Pineapple Fruit Injuries Caused by Larvae of the Moths Ereunetis flavistriata and Pyroderces rileyi*

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Among *Lepidoptera* infesting the pineapple, *Ananas comosus* (L.) Merr., in the Territory of Hawaii, the two most abundant species are *Ereunetis flavistriata* Walsm., the sugar cane bud moth, and *Pyroderces rileyi* (Walsm.), the pink cornworm, locally sometimes called pink bud moth. Although well authenticated reports indicate that both species sometimes attack living parts of certain plants, these insects are generally regarded primarily as scavengers, their larvae feeding most commonly on dead vegetable matter. Both species occur widely on developing pineapple fruits, sometimes in abundance, but the significance of this infestation has been the subject of contradictory reports.

This paper presents evidence, obtained by the writer during two periods of fruit disease investigation, that larvae of both *Ereunetis flavistriata* and *Pyroderces rileyi* sometimes attack pineapple fruits, producing characteristic but minor wounds that appear important chiefly as ports of entry for pathogenic microorganisms. The injuries, rather than the insects, were the center of attention in these studies.

LITERATURE

Tryon (5) in a study of fruitlet core rot of pineapple in Queensland, observed (p. 462) that the caterpillar of a diminutive moth, probably one of the *Tineinae,* frequently occupies the Blossom cup of the pineapple fruitlet, consuming stamens and style. He states: "These insects are, however, found in both healthy and diseased fruitlets alike, but usually in those that are quite sound, and, moreover, no disease seems to ever attend their presence."

Ereunetis flavistriata, the sugar cane bud moth, so-called because it sometimes eats into young cane buds protected by dry leaf sheaths, was reported by Swezey (4) to feed on the dry leaves of pineapple and sometimes to be numerous among the bracts at the base of the fruit where he considered that they fed merely on dead tissue.

Concerning this same insect on pineapple fruits, Illingworth (2) stated that while the caterpillars are feeding "upon the essential organs of the flower, in the calyx cavity, they frequently gnaw into the surrounding living walls." He also reported these caterpillars

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to be common around the base of the fruit where they sometimes eat out small cavities between the eyes, but he neither described nor illustrated the wounds. Illingworth suggested that, during such feeding, these larvae may inoculate fruits with pathogenic microorganisms.

Pyroderces rileyi, an insect known to feed on diverse living plant materials in addition to dead vegetable matter, has been reported injurious to pineapple by Illingworth (3), who stated: "The tiny pink caterpillars of this species are particularly troublesome on the fruits. They live in the withered flowers and outer calyx cavities and frequently gnaw the leaves of the crown. Rot organisms enter through the wounds, causing the breaking down of the fruit." The illustrations cited by Illingworth at this point, however, indicate confusion with yellow spot, a virus disease that frequently causes a breakdown of the fruit following infection and necrosis of the crown.

More recently, Herford (1) investigated both *Ereunetis flavistriata* and *Pyroderces rileyi* in relationship to pineapple, chiefly on the island of Oahu. Herford confirmed the abundant association of these insects with pineapple but reported that fruit infestation with both species is usually confined to young fruits, and that "contrary to certain claims, they appear to do very little damage." From other statements it is evident that Herford recognized no pineapple fruit injury attributable to either insect.

EREUNETIS FLAVISTRIATA

During a search for ports of entry of pathogenic microorganisms into ripening pineapples during March 1939, the writer found that larvae of *Ereunetis flavistriata* are able to feed on fleshy calyx and bract tissues of pineapple fruits in various stages of development, from less than half grown to fully ripe. The relationship of characteristic feeding scars to this insect was indicated by their close association with webbing, pellet-covered cocoons, and the gray caterpillars themselves, numerous larvae having been found with their heads in the bottoms of fresh pits and holes.

Experimental confirmation was obtained when larvae collected from pineapple fruits were confined to limited areas on ripe or nearly ripe fruits that initially were entirely free from anything that might be confused with caterpillar injury. Cylinders of transparent sheet celluloid, approximately $2\frac{7}{8}$ inches in diameter by 4 inches tall, were attached to the fruit with dental plaster. Larvae of *Ereunetis flavistriata* were then introduced and the top of the cylinder closed with a piece of closely woven white cloth, secured in place with rubber bands. Six such experimental cultures were established March 9, with first ratoon fruits and with larvae chiefly half grown or larger, both fruits and larvae collected from the Palawai Basin, Lanai. When the cages were removed for final fruit examination

March 17, caterpillar injury was found on each of the 6 fruits. Some of the insects had pupated and some had escaped, with the result that larvae recovered were always fewer than introduced. No insect of any other species, however, was found in any cage. An indication of the extent of injury is provided by the numbers of feeding scars, shown in Table 1. Fruits and larvae from Wahiawa, Oahu, handled similarly have given comparable results. Adults of *E. flavistriata* were reared from both Oahu and Lanai larvae.

