

The Identity and Host Plants of Blossom Midge in Hawaii¹
(Diptera: Cecidomyiidae: Contarinia)

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INTRODUCTION

A small cecidomyiid midge which frequently infests the flower buds of tomato has been known to exist in Hawaii since 1906 when Dr. O. H. Swezey (13)² of the Hawaiian Sugar Planters' Association Experiment Station reared adults from larvae infesting tomato buds. Until the present report, published literature, summarized below, listed at least four species of *Contarinia* as occurring in Hawaii. These were:

- (1) *Contarinia sorghicola* (Coq.), the sorghum midge.
- (2) *C. solani* (Rübs.), on tomato.
- (3) *C. maculipennis* Felt, on hibiscus and pikake (*Jasminum sambac*).
- (4) *C. lycopersici* Felt, on tomato, eggplant and pepper.

The distinctive sorghum midge is well known and has not been confused with other species in Hawaii. However, knowledge of the biological and taxonomic relationships of the flower-infesting *Contarinia* in Hawaii has been confused in the past. The purpose of this paper is to present evidence indicating that the tomato-infesting midge, which was referred to in the literature as *Contarinia solani* (Rübsaamen) in earlier years and as *C. lycopersici* Felt during recent years, is the same species found infesting hibiscus (and several other plants discussed later). The bud midge from hibiscus was described by Felt as *C. maculipennis*. Host and breeding records, which demonstrate that the blossom midge in Hawaii breeds in a singularly wide range of hosts, are summarized. These include more plant families than have been known for any other species of gall midge thus far reported.

LITERATURE

In the first record of blossom midge from Hawaii, Swezey (13) listed the species under the name *Contarinia solani* (Rübsaamen). This name correctly applies to a species which had been reared

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² Figures in parentheses refer to literature cited at the end of the article.

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from the blossoms of *Solanum dulcamara* in Germany and was described by Rübsaamen (12) in 1891. Swezey's original note follows: "*Contarinia solani* was bred from tomato buds where the larvae fed upon the young ovary of the blossom causing the buds and blossoms to blight and eventually fall off. The larvae of this species also pupate in the ground."

In 1911 Felt (5) described as *C. lycopersici* a species which had been reared from tomato flowers at St. Vincent, West Indies. Felt stated that *lycopersici* is related to *solani* but is a distinct species.

Barnes (1) in 1932 recorded the presence of *C. lycopersici* in Trinidad, West Indies where it was found infesting the flowers of tomato.

Tucker (14) in 1935 reported that several tomato fields in Barbados, West Indies had been infested with a blossom midge which did considerable damage to the flowers. The species had not been identified, but Tucker suggested it was *C. lycopersici*. In 1937 Barnes (2) confirmed the presence of *lycopersici* in Barbados.

Barnes (2), who had not had the opportunity of examining the blossom midge of Hawaii, but had studied specimens of *lycopersici* from the West Indies, commented in 1937 on the reported occurrence of *C. solani* in Hawaii as follows: "I believe that this is an erroneous identification and that the midge in question must be *C. lycopersici* Felt which is closely allied to *C. solani* but is distinct. *C. lycopersici* was described from larvae doing exactly the same type of damage to tomato buds in St. Vincent, West Indies, as O. H. Swezey described was taking place on Oahu."

In 1938 Illingworth (11) called attention again to blossom drop of tomato in Hawaii due to infestations of blossom midge.

In 1941 Callan (4) summarized the known distribution of *C. lycopersici*. He listed Trinidad, St. Vincent, Barbados, Grenada, St. Lucia and Dominica in the West Indies, British Honduras in Central America, British Guiana in South America, and Hawaii. Callan's record for Hawaii was based upon the conclusion of Barnes, cited above, regarding the identity of the species in Hawaii. All collections reported by Callan and earlier writers were made from tomato blossoms.

