A TRAP-NEST SURVEY OF SOLITARY BEES AND WASPS IN WISCONSIN, WITH BIOLOGICAL NOTES

T. W. KOERBER\textsuperscript{1} and J. T. MEDLER\textsuperscript{2}

University of Wisconsin, Madison

Many species of solitary bees and wasps nest in hollow stems, holes in logs, and similar natural locations. Among the previous students of bee and wasp biology, only a few workers in Europe and North America have provided different types of artificial nesting holes and have recorded the acceptance of such holes by various species. Since 1951, artificial nesting holes or “trap-nests” have been used in northern Wisconsin in connection with research on the pollinators of legume seed crops. The success experienced in attracting not only Megachilidae, but eumenid, sphexid, and pomphilid wasps with a relatively few trap-nests, and in a limited area, suggested that a similar study on a state-wide scale would add to our knowledge regarding these insects. Accordingly, a trap-nest survey was made in order to learn more about the distribution and nesting biology of solitary bees and wasps in Wisconsin. This is a report on the data obtained during the 1956 season.

METHODS

The trap-nest used in this survey was a section of sumac stem about eight inches long with a six inch hole bored in the center. The diameter of the hole was either $\frac{1}{4}$-inch or $\frac{1}{8}$-inch.

Twenty locations (Figure 1) were selected to represent different major habitats and to give a state-wide distribution. In the spring of 1956, bundles of trap-nests were placed at trapping sites at each location. Each bundle contained three sticks with $\frac{1}{4}$-inch holes and three sticks with $\frac{1}{8}$-inch holes. The bundle of trap-nests was held together with a $\frac{1}{2}$-inch rubber band cut from old automobile tire inner tube. Each bundle also contained a solid stick of wood about one inch square and six to eight inches long. This stick had two hooks by which the bundle was attached to a wire around a tree

\textsuperscript{1} Research Assistant, Department of Entomology, University of Wisconsin. Now with the Division of Forest Insect Research, U. S. Forest Service, California Forest and Range Experiment Station, Berkeley, California. Information given in this paper was submitted in partial fulfillment of the requirements for the degree of Master of Science in Entomology at the University of Wisconsin.

\textsuperscript{2} Associate Professor, Departments of Agronomy and Entomology, University of Wisconsin, Madison. This work was supported in part by the Research Committee of the Graduate School of the University of Wisconsin from funds supplied by the Wisconsin Alumni Research Foundation.
or to a fence wire. The solid stick carried the serial number of the
bundle written in indelible pencil.

Two bundles of trap-nests were placed at each site. A high bundle
was placed four to seven feet above the ground and a low bundle
between the ground and the two foot level, usually directly below
the high bundle. The bundles were inspected at four to six week in-
tervals during the summer. Each sumac stick was examined and
those which contained nests were brought back to the laboratory
for study. The occupied trap-nests were immediately replaced with
empty ones, so that each bundle of trap-nests contained the same
number of sticks with the same size holes throughout the summer.

The trap-nests which were brought back to the laboratory were
split carefully so that damage to the contents was kept to a mini-
mum. A diagram was made and notes were taken on the contents
of each nest. Photographs were made of many of the nests and of
representative specimens. The immature insects were transferred
to individual vials for rearing and observation. A coding system
was devised to indicate location, site, nest, and cell. Every specimen
could be associated with its nest by means of the code designations,
and also with all notes, pictures and diagrams.

RESULTS

The number of nests built by each of the important species at
the twenty locations is given in Table 1. There were different num-
bers of trapping sites and trap-nests used at the various locations.
Of the 1647 trap-nests placed at the 94 trapping sites, 778 or
47.2% were accepted by bees and wasps.

Considerable data were obtained on the distribution, abundance
and habitat preferences of the various species of bees and wasps
that used the trap-nests. All of these insects built a linear series of
cells which they provisioned with food for their larvae. An egg was
deposited in each provisioned cell and the resulting larva grew to
maturity, pupated and finally emerged as an adult bee or wasp.
The various species differed widely in the materials used to con-
struct the cells, the size and number of cells per nest, and the cell
provisions. The information obtained on nest construction, biology
of the progeny, and the parasites, is not given in this report. These
data have been consolidated with data obtained during a period of
several years and will be published in a series of reports on the
biologies of the various species.

