# *Hedylepta blackburni* (Butler), A Perennial Pest of Coconut on Wind-swept Sites in Hawaii

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The coconut leafroller, *Hedylepta blackburni* (Butler) (Lepidoptera: Pyraustidae), an endemic insect, has been a pest of the coco palm, *Cocos nucifera* L., on the windward side of the islands of Hawaii for more than a century (Hillebrand, 1888; Meyrick, 1899; Fullaway, 1961; Swezey, 1952; 1954). In the spring of 1959 this insect was apparently more numerous than usual and caused considerable feeding injury to trees on exposed sites on the windward side on all of the islands. Observations at the time revealed that although the insect could be found throughout the islands there was relatively little feeding on trees in leeward areas or on trees protected from the wind on the windward side. The observations prompted the writer to make some intensive investigations at several different sites on Oahu during the summer of 1959 to obtain data on feeding injury and the abundance of parasites, as well as *H. blackburni*, in the different areas and to follow-up with supplementary studies during the next several years.

On the basis of the 14-year study, an attempt is made to develop a general comprehensive picture of the pest and non-pest status of *H. blackburni* under different ecological conditions, particularly in relation to wind exposure, which may be an important factor in preventing the principal larval parasite, *Trathala flavoorbitalis* (Cameron), from being effective as a biological control agent in wind-swept areas.

## METHODS

The basic quantitative data presented on the abundance of *H. blackburni* and its parasites were based on counts made from examining relatively mature fronds cut from the middle portion of trees at each of the different localities sampled between 5 June and 22 June 1959. This was immediately following the peak in feeding in May and after emergence of most of the adults of *H. blackburni* of that brood. Consequently, pupae were recorded as emerged, parasitized or dead of unknown causes, and the number of cocoons and puparia of parasites were tallied by species. Somewhat similar samples were taken in May, 1959 but due to the prevalence of living larvae and pupae, the data were not included

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with the June data. However, from the May larval and pupal collections many adult parasites were reared and useful information obtained for the identification of the parasites from the appearance of the cocoons and puparia and from the emergence holes in parasitized *H. blackburni* pupae.

Larval feeding was estimated in percent of the leaf blade eaten on each of the above 1-frond samples and also for fronds on trees at various localities on the different islands a number of times during the latter half of 1959 and the first half of 1960. The number of new fronds free of feeding injury were also noted. Similar estimates of feeding were made at many of the localities periodically between 1960 and 1972, with an extensive survey on the different islands in 1965, 1971, and 1972.

## Results

### Feeding injury by and abundance of *H. blackburni.*

In the spring of 1959 conspicuous feeding injury by *H. blackburni* was evident at a number of localities on Oahu and the outer islands. It was found that the only trees that had been heavily fed upon were growing on sites exposed more or less to the full force of our northeasterly tradewinds. Data obtained from more intensive studies made on Oahu during June of 1959 supplied further evidence that larval feeding and *H. blackburni* survival to the pupal and adult stage were directly related to exposure, being greater on windswept sites than semi-protected sites, and greater on semi-protected sites than protected ones (Tables 1 and 2).

TABLE 1. *Summary of data from* June 5-22, 1959 *samples from Oahu*

| *Sites* | *No. samples (fronds)* | *No. larval parasites* | *No. pupal parasites* | *No. moths* | *% of leaf blade eaten (aver.)* |
|---|---|---|---|---|---|
| Exposed | 11 | 319 | 158 | 667 | 65 |
| Semi-exposed | 19 | 3209 | 139 | 547 | 20 |
| Protected | 13 | 1287 | 7 | 35 | 5 |

TABLE 2. *Estimates of* H. blackburni *populations based on* June 5-22, 1959 *samples.*

| *Sites* | *No. parasitized larvae, plus host pupae, per frond* | *No. pupae per frond* | *No. moths per frond* |
|---|---|---|---|
| Exposed | 107.0 | 78.0 | 60.6 |
| Semi-exposed | 206.8 | 38.0 | 28.8 |
| Protected | 101.6 | 3.4 | 2.7 |

