue which vary with the light. Newly emerged flies are wholly straw-colored, with nearly clear wings, but the body soon darkens and the characteristic patterns on both body and wings soon become well-defined. The wing pattern does not seem to be absolutely constant, and some slight variations, both of shade and pattern, are often noted. Female ovipositor brown, tipped with black hairs, stout, mainly cylindrical but slightly flattened on the under side, tapering uniformly to the tip.

#### OVIPOSITION

When a female fly is ready to deposit eggs, her first care is to find a suitable host in which to place them. Various kinds of fruits serve for this purpose and they are attacked in various stages of maturity, according to the fruit chosen and the season of the year when oviposition takes place. When the female fly alights upon a fruit, she first explores the surface, all the time gently waving her wings in the manner characteristic of these insects. Then when a seemingly satisfactory point is found, she stops and bends the ovipositor at right angles to the body, the abdomen remaining in the customary horizontal position and the ovipositor being bent at the point where it joins the abdomen. In this position the tip of the ovipositor just touches the surface of the fruit. Then the stylets are exerted and introduced into the rind. As they enter, the fly sways slightly backward, so that the ovipositor forms an acute angle (about 50 per cent.) with the body, in which position she remains during the major portion of the time occupied in oviposition, which varies from a trifle over thirty seconds to about a minute and a half. Then ensues a period of rest and exploration of from two to three minutes, before another puncture is made. The eggs are elongated, somewhat spindle shaped, whitish in color

and about 1 mm. in length. They are sometimes placed singly but often several occupy the same cavity and a single fruit may be oviposited in many times by the same or by different insects; thus it may happen that a fruit bears the marks of the ovipositors of so many females as to almost cover its surface with scars.

#### THE LARVÆ

The eggs hatch, commonly in from two to four days, into minute white larvæ, which immediately start eating their way through the fruit. These larvæ are of the usual maggot type, slenderly pointed at the forward end and terminating bluntly at the opposite extreme. As they grow they also darken in color until when three-fourths grown they are creamy white, after which they become creamy, to yellow, and finally attain a length of from 7 to 9 mm. or even 10 mm. In summer the larval period averages from twelve to fifteen days, which may be prolonged to several weeks by the cold of winter.

#### THE PUPÆ

Upon becoming full grown the larvæ leave the fruit and burrow several centimetres into the soil, there to form the pupa, which is of the usual castaneous, capsule-like type. Or the pupa may be formed under the first convenient object, or even in an exposed position if the larva cannot bury itself. The pupal period also varies greatly, ranging from twelve days to several weeks, according to temperature.

#### THE ADULT

Upon emerging from the pupa, the adult fly is very soft and can easily make its way through the small cracks and interstices of the soil until it reaches freedom at the surface. There its body hardens and the wings expand until it is able to fly in search of the fruit juices, sap or honey-dew upon which the adult normally feeds.

In confinement the flies die within three or four days, unless supplied with food, but if syrup or juicy fruit is supplied them, they may live for astonishing lengths of time. Without any special attention, the writer has kept flies alive for more than three months and has no idea but that this period may be greatly prolonged under more favorable conditions. In this connection, it was noted that the males generally died first, just as they often are first in emerging from the pupa.

Fertilization of the female often takes place during the first day after emergence, and eggs have been secured upon the third day, but generally oviposition begins upon the seventh or eighth day after emergence and may continue for a long period. The maximum length of time during which a female may deposit eggs has not yet been deter-

mined, nor has the maximum number of eggs laid per day, but as several eggs seems the normal rate per day during a prolonged period, it seems reasonable to calculate that the average female *Anastrepha fraterculus* is capable of depositing between 500 and 800 eggs during her lifetime.

#### HOST FRUITS OF *A. FRATERCULUS*

The eggs are deposited in, and the resulting larvæ more or less completely destroy the following fruits, according to a recent list published by the United States Federal Horticultural Board.<sup>1</sup>

Guava (*Psidium guajava*), coffee berries, pear, peach, mango, orange, *Eugenia* spp. *Phylocalyx*, Japanese plum, Japanese persimmon, Pará plum, (*Spondias* spp?) *Anona humboldtiana*, jobo amarillo, jobo de la India.

