The Biology, Host Range, Parasites, and Hyperparasites of Koa Seed Insects in Hawaii: a Review

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ABSTRACT

The biology and host range of koa seed insects, their parasites, and hyperparasites in Hawaii are reviewed. The information reported may be applicable to other native or introduced legumes because of the wide host range of a few of the insects.

Koa, *Acacia koa* Gray, is considered the most valuable native timber species in Hawaii. Pure stands of koa cover approximately 7.5 thousand hectares (18.6 thousand acres) with an additional 172.4 thousand hectares (426 thousand acres) of koa-ohia mixture in the native forest ecosystems within the State.

Selective logging has reduced the quality of koa to less desirable commercial grade trees. Since 1978, the Hawaii State Department of Land and Natural Resources has been replanting sites where koa once grew. The emphasis on reforestation of this high value hardwood has stimulated research by the Forest Service, U.S. Department of Agriculture, to select and propagate genetically superior trees. Progeny from these trees will then be used to establish viable seed orchards.

Insects present a potentially serious threat to koa seed production. In a recent survey, I found that up to 86% of the seed was destroyed by insects, and three insects were responsible for 93% of the damage (Stein 1983).

This review discusses the biology and host range of the koa seed insects, and lists their parasites. Previously published biological data for these insects were augmented with information from the Bernice P. Bishop Museum, University of Hawaii, State Department of Agriculture, and personal observations. Hemiptera or Homoptera species that ultimately affect seed production by feeding upon flowers or the seedpod were excluded. The information reported should benefit workers who need to develop control measures for these koa seed insects. Because of the wide host range of a few of these insects, this information may be applicable to other native or exotic legumes.

SEED INSECTS

Cryptophlebia illepida (Butler). The koa seedworm is an endemic insect and the more abundant of the two *Cryptophlebia* spp. found on all the major Hawaiian Islands. It occurs from sea level to over 2000 m elevation (Table 1). Zimmerman (1978) speculated that the native *C. illepida* reached Hawaii in recent geologic time and is in the preliminary stages of evolving new endemic Hawaiian forms.

In Hawaii, the koa seedworm has a wide host range, which includes *Acacia confusa, A. farnesiana, A. koa, A. koaia, Alectryon macrocossum, Gassia glauca, Dodonaea viscosa, Inga edulis, Litchi chinesis, Macadamia ternifolia, Mangifera indica, Mezoneuron kauaiense, Phaseolus* sp., *Pithecolobium dulce, Sapindus oahuensis, S. saponaria* (Swezey 1933, 1935, 1936; Swezey and Zimmerman 1946; Davis 1953); *Bauhinia* spp., and *Leucaena leucocephala* (records of author).

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Mating and oviposition of this seedworm are nocturnal activities with individual females laying up to 367 eggs in 4 days. The eggs are laid on the surface of *Acacia* seedpods. One female laid 128 eggs in a single night (Namba 1957). Namba (1957) found that unmated females laid their full complement of eggs within 11 days of emergence. The eggs hatch within 5 days, and the first-instar larva bores into the pod, constructs a silk shield over the entrance hole and rests before it continues to bore into the seed. Individual larva usually consume several seeds in one pod or migrate from one pod to another. The larva goes through five instars in 16 days. During the fifth instar, the larva precuts an exit hole and then pupates in the pod. After 9 days of pupation, the pupa wriggles through the gallery to emerge on the pod surface.

Parasites reared from the koa seedworm include *Brachymeria obscurata* (Walker), *Bracon mellitor* Say, *Coccygomimus punicipes* (Cresson), *C. sanguinipes* (Cresson), *Euderus metallicus* (Ashmead), *Eupelmus* sp., *Eriborus sinicus* (Holmgren), *Perisierola emigrata* Rohwer, *Pristomerus hawaiiensis* Perkins, *Sierola cryptophlebiae* Fullaway, *S. koa* Fullaway, *Sierola* sp., and *Trathala flavo-orbitalis* (Cameron) (Namba 1957, Zimmerman 1978).

Cydia sp. In Hawaii, the genus *Cydia* forms a complex of closely related species, many of which remain undescribed. Most of the males of this genus are distinguished by a strongly-developed sex pouch on the underside of the hind wings with an opening to the dorsal surface.

Several specimens of an undescribed species of *Cydia* were reared from seedpods collected at 2320 m elevation (Table 1) in the Honuaula Forest Reserve on the island of Hawaii during a recent survey of koa seed insects (Stein 1982). This tortricid appears to be endemic to the island of Hawaii, with a sporadic distribution above 2000 m in north Kona.

