Observations on Nutgrass Insects in Hawaii with Notes on the Host Range of Bactra truculenta Meyrick and Athesapeuta cyperi Marshall

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INTRODUCTION

Throughout many parts of the world, the purple nutgrass, *Cyperus rotundus* L., is regarded as a troublesome weed and often as an important pest. A closely related species, *C. esculentus* L., frequently called yellow nutgrass or chufa, is also often classified as a weed, although in certain areas it is a source of food for wildfowl, livestock and occasionally even for humans.

Both species are believed to have originated in the Mediterranean region, and various control practices have been employed throughout the world for their destruction. Because of its more durable rhizome system, purple nutgrass has resisted both cultural and chemical control measures in many areas and has been investigated for possibilities of eradication by means of biological control. Hawaiian scientists were the first to attempt this when they studied insect pests of nutgrass in the Philippines and introduced two insects from that country into Hawaii in 1925 to combat *C. rotundus* (Swezey 1926, Pemberton 1948).

These two insects were *Bactra truculenta* Meyrick (Olethreutidae) and *Athesapeuta cyperi* Marshall (Curculionidae) which soon became established on Oahu and spread to the islands of Hawaii and Maui. Initially, the moth seemed most promising (Swezey, 1927–1928), but eventually native parasites reduced its effectiveness (Swezey 1931, 1935, 1946). The weevil was somewhat slower in spreading, but now, at least on several of the islands, has a range equal to that of *B. truculenta* (Swezey and Pemberton, 1931).

The author spent three and one-half months (April 15–July 31, 1963) on the island of Hawaii studying the host range of *B. truculenta* and *A. cyperi* to determine if introductions into southern California for biological control of nutgrass would be safe. During these studies, there was ample opportunity to examine the insect fauna of both *C. rotundus* and *C. esculentus*.

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BACTRA TRUCULENTA MEYRICK

Life history studies: This olethreutid was first described by Meyrick from India (1909). It is also recorded from the Philippines and Burma and may possibly occur in South America (Williams, 1931). Both Ghosh (1921) and Williams (1931) have published brief accounts on the biology of this moth and further findings by the author follow below.

The eggs, laid either in the midrib groove or on the smooth surface of the nutgrass leaf, are flattened and usually overlapping in a row. Several hundred eggs were held at an average temperature of 74.2° F. (range of 65.6–82.8) over a two-week period and found to hatch in five and one-half to six days at an elevation of 75 feet.

The eggs are white when first laid, and the embryo can be distinguished after two to three days. The eyes are visible after three to four days and the internal organs in five to six days. At the time of hatch, the larva is pale yellow with a black prothoracic shield and head capsule.

Just before emergence from the egg, the larva initiates biting motions against the chorion. As this behavior becomes more intensified, the head is swung back and forth as the larva searches for other possible emergence areas. Eventually, the chorion is broken and the larva makes its exit.

After emergence, many larvae crawl a short distance away from the egg, burrow into the leaf and tunnel toward the base of the plant. They may later emerge from the leaf and start a new tunnel or simply crawl over the plant and eventually make their way down to the base of the stem where they tunnel directly into the stem tissue. A few of the larvae drop off the leaves, suspended by a delicate silk strand, and are blown to neighboring plants.

After entering the plant, the larvae make their way to the meristematic stem tissue and some eventually reach the bulb and feed on its contents. The first sign of infestation is the yellowing of the inner leaves of the plant as they are severed from the main portion of the stem. These leaves wither and die and usually the whole plant eventually succumbs. Sometimes an adventitious shoot is sent up from the base of the plant which survives after the parent plant dies.

Under laboratory conditions, the larval period lasted from 18 to 20 days at an average temperature of 75° F. The pupa was formed in a lightly constructed cocoon in the basal stem portion of the plant. The adult moth emerged in about a week and was capable of ovipositing in about two days. Two females that were reared from larvae were caged until death and found to have laid 77 and 130 eggs, respectively.