TABLE 1. *Ereunetis flavistriata* INJURY TO EXPERIMENTALLY INFESTED FRUITS

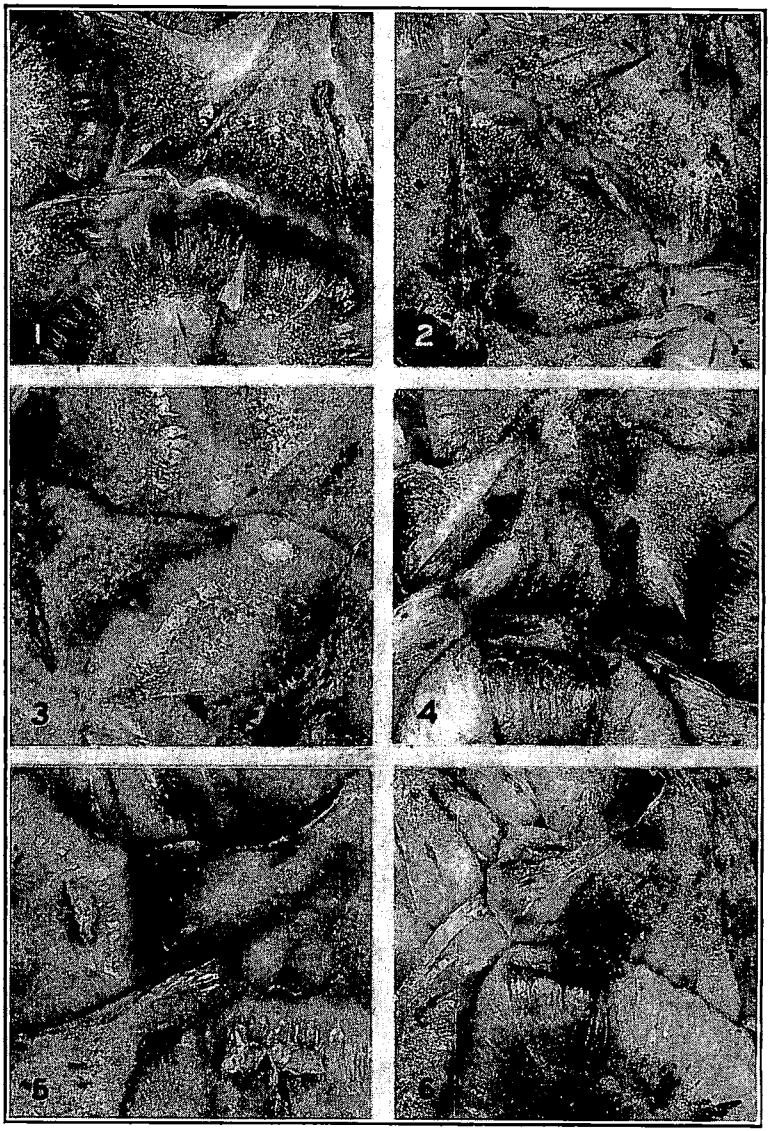
Fruit no.	Larvae introduced	Larvae recovered	Separate feeding scars
1	4	1	2
2	5	3	5
3	6	4	2
4	6	5	6
5	6	5	10
6	6	1	3

Feeding occurs either directly in a crevice between fruitlets (fig. 3) or, more commonly, low on the sides of the crevice, that is, on the shoulders of calyx and bracts (fig. 2). The wounds vary from less than 1 mm. in diameter to over 2 mm. wide and, in extreme cases, 10 mm. long; and, although usually very shallow, sometimes are rounded cavities as much as 4 mm. deep. Such deep wounds, if made before the fruit ripens, may fill with soft pale gum that gradually hardens and darkens to deep amber (fig. 6).