On the basis of observations and collections by members of the University of Hawaii Agricultural Experiment Station, Holdaway (8) in 1944 listed blossom midge, under the name *C. lycopersici*, as a submajor pest of eggplant and pepper as well as of tomato in Hawaii. In 1945 blossom midge was again listed by Holdaway *et al* (9) as a potentially serious pest of tomato, eggplant and pepper in Hawaii.

In 1933 Felt (6) described, as *Contarinia maculipennis*, a midge which O. H. Swezey had reared from the buds of hibiscus in Hawaii.

Illingworth (10) in 1934 stated that he had received hibiscus buds infested with midge larvae from the island of Hawaii about 1928.

Fullaway (7) in 1934 reported breeding the "hibiscus bud midge" from buds of *Jasminum sambac* (pikake).

EVIDENCE OF THE COIDENTITY OF MIDGES INFESTING DIFFERENT HOST PLANTS IN HAWAII

In April 1944 the writer began an investigation of the ecology and life history of blossom midge in Hawaii. Among the first objectives of this study was the determination of the identity and host range of the midge occurring on tomato. This species was believed by Holdaway *et al* (8, 9) to be the same as that infesting pepper and eggplant. Examination of material in the collection of the University of Hawaii Agricultural Experiment Station revealed specimens reared from *Momordica charantia* (bitter melon) and from *Brassica chinensis* (white mustard) which appeared to be identical with those reared from tomato, eggplant and pepper. During the course of the investigation, similar midges were reared from *Solanum rantonnetii* Carr. (Paraguay nightshade) and *Solanum tuberosum* L. (potato) as well as from several species of *Lycopersicon*. These and other records are summarized later in this paper.

Until January 1945 bud midge from hibiscus and *Jasminum sambac* had not been seen by the writer. It had been assumed that this midge, described as *C. maculipennis* Felt, was distinct from the species infesting crop plants. A field observation provided the first hint of their coidentity.

On January 3, 1945 the writer encountered a blossom midge infestation in a field of tomatoes in the upper Kipapa region near Wahiawa, Oahu. The number of tomato plants and blossoms found infested with midge larvae diminished with increased distance from one corner of the field. At the edge of the field in this corner occurred a hibiscus bush 80 per cent of the buds of which were infested with midge larvae. The close proximity of the infested hibiscus to the portion of the tomato field in which the highest incidence of midge infestation occurred suggested that hibiscus had served as the source of infestation for tomato. Moreover, this circumstance also suggested that the midge described from hibiscus as *C. maculipennis* Felt was not a distinct species from the one commonly infesting tomatoes in Hawaii and provisionally called *lycopersici*.

Midge adults reared from tomato and hibiscus appeared identical to the writer. However, in order to obtain more conclusive evidence that only a single species was involved in the infestations found on plants of different families, the experiments described below were conducted and specimens from the various hosts were submitted to

Dr. H. F. Barnes³ of the Rothamsted Experimental Station, England, for examination.

Midge adults that were reared from larvae infesting hibiscus in the field were caged January 18, 1945 on Bounty tomato plants growing in clay pots in the University of Hawaii greenhouse at Honolulu. Five days later, mature tomato flowers and unopened buds in varying stages of development were examined for the presence of midge larvae. Several buds and a few open blossoms were found to be infested. In addition, a few buds carried midge eggs alone or eggs and a few first instar larvae on the inner walls of the syngenesious androecium. Most of the infested buds were approaching maturity but had not yet opened. The larvae were transferred from the tomato buds to glass vials containing moist soil. They immediately entered the soil where they subsequently pupated. The first adults emerged 14 days after the larvae had entered the soil.

As a parallel experiment, midge adults reared from larvae infesting tomato buds and blossoms in the field were also caged on tomato plants in the greenhouse. They oviposited in the tomato buds and the duration of the life cycle coincided with that of the midges originally reared from hibiscus and later bred on tomato under cage conditions.

Uncaged tomato plants of the same size and variety as those used in the above experiments were maintained as controls. They were kept on the same bench with the test plants and remained free from infestation during the experiments.