To the foregoing can be added the following fruits which the writer knows to be infested in Northern Argentina: strawberry guava (*Psidium* [*Campomanesia*] *cattleianum*), Chinese guava (*Psidium* [*Campomanesia*] *lucidum*), fig (*Ficus carica*), pomelo (*Citrus decumana*), kumquat (*Citrus japonica*), tangerine (*Citrus nobilis*), apricot (*Prunus armeniaca*), avocado (*Persea americana*), chirimoya (*Anona cherimola*). In addition it may be stated that the fruits of *Feijoa selowiana* have been reported as infested at times, and that in several instances the writer has found lemons (*Citrus medica limonum*) which showed evidence of having been "stung" by the fly, although no larvæ have so far been found in the last named fruit.

#### METHODS OF ATTACK IN DIFFERENT TYPES OF FRUIT

In the region under discussion the first fruits to be attacked in the spring are probably the apricots, which are soon followed by peaches, and it is the latter fruit which may be regarded as the principal summer host of the insect. Adult females which have successfully passed the colder months or which have emerged from over-wintering larvæ or pupæ, become active early in spring and place eggs in early apricots where the larvæ develop at a comparatively rapid rate. These larvæ give rise to a large number of flies which are ready and waiting for the early peaches, and in the haste to deposit eggs some fruits are "stung" while yet not much more than half-grown, but in these the larvæ are not able to develop. Such peaches may drop or may cling to the tree, but in any case they "mummify" and do not become soft with rot, which latter condition seems to be more or less essential to the success-

<sup>1</sup> A Manual of Dangerous Insects Likely to be Introduced in the United States Through Importations. Edited by W. Dwight Pierce. Washington, D. C., Aug. 15, 1917.

ful development of the larvæ. The most propitious time for oviposition in peaches seems to be two or three weeks before the fruit would normally ripen. At this time they are still firm and green, but the pulp loses its excessively hard, dry, astringent qualities and becomes sweet enough and moist enough to nourish the young larvæ. These now develop very rapidly and eat out a large part of the flesh and cause the rest to rot so that the larvæ are nearly always enveloped in a decaying mass which seems exactly to answer their requirements. At this stage the fruit colors up and may appear normal except for a few small holes which the worms make in order to obtain air, but it is soft to the touch, and when opened presents a disgusting mass of corruption, filled with from three or four to thirty or more wriggling, whitish maggots. This decay causes a premature ripening of the unattacked flesh and the whole fruit falls to the ground at a time when sound fruits of equal age have as yet scarcely begun to ripen. If it still contains undeveloped maggots, these are generally able to finish their development in the fruit upon the ground.

Under the favorable conditions of abundant food and suitable temperature which obtain at this season, the egg period is passed in two days, larvæ develop in another seven to ten days; and the pupal period is passed in twelve to fifteen days more, so that we may have adults from eggs deposited only three weeks before. This, however, is the minimum, attained only under the most favorable conditions, and the normal time from one generation to another is very close to thirty days in summer.

By the end of the peach season, the flies have reached their maximum number and there is scarcely enough fruit for all to place their eggs in during years of heavy infestation, so almost any kind of fruit is used for oviposition, but only in certain kinds do the maggots succeed in developing. After the peaches have all been destroyed, the females turn their attention to later fruits, such as chimoyas and guavas, each of which serve as host for one or more generations of the insect. Fruits then become somewhat scarce and not much is left except persimmons, which to some extent engage the attention of such females as are bent on oviposition. Thus pass the summer months of December, January and February and oranges will soon be in a condition to attack. Meanwhile the females content themselves with eating, sunning themselves in warm nooks, or keeping in the shade at mid-day, and waiting. They can pass long periods without depositing eggs and yet be in perfect condition to resume this function as soon as an opportunity is presented, so their numbers do not diminish to any very great extent during a short scarcity of fruit. By the end of February or the beginning of March oviposition begins in oranges but the fruit is gen-



erally too green and very few if any of the first maggots develop, even if the eggs hatch. But from the middle of March to the last of April, or even longer during favorable weather, larvæ regularly develop in many of the oranges of this section. Especially is this true in thin-skinned varieties or those with a loose peel such as the tangerines have.