Parasites: The gradual lack of effectiveness of *Bactra* on nutgrass in succeeding years after its introduction was generally attributed to parasitization of the eggs by *Trichogramma minutum* (Swezey 1931, 1931a, 1946). The author found egg clusters of *Bactra* which ranged from 0 to 100 percent parasitized by *T. minutum*. Parasitized eggs appear totally black to the naked eye, in contrast to the yellow color of unparasitized eggs. This color appears to be due to a darkening of the inside of the chorion and not to the body of the parasite itself.

The only other recorded parasite of *B. truculenta* appears to be *Chelonus blackburni* Cameron (Braconidae) which was recorded from one larva on the

island of Maui (Swezey 1929). However, I discovered that during May and June many of the moth larvae feeding on yellow nutgrass in the sugar plantations were parasitized by two ichneumonids, *Diadema blackburni* (Cameron) and *Eriborus* sp.[2] Each is a larval parasite which emerges from the body of the caterpillar after it has spun its cocoon and then forms its own cocoon inside the *Bactra* cocoon.

Host plant studies: Very little information is available concerning the host range of *Bactra truculenta*. Pemberton (1948) mentions that tests were made with this moth in Honolulu in 1922 on economic plants, but I have been unable to find any account of these experiments.

According to all previous records, it appeared that *B. truculenta* was confined to *Cyperus rotundus* and substantiating this was the report that it had never been recorded injuring any crop or garden plant in India or the Philippines (Swezey, 1926). Since its introduction into Hawaii, however, it has been discovered feeding on *Kyllingia monocephala* Rottb. (Swezey 1929) and *K. pumila* Michaux (Williams, 1931).

In order to insure that this insect would not harm other plants if introduced into California, host plants studies were conducted with plants in the Gramineae, Cyperaceae, and Juncaceae.

The results are shown in table 1. In the oviposition studies, 10 to 15 adult moths were caged with the host plant. In the larval feeding tests, newly hatched larvae were placed both on and in potted and cut plants.

Results indicate that the adults will oviposit on a wide variety of plants; however, the feeding habits of the young larvae are much more restricted and of the plants tested, development can be completed only on *C. rotundus*, *C. esculentus*, *C. alternifolius* L. and *C. papyrus* L. Only a few larvae were able to complete their development on the latter two plants, and the pupae were all destroyed by ants before they could mature. I have been unable to locate infested plants of *C. papyrus* and *C. alternifolius* in the field, but *Bactra* larvae are quite common in *esculentus*. In order to determine if *Bactra* adults showed any preference in regard to oviposition on various host plants, a number of potted plants were trimmed to about the same surface area of foliage and placed in a large screen cage with 20 adult moths.

After 4 days, the plants were removed and examined for eggs. The number of eggs laid on each plant is as follows:

Cyperus rotundus L.	37
Sorghum halepense (L.) Pers.	29
Cyperus esculentus L.	17
Cyperus alternifolius L.	17
Avena sativa L.	9
Tropaeolum majus L. (nasturtium)	0

The results indicate that the adults do show a preference, yet plants other than the desired host (*C. rotundus*) are also chosen for oviposition.

The first instar of *Bactra truculenta* was unable to live on any of the other sedges and the rushes and grasses tested. When later instars were placed on corn, wheat, and oats, they fed for a day or two and then succumbed.

[2] Determined by Dr. L. M. Walkley, Entomology Research Division, Beltsville, Maryland.

ATHESAPEUTA CYPERI MARSHALL

Life history studies: This barine was described by Marshall in 1928 and is known to occur only in the Philippines. Close relatives are found in India (Marshall, 1928) and Burma (Ghosh, 1921).