I know of only three other *Cydia* species that have previously been recorded above 1220 m in the vicinity of Honuaula Forest Reserve. *Cydia oblique* (Walsingham) has no host record associated with its Hualalai collection at 1525 m, but *Cydia montana* (Walsingham) and *C. plicata* (Walsingham) were recorded on mamane *(Sophora chrysophylla)* (Zimmerman 1978).

Cydia rufipennis (Butler). This endemic insect was first described by Butler (1881), placed in *Adenoneura* by Walsingham (1907), and finally combined with *Cydia* by Zimmerman (1978). Superficially, *C. rufipennis* appears to be a diminutive form of *C. plicata* (Walsingham), but the genitalia are distinctive (Zimmerman 1978). Although the holotype was described from the Koolau Mountains on Oahu, this species is also found on Kauai, with an elevational range from near sea level to 1220 m (Table 1). The only recorded host is *A. koa.*

Cydia rufipennis usually attacks koa seeds at an earlier stage of development than seeds damaged by the koa seedworm (Bridwell 1919). Larvae feed on the developing seeds within the pods and occasionally, on flowers and buds. Bridwell (1919) reported that larvae emerge from the pod and pupate in the leaf litter. However, I have observed pupation take place in the seedpod.

Natural enemies are few and the only parasite I encountered was the ichneumonid *Pristomerus hawaiiensis.* Williams (1926) found adult female eumenid wasps *(Odynerus oahuensis* Dalla Torre) provisioning their nests with *Cydia* larvae obtained from unopened koa flowers that had fallen to the ground.

Araecerus levipennis Jordan. The koa haole seed weevil (Fig. 1A) was first found at Pearl Harbor 1954 and subsequently identified as *A. levipennis* Jordan (Ford and Chilson 1955, Hardy 1956). The distribution of this seed borer includes Midway Island, China, Formosa, Philippines, and all the major Hawaiian Islands from sea

level to 1525 m elevation (Table 1) (Stein 1983). In Hawaii, the koa haole seed weevil has been recorded from *A. koa, A. confusa, Tephrosia purpurea, Bauhinia* sp., and *L. leucocephala* (Gressitt 1957, Chilson 1959).

The biology of this seed weevil on koa haole *(Leucaena glauca)* was studied by Sherman and Tamashiro (1956). They found that female beetles chewed holes in the pods and placed the eggs next to the seeds. Average time for eclosion was 4.4 days. After eclosion, the larva bored into the seed and consumed the embryo without destroying the seed coat. Pupation occurred within the seed coat and varied from 6 to 11 days.

The koa haole seed weevil is the most abundant koa seed insect in Hawaii. Twenty-five years after its discovery, it is still relatively parasite-free. The few existing insect parasites within the State are apparently not important in regulating populations of this seed weevil. The eupelmid, *Eupelmus cushmani* (Crawford), was the only parasite reared from this beetle in recent years (Stein 1983). The braconid *Spathius pursius* Nixon, an ectoparasite of the larva, appears to have a limited ecological niche. This parasite has been recovered from beetles attacking koa haole (Beardsley 1963) but has never been reared from infested seeds of *Acacia.* The predacious mite, *Pyemotes ventricosus* (Newport), appears to be the only important biological factor affecting the beetle populations (Sherman and Tamashiro 1956).

Stator limbatus (Horn). This bruchid was first found in Hawaii on monkey-pod *(Pithecellobium saman)* trees at Waipio substation on Oahu in 1919, and later on koa in 1924 (Swezey 1924). *Stator limbatus* has a discontinuous statewide distribution ranging from 15 to 245 m in elevation (Table 1) (Stein 1983).

Swezey (1928) found that *S. limbatus* often destroyed more than 90% of *Acacia* seed crops on the island of Oahu (Fig. 1B, 1C). However, *S. limbatus* is often classified as a secondary pest because it attacks the seed through entrance holes made by other insects such as *C. illepida, C. rufipennis,* and *A. levipennis.*

TABLE 1. Distribution of koa seed insects, their parasites, and hyperparasites during the 1978 growing season.

