THE BIOLOGY OF SOLIERELLA PLENOCULOIDES PLENOCULOIDES

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SOLIERELLA PLENOCULOIDES PLENOCULOIDES

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ABSTRACT

SOLIERELLA PLENOCULOIDES PLENOCULOIDES

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The study was conducted at the Kellogg Gull Lake Biological Laboratories in Kalamazoo Co., Michigan, to determine the biological relationships of the small wasp, Solierella plenoculoides plenoculoides (Fox).

The biology of the wasp is the culmination of observations made in the summers of 1965, 1966, and 1967. The adult is active from June 20 until July 30 in southern lower Michigan. The larva develops within one week. It constructs a cocoon and remains in a diapause state as a prepupa until May when pupation occurs.

The nests are constructed and partitioned with sand grains, seeds, flower petals, insect body parts, grass stems, wood chips, snail shells, or any other small particulate matter available. Cells are constructed containing four or five first instar grasshopper nymphs, Melanoplus femur-rubrum femur-rubrum (DeGeer), being the more prevalent species selected. The egg is attached behind the metacoxa and extends obliquely toward the procoxa.

Block trap nests were used to produce high population densities. Many were modified by splitting to allow greater facility for observing larval activity.

Feeding and cocoon construction were observed for the first time. The peculiar maceration-digestion of the grasshopper prey was noted. Also the maceration of sand grains with silk to produce the ovoid cocoon was observed.

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The data presented here were collected at the Kellogg Gull Lake Biological Laboratories in Kalamazoo County, Michigan. I wish to thank Dr. G. H. Lauff, Director of the Gull Lake Laboratories, whose help in photography and readying facilities was greatly appreciated.

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INTRODUCTION

Some thirty four species of the genus Solierella are now known and are widespread throughout North America. Members of the genus are restricted to sandy soil situations where there is sufficient flowering vegetation for adults to feed and other vegetation to sustain prey. Montane species occur in stony areas without much undergrowth, whereas seashore species live among sand dunes.

This miscophine genus may be recognized by having the eyes entire and slightly convergent dorsally; ocelli normal and arranged in a somewhat obtuse triangle; marginal cells truncate and appendiculate; three submarginal cells; the second petiolate receiving one or two recurrent veins; anal lobe of the hind wing small; middle tibia with a single apical spur; and pygidial area reduced or absent.

Biologically the genus is a diverse group with digging-burrowing forms, wasps nesting in deserted ground burrowing wasp or spider nests; and those forms that nest in former holes constructed by other insects in bush, tree, and bramble stems. The females of the digging-burrowing species possess foretarsal spines, whereas those nesting in deserted excavations of other insects lack the necessary digging spines.

Prey capture is also very diverse. The majority of the species prey upon immature Orthoptera and Hemiptera.

Williams (1950) has reported S. peckhami (Ashmead) to use the immature lygaeid, Pameca sp.; S. corizi (Williams) utilizes penultimate Hemiptera nymphs of Corizus hyalinus (Fabre); S. inerme (Cresson) feeds upon immature green capsid bugs. Two California species, S. nigra (Ashmead) and S. blaisdelli (Bridwell), both prey upon the immature lygaeid, Nysius ericae minutus (Uhler). S. rohweri (Bridwell) has also been reported by Bridwell (1920) to utilize an immature species of Nysius. Williams also cited two European species, reported by Ferton, S. compeditus (Piccloli) which has been known to store immature lygaeids, and S. xambeuri (Andre) which uses immature hemipterans.

S. similis (Bridwell), which is closely related to S. p. plenoculoides (Fox), has been noted by Williams to capture acridid grasshoppers of its own size (6.5 mm) or smaller. S. fossor (Rohwer) has also been noted to use immature oedipodine grasshoppers. Penultimate and mature grasshoppers, Melanoplus ligneolus (Scudder), are used by S. striatipes (Ashmead). In this instance only one grasshopper is used, the prey being two times the size of the wasp.

Newton (1960) found an undetermined species of Solierella storing a single fourth instar grasshopper, Ageneotettix deorus (Scudder).

A unique case of S. sayi (Rohwer) storing mature psocids, Psocus californicus (Banks), has been reported by Williams (1950).

Based upon the variance in nesting behavior and prey selection, some hymenopterists consider the existing genus as three distinct genera: Solierella, Silaon, and Nitelliopsis. According to Williams (1950) the latter two are now thought to be subgenera of Solierella. The inconsistencies within the genus of digging-burrowing types vs. the forms that nest in pre-existing holes, prey selection of Orthoptera or Hemiptera and the one species that selects psocids indicate the necessity for a revision of the genus or perhaps splitting the genus.

