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L. O. Howard, Chief

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A STUDY OF COMPSILURA CONCINNATA, AN IMPORTED TACHINID PARASITE OF THE GIPSY MOTH AND THE BROWN-TAIL MOTH.

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INTRODUCTION.

Compsilura concinnata Meigen (Pl. I, fig. 1), one of the imported tachinid parasites of the gipsy moth and the brown-tail moth, was introduced into Massachusetts first in 1906, at which time these moths were so abundant and destructive, particularly in eastern Massachu-

[1] The writer wishes to express his appreciation of the help given by the various assistants at the Gipsy Moth Laboratory as well as by the field men, both at the laboratory and in collecting host material; to Mr. A. F. Burgess and Dr. John N. Summers for their helpful suggestions and advice; to Mr. R. T. Webber for furnishing rearing records, the bulk of the native host list being the results of his experiments; to Mr. C. F. Muesebeck for assisting in the dissections and drawings of some of the figures in this bulletin; and to Mr. A. M. Wilcox, who furnished large quantities of parasite-free host material for use in the reproduction experiments on Compsilura.

setts, that enormous areas of forest and shade trees were defoliated annually. In some residential sections life was rendered almost unbearable by the presence of enormous numbers of caterpillars. Although the history of the introduction and destructive work of these two pests has already been published,[1] few except eye witnesses could realize the serious conditions that existed at the time parasite introduction was begun.

Since 1891, when the gipsy moth covered an area of approximately 200 square miles, it has spread until in 1916 it involved 20,715 square miles, and is found in all of the New England States. In some localities in Massachusetts, where it was once accounted a plague, the severity of the infestation has been reduced to such an extent that the pest is more easily controlled.

The brown-tail moth was first regarded as a serious problem in 1897, when it was found in 15 towns close to Boston. Since then it has spread until now (1916) it covers a territory of 38,118 square miles, occurring in all of the New England States. Both sexes of the brown-tail moth are strong fliers. This important factor helps to explain why this insect is found over a larger area than the gipsy moth, the female of the latter species being unable to fly.

The life cycle of both the gipsy moth and the brown-tail moth is such that all stages, with the exception of the imago, are attacked by parasites. The internal-feeding parasite *Compsilura concinnata* is parasitic only upon the larvæ of these two hosts, and, while it has been reared occasionally from the pupæ, it will not complete its life cycle if the attack is delayed until the host pupates. These two hosts form an ideal combination for Compsilura, as the brown-tail moth larvæ occur in the field a short while after the parasite emerges from

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[1] "Insect Life," Vol. III, p. 297.

"Fifth Report of Entomological Commission," A. S. Packard, 1890, p. 138.

"The Gipsy Moth," Forbush and Fernald, 1896. State of Massachusetts.

"The Gipsy Moth in America," Bureau of Ent. Bull., New Series, No. 11, 1897.

"The Brown-tail Moth," Fernald and Kirkland, 1903. State of Massachusetts.

"Report on the Gipsy Moth and Brown-tail Moth," C. L. Marlatt, Bureau of Ent. Circ. No. 58, 1904.

"A Record of Results from Rearings and Dissections of Tachinidae," Townsend, Bureau of Ent. Bull. Tech. Series No. 12, Part VI, 1908.

"Parasites of the Gipsy and Brown-tail Moths Introduced into Massachusetts," W. F. Fiske, 1910. State of Massachusetts.

"Report on Field Work Against the Gipsy and Brown-tail Moths," Rogers and Burgess, Bureau of Ent. Bull. No. 87, 1910.

"The Importation Into the United States of the Parasites of the Gipsy Moth and the Brown-tail Moth," Howard and Fiske, Bureau of Ent. Bull. 91, 1911.

"The Gipsy Moth as a Forest Insect, with Suggestions as to its Control," W. F. Fiske, Bureau of Ent. Circ. No. 164, 1913.

"The Dispersion of the Gipsy Moth," A. F. Burgess, Bureau of Ent. Bull. No. 119, 1913.

"The Gipsy Moth and the Brown-tail Moth, with Suggestions for their Control," A. F. Burgess, Farmers' Bull. No. 564, 1914.

"Report on the Gipsy Moth Work in New England," A. F. Burgess, Dept. of Agri. Bull. No. 204, 1915.

hibernation. The gipsy-moth larvæ are a little later, and the bulk of the Compsilura reared at the gipsy-moth laboratory come from this host.

HISTORY OF COMPSILURA CONCINNATA MEIGEN.

DESCRIPTION.

Compsilura concinnata is larviparous, the eggs hatching in the uterus and the young being injected into the host by means of a larvipositor, which is inserted in an opening of the host integument made by a grooved, curved piercer, resembling a V in shape. When parasites were first imported there were among them certain tachinid puparia, some of which were not specifically identified at that time. It is probable that in this lot of unidentified puparia were some of the *Compsilura concinnata*, although, if such was the case, no record was kept.

Compsilura concinnata was first described in 1824 by Meigen, in "Systematische Beschreibung des bekannten europäischen zweiflügeligen Insekten," Volume IV, page 412, under the name of *Tachina concinnata*. Following is a translation of the original description:

Length 7½ mm. Face white, both sides to above the middle with vibrissæ; palpi orange. Vertex rather narrow, white, with a deep black stripe; bristles reaching up to the hypostoma. Antennæ somewhat shorter than the hypostoma, brown, with a larger bristle, which is thickened for about one-third of its length. Thorax whitish; the dorsum with blackish iridescence and four deep black stripes; the outer somewhat broader. Abdomen cone shaped; the first segment and a dorsal line and band on the hind edge of the next segment polished black; venter of abdomen carinate, black, with whitish incisions. Legs black, alulæ white; wings almost glossy transparent; apical cross vein straight, with rounded corners; the veins converge closely on the edge of the wing before its apex, the usual cross vein somewhat curved. The above description was from a female.

The larva and puparium (Pl. I, fig. 2) of Compsilura were both described in 1834 by Bouché in "Naturgeschichte der Insekten . . .", printed in Berlin, page 57. A translation of the descriptions follows:

The larva is elliptical, somewhat narrower anteriorly, roughish, fleshy, soft, variable, with swollen outlines and very finely grooved. The thoracic incision is black, as are also the articulation pieces of the abdomen, armed with little sharp points. The spines are arranged more or less in wavy rows. The black, short, and stout mouth hooks are almost straight. The antennae are wartlike, double, clear brown. The prothoracic stigmata are short, yellow, and parted. The hind part (last segment) is small, rounded, shallowly excavate posteriorly. In this depression are the two round, black stigmata bearers, provided on the inner side with white, round, transparent spots and brown three-divided stigma. Length 7½ mm.

The pupa is dark brown, elliptical-stout. Almost a smooth barrel. The segments are linked together, a little muricate at the abdomen. The prothoracic stigmata of the coming fly forms short blunt points. The blackish-brown posterior stigmata bearers are close together, and are provided with trifoliate stigmata. Length, 6½ mm.

In the description of the larva Bouché neglected to speak of a very important point, the anal hooks of the first-stage larvæ. This character has been found only in one other tachinid first-stage larva, that of the closely allied genus Dexodes. It is very easy to determine this stage by these hooks and to verify the fact that Compsilura parasitizes early-stage brown-tail moth larvæ in the fall, as has been found from various dissections. Pantel describes and illutrates these hooks in "La Cellule." (Fig. 1.) There are three of these peristigmatic hooks; two prestigmatic and one retrostigmatic. It is with these hooks that the larva attaches itself to the peritrophic membrane just previous to molting into the second stage. As the larva grows, the molt skins are pushed down on to this funnel until just previous to emerging, when the full-grown third-stage maggot breaks loose and forces itself out of the dead host. This is done in the following manner: The anterior end of the parasite, assisted by the mouth hooks, makes a small opening in the integument of the host and by a gradual process of extending and retracting the anterior part of the body the larva finally succeeds in passing out. If the host is one that has spun a cocoon, the parasite larva will pupate within this, but if not, it will drop to the ground or pupate near the host. The time between emergence of the larva and pupation is governed by such things as temperature and location, whether on a tree trunk, in soil, or elsewhere.

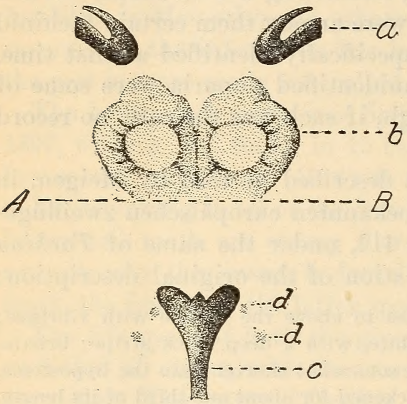

FIG. 1.—*Compsilura concinnata:* Posterior stigmata and peristigmatic hooks of first-stage larva. *a*, Prestigmatic hooks, paired; *b*, stigmatic plate; *c*, retrostigmatic hook; *d*, sensory terminations, finger-like or as punctate areas; *A—B*, horizontal line along which the skin folds over the stigmata as two grasping lips. Highly magnified. (Redrawn from Pantel.)