Because of similar nesting habits, it might be expected that the
species utilizing the trap-nests would compete for the limited num-
ber of nesting holes. It was not possible to measure exactly the in-
terspecific competition. However, it appeared that intraspecific com-
petition was more important than interspecific competition, because
<table>
<thead>
<tr>
<th>Trapping Sites</th>
<th>Launching Species</th>
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<tr>
<td>Cave Point, Door Co.</td>
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<td>Devils Lake State Park, Sauk Co.</td>
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<td>Dietz Farm, Bayfield Co.</td>
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<td>Gurney, Iron Co.</td>
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<td>Highbridge, Ashland Co.</td>
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<td>Interstate Park, Polk Co.</td>
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<td>Kettle Moraine State Forest, Waukesha Co.</td>
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<td>Lucerne Farm, Waushara Co.</td>
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<td>Madison Lake, Fond du Lac Co.</td>
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<td>Waukesha State Park, Door Co.</td>
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<td>Wausau, Marathon Co.</td>
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<td>Wisconsin Rapids, Rock Co.</td>
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<td>Point Beach, Manitowoc Co.</td>
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<td>Wyatt Park, Wausau Co.</td>
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<td>Wyatausa State Park, Grant Co.</td>
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<td><em>TOTAL</em></td>
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**Note:** The table represents the number of nests of each of the principle species taken at each of the trapping areas.
the various species showed differences in distribution, hole size preference, and food requirements for provisioning cells. The availability of food may have been related to the distribution and abundance of the species, but food was plentiful and, therefore, not considered to be a major factor in the selection of the nesting site.

Three species of megachilid bees, *Megachile inermis* Proc., *M. relativa* Cress., and *M. mendica* Cress., occurred in considerable numbers in the trap-nests. All used pollen and nectar to provision their cells. *M. inermis* was found in the northern part of the state and *M. mendica* in the southern part only. Nests of *M. relativa* were common in northern locations, but became less abundant in southern Wisconsin, and none were taken at two of the southernmost locations. Nests taken in the southern part of the state generally produced smaller specimens of *M. relativa* than those obtained from locations farther north. *M. mendica* preferred to nest in dry open locations where few *M. relativa* nests were built. The habitats in which *M. relativa* and *M. inermis* built their nests were similar except that *M. relativa* built many nests in fence rows, whereas *M. inermis* was apparently restricted to woodland habitats. *M. inermis* is a large bee and was unable to use holes having a diameter of a 1/4-inch. *M. relativa* and *M. mendica*, which are smaller bees, were able to use both 1/4-inch and 5/6-inch holes. The distribution of these three species is shown in Figure 2.

Two species of eumenid wasps, *Rygelium foraminatum* (Sauss.) and *Ancistrocerus antilope* (Panz.), were found commonly throughout Wisconsin. Both species provisioned their cells with caterpillars and used both size holes. However, the two species differed in their habitat preference. *R. foraminatum* showed a strong preference for open areas and fence rows. *A. antilope* preferred woodland locations, although its preference was not so strongly defined as that of *R. foraminatum*. The habitat preferences of these two species were much more strongly indicated at the extreme northern and southern locations. In the north *A. antilope* nested in nearly all habitats whereas *R. foraminatum* was found only in the most open locations. In the south *R. foraminatum* was found under a variety of conditions and *A. antilope* nested only in heavily wooded locations.

It seemed that the relative abundance of *R. foraminatum* and *A. antilope* was strongly influenced by the proportion of wooded land to open land in any given area. A high proportion of wooded land such as exists in northern Wisconsin could produce conditions favorable for *A. antilope*. Some members of the resulting large population of *A. antilope* would be forced to nest in the less favored open areas. A high proportion of open land with fence rows such as exists in the southern part of the state would favor a large population of *R. foraminatum*. The combination of a high *R. forami-
FIGURE 1. Locations of twenty trap-nest sites in Wisconsin, 1956.
FIGURE 2. Distribution of three species of Megachile at trap-nest sites.
FIGURE 3. Distribution of two species of Eumeninae at trap-nest sites.
FIGURE 4. Distribution of Trypoxyloninae, Sphecinae, and Pepsinae at trap-nest sites.
natum population and a reduced area of favorable habitat would tend to limit *A. antilope* to small populations in the areas of favorable habitat. The distribution of the two species is shown in Figure 3.