Table. 1. Results of Host Plant Studies for Ovipositional Sites and Larval Feeding of Bactra truculenta Meyrick

Host Plants	Eggs Deposited	Larvae Fed (first instar)	Development Completed
Gramineae			
Avena sativa L.	+	−	−
Triticum vulgare Vill.	+	−	−
Bromus unioloides H.B.K.	+	−	−
Sorghum halepense (L.) Pers.	+	−	−
Zea mays L.	+	−	−
Festuca elatior L.	+	−	−
Poa annua L.	−	−	−
Hordeum vulgare L.	+	−	−
Lolium perenne L.	+	−	−
Dactyles glomerata L.	+	−	−
Cyperaceae			
Cyperus esculentus L.	+	+	+
C. alternifolius L.	+	+	+
C. papyrus L.	+	+	+
Carex wahuensis C. A. Meyer var. *rubiginosa* R. Krauss	0	−	−
Eleocharis obtusa Schultes	0	−	−
Scirpus lacustris L.	0	−	−
Fimbristylis polymorpha Boeckeler	0	−	−
Killingia pumila Michaux	+	+	Plant died
Juncaceae			
Luzula campestris (L.) DC. var. *hawaiiensis* (Buch.) Degener and Fosberg	+	−	−
Juncus bufonius L.	+	−	−

0 = not tested
+ = yes
− = no

As with most of the weevils of this tribe, little of their biology is known. The following observations will supplement Williams' notes (1931) on the biology of this weevil.

Adults were kept in petri dishes and a fresh portion of the nutlet, stem, and lower portion of nutgrass leaves was supplied every other day. Eggs were deposited in cavities in the tubers of the plants. They were about one-fourth mm. long, pearly white when laid, and remained so except for the head capsule which turned black just before hatching. The incubation period lasted four to five days at an average temperature of 75° F.

The young larvae apparently enter the base of the stem and make their way to the meristematic tissue and down into the tuber where they feed on its contents.

Pupation occurs in the hollowed-out tuber, and the adult is formed after 10 to 11 days (at average temperature of 75° F.). The newly formed adults seem to spend several days inside the tuber before making their way to the outside.

In the field during the day, the adults could be found in the soil, hidden between the bases of the leaves, or rarely exposed on the leaf surface. In the laboratory, they fed on all parts of the plant but preferred the basal stem portion and the nutlet. The adults appear to have a preoviposition period which may last up to two months or longer. Mating was observed one month after emergence, but oviposition occurred much later. No parasites of the weevil were recovered.

Host plant studies: Because of the long preoviposition period of the nutgrass weevil, there was no opportunity to test various plants for oviposition sites and determine the host range for the early larval instars.

Instead, adults were placed on various plants and third and fourth larval instars were transferred from nutgrass stems obtained in the field and placed on stems of various test plants in the laboratory.

The results are shown in table 2. In the laboratory, the adults fed only on

Table 2. Results of Host Plant Tests with Adults and Older Larvae of Athesapeuta cyperi Marshall

Host Plants	Larval Stage	Larvae Fed	Development Completed	Adult Fed
Gramineae				
Avena sativa L.	3rd	+	+	−
Triticum vulgare Vill.	3rd	+	−	0
Zea mays L.	4th	+	−	−
Triticum vulgare Vill.	4th	+	+	0
Cyperaceae				
Cyperus papyrus L.	4th	+	−	+
C. esculentus L.	3rd	+	+	+
C. alternifolius L.	4th	+	−	−
Carex wahuensis Meyer var. *rubiginosa* Krauss.		0	0	−
Juncaceae				
Juncus bufonius L.	3rd and 4th	+	−	0
Other				
Bidens sp.		0	0	−
Tropaeolum majus L. (Nasturtium)		0	0	−
Coreopsis sp.		0	0	−

0=not tested
+=yes
−=no

C. esculentus L. and *C. papyrus* L. The data gained from the larval trials suggest that, as with the moth, later larval instars can complete the remainder of their development on a wider range of plants than can the first instars.

In the field, *C. esculentus* was heavily attacked and appears as acceptable to the weevils as C. *rotundus*. Larvae were also found in *C. polystachyos* Rottb., and an adult was observed feeding on *K. pumila*.