DISTRIBUTION IN EUROPE.

Compsilura concinnata is found in Europe in practically all of the territory covered by the brown-tail moth. It has been imported into the United States from 10 European countries and possibly from Japan. Very little work has been done with the parasite in Europe beyond Pantel's investigations. Compsilura has been described under a number of synonyms by various authors, and reference to these synonyms can be found in the "Katalog der Paläarktischen Dipteren," Volume III.[1]

[1] See also "Bibliography," pp. 25–26.

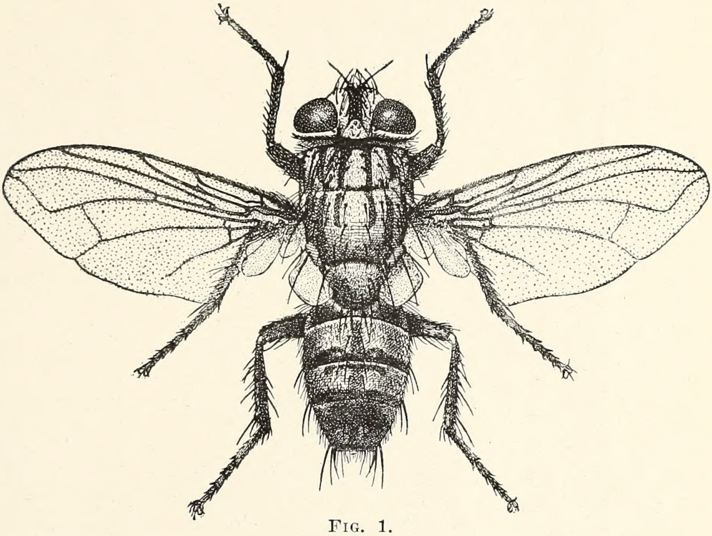

FIG. 1.

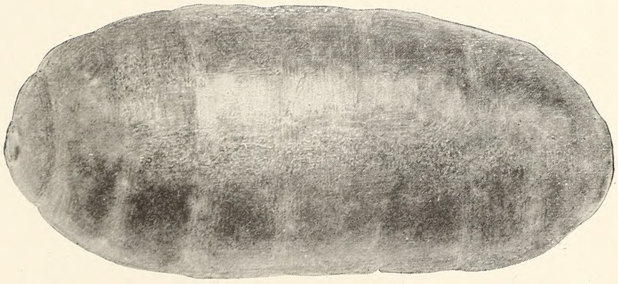

FIG. 2.

ADULT AND PUPARIUM OF COMPSILURA CONCINNATA.

FIG. 1.—Adult female. FIG. 2.—Laterial view of puparium. Fig. 1, 6½ times natural size; fig. 2, about 10 times natural size.

HOSTS, EUROPEAN AND AMERICAN.

This parasite attacks a large number of both nocturnal and diurnal hosts in Europe, the host list comprising 58 different species. In the United States it does not attack so many, probably due to its recent importation to this country. In time the host list for Compsilura in the United States will, no doubt, surpass that in Europe, for within the few years it has been established in New England a host list comprising 33 species already has been compiled,[1] and undoubtedly it attacks more than are known at the present time. All of the records given in the list of native hosts of Compsilura were secured at the gipsy moth parasite laboratory, Melrose Highlands, Mass. In a few instances these records have been duplicated by investigators at other places.

Table I gives the European host list.

TABLE I.—*Foreign hosts of Compsilura concinnata; records from the "Katalog der Paläarktischen Dipteren" and from the Bibliography.*

Abraxas grossulariata L.
Acronycta aceris L.
Acronycta alni L.
Acronycta cuspis Hübn.
Acronycta megacephala F.
Acronycta rumicis L.
Acronycta tridens Schiff.
Araschinia levana L.
Araschinia prorsa L.
Arctia caja L.
Attacus cynthia L.
Catocala promissa Esp.
Cimbex humeralis Fourcr.
Craniophora ligustri Fab.
Cucullia lactucae Esp.
Acronycta verbasci L.
Dasychira pudibunda L.
Dilina tiliae L.
Dipterygia scabriuscula L.
Drymonia ruficornis Hübn.
Euproctis chrysorrhoea L.
Heteromorpha caeruleocephala L.
Hyloicus pinastri L.
Libytha celtis Laich.
Macrothylacia rubi L.
Mamestra brassicae L.
Mamestra oleracea L.
Mamestra persicariae L.
Malacosoma neustria L.
Oeonistis quadra L.
Papilio machaon L.
Phalera bucephala L.
Pieris brassicae L.
Plusia festucae L.
Plusia gamma L.
Poecilocampa populi L.
Pontia rapae L.
Porthetria dispar L.
Porthetria monacha L.
Porthesia similis Fussl.
Melalopha anachoreta Fab.
Pyrameis atalanta L.
Smerinthus populi L.
Spilosoma lubricipeda L.
Stauropus fagi L.
Stilpnotia salicis L.
Taeniocampa stabilis View.
Thaumetopoea processionea L.
Thaumetopoea pityocampa Schiff.
Timandra amata L.
Trichiocampus viminalis Fall.
Trachea atriplicis L.
Vanessa antiopa L.
Vanessa io L.
Vanessa polychloras L.
Vanessa urticae L.
Vanessa xanthomelas Esp.
Yponomeuta padella L.

The following is the American host list:

TABLE II.—*American hosts of Compsilura concinnata.*

Apatela hasta Guen.
Arctiid sp.
Autographa brassicae Riley.
Callosamia promethea Dru.
Cirphis unipuncta Haw.
Cimbex americana Leach.
Deilephila gallii Rott.
Diacrisia virginica Fab.
Deidamia inscripta Harris.
Ennomos subsignarius Hübn.
Estigmene acraea Dru.
Euchaetias egle Dru.
Geometrid sp.
Hemerocampa leucostigma S. & A.
Hyphantria cunea Dru.
Malacosoma americana Fab.
Malacosoma disstria Hübn.
Mamestra adjuncta Boisd.
Mamestra picta Harris.
Melalopha inclusa Hübn.
Noctuid sp.
Notodontid sp.
Notolophus antiqua L.
Papilio polyxenes Fab.
Plusiodonta compressipalpis Guen. (By Reiff, at Forest Hills, April 7, 1913.)
Pontia rapae L.
Phlegethontius quinquemaculata Haw.
Rhodophora florida Guen. (By Reiff, at Forest Hills, Sept. 8, 1913.)
Schizura concinna S. & A.
Vanessa antiopa L.
Vanessa atalanta L.
Vanessa huntera Fab.
Xylina sp. Ochs.

[1] This covers all records, including those of the year 1916.

IMPORTATIONS TO UNITED STATES.

Compsilura was first imported into the United States in 1906, though it was not determined as such, being included in the general classification of Tachinidae. In 1907, from shipments of brown-tail moth larvæ and gipsy moth larvæ and pupæ there were secured 104 puparia which were determined as *Compsilura concinnata.* These came from France, Germany, and Austria. Most of the Compsilura imported in 1907 were found free in the boxes of brown-tail moth larvæ, and a few in the gipsy moth shipments. In 1908 an experiment was tried in shipping live puparia from Europe to Melrose Highlands, Mass., but it was not successful, as the puparia were nearly all broken. That year 220 Compsilura were received. The year 1909 was the banner year in importations of Compsilura, a total of 6,626 being secured from foreign shipments, about 50 per cent of these coming from gipsy-moth material. This was the first time that Compsilura was accepted as more than an occasional parasite of *Porthetria dispar.* During the year 1910 the majority of the 1,859 Compsilura received were secured from gipsy-moth shipments in the late larva and early pupa stages. No puparia shipped as such were received, as those sent the previous year came in such poor condition. The season of 1911 was the last during which Compsilura was imported. In this year 1,233 were received, about 75 of which came as puparia, practically all of the others being secured from brown-tail moth shipments. In the period between 1906 and 1911 Compsilura was received from nine European countries as well as a few possibly from Japan, a grand total of 10,042 being received at the Gipsy Moth Laboratory.

COLONIZATION.

There is no record of the number of Compsilura colonized in 1906 or 1907, but in Bulletin 91 of the Bureau of Entomology, page 220, reference is made to efforts along this line.

In 1907 a large colony was liberated at the location of one of the colonies of 1906, in the town of Saugus, Mass. No colonization was attempted in 1908, but in 1909 several colonies were established throughout eastern Massachusetts in the gipsy-moth area. Very little colonization was done in 1910 and 1911, a total of 1,304 being colonized during that time. It was in 1910 that a colony of this parasite was put out in Washington, D. C., to combat the white-marked tussock moth (*Hemerocampa leucostigma* S. & A.). In 1912 colonization of Compsilura in New England was again resumed on a larger scale than at any previous time, and this has been continued until the entire gypsy-moth area has been covered. This parasite does not appear to be so firmly established in the brown-tail moth area where the gypsy moth is not found, though colonization has been made there. It is true that it will perpetuate itself without the gypsy moth, but not in such large numbers, as collections made from these outlying towns have shown.