On March 17, 1945 midge adults reared from larvae naturally infesting *Jasminum sambac* (pikake) were caged on two Bounty tomato plants,⁴ to determine if they would breed on tomato. Seven days later 15 infested buds were removed from the caged test plants. A few buds carried eggs and very small larvae, but the majority of buds contained larvae which were mature or approaching maturity. These were transferred to pupation vials containing moist soil. The first adults emerged on the 13th day after the larvae had been transferred to the pupation vials.

The midges reared on tomato, as progeny of parents reared from hibiscus and pikake, appeared to the writer to be indistinguishable from specimens reared from naturally infested tomatoes. Their coidentity was confirmed by Dr. Barnes as discussed later in the paper.

After determining that midges reared from field infestations of hibiscus and *Jasminum sambac* would breed on tomato, the specimens involved in these experiments as well as material reared from

³ Dr. Barnes is an eminent authority on the taxonomy of this difficult family and his interest in the problem is greatly appreciated.

⁴ Pupation jars containing emerging adults and also larvae and pupae in various stages of maturity were placed inside the experimental cages. Therefore, adults emerged daily for several days after the initial introduction on March 17.

the following hosts were sent to Dr. Barnes for identification: tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), Paraguay nightshade (*Solanum rantonnetii*), garden pepper (*Capsicum frutescens*), white mustard (*Brassica chinensis*), bitter melon (*Momordica charantia*), hibiscus, and pikake (*Jasminum sambac*). Since sending these specimens to Dr. Barnes, blossom midge has also been reared from Irish potato (*Solanum tuberosum*).

Dr. Barnes compared the specimens from Hawaii with *C. lycopersici* bred from tomato in Trinidad and Barbados, West Indies, and also with *C. solani* reared in England. His analysis of the problem is summarized below. Quotations are from Dr. Barnes' letter to the writer dated October 1, 1945.

1. There is probably one species of *Contarinia* in Hawaii which will live on the host plants cited above.

2. Most of the specimens from the West Indies "agree better with Felt's original description of *lycopersici* than with his description of *maculipennis*." However, certain individuals from Trinidad resemble very closely the specimens from Hawaii.

3. All of the specimens from Hawaii, with the exception of those from white mustard which were too broken to permit satisfactory examination, agree more closely with Felt's *maculipennis* description than with his description of *lycopersici*. However, Dr. Barnes writes, "There is considerable variation in the accepted specific characters and a special study is needed of individuals reared under different conditions and on different plants."

4. There is considerable evidence suggesting that the midge in Hawaii is the same species as *C. lycopersici* which occurs on tomato in the British West Indies. "The weight of biological evidence would justify your sinking *maculipennis* as a synonym of *lycopersici*." Nevertheless, Barnes would prefer postponement of such action until experiments can be conducted in the British West Indies to determine if *lycopersici* in that region is also capable of breeding on the different plant hosts reported from Hawaii.

HOST AND COLLECTION RECORDS OF BLOSSOM MIDGE IN HAWAII

The host range of this midge (probably *C. lycopersici*) is of unusual significance because it includes species in five different plant families. Gall midges in general have a very narrow host range. Barnes (3) in 1939 reported, "The only recorded instance of a gall midge living on plants belonging to two families is that of *Macrolabis corrugans* F. Lw. which is reported to live on certain Umbelliferous and Labiate species."

Blossom midge adults have been reared from larvae found infesting the flower buds of all the plants listed in table 1. In addition, with but a few exceptions, midges were reared to the adult stage to provide the records which are listed under each host.