The study of the recovery of trees following the peak in feeding in May of 1959 revealed that there were wide differences among the localities in respect to the rate new fronds were added and old fronds shed from the trees, as well as in the total number of fronds per tree. By mid-July, 1959 in many localities there was 1 fully unfolded new frond clean, free of noticeable larval feeding, at the top of the trees at most of the sites. These fresh green fronds were particularly conspicuous on trees that had been heavily damaged, often with 50% or more of the blade of the leaves removed and that remaining, particularly on older fronds, often discolored and shredded by wind. By the middle of November the number of clean new fronds at the top of trees in exposed and semi-exposed sites had increased to a maximum of 5 but in some cases was as few as 2. A follow-up study in March, 1960, ca. 10 months after the peak feeding of the preceding May, at 16 localities on Oahu indicated that the number of new clean fronds had increased to a maximum of 10 per tree, with a mean of 5.6 but was as few as 2 to 3 at 2 of the sites. It may be appropos to point out that recovery rate of the trees would be affected in part by the continuing *H. blackburni* infestations in some areas and also associated to some extent with tree vigor or site conditions, with the greater number of new fronds produced by vigorous trees. In some of the areas there were successive broods or generations of *H. blackburni* throughout the period from May, 1959 to February, 1960 but there were fewer larvae during the fall and winter months than in May, 1959. Examples of continuing infestations through the fall and winter months are illustrated in Fig. 4, 5, and 8.

Investigations since February, 1960 have been confined primarily to annual or biennial visits to the several localities on Oahu and certain localities on Hawaii, Kauai, Maui, and Molokai to record the larval feeding on the individual fronds of 2 or more trees at each locality. In addition, in many instances several fronds were also examined for *H. blackburni* eggs, larvae and pupae, as well as cocoons and puparia of parasites. In February of 1965, some 8 months after the peak in larval feeding in the spring of 1964, many localities were visited on the outside islands, as well as 23 of the Oahu localities included in the 1959 study. It was found that the insect had continued to persist at a sufficiently high population level to cause noticeable feeding damage in many of the areas. Furthermore, at 6 of these 23 Oahu localities living *H. blackburni* larvae were present. On Kauai in relatively exposed sites the upper half of many trees were relatively clean or free of feeding and the lower half conspicuously fed upon, with 50 to 75% of the blade eaten being common. For example, an exceptionally large vigorous tree at Barking Sands had a total of 36 fronds; the upper 16 were clean and the lower 20 fronds with 75 to 90% of the blade eaten. At Lihue, on a tree with 25 fronds, the upper 3 were clean, the next 4 were currently infested with 1-3 colonies of small larvae per frond and the lower 18 fronds with 25 to 50% of the

blade removed. Again in 1971 and 1972 many of the study sites were revisited and the observations revealed that the feeding injury was similar to that for 1959 and 1965, with heavy feeding confined to wind-swept sites. Good examples of such exposed sites are the golf course area near Wailua on Kauai and along the beachfront in Waimanalo, Lanikai, and Kailua on the windward side of Oahu. In contrast, there was relatively little or no readily noticeable feeding on trees on protected sites in gulches on the windward side and in sheltered leeward sites, such as at Poipu Beach on Kauai, Kaunakakai on Molokai, and Waikiki on Oahu. These differences in feeding damage in respect to exposure were spectacular as is illustrated by the several Figs. All of these photographs were taken on the same date, 15 August 1972, and are representative of conditions at the same or similar sites in the summer of 1959, 1964, and 1971, as well as 1972, but the injury was probably somewhat heavier in those years than in most summers during the 1959-72 period.

In many instances during the 1959-72 period, it was repeatedly observed on Kauai, Maui, Molokai and Oahu that where there were several trees in a group on exposed sites, the trees on the windward side were more heavily fed upon than those on the leeward side. It was also repeatedly observed that trees less exposed to wind due to protection by buildings or other kinds of windbreaks, including trees of less height, were noticeably less damaged, as illustrated by the smaller tree at the left in Fig. 6.

PARASITES: From the several collections of eggs, larvae and pupae of *H. blackburni* made in May, 1959 adults of the following parasites were reared:

| Egg Parasites | Family |
|---|---|
| *Trichogramma* sp. | Trichogrammatidae |
| Larval parasites | |
| *Achaetoneura archippivora* (Willison) | Tachinidae |
| *Chaetogaedia monticola* (Bigot) | Tachinidae |
| *Eucelatoria armigera* (Coquillet) | Tachinidae |
| *Bracon omidivorum* (Terry) | Braconidae |
| *Casinaria infesta* (Cresson) | Ichneumonidae |
| *Horogenes blackburni* (Cameron) | " " |
| *Trathala flavoorbitalis* (Cameron) | " " |
| Pupal parasites | |
| *Brachymeria obscurata* (Walker) | Chalcididae |
| *Echthromorpha agrestaria fuscator* (Fabricius) | Ichneumonidae |

Several adults of *Trichogramma* sp. were reared from *H. blackburni* eggs but the percentage of parasitization was not determined.

