The Introduction, Propagation, Liberation, and Establishment of Parasites to Control Nezara viridula variety smaragdula (Fabricius) in Hawaii (Heteroptera: Pentatomidae)

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INTRODUCTION

A serious pest of fruits, nuts, vegetables and ornamentals, the southern green stink bug, *Nezara viridula smaragdula* (Fabricius),[1] was discovered on the University of Hawaii Farm, Honolulu, in October 1961. Despite cooperative eradication efforts by University of Hawaii and State Department of Agriculture entomologists, it became widespread on Oahu and, by August 1963, had appeared on all major neighbor islands.

The build-up of large stink bug populations in Hawaii was undoubtedly aided by favorable climatic conditions, lack of natural enemies, and the availability of preferential wild weed hosts such as *Asystasia coromandeliana:* cheese weed, *Malva parviflora; Crotalaria* spp.; castor bean, *Ricinus communis;* black nightshade or popolo, *Solanum nigrum; Amaranthus* spp.; wild spider flower, *Gynandropsis gynandra*, and garden crops, particularly soybean, *Glycine* sp. and string bean, *Phaseolus* sp. All are nearly ubiquitous in the lowland areas and sustain all stages of the stink bug. Since chemical control was limited by the lack of an effective residual insecticide, and since well-known enemies of the stink bug were known to occur in Australia and the West Indies, arrangements were made with these countries to send parasites.

Beginning December 1961, 10 shipments of the egg parasites *Telenomus basalis* Wollaston, *Xenoencyrtus niger* Riek, and *Telenomus* sp. were received from Australia through the courtesy of Dr. Douglas Waterhouse. All were successfully propagated in our facilites and widely liberated in the state.

This was followed by a trial shipment of 37 puparia of unknown ages of the tachinid, *Trichopoda pennipes* var. *pilipes* Fabricius, from Antigua, West Indies, sent by Dr. Fred Bennett on March 24, 1962. Of these, 22 adults emerged at widely spaced intervals. After initial placements, eight were released at Makaha Valley, Waianae on April 2, 1962 and four were liberated at the Old Quarry, University of Hawaii on April 5, 1962. The remainder, which was held as breeding stock died, so attempts to increase the quarantine colony were unsuccessful. In the meantime, arrangements for further tachinid shipments were made with

[1] Identified by Dr. H. Ruckes, American Museum of Natural History, New York.

the Commonwealth Institute of Biological Control at Trinidad and these began to arrive on August 12, and in November 1962 from Montserrat. In addition, the egg parasites, *Ooencyrtus submetallicus* (Howard) and *Ooencyrtus trinidadensis* Crawford, were received.

Breeding and propagation were successful and widespread releases were made between Koko Head and Waianae beginning August 28, 1962. These liberations were extended to windward (North) Oahu following the establishment of *Nezara* at Waimanalo, Kaneohe, Lanikai, and Kailua in late 1962. By July 1963, *Nezara* had been reported from most coastal areas around Oahu. Upon the discovery of the stink bug at Lawai, Kauai in August 1962; Kawaihae, Hawaii on June 13, 1963; Kaunakakai, Molokai on August 25; Kahului, Maui on August 26; and Lanai on August 27, 1963, liberations of both egg and adult parasites of *Nezara* were made at or near all infested localities and temporary facilities for rearing, breeding and propagating these parasites were set up on Kauai, Maui, and Hawaii to effect establishment in all infested areas as rapidly as possible. Eradication of the stink bug at Kawaihae and Kona on the island of Hawaii was attempted but was unsuccessful.

REARING METHODS

NEZARA VIRIDULA

Four hundred stink bugs were placed in 17″ × 16″ × 28″ screen cages and provided with string beans and corn on the cob. The string beans were strung on a wire from one end of the cage to the other while the corn cobs were impaled on nails which were driven into the frame at different levels. For insectary-reared stink bugs, preoviposition ranged from 14 to 16 days and two to four egg clusters, averaging 75 eggs per cluster, were laid during the lifetime of the female which was usually 2 to 3 months. Since it was necessary to have both eggs and adults in great numbers for propagation of egg and adult parasites, the insectary-reared stock was augmented with field-collected bugs as often as possible.

For easy recovery of egg clusters, paper towels folded over a string or bouquets of *Porana paniculata* were provided for egg laying. Since the egg clusters were usually laid early in the morning, the eggs were removed as soon as possible to avoid egg predation by adult *Nezara*, and placed in petri dishes for hatching. However it appears that this predation was minimized when corn was used for food. Hatching usually took 6 to 8 days and the first and second instar nymphs were held in wide-mouth gallon jars or 10″ × 10″ × 10″ cages. Upon reaching the third instar, the nymphs were transferred to larger cages.