Biology

Solierella plenoculoides plenoculoides (Fox) (Det. H. E. Evans) is a small (male 5.0 mm, female 6.0 mm) solitary sphecid wasp, usually with small whitish spots on the dorsum of the pronotum and near the middle of the tibiae and tibial spurs. A fine silvery pubescence may be found on the sides of the thorax, abdomen, and frontal-clypeal surfaces.

Krombein and Evans (1954, 1955) found species closely related to *Solierella p. plenoculoides* (Fox) nesting on sandy flats bordering wood lots. Before this study, I had noted that *S. p. plenoculoides* was found in association with an old field situation bordering wooded areas. Therefore, the study areas were selected to provide optimum conditions for the wasps' nest selection. A sandy soil, sun exposure, appropriate source of adult wasp food, and suitable habitat where prey might be found was located in the immediate vicinity of the Kellogg Gull Lake Biological Station in Kalamazoo Co., Michigan.

In the old field environment the typical seasonal succession of plants could be found during the study period. *Vicia sp*. was found in abundance in June; while *Melilotus alba* and *M. officinalis* and *Medicago savita* were the dominant flowering plants during the major nest construction period of late June and early July. These latter two clovers supplied the adult with food and quite often the flower petals and seeds were used in nest construction.

The environmental characteristics of the study sites bordering the wooded areas were basically similar. Each site had adjacent sandy soil with *Melilotus* and a grassy border. The sites differed only in the degree of enclosure by trees. Two sites faced an open field and were backed by the trees while the third site was a small abandoned firing range gouged from the hillside (Fig. 6), surrounded by *Quercus sp*., *Sassafras albidium*, and *Carya* sp. on three sides. The basin formed an old field situation, with grass covered sides interspersed with *Solidago* spp. and *Rhus typhina*. During the three year study, Sassafras seedlings were continually encroaching upon the study area. A fourth site, a dry marsh, presented the most variant environment due to the luxuriant Typha latifolia growth and damp soil.

It was anticipated that the variance of the nesting sites would provide information pertaining to the ecological preferences of the wasp.

Artificial nests:

Solierella p. plenoculoides and its closely related species are not burrowing-nesting forms as are many other sphecids. They must rely on the holes made by other insects for their nesting sites. The wasp may utilize an abandoned spider burrow, a buprestid or cerambycid larva excavation, or perhaps, as has been noted, the abandoned Solidago gall of a tephritid fly (Muesbeck, et.al., 1951).

For these reasons trap nests could adequately serve as nesting sites if the environment was conducive to the wasp's activities.

White pine blocks of wood (20 mm x 20 mm x 150 mm) were used as artificial nesting sites. The blocks were drilled to a depth of 75 to 120 mm using bore diameters of 1/8 in. (3.2 mm), 3/16 in. (4.8 mm), and 1/4 in. 6.4 mm). The blocks were banded together in groups of nine with alternating entrances and varying bore diameters and dispersed among the nesting sites as equally as possible from ground level to four feet above ground.

Some of the blocks were cut longitudinally to expose the upper rim of the bore. This allowed easy access to the nest without disturbing the wasp's nesting process. It also facilitated exact measurements of the nest contents, order of construction, and larval activity for the nest was not disturbed or totally disrupted by the necessary splitting of the block.

A series of split blocks were wrapped with Saran Wrap in the manner described by Matthews and Fischer (1964). This method proved to be unsatisfactory for the present study due to the retention of excess moisture which frequently enhanced mold growth.

A third type of block nest was constructed of wood slabs (1 x 4 x 8 inches -- 25 x 100 x 200 mm) with three inch grooves on the surface made by a 1/8 inch gouge, providing a board with a series of 25 - 40 openings. Three boards were bolted together, producing an "apartment house" for the wasps. This type of artificial domicile resulted in only moderate success. The wasps encountered problems in orientation for they continually flew into the wrong opening and therefore several nests were not completed. With some minor alterations orientation problems could possibly be avoided for this type of nesting block.

It was later found that S. p. plenoculoides showed a preference for the 1/8 inch (3.2 mm) diameter bores indicated by the fact that the majority of the nests were observed in this diameter bore.

The nest blocks examined for larval and pupal development, were stored in glass test tubes which were sealed with an extra fine mesh silk bolting cloth for overwintering and future observations. This prevented the entrance or exit or parasites and the adult wasps upon emergence. A drop of sugar solution placed on the cloth allowed the adults to feed in the laboratory during observations.