Larval parasitization on the trees on the exposed, semi-exposed and protected sites in June, 1959, was 27.1, 81.6 and 96.7%, respectively (Table 3). These data indicate that there was a sharp increase in parasitization with wind protection, which is the direct reverse of *H. blackburni* survival. If viewed in terms of number of larval parasites per host pupa, or survivor, the magnitude of the differences between sites may be more readily visualized (Table 3).

The ichneumonid, *T. flavoorbitalis,* was the predominant larval parasite in the June, 1959 samples, representing 67% of those in the samples from exposed trees, 90% of those from semi-exposed trees and 99% of those from protected trees (Table 4). *T. flavoorbitalis* cocoons were commonly found in a number of leeward areas throughout the 1959-72 period, even though the *H. blackburni* populations were relatively low in these areas during the period.

TABLE 3. *Larval parasitization of* H. blackburni; June 5-22, 1959 *samples.*

| *Sites* | *No. larval parasites per frond* | *No. larval parasites per pupa* | *% parasitization*[1] |
|---|---|---|---|
| Exposed | 29.0 | .4 | 27.1 |
| Semi-exposed | 168.9 | 4.4 | 81.6 |
| Protected | 99.0 | 29.2 | 96.7 |

[1]No. parasite cocoons and puparia, divided by no. pupae plus parasite cocoons and puparia, multiplied by 100.

TABLE 4. *Relative abundance of the* 6 *larval parasites in the* June 5-22, 1959 samples.

| | | *Percent* | | | |
|---|---|---|---|---|---|
| *Sites* | *No. parasites in samples* | *Trathala flavoorbitalis* | *Casanaria infesta* | *Tachinids*[1] | *Bracon omidivorum* |
| Exposed | 319 | 67.1 | 2.2 | 28.5 | 1.9 |
| Semi-exposed | 3209 | 90.1 | 0.5 | 3.9 | 5.5 |
| Protected | 1287 | 99.4 | 0 | 0.6 | 0 |

[1]*Achaetoneura archippivora* (Williston), *Chaetogaedia monticola* (Bigot), *Eucelatoria armigera* (Coquillet).