Eggs are often deposited in large numbers in oranges, but no larvæ develop. This was very puzzling at first but it has since been found that during oviposition some of the oil cells, so numerous in citrus fruits, are often ruptured and the strong essential oil thus liberated destroys the eggs. But even if this accident is escaped, not all danger is passed, for if the eggs be deposited in very thick-skinned fruits such as bitter oranges, pomelos, or even some seedling oranges, the larvæ are very apt to starve to death before they can penetrate the innutritious rind and arrive at the pulp on which alone they can thrive.

Another puzzling question was why the fruit so often dropped when no signs of larvæ could be found in them. After extensive experiments it was proven to the writer's satisfaction that even if no eggs were deposited by the female at the time oviposition was attempted, yet the resulting punctures were often sufficient to allow the fruits to become infested with *Colletotrichum* and other fungus spores or by bacterial rots which caused a premature ripening and fall of the fruit, and it is probable that the ovipositor of the female really acts as the vehicle of infection in many cases. Especially was it noted that pomelos are almost sure to develop typical *Colletotrichum* spots after being "stung" by the fly, and it is due to the fungus and not to the fly larvæ that they drop prematurely, for the fly larvæ rarely reach maturity by tunneling the thick rind of this fruit. The eggs may hatch and the young maggots may feed for awhile but they generally die before pupating.

The growth of *A. fraterculus* larvæ in citrus fruits is slower than in the other fruits mentioned, and this may be due partly to the qualities of the fruits themselves, but is more apt to be the effect of the lower temperature which always occurs during the autumn and winter, when the citrus fruits are ripening. During the first part of the season larvæ developed in the orange in from twenty to thirty days and then remain in the pupal stage from fifteen to twenty-five days longer (according to temperature) or a matter of from thirty-five to fifty-five days for the immature stages, but as the weather grows colder development becomes slower until finally it stops completely and the coldest season is spent in a quiescent state by both larvæ and pupæ, but the adult continues actively feeding during warm days even if the temperature has dropped as low as freezing the previous night. Thus we have *A. fraterculus* passing the coldest months of July and August as larvæ in citrus fruits, as pupæ protected by the soil, and as adults, which have



been seen to survive temperatures as low as  $-7^{\circ}$  C. By means of this resistance to unfavorable conditions all stages are able to withstand the cool weather and resume their normal activities with the more favorable weather of early spring, when a new swarm, composed of both over-wintering females and those freshly emerged, is ready to attack the early apricots, thus completing the yearly cycle.

#### CLIMATIC CONDITIONS

Climatic conditions seem to be the decisive factor as to whether this insect will be severely destructive or only moderately so. If conditions have been favorable to a heavy crop of fruit, a good proportion of the same may, during the first part of the season, be free from attack, but from this very abundance of food results such a great and rapid increase of flies that the fruit maturing during the remainder of the season is apt to be very largely infested. Thus, a big peach crop gives rise to a swarm of fruit-flies which multiply rapidly in the many successive and suitable summer fruits, until oranges are sufficiently developed for oviposition in the autumn. These, being practically the only fruit left, receive the full attention of almost all the flies and a heavy infestation results. On the other hand, unfavorable weather conditions tend to check the increase of the fruit-fly, but sometimes they also result in curtailing the fruit crop as well, so that things are pretty evenly balanced and nearly all the fruit is again infested. However, if the unfavorable weather occurs early enough in the season, the flies may be severely checked without doing much damage to fruit-trees which have not bloomed as yet, and a good crop of comparatively clean fruit results.

Now, what climatic conditions may bring about these results? Naturally one thinks of cold. But a cold spell of sufficient duration and intensity is seldom encountered in the semi-tropics. Nor is it a condition to be desired from other points of view. During the present winter this locality has suffered from temperatures of from  $0^{\circ}$  C. to  $-7^{\circ}$  C., followed by warm sunshine, and at mid-day many specimens of *A. fraterculus* were observed as active as ever. Thus it appears that even a killing frost does not have much effect on the adults, and even less on larvæ in oranges or upon pupæ which may be safely protected in the soil.

As to humidity. Where rains occur in the hot season, as here in Northern Argentina, they only stimulate plant growth and tend toward increasing the food supply of the flies and to the rapid development of the latter in all their stages. In fact it has been noted repeatedly that during and after a rainy season, damage by the fruit-fly is generally more severe.