FIELD OBSERVATIONS

In general, both insects appear to be more plentiful at the lower elevations in Hawaii although the weevil has been recorded as high as 3,000 feet on Oahu (Zimmerman, 1936).

Both the moth and the weevil are often found in the same locality and although they may occur side by side, have never been found together in one plant. In fact, I have never found more than one of these insects in a single nutgrass plant.

In plants of *C. esculentus* in the sugarcane field on Hawaii, the weevil appeared more abundant than the moth in May, and out of 25 plants examined, six were infested with the weevil and three with the moth. This may be due to parasitization of the moth, however.

In a macadamia nut orchard infested with *C. rotundus*, the moths were much more plentiful than the weevil and continued breeding throughout the summer months. It is difficult to say what factors play the leading role in the abundance of these two insects. The extremes of temperature and moisture found in Hawaii offer a good chance to study the effect of physical factors on the distribution of these insects.

REPORTS OF HAWAIIAN NUTGRASS INSECTS

A number of other insects have been reported feeding on *C. rotundus* in Hawaii at one time or another and will be briefly discussed below. Most of these are not specific to nutgrass.

Two species of mealybugs, *Dysmicoccus brevipes* (Cockerell) and *Geococcus radicum* Green have been reported on the roots of nutgrass, *C. rotundus*, in the Hawaiian Islands. Both also attack pineapple.

Two species of thrips, *Taeniothrips cypraceae* Bianchi and *Haplothrips (Hindsiana) sakimurai* Moulton have also been reported attacking *C. rotundus* in Hawaii. Both are found on other plants.

The aphid *Schizaphis cyperi* (Van der Goot) was first found in the Hawaiian Islands in 1939 and feeds on the above-ground portion of *C. rotundus* L. (Zimmerman, 1948).

Several species of Lepidoptera have been reported feeding on *C. rotundus* in Hawaii. These are *Spodoptera mauritia* Boisduval[3] (Williams, 1931), *Spodoptera exempta* (Zimmerman, 1958), and *Pseudaletia unipuncta* (Zimmerman, 1958).

Beardsley (1963) noted adults of *Sphenophorus cariosus* (Olivier) around the roots of nutgrass, *C. rotundus*, and observed adults feeding and ovipositing on this plant under laboratory conditions.

INSECTS ASSOCIATED WITH NUTGRASS IN HAWAII

During this study in the summer of 1963, I came across the following insects associated with nutgrass. The aphid, *Schizaphis cyperi*, was collected on *C. rotundus* behind the laboratory in Hilo, Hawaii. Its occurrence seems to depend on the activity of ants which distribute the aphids from plant to plant. Most of the aphids were clustered on the basal stem portion of the plant.

[3] Owing to a misidentification, Hawaiian records of *S. mauritia* prior to 1938 should apply to *S. exempta* (see PROCEEDINGS 10:75, 1938).

Rhopalosiphum rufiabdominalis (Sasaki)[4] is a very common aphid found on roots of *Cyperus esculentus* in cane fields. Individuals of all sizes can be found on root clusters just beneath the tuber, and they are frequently attacked by coccinellid larvae. Their feeding often causes a general chlorotic condition of the plant. In one field, out of 50 plants of *C. esculentus*, 31 were infested with this aphid.

Taeniothrips cyperi was common in the basal portion of the leaves in both *C. rotundus* and *C. esculentus*. When in large numbers, their feeding produces a scarring effect on the leaves which then show a purplish cast.

Specimens of *Dysmicoccus brevipes* (Cockerell)[5] were feeding on the tubers of both *C. rotundus* and *C. esculentus*. *Saissetia nigra* (Nietner)[5] was found on leaves of many *C. rotundus* plants at Hilo during July. Several specimens of *Chorizococcus* (=*Trionymus*) *rostellum* (Hoke)[5] were discovered on the roots of *C. esculentus* at Hilo, also during July.

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[4] Determined by L. M. Russell, Entomology Research Division, Beltsville, Maryland.

[5] Determined by J. W. Beardsley, University of Hawaii, Honolulu.