LIFE HISTORY AND HABITS OF THE CICADA KILLER IN OHIO

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The Cicada Killing Wasp (*Sphecius speciosus* Drury[2]) has long been of interest to entomologists and of much popular interest to naturalists wherever it occurs. Riley (18) in 1893 published in "Insect Life" the first account of its life history and habits. Observations of the writers have revealed a number of inaccuracies in this report and omission of essential data. These errors and omissions have been repeated by subsequent writers on the subject, particularly Marlatt (12), and Smith (20). Certain of these inaccuracies have been corrected, (Davis 5), but as yet no complete account of the life history and habits of this insect has appeared. For this reason the writers are here attempting to bring together the essential facts concerning its life history and habits based on published accounts and their own observations.

Beginning with the summer of 1934, and continuing through 1940, we studied the habits of this wasp for a period of a week or more each year during the height of its activity. A large part of the data reported on were collected from a colony of these insects consisting of several hundred burrows on a 4-H Club Camp site in Eden Township, Licking County, Ohio. Many observations have been made, however, at other colonies in southern Ohio counties. In addition to our own observations those of other interested individuals have been reported to us.

DESCRIPTION AND DISTRIBUTION

Due to its large size, general distribution and interesting habits *Sphecius speciosus* has been described in many insect books and needs no further description here. Its habit of digging burrows and provisioning them with cicadas is the means by which it is usually recognized and has earned it the name of cicada killer, sand hornet or golden digger-wasp.

In Ohio, *Sphecius speciosus* is most abundant in the southern two-thirds of the state but records from as far north as Cleveland in Cuyahoga County and Van Wert in Van Wert County have been obtained. Colonies appear to be most numerous in the unglaciated Allegheny Plateau and to occur only locally elsewhere. Although complete records are not available it is quite probable that it occurs in all of the counties, south of the Lake Erie drainage. Twenty-five of the 27 counties for which records are available are in this area.

LIFE HISTORY

Emergence:

At Dayton, Ohio, during a three-year period (1937–1939), the average date for the emergence of adults from Sphecius larval cases stored over winter in well-drained soil was July 1. Specimens stored at room temperature emerged approximately one month earlier. The adults made a nearly perpendicular tunnel to the surface in completing their emergence.

It is interesting to note that the emergence date of Sphecius closely approximates that of its prey, as was indicated by the concurrent appearance of cicadas at Dayton, Ohio, in 1939 and 1940. As noted later, however, Sphecius does not begin to prey upon cicadas until several weeks after its emergence.

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[2]Order Hymenoptera, family Sphecidae, sub-family Bembicinae, tribe Nyssonini.

Feeding and Mating:

The activity of the cicada killer immediately after emergence is apparently not well known. Recent observations only substantiated those of other observers who report that during this period adults feed upon the exudations of various trees including willows, oaks, sycamores, and the flowers of compositae and other plants.

Mating activity occurs concurrently with feeding and may take place far from where burrows are later established, Davis (5). Marked specimens released at Dayton, Ohio, from June 25 to July 3, 1939, were not again observed for at least two weeks. Shortly after their reappearance the excavation of burrows was begun.

Mating has been observed to take place in the air by a number of observers, Davis (5), Denton (7), Manee (11), and the authors. Males perch on exposed vegetation and pursue females which come near. When mating does occur the pair often drop to the ground together but recover quickly. Females have been observed similarly to pursue members of their own sex which makes it difficult to determine if mating is actually taking place. J. W. Sites, however, in conversation, has reported observing a pair of cicada killers quietly copulating while resting on a tall weed in a field near Zanesville, Ohio, July 29, 1940. This pair was so quiet that he was able to capture them easily.