Table 1. Host and Collection Records of Blossom Midge in Hawaii

HOST PLANT	DATE	LOCALITY*	COLLECTOR	
SOLANACEAE				
<i>Lycopersicon esculentum</i> Mill. (tomato)	6-3-42	U. H., Manoa	F. G. Holdaway & T. Nishida	
	6-24-42	U. H., Manoa	T. Nishida	
	4-29-44	U. H., Manoa	D. D. Jensen	
	5-3-44	U. H., Manoa	D. D. Jensen	
	5-16-44	U. H., Manoa	D. D. Jensen	
	6-20-44	Waialua	D. D. Jensen & T. Nishida	
	12-4-44	Kipapa Airfield	D. D. Jensen	
	1-3-45	Upper Kipapa	D. D. Jensen	
	1-11-45	Koko Head	D. D. Jensen	
	2-13-45	Poamoho	D. D. Jensen	
	7-25-45	Poamoho	Reported by W. A. Frazier	
	5-1-44	U. H., Manoa	D. D. Jensen	
	<i>L. peruvianum</i> var. <i>dentatum</i> Dun.			
<i>L. peruvianum</i> var. <i>humifusum</i> Müll.	5-1, 3-44	U. H., Manoa	D. D. Jensen	
<i>L. pimpinellifolium</i> (Jusl.) Mill.	5-4, 6, 9-44	U. H., Manoa	D. D. Jensen	
<i>L. esculentum</i> x <i>L. pimpi-</i> <i>nellifolium</i> (Jusl.) Mill.	5-1-44	U. H., Manoa	D. D. Jensen	
<i>L. esculentum</i> x <i>L. hirsu-</i> <i>tum</i> Humb. & Bonpl.	5-3-44	U. H., Manoa	D. D. Jensen	
<i>L. (hirsutum</i> x <i>esculentum</i>) x <i>peruvianum</i> (L.) Mill.	8-3-45	Poamoho	D. D. Jensen	
<i>Capsicum frutescens</i> L. (pepper)	5-10-43	Kaimuki	E. Akamine	
	6-4-43			
	7-23-43	Kaimuki	T. Nishida	
	6-20-44	Waialua	D. D. Jensen & T. Nishida	
	3-21-45	U. H., Manoa	D. D. Jensen	
	4-17-45	U. H., Manoa	D. D. Jensen	
	5-22-45	U. H., Manoa	D. D. Jensen	
	5-10-42	Kaimuki	E. Akamine	
	<i>Solanum melongena</i> L. (eggplant)	6-7-42	Pauoa Valley	T. Nishida
		2-16-43	Haiku, Maui	J. Shigeta
4-28-43		Manoa	T. Nishida	
8-15-42		U. H., Manoa	T. Nishida	
6-4-43		Kaimuki	E. Akamine	
7-11, 26-44		Honolulu	T. Nishida	
<i>Solanum rantonnetti</i> Carr. (Paraguay nightshade)				
<i>Solanum tuberosum</i> L. (potato)	5-25-32	Waianae	O. H. Swezey	
	5-15-45	Waipahu	D. D. Jensen	

* All collections listed were made on Oahu unless otherwise indicated.

Table 1.—Continued

HOST PLANT	DATE	LOCALITY*	COLLECTOR
CUCURBITACEAE			
<i>Momordica charantia</i> L. (bitter melon)	2-16-43	Haiku, Maui	J. Shigeta
	3-2-45	Haiku, Maui	D. D. Jensen
	5-15-45	Waipahu	D. D. Jensen
MALVACEAE			
<i>Hibiscus</i> sp.	1-3-45	Upper Kipapa	D. D. Jensen
	1-26-45	Manoa	D. D. Jensen
	2-7, 16-45	Manoa	D. D. Jensen
OLEACEAE			
<i>Jasminum sambac</i> Soland. (pikake)	1-11-45	Kaimuki	D. D. Jensen
	3-2-45	Waihee, Maui	D. D. Jensen
CRUCIFERAE	3-19-45	Waiau	D. D. Jensen
	<i>Brassica chinensis</i> L. (white mustard cabbage)	1-2-43	U. H., Manoa (greenhouse)

* All collections listed were made on Oahu unless otherwise indicated.