Mating:

Upon emergence, the males, which tend to precede the females by a few days, may be found flying in small circles close to the ground surface. Usually a single male defends a territory of approximately one square foot by flying, landing, and running over the sandy surface bordering wooded areas. When a female flies through the maze of males, she is immediately seized by one or more males. Short conflicts may ensue between males which result in the escape of the female. Eventually a male mounts the female dorsally, grasps her antennae with his mandibles, encircles her thorax with his legs, and constantly strokes her head and face with his antennae. The male rubs his abdomen over the female's abdomen. Immediately prior to copulation, the male strokes her abdomen ventrally with his metathoracic legs. He quickly slides posteriorly and copulation occurs. This entire procedure requires less than one minute. A female is receptive to mating with one male several times or with several males as was observed on several occasions in the laboratory and field. Therefore, it is possible that sperm from several males could be stored and used for fertilization of the eggs. Males live for about one week after mating, whereas the famales may live for two or three weeks.

In lower Michigan the adult population of S. p. plenoculoides increases from the first emergences in the middle of June (Figs. 7 and 8), with peaks occuring during the first weeks of July and then usually tapering to a few individuals during the first week in August.

Nesting:

Nest site selection procedures are consistent. The female lands near an opening or may run over the surface of a wood slab seeking an opening. When an aperature is found, she investigates it thoroughly to the depth of the bore (this was observed in the split blocks by removing the top while the wasp remained inside). If the site is suitable, she may then begin construction by bringing material for cell partioning consisting of sand grains, seeds, flower petals, insect body parts, grass stems, wood chips, snail shells, or practically anything she is able to transport by means of her mandibles, or she may immediately provision the first cell with the prey. Normally, the wasp will select a few bits of debris or sand and place them in the bottom of the nest before initiating cell provisioning.

Prey:

The prey consists of first instar grasshopper nymphs, Melanoplus femur-rubrum femur-rubrum (DeGeer), Encoptolophus sordidus sordidus (Burmeister) and Syrbula admiralis (Uhler) (Det. I. J. Cantrall). Thirty two Melanoplus, seven Encoptolophus and one Syrbula were identified. Due to the young age of the one immature Syrbula nymph, the morphological characters were not sufficiently developed to allow a positive identification.

Capture of the prey has not been observed in the field. Steiner (1958) has experimented with the stinging procedure of the allied Liris nigra (Linden). He found that the wasp stings the prey (Gryllidae) through the thoracic sternites into the ganglionic masses. Williams (1950) has reported the ventral stinging of the acridid prey of S. similis. Since Liris and Solierella are closely allied, it is conceivable that they subdue their prey in a similar manner.

Solierella transports the nymph by grasping it laterally with her pro- and meso-thoracic legs and carrying it to the nest by progressive number of short (1 - 2 feet) flights. In most cases she carried it into the nest immediately and placed it in the cells.

During one observation, the grasshopper was placed approximately 12 inches from the nest opening. The wasp flew into the nest, remained a few seconds, then flew back to retrieve the grasshopper and placed it in the nest. On another occasion it was observed that the grasshopper jumped and thus escaped. Steiner (1958) in his experiments on stinging in wasps noted that if the wasp did not administer enough venom while subduing the prey, the gryllid was not permanently affected. This may have occured in the above observation.

The number of grasshopper nymphs per cell varied from one to nine with a mean of five. The nymphs were placed ventral side up and head first into the cell in a rather tight neat arrangement. It seems that some care is taken by the wasp when packing the grasshoppers in the cell. The positioning of the prey and proximity of each provided a rather close grouping.

Egg Deposition:

Newton (1960) observed that the egg of *Solierella* sp., attached behind the metacoxa, extended posteriorly across the first abdominal sternum. By contrast, the egg of *S. plenoculoides* is attached by the narrow anterior end to the metacoxa and curves obliquely across the sternum toward the procoxa (Fig. 1). The egg may be attached to either the right or left side of the grasshopper. There was seemingly no consistency of right or left metacoxal attachment within the cells of a nest. Williams (1950) reports the similarity of egg positioning on an acridid by the closely related *S. similis*.

When five or more grasshoppers are utilized, the egg is normally deposited on the third grasshopper placed in the cell. Some variation was noted in the egg laying pattern when less than five grasshoppers were placed in the nest, the egg being deposited on the second or third grasshopper. A small number of cases were observed in which nine acridids were placed in the cell but no egg was laid.

Cell Closure:

Upon provisioning the cell, the female immediately begins a series of trips using any particualte matter available in the vicinity of the nest to seal the cell, using debris similar to the material used for beginning the nest. The time involved obtaining material depends upon the availability of sand and debris, but ranged from ten seconds to over two minutes. Generally the flights were short - no more than four feet from the nest. Often she would simply run around the nest area. Because the flights were quick and darting, watching her collect material was both difficult and exasperating.