Sex Ratio:

Of 25 adults emerging from stored larval cases, 15 were males and 10 females. Seven specimens collected in Muskingum County were females and of the specimens at the Ohio State University and the Ohio State Museum 29 are males and 37 are females. Denton (7), records obtaining 13 females and 7 males from a group of 20 specimens he collected from a colony on August 2, 1930, at Robbinsville, North Carolina. These collections, totaling 128 specimens, indicate a sex ratio of 70 females to 48 males, or 59.3 per cent females to 40.7 per cent males. During the height of Sphecius activity, however, males are seldom observed.

Digging and provisioning of burrows begins in mid-July and reaches a peak of activity the first two weeks in August. A marked Sphecius released at Dayton on July 3, 1939, was observed cruising back and forth along a lawn terrace on July 17 and began excavating there on July 22. Usually by the first of August there is considerable digging and provisioning of burrows in Sphecius colonies. Although they have been observed to be abundant as early as July 4, at the Eden Township colony in Licking County, their burrows have not appeared in large numbers there until some weeks later.

Location and Description of Colonies:

With few exceptions cicada killer colonies are located in well-drained, light-textured soil, in full sunlight where vegetation is scant or absent. Included in the list of sites studied in Ohio are such locations as: tree seedling and lining out beds at the Marietta and Zanesville tree nurseries, greenhouse flat boxes at Zanesville, a cinder roadbed at Zanesville, tennis courts on the Ohio State University campus, a school yard at Rocky River, a new earth fill in a city yard at Dayton, a formal garden surrounded by a concrete platform at a railroad station at Cambridge, a tobacco field in Clermont County, and frequently in lawns, over-grazed pastures, and old fields in the southern part of the state.

Size of colonies studied varied from one of two burrows to one of 373. The latter colony is definitely known to be at least 9 years old and is probably much older. It occupies an area of approximately one acre of thin pasture. The area occupied is variable and does not seem to be limited by the number of burrows. The distance between burrows ranges from a little more than one foot to 15 feet or more. Burrows in the large colony studied were grouped in units where they averaged 6.9 per 100 square feet.

Digging of Burrows:

Digging of burrows begins before mating activity ceases in the colony and continues throughout the summer until late August. The cicada killer accomplishes excavation by using the mouth parts to dislodge soil and other particles and to cut through roots of plants. The material so removed is pushed under the wasp's body by the fore legs and after a small amount accumulates it is kicked out behind in much the manner employed by a dog. As digging progresses beyond

the point where this method is effective the soil is dragged to the surface by the forelegs or is pushed out with the head. The accumulated pile of soil outside the burrow is kept away from the opening and a neat U-shaped entrance to the burrow is maintained. (Fig. 1).

The burrow, when in readiness for the first cicada, is dug usually to a depth of 6 to 10 inches. It measures approximately one-half inch in diameter and from 12 to 18 inches in length from the entrance to its terminus where the first cell is excavated. The rate at which digging progresses probably varies with the soil condition. The rate of digging observed in a well-packed, clay fill at Dayton, Ohio, gives some indication of the cicada killer's digging ability. In this case a tunnel was dug out ready for the first cicada between 2 P. M., July 21, and sometime prior to 8 A. M. July 22. Approximately one-half pint of soil was removed during this period.

Cells in which cicadas are stored are broadly egg-shaped with the long axis in the horizontal plane and perpendicular to the tunnel. They measure approximately 2 inches deep, 1½ inches wide, and slightly over an inch high. The walls of the cells are smoothly shaped and no loose dirt is left on the cell floor. Shaping of the cell is probably accomplished with the same tools as used in excavating the burrows.

Generally, after a cell has been provisioned with a cicada or cicadas, and an egg laid on one of them, it is plugged with a thin wall of earth and a new cell made immediately in front of it. As many as four provisioned cells have been found in one such series. After a cell or series of cells is completely provisioned a new lateral off the main tunnel is excavated and the process repeated. The number of cells fitted per burrow varies considerably but was found to average 15.8.