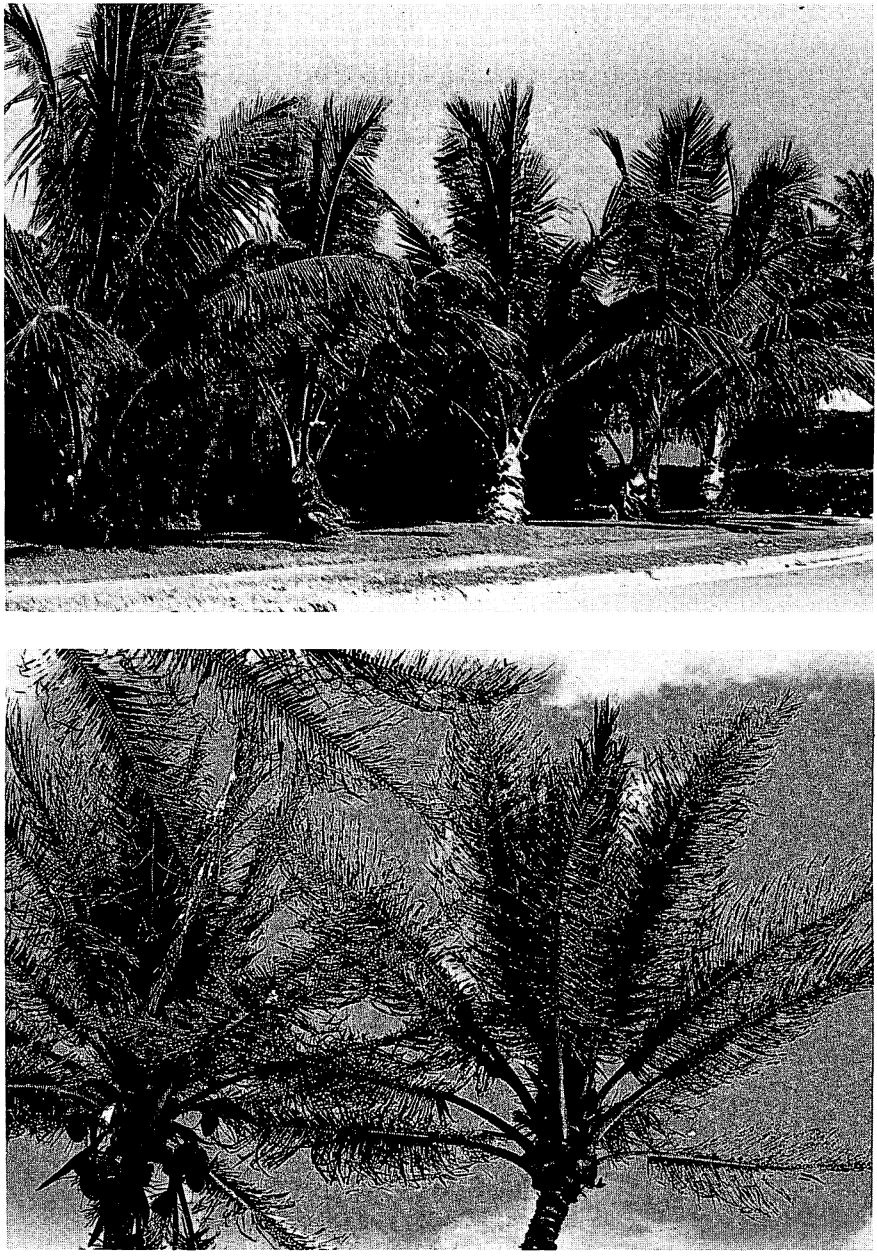

PLATE I.

FIG. 1. Coconut trees in the Waialae-Kahala area on leeward Oahu; essentially no noticeable feeding injury. 15 August 1972.

FIG. 2. Coconut trees on beach at Lanikai on windward Oahu; very heavy feeding. 15 August 1972.

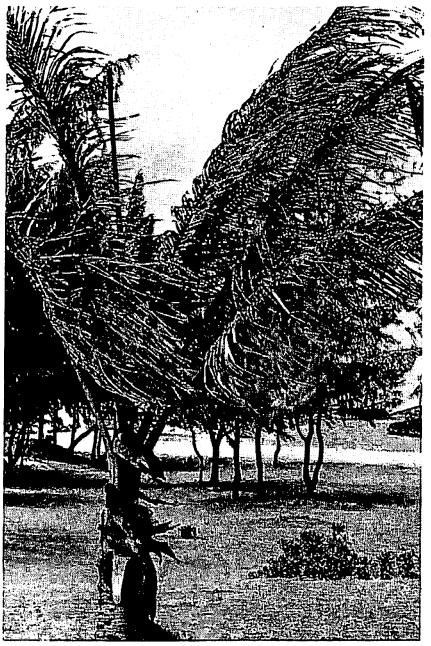

PLATE II.

FIG. 3. Small tree in Waialae-Kahala area on leeward Oahu. 15 August 1972.

FIG. 4. Small tree in Waimanalo Beach Park on windward Oahu. 15 August 1972.

FIG. 5. Upper part of small tree shown in Fig. 4; most recent, partially unfolded frond, infested with *H. blackburni* larvae; illustrates continuing infestation. 15 August 1972.

PLATE III.

FIG. 6. Coconut trees at Lanikai on windward Oahu, ca. 200 yards inland from beach and the trees shown in Figs. 2, 7 and 8.

FIG. 7. Heavy feeding on tree on beach at Lanikai. 15 August 1972.

FIG. 8. Heavy feeding on trees on beach at Lanikai. Youngest, partially unfolded frond at top infested with young *H. blackburni* larvae; indicates continuing infestation. 15 August 1972.

Another ichneumonid, *C. infesta,* occurred in relatively small numbers. A braconid, *B. omidivorum,* accounted for 5.5% of the larval parasites in the samples from the semi-exposed trees and 1.9% of those from exposed ones. The 3 species of tachinids, *A. archippivora, C. monticola, E. armigera,* accounted for 28.5% of the larval parasitization in the samples from the exposed trees, 3.9% from the semi-exposed trees and 0.6% from the protected trees.

Pupal parasitization was 17 to 22%, with essentially no difference between the exposed, semi-exposed and protected sites. The actual numbers of pupal parasites per frond in the exposed, semi-exposed and protected were 14.4, 7.3 and 0.5, respectively, and directly related to the number of pupae per frond (Table 2). Apparently only 2 pupal parasites were involved, *B. obscurata* and *E. agrestaria fuscator,* with the former species accounting for ca. 90% of the parasitization.