Species	Distribution	
	Location[a]	Elevation (m)
Lepidoptera		
Cryptophlebia illepida	All major islands	15-2000
Cydia rufipennis	K, O	15-1220
Cydia sp.	H	2320
Coleoptera		
Araecerus levipennis	All major islands	15-1525
Stator limbatus	All major islands	15-245
Stator pruininus	All major islands	15-2045
Hymenoptera		
Diadegma blackburni	All major islands	30-1830
Eupelmus cushmani	H, M, K, O	15-1525
Gelis tenellus	H, M, K, O	30-1830
Pristomerus hawaiiensis	All major islands	15-2000
Unknown Eulophidae	M	30

[a]H = Hawaii; K = Kauai; O = Oahu; M = Maui.

Although the distribution of this insect is scattered, severe damage in localized areas often occurs because of its short life cycle, multiple generations, and continuous reinfestation of the same seed crop. As many as six adults have emerged from a single *P. saman* seed (Janzen 1977), and as many as three adults emerged from a single *A. koa* seed (Stein 1983). Mitchell (1977) found that *S. limbatus* attacked damaged *Cercidium floridum* pods, with the infestation increasing exponentially as the pods became larger.

The trichograma wasp, *Uscana semifumipennis* Girault, was introduced into Hawaii in 1910 as a primary egg parasite of several different bruchids, and was reported infesting *S. limbatus* shortly after the beetle was first discovered (Swezey 1929). Swezey (1928) reported that braconid *Glyptocolastes bruchivorus* Crawford heavily parasitized this beetle.

Stator pruininus (Horn). The pruinose bean weevil is another introduced bruchid beetle, first discovered in Hawaii in August 1917. Stein (1983) found that this bruchid was not as abundant or as serious a pest on *A. koa* as *S. limbatus.* However, the pruinose bean weevil was not restricted to lower elevations and gradually displaced *S. limbatus* at higher elevations (Table 1). *Leucaena leucocephala* has been reported as the favorite host, but this bruchid has also been recorded as infesting *A. confusa, A. koa, S. chrysophylla, Cyathodes* sp., *Scaevola sericea* (Fullaway and Krauss 1945); *Erythrina sandwicensis, Sesbania sesban, Indigofera suffruticosa,* corn, and beans (records of author and Hawaii State Dept. of Agriculture).

Fullaway and Krauss (1945) reported that the female chewed a hole in koa pod and glued eggs directly to the seed coat (Fig. 2A). Several larvae survived and pupated within the same seed coat.

Parasites reared from the pruinose bean weevil are the trichograma wasp *Uscana semifumipennis* Girault, along with the braconid *Heterospilus prosopidis* Viereck, and *Charitopodinus swezeyi* (Fullaway and Krauss 1945). I have also reared an unidentified native male Eulophidae from this bean weevil (Table 1).

PARASITES

Eupelmus cushmani (Crawford). This small, metallic green wasp (Fig. 2B) was introduced from Guatemala in 1934, as a control agent for the pepper weevil *Anthonomus eugenii* Cano (Swezey 1939). This parasite has a broad host range and quickly spread to other Coleoptera on all the major islands, from sea level to 1525 m elevation (Table 1). Although this wasp was found at fairly high elevations, it was more prevalent below 1000 m (Stein 1983).

Little is known about the biology of *E. cushmani* except its life cycle associated with the cotton boll weevil in Texas and Louisiana (Pierce et al. 1912), and mating behavior (Pierce and Cushman 1915). Stein (1983) reported that *E. cushmani* infested less than 1% of *A. levipennis* larvae. This agreed with a low parasitization rate of *A. levipennis* infesting *L. leucocephala* seeds in Hawaii (Hinckley 1961).

The biology of *E. cushmani* along an altitudinal gradient from sea level to 1700 m corresponded to differences found between summer and fall generations in Louisiana and Texas. In the southern United States, egg and larval stages were longer in July than in August. However, this trend was just the opposite for pupation. The pupal stage lasted 6 days longer in September than in July (Pierce et al. 1912). At higher elevations in Hawaii, cool temperatures shorten the egg and larval stages, but prolong pupation. Lavae of *E. cushmani* in Hawaii were solitary external parasites that pupated within the seed coat after *A. levipennis* was consumed.