A pepsid spider wasp, *Dipogon sayi* Banks, occurred throughout the state, and appeared to be equally abundant at all the locations. It showed a strong preference for woodland habitats, including the edges of wooded areas. Relatively few trap-nests were utilized in dry and wet open habitats such as upland fields and pastures or marshes and wet meadows.

Only those trap-nests in the southern part of Wisconsin were utilized by sphexid wasps in the genus *Trypoxylon*, the most common species being *T. striatum* Prov. Also collected was *T. rubro- cinctum* Pack., but as this species is only about half the size of *T. striatum*, it probably preferred to use smaller holes than the ones in the trap-nests. We do not have enough data on *Trypoxylon* to evaluate habitat preferences.

Although *D. sayi* and *Trypoxylon* spp. provisioned their nests with spiders, they were not in competition for food, as the spiders used by *D. sayi* were mainly Thomisidae, whereas those used by *Trypoxylon* were mainly Argiopidae.

Another sphexid, *Chlorion harrisi* Fern., was collected at 4 widely distributed sites, but showed a very limited habitat requirement. The species was found only in the trap-nests located in large, well-drained open fields. Nests were provisioned with nymphs and adults of saltatorial orthoptera, mostly in the genus *Oecanthus*. Host species sampled from nests included *Oecanthus quadripunctatus* Beut., *O. augustipennis* Fitch, *O. niveus* (DeG.) *Neocacea bipunctata* (DeG.), and *Conocephalus fasciatus* (DeG.). The distribution of the pepsid and sphexid wasps is shown in Figure 4.

Isopods, spiders, caterpillars and ants competed with the bees and wasps for the trap-nests. The isopods invaded trap-nests placed near the ground or in wet locations, but were probably not very important competitors, using the holes only for shelter.

Small spiders in the family *Gnaphosidae* constructed an oval silken case, open at one end, in which to live. The \( \frac{1}{4} \)- or \( \frac{1}{8} \)-inch hole in the end of the trap-nest seemed to be an ideal place to construct the case. The number of trap-nests used this way was not very large but the spiders were apparently permanent residents, using the same stick all summer. Spiders in the family *Agelenidae* built a large sheet-like web at the end of the bundle of trap-nests, blocking the holes. The spider spent most of its time in a tubular retreat between the sticks. These spiders probably do not compete with the bees and wasps in nature, since they do not get into the nesting holes. It was interesting to find these spiders preventing wasps
from using a trap-nest, while other spiders were being used as food by wasps in other trap-nests in the same bundle.

In some locations in the northern part of the state, forest tent caterpillars, _Malacosoma disstria_ Hbn., entered the trap-nests to spin cocoons and pupate. The competition from these caterpillars was not extensive and probably was coincidental with a local caterpillar outbreak. The lepidopterous larva, _Chamyris cerintha_ Treitschke, entered some of the sticks. This species was widely distributed, but was not particularly abundant in any one place. The larvae enter holes in the late summer, pupate, and emerge as adult moths in the spring; so the occupied holes are again available to bees. At one trapping area, Lucerne Farm, Waushara County, cutworms were very abundant and used the holes of the trap-nests as resting shelters during the day. All of the trap-nests located at three places in the infested area, including those six feet from the ground, were taken over by the cutworms, up to three or four cutworms occupying each trap-nest. Presumably, any natural holes suitable for nesting by bees or wasps would be similarly occupied by cutworms. If high populations of cutworms existed over any extensive area, the solitary bees and wasps might have considerable difficulty finding suitable holes for nesting.

Ants\(^4\) were the most important of all the competitors and occupied trap-nests in all parts of the state. Carpenter ants, of which four species, _Camponotus pennsylvanicus_ (Degeer), _C. nearcticus_ Emery, _C. noveboracensis_ (Fitch), and _C. caryae_ (Fitch), were identified, used only one trap-nest at a given time and place. A dealate female entered a trap-nest, constructed a plug of pith to close the hole and reared a brood of workers. Except for _C. nearcticus_, this process was rather slow, so that the ant populations in the nests never amounted to more than a few individuals at the end of four to six weeks when the occupied nests were collected. However, the trap-nests seemed to be well suited to _C. nearcticus_, and several colonies in excess of 500 individuals were taken; possibly as the result of the migration of existing colonies into the sticks.