The use of other bugs to increase parasite production was explored and the native scutellerid, *Coleotichus blackburniae* White, and the pentatomid, *Murgantia histrionica* (Hahn), were successfully parasitized under insectary conditions by *Trichopoda* but the recovery of puparia was very poor in comparison with *Nezara*. To date, one parasitized *C. blackburniae* in the field has been reported to me by Dr. W. Mitchell (personal communication).

Although parasitization of *Coleotichus* and *Murgantia* by *Trichopoda* did not appear promising under insectary conditions, tests with *Ooencyrtus submetallicus*, *O. trinidadensis*, and *Telenomus basalis* on the eggs of *Coleotichus* showed much

promise. In an initial placement with 25 *C. blackburniae* eggs, 184 *O. trinidadensis* emerged from the parasitized eggs 18 days later, an average of 7.4 parasites per egg. A placement of 27 *C. blackburniae* eggs with *O. submetallicus* produced 117 parasites, an average of 4.3 per egg. In an observation reported by James Kim, insectary supervisor, the following was noted: "On November 1, 1963, an egg cluster containing 28 eggs of *C. blackburniae* was recovered from a screened cage where adults of *Coleotichus* were held. The eggs were parasitized and were placed in a jar for emergence. On November 8, 1963, 6 *T. basalis* adults emerged, followed by 21 the following day." Thus, a total of 27 *T. basalis* was recovered from 28 eggs.

Egg Parasites

In the rearing of the egg parasites *Telenomus basalis*, *Ooencyrtus trinidadensis*, *O. submetallicus*, and *Xenoencyrtus niger*, 50 to 100 one-day old parasites were put with one- to two-day old *Nezara* egg clusters which were in shallow containers and held in wide-mouth gallon jars. Food was provided by applying tiny drops of a honey and water solution to the sides of the jar with a fine camel-hair brush, and water was provided daily by an atomizer. The parasites were held with the egg clusters for two days and, following the second placement, were released in the field. Parasitized eggs, which are black in color, were held in glass tumblers to conserve space.

The total life cycle for these egg parasites was as follows: *T. basalis*, 10 to 12 days, *O. trinidadensis* and *O. submetallicus*, 18 days.

Adult Parasites

Trichopoda: 15 to 20 pairs of sexually mature *Trichopoda* were placed in a 17″ × 16″ × 28″ cage containing 400 *Nezara* adults. Food consisted of a solution of honey and water, flowering bouquets of *Porana*, and water provided through a saturated dental roll.

Parasitized adults were usually removed daily and placed in a 10″ × 10″ × 10″ cage. Upon issuance from the host, the mature *Trichopoda* larvae dropped through a ⅛-inch hardware cloth into a sand-covered tray where they pupated. Pupae were collected daily, placed over damp peat moss in petri dishes, and held in gallon jars. Under these conditions, between 80 to 90 percent emergences were obtained.

Trichopoda, under insectary conditions, lived 5 to 6 days; incomplete field observations suggested 12 days. The egg and larval stages (including 30 to 40 hours for hatching of the egg) took 15+ days; the pupal stage 13 days; and the preoviposition period 1 day; a total of 29 days.

RECOVERY AND ESTABLISHMENT

Egg Parasites

The first recovery of the scelionid, *T. basalis*, was made at the old Moiliili Quarry, University of Hawaii, August 1962. Since then, widespread recoveries have been made on Oahu. For Hawaii, the first recovery was in Hilo (with 137″

rainfall) in November 1963, followed by recoveries in Kailua (31″) and Honomalino, Kona (approximately 70″) in December 1963. It has not been recovered from the other neighboring islands.

According to Cumber (1953), *Telenomus* depends upon warm and dry climatic conditions for successful establishment and effectiveness. The recoveries in table 1 include both wet and dry localities and indicate good adaptability to Hawaiian climatic conditions.

Table 1. Recovery and Percent Parasitism, Telenomus basalis on Oahu 1963

Date*	Locality	Host	Eggs	Percent Emergence
7/15/63	Ewa alfalfa field	alfalfa	51	99
7/17/63	Waimano Home	amaranth	98	100
7/18/63	Makaha Valley	acerola leaf	71	100
8/5/63	McCully	althea leaf	58	100
9/27/63	Kailua	amaranth	52	100
9/28/63	Makaha Valley	yard-long beans	92	100
10/4/63	Makaha Valley	lima beans	69	50
10/16/63	Waimanalo	string beans	78	100
10/16/63	Waimanalo	string beans	44	100
12/26/63	Lanikai	asystasia	73	100
				Average 94.9

* The first and only recovery for 1962 was made at Moiliili Quarry, University of Hawaii in August. The egg cluster was 100% parasitized.