Hunting and Provisioning Burrows:

The Cicada Killer, like other solitary wasps, Peckham (15), makes no effort to obtain its prey until a cell has been made ready for it. Attempts to alter this habit by placing a healthy cicada at or near the burrow entrance during the digging of the tunnel proved unsuccessful. Equally unsuccessful were attempts to entice Sphecius to attack cicadas tethered with a thread and permitted to fly about their colonies while they were actively working and flying around.

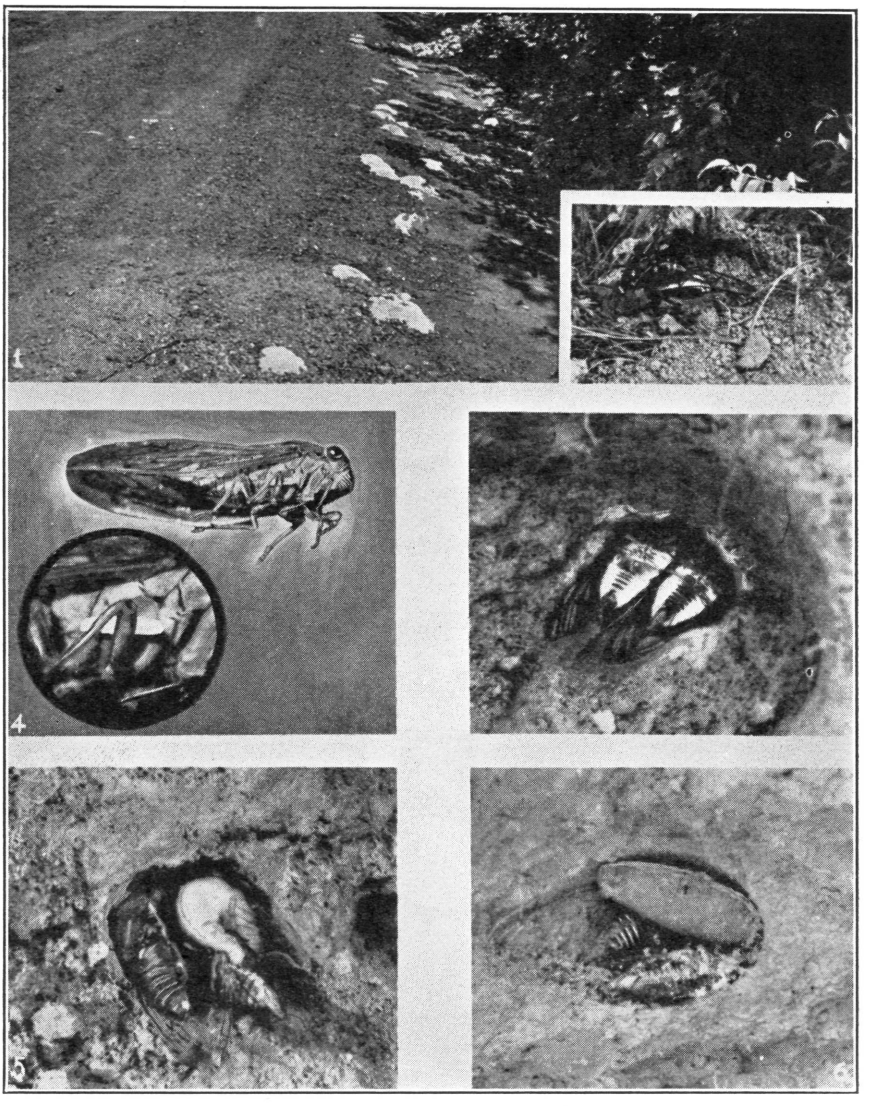
Sometimes before leaving the vicinity of its burrow a wasp would circle around it several times before departing in the direction from which it later returned with a captured cicada. Equally often, however, no preliminary maneuvers were engaged in, the Sphecius simply flying directly toward its hunting territory, or if windy, heading first into the wind and, after gaining a height of 10 to 15 feet, flying in the desired direction.