During the years 1912 to 1916 the entomological branch of the Dominion of Canada collected in New England and shipped for colonization to New Brunswick and Nova Scotia 32,824 Compsilura to combat the brown-tail moth. In 1914 and 1915 assistants of the branch of Cereal and Forage Insect Investigations of the United States Bureau of Entomology collected and sent Compsilura to Arizona and New Mexico to be used in the fight against the range caterpillar *Hemileuca oliviae* Ckll., a total of about 4,000 of these parasites being divided between the two States. During the years 1915 and 1916 about 3,000 Compsilura were sent to Florida to be used against the fall army worm (*Laphygma frugiperda* S. & A.). Compsilura has not proved as successful in the West and South as it has in New England up to the present time. In Arizona and New Mexico the conditions are so radically different from those in New England that even though the parasite becomes established it will take some time for it to became climatically adjusted. It has been too recently colonized in the South to justify predictions as to the results that will be accomplished. In Canada it more nearly approaches its standing, as an effective parasite, in the outskirts of the brown-tail moth infestation in New England and in time should prove a valuable aid in the control of this pest.

SPREAD.

The rate of spread of Compsilura has been determined in two ways: (1) By scouting, which consists of carefully examining gipsy moth and brown-tail moth infestations in localities just outside the area previously recorded as covered by Compsilura, and (2) by collections of various lepidopterous larvæ from towns beyond the known spread of the parasite. This rate of spread has been found to be approximately 25 miles per year, and this is taken into consideration in colonizing the parasites, the colonies having been put out in most cases about 25 miles apart in all directions. This proves that the insect is a strong flier, for there are no artificial means worth considering that will assist in its dispersion.

RECOVERY.

The first recovery of Compsilura was made in New England in 1907, a single specimen reared from a field collection of gipsy-moth larvæ. Attempts to recover this parasite failed in 1908, but in 1909, soon after colonization, several puparia were reared from collections of both brown-tail moth and gipsy-moth larvæ, which proved that the parasite had become established from the colonies of 1906 and 1907. It was in 1909 that assistants from the laboratory, in scouting for larvæ of *Calosoma sycophanta* L., found numbers of Compsilura puparia in the field. Since the first substantial recovery in 1909 the parasite has been recovered from 303 towns in New England. These towns are scattered throughout the entire gipsy-moth area, with very few outside. (See map, Pl. II.) An interesting recovery of Compsilura was made in 1915, from the Island of Nantucket, Mass., 25 miles from the mainland, where the nearest colony of the parasite is located.

Compsilura is scattered over so wide a territory that it is usually possible to collect it in almost any part of New England within the gipsy-moth area. This is especially so where the gipsy moth is abundant in a locality not far distant from where Compsilura has been colonized any length of time. The general method is to make trial collections of 100 fourth-stage larvæ and maintain them in feeding trays.[1] These trays are small and rectangular, the bottoms being covered with thin cloth and a narrow band of tanglefoot applied near the top to prevent the escape of larvæ. If this trial collection shows a parasitism of 8 to 10 per cent, the location is considered a good field for bulk collections to secure parasite material for colonization. In a few instances where both trial and bulk collections showed a very high percentage of parasitism the first year, it has not been considered necessary to make trial collections from a given locality the following year. This is not always relied upon, however, as Compsilura may be present in a locality in fairly large numbers one year, while the following year collections from the same locality will give a low percentage of parasitism. This is particularly true of places where the brown-tail moth is scarce and which may have a good infestation of gipsy moths. Compsilura seems to be more prevalent where there is a rather heavy infestation of both brown-tail moths and gipsy moths.

All of the collections are sent by mail or brought into the laboratory in wooden boxes 3½ by 5¼ by 9½ inches. These boxes have a hole in one end through which the larvæ are put as they are collected, about 350 to 400 larvæ in each box; this hole is then covered by a piece of tin or zinc, which is secured by four tacks. Fresh food is placed in the boxes as the larvæ are collected; this keeps them separated in transit. As soon as these boxes are received at the laboratory they are opened, the location recorded and filed under a number, and the larvæ counted and placed in a feeding tray, the size of which is governed by the number from a single locality.

[1] These trays have been described in Department of Agriculture Bull. No. 250, July, 1915.

MAP SHOWING DISTRIBUTION OF COMPSILURA CONCINNATA IN NEW ENGLAND. THE AREA INCLOSED BY THE HEAVY LINE IS THE TERRITORY COVERED BY COMPSILURA. THE CROSSES SHOW WHERE IT HAS BEEN COLONIZED OUTSIDE THIS AREA, BUT HAS NOT YET BEEN RECOVERED.

These trays are carefully examined and all of the Compsilura puparia removed and counted every two or three days, records being kept under the locality number. As these puparia are removed they are kept in a cool place until a sufficient number, 500, is secured, when they are ready to be sent to some point for colonization.

DISCUSSION OF CLASSIFICATION OF COMPSILURA CONCINNATA.

The parasitic Diptera, which include Tachinidae, are classified according to structure and method of attack. Method of attack is governed by the structure of the insect, and J. Pantel, in "La Cellule," Volume I, has classified these parasites, grouping them in the form of a key, according to structure. As this entire classification is too lengthy for reproduction here, the writer will give merely an extract of the group containing Compsilura.

FIG. 2.—*Compsilura concinnata:* Ovariole of adult female at hatching. Greatly enlarged. (Pantel.)

Group VII. Species which, by means of distinct perforating and laying instruments, insert hatched larvæ, or those about to hatch, in the body of the host.

Enumeration of species.	*General host index.*
Compsilura concinnata Meig. *Dexodes nigripes* Fall. *Vibrissina demissa* Rond.	A very long list of caterpillars and false caterpillars. (Pantel here notes that he has bred them from 12 (species) bombycid caterpillars (Townsend).)

While Compsilura is moderately fecund, each female deposits larvæ singly beneath the skin of the host. The ovaries, at the time of hatching, form an obconic bundle consisting, on an average, of 14 ovarioles or strings of developing eggs, and each ovariole containing, on an average, 8 developing eggs. (Fig. 2.) These averages were arrived at from dissections of 50 sexually mature females. This would make the reproductive capacity of Compsilura approach 225, but this total is not reached, as a general thing, as dissections of adults, which were three to four weeks old, have shown. A series of dissections have shown that the average reproductive capacity of Compsilura is from 90 to 110 larvæ.

The paired oviducts leading from the ovaries into the anterior uterus, the three spermathecæ, and the accessory glands are shown in the illustration of the reproductive system of an unfertilized female (fig. 3). The posterior uterus in an unfertilized female is a short, nearly straight passageway which is empty, but which, when the female becomes gravid, elongates, as the developing young descend, into a long intestine-like incubating organ leading to the larvipositor. These developing larvæ are arranged transversely for about halfway down the posterior uterus, causing this organ to resemble a flat, more or less coiled ribbon, gradually enlarging toward the external organs of reproduction. As the developing larvæ are forced downward their axes gradually change until the axis of the posterior uterus and the larvæ is the same. (Fig. 4.)

At the distal termination of the posterior uterus is the "laying organ" or larvipositor. This is slightly chitinized and has a small tubelike opening just large enough for the passage of one larva. This organ, as well as the anus, arises in the venter of the sixth abdominal segment and is curved forward when at rest, fitting into the carinate venter of the fifth abdominal segment. The larvipositor fits into a curved chitinous hook or piercer, which is grooved, reresembling a V in structure. Beneath this hook is a supporting organ arising from the fifth segment, which is strongly spined on both sides in such a manner that it reinforces the piercer while the female is in the act of attacking the host caterpillar. The parasite larvæ, as they are forced down the posterior uterus, are turned in some manner and are injected into the host, with the anterior end first. This was the conclusion the writer reached after making a number of dissections of females after they had deposited part of their young. In these dissections some of the larvæ were found to be inclosed in a very thin membranous sheath, which fitted the body very closely, while others were found naked. This leads to the inference that Compsilura deposits both bare and inclosed larvæ. Pantel suggests that this might be possible on account of a prolongation of the egg stage, due to the absence of an appropriate host.

