Status of the biological control of banana poka, *Passiflora mollissima* (aka *P. tarminiana*) in Hawaii

R.D. Friesen,[1] C.E. Causton[2] and G.P. Markin[3]

Summary

Surveys were conducted between 1982 and 1995 on banana poka, *Passiflora mollissima* Bailey (also known as *P. tarminiana*, subgenus *Tacsonia*) and related species in the Andes Mountains of South America. The objective was to identify potential biocontrol agents for control of banana poka in Hawaii, USA. Host-related insect diversity was greatest in Colombia, Ecuador, Peru and Venezuela, and poorest in Bolivia and Chile. Insect species observed represented eight orders, 35 families and approximately 67 species. Fifteen species were evaluated as potential biocontrol agents, of which five received in-depth testing. Two moths, *Cyanotrica necyria* Felder and Rogenhofer (Lepidoptera; Notodontidae) and *Pyrausta perelegans* Hampson (Lepidoptera; Pyralidae), were approved and released in Hawaii in 1988 and 1991, respectively; however, *C. necyria* did not establish and *Pyr. perelegans* established but has had negligible impact. A third moth, *Josia fluonia* Druce, *J. ligata* group (Lepidoptera; Notodontidae), had been approved for release and two flies, *Dasiops caustonae* Norrbom and McAlpine (Diptera; Lonchaeidae) and *Zapriothrica* nr. *salebrosa* Wheeler (Diptera; Drosophilidae), were undergoing final evaluation when the programme was terminated. A pathogen, *Septoria passiflorae* Syd., was released in 1996, with mixed results. Banana poka remains a serious weed pest in Hawaii.

Keywords: foreign exploration, South America, *Passiflora tripartita*, *Passiflora tarminiana*, weed biological control.

Introduction

Banana poka, *Passiflora mollissima* Bailey (also referred to in literature as *P. tripartita* and *P. tarminiana*), was introduced into Hawaii from South America as an ornamental around the year of 1900, but escaped domestication to become a major forest weed in the upper elevation mountain rain forests (La Rosa, 1984). *P. mollissima* vines form dense mats of vegetation that cover understory plants and climb into overstory canopies of Koa, *Acacia koa* A. Gray, and ‘Ohi’a, *Metrosideros polymorpha* Gaud., causing higher incidence of tree limb breakage from their weight and wind blowdown (Warshauer *et al.*, 1983; La Rosa, 1984). Feral pigs feed on the fallen fruit, severely disturbing the soil and surrounding plants by their rooting, and disseminating the seeds in their excrement.

By the early 1980s, banana poka was considered the most serious threat to upper elevation forests of Hawaii, severely infesting 520 km^2 (Warshauer *et al.*, 1983). In 1982, the State of Hawaii appropriated funds to the Department of Forestry and Wildlife (DOFAW) for the evaluation of the potential for biological control of *P. mollissima*, marking the beginning of a concerted effort to control it.

This paper summarizes the results of foreign exploratory work from 1982 to 1996 in South America, describes the most promising insects that were studied, and identifies those having potential as biological control agents.

[1] Southern Kansas Cotton Growers Cooperative, Inc., PO Box 321, Winfield, KS 67156, USA.
[2] Department of Terrestrial Invertebrates, Charles Darwin Research Station, A.P. 17-01-3891, Ecuador.
[3] USDA Forest Service, Rocky Mountain Research Station, Bozeman, MT 59717-2780, USA.
Corresponding author: R.D. Friesen <southern.kansas.2@pcca.com, causton@fcdarwin.org.ec, gmarkin@fs.fed.us>.
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Materials and methods

Passiflora species of the subgenus *Tacsonia*, which include *P. mollissima*, occur throughout the Andes of South America, from 2000 to 3200 m, where they are cultivated for their fruits (Killip, 1938). *P. mollissima* and its related forms are typically associated with humans. Surveys included commercial stands, single plants or small stands around homes, and feral plants in natural or disturbed areas. Commercial sites frequently were exposed to regular applications of insecticide, which reduced their utility for insect collection.