Lycopersicon esculentum Mill. (tomato). Blossom midge infestations in common tomato have varied in severity in Hawaii from a fraction of 1 per cent to over 80 per cent of the mature buds sampled. These observations agree with those reported by Callan (4) from Trinidad where *Contarinia lycopersici* was found infesting from 1.1 per cent to 83 per cent of the tomato flowers examined.

Capsicum frutescens L. (garden pepper). In several instances practically 100 per cent of the flowers of peppers in small private garden plantings have been found infested with midge larvae.

Solanum melongena L. (eggplant). Eggplant may at times be subject to heavy infestation by blossom midge. However, tomato and pepper may be preferred hosts because, on several occasions, midge larvae have been found infesting these plants growing in close proximity to non-infested eggplants.

Solanum tuberosum L. (potato). Blossom midge has been reared from Irish potato blossoms on only two occasions. However, this paucity of records from potato may be due to factors other than host preference. Since an infestation in potato blossoms does not result in economic loss, as is the case with infestations of tomato, pepper and eggplant flowers, the presence of midge larvae in potato blossoms ordinarily would go unnoticed. Moreover, potatoes do not blossom profusely in Hawaii. Furthermore, much of the potato acreage in the Territory is not grown in close proximity to perennial hosts of midge which might serve as ready sources of infestation.

The specimens reared from potato have not yet been submitted to Dr. Barnes for determination. However, there is little doubt that they will prove to be the same species that breeds on the other host plants listed.

Solanum rantonnetii Carr. (Paraguay nightshade). This plant is very rare in Hawaii. It was not known to exist here until July 1944 when Mr. T. Nishida of the University of Hawaii Agricultural Experiment Station submitted a specimen to Miss Marie Neal of the Bishop Museum for identification. He found most of the blossoms heavily infested with pepper weevil larvae. A few buds were found to harbor small dipterous larvae which were called to the attention of the writer. They were reared to the adult stage and proved to be blossom midge.

Momordica charantia L. (bitter melon). Mr. Shigeta reported severe damage by midge larvae to bitter melon flowers. Infested blossoms failed to open and hence did not become pollinated. Although the writer found infested blossoms at Haiku, Maui and at Waipahu, Oahu the percentage infestation was extremely low.

Hibiscus sp. Although only a few infestations of midge on hibiscus have been recorded, it is apparent that at times most of the blossoms on a bush may be infested. Over 80 per cent of the buds on a single plant in the upper Kipapa district were found infested on January 3, 1945.

Jasminum sambac Soland. (pikake). Pikake, which produces a profusion of blossoms, is apparently an important host of the midge. Since it is a perennial plant, grown in commercial stands to produce flowers for the lei industry, it may prove to be one of the key host plants in maintaining a midge population throughout the year. Over 75 per cent of the living buds sampled were found infested in the January 11, 1945 collection reported above.

Brassica chinensis L. (white mustard cabbage). This plant has not yet been found infested in the field. The single record to date is based on an infestation which developed on plants grown in the greenhouse. A note accompanying the collection data stated that the midge larvae were "fairly abundant" and that they occurred also on tomato flowers.

SEASONAL OCCURRENCE AND ABUNDANCE OF BLOSSOM MIDGE IN HAWAII

It has not yet been possible to make a consistent and detailed investigation of the abundance and distribution of blossom midge during each month of the year. However, the collection records summarized above reveal that this species apparently breeds in some of the solanaceous crop plants throughout the year. Collec-

tions have been made from either tomato, pepper or eggplant during every month of the year except September, October and November. It is probable that a careful search will reveal infestation during these months as well.

Most of the infestations which have been reported as a result of midge damage have occurred during the spring and early summer months, particularly May and June. However, during a search for the midge at other seasons, extremely heavy infestations were found on hibiscus and *Jasminum sambac* in January.

