

An Annotated List of Infectious Diseases of Insects in Hawaii. Part II.^{1, 2}

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Since the presentation of the first list of infectious diseases of insects in Hawaii at the Eighth Pacific Science Congress in 1953 (Tanada, in press), a substantial number of additional diseases have been recorded and it was thought desirable to compile a second list. The supplementary list presented here includes records from recent observations and references that were omitted from the first list. The names of the collectors of the diseases newly recorded in Hawaii are given in the table.

No new bacterial pathogen was observed during 1954-1955 in Hawaii. However, the writer conducted laboratory and field tests with *Bacillus thuringiensis* Berliner which was found infectious for the diamond back moth, *Plutella maculipennis* (Curtis), the cabbage webworm, *Hellula undalis* (Fabricius), and the cabbage looper, *Trichoplusia ni* (Hübner). The first species was much more susceptible to the bacterium than were the latter two species.

In the summary of his study on Hawaiian fungi, Bessey (1943) notes that only three species of Entomophthoraceae had been reported from Hawaii at that time. These three are all in the genus *Entomophthora* and were included in the first list. Recently two species of entomophthoraceous fungi, *Empusa aphidis* Hoffman and *E. muscae* Cohn, that are cosmopolitan in distribution, were found in Hawaii. Mr. F. Bianchi in January, 1953, observed colonies of sugar cane aphid, *Aphis sacchari* Zehntner, killed by a fungus at Mountain View, Hawaii. This fungus was identified by Dr. M. L. Lohman of the University of Hawaii as *Empusa aphidis*. *Empusa muscae* was found in January, 1954, by the writer on houseflies (*Musca domestica* L.) collected on a metal clothesline at his home on the University of Hawaii campus in Honolulu. This fungus was identified by Dr. E. A. Steinhaus of the University of California, Berkeley. Throughout 1955, Mrs. Edna Tanada has diligently collected from her clothesline houseflies killed by the fungus. She found 14 dead flies in March, 29 in May, 9 in June, 22 in July, 2 in August, 2 in

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September, 58 in October, 57 in November, and 16 in December. These records indicate that the fungus is active throughout the year.

Although in recent years there has been some doubt as to the pathogenicity of fungi in the genera *Sphaerostilbe*, *Torrubiella*, *Nectria*, and *Ophionectria* (Holloway and Young, 1943; Fisher, 1950), those recorded from Hawaii are included in the present list, since they have not been definitely proved non-parasitic. These fungi were listed by both Stevens (1925) and Parris (1940). Some of Steven's information was from unpublished records of O. H. Swezey.

In the first list, five species of scales were recorded as hosts of the white-halo fungus, *Verticillium lecanii* (Zimmerman). The writer found another scale, *Saissetia hemisphaerica* (Targioni—Tozzetti), parasitized by this fungus in Hilo, Hawaii, in March, 1953.

The number of hosts parasitized by the ubiquitous fungus *Beauveria bassiana* (Balsamo) Vuillemin is increasing each year. Mr. H. K. Nakao of the Territorial Board of Agriculture and Forestry noticed in February, 1954, that some of the larvae of *Blepharomastix acutangulalis* (Snellen) in his laboratory culture were attacked by a fungus, which was identified by the writer as *B. bassiana*. Field specimens of the nutgrass armyworm, *Laphygma exempta* (Walker), the housefly, *Musca domestica*, and the carpenter bee, *Xylocopa varipuncta* Patton, were also found infected by a fungus that was determined by the writer to be *B. bassiana*. The writer collected the specimens of *L. exempta* at Piikea, Hawaii, in March, 1954. The housefly was collected by Mrs. Tanada on her clothesline in November, 1955. This specimen had a bloated abdomen which was light red in color. It was kept overnight in a tightly stoppered vial at room temperature. The next morning the fly was almost completely covered by a white fungus mycelium. Mr. R. H. Van Zwaluwenburg brought in the fungus-infected carpenter bee which was collected in November, 1955, at Kailua, Oahu, by a student, H. J. Vaspra.

Species of *Sporotrichum* and *Botrytis* were listed by Stevens (1925) and Parris (1940) as parasites of Hawaiian insects. Parasitic fungi listed in these two genera are often species of *Beauveria* according to MacLeod (1954).