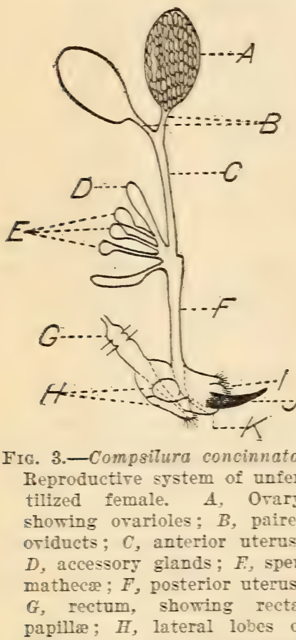

FIG. 3.—*Compsilura concinnata:* Reproductive system of unfertilized female. *A*, Ovary, showing ovarioles; *B*, paired oviducts; *C*, anterior uterus; *D*, accessory glands; *E*, spermathecæ; *F*, posterior uterus; *G*, rectum, showing rectal papillæ; *H*, lateral lobes of dorsum of sixth abdominal segment; *I*, reinforcement of piercer, from dorsum of fifth abdominal segment; *J*, piercer; *K*, larvipositor. Greatly enlarged. (Original.)

DISCUSSION OF LARVA STAGE OF COMPSILURA CONCINNATA.

Compsilura larvæ pass their entire life within the body of the host. The young larva is introduced generally into the intestines, where it is motile, floating free until just previous to molting into the second stage, when it becomes attached to one of the stigmata or vesicles of the branching trachea. This is done by means of the three anal hooks which are found in the first-stage Compsilura maggot. (Figs. 1 and 5.)

Respiration takes place through the anal stigmata of the larva, air being furnished by the stigma or trachea of the host. A tracheal funnel is formed by the maggot pushing itself backward against the

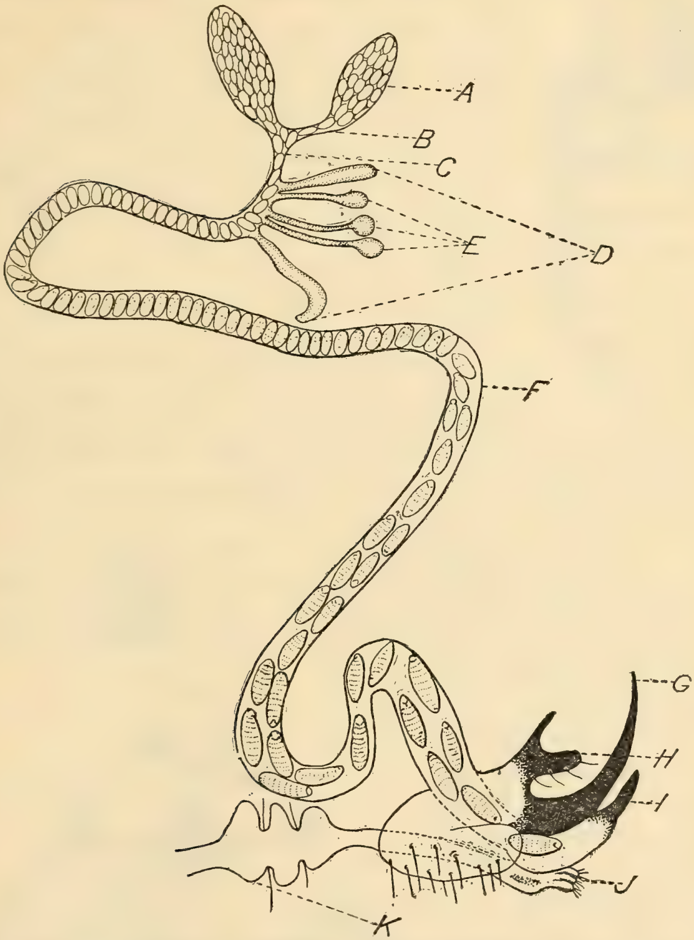

FIG. 4.—*Compsilura concinnata:* Reproductive system of fully developed fertilized female. *A,* Ovary; *B,* oviduct; *C,* anterior uterus; *D,* accessory glands; *E,* spermathecæ; *F,* posterior uterus; *G,* piercer; *H,* support for piercer; *I,* Larvipositor; *J,* anus; *K,* rectum, showing rectal papillæ. Greatly enlarged. (Original.)

place of attachment. This leaves the anterior end of the parasite larva free for feeding. As the larva molts, it pushes the exuvium down on the funnel, and it is possible to locate both the first and second stage mouth-hooks upon dissection of the host. The larva remains in this funnel until just previous to emergence from the host, when it breaks loose and emerges ready for pupation.

The larvæ differ somewhat in appearance in the three stages. In the first-stage larvæ the mouth-hook is single pointed, being heavily chitinized throughout with the exception of the inside areas of the divided posterior part. This posterior end is membranous and serves as a place of attachment to hold the hook in position, this being true of all three stages. The first segment has a row of heavy spines around its base, while the second segment is thickly studded with the same kind of spines. The ventral part of the remaining segments is also fitted with the same spiny structure, in this case the spines extending upward laterally along the anterior border of each segment. All of the segments are more or less covered with what, under the high-power microscope, appear to be very small granulations. On the last abdominal segment there is a peculiar set of hooks that make possible the determination of first-stage Compsilura. These are for the purpose of attachment to the stigma of the host. (Fig. 5.)

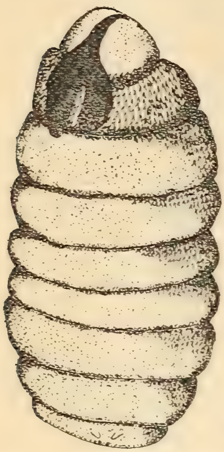

FIG. 5.—*Compsilura concinnata:* First-stage larva, right lateral view. Greatly enlarged. (Original.)

The second-stage larva of Compsilura differs from the first in three main points: (1) The mouth-hook is double throughout, the halves being jointed by a chitinous structure, and is jointed in one place (fig. 6); (2) the chitinous part of the hook extends farther basally, the whole outline of the hook being more uneven; and (3) the heavy spines on the integument are lost in this stage, while the anterior border of each abdominal segment has two or three rows of lighter spines, which extend completely around the body. The first segment is more contracted on the ventral surface, grading off at a gradual angle to its junction with the second segment. The anal hooks are wanting in this stage and the permanent structure of the anal stigmata is clearly shown.

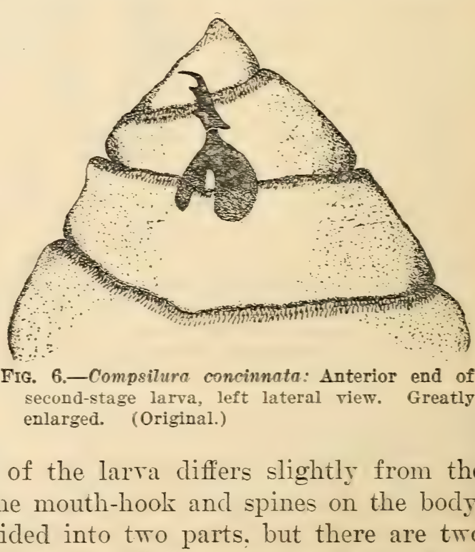

FIG. 6.—*Compsilura concinnata:* Anterior end of second-stage larva, left lateral view. Greatly enlarged. (Original.)

The third and last stage of the larva differs slightly from the second in the structure of the mouth-hook and spines on the body. The mouth-hook is still divided into two parts, but there are two joints in it. (Fig. 7.) The heavy chitinous structure does not extend so far basally, but the membranous portion is larger than in the second stage. The spiny armature is even less than in the second stage, only a thin sprinkling of spines being present on the anterior end of each segment. The anal stigmata are black and much larger than in the second stage, appearing as they will be found in the puparium (fig. 8).

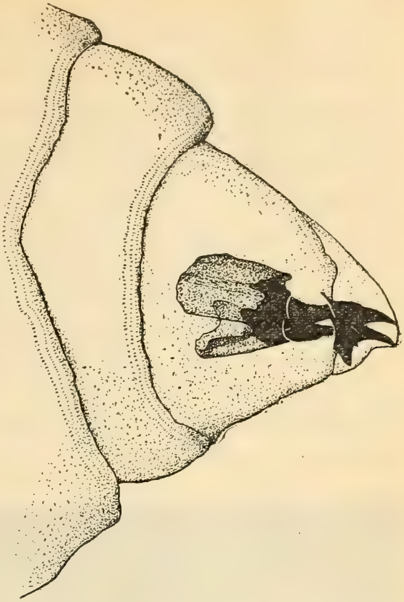

FIG. 7.—*Compsilura concinnata:* Anterior end of third-stage larva, right lateral view. Greatly enlarged. (Original.)

LIFE HISTORY.

METHOD OF HANDLING.

The collection and handling of host material in the laboratory has been referred to in the preceding pages. The methods of handling the parasite in determining its life history follow.