In hunting, the wasp approaches a tree or shrub and slowly circles closely about the trunk, gradually working its way up through the limbs and branches. It sometimes alights on the bark and continues the search on foot.

The method of attacking cicadas when located has been ably described by Mr. Conrad Roth of Portsmouth, Ohio, (in a letter of August 23, 1939) who witnessed a capture of *Tibicen pruinosa* at close range. "The wasp darted backward and forward in front of the cicada several times meanwhile bending the tip of the abdomen downward and forward. It then hit the cicada viciously and injected the sting between the abdominal segments. The cicada buzzed shrilly and immediately ceased struggling. The wasp managed to hold its prey to the limb of the tree and pulled it up on the top side of the limb. After this effort the wasp turned the cicada over on its back, straddled it, grasped the body firmly and flew off with the burden toward a Sphecius burrow."

In carrying its prey, Sphecius has always been observed to hold it firmly in an inverted position by locking its middle pair of legs about the neck between the eyes and the pronotum, (Fig. 2). Early writers, Riley (18), Smith (20), Marlatt (12), figured Sphecius dragging a cicada right side up. This error was corrected, however, by Davis (5).

Reports have been received indicating that a Sphecius sometimes takes its prey while in full flight. J. N. Knull, in conversation, reported one such capture which he witnessed at Cape Henry, New Jersey. In this instance the wasp hit the cicada while in flight and tumbled to the ground with it. Whether it stung its prey while in the air or after striking the ground was not observed. That this is not the usual method of attack, however, is evident from the apparent safety enjoyed by cicadas observed flying to and from trees 10 to 25 feet in height while cicada killers were busy searching the lower limbs in the usual methodical manner. It is quite likely,



1. A colony of burrows along a cinder roadway.
2. An adult female wasp with a captured cicada.
3. A male and female cicada (*Tibicen lyricen engel.*) stored in a cavity.
4. Egg of wasp on captured cicada.
5. Nearly full grown larva feeding on cicada.
6. Earthen case in which larva overwinters and completes life cycle.

however, that should a cicada attempt escape by flight after being located, pursuit and probably capture would result.

The captured cicada is carried in flight to the burrow entrance from distances sometimes in excess of 100 yards. Usually flight terminates at or within a few inches of the entrance and the cicada is then speedily carried down the tunnel. Less successful landings in grass or other vegetation frequently result in abandonment of the prey as the struggle to drag the burden to the burrow becomes too great. Davis (4), reported an observation by Morse of Sphecius dragging its prey up a maple tree and taking off from a high point after an unsuccessful struggle to reach its burrow through grass on the ground. Similar observations have been recorded by Davis (5), and Manee (11).

Cicadas are placed in the cells on their backs with their heads directed away from the open side (Fig. 3). When more than one cicada is placed in a cell they are laid side by side and all in the same direction. The number of cicadas stored per cell varies between 1 and 3 and averages 1.3.

Species of cicadas stored in burrows usually were those common in the vicinity of the colonies. Their relative abundance was about proportional to that noted from the number of males of each species heard in the immediate vicinity. Table I lists the species taken from colonies, by habitats, for which definite determinations have been made by W. T. Davis. In addition to these species, records of the following have been obtained: *Tibicen robinsoniana* taken from a cicada killer in Adams County, Ohio, August 11, 1935, by Conrad Roth and Edward S. Thomas; *T. marginalis* reported being carried by Sphecius up a telephone pole by Manee (11); and Sphecius hunting in willows in which *T. marginalis* were abundant, reported from Butler County in 1937 by E. E. Good. Davis (5), believed that *T. auletes* is taken also but no records have been found to substantiate his belief. Riley (8), reported the taking of *T. pruinosa* as has also Mr. Conrad Roth of Portsmouth, Ohio. Viereck (22) records it as preying on *T. dorsata*, *T. tibicen*, and *T. marginata* based on records by Ashmead.