T. basalis is easily propagated in the insectary and, with increasing numbers of recoveries in the field, averaging 94.9 percent parasitism, it appears that this egg parasite will be eminently successful in the biological control of *Nezara*. The other egg parasites, *O. submetallicus*, *O. trinidadensis*, *Xenoencyrtus niger*, and *Telenomus* sp. have not been recovered.

Adult Parasites

Of the two tachinid introductions, *Trichopoda pennipes* var. *pilipes* (West Indies) and *T. pennipes* (Florida), the former is well established on Oahu and Kauai and is becoming established in Hilo and Kona, Hawaii. The latter has not been recovered but its recovery is believed imminent.

Although the recovery of *Trichopoda* was first recorded at Waimano Home, Waiau in October 1962, further recoveries were not noted until January, April and May 1963, in Nuuanu Valley, Ewa District and Manoa Valley respectively. It will be noted in Table 2 that beginning in July 1963 and continuing through December 1963, recoveries of *Trichopoda* were recorded from all major districts of Oahu, with parasitism ranging from 34.5 to 100 percent. The widespread distribution of *Trichopoda* on Oahu indicates good adaptability to Hawaiian climatic conditions. The adults are a common sight in some stink bug-infested

Table 2. Recovery and Percent Parasitism, Trichopoda pennipes var. pilipes For Oahu, in 1963

Lot No.	Date Collected	Locality	Total Collected	No. Parasitized	Percent Parasitized
1–3	7/17–7/23	Waimano Home	539	389	72.2
4/36	7/19–12/30	Ewa alfalfa field	7,274	2,566	35.3
37–38	9/5–12/4	Kaneohe Hospital	95	62	65.3
39–40	9/16–12/18	Kahaluu Valley	97	53	54.6
41–43	9/26–11/14	Makaha Valley	276	168	60.9
44	10/8	Waikane	66	47	71.2
45	10/14	Kahuku	29	10	34.5
46	10/15	Hauula	25	9	36.0
47	10/16	Waimanalo	83	35	42.7
48	10/16	Ewa Depot	148	114	77.0
49–51	10/17–12/20	Koko Head	131	47	35.9
52	10/21	Nanakuli	32	16	50.0
53	10/28	Maile	39	29	74.4
54	10/30	Waialua	26	19	73.1
55	10/31	Maunawili	52	31	59.6
56	11/1	Kipapa	10	10	100.0
57	11/1	Waipio	40	31	77.5
58	11/6	Puuiki	68	43	63.2
59	11/8	Poamoho	30	13	43.3
60	12/18	Kahana Bay	7	7	100.0
61	12/26	Waipahu	20	12	60.0
62	12/36	Lanikai	15	9	60.0
		Total	9,101	3,720	40.9

localities and one bug observed at Wahiawa, Oahu by Dr. Mitchell, University of Hawaii, had 237 eggs on its body.

IDENTITY OF THE WEST INDIES TRICHOPODA

Bennett (1963, unpublished report) discussed identity of the West Indies *Trichopoda* and stated that the question was raised in 1954 when long series of adults reared from *Nezara viridula* from Florida and Montserrat were sent to the Commonwealth Institute of Entomology. He cited from a note by the late Dr. Van Emden, "It is obvious that the material of males with orange wing base is insufficient for deciding the question of the status of this form (if this can be decided at all without reference to breeding experiments) but the present evidence seems to indicate that the difference in wing coloration is not closely linked up with the difference in other characters, especially the genitalia. On the other hand, the difference in the latter may indicate a significant geographical variation, forms with more elongate superior forceps occurring in the United States, while in Central America and the West Indies this structure is more or less distinctly, and often very conspicuously, shorter." In April 1962, Bennett sent specimens collected in Antigua to the Commonwealth Institute of Entomology and these were examined by R. W. Crosskey who made the following comments: "These specimens are all dark-winged and agree with *Trichopoda pilipes* whether this is regarded as a good species or as a variety of *pennipes* F. So far as I know the rela-

tionship between the different color forms is still not understood and I can add nothing to the remarks already made by Dr. Van Emden on this complex. However the specimens are not *pennipes* sens. stricto and the name *pilipes* applies, and it might be better to call the material *pennipes* var. *pilipes*."

ENEMIES OF TRICHOPODA

A pupal hyperparasite, *Exoristobia philippinensis* Ashmead, was reared from laboratory held *Trichopoda* pupae obtained from the University of Hawaii and later from our insectary stock. This encyrtid was first taken in a light trap in Honolulu in 1961 by Dr. John Beardsley and was later reared by Beardsley from sarcophagids at Waipahu. Although *Exoristobia* was eliminated from our Honolulu insectary, it appeared in our Honaunau Insectary in Kona, Hawaii, constituting the first record for that island.