Speare (1912a) reported a *Cordyceps* sp. (probably *Isaria Saussurei* Cooke) as a parasite of *Polistes* sp.; however, in 1920, he revised his identification and called the fungus *Hirsutiella Saussurei* (Cooke) Speare. He also described in 1920 two new species, *Hirsutiella fusiformis* Speare on crickets and *H. citriformis* Speare on two homopterous insects, *Perkinsiella saccharicida* Kirkaldy and *Siphanta acuta* (Walker). The *Isaria* sp. reported by Van Dine (1904) on the above two homopterous insects is probably *H. citriformis*.

Corn aphids, *Aphis maidis* Fitch, killed by a fungus were collected by Mr. H. I. Rainwater at Mokuleia, Oahu, in 1955. This fungus was identified by Dr. C. G. Thompson of the Entomology Research Branch, U.S.D.A., as *Acrostalagmus* sp., probably *aphidum* Oudemans.

TABLE 1. Infectious diseases of insects in Hawaii. This list supplements the first list presented at the Eighth Pacific Science Congress in 1953.

TYPE OF INFECTION	PATHOGEN	HOST	LABORATORY OR FIELD INFECTION	COLLECTORS OR REFERENCES
Bacterial	<i>Bacillus thuringiensis</i> Berliner	<i>Plutella maculipennis</i> (Curtis)	Laboratory and field (artificial)	Y. Tanada
		<i>Hellula undalis</i> (Fabricius)	Laboratory and field (artificial)	Y. Tanada
		<i>Trichoplusia ni</i> (Hübner)	Laboratory and field (artificial)	Y. Tanada
Bacterial	<i>Serratia marcescens</i> Bizio	<i>Dacus dorsalis</i> Hendel	Laboratory	Steinhaus, 1951
Fungus	<i>Empusa muscae</i> Cohn	<i>Musca domestica</i> L.	Field	Y. Tanada
Fungus	<i>Empusa aphidis</i> Hoffman	<i>Aphis sacchari</i> Zehntner	Field	F. Bianchi
Fungus	<i>Sphaerostilbe coccophila</i> Tulasne	Superfamily Coccoidea	Field	Carpenter, 1920
Fungus	<i>Torrubiella</i> sp.	<i>Omiodes accepta</i> (Butler)	Field	Stevens, 1925; Parris, 1940
Fungus	<i>Nectria subcoccinea</i> Saccardo and Ellis	Superfamily Coccoidea	Field	Stevens, 1925; Parris, 1940
Fungus	<i>Ophionectria coccicola</i> (Ellis and Everhart) Berlese and Voglino	<i>Lepidosaphes beckii</i> (Newman)	Field	Stevens, 1925; Parris, 1940
Fungus	<i>Verticillium lecanii</i> (Zimmerman)	<i>Saissetia hemisphaerica</i> (Targioni-Tozzetti)	Field	Y. Tanada
Fungus	<i>Beauveria bassiana</i> (Balsamo) Vuillemin	<i>Cylas formicarius elegantulus</i> (Summers)	Laboratory	Sherman, 1952

TABLE 1.—(Continued) Infectious diseases of insects in Hawaii. This list supplements the first list presented at the Eighth Pacific Science Congress in 1953.

TYPE OF INFECTION	PATHOGEN	HOST	LABORATORY OR FIELD INFECTION	COLLECTORS OR REFERENCES
		<i>Euscepes postfasciatus</i> (Fairmaire)	Laboratory	Sherman, 1952
		<i>Pieris rapae</i> (L.)	Field	Tanada, 1955c
		<i>Blepharomastix acutangulalis</i> (Snellen)	Laboratory	H. K. Nakao
		<i>Laphygma exempta</i> (Walker)	Field	Y. Tanada
		<i>Musca domestica</i> L.	Field	Mrs. E. Tanada
		<i>Xylocopa varipuncta</i> Patton	Field	H. J. Vaspra
Fungus	<i>Sporotrichum</i> sp. ? (= <i>Beauveria</i> sp.)	<i>Semnoprepia</i> sp.	Field	Stevens, 1925; Parris, 1940
Fungus	<i>Sporotrichum</i> sp. ? (= <i>Beauveria</i> sp.)	<i>Genophantis</i> sp.	Field	Stevens, 1925; Parris, 1940
Fungus	<i>Botrytis grassi</i> ?	<i>Adoretus sinicus</i> Burmeister	Field	Stevens, 1925; Parris, 1940
		<i>Anomala orientalis</i> (Waterhouse)	Field	Stevens, 1925; Parris, 1940
		<i>Oxydema fusiforme</i> Wollaston (= <i>Pseudolus hospes</i> Perkins)	Field	Stevens, 1925; Parris, 1940
		<i>Polytus mellerborgi</i> (Boheman) (= <i>Calandra remota</i> Sharp)	Field	Stevens, 1925; Parris, 1940
		<i>Stenommatius muscae</i> Marshall	Field	Stevens, 1925; Parris, 1940