The number of cells per nest varied from one to six with a mean of two.

Cell closure as compared to nest closure presented an interesting variation. Generally the adult devoted little time or care partitioning the cells from one another. She would fly out to pick up a sand grain or other material, carry it back into the nest and deposit it quickly. A number of trips were made in this manner to form a very loose division of debris (10 mm) separating the cells.

Nest closure proceeds with an infinite number of trips to provide the necessary debris for the 50 to 75 mm. plug. Each bit of material is carefully maneuvered into position to form a tight conglomerate mass of debris which seals the nest. In one instance a wasp attempted to place a large wood chip in the entrance. After a minute of twisting and juggling she dropped it and retrieved a smaller chip which she positioned properly.

During these phases of nest construction, the wasp may occasionally fly to nearby flowers for nectar. The time involved for feeding was approximately three minutes.

After completing the nest and sealing the entrance with the same type of debris used to partition the cells, the female began to seek out new openings, presumably for additional nests. Using the large number of cells found in some nests as a criterion, the wasp is capable of producing several eggs and therefore several nests.

Growth and Development:

Egg:

The white-grey colored, smooth, shiny, opaque egg is ovoid cylindrical, tapered anteriorly at its point of attachment. The egg is 1.0 to 1.5 mm long and approximately 0.5 mm at its greatest girth.

As the egg develops, the chorion becomes transparent, exposing the embryonic internal morphology. The time period for eclosion is approximately 24 hours after deposition. However, it is difficult to discerne the actual "hatching" process since the chorion is apparently not shed and the larva at this early stage of development has no morphological features to distinguish it from the egg. Soon after the chorion becomes transparent, the probable time of eclosion, peristaltic movements may be viewed in the gut of the undifferentiated larva as the food is forced posteriorly.

Larval Growth:

The larva completes growth and development within one week. During this period, morphological patterns develop which are distinguishing features for the time interval. The larva feeds continually with a uniform growth pattern as the somites progressively enlarge and differentiate. Instars and stadia number are difficult to determine for this reason.

Within 12 hours after feeding is initiated the head capsule is sufficiently enlarged to be distinguished from the other developing somites. Internally the larva turns a light yellow-green. The outer epidermis lacks segmental lines.

Within 15 - 24 hours after eclosion, a faint red color displaces the green internal color and definite segmental lines become evident (Fig. 3).

When the larva is in the 36-48 hour period, abdominal nodules which extend laterally and ventrally, are seen as the segmental lines and the red color becomes deeper in shade (Fig. 2. At this time of development, three grasshoppers have been eaten by the larva simply lying next to the prey. When the larva has completed feeding on a grasshopper, it begins searching movements by anterior torsion of the body. Due to the compact mass of grasshoppers, it quickly contacts another new acridid. The larva begins macerating any body part it contacts. This might be a tarsal segment, abdomen, or antenna. By progressive pulling-macerating motions, <u>Solierella</u> soon aligns itself next to the grasshopper for complete feeding. The exoskeleton is destroyed to expose the soft internal organs upon which it feeds.

After three grasshoppers have been consumed, the feeding behavior of the larva changes. The larva turns on its dorsum, curving its entire ventral aspect slightly, which with the laterally upturned nodules forms a concave channel. By means of the flexing and twisting motions of the anterior body, similar to that described above, the larva searches for and grasps the fourth grasshopper with its mandibles, pulls it over a portion of its venter, and immediately begins to macerate the prey. Maceration continues until a black mass is formed in the concave channel. Apparently salivary secretions or digestive enzymes are mixed with this material by malaxation. Presumably this is a type of predigestion to ease absorption of food. The black mass is constantly rechewed and as this process continues, internal, anterior to posterior peristaltic contractions may be discerned through the transparent skin, indicating that food materials are being taken in from this black mass. This manner of feeding continues through the fourth and fifth days, while the larva grows to nearly fill the cell and completes the maceration-digestion of the fourth and fifth prey.

A liquid is secreted anally by the larva, which dries within a few hours to form a yellow cap on the macerated grasshopper material (Fig. 4).

In the mature larva, abdominal nodules, a definite head capsule, and incised segmental sutures are evident externally (Fig. 4). Through the transparent integument, the white, sinuate, tracheal tubes are evident laterally. The gut is prominently red, apparently from ingested food.