Sampling of plants included visual inspection of foliage and dissection of flower buds, open flowers, fruit, roots, crowns and stems. Rearing and biological studies were conducted in laboratories in Venezuela (Causton *et al.*, 2000), Colombia and Hawaii. Host specificity testing was carried out in the Hawaii Volcanoes National Park (HVNP) insect quarantine facility. Voucher specimens were submitted to the USDA ARS Systematics Entomology Laboratory (SEL) in Beltsville, MD, as the definitive taxonomic authority. Many specimens came back as 'unidentifiable species', but a few new species descriptions were obtained. Specimens were retained at the USDA FS Institute of Pacific Island Forestry in Hilo, HI.

Results

Species of the subgenus *Tacsonia* most commonly observed above 2200 m were *P. mollissima* (curuba, tumbo, taxo) and *P. mixta* L. Other species were only rarely observed, for example, *P. manicata* L., *P. pinnatistipula* Cav. Below 2200 m, *Tacsonia* species were replaced primarily by *P. edulis* Sims (i.e. maracuyá or passionfruit), *P. ligularis* Juss (granadilla amarilla) and *P. quadrangularis* L. (badea). We included *P. edulis* in our surveys due to concern over agent crossover to Hawaiian passionfruit, although its acreage and economic importance is small (Martin, 1994).

Table 1 summarizes the species of insects encountered. Where possible, the findings reported by Pemberton (1989), Causton *et al.* (2000) and unpublished reports by Markin and Friesen are included. The primary insect species studied during the course of the Hawaiian programme are briefly described below.

Lepidoptera

***Cyanotricha necyria* Felder (Notodontidae):** This was the first species to be pursued as a biological control agent due to its severe impact on commercial production in western Colombia and central Ecuador, where severe outbreaks frequently defoliated the plants (Casañas-Arango *et al.*, 1990). *C. necyria* was tested and released in 1988 (Markin and Nagata, 1989; Markin *et al.*, 1989), but failed to become established in Hawaii (Markin *et al.*, 1989; Campbell *et al.*, 1993).

***Pyraustaperelegans* Hampson (Pyralidae=Crambidae):** This bud-feeder was widespread in Colombia, Ecuador, Peru and Venezuela. In Colombia, *Pyr. perelegans* was considered to be of major economic impact (Rojas and Chacón, 1983). The biology of *Pyr. perelegans* is discussed by Rojas and Chacón (1982). *Pyr. perelegans* was released in 1990 and is now established in Hawaii. However, populations have remained low and impact is negligible (Campbell *et al.*, 1993; Markin and Nagata, 2000).

***Acrocercops* nr. *pylonias* Meyrick (Gracillariidae):** This leaf-miner was commonly observed attacking *P. mollissima* and *P. mixta* in Colombia and northern Ecuador and possibly in Venezuela. In Colombia, damage due to *A.* nr. *pylonias* was incidental at all sites except for one near Pasto, where the leaf-miner was the dominant pest (Hugo Calvache, personal communication, December 1988). Late instar larvae form a distinct blotch that can cover several square centimeters of the upper leaf surface. Impact of the blotches was perceived small (Pemberton, 1989). This insect appeared promising and was scheduled for further field biology studies at the time the programme was cancelled in 1996.

***Odonna passiflorae* Clarke (Oecophoridae):** Larvae of this species bore the vines and root crowns of mature *P. mollissima*, that is, stems of 25–50 mm diameter. Multiple attacks in the root crown can kill the entire plant (Chacon and de Hernandez, 1981). Unfortunately, Colombia was the only country where we found *O. passiflorae*, and collecting the insect was difficult. One stand of *P. mollissima* was discovered near Lake La Cocha that suffered consistent losses of vines attributed to this pest species, but the planting was destroyed before extensive studies could be concluded.

Heliconiidae: *Agraulis vanillae* L., *Dione glycera* C&R Felder and *D. juno* Cramer: All three species were commonly observed at many of the survey sites and were polyphagous among *Passiflora* species, including *P. edulis* (Table 1). *D. juno*, a gregarious species of typically 20–50 larvae per cluster, was capable of denuding entire plants, while foliar damage due to *Agr. vanillae* was only sometimes significant, primarily on very young vines. *D. glycera* was widely distributed, but larval density was always very low and feeding damage negligible. *Agr. vanillae*, *D. juno* and *D. glycera* were particularly susceptible to nuclear polyhedrosis viruses (NPVs). *Agr. vanillae* is already present in Hawaii, but has had no discernible impact on *P. mollissima*.