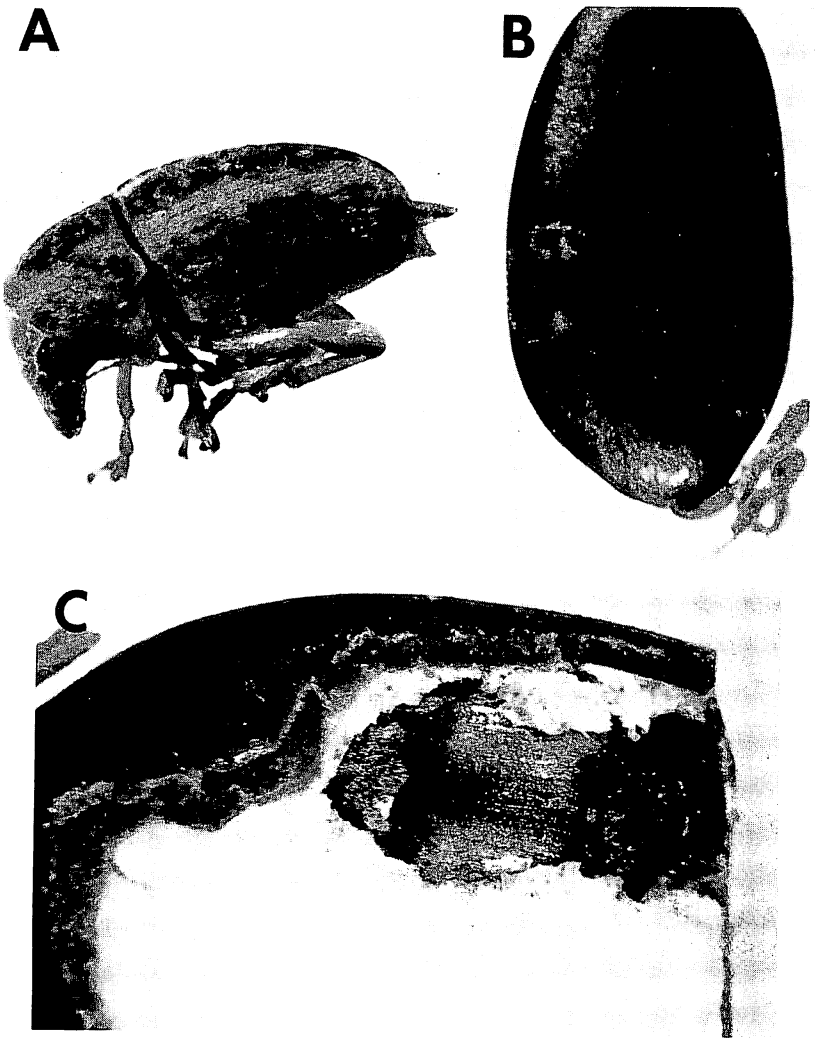

FIGURE 1. A, Koa haole seed weevil *(Araecerus levipennis);* B, koa seed with precut emergence hole and cap over pupal chamber of *Stator limbatus;* C, seed coat removed to show callow adult in pupal chamber.

Davis and Krauss (1965), Fullaway (1957), and Peck (1963), reported the following beetles as hosts: *Acanthoscelides ochraceicolor* (Pic), *Anthonomus grandis* Boheman, *Araecerus fasciculatus* (De Geer), *A. levipennis* Jordan, *Apion antiquum* Gyllenhal, *Cylindrocopturus adspersus* (LeConte), *C. longulus* (LeConte), *Lixus scrobicollis* Boheman, *Trichobaris texana* LeConte, *Microlarius* sp., and *Mimosestes sallaei* (Sharp). Hosts other than Coleoptera are suspect. Other hosts — *Agonoxena argaula* Meyrick, *Diatraea saccharalis* Fabricius, *Procecidochares utilis* Stone, and *Tenodera angustipennis* Sassure — reported by Thompson (1954) and Weber (1957) were probably associated with misidentifications of other *Eupelmus* species.