In the fall of 1914, when the life-history work on Compsilura was begun, the notes at the laboratory were thoroughly reviewed and all of the information concerning this parasite assembled. All of the available literature was studied, and, while several authors had written of Compsilura, very little could be found concerning the actual life history of the parasite. At this time experiments were being carried on to investigate the life history of *Apanteles lacteicolor* Vier., and it was from the type of tray then in use that the present "reproduction tray" (fig. 9) for Compsilura was evolved. This tray measured 12 by 12 by 5 inches, with a groove around three sides, in which a sliding glass cover could be fitted. The bottom of the tray was of muslin, which permitted of partial ventilation and could be replaced. In two opposed

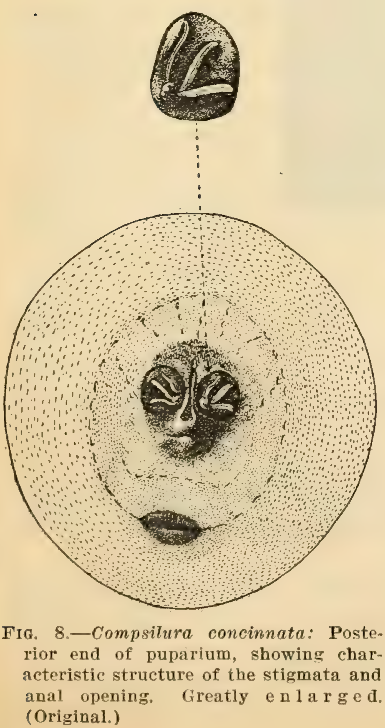

FIG. 8.—*Compsilura concinnata:* Posterior end of puparium, showing characteristic structure of the stigmata and anal opening. Greatly enlarged. (Original.)

sides were holes covered with fine copper screen, affording good ventilation. In the center of the front of the tray was a hole 3 inches in diameter, in which was fitted a round plug having a 1-inch hole through the center for inserting a vial containing foliage; by this arrangement the stem of the foliage could be kept in water. The experiment number label, with the number and species of hosts, number of both sexes of Compsilura, and the date begun, was also pasted on the front. In the right side of the tray was a smaller hole for the purpose of placing the parasites in the tray, this being closed with a cork.

During the summer of 1915 sugar water was used as food, being sprayed on the leaves and on the sides of the tray. This was found to be unsatisfactory, first, because sugar water was not heavy enough food for the flies and they did not live for any length of time, and, second, when this sticky substance was sprayed over the leaves and the sides of the tray the flies frequently would become stuck to it. During the season of 1916 honey water in the proportion of one part honey to three of water was used very satisfactorily. This was fed to the flies by the use of an atomizer, with which it was sprayed on a sponge placed in a watch glass. In the bottom of the tray was kept a small dish of sand, which was moistened each day, thus keeping the humidity constant. Temperature records were kept with a self-recording thermometer placed near the reproduction trays. The experiments were conducted in a house which had three screened windows on one side and the opposite side built so that about half of it was open and well screened. One end was closed and the other had a screen door in it. The three sides being thus open, good ventilation was afforded. The reproduction trays were arranged on two sides of this shed on shelves which were constructed of narrow strips to facilitate ventilation in the trays.

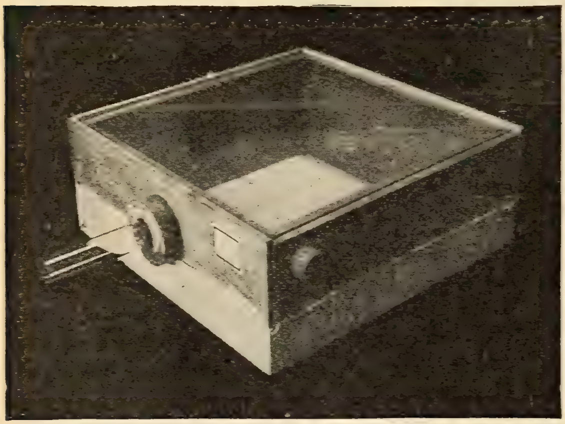

FIG. 9.—Reproduction tray used in life-history experiments on *Compsilura concinnata*. (Original.)

During the summer of 1915 difficulty was experienced in securing parasite-free hosts, the only material of this nature that could be had in large numbers being the brown-tail moth larvæ. These were reared from the hibernating webs collected the previous fall. A large number of gipsy-moth larvæ were hatched for this purpose, but owing to the high percentage of mortality, due to the so-called wilt disease, few survived long enough to be used in the experiments. In the spring of 1916 efforts were made to secure more of the parasite-free material, with the result that the writer was more successful than before. A large number of brown-tail moth larvæ were reared from the webs, and several thousand gipsy-moth larvæ were hatched out. These hosts were kept in large "tanglefooted" trays, which were covered with fine screen cloth, to prevent any possibility of parasitism being effected from outside sources. Through the cooperation of the assistants of the Bureau of Entomology at the Bussey Institution an abundance of parasite-free material was secured of the species *Bombyx mori* L., *Hemerocampa leucostigma* S. & A., and *Callosamia promethea* Drury, which had been reared in a greenhouse, where it was impossible for parasitism by Compsilura to take place.

LARVA AND PUPA STAGES.

The conditions under which the life history of Compsilura was studied were so different from the normal that no doubt it varies from that actually obtaining in the field. Nevertheless, as nearly the normal environment of the fly as was possible under laboratory conditions was simulated.

The length of the larva stage in Compsilura varies with the season, being unaffected by temperature to any appreciable extent. Tables III and VI indicate the length of the larva stage under laboratory conditions. As shown, the adult flies were of varying ages at the beginning of each experiment, this apparently affecting the length of the larva stage. The length of the stage for each larva was computed from the time the experiment was begun, for it was impossible to note the time at which each adult attacked the host larva. The length of the pupa stage is also shown in Tables III and VI. The puparia used in these experiments were removed from the various trays as soon as they had hardened and become the characteristic dark-brown color.

TABLE III.—*Length of larva and pupa stages of Compsilura concinnata under laboratory conditions, Melrose Highlands, Mass., 1916.*

Experiment begun.	Age of female Compsilura when experiment began.	Number of Compsilura larvæ secured.	Average number of days in larva stage of Compsilura.	Number of puparia that emerged.	Average length of pupa stage.	Proportion of sexes.		Number and stage of hosts.	Species and stage of host.
						Male.	Female.		
1916.	*Days.*				*Days.*				
July 13	3	28	16.64	24	12	13	11	100, fourth stage	Brown-tail moth, larvæ.
17	17	6	9.83	3	14.50	2	1	50, fourth stage.	Do.
6	6	19	13.57	15	10.40	7	8	60, third and fourth stages.	Gipsy-moth, larvæ.

The pupa stage of Compsilura is passed in two ways. In the field, puparia will be found both in the crevices of the bark and in the webs of prepupal brown-tail moth larvæ or "spin-ups." They will also be found about 1 inch beneath the surface of the soil at the base of trees. The average length of the pupa stage in the soil is from two to four days greater than above ground.

ADULT STAGE.

The length of the adult stage under laboratory conditions varies with the temperature and methods of handling. The methods of handling have been previously mentioned. The average length of the adult stage of Compsilura is shown in Table IV.

TABLE IV.—*Average length of adult stage of Compsilura concinnata, Melrose Highlands, Mass., 1916.*

22 days for 35 mated males in glass-covered trays.
18 days for 35 mated females in glass-covered trays.
13.5 days for 22 unmated males in glass-covered trays.
4.5 days for 22 unmated females in glass-covered trays.

GESTATION.

The period of gestation varies with the temperature, an increase in temperature tending to shorten the period. A new supply of hosts was added every two days and close watch for the emergence of Compsilura larvæ was maintained. The time required for the period of gestation was reckoned from the time of mating to the time the adults and hosts were separated; then, to get accurately the length of the larva stage, each maggot was isolated as it emerged from the host and the larva stage was reckoned from the end of the period of gestation. (See Table V.)

TABLE V.—*Gestation period of Compsilura concinnata: Single females in each experiment, Melrose Highlands, Mass., 1916.*

Date experiment began.	Age of fly at copulation.	Number of Compsilura larvæ secured.	Average length of larva stage.	Number and stage of hosts.	Host.	Gestation period.
	Days.		*Days.*			*Days.*
July 13	1	3	9.5	30, fourth stage	Brown-tail moth larvæ	4.5
14	2	13	7.42	70, fourth stage	do	5
16	2	8	7.23	60, fourth stage	do	3
31	2	1	10	70, fourth stage	do	6
Average						4.5

PARTHENOGENESIS.

Since it was thought that Compsilura might, at times, be parthenogenetic, a series of experiments was conducted to determine whether this is the case. In each case 5 unfertilized females were placed in trays with 25 third and fourth stage gipsy-moth larvæ which had been reared under screen from hatching. Attempted larviposition was noted, but in no case were Compsilura larvæ secured and none were found upon dissecting the hosts. This same false larviposition was noted with larvæ of *Bombyx mori.* The piercer punctured the integument of the host, for each time an attack was made the caterpillar bled at the point of attack. A number of the Compsilura used were dissected, but none showed uterine eggs or developing maggots in the uterus. In several of these females the posterior uterus had become lengthened as is the case after fertilization.