***Josia fluonia* Druce (Notodontidae):** Larvae of this moth were observed feeding on foliage of *P. mollissima* only in central and northern Ecuador. The moths are day-flying. Larval density was low, that is, usually several larvae per plant, and feeding damage was typically light. *J. fluonia* was tested and cleared for release in 1996, but the programme was terminated before releases were made.

***Josia ligata* group (Notodontidae):** Larvae were observed feeding on foliage of *P. mollissima* and *P. mani-*

Table 1. List of insects observed feeding on *Passiflora* species in the Andes of Bolivia, Chile (Ch), Colombia, Ecuador, Peru, and Venezuela, 1982–1994. Information includes their order, family, insect species, *Passiflora* host species, stage host tissue, country. Table includes unpublished and previously published findings, e.g., Causton *et al*. (2000), Pemberton (1989), from the Hawaiian biological control project.

Order	Family	Insect Species	Passiflora host species	Stage-Host tissue	Country[a]
Coleoptera	Buprestidae?	Unidentified sp.	*P. mollissima*	larvae—live stem	V
	Cerambycidae	Unidentified sp.	*P. mollissima*	larvae—dead crown	C
		near *Hebestola* sp.	*P. mollissima*	larvae—dead stems	V
		near *Lepturges* sp.	*P. mollissima*	larvae—dead stems	V
		Trachyderes sp.	*P. mollissima*	larvae—dead stems	V
	Chrysomelidae	Cassidinae (unident. sp.)	*P. mollissima*	adults—leaves	V
		Diabrotica sp.	*P. mollissima*	adults—leaves	C, V
		Epitrix sp.	*P. mixta*	adults—leaves	E
			P. mollissima	adults—leaves	P, V
			P. pinnatistipula	adults—leaves	P
		Lactica brevicolis Jacoby	*P. mollissima*	adults—leaves, flowers	V
		Lactica sp.(?)	*P. mollissima*	adults—leaves, flowers	P
			P. mixta	adults—leaves, flowers	E
		Paralactica sp.(?)	*P. manicata*	adults—leaves, flowers	E
			P. mollissima	adults—leaves, flowers	E, V
	Curculionidae	*Brachyomus* sp.	*P. mollissima*	adults—leaves, terminals	V
		Compsus sp.	*P. mollissima*	adults—leaves, terminals	V
		Cryptorhyncus cerdo Fiedler	*P. mollissima*	adults—leaves, terminals	V
		Exorides ?*lajoyei* Bovie	*P. mollissima*	adults—leaves, terminals	V
		E. ?*corrugatus* Marshall	*P. mollissima*	adults—leaves, terminals	V
		Pandeletius ?andeanus Howden	*P. mollissima*	adults—leaves, terminals	V
	Elateridae	Unidentified sp.	*P. mollissima*	adults—?	V
	Lucanidae	Unidentified sp.	*P. mollissima*	adults—?	V
	Scarabidae	Unidentified sp.	*P. mollissima*	larvae—roots	B
		Unidentified sp.	*P. mollissima*	adults—?	V
	Scolytidae	Unidentified sp.	*P. mollissima*	larvae, adults—stem, branches	V
Diptera	Drosophilidae	*Zapriothrica* nr *salebrosa* Wheeler	*P. mollissima*	larvae—flower buds	E, V, C
		Zapriothrica nr *nudiseta* Wheeler	*P. mollissima*	larvae—flower buds	C
			P. mixta	larvae—flower buds	E, V
			P. mollissima x *P. exoniensis*	larvae—imm. fruit	V
	Lonchaeidae	*Dasiops caustonae* Norrbom and McAlpine	*P. manicata*	larvae—imm. fruit	E
			P. mixta	larvae—imm. fruit	V
			P. mollissima	larvae—imm. fruit	B, E, V
			P. mollissima x *P. exoniensis*	larvae—imm. fruit	V
		Dasiops curubae Steyskal	*P. mollissima*	larvae—flower buds	B, E
		Dasiops gracilis Norrbom and McAlpine	*P. edulis*	larvae—imm. fruit	V
		Dasiops inedulis Steyskal	*P. edulis*	larvae—flower buds	B, V
		Dasiops spp. (specimens unident.)	*P. mollissima*	larvae—flower buds	C
		Neosilba sp. (poss *N. certa* Walker)	*P. mollissima*	larvae—imm. fruit	E
	Mycetophilidae	*Mycetophila* spp.	*P. mollissima*	larvae—flower buds	C, E, V
			P. mixta	larvae—flower buds	E
Hemiptera	Coreidae	*Leptoglossus* sp.	*P. mollissima*	adults, nymphs—fruit, stems	V

(continued on next page)

Table 1. (Continued) List of insects observed feeding on *Passiflora* species in the Andes of Bolivia, Chile (Ch), Colombia, Ecuador, Peru, and Venezuela, 1982–1994. Information includes their order, family, insect species, *Passiflora* host species, stage host tissue, country. Table includes unpublished and previously published findings, e.g., Causton *et al*. (2000), Pemberton (1989), from the Hawaiian biological control project.

Order	Family	Insect Species	Passiflora host species	Stage-Host tissue	Country[a]
		Unidentified sp.	*P. mollissima*	adults—unknown	E
	Pentatomidae	Unidentified sp.	*P. mollissima*	adults—fruit?	V
	Pyrrhocoridae	Unidentified sp.	*P. mollissima*	adults—fruit?	V
	Tingidae	Unidentified sp.	*P. mollissima*	adults, nymphs—leaves	B
Hymenoptera	Apidae	*Trigona* sp.	*P. mollissima*	adults—flowers	V
Homoptera	Cicadellidae	Unidentified spp. (various)	*P. mollissima*	adults—leaves	V
	Cercopidae	Unidentified sp.	*P. mollissima*	adults—leaves	V
	Pseudococcidae	Unidentified sp.	*P. mollissima*	adults, immatures(?)—leaves	V
	Coccidae	Unidentified sp.	*P. mollissima*	adults, immatures(?)—leaves	V
Lepidoptera	Arctiidae	*Lophocampa* sp.?	*P. mollissima*	larvae—leaves	V
		Turuptiana neurophylla	*P. mollissima*	larvae—leaves	C
		Turuptiana sanguinipectus(?) Seitz	*P. mollissima*	larvae—leaves	E
		Unidentified sp.	*P. mollissima*	larvae—leaves	V
	Coleophoridae	Unidentified sp.	*P. mollissima*	larvae—leaves	V
	Geometridae	Unidentified sp.	*P. mollissima*	larvae—leaves, flowers	B, E, V
	Gracillariidae	*Acrocercops* sp. near *pylonias*	*P. mollissima*	larvae—leaves	C, E, P
			P. mixta	larvae—leaves	E
		Unidentified sp.	*P. mollissima*	larvae—leaves, fruits	V
	Heliconiidae	*Agraulis vanillae* L.	*P. mollissima*	larvae—leaves	B, C, E, P, V
			P. edulis	larvae—leaves	E, V
			P. ligularis	larvae—leaves	E, P
			P. manicata	larvae—leaves	E, P
		Dione glycera C&R Felder	*P. alata*	larvae—leaves	V
			P. edulis	larvae—leaves	V
			P. ligularis	larvae—leaves	V
			P. mollissima	larvae—leaves	B, C, Ch, E, P, V
		Dione juno Cramer	*P. edulis*	larvae—leaves	E, P, V
			P. ligularis	larvae—leaves	E
			P. manicata	larvae—leaves	E
			P. mollissima	larvae—leaves	V, E
		Euptoieta hegesia Comstock	*P. mollissima*	larvae—leaves	V
	Noctuidae	*Copitarsia* sp. (?)	*P. mollissima*	larvae—leaves, flower buds,	E, V, P
		Copitarsia consueta	*P. mollissima*	larvae—flowers	C
	Notodontidae[b]	*Cyanotricha necyria* Felder	*P. manicata*	larvae—leaves	E
			P. mollissima	larvae—leaves	C, E, P
		Josia fluonia Druce [not released]	*P. mollissima*	larvae—leaves	E
		Josia ligata group	*P. mollissima*	larvae—leaves	E
			P. manicata	larvae—leaves	E
	Oecophoridae	*Odonna passiflorae* Clarke	*P. mollissima*	larvae—stems	C
	Psychidae	Unidentified sp.	*P. mollissima*	larvae—leaves	B, V
	Pyralidae (= Crambidae)	*Pyrausta perelegans* Hampson	*P. mixta*	larvae—flower buds, fruit stem tips	E, P, V

Table 1. (Continued) List of insects observed feeding on *Passiflora* species in the Andes of Bolivia, Chile (Ch), Colombia, Ecuador, Peru, and Venezuela, 1982–1994. Information includes their order, family, insect species, *Passiflora* host species, stage host tissue, country. Table includes unpublished and previously published findings, e.g., Causton *et al*. (2000), Pemberton (1989), from the Hawaiian biological control project.

Order	Family	Insect Species	Passiflora host species	Stage-Host tissue	Country[a]
			P. mollissima	larvae—leaves, flower buds, stem tips	C, E, V, P
	Saturniidae	Unidentified sp.	*P. mollissima*	larvae—leaves	V
	Tortricidae	Unidentified sp.	*P. mollissima*	larvae—leaves, stems, stem tips	V
		Unidentified sp.	*P. mollissima*	larvae—leaves	V
Lepidoptera	Unidentified	Unidentified sp.	*P. mollissima*	larvae—stems	V
Orthoptera	Acrididae	*Meridacris subaptera*	*P. mollissima*	adults—leaves	V
Thysanoptera	unidentified	Unidentified sp.	*P. mollissima*	adults, nymphs—unknown	V

[a] B = Bolivia; Ch=Chile; C=Colombia; E=Ecuador; P=Peru; V=Venezuela
[b] For the family Notodontidae, we used the classification of Miller (1996).

cata only in central and northern Ecuador. Larvae of *J. ligata* were very similar to *J. fluonia* larvae in appearance, behaviour and feeding damage. However, *J. ligata* was found to be able to complete development on several *Passiflora* species, including *P. edulis*, dropping it from further consideration.

Diptera

Zapriothrica nr. ***salebrosa*** **Wheeler (Drosophilidae):** This flower bud-attacking fly was probably the most common and widely distributed insect found during our surveys and has long been recognized as a pest of *P. mollissima* (Chacon and Rojas, 1984; A.D. Casañas, 1984, unpublished results); it was observed in Colombia, Ecuador, Peru and Venezuela. However, Casañas-Arango *et al.* (1996) and Causton *et al.* (2000) mention another similar species, *Z.* nr. *nudiseta*, attacking only *P. mollissima* in Colombia, suggesting that taxonomic review of this group may be necessary. Pemberton (1989) identified *Z.* nr. *salebrosa* as a candidate agent and preliminary studies were conducted in the field in Colombia. The biology of *Zapriothrica* sp. is discussed by Casañas-Arango *et al.* (1996). The release of *Pyr. perelegans*, another bud-feeder, and studies of a fruit-attacking fly *Dasiops caustonae* Norrbom and McAlpine (Diptera; Lonchaeidae) lead to putting studies of *Z.* nr. *salebrosa* on hold.

Dasiops **species (Lonchaeidae):** Species of the genus *Dasiops* have long been recognized as major pests of cultivated species of *Passiflora* (Posada *et al.*, 1976; Chacon and Rojas, 1984). Lonchaeid larvae were regularly encountered in flower buds or in the developing fruit in all of the countries surveyed except Chile (Table 1), often causing significant losses of fruit bodies. Field identification of the species proved to be impossible. A taxonomic review of *Dasiops* species associated with *Passiflora* described three of the five species we collected from *P. mollissima* as capable of attacking *P. edulis*, that is *D. curubae*, *D. gracilis* and *D. inedulis* (Norrbom and McAlpine, 1997). A newly described species, *D. caustonae* Norrbom and McAlpine, appeared to be confined to *Passiflora* species in the subgenus *Tacsonia*, except for *P. manicata*, and was the only insect found attacking the developing fruit. Its biology is discussed by Causton and Rangel (2002). Attempts to colonize *Dasiops* species in quarantine in Hawaii failed due to our inability to induce mating, although oviposition of sterile eggs readily occurred.

Mycetophila **(Mycetophilidae):** At least two species of these fungus gnats were observed attacking flower buds in Northern Ecuador , Colombia and Western Venezuela; bud loss was often very significant. Specimens of adults could only be determined to the genus level (Gagné, personal communication, 1995). Multiple larvae were found in each infested bud, with up to 17 in one bud (Causton *et al.*, 2000). The larvae were very sensitive to disturbance and/or dehydration, as healthy larvae within dissected buds usually died shortly after inspection.

Coleoptera

Longhorned Beetles (Cerambycidae): Cerambycids were collected from mature vines of *P. mollissima*, that is, older than 8 years, at two locations. Larvae of an unidentified species, 1–2 cm long, were recovered from root crowns of dead vines in the Lake La Cocha area in Colombia. At least three species of cerambycids, near *Hebestola* sp., near *Lepturges* sp. and *Trachyderes* sp., were recovered from dead or dying branches of vines

in Venezuela (Table 1). Further investigation will be necessary to confirm their identities and feeding type, that is, as primary or secondary.

Leaf Beetles (Chrysomelidae): Adults of several species of leaf beetles were observed feeding on foliage and/or blooms of several *Passiflora* species in Colombia, Ecuador, Peru and Venezuela, but no eggs or larvae were recovered in the field and breeding colonies could not be established in the laboratory. Adults of *Diabrotica* sp. and *Epitrix* sp. were quite common in Venezuela, but were observed to be polyphagous (Causton *et al.*, 2000).

Discussion

Except for the fungal pathogen, *Septoria passiflorae* Syd. released in 1996, no new insect agents have been released since *Pyr. perelegans* in 1990. However, progress was made in identifying several promising candidates and eliminating others. Below is a ranking and brief justification of the agents we consider most promising for future work: (1) *Z.* nr. s*alebrosa*/*Z.* nr *nudiseta* because of their potential impact on reproduction of *P. mollissima*. Their biology and colonization techniques have already been determined, although species identities and distinctions need to be clarified; (2) *O. passiflorae* was capable of killing mature plants. Aspects of its biology and a local collaborator for collection of the species are known, which could facilitate initiation of biological studies; (3) *D. caustonae* and (4) *Mycetophila* sp. due to their potential to significantly impact reproduction of *P. mollissima*. Before studies may progress, the problem of establishing reproducing colonies in captivity needs to be solved. Host testing in the insects' country of origin could bypass this problem; and (5) the unidentified lepidopteran stem borer from Venezuela (Causton *et al.*, 2000). Like *O. passiflorae*, this species is recognized as having potential for significantly increasing plant mortality in Hawaii. However, this insect species was only observed once throughout the duration of the 4-year Venezuelan study. Confirmation of its identity remains first priority. Other candidates of lower priority but of potential interest include the chrysomelid beetles from northern Ecuador and cerambycid beetles from Colombia and Venezuela. As a note, although *C. necyria* and *Pyr. perelegans* were not successful in Hawaii, they may be well suited for different environments.

A third biological control agent, the fungal pathogen *S. passiflorae*, was also identified during the Hawaiian programme, tested and released in 1996 (Trujillo, 2001). The pathogen is now established through parts of the range of *P. mollissima* in Hawaii and is credited with giving substantial reduction in biomass by causing early defoliation in certain areas (Trujillo, 2001, 2004). However, in parts of the range, the pathogen is ineffective or is no longer giving adequate control (Markin, personal communication, May 2006).

P. mollissima remains an invasive exotic species in Hawaii and in other parts of the world. If, in the future others should decide to attempt biocontrol of *P. mollissima*, we hope that this summary of our survey results will be of value.

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References

Campbell, C.L., Markin, G.P. and Johnson, M.W. (1993) Fate of *Cyanotricha necyria* (Lepidoptera:Notodontidae) and *Pyrausta perelegans* (Lepidoptera:Pyraustida), released for the biological control of banana poka (*P. mollissima*) on the Island of Hawaii. *Proceedings of the Hawaiian Entomological Society* 32, 123–130.

Casañas-Arango, A.D., Trujillo, E.E., Rojas de Hernandez, A.M. and Taniguchi, G. (1990) Field biology of *Cyanotricha necyria* Felder (Leptidopter; Dioptidae), a pest of *Passiflora* species in southern Colombia and Ecuador's Andean Region. *Journal of Applied Entomology* 109, 93–97.

Casañas-Arango, A.D., Trujillo, E.E., Friesen, R.D. and Rojas de Hernandez, A.M. (1996) Field biology of *Zapriothrica* sp. Wheeler (Diptera; Drosophilidae), a pest of *Passiflora* spp. of high elevation possessing long tubular flowers. *Zeitschrift fur Angewandt Entomologie* 120, 111–114.

Causton, C.E. and Rangel, A.P. (2002) Field observations on the biology and behaviour of *Dasiops caustonae* Norrbom and McAlpine (Dipt., Lonchaeidae), as a candidate biocontrol agent of *Passiflora mollissima* in Hawaii. *Journal of Applied Entomology* 126, 169–174.