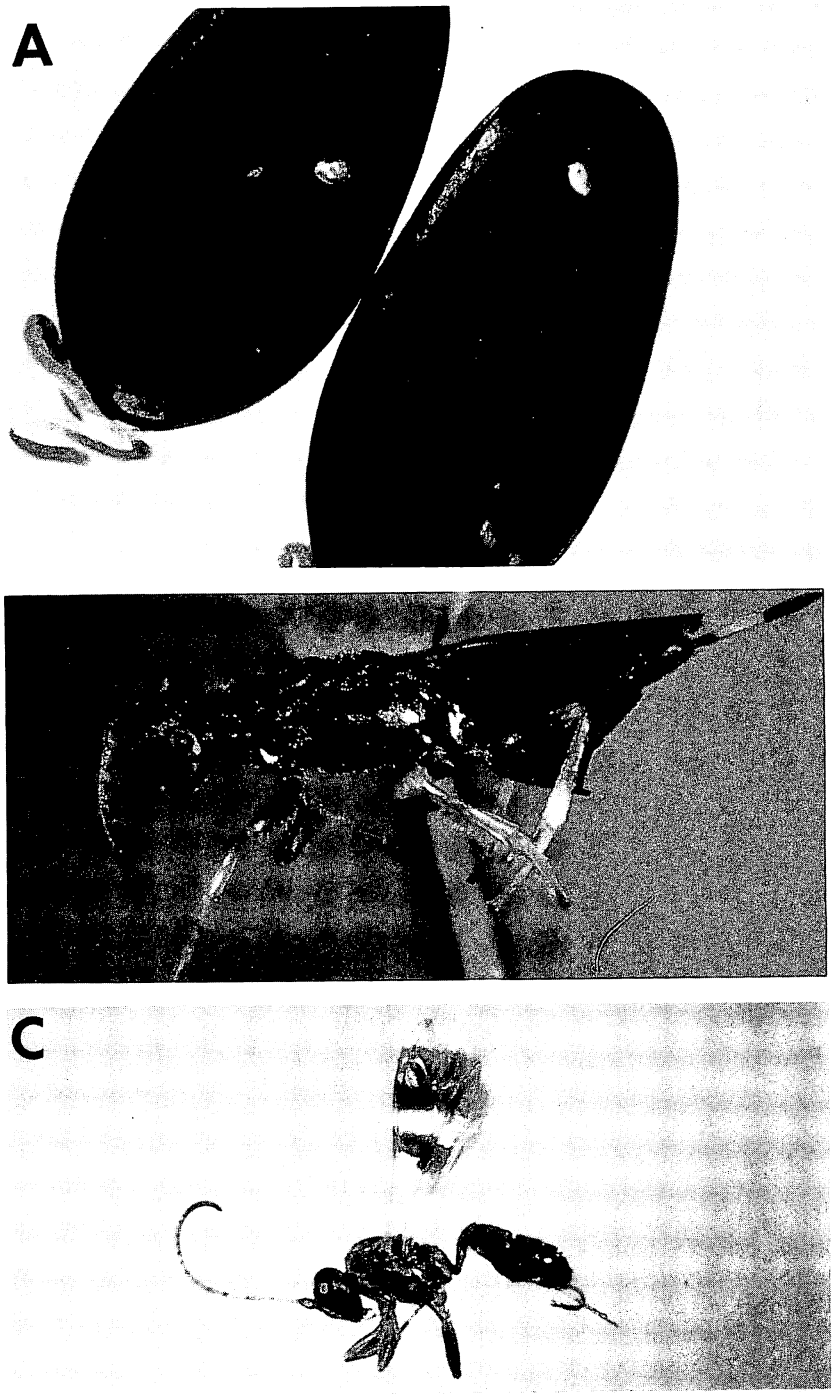

FIGURE 2. A, Pruinose bean weevil *(Stator pruininus)* eggs glued to koa seed coat; B, *Eupelmus cushmani;* C, Hyperparasite *Gelis tenellus.*

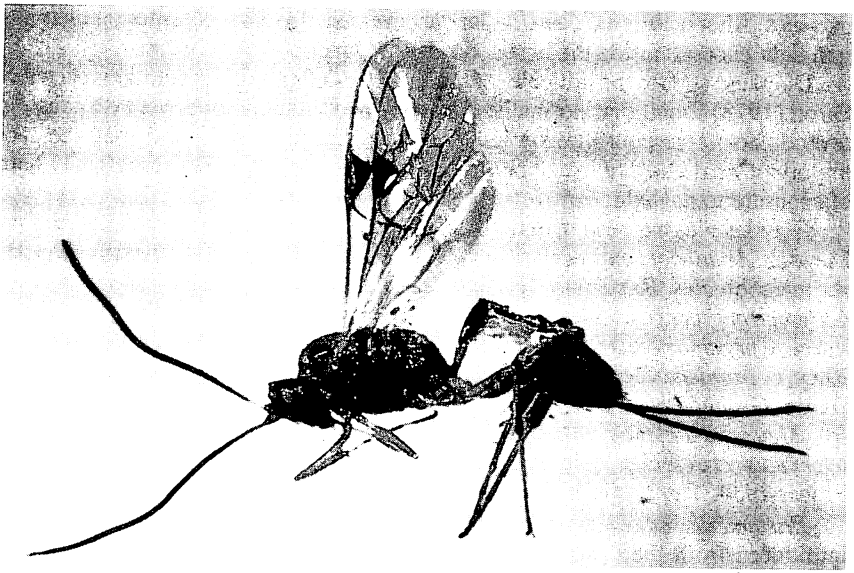

FIGURE 3. *Pristomerus hawaiiensis.*

Diadegma blackburni (Cameron). This parasite of Lepidoptera is one of the more common endemic insects in Hawaii. It occurs throughout the State from sea level to an altitude of 1830 m (Table 1).