Cocoon Construction:

When ready to pupate, the larva becomes quiescent for more than an hour prior to actual cocoon construction. The larva extends many silk strands perpendicularly, longitudinally, and obliquely in the cell. Often the macerated mass with the yellow cap is entrapped and suspended in the silk scaffolding. Actual cocoon construction is initiated using sand grains macerated with silk spun from the mouth. The cocoon is begun by building a girdle of this material mesally and working anteriorly and posteriorly until only the two ends remain exposed. The larva completes the anterior end of the cocoon, the end toward the nest entrance, prior to the posterior end. The larva twists itself within the cocoon to complete the posterior end, but is now oriented away from the nest entrance. The reorientation may be observed as the larva twists itself within the pliable cocoon walls to once again face the nest entrance. Twenty four hours after the cocoon is completed the walls form a rigidly protective shell (Fig. 5). Actual cocoon construction was observed to take 15 to 22 hours.

Deleurance (1945), describing the biology of Tachsphex costai (Destefani), found that it also incorporated extraneous material into the construction of the cocoon. He did not state whether this was actually macerated with the silk secretion.

When the cocoon of Solierella is wet, it has a reddish tint with an anterior white cap. As the cocoon dries, it becomes grey and the cap is not as prominent. This cap has a small brown spot on the inner surface. The silk lined cocoon is internally smooth with no evidence of the sand grains protruding into the lumen.

Post-larval Development:

Upon completion of the cocoon the pre-pupa stage overwinters until late April or May at which time the pupa is formed. The earliest observed emergence occured during the first week of June. Rau (1928) observed the emergence of S. niger from the cocoon. The insect chews a round hole from the anterior end of the cocoon. This would correspond to the small white cap noted above. All my observations substantiate this emergence pattern.

Analysis of the data reveal a lack of correlation between nest cell series and wasp sex. There is a tendency for the males to emerge first from the smaller cocoons (5.0 x 2.0 mm) of the outer cells; and females to emerge later from the larger cocoons (6.0 x 2.5 mm) deeper in the nest. However, several males were found in the first cells to indicate that order is not necessarily of importance with the species. The loose type of nest construction would not create serious exit problems as is the case of many other Hymenoptera. Usually the cocoons do not completely fill the cell. Therefore, the emerging male could conceivably pass through the anterior cell without destroying the pupating wasp.

Competition:

One Solierella female usurped the nest of a Trypoxylon sp. wasp. Three cells provisioned with spiders and sealed with a mud plug were found. Solierella completed the nest with three cells anterior to the Trypoxylon cells.

At times dead adult insects were found in the nests. A queen ant was found deep in a nest. Presumably she had been overwintering in the bore, but died. The strangest case was the enclosure of an adult Solierella p. plenoculoides. It is possible that she died in the nest and another female simply constructed another cell and completed closure of the nest.

Matthews (1965) reported that Solierella was a successful competitor for the nesting blocks with the megachilid, Heriades carinata (Cresson). This was found only in the nesting blocks with a 1/8 inch (3.2 mm) bore, the preferred size for Heriades.

Krombein (1967) reported of one case of Solierella affinis blaisdelli (Bridwell) superceding a vespid wasp.

Several nests were destroyed by a small ant, Crematogaster lineolata lineolata (Say) (det. R. L. Fischer). The ant was observed carrying away the grasshopper prey and the wasp larvae. Apparently they are predacious on other insect forms. The ant species does not construct a ground nest, but may be found under loose bark of trees or wood crevices.

Parasitism:

Parasitism was evidenced in one instance by the occurance of a phorid fly, Megaselia (megaselia) aletiae (Comstock) (Det. G. Thompson) in a cell. The fly larva fed upon the grasshopper prey and so competed successfully with the wasp for the food. Theoretically, this might not be a true case of parasitism.

Four pupae were found to be parasitized by a eulophid wasp, Melittobia chalybii (Ashmead) (det. B. D. Burks). The chalcids were always found to be associated with the Hymenoptera host. Several eulophid adults (eleven in one case) would emerge from the Solierella cocoon by means of a small hole chewed in the side. The eulophid is a common parasite of Hymenoptera and often becomes established in laboratories where other Hymenoptera are being cultured and may become a serious pest.

Climatic Factors:

S. p. plenoculoides is very susceptible to climatic fluctuations which greatly affect the nesting behavior of the wasp. During periods of cloud cover which exist during the approach of a low pressure system, the wasp was not actively constructing nests. If a cloud shadowed the nesting area for a few minutes, all activity would cease and the wasp would either remain in a nest or crevice. Temperature had an affect, especially during the morning hours until noon. At temperatures of 80° F. or higher the wasp was very active. As the temperatures dropped, activity was reduced. Moisture was also a deterrent factor to nest construction. If the nesting blocks became wet during a thunder shower or heavy dew, the wasp would not continue construction.