Probably all of the cicadas with arboreal habits occurring within the range and active season of Sphecius are taken to some extent. *Okanaga rimosa* and the 17-year cicadas, *Magicicada septendecim* (Lin.), and *M. cassini* Fisher, and *Melampsalta calliope*, are too early in their appearance to be taken by Sphecius in Ohio. With the exception of possible stragglers their season is usually over two or more weeks before active hunting by Sphecius begins. Museum records of *Magicicada* in Ohio, for instance, range from May 26 to June 28.

The sex ratio of cicadas stored in burrows is greatly in favor of females. Of 703 Sphecius captured cicadas examined but 204 were males giving a sex ratio of 7 females to 3 males. Davis (5), noted this and in so doing called attention to the erroneous idea prevalent among naturalists that Sphecius secures its prey by hunting only singing males. The disproportionate sex ratio may be due to the greater susceptibility of females to the hunting system employed by the wasp. Male cicadas are probably more readily disturbed than are ovipositing females.

Laying of Eggs and Development of Larvae:

Only one egg is laid per cell irrespective of the number of cicadas it contains. Eggs are cylindrical or cigar shaped, transulcent, greenish-white in color and measure from 3 to 5 millimeters in length. The egg is placed lengthwise snugly under the femur of one of the middle pair of legs, (Fig. 4).

Eggs found on cicadas in the last completed cells in a number of burrows hatched within 24 to 36 hours. Presumably they were only a few hours old as wasps had been observed a short time previously to enter the burrows with cicadas. The newly-hatched larvae began feeding by inserting their mouthparts into the body cavity of the host at the base of a mesothoracic coxal plate. (Fig. 5). As the larva grew its feeding was transferred to the base of each of the remaining coxal plates until nothing remained of the cicada but a skeleton. When more than one cicada was available feeding was continued in the same manner on the second or third specimen.

Growth of the larvae is very rapid. One specimen which hatched prior to 8 A. M. August 29, 1939, had attained a length of 1.6 centimeters 48 hours later, and had completely eaten the body contents of the cicada on which it was feeding in 82 hours. At that time it measured 2.8 centimeters in length when quiet and 3.2 centimeters when extended in feeding. After feeding

briefly at the base of one coxal plate of another cicada it became restless and crawled around for several hours. By 8 A. M. September 2, 1939, 14 hours later, it had begun to spin a larval case consisting of a very open framework of thin fibres. By 5 P. M. of the same day a thin, silken-like, cylinder-shaped case had been woven which was open at both ends. The larva could easily be observed through this case as it seemingly shellacked the inner surface with a gelatinous substance applied by the mouth parts. The larva was observed virtually to crawl over itself in the cramped quarters of the larval case as it applied the finishing touches to the interior. After the open cylinder was apparently completed the ends were spun and sealed shut.

The completed larval case was broadly spindle shaped (Fig. 6), measuring 4.4 centimeters in length and about 1.5 centimeters in diameter. Both ends of larval cases are truncated with one noticeably larger than the other. Near the center of the cases a narrow band of outwardly opening pores occurs. The number of pores present in a series of 25 cases varied between 6 and 14 with an average of 10. The exact function of these pores is not known but presumably they represent some sort of respiratory or moisture regulating mechanism.

As the case hardens it becomes earthen-brown, stiff, and capable of withstanding reasonable handling. Soaking in water at room temperature for a half hour did not seem to weaken the cases nor to injure their occupants. Storage of the cases under very moist conditions for several months, however, made them soft, whereas storage in dry sand for the same length of time caused them to become very hard and brittle.