The female parasite oviposits directly into the host larva. Larvae are not killed immediately, but continue to grow and eventually spin a cocoon before the parasite develops completely (Fullaway and Krauss 1954). *Diadegma blackburni* emerges from the larval host and pupates within its light brown cocoon normally spun inside the host cocoon. This parasite usually attacks species in the families Tineidae, Tortricidae, and Pyralidae, especially species of *Hedylepta* and *Oeobia. Diadegma blackburni* has also been reared from *Epagoge infaustana* Walsingham, *Gemophantis iodora* Meyrich, *Pyrusta constricta* (Butler), *Phlyctaenia* spp., *C. illepida,* and undoubtedly *Cydia* spp.

Gelis tenellus (Say). This ichneumonid (Fig. 2C) has been found throughout the United States and Canada below the boreal zone, and on all the major Hawaiian Islands, except Molokai and Lanai, from sea level to 1830 m elevation (Table 1).

This polyphagus hymenopteran has a wide host range and is known to be one of the most abundant hyperparasites of the gypsy moth, *Lymantria dispar* (Linnaeus), the fall webworm, *Hyphantria cunea* Drury, and the brown moth, *Nygmia phaeorrhoea* (Donovan) (Dustan 1923, Giron 1978, Proper 1934). It has also been recorded as a primary parasite of the cherry casebearer, *Coleophora pruniella* Clemens (Doner 1936).

In Hawaii, this hyperparasite has multiple broods with overlapping generations. Doner (1936) found that eclosion occurs within 2 days of oviposition, and the larvae pass through five instars in the 7 days before pupation. The pupal stage lasts an additional 7 days. At 25°C, adult longevity is about 40 days. Peak oviposition occurs from 6 to 10 days after adult emergence, with an average of 43 eggs per female (Giron 1978). The females deposit eggs on late instar and prepupal larvae of primary

parasites. After eclosion *G. tenellus* larvae develop as external parasites on their host, spin light cocoons inside the host cocoon, and pupate.

Diapause adds to the difficulty of keeping track of multiple generations each year. Giron (1978) found that normally, 30% of the population underwent diapause. Of several factors responsible for inducing this diapause, he found that the most important was light. Almost 100% of the population went into diapause after 11 hours of exposure to daylight.

Gelis tenellus has been reared from the following insect hosts: *Agonoxena argaula* Meyrick, *Apanteles congregatus* (Say), *A. lacteicolor* (Viereck), *A. liparidis* (Bouche), *A. melanoscelus* Ratzeburg, *Campoplex pelosulus* Provancher, *Cermastus* sp., *Chrysopa microphya* McLeach, *C. nigricornis* Burm., *C. florabunda* Fitch, *C. rufilabris* Burm., *Chrysopoctonus rileyi* Ashmead, *Coleophora innotabilis* Brown, *C. malivorella* Riley, *C. pruniella* Clemens, *C. salmani* Hein, *C. tiliaefoliella* Clemens, *Diprion similis* Hartig, *Grapholitha molesta* Busck, *Hyposmocoma liturata* Walsingham, *Hyposoter* sp., *Meteorus datanae* Muesebeck, *Meteorus versicolor* Wesmael, *Microbracon pygmaeus* Provancher, and *Pristomerus hawaiiensis* Perkins (Doner 1934, 1936; Proper 1934; Thompson 1957; Giron 1978).

Pristomerus hawaiiensis Perkins. This ichneumonid is thought to have been introduced from the Orient. *Pristomerus hawaiiensis* (Fig. 3) is one of the more prevalent parasites of Lepidoptera larvae in Hawaii and is found on all the major islands from sea level to 2000 m elevation (Table 1). Distribution of this parasite coincided with the distribution of known koa seed lepidopterous pests, including *C. illepida* and several species of *Cydia* (Stein 1983).