_Crematogaster cerasi_ (Fitch) invaded the trap-nests early in the summer. They excavated almost all of the pith, except for a thin layer at one end of the stick. At the other end of the stick a thin plug was constructed with a hole just large enough to admit a single ant. It is not known whether established colonies moved into the trap-nests, or whether the ants had a high rate of reproduction, but sticks which had been at a trapping site for five or six weeks contained 20 to 50 adult ants and almost enough eggs, larvae and

\(^4\) The authors express appreciation to Dr. W. L. Brown, Jr., and Dr. M. R. Smith who determined the species of ants. We wish to gratefully acknowledge the generous help by T. B. Mitchell in the determination of bees, and K. V. Krombein in the determination of wasps.
pupae to fill a 20 ml. vial. Several or all of the trap-nests in a bundle were used. In cases where several trap-nests were used, it was not possible to determine if more than one colony of ants was involved. Many of the colonies apparently failed to maintain themselves or moved. For example, trap-nests were placed at four locations on May 20. Two weeks later the traps were inspected and ant invasion was found at three of the four locations. At the end of three more weeks ants were found at only one location. A strong colony was maintained at this location through the entire summer in spite of efforts to eradicate the ants on two occasions by pouring chloroform into the holes. Another colony which invaded an entire bundle of trap-nests in Vernon County was left undisturbed. A strong colony was present when the site was inspected in August. Five weeks later the ants were no longer present and several of the trap-nests had been used by D. sayi.

Tapinoma sessile (Say) used the trap-nests in much the same way as Crematogaster. This species appeared in large numbers and invariably invaded all of the trap-nests in a bundle. The pith was excavated and thin plugs with small entry holes were constructed at either end of the sticks. In addition to rearing their brood in the bore of the trap-nests these ants closed the interstices between the sticks with a dark fibrous material and used the resulting chambers for brood rearing. These ants were very aggressive in spite of their extreme small size. When the nests were disturbed the ants rushed out in large numbers, attempted to bite, and produced drops of strong-smelling acid from the ends of their abdomens.

At a single location in Door County, a nest of Leptothorax canadensis Prov. was found, which contained 6 workers, 40 eggs, 12 small larvae and 15 large larvae.

Although the various ant species compete with the bees and wasps for nesting holes they probably make more nesting sites available. The excavation of pith from the trap-nest added two inches to the length of the nesting hole. Under natural conditions these ants would excavate even deeper holes which would later be available to solitary bees and wasps for nesting sites. Colonies of ants were found nesting in dead sumac stems where they excavated the pith from the center of the stems.

In those bundles where ants did not occupy all of the trap-nests, the bees and wasps were not prevented from using those remaining. Some ant colonies disappeared during the summer and the enlarged holes were used by bees and wasps. The reasons for ant abandonment are not understood, as attempts to eradicate the ants by removing the occupied sticks or pouring chloroform into the holes were to no avail. It would seem that some interesting studies on ant biology could be made using this trap-nesting technique.
DISCUSSION

Although artificial nests or trap-nests have been used previously in small numbers or in restricted areas to obtain data on the biology and ecology of various solitary bees and wasps (Krombein, 1955), they have never been used before in a survey over a wide area. The trap-nest technique is especially valuable as a means of obtaining data on the biology of insects. If the trap-nests are properly placed, much information can be gathered in a relatively short period of time on the distribution and abundance of species which ordinarily are rarely encountered.

By using trap-nests, large numbers of the immature stages of solitary bees and wasps may be obtained for studies of their life cycles. Observations made on a large sample of larvae from many nests yield very reliable data.

The sumac stick trap-nests have several advantages over most of the other types that have been used. They closely approximate hollow sumac stems which are natural nest sites. Sumac grows abundantly along roadsides and in waste land, so that a practically unlimited supply is available free of charge. The sumac stems have a pith center which is very easily drilled out to form the nesting hole. The sticks are straight-grained, which facilitates splitting with a pocket knife without injury to the nests. Using a power-driven saw and drill