The number of cicadas placed in each cell as food has a direct effect on the size of the larval cases and may have some effect on sex, Clausen (3). In one series of observations 47 cells containing small or medium sized larval cases were found to be provisioned with but one cicada. Cells containing large larval cases in the same set of observations were found to have been provisioned with 2 cicadas in 19 cells and with 3 cicadas in 5 cells. Only 2 large larval cases were found with single cicadas and each of these had a large female *T. lyricen*. The average length of 135 larval cases was 3.2 cm. and average width at the widest point was 1.1 cm. The smallest larval case found measured 2.1 cm. in length and .7 cm. in diameter. The largest specimen found was 4.7 cm. in length and 1.6 cm. in diameter.

Soon after the case is completed the larvae shrink in size and the skin appears leathery as contrasted to its thin translucent appearance during feeding, (Fig. 5). The larvae remain in this quiescent stage over winter and begin pupation about one month before emergence, or the latter part of May. Earliest date of pupation of specimens stored out of doors at Dayton in 1939 was May 25. By the first of June all of the approximately 25 larval cases so stored contained well-developed pupae.

The waning of the cicada population in early September marks the end of the active adult cicada killer's life. By early September few adults can be found and before the first frost they are usually absent in the vicinity of colonies. Apparently neither sex overwinters in the adult stage. The life span of adults is remarkably long for such busy insects, covering approximately 65 days, if the dates July 1 and September 1 are considered mean first and last dates.

Since adults are known to feed only for a short time during the mating period the food assimilated must be used with a very high degree of efficiency to permit their tremendous energy output during the active adult life span.

An approximation of the life history of Sphecius by time intervals has been computed from the data assembled and is about as follows:

Egg.....24–48 hours—Late July through August.
Larva.....4–10 days feeding—Late July through August.
270–310 days quiescent—Late July to June 1.
Pupa.....25–30 days—June 1 to July 1.
Adult—60–70 days—July 1 to mid-September.

BEHAVIOR

In size and apparent aggressiveness the cicada killer appears to be one of the most formidable of North American wasps. It is, however, unexpectedly docile. In the course of this study, specimens have been removed from burrows with forceps, banded with colored thread, and released. Others have been knocked to the ground or brushed from captured cicadas with the bare hands. These and other forms of disturbance have never occasioned even a threatened

attack. As has been reported by other observers, however, upon entering a colony, an intruder is sometimes approached in a businesslike manner but with no actual attack resulting.

That Sphecius can and will sting has never been doubted. This was ably demonstrated to one of the writers by a large specimen during capture. The sting penetrated the flesh close to the tip of his right index finger. An initial sharp pain was followed by numbness, a slight swelling, and stiffness which lasted for about a week.

Throughout the summer and during mating activity, the male Sphecius is very aggressive and vigorously pursues various insects and even inanimate objects tossed near his perch, as well as females of the species. In one instance a Sphecius was observed to chase an English sparrow which chanced to fly within 25 feet of his perch. There are some indications that a rather well-defined territory is established by the male, within which all intruders are investigated in a vigorous manner. This territory may well represent the visual limits exciting response in this insect. These guarding activities are not confined to the males, however, as large females have been observed to exhibit somewhat similar behavior.

SOCIAL AND SOLITARY HABITS

The cicada killers are generally considered to be solitary wasps. Nevertheless, they exhibit certain traits of the social insects that are of particular interest. The most obvious of these is their habit of living in colonies made up of individual burrows.

On some occasions more than one female will utilize the same burrow. At the colony in Licking County a marked female was observed freely to enter and leave within a few minutes four different burrows, which were being used by unmarked females. Upon occasion two females have been observed to pass at a burrow entrance, one leaving and the other entering. No show of antagonism was apparent between them. In the same colony 2 females, each in a different cell within the same burrow and each with a cicada on which an egg had been laid, were found August 13, 1940, when one of the writers and Robert Paton were digging out the burrow. On the same date we were able to transfer cicada-laden wasps from the burrow entrance, where they landed, to nearby burrows. When this was done the new burrows were entered immediately. A similar observation was made at the same colony in 1938.