On a fruit that is not yet ripe, these *Ereunetis flavistriata* wounds are at first clean and white (figs. 1, 2) but they rapidly turn light brown with the formation of wound cork and, more slowly, develop narrow, dark brown borders (fig. 5). Wounds made early, while the fruit is still enlarging, are gradually lifted, by growth of the bracts and calyx from their bases, until they may lie as much as 5 mm. from the bottom of the crevice. Early wounds, if particularly deep, may result, at maturity, in continuous corky surfaces from one fruitlet to another (fig. 4).

During ripening, a pineapple fruit loses its capacity to heal wounds by cork formation, with the consequence that the wounds on ripe fruits either dry out, if the fruit is of a relatively dry, opaque-flesh type, or promptly exude juice if highly translucent. Especially the juicy wounds are attractive to insects, including *Carpophilus* spp., *Atherigona excisa* (Wied.), *Chymomyza procnemis* (Will.), and *Drosophila* spp.

Bud moth injury is most frequent on surfaces that have been protected from sun and wind. On a fruit that has stood erect during its development, these are chiefly near the base. In ratoon fields,



FIGS. 1 to 6.—*Ereunetis flavistriata* injuries on pineapple fruits. ×2.

1. Fresh, white, elongate wound in bottom of crevice between fruitlets.
2. Two relatively fresh wounds on calyx shoulder; also pellets of excrement distributed in a sparse web.
3. Deep holes extending directly through bottom of crevice.
4. Older corky wounds on opposite sides of crevice, with narrow band of cork across crevice. Note dark margins of wounds.
5. Old corky wounds with dark margins, situated high on calyx shoulder in consequence of growth after feeding occurred.
6. Two drops of hardened gum in a pair of deep holes within the area of a larger shallow wound.

however, where fruits frequently lie almost horizontally, with one side closely pressed against leaves, bud moth injury may extend far towards the crown along the protected side. Where fruiting is irregular, injury is more frequently observed and, characteristically, is more extensive, on fruits that have been crowded and shaded by tall surrounding plants.

Although Herford (1) found infestation chiefly limited to young fruits, the present observations indicate that injury occurs chiefly after fruits are approximately 1/3 grown. Prior to that time, the calyxes and bracts of individual florets tend to form conical projections with very narrow crevices between. Later growth, however, is accompanied by a flattening of the fruitlet surface and a widening of the crevices between fruitlets, and it is in these crevices that this insect injury occurs.

Bud moth injury to pineapple fruits was widespread during March and April 1939. On the island of Lanai, where the initial observations were made, the injury occurred in every field examined and on almost every fruit in some fields. It has since been found on eastern Kauai and in the Wahiawa and Kunia districts on Oahu. Variations from field to field include not only differences in percentages of fruits infested and in extent of injury to these, but differences in stage of fruit development at which injury occurred.

Because of its shallowness and limited extent, *Ereunetis flavistriata* injury appears important only insofar as it opens ports of entry for pathogenic microorganisms. Wounds in unripe fruits, because of their prompt healing, appear unimportant even in this way, except in that their corky surfaces may crack during ripening. Of greater importance are the wounds made during ripening that, being attractive to miscellaneous insect vectors of yeasts, bacteria and fungi, appear to contribute to early deterioration of the ripened fruit.

These are not the only wounds on ripening pineapples that serve as ports of entry, others being, apparently, growth cracks resulting from stresses set up in the expanding fruit. Deep growth cracks usually occur between fruitlets, especially between contiguous margins of floral bracts, but some occur through the middle of a bract, particularly where the phyllotaxy is irregular. The relative importance of growth cracks and bud moth injury in allowing the entry of insect vectors of microorganisms is yet to be determined.

During these studies, very few *Pyroderces rileyi* larvae were seen on fruit surfaces, and these did not appear to be associated with any feeding injury.

PYRODERCES RILEYI

While studying internal characteristics and diseases of pineapple fruits, chiefly in the Makawao district, Maui, during August and September 1933, the writer found the pink larvae of *Pyroderces*

rileyi eating into ripening fruits, thereby allowing the entry of fungi that promptly initiated a firm dark-brown rot of limited extent. The fruits dealt with came chiefly from 2 fields. Smaller numbers examined from other fields in this area indicated that the injury occurred generally here, but limited observation during the same period on west Maui, Lanai, and Oahu indicated a much more sparing occurrence than near Makawao. Since that time no comparable study has been undertaken in the Makawao district, and fruits from other localities have shown very little of this injury.