## DISCUSSION

The fluctuations in the abundance of *H. blackburni* and the feeding injury to coconut trees by it in Hawaii during the past 14 years may possibly be representative of the general status of this defoliator over the past century. Past records show that it caused conspicuous injury to trees in exposed areas, such as in the Lahaina, Maui area, more than 100 years ago (Swezey, 1954). Swezey observed the depredations of *H. blackburni* and reared it many times during the first half of the 20th century. He referred to it as a coconut pest on the windward side of Hawaii, Kauai, Maui and Oahu, the same areas where it has been most numerous during the past 14 years.

*H. blackburni* survival, based on the number of pupae and pupal skins from which moths had emerged (moths) per frond, was directly related to exposure to our northeasterly tradewinds (Table 2) and, as would be expected, feeding injury was directly related to the pupal population, which was a measure of larval survival. Although it was not possible to obtain a direct measure of either the egg or larval population from the samples, parasite cocoons and puparia were a measure of the number of *H. blackburni* larvae killed by parasites. Most of the larvae killed by parasites died before they reached one-half the size of fully grown larvae and consumed much less foliage than non-parasitized larvae that survived and developed into pupae. The data indicate that the pupal and adult populations in the samples from the exposed trees were about twice those from the semi-exposed trees and over twenty times those from the protected trees. Therefore, survival and feeding injury were directly related to exposure to wind and this was repeatedly corroborated from the supplementary investigations and observations made throughout the period of study.

Larval parasitization, on the other hand, was the direct opposite, inversely related to exposure to wind, being much higher in the samples

from the protected than the semi-protected trees, and also much higher from the semi-protected than the exposed trees. If considered on the basis of the number of larval parasite cocoons and puparia per *H. blackburni* pupa, these differences become even more impressive. In actual numbers of parasite cocoons and puparia per frond there were also far fewer in the June, 1959 samples from exposed than semi-exposed and protected trees, even though the larval populations apparently were ca. the same from the exposed and protected trees (Table 3). Other factors could be involved but it is suspected that under exposed conditions, our strong tradewinds may be a hinderance to these larval parasites, especially *T. flavoorbitalis*. This parasite was by far the most important of the 6 larval parasites involved, particularly in the semi-exposed and protected sites. The limited data on the other 5 species would indicate that they were probably not as adversely affected in exposed situations or favored in protected situations as was *T. flavoorbitalis*.

Pupal parasitization was only ca. 20% in the samples from the exposed, semi-exposed and protected trees and apparently neither *B. obscurata* nor *E. agrestaria fuscator* was especially adversely affected by wind exposure as appeared to be true with the larval parasite *T. flavoorbitalis*.

The larval feeding injury data obtained over the past 14 years indicate that *H. blackburni* has been present in sufficient numbers to cause noticeable feeding damage each year in most but not all areas on the different islands throughout the period. This statement appears to be valid even though data on the addition and retention of fronds on trees of variable ages and growing under different ecological conditions were limited. Nevertheless, the data obtained during the latter half of 1959 and early months of 1960 indicate that new fronds were added at a maximum rate of ca. 1 frond per month to a minimum of 1 frond per 4 to 5 months. The maximum number of fronds observed on a tree was 36 but in most cases there were only 10 to 25 per tree. These and the follow-up data obtained over the past decade suggest that probably most fronds are shed in 2 to 3 years, which means that feeding injury data taken on a particular date would provide some measure or information on the activity and abundance of *H. blackburni* during the preceding several months.

For the past 14 years *H. blackburni* has persisted as a pest of coconut trees in windswept areas in Hawaii, has apparently done so for more than a century, and might be expected to continue to be a pest in these areas unless the ecosystem is changed through the introduction of more effective biological control agents or some other means. As has been shown the species, although widespread in the islands, causes little or no injury to trees in relatively protected sites, even on the windward side of the islands. This would suggest that landscape architects and others responsible for the selection of ornamentals to plant in parks, along streets and highways, around public buildings, as well as private residences,

should be apprised of the importance of *H. blackburni* as a pest of coconut trees planted in exposed sites where there is a good likelihood that this insect will be a serious pest. If planting on such sites is done the hazard may be reduced by planting in groups, and on the leeward side of other trees or buildings in order to reduce the exposure of the coconut trees to wind. The idea is not new as far as pest management on crops is concerned but provides a good example to illustrate the need to consider pests and their ecology, as well as plant species and their ecological requirements. The accompanying photographs illustrate the appearance of defoliated versus non-defoliated coconut trees, differences associated with site conditions without the use of insecticides.

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