Smith (19), in reporting on a colony of approximately 50 burrows in Philadelphia, Pennsylvania, said that 40 or more individuals were removed without making a noticeable decrease in the number of individuals flying about. Since the sex ratio probably slightly favors females it is apparent that in this colony there must have been many more females than there were burrows.

Observations made to date have not made clear how frequently these apparently social habits occur. It would appear, however, that the habits of this insect are not strictly solitary.

MORTALITY

After larval cases have been formed, losses of Sphecius from natural causes are apparently very low during the normal life span. Losses, however, are very high between the time the eggs are laid and the larval cases are formed. Of 525 cells examined only 201, or 38.28 per cent, contained sound larval cases. The remaining number contained often untouched cicadas, which were frequently covered with mold.

The high mortality is probably due to a number of causes of which only one has been definitely determined. A secondary host relationship was discovered during 1939 between certain flies and Sphecius. Sarcophagid flies observed resting on a mound of earth outside a Sphecius burrow at Cambridge, Ohio, July, 1939, aroused interest in the possibility of such a relationship. Opportunity to investigate was not afforded, however, until similar observations were made in Clermont County, Ohio, in late August of the same year. Subsequent examination of 10 burrows at this location yielded records of one or more cells containing larvae of diptera in the stored cicadas in all but one burrow. Larvae were found in stages of development ranging from newly-hatched maggot clusters to fully-developed puparia.

In some cases both Diptera and the Sphecius larva were feeding on the same cicada. It is evident, from observations made on infested cicadas to which a live Sphecius was still attached, that the fly maggots consumed the available food supply before Sphecius secured sufficient food to complete its development. The smallest number of fly larvae found in a cicada was 16 and the

greatest 27. These larvae, when ready to pupate, ranged from .9 to 1.1 centimeters in length. In the 10 burrows excavated, 87 cells containing cicadas were found. Of these, 26 contained healthy appearing Sphecius larvae, 10 contained cicadas infested with fly larvae, two of which had dead Sphecius larvae still present. The remaining 51 cells contained only dead and often decomposed cicadas. In one burrow containing 9 cells at Washington, Indiana, 2 cells contained healthy Sphecius, one contained cicada and fly larvae and the remaining cells contained only dead cicadas.

One adult fly was captured as it rested on a pile of earth excavated from a burrow. Another was captured in a cell containing diptera puparia and 4 additional adults were obtained from puparia collected. The first two specimens and two of the latter 4 were sent to Mr. David G. Hall of the U. S. National Museum. Mr. Hall's determinations are as follows:

Metopia leucocephala (Rossi), *Sarcophagidae*—2.
Zygobothria sp. (probably *incompta V. d. w.*) *Tachinidae*—1.
Chaetoplagia atripennis Coq.—*Tachinidae*—1.

Mr. Hall stated that the two species of Tachinidae are not known to have any connection with fossorial wasps but that the Sarcophagid is a common parasite of these insects.

In view of the indeterminate status of the flies, further study is needed before more data can be presented. It is sufficient for the present to call attention to the records of their relationship to Sphecius survival.

ECONOMIC IMPORTANCE

The cicada-killer has slight economic importance. In the southern part of the state it has been considered a pest in city lawns, gardens, nurseries, greenhouses, and golf courses. In lawns and on golf courses the unsightly piles of earth removed from the burrows are considered objectionable. In gardens, nurseries, and greenhouses, burrows are sometimes made so close to plants that death to the plant ensues. In nurseries the earth removed from burrows when placed on young seedlings is often deeper than the plant can stand and death results. In addition, colonies of this formidable appearing wasp around city homes and playgrounds cause no little fear to the uninitiated.

In no case has the actual damage reported been of much economic importance. Most of its importance in this respect is properly listed as a nuisance factor. Smith (19), reports complete control of a colony of Sphecius by placing a teaspoonful of calcium cyanide at the entrance of each burrow. Blake Hanan reported, in conversation, that a colony established in a schoolyard at Rocky River, Ohio, was eliminated by a liberal application of old machine oil.