COPULATION.

When union was successfully accomplished, copulation lasted from 26 minutes to 1 hour and 50 minutes, and while a number of records were secured, the foregoing represents the extremes. Attempted coition was noted at times which occupied several seconds, but in cases of such short duration these attempts were unsuccessful. The results of observations on copulation seem to be more or less contradictory. In some cases Compsilura were confined in glass jars, screen cages, or glass-covered trays for several days, and did not copulate; whereas in one case a male, which was 16 days old and had been mated previously, copulated for 1 hour and 50 minutes with a female which was only 24 hours old. Another pair that were only 18 hours old copulated for 1½ hours. In cases where copulation occurred soon after emergence from puparia the temperature and humidity were quite high. It was observed also that the flies will copulate more readily if the male is from 2 to 4 days older than the female.

LARVIPOSITION.

Compsilura will attempt larviposition in confinement when only one day old and before copulation takes place. It is physically impossible that this attempted larviposition can be effective, as Compsilura is viviparous and young larvæ have not had sufficient time to develop within the mother in that length of time.

The method of larviposition is as follows: The female approaches the host, stopping within about an inch of it and, after surveying the victim carefully, strikes quickly. The host makes a quick movement of the entire body and the Compsilura flies off, only to return immediately until she is finally satisfied. If larviposition is successful at the first attempt, the parasite seems satisfied for a few moments. Records were secured of Compsilura attacking one gipsy-moth larva as many as seven or more times in rapid succession, the whole occurring within 1½ minutes. Larviposition will be attempted shortly after copulation, as records show that this occurs within 26 minutes after coition has been completed.

The host larva will be attacked in almost any portion of the body, as larviposition was attempted on the head capsule, the middle part of the body, and the posterior segments. Although the middle portion seems to be preferred, this may be due to the host's inability to disturb the parasite as easily in this portion as it does on either the anterior or posterior end.

ACTION ON HOSTS OTHER THAN THE GIPSY AND BROWN-TAIL MOTHS.

In working out the life history of Compsilura various hosts were used, all, with one exception, being indigenous to this country. Sixteen native species were utilized, and while Compsilura had been reared from most of these, attempts at reproduction in the laboratory failed on all but four. A matter of interest in connection with reproduction on *Callosamia promethea* and *Bombyx mori*, which had been reared parasite-free beneath screen, was the high percentage of superparasitism. This was particularly true of *Bombyx mori*, in several instances as many as 10 Compsilura puparia being secured from a single host; and of *Hemerocampa leucostigma*, it being a very common occurrence for from 3 to 4 Compsilura puparia to be reared from one host. In Table VI are given the results of reproduction upon these three hosts.

TABLE VI.—*Development of Compsilura concinnata in various hosts, Melrose Highlands, Mass., 1916.*

Date.	Age of flies when experiment began.	Number of Compsilura larvæ.	Average length of larva stage.	Number of puparia secured.	Length of pupa stage.	Proportion of sexes.		Number and stage of host.	Host.
						Male.	Female.		
	Days.		Days.		Days.				
July 19	3	30	14.76	26	12	19	6	50, third[1] and fourth stages.	H. leucostigma.
15	18	5	17.20	3	17.33	1	2	15, third stage....	C. promethea.
18	2	23	22.27	17	16.25	8	9	25, third and fourth stages.	Do.
19	2	5	19	5	15.80	3	2	25, fourth stage...	Do.
19	3	59	15.60	30	11.60	17	13	35, fourth stage...	Bombyx mori.
24	4	60	19.05	....	....	......	......	50, fourth stage...	Do.

[1] These stages refer to each molt of the host larva.

Pontia rapae is a splendid intermediate host for Compsilura, this pest being found in New England wherever cabbage is grown, and because of the overlapping of its broods, which makes it possible to find nearly all stages of larvæ in the field from spring until winter, Compsilura is assured of at least one host upon which to perpetuate itself. Fortunately, however, Compsilura is not compelled to rely solely upon *Pontia rapae* for existence, as a glance at the native host list will show.

EFFECT OF TEMPERATURE UPON VARIOUS STAGES OF COMPSILURA CONCINNATA.

Temperature, under laboratory conditions, appears to exert little influence in the development of larvæ within the host. This is particularly true during the summer season. In the late summer the larva stage is lengthened, but in averaging the whole season when Compsilura larvæ were secured, July 13 to August 24, it was found that the larva stage was lengthened at a time when there was very little variation in average temperature. (See Table VII.)

TABLE VII.—*Effect of temperature upon length of larva stage of Compsilura concinnata under laboratory conditions, Melrose Highlands, Mass., 1916.*

Number of individuals.	Larva stage.	Average temperature.	Number of individuals.	Larva stage.	Average temperature.
	Days.	*° F.*		*Days.*	*° F.*
1	6	72	2	11	71
4	7	74	1	14	74
4	8	73	1	15	71
8	9	72	1	16	71
2	10	72			

This average temperature, as noted in Table VII, was secured by taking four readings a day and averaging the whole.

The effect of temperature upon the pupa stage is shown in Table VIII.

TABLE VIII.—*Effect of temperature upon length of pupa stage of Compsilura concinnata under laboratory conditions, Melrose Highlands, Mass., 1916.*

Number of individuals.	Pupa stage.	Average temperature.	Number of individuals	Pupa stage.	Average temperature.
	Days.	*° F.*		*Days.*	*° F.*
3	7	71	9	15	66
2	9	67	4	16	64
13	10	72	4	17	64
5	11	71	2	18	66
46	12	72	3	19	63
13	13	69	1	20	63
7	14	68			

Temperature averages shown in Table VIII were secured in the same way as for the larva stage. The shorter pupal periods were observed in the middle of the summer and those of longer duration in the late summer and early fall. All of these records were made from puparia above ground, the length of the pupa period in those below the surface of the soil being from two to four days greater.

The effects of temperature on adult Compsilura are shown in figure 10. The temperature was determined by readings at noon each day, when observations were made on the activity of the adults. It is practically impossible to rate terms of activity in either degrees or percentages, so the following terms were adopted: (1) *Very active.*

Constantly flying; copulating; larvipositing freely and feeding. (2) *Active.* Flying a little; larvipositing some; crawling around and feeding. (3) *Inactive.* Crawling around; no copulation or larviposition; very little feeding. (4) *Very inactive.* Practically dormant, sluggish.

SEASONAL HISTORY.

PRESENCE IN FIELD AND NUMBER OF GENERATIONS.

Compsilura occurs in the field, as shown by collections of adults in 1915, on May 1. It was on this date that two male specimens were collected. The latest that adults were taken in the field was October 28 and 29, 1915. This represents the extremes of collections of adults of this parasite. The earliest collections of puparia in the field were made June 16, 1915, from brown-tail moth "spin-ups," and the latest record, from a collection of *Pontia rapae*, made September 30, 1915. Among collections of host material for Compsilura is that of brown-tail moth "spin-ups" and the time of occurrence of these in the field varies from year to year, the average being about June 25. Immediately following these is begun the collection of gipsy-moth larvæ for this parasite. Figuring on the foregoing basis of collections, and allowing a range of 28 to 30 days for completion of life history in the field, it will be found that three full generations are passed during the season.

In the laboratory the period from adult to adult averages 24 days, and with a "gestation period" of 4.5 days, the life cycle involves about the same length of time as is required under natural conditions in the field. It was found possible to secure more than three generations annually in the laboratory by supplying hosts later than they could be found in the field.

The most accessible host in the spring is the brown-tail moth larva, which is attacked soon after emergence from the hibernating web. The growth of the parasite in this host during the early part of the larval period is more or less retarded owing to the slow spring development of the young brown-tail moth larvæ. Just previous to pupation of the host, while the brown-tail moth larva is spinning its cocoon, the parasite larva emerges and pupates within the loosely woven web. A short time after this the appearance of adult Compsilura is noted, and puparia are to be found in the early gipsy-moth larvæ, some few coming from the late fourth and early fifth stage hosts. These are evidently part of the same generation as those from the brown-tail moth larvæ. The early issuing adults emerge from the brown-tail moth hosts in time to attack the later stages of the gipsy-moth larvæ together with native hosts, which are prevalent at this time, and this constitutes the beginning of the second generation of Compsilura. Those issuing from this second generation the last of August and first of September constitute the third generation and furnish the adults which attack the hosts in which the Compsilura larvæ later hibernate.