The graph (Fig's 7 and 8) indicates great fluctuations in nesting activity. In 1966, for example, nesting activity began the third week of June and progressed until June 27 when the temperature dropped and cloud cover was present. On the 28th it rained. By June 29, the skies cleared and increased activity was noted. From July 4 until July 15 clouds and rain persisted intermittantly. During this 10 day period, high temperatures varied from high 70° to low 90° F. Because of cloud cover however, nesting activity was quite low. During the last two weeks of July, high temperatures and negligible cloud cover was encountered resulting in an increase in nesting activity followed by complete cessation by July 30.

It appears from the evidence of 1965, 1966, and 1967 that nesting activity is closely allied to the local weather fluctuations.

Mold was an important factor throughout the entire study (Table 1). The larvae did not complete development when mold was present on the grasshoppers. Occasionally, mold developed in the cocoon thus destroying the pupa. This was only found when the cocoon has an imperfection such as a small crack in the lining. Other cells in the same nest were moist enough for mold growth, but the linings were intact.

Summary and Discussion:

Prior to this biological study of *S. p. plenoculoides* nothing was known concerning its prey. By storing five grasshopper nymphs per cell, *Solierella* would appear to be one of the lesser biological controls of *Melanoplus f.-r. femur-rubrum*. Also considering the small number of nests constructed (two or three) and the high mortality of *Solierella*, the wasp is of minor importance in the control of the acridid.

Fifty seven nests were successfully completed by the wasps during the three year study. One hundred ten cells were observed; twenty eight adults were found in the cocoons; and thirteen adults actually emerged including eight males and five females. Of all the adults studied (emerged or dead in the cocoon) two were oriented away from the nest entrance. The process by which the wasp orients itself is not yet known.

As seen in Table 1, the majority of the potential population dies before completing its life cycle. By eliminating the nests that were empty and placing the proportion of the larvae killed accidentally into the population, a small minority (20%) attain adult status.

The adult wasp is capable of completing a nest within a 24 hour period. This requires a great number of trips to construct the partitions and nest closures. These are made very rapidly (from two to five seconds) when a ready source of debris and sand is available.

Literature Cited:

Bridwell, J. C. 1920. Miscellaneous Notes on Hymenoptera. 2nd Paper, With Descriptions of New Species. Proc. Hawaiian Entomol. Soc. 4:386-402.

Deleurance, E. P. 1945. Sur L'Ethologie d'un tachytes Chasseur de Mantes, Tachysphex costai (Dest.) (Hymenoptera sphecidae). Bull. Mus. Nat. Hist. de Marseille. 1:25-29.

Evans, H. E. 1958. Studies on the Larvae of Digger Wasps (Hymenoptera: Sphecidae) Part IV: Astatinae, Larrinae, and Pemphredoninae. Trans. Amer. Entomol. Soc. 84:109-139.

Fox, W. 1893. A New Species of Niteliopsis. Psyche 6:555.

Krombein, K. V. and H. E. Evans. 1954. A List of Wasps Collected in Florida, March 29 to April 5, 1953 with Biological Annotations (Hymenoptera, Aculeata). Proc. Entomol. Soc. Washington 56:225-236.

__________ . 1955. An Annotated List of Wasps Collected in Florida, March 20 to April 3, 1954, (Hymenoptera, Aculeata). Proc. Entomol. Soc. Washington 57:223-235.

Krombein, K. V. 1967. Trap Nesting Wasps and Bees. Life History, Nests and Associates. Smithsonian Press. 177-178.

Kurczewski, F. E. 1967. A Note on the Nesting Behavior of Solierella inermis (Hymenoptera: sphecidae, Larrinae) Journ. Kansas Entomol. Soc. 40:203-208.

Matthews, R. W. and R. L. Fischer. 1964. A Modified Trap Nest for Twig-nesting Aculeata. Proc. N. Cen. Branch Entomol. Soc. Amer. 19:79-81.

Matthews, R. W. 1965. The Biology of Heriades carinata (Cresson) (Hymenoptera, Megachilidae) Cont. Amer. Entomol. Inst. 1:1-33.

Muesbeck, C. F. W., K. V. Krombein, and H. K. Townes. 1951. Hymenoptera of America North of Mexico. Synoptic Catalog, U.S.D.A. Monograph. 2:1-1429.

Newton, R. C. 1960. The Nesting Habits of the Wasp Solierella sp. and the location of its egg on the Grasshopper, Ageneotetti deorum. Jour. Econ. Entomol. 53:958-959.