Both of these methods have objectionable features: The first because of the poison hazard; and, the second because of its deleterious effect on vegetation and unsightly appearance. It would seem that, where feasible, frequent watering and aiding vegetation to grow thickly by means of lime and fertilizer applications, if necessary for one or two seasons, would prove an effective control measure because a well-drained soil and scant or no vegetation are two requisites of a successful Sphecius colony.

The major beneficial habit of this wasp is its destruction of cicadas. Although the cicadas taken by Sphecius do not reach serious economic importance in this state, they are a destructive insect. That Sphecius can materially effect the population of cicadas is evident from the number of cicadas stored in individual colonies. In one colony of 373 burrows studied in 1937–38 in Licking County, an average of 30.4 cicadas per burrow were found in 13 carefully excavated burrows selected at random, after provisioning had ceased. On this basis the number of cicadas stored in burrows in the entire colony during 1937 numbered 11,339. The area from which they were taken is not known but since most of the species present were *T. lyricen engelhardti*, which occurs commonly in oak-chestnut forests, they presumably came from forest of this type in the vicinity of the colony. The total

amount of this type of forest within a quarter of a mile radius of the colony is estimated to be considerably less than 50 acres.

Burial of such large numbers of cicadas over a period of years in a limited area has had a noticeable effect on soil conditions. The most evident effect is the incorporation of organic matter in the soil due to the decomposition of the stored cicadas. Loosening of the soil due to digging of burrows and cavities by the adult

TABLE I

CICADAS COLLECTED BY HABITAT AND SPECIES

DATE AND LOCALITY	TYPE OF SITE AND VEGETATION	SPECIES OF CICADA BY NUMBER AND SEX							
		T.canicularis		*T.chloromera*		*T. linnei*		*T. lyricen engel.*	
		♂	♀	♂	♀	♂	♀	♂	♀
Muskingum Co., Ohio. 8-14-34	Abandoned crop field near old field association and 150 yards from oak hickory woods.			3	1	4	0	1	0
Eden Twp., Licking Co., Ohio, Aug., 1937	Closely grazed pasture adjacent to oak-chestnut forest and old fields.	3	0			8	5	5	21
Glen Este, Clermont Co., Ohio. 8-27-39	Old field—partly grown up with elm, beech-maple woods within 150 yards.			4	15	1	0	0	2
Washington, Indiana. 9-21-39	Nursery—sandy soil 100 yards from old fields; 200 yards from oak-hickory woods.			0	8	0	1		
Dayton, Ohio. 8-30-38	New fill—edge of city limits with many abandoned fields within 100 yards.					0	6		
Totals.....	.....	3	0	7	24	13	12	6	23
	Totals—old field association.			7	24	5	7	1	2
	Totals—Oak Hickory Chestnut association.	3	0			8	5	5	21

wasp is also apparent. Local as these effects are they indicate how myriads of other invertebrates, over a long period of time, have probably added to the formation of vitally important top soil.

To the students of the *Cicadidae*, Sphecius is a valuable ally. By observing the cicada-collecting habits of this insect much can be learned of the distribution and relative abundance of cicadas. It is possible also, to easily obtain specimens of cicadas in good condition by intercepting the burdened wasps as they return to their burrows. Mr. Conrad Roth reports successfully collecting cicadas by plug-

ging Sphecius burrows in the morning and returning later in the day to pick up specimens left by the returning wasps when they found their burrows plugged. Colonizing of Sphecius in localities where cicada-collecting is desired promises a unique method of collecting. An attempt to establish a colony by storing larval cases in a likely place met with moderate success when tried at Dayton, Ohio, in 1939. Of several females released, one established a burrow within a few yards of the place where the larval cases were stored.

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