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TYPE OF INFECTION	PATHOGEN	HOST	LABORATORY OR FIELD INFECTION	COLLECTORS OR REFERENCES
		Scolytidae	Field	Stevens, 1925; Parris, 1940
Fungus	<i>Hirsutella Saussurei</i> (Cooke) Speare (= <i>Isaria Saussurei</i> Cooke)	<i>Polistes</i> sp.	Field	Speare, 1920
Fungus	<i>Hirsutella citriformis</i> Speare	<i>Perkinsiella saccharicida</i> Kirkaldy	Field	Speare, 1920
		<i>Siphanta acuta</i> (Walker)	Field	Speare, 1920
Fungus	<i>Hirsutella fusiformis</i> Speare	Gryllidae	Field	Speare, 1920
Fungus	<i>Acrostalagmus</i> sp. prob. <i>aphidum</i> Oudemans	<i>Aphis maidis</i> Fitch	Field	H. I. Rainwater
Fungus	<i>Fusarium moniliiforme</i> Sheldon	<i>Syagrius fulvitaris</i> Pascoe	Field	Parris, 1940
Virus	<i>Borrelina</i> sp.	<i>Pseudaletia unipuncta</i> (Haworth)	Field	Tanada, 1955a; Davis, 1955
Virus	<i>Borrelina</i> sp.	<i>Blepharomastix acutangulalis</i>	Laboratory	H. K. Nakao
Virus	<i>Borrelina</i> sp.	<i>Vanessa cardui</i> (L.)	Field	Y. Tanada
Virus	<i>Borrelina</i> sp.	<i>Catabena esula</i> Druce	Laboratory	H. K. Nakao
Virus	<i>Bergoldia</i> sp.	<i>Pseudaletia unipuncta</i>	Field	Tanada, 1955a
Protozoan	<i>Perezia mesnili</i> Paillot	<i>Apanteles glomeratus</i> (L.)	Field	Tanada, 1955b
Protozoan	Microsporidia	<i>Hellula undalis</i>	Field	Y. Tanada
Protozoan	Microsporidia	<i>Blepharomastix acutangulalis</i>	Laboratory	H. K. Nakao

Stevens (1925) and Parris (1940) referred to Speare (1912*b*) as having listed the following four insects as hosts of *Metarrhizium anisopliae* (Metchnikoff) Sorokin: *Conoderus exsul* (Sharp) (= *Monocrepidius exsul* Sharp), *Pantomorus godmani* (Crotch) (= *Pantomorus fulleri* Champion), *Gonocephalum seriatum* (Boisduval), and *Plusia chalcites* (Esper). However, the writer was unable to find these four species listed as hosts of *M. anisopliae* in Speare's publication, and so they have not been included in the present list.

The first list presented in 1953 contained only two determined virus diseases of insects in Hawaii; the present list includes five additional viruses—four in the genus *Borrelina* and one in the genus *Bergoldia*. This is the first record of the following three *Borrelina* spp. in Hawaii. Two of the *Borrelina* spp. were observed in the laboratory by Mr. Nakao in larvae of *Blepharomastix acutangulalis* in March, 1954, and in larvae of *Catabena esula* Druce in July, 1955. The viruses were identified by Dr. Steinhäus and Mr. K. M. Hughes of the University of California, Berkeley. The polyhedra of a *Borrelina* sp. were found by the writer in infected and dead larvae of the painted lady, *Vanessa cardui* (L.), collected at Kohala, Hawaii, in May, 1955. An outbreak of this insect was defoliating the wild thistle growing on the rangeland.

Two new records of protozoan diseases are included in the present list. A microsporidian was observed within larvae of the cabbage webworm, *Hellula undalis*, collected in the field at the University of Hawaii in August, 1953. Mr. Nakao noticed in March, 1954, a microsporidian in laboratory-reared larvae of *Blepharomastix acutangulalis*. Neither of these microsporidians has yet been identified to species.

SUMMARY

This list of infectious diseases of insects in Hawaii supplements the list that was presented at the Eighth Pacific Science Congress in 1953. It includes approximately 26 pathogenic microorganisms and 40 insect hosts. Sixteen of the records have not been recorded previously in Hawaii.

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