Conditions due to altitude cannot be thoroughly discussed until more data are collected, but it appears likely that this is not an important factor, from a practical view-point, if other conditions are favorable, as the fly has been collected by the writer at various elevations, ranging from 1,000 feet to nearly 4,000 feet. In other and more tropical regions it has been collected at slightly above sea level, so it appears safe to venture that this insect is capable of making itself very obnoxious at any altitude up to at least 4,000 feet, if conditions of temperature, etc., are favorable.

There remain to be discussed, heat and drouth. These two factors often occur together, and when they are severe are certainly a great check to the fruit-fly. Either condition alone may greatly curtail the insect's food by causing fruit-trees to bloom but scantily or by causing fruit to drop after it has been formed. When both heat and drouth are severe (and especially if prolonged) fruit is certain to be very scarce and the fly is consequently checked in its multiplication, in which case the fruit of the succeeding season will be comparatively free from maggots. Not only do the above conditions cause a scarcity of the flies' food, but many larvæ and pupæ are killed outright and the adults are greatly restricted as to the time during which they can oviposit. With a temperature much over 100° F., larvæ are often literally cooked in the fruit which fall in the sun, before they can escape and enter the soil; and even if they do succeed in burying themselves, such excessive temperatures as were experienced in Tucumán during the summer of 1917<sup>1</sup> were enough to bake them everywhere the sun reached. Such a temperature is also fatal to emerging flies, and even the mature adults refuse to oviposit during the hotter parts of the day, but remain motionless on the underside of leaves, or upon the ground in the shade. It has been noticed that after a prolonged hot, dry period, *A. fraterculus* is much less numerous than usual and that unless very favorable conditions for its rapid increase occur during the succeeding winter, spring or early summer, the fruit of these seasons will be comparatively free from attack by the larvæ. However, by the end of summer they have generally become numerous enough to again be conspicuous and to do a large amount of damage during the succeeding year, unless something happens to give them another check.

#### PARASITES

This check to their multiplication may be either natural or artificial, and in addition to causes of the former kind discussed above, may be mentioned parasites. However, these are, as yet, very little known.

<sup>1</sup> January 20, 1917. Maximum at the Experiment Station, 114° F. in the shade. Maximum in the city of Tucumán, 118.5° F. in the shade.

In rearing thousands of specimens of *A. fraterculus* from all sorts of fruit hosts, only a very small number of parasites have thus far been encountered and these were all a certain *Ichneumonid* as yet undetermined. It has been reported that other parasites attack *A. fraterculus* in Brazil, but the writer has no authoritative information as to how effective a check they really are. Doubtless some of the parasites of *Ceratitis capitata* could be used to good advantage against our South American fruit-fly, but the opportunity for giving them a trial has not yet presented itself.

#### ARTIFICIAL CONTROL

As is often the case with other species of fruit-flies, artificial control of any kind has not yet proven very successful against *A. fraterculus*. Such measures have been recommended as the destruction of infested fruit, the capture and destruction of adult flies, poisoned sprays, etc., but conditions here, as elsewhere, prevent such measures from being effective. People in general are too careless or indifferent to the clean cultural measures recommended and very little can be done at general control until every individual is willing to shoulder his portion of the responsibility. Poisoned sprays give some promise of being useful under certain conditions and will be given a more extensive trial during the coming year.

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### THE LIFE HISTORY AND EARLY STAGES OF CALOPHYA NIGRIPENNIS RILEY

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According to E. A. Schwarz in his paper "Notes on North American Psyllidæ" (Proc. Ent. Soc. Wash., Vol. VI, p. 234) the development of this species was carefully studied by Mr. Theo. Pergande many years ago and some fine drawings illustrating the various stages were made by Dr. Marx. However the manuscript and some of the drawings could not be found after the death of Dr. C. V. Riley. The drawings, of the first and second larval stages, which accompany this paper were copied from those by Dr. Marx, which appeared in Mr. Schwarz's paper.

The species appears to live exclusively on *Rhus copallinum* L., and ranges according to Van Duzee (Check List of the Hemiptera of America, North of Mexico) from Connecticut southward to Georgia and Florida. In New Jersey we have found *Calophya nigripennis* to be fairly common although it does not by any means occur every place where its food plant grows. According to Stone (N. J. State Mus. Rept., 1910) *Rhus copallinum* L. is found frequently in sandy soil