Peckham, G. W. and E. G. Peckham. 1905. Wasps-Social and Solitary. Boston, Houghton-Mifflin and Co. 95-96.

Rau, P. 1928. Field Studies in the Behavior of Non-Social Wasps. Trans. Acad. Sci. St. Louis. 25:325-489.

Rau, P. and N. Rau. 1918. Wasps Studies Afield. Princeton, N. U. Princeton Univ. Press 124-135.

Steiner, M. A. 1958. Contribution à l'étude biologique des Sphègides (Hyménopteres). L'Influence des piqures de Liris nigra V. d. L. (=Notogonia pompiliformis Pz.) sur sa proie. Note. Academie Des Sciences. 150-152.

Williams, F. X. 1913. The Larridae of Kansas. Univ. of Kansas Sci. Bull. 8:117-213.

__________ . 1950. The Wasps of the Genus Solierella in California. Proc. Calif. Acad. Sci. 26:355-417.

Figure 1. Position of _S_. _p_. _plenoculoides_ egg on prey.

Figure 2. Forty eight hour larva of same feeding on grasshopper.

Figure 3. Twenty four hour larva of same feeding on first grasshopper.

Figure 4. Mature larva of same showing the position of the macerated prey (black) and formation of the yellow anal secretion (stippled).

Figure 5. Enlargement of Cocoon.

Fig. 1

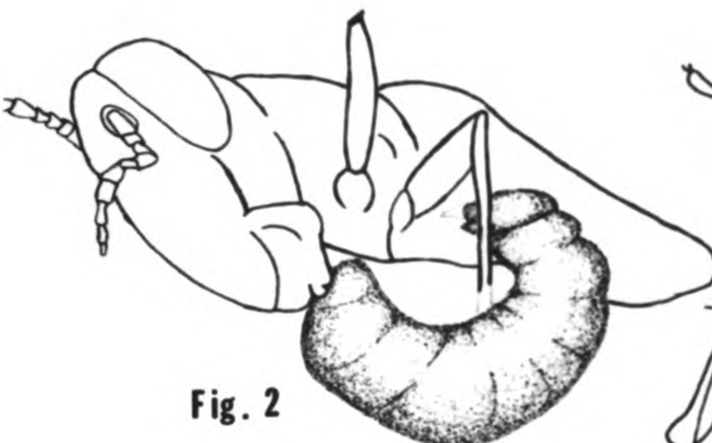

Fig. 2

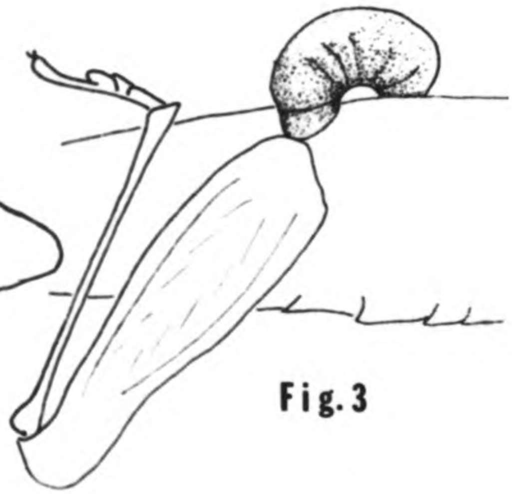

Fig. 3

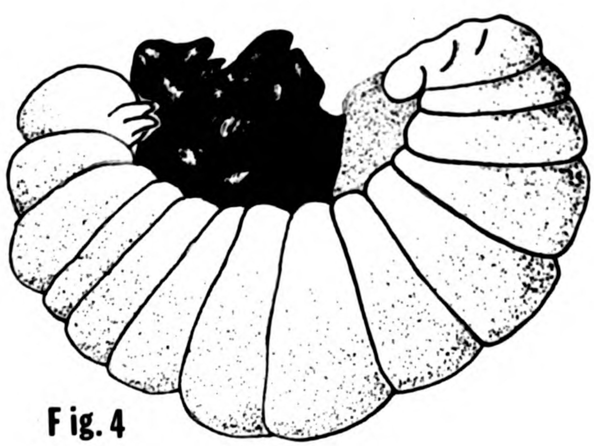

Fig. 4

Fig. 5

Figure 6. Nesting habitat in the abandoned target range.

Figure 7. Seasonal distribution of *S*. *p*. *plenoculoides* in 1965.

Figure 8. Seasonal distribution of *S*. *p*. *plenoculoides* in 1966 and 1967.