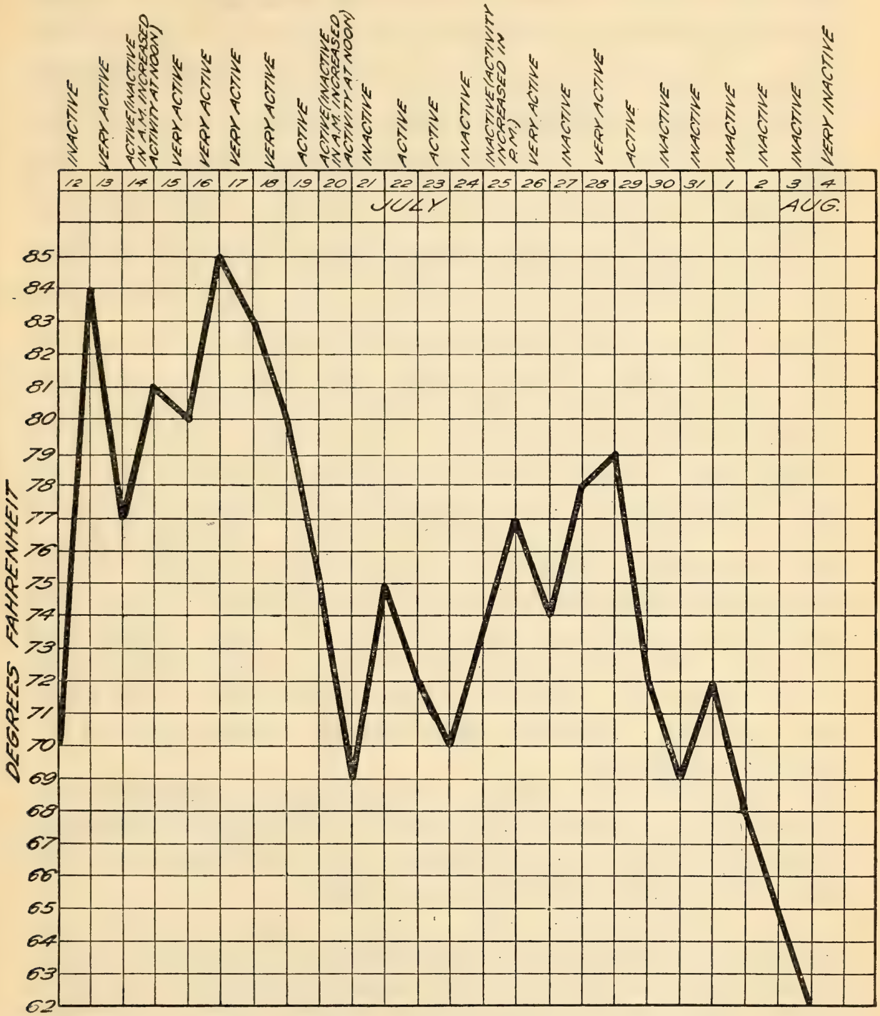

FIG. 10.—Diagram illustrating relation of temperature to activity of adult *Compsilura concinnata*, July and August, 1916. (Original.)

HIBERNATION.

Hibernation of Compsilura is the point in the life history of the parasite which has not been completely worked out, although enough has been accomplished in this line to warrant its discussion here. Several cases of hibernation of Compsilura have been recorded, but only six hosts have given absolute records. These are

Papilio polyxenes Fab., *Diacrisia virginica* Fab., *Deilephila gallii* Rott., *Deidamia inscriptum* Harris, *Callosamia promethea* Drury, and an unidentified geometrid. In all of these cases the parasites passed the winter as larvæ, emerging and pupating in the spring. No doubt when the host material lately in hibernation at the laboratory is fully examined the list of hosts in which Compsilura passes the winter will be materially increased. A single record of hibernation was noted in a chrysalid of *Pontia rapae* that was kept inside during the winter, the Compsilura emerging January 18, 1915. While it would seem that this host is ideal for the hibernation of Compsilura, in no other case has the parasite been recorded as passing the winter in it, although several thousand chrysalids of *Pontia rapae* have been collected from localities where Compsilura has been recovered in the fall and placed in hibernating quarters.

Attempts which have been made to carry Compsilura through the winter in the adult and pupa stages, under laboratory conditions, have proved unsuccessful. In the early fall of 1916 a number of puparia were divided into two lots, one of which was placed in an ordinary glass vial and the other in a box of leaf mold and loam. Both lots were then put in an ice chest where the temperature varied from 40° to 42° F., and where the humidity was high and constant. A month later some of the puparia were taken from the vial and opened, disclosing well-developed, healthy nymphs. A few were opened from time to time until November 15, when the last were found dead. The last puparia found alive had been confined in the ice chest for 49 days, and it would appear that under natural conditions the puparia might hibernate, although attempts made in this direction have failed.

In Bulletin 91 of the Bureau of Entomology, published in 1910, is found the only plausible explanation of the failure of Compsilura to hibernate within the overwintering brown-tail moth larvæ. On pages 219 and 220 is the following paragraph:

> Larvæ, which are almost certainly *Compsilura concinnata*, have been occasionally found in living brown-tail moth caterpillars during the winter months. It is presumed if these larvæ were able to mature under these circumstances, that they would have been reared before now from some among the hundreds of thousands of brown-tail caterpillars which have been carried through their first three or four spring stages in the laboratory. None having been reared under these circumstances, the only logical conclusion is that they start into activity so early and develop so rapidly as to cause the death of the host before they are sufficiently advanced to pupate successfully.

This, no doubt, is true, for the writer conducted experiments under ideal conditions for the hibernation of Compsilura, if this were possible, in hibernating brown-tail moth larvæ. From several places where Compsilura was prevalent during the summers of 1914 and 1915, hibernating webs of brown-tail moth larvæ were collected during the following fall and spring, and when the season began they were placed in feeding trays which were kept covered with fine mosquito screening. These were fed until the hosts pupated, and although this experiment was repeated for two years, the trays being carefully examined at least once a week during the time of feeding, no Compsilura were secured.

The results of these experiments substantiate the statement referred to in the foregoing bulletin, that it is impossible for Compsilura larvæ to hibernate in overwintering brown-tail moth larvæ. Dissections during the fall of 1915 showed conclusively that Compsilura attacks the young brown-tail moth larvæ and will live through part of the first larval instar in this host, but that the small size of the host prevents the parasite larva from maturing sufficiently to pupate.

SECONDARY PARASITISM.

Secondary parasites of Compsilura play an important part in the spread and effectiveness of the tachinid parasite. These secondaries attack the Compsilura maggot immediately following its emergence from the host, or the fresh puparia, and before it has hardened. From no puparia secured from beneath the surface of the soil have secondary parasites emerged, only those found above ground being attacked. During the seasons of 1915 and 1916 1,164 Compsilura puparia were collected in various parts of New England over the entire area covered by this parasite, and from 10.31 per cent of them secondary parasites issued.

SUPERPARASITISM.

To ascertain the effectiveness of Compsilura, a series of experiments was conducted from 1912 to 1916, with gipsy-moth larvæ collected on the border towns of Compsilura dispersion for the years 1909 to 1913, five towns being selected in which the parasites were first recovered in the five-year period mentioned. These border towns have furnished the host material each year for the last four years, and the collections yielded an average parasitism of 10.21 per cent. These results were secured by making collections of from 10 to 20 fifth-stage gipsy-moth larvæ and feeding them singly, either in small trays or in screened boxes, care being exercised to safeguard them from any parasitism after reaching the laboratory.

It was from these same experiments that the highest parasitism by Compsilura was gained, and in several cases three puparia were secured from a single host larva. Data were also obtained from the foregoing experiments on the effect of wilt on Compsilura parasitism. If the parasite larva is ready to molt into the last larval instar, although the death of the host occurs from wilt, it will not prevent further development of the parasite larva, but pupation will be accelerated. The larva can not remain in its tracheal funnel after the body contents of the host become flaccid, but it will be seen moving slowly about, and will emerge from two to five days after the death of the host.

Similar experiments were conducted during the years 1915 and 1916 with brown-tail moth larvæ, treated in the same manner as were the gipsy-moth larvæ, with the average result of two parasites per larva, at times as many as four puparia being secured from one host.

SUPERNUMERARY PARASITISM.

The fight for ascendancy between some of the tachinid and hymenopterous parasites is well illustrated by a study of Compsilura parasitizing brown-tail moth larvæ. When two internal feeding parasites of different orders occur in a single host larva and complete that part of their existence which is passed within the host, parasitism is described as "supernumerary." This is illustrated by Compsilura and *Meteorus versicolor* Vier. in their occurrence in brown-tail moth larvæ. It was noted, in an experiment where brown-tail moth larvæ were isolated and fed in single boxes, that *Meteorus versicolor* was present to quite an appreciable extent. The hosts did not die immediately after emergence of this hymenopterous parasite, and in from two to four days, in some cases, Compsilura would emerge. In no case were any Compsilura secured previous to emergence of Meteorus.

ECONOMIC IMPORTANCE.