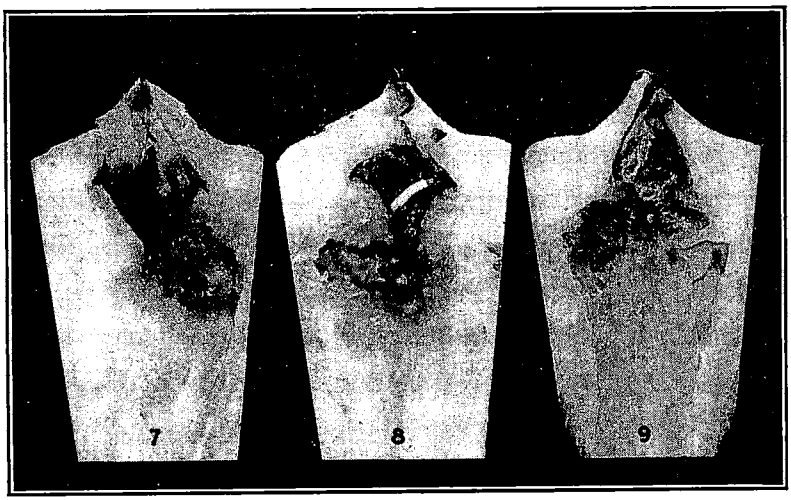
The feeding wounds of *Pyroderces rileyi* larvae are of different nature and occur in different locations on the fruit than those of *Ereunetis flavistriata.* Habits of the insects themselves on pineapples are different. Unlike the sugar cane bud moth, which is found between sterile bracts at the fruit base or, on the fruit surface, hiding under its pellet-strewn web in crevices between fruitlets or under margins of fruitlet bracts, *P. rileyi* larvae were found, during these studies, predominantly within blossom cups, enclosed by the fleshy sepals. Here they feed chiefly on the remains of petals, stamens and style, and, only occasionally, during ripening of the fruit, in the flesh itself.

Wounds made by this insect vary from shallow pits to irregular tunnels of variable diameter, length, and direction, extending inward from the lining of the blossom cup (figs. 7, 8, 9). This lining is hard and smooth except at the bases of petals, stamens and style, and it is chiefly through either the base of the style, in the very bottom of the blossom cup, or, less often, through bases of petals or stamens at the side of the cup, that larvae eat their way into the fruit. Those floral parts normally wither and die soon after blossoming. In some fruitlets, however, some or all remain fleshy for an indefinite period and, by their bulk, prevent the usual tight closure of the blossom cup by the sepals. *Pyroderces rileyi* injury appeared more abundant where these parts had remained fleshy than in normal fruitlets.

The withered floral parts within blossom cups are usually infested by various fungi, especially species of *Penicillium.* Usually these fungi are unable to enter the flesh but, when the lining of the blossom cup is injured, as with a needle, they enter promptly and produce a firm dark-brown rot of limited extent. It was not surprising therefore to find a rot of this type beginning promptly at points of entry of *Pyroderces rileyi* larvae. Commonly, the entire feeding tunnel was enclosed in a rounded mass of firm, dark-brown rotted tissue (figs. 7, 8, 9) from which the only microorganisms that could be isolated consistently were 3 species of *Penicillium.* That such rot may develop while the larva is still feeding is indicated by tunnels that were involved in the characteristic rot near the blossom cup but that, at their inner extremity, were fresh and clean.

This rot not only increases the importance of *Pyroderces rileyi*

injury but also facilitates recognition of the injury itself, since clean, fresh tunnels, because of their lack of color contrast, are difficult to see in a slice of the fruit. On the other hand, under the conditions of these observations, rot of a type that could be confused with this was almost never found in the absence of typical caterpillar injury. Because of these facts, in gathering data on the occurrence of this injury, the characteristic rot was made the primary criterion, followed by examination of the interior of the rotted mass for evidence of caterpillar injury itself. An undetermined amount of very fresh injury must, therefore have been overlooked.



FIGS. 7, 8, 9.—*Pyroderces rileyi* injuries and associated rot, shown in sections of pineapple fruitlets. Photographed from preserved specimens. × 1.5.

7. Feeding tunnel extending downward and to the right from base of style, and surrounded by brown rotted tissue.
8. Sections of irregular tunnels surrounded by rotted tissue; also larva, bleached by the preservative, in frass-filled blossom cup.
9. Tunnels extending laterally from base of frass-filled blossom cup, and area of extensive feeding below the well-defined tunnel at the left.