Fig. 6

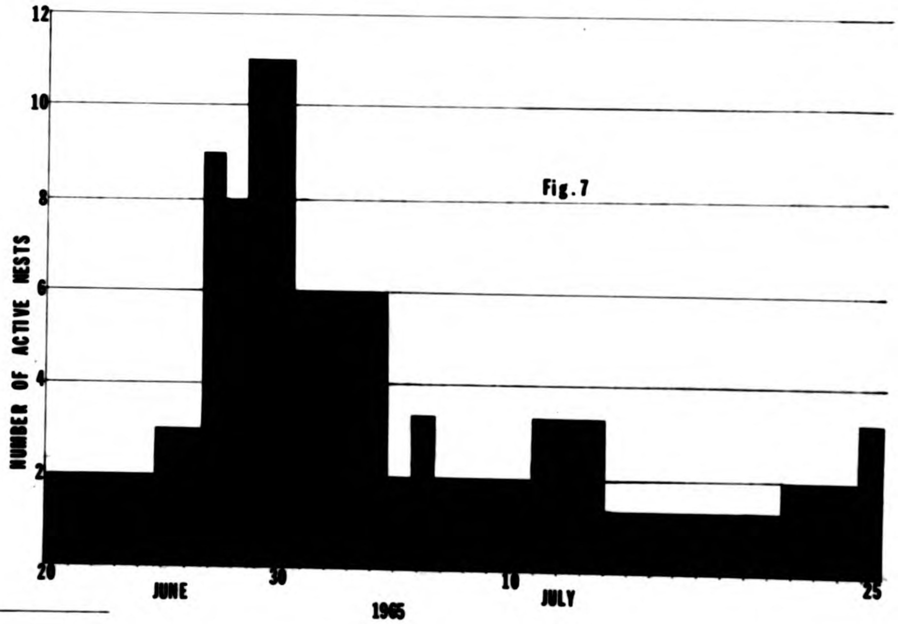

Fig. 7

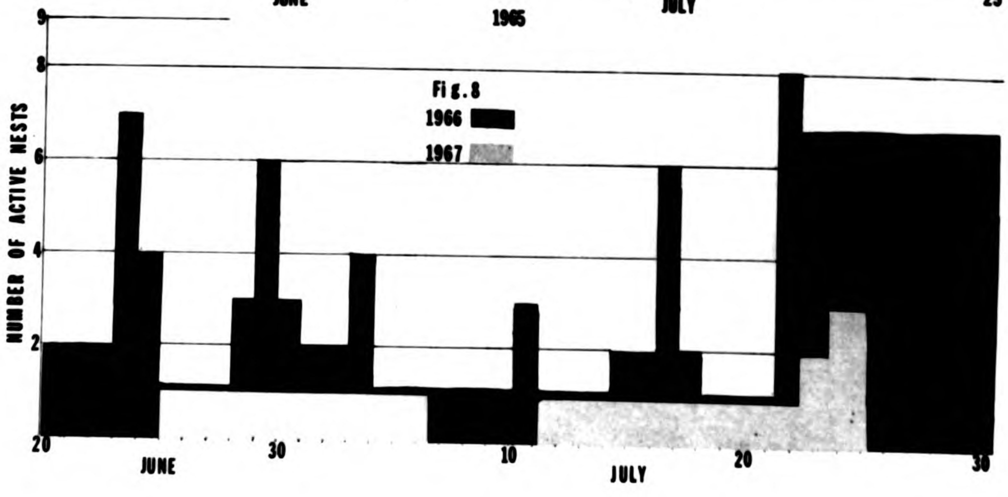

Fig. 8

TABLE I

Rearing Data for

S. p. plenoculoides

from Michigan Trap Nests

	1965	1966	1967	Percentage
Total number of nests. . .	57	53	9	
Total number of cells. . .	108	106	18	
Empty Cells.	20	6	1	11.2 %
Unsuccessful Rearing . . .				
Mold.	4	9	2	6.4 %
Egg not laid or failed to hatch . . .	7	9	3	8.2 %
Larva natural mortality	13	21	5	16.8 %
Larva killed accidentally.	2	15	--	7.3 %
Pupa died - no emergence.	15	15	--*	14.0 %
Ant destruction of nest	9	1	2	5.0 %
Chalcid parasitism. .	13	5	--	7.9 %
Diptera parasitism. .	3	3	--	2.6 %
Adult-non-emergence .	19	--	--*	8.9 %
Successful Rearing				
Males	2	10	(5)*	5.8 %
Females	1	6	--*	3.2 %
Extended diapause . .	--	6	--*	2.8 %

* Not calculated in precentages.