The host list of *P. hawaiiensis* is extensive and includes species in 19 genera of Lepidoptera: *Alucita objurgatella* (Walsingham), *Anatrachyntis rileyi* (Walsingham), *Carposina altronotata* (Walsingham), *C. graminicolor* (Walsingham), *C. nigronotata* (Walsingham), *C. trigonotata* (Walsingham), *Carposina* spp., *Crocidosema blackburni* (Butler), *C. marcidella* (Walsingham), *Cryptophlebia illepida* (Butler), *Cydia conspicua* (Walsingham), *C. plicata* (Walsingham), *C. walsinghamii* (Butler), *Eccoptocera foetorivorans* (Butler), *Epinota lantana* (Busck), *Genophantis leahi* Swezey, *Ithome concolorella* (Chambers), *Mapsidues auspicata* Walsingham, *Merimnetria compsodellta* (Meyrick), *M. elegantior* Walsingham, *Oeobia chytropa* (Meyrick), *O. micacea* (Butler), *Omphisa anastomosalis* (Guenee), *Orneodes objurgatella* Walsingham, *Pectinophora gossypiella* (Saunders), *Phthorimaea operculella* (Zeller), *Spheterista infaustana* (Walsingham), *S. pleonectes* (Walsingham), and *Stenoptilodes taprobanes brachymorpha* (Meyrick) (Swezey 1915, 1954; Van Zwaluwenburg 1947; Zimmerman 1958a, 1958b, 1978).

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REFERENCES CITED

Beardsley, J.W. 1963. *Spathius pursius* Nixon. Notes and exhibitions. Proc. Hawaii. Entomol. Soc. 18:202.

Bridwell, J.C. 1919. Some notes on Hawaiian and other Bethylidae (Hymenoptera) with descriptions of new species. Proc. Hawaiian Entomol. Soc. 4:21-38.

Butler, A.G. 1881. On a collection of nocturnal lepidoptera from the Hawaiian Islands. Ann. Mag. Nat. Hist. 7:392-409.

Chilson, L.M. 1959. *Araecerus levipennis* Jordan. Notes and exhibitions. Proc. Hawaii. Entomol. Soc. 17:24.

Davis, C.J. 1953. New host and insect records from the island of Hawaii. Proc. Hawaii. Entomol. Soc. 15:35-86.

——— and **N.L.H. Krauss. 1965.** Recent introductions for biological control in Hawaii — X. Proc. Hawaii. Entomol. Soc. 19:89-90.

Doner, M.H. 1934. Observations on the biology of *Microbracon pygmaeus* (Prov.), an important parasite of *Coleophora pruniella* Cl. Ann. Entomol. Soc. Am. 27:435-442.

——— **1936.** Hymenopterous parasites of *Coleophora pruniella* Cl., and parasites recorded from other species of *Coleophora.* Ann. Entomol. Soc. Am. 29:224-244.

Dustan, A.G. 1923. A histological account of three parasites of the fall webworm *(Hyphantria cunea,* Drury). Proc. Acadian Entomol. Soc. 8:73-95.

Ford, E.J., Jr., and L.M. Chilson. 1955. *Araecerus* sp. Notes and exhibitions. Proc. Hawaii. Entomol. Soc. 15:376.

Fullaway, D.T. 1957. *Eupelmus cushmani* (Crawford). Notes and exhibitions. Proc. Hawaii. Entomol. Soc. 16:182.

——— and **N.L.H. Krauss. 1945.** Common insects of Hawaii. Tongg Publishing Co., Honolulu, Hawaii. 228 pp.

Giron, A.R. 1978. Notes on the diapause inducement of the hyperparasite *Gelis tenellus.* Ann. Entomol. Soc. Am. 71:827-829.

Gressitt, J.L. 1957. *Araecerus levipennis* Jordan. Notes and exhibitions. Proc. Hawaii. Entomol. Soc. 16:193.

Hardy, D.E. 1956. *Araecerus levipennis.* Notes and exhibitions. Proc. Hawaii. Entomol. Soc. 16:11.

Hinckley, A.D. 1961. Comparative ecology of two beetles established in Hawaii: An Anthribid, *Araecerus levipennis,* and a Bruchid, *Mimosestes sallaei.* Ecology 42:526-532.

Janzen, D.H. 1977. Intensity of predation on *Pithecellobium saman* (Leguminosae) seeds by *Merobruchus columbinus* and *Stator limbatus* (Bruchidae) in Costa Rican deciduous forest. Trop. Ecol. 18:162-176.

Mitchell, R. 1977. Bruchid beetles and seed packaging by Palo Verde. Ecology 58:644-651.

Namba, R. 1957. *Cryptophlebia illepida* (Butler) (Lepidoptera: Eucosmidae) and other insect pests of the Macadamia nut in Hawaii. Proc. Hawaii. Entomol. Soc. 16:284-297.

Peck, O. 1963. A catalogue of the Nearctic Chalcidoidea (Insecta: Hymenoptera). Entomol. Soc. Can. Mem. 30. 1092 pp.

Pierce, W.D., and R.A. Cushman. 1915. A few notes on the habits of parasitic Hymenoptera. Entomol. Soc. Wash. 17:164-167.

——— and **C.E. Hood. 1912.** The insect enemies of the cotton boll weevil. USDA Bur. of Entomol. Bull. 100. 99 pp.

Proper, A.B. 1934. Hyperparasitism in the case of some introduced Lepidopterous tree defoliators. J. Agric. Res. 48:359-376.

Sherman, M., and M. Tamashiro. 1956. Biology and control of *Araecerus levipennis* Jordan (Coleoptera: Anthribidae). Proc. Hawaii. Entomol. Soc. 16:138-148.

Stein, J.D. 1983. Insects associated with *Acacia koa* seed in Hawaii. Environmental Entomol. 12:299-302.

Swezey, O.H. 1915. A preliminary list of the hymenopterous parasites of Lepidoptera in Hawaii. Proc. Hawaii. Entomol. Soc. 3:99-109.

——— **1924.** Bruchids in koa seeds. Notes and exhibition. Proc. Hawaii. Entomol. Soc. 5:342.

——— **1928.** *Glyptocolastes bruchivorus* Crawford. Notes and exhibition. Proc. Hawaii. Entomol. Soc. 7:23.

——— **1929.** Notes on the egg-parasites of insects in Hawaii. Proc. Hawaii. Entomol. Soc. 7:282-292.

——— **1933.** New records of insects on Molokai and miscellaneous notes. Proc. Hawaii. Entomol. Soc. 8:274.

_____ **1935.** *Argyroplace illepida* (Butler). Notes and exhibition. Proc. Hawaii. Entomol. Soc. 9:30.
_____ **1936.** Fruit-eating and seed-eating insects in Hawaii. Proc. Hawaii. Entomol. Soc. 9:196-206.
_____ **1939.** Recent records of the introduction of beneficial insects in the Hawaiian Islands. Proc. Hawaii. Entomol. Soc. 10:349-352.
_____ **1954.** Forest entomology in Hawaii. An annotated checklist of the insect faunas of the various components of the Hawaiian forests. Bernice P. Bishop Mus. Special Pub. 44, 1-266.
_____ and **E.C. Zimmerman. 1946.** Synonymic notes on *Argyroploce illepida* (Butler) and *A. carpohaga* (Walsingham) (Lepidoptera: Eucosmidae). Proc. Hawaii. Entomol. Soc. 12:629-632.
Thompson, W.R. 1954. A catalogue of the parasites and predators of insect pests. Section 2, Host parasite catalogue. Part 3 Hosts of the Hymenoptera (Calliceratid to Evaniid). Commonw. Inst. of Biol. Control, Ottawa, Can. 332 pp.
_____ **1957.** A catalogue of the parasites and predators of insect pests. Section 2. Host parasite catalogue. Part 4, Hosts of the Hymenoptera (Ichneumonidae). Commonw. Inst. of Biol. Control, Ottawa, Can. 561 pp.
Van Zwaluwenburg, R.H. 1947. *Genophantis leahi* Swezey. Notes and exhibitions. Proc. Hawaii. Entomol. Soc. 13:25.
Walsingham, T.D. 1907. Microlepidoptera. *In:* Fauna Hawaiiensis, David Sharp, ed. 1:469-759. Cambridge Univ. Press.
Weber, P.W. 1957. *Agonoxena argaula* Meyrick. Notes and exhibition. Proc. Hawaii. Entomol. Soc. 16:194.
Williams, F.X. 1926. Notes on the habits of the bees and wasps of the Hawaiian Islands. Proc. Hawaii. Entomol. Soc. 6:425-464.
Zimmerman, E.C. 1958a. Insects of Hawaii. Vol. 7, Macrolepidoptera. Univ. Hawaii Press, Honolulu. 542 pp.
_____ **1958b.** Insects of Hawaii. Vol. 8, Lepidoptera: Pyralodiea. Univ. Hawaii Press, Honolulu. 456 pp.
_____ **1978.** Insects of Hawaii. Vol. 9, Microlepidoptera, Parts I and II. Univ. Hawaii Press, Honolulu. 1903 pp.