The white-marked tussock moth, *Hemerocampa leucostigma*, which a few years ago was a serious pest in many localities in New England, has practically disappeared since Compsilura was established. The saturniid *Callosamia promethea*, which in past years was very common in the area covered by Compsilura, is now quite rare. While the cabbage worm, *Pontia rapae*, is still a serious pest, its numbers have been materially lessened in some sections, Compsilura, no doubt, playing an important part in this decrease. The celery worm, *Papilio polyxenes*, is not so common now as it was previous to the importation of Compsilura. The fall webworm, *Hyphantria cunea*, which could be found in eastern Massachusetts in large numbers in 1910, is scarcely noticed now. The writer does not claim that Compsilura is the sole cause of the disappearance of these pests, but this parasite has been reared from all of them, and it is significant that the decrease has occurred since the advent of Compsilura. Outside of the area in which this parasite occurs, many of these caterpillars will be found in considerable abundance. The gipsy moth and brown-tail moth infestation has been materially lessened in sections where this parasite has been firmly established for some time, but spraying, hand-suppression work, and the effects of predacious enemies, disease, and other parasites have all had their parts to play in causing the decrease, not only of the gipsy moth and the brown-tail moth, but of other native pests as well.

From the foregoing it will be seen that *Compsilura concinnata* is the most important tachinid parasite brought into this country for combatting the gipsy moth and the brown-tail moth, and that it attacks both freely. Judging from its increasing list of native hosts in the United States, it bids fair to become one of the most important economic parasites in this country. Compsilura has been established in the United States only 10 years, and during that time it has been recorded from a large number of native hosts, and no doubt this host list is much longer than is known at the present time.

BIBLIOGRAPHY.

(Taken from Katalog der paläarktischen Dipteren, Volume III, pages 308–310.)

COMPSILURA (BOUCHÉ) CONCINNATA (MEIG.).

Bouché, Naturg. d. Insekt., I. 58. (1834) ; Mik, Wien. entom. Zeitg. XIV. 52 (1894).

GENERIC SYNONYMS.

Doria Meig., S. B., VII. 263. 47. (1838) ; Macq., Annal. Soc. entom. France, (2). VI. 98 XIV. (1848) ; R.–D., (Posth)., I. 534. I. (1863).
Machaerea Rond., Dipt. ital. Prodr., III. 159. 26. B. (1859).

CONCINNATA MEIG.

BIBLIOGRAPHY.

Concinnata Meig., S. B., IV. 412. 301. (Tachina) (1824) et VII. 263. t. LXXII. f. 34–39. (Doria) (1838) ; Bouché, Naturg., 57. 39. t. V. f. 15–19. (Tachina) (1834) ; Macq., Soc. Sci. Lille, 1833. 280. 9. (Phorocera) (1834), Suit. à Buff., II. 128. 19, (Metopia) (1835) et Annal. Soc. entom. France, (2), VI. 98. 1. t. IV. f. 5. (Doria) (1848) ; Hart., Jahresh. Fortschr. Forstwiss., I. 296, 27. (Tachina) (1838) ; Walk., Ins. Brit. II. 88. 156. (Tachina) (1853) ; Schin., F. A., I. 489. (Phorocera) (1862) ; R–D., Posth., I. 536. I. (Doria) (1863) ; Wulp, Entom. Tijdschr., (2), IV. 144 et 153. (Phorocera) (1864) ; Rond., Atti Soc. Ital. Sci. Nat., XI. 583. nota. 5. (Phorocera) (1868) ; Meade, (Entom)., XIV. 288. (1881), XV. 24. (Phorocera) (1882) et Entom. Monthly Mag., (2) III. 210 (Phorocera) (1882) ; Wachtl, Wien. entom. Zeitg., I. 278. 29. (Phorocera) (1882) ; Bertolini, Almanacco Trento, 19. f. 33. (Tachina) (1886) ; Gercke, Wien. entom. Zeitg., VIII. 220. (Phorocera) (1889) ; Wachtl et Korn., Die Nonne, 25. (1893) ; Mik, Wien. entom. Zeitg., XIII. 52. 26. (1894) ; Mik et Wachtl, Wien. entom. Zeitg. XIV. 236. (1895) ; Pand. Rev. entom., XIV. 335. 3. (Zenillia) (1895) ; Wulp et Meij. Naamlist, 83. (Phorocera) (1898) ; Girschn., Entom. Nachricht., XXV. 178. 6. (1899) ; Meij., Zool. Jahrbuck., XV. 680. f. 50. (Phorocera) (1901) ; Townsend, U. S. Dept. Agr. Bur. Ent. Tech. Ser. 12, Pt. VI. 102 (1908) ; Pantel, J. La Cellule, XXVI. fasc. 1. 86–93. (1910) ; Fiske, W. F., Parasites of Gipsy and Brown-tail Moths Introduced into Mass. 36 (1910) ; Howard and Fiske, U. S. Dept. Agr. Bur. Ent. Bul. 91, 265 (1911) ; Burgess, A. F., U. S. Dept. Agr. Bul. 204. 16 (1915).

SPECIFIC SYNONYMS AND BIBLIOGRAPHY OF EACH.

acronyctae Bouché, Naturg., 57. 40. (Tachina) (1834).
antiopis R.–D., Myod., 134. 9. (Phorocera) (1830).
apricans R.–D., Myod., 133. 4. (Phorocera) (1830) et Posth., I. 508. (1863) ; Macq., Suit. a Buff., II. 128. 17. (Metopia) (1835).
ardeacea R.–D., Posth., I. 538. 2. (Doria) (1863).

bombycivora R.–D., Myod., 136. 14. (Phorocera) (1830) et Posth., I. 509 et 533. (Phorocera) (1863).

cajae R.–D., Myod., 135. 12. (Phorocera) (1830) et Posth., I, 509 et 533. (Phorocera) (1863).

flavifrons R.–D., Rev. Mag. Zool., III. 6. 9. (Phorocera) (1851).

flavipennis R.–D., Myod., 136. 15. (Phorocera) (1830) et Posth., I. 509 et 533 (1863) ; Macq., Suit. a Buff., II. 128. 20. (Metopia) (1835).

gracilis R.–D., Myod., 136. 16. (Phorocera) (1830) et Posth., I. 509. et 533 (1863).

Guerini R.–D., Annal. Soc. entom. France, (2). VIII. 178. (Phorocera) (1850).

iovera R.–D., Myod., 135. 10 (Phorocera) (1830).

meditabunda Meig., S. B. VII. 263. 3. (Doria) (1838) ; Schin., F. A., I. 493. (1862) ; R.–D., Posth., I. 538. 3. (Doria) (1863) ; Stein, Entom., Nachricht., XXVI. 143. (1900).

munda Meig., S. B., IV. 395, 271. (Tachina) (1824) et VII. 261. 16. t. LXXII. f. 28–30. (Phorocera) (1838) ; Wulp, Entom. Tijdschr., (2). IV. 144. (Phorocera) (1864) ; Stein, Entom. Nachricht., XXVI. 148. (1900) ; Villen., Bull. Soc. entom. France, 1900. 161. 4. (1900).

myioidea R.–D., Myod., 135. 13. (Phorocera) (1830) et Posth., I. 509 et 533. (1863).

nitens, R.–D., Myod., 134. 6. (Phorocera) (1830) et Posth., I. 509 et 533. (1863).

noctuarum R.–D., Myod., 134. 6. (Phorocera) (1830) et Posth., I, 509 et 533. (1863) ; Macq., Soc. Sci. Lille, 1833. 280. 8. (Phorocera) (1834) et Suit. a Buff., II. 128. 18. (Metopia) (1835).

pieridis R.–D., Annal. Soc. entom. France, (2). VIII. 179. (Phorocera) (1850).

prorsae R.–D., Myod., 134. 8. (Phorocera) (1830).

pusilla R.–D., Annal. Soc. entom. France, (2). VIII. 181. (Phorocera) (1850).

pygarae R.–D., Myod., 135. 11. (Phorocera) (1830).

serriventris Rond., Dipt. ital. Prodr., III. 159. 1. (1859) et IV. 159. (Machaerea) (1861) ; B. & B., Denkschr. Akad. Wein., LVI. t. 11. f. 33 (Machaerea) (1889).

stupida Wulp (nec. Meig.), Entom. Tijdschr., (2) IV. 144. (Phorocera) (1864) ; B. & B., Denkschr. Akad. Wien., LX. 224. (1893).

taeniata Meig., S. B., IV. 389. 260. (Tachina) (1824) et VII. 261. 11. (Phorocera) (1838) ; Macq., Annal. Soc. entom. France, (2). VIII. 429. 14. t. XII. f. 4. (Phorocera) (1850) ; Stein, Entom. Nachricht., XXV. 149. (1900) ; Villen., Bull. Soc. entom. France, 1900. 161. 4 (1900) ; Strobl. Glasnik Zem. Mus. Bosn. Herceg., XIV. 488. (Phorocera) (1902) et Wiss. Mittheil. Bosn. Herceg., IX. 548. (Phorocera) (1904).

varia R.–D., Annal. Soc. entom. France, (2) VIII. 134. (Phorocera) (1850).

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