Intimate association of *Pyroderces rileyi* larvae with this injury, in the absence of other insects capable of producing injury of similar type,* establishes the causal relationship. The characteristic pink caterpillars were found singly in blossom cups, in association with the injury, or within the tunnels always with the head towards the innermost extremity of the tunnel. Less frequently, cocoons, apparently those of this same insect, were found within blossom cups. Among 768 fruits examined from one field, 50.2 per cent of all 229

* A very few gray larvae, apparently *Ereunetis flavistriata,* were associated with injury of similar type.

affected fruitlets contained either a larva or a cocoon, and among 738 fruits from another field, 58.2 per cent of the 189 affected fruitlets contained a larva.

Not all larvae in blossom cups, however, were associated with injury, many of them feeding only on petals, stamens and style. Their presence was indicated by fresh frass within the blossom cup. Where injury had occurred, the frass frequently was imbedded in a quantity of pale brown gum. Many other blossom cups, containing sparse, dry frass with no evidence of injury, gave evidence of an abundant, earlier infestation.

To gather data on the occurrence of frass, larvae, and injury, 96 ripe fruits, from two fields, were examined in detail. Each blossom cup was exposed by paring off the projecting sepal tips; then, where frass or larvae occurred, deeper cuts were made in search of injury. Frass was present in every fruit, and in 22.6 and 20.1 per cent, respectively, of all fruitlets. Larvae were found in 77.3 and 56.7 per cent of all fruits from these 2 fields but in only 1.7 and 0.7 per cent of the individual fruitlets. Plainly, the greater part of the total insect infestation had occurred earlier. *Pyroderces rileyi* injury, still less abundant, was found in 7.9 and 20.0 per cent of all fruits but usually in only one fruitlet per fruit. Larvae were less abundant than in the larger samples reported above, occurring in only 15.2 and 28.6 per cent of the injured samples. From these data it appears that these larvae do not injure immature fruits, that few of the larvae present when fruits are ripe cause injury, but that some injury occurs sufficiently early that the insects emerge before the fruit is fully ripe.

During these studies, only 2 pineapple varieties were dealt with, Cayenne and Hilo. *Pyroderces rileyi* injury, or that part of it rendered conspicuous by development of rot, was found in 25.8 per cent of the Cayenne fruits but in only 12.5 per cent of the 295 Hilo fruits taken on the same dates from the same plots of a fertilizer experiment. The difference appeared clearly significant.

Also significant were differences in abundance of such injury in Cayenne in relationship to plant spacing and exposure, the injury being most abundant in fruits from crowded or shaded plants. With 4-row beds running nearly north and south, injury was least frequent in the west row, most in the 2 inside rows, and intermediate in the east row. These rows were uniformly 17 inches apart, with wider space between beds, giving the west row the greatest exposure of all. When the plants were only 12 inches apart in the row, there was more *Pyroderces rileyi* injury in all rows than when either 15 or 18 inches apart, but, contrary to expectations, there was more with 18 inch than 15 inch spacing.

SUMMARY

This paper describes and illustrates minor injuries to pineapple

fruits made by caterpillars of two Microlepidoptera, *Ereunetis flavistriata* and *Pyroderces rileyi*.

Ereunetis flavistriata larvae feed in the crevices between fruitlets on protected surfaces of fruits ranging from less than half grown to fully ripe. On green fruits the wounds, which vary from shallow pits to rounded holes, heal with wound cork. Wounds on ripe fruits, however, do not heal but are attractive to insect vectors of microorganisms that accelerate deterioration of ripe fruits. During March and April 1939 this insect injury was recorded on Lanai, Oahu, and Kauai, and, in some fields, was seen on almost every mature fruit.

Pyroderces rileyi larvae feed on withered floral parts enclosed within blossom cups, usually without injuring the fruit. In the Makawao area, Maui, during August and September, 1933, however, injury was frequent, the larvae eating through bases of styles, stamens or petals into the ripening flesh. Species of *Penicillium*, usually present on the withered floral parts, entered these wounds and produced a characteristic dark brown rot of limited extent. This injury was more abundant in the Cayenne than the Hilo variety, and, in the Cayenne, was more prevalent in fruits from crowded plants, and plants from inside rows of 4-row beds, than in fruits developed under full exposure.

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