SUMMARY

Nezara viridula smaragdula (F.), the southern green stink bug, was discovered on Hawaii in October 1961, and by August 1963 was found established on all neighbor islands. Efforts to eradicate it were unsuccessful. Since biological control of some pests in Hawaii has been eminently successful, and since enemies of the southern green stinkbug were well documented in Australia, Florida, and the West Indies, arrangements were made to introduce the scelionid parasite *Telenomus basalis* from Australia and the tachinid, *Trichopoda pennipes* var. *pilipes* from the West Indies. These were received and are currently being produced and liberated throughout the state. Subsequently, the egg parasites *Ooencyrtus trinidadensis* and *O. submetallicus* from the West Indies and *Xenoencyrtus niger* from Australia and *Trichopoda pennipes* from Florida were received, but have not been recovered to date.

Nezara was the principal bug used for host propagation but the immigrant harlequin bug, *Murgantia histrionica* (Hahn) and the native scutellerid, *Coleotichus blackburniae* White were tried. Results were unsatisfactory with the harlequin bug but the eggs of *C. blackburniae* showed some promise with the encyrtids, *O. submetallicus* and *O. trinidadensis*. Of the various foods tried for the southern green stink bug, corn and string beans held up best and were generally available throughout the year.

The egg parasite *Telenomus basalis* and the West Indies tachinid, *Trichopoda pennipes* var. *pilipes* were successfully propagated and, since their liberation, have become well established on Oahu. *Trichopoda* is also fairly well established on Kauai. During 1963, a total of 767,525 egg parasites and 15,712 adult parasites* were propagated in the Honolulu Insectary.

Although both parasites are well established in many localities and good biological control is suggested, more data on seasonal trends of the host, parasitism, and other factors are needed, especially from the neighboring islands where recoveries and establishment are just getting under way.

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* Includes West Indian, and Florida *Trichopoda*. Propagation of the former was discontinued in October, 1963.

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BIBLIOGRAPHY

BEARD, R. L. 1940. The biology of *Anasa tristis* (De Geer) with particular reference to the tachinid parasite *Trichopoda pennipes* Fabr. CONN. AGRIC. EXPT. STA., BULL. 444:595–680.

CUMBER, R. A. 1953. The establishment in New Zealand of *Microphanurus basalis*, egg parasite of the green vegetable bug, *Nezara viridula* L. NEW ZEALAND JOUR. SCI. TECH., ENT. RES. STA. PUB. 18, Sec. B, 34(4):267–269.

DRAKE, CARL J. 1920. The southern green stink bug in Florida. QUARTERLY BULL., STATE PLANT BD., FLORIDA 4(3):41–94.

DIETRICH, E. J. and R. VAN DEN BOSCH. 1957. Insectary propagation of the squash bug and its parasite *Trichopoda pennipes* Fabricius. JOUR. ECON ENT. 50(5):627–629.

HOKYO, NOBUHIKO and K. KIRITANI, 1963. Mortality process in relation to aggregation in the southern green stink bug. RES. POPULATION ECOLOGY. 5(1):23–30.

KIRITANI, KEIJI and NOBUHIKO HOKYO. 1962. Studies on the life table of the southern green stink bug, *Nezara viridula*. JAPAN. JOUR. APPLIED ENT. ZOOL. 6(2):124–140.

KIRITANI, K. 1963. Oviposition habit and effect of parental age upon the postembryonic development in the southern green stink bug, *Nezara viridula*. JAPAN. JOUR. ECOLOGY. 13(3):88–96.

KIRITANI, K., NOBUHIKO HOKYO and KATUTIYO KIMURA, 1963. Survival rate and reproductivity of the adult southern green stink bug, *Nezara viridula*, in the field cage. JAPAN. JOUR. APPLIED ENT. ZOOL. 7(2):113–124.

MITCHELL, WALLACE C. 1963. Southern green stink bug. UNIV. HAWAII COOP. EXT. LEAFL. 8 pp.

O'CONNOR, B. A. 1950. *Trichopoda pennipes* F. in Fiji and the British Solomon Islands. AGRIC. JOUR. DEPT. AGRIC. FIJI. 21(3):63–71.

TOWNSEND, C. H. T. 1897. On a collection of Diptera from the lowlands of Rio Nautla in the State of Veracruz. ANN. MAG. NAT. HIST. VI, 20:279.

VAN DER WULP, F. J. 1903. *Trichopoda pennipes* F. BIOL. CENT. AM. DIPTERA. 2:434.

WORTHLEY, HARLAN N. 1924. The biology of *Trichopoda pennipes* Fab. A parasite of the common squash bug, pts. 1 and 2. PSYCHE. 31:7–16, 57–77.

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