SUMMARY

1. Experiments are reported which demonstrate that the gall midge, *Contarinia maculipennis* Felt, which infests hibiscus in Hawaii, is the same species which breeds in tomato blossoms and was known in Hawaii under the names *Contarinia solani* (Rübsaamen) and *C. lycopersici* Felt. Midge adults reared from hibiscus and *Jasminum sambac* have been shown to breed on tomato where they complete a life cycle indistinguishable from that of specimens originating on tomato.

2. The biological evidence reported and a comparison of specimens from Hawaii with *lycopersici* from the British West Indies indicate the probability that the species occurring in Hawaii is also *lycopersici*. If such is the case, the name *maculipennis* is a synonym of *lycopersici*. However, in the West Indies *lycopersici* has been recorded only from tomato while the species in Hawaii is now known to breed in several unrelated plants. This fact makes it inadvisable at present to relegate the name *maculipennis* to synonymy, since the possibility exists that the midge in the West Indies is biologically distinct from the midge in Hawaii despite the apparent absence of consistent morphological differences.

3. In Hawaii blossom midge has been reared from the following host plants: SOLANACEAE: *Lycopersicon esculentum* (tomato), *L. pimpinellifolium*, *L. peruvianum*, *Capsicum frutescens* (garden pepper), *Solanum melongena* (eggplant), *Solanum tuberosum* (Irish potato), *Solanum rantonnetii* (Paraguay nightshade); CRUCIFERAE: *Brassica chinensis* (white mustard or pak choy); CUCURBITACEAE: *Momordica charantia* (bitter melon); MALVACEAE: Hibiscus; OLEACEAE: *Jasminum sambac* (pikake).

The wide host range of blossom midge in Hawaii, involving five different plant families, is unique among gall midges of the family Cecidomyiidae. Only one other species has been recorded from plants belonging to more than one family, and in this instance only two plant families are involved.

LITERATURE CITED

- (1) Barnes, H. F. 1932. Notes on Cecidomyidae. *Ann. & Mag. Nat. Hist.*, 9: 482.
- (2) ————. 1937. Check list of the Cecidomyidae of Oceania. *B. P. Bishop Mus., Occ. Papers* 13 (6): 61-66.
- (3) ————. 1939. Some gall midge species and their host plant range. *Ann. Appl. Biol.* 26: 319.
- (4) Callan, E. McC. 1941. The gall midges (Diptera, Cecidomyidae) of economic importance in the West Indies. *Tropical Agric.* 28 (6): 117-127.
- (5) Felt, E. P. 1911. Four new gall midges (Dipt.). *Ent. News* 22: 303-304.
- (6) ————. 1933. A hibiscus bud midge new to Hawaii. *Proc. Haw. Ent. Soc.* 8 (2): 247-248.
- (7) Fullaway, D. T. 1934. Note on *Contarinia maculipennis*. *Proc. Haw. Ent. Soc.* 8 (3): 361.
- (8) Holdaway, F. G. 1944. Insects of vegetable crops in Hawaii today. *Proc. Haw. Ent. Soc.* 12 (1): 68-70.
- (9) ————, Jensen, D. D. and Nishida, T. 1945. Miscellaneous insect problems. Report of the University of Hawaii Agricultural Experiment Station for the Biennium ending June 30, 1944: 62.
- (10) Illingworth, J. F. 1934. Note on *Contarinia maculipennis*. *Proc. Haw. Ent. Soc.* 8 (3): 361.
- (11) ————. 1938. Note on tomato blossom midge. *Proc. Haw. Ent. Soc.* 10: 15.
- (12) Rübsaamen, E. H. 1891. Neue Gallmücken und Gallen. *Berliner Entomolog. Zeitschrift* 36: 396-397.
- (13) Swezey, O. H. 1906. Notes on some Cecidomyidae not previously reported from Hawaii. *Proc. Haw. Ent. Soc.* 1: 79.
- (14) Tucker, R. W. E. 1935. Report on Entomological Section for year ending March 31, 1935. *Agric. Jour., Barbados*, 4 (2): 65.