Causton, C.E., Markin, G.P. and Friesen, R. (2000) Exploratory survey in Venezuela for biological control agents of *Passiflora mollissima* in Hawaii. *Biological Control* 18, 110–119.

Chacon, P. and de Hernandez, M. (1981) Immature stages of *Odonna passiflorae* Clarke (Lepidoptera: Oecophoridae): Biology and morphology. *Journal of Research on Lepidoptera* 20, 43–45.

Chacon, P. and Rojas, A.M. (1984) Entomofauna asociada a *P. mollissima*, *P. edulis f flavicarpa,* y *P. quadrangularis* en El Departamento Del Valle del Cauca. *Turrialba* 34(3), 297–311.

Killip, E.P. (1938) The American species of Passifloraceae. Field Museum of Natural History (Chicago) Botanical Series 19.

La Rosa, A.M. (1984) The Biology and Ecology of *Passiflora mollissima* in Hawaii. Cooperative National Park Studies Unit, University of Hawaii at Manoa, Department of Botany, Technical Report No. 50, 168 pp.

Markin, G.P. and Nagata, R.F. (1989) Host preference and potential climatic range of *Cyanotricha necyria* (Lepidoptera: Dioptidae), a potential biological control agent of the weed *Passiflora mollissima* in Hawaiian forests. University of Hawaii at Manoa, Department of Botany, National Park Service Technical Report No. 67, 35 pp.

Markin, G.P. and Nagata, R.F. (2000) Host suitability studies of the moth, *Pyrausta perelegans* Hampson (Lepidoptera: Pyralidae), as a control agent of the forest weed banana poka, *Passiflora mollissima* (HBK) Bailey, in Hawaii. *Proceedings of the Hawaiian Entomological Society* 34, 169–179.

Markin, G.P., Nagata, R.F. and Taniguchi, G. (1989) Biology and behavior of the South American moth, *Cyanotricha necyria* (Felder and Rogenhofer) (Lepidoptera: Notodontidae), a potential biological control agent in Hawaii of the forest weed, Passiflora mollissima (HBK) Bailey. *Proceedings of the Hawaiian Entomological Society* 29, 115–123.

Martin, D.A. (1994) *Statistics of Hawaiian Agriculture*. Hawaii State Department of Agriculture, Honolulu, HI, USA, 100 pp.

Norrbom, A.L. and McAlpine, J.F. (1997) A revision of the neotropical species of *Dasiops rondani* (Diptera: Lonchaeidae) attacking *Passiflora* (Passifloraceae). *Memoir Entomological Society of Washington* 18, 189–211.

Pemberton, R.W. (1989) Insects attacking *Passiflora mollissima* and other *Passiflora* species: Field survey in the Andes. *Proceedings of the Hawaiian Entomological Society* 29, 71–84.

Posada, I.O., De Polonia, I.Z., De Arevalo, I.S., Saldarriage, A.V., Garcia, F.R. and Cadenas, R.E. (1976) Lista de insectos daniños y otras plagas en Colombia. Boletín técnica No. 43 Oct. Instituto Colombiano Agropecuario, Bogotá, Colombia, pp. 337–342.

Rojas de Hernández, M. and Chacón de Ulloa, P. (1982) Contribución a la Biología de *Pyrausta perelegans* Hampson (Lepidoptera: Pyralidae). *Brenisia* 19–20, 325–331.

Rojas de Hernández, M. and Chacón de Ulloa, P. (1983) Entomofauna Asociada al Cultivo de la Curuba en El Departamento del Valle. *Coagro* 45, 21–27.

Trujillo, E.E. (2001) Effective biomass reduction of the invasive weed species banana poka by *Septoria* leaf spot. *Plant Diseases* 85, 357–361.

Trujillo, E.E. (2004) History and success of plant pathogens for biological control of introduced weeds in Hawaii. *Biological Control* 33, 113–122.

Warshauer, F.R., Jacobi, J.D., La Rosa, A.M., Scott, J.M. and Smith, C.W. (1983) The distribution, impact, and potential management of the introduced vine, *Passiflora mollissima* (Passifloraceae) in Hawaii. Coop. National Park Studies Unit, University of Hawaii at Manoa, Department of Botany, Technical Report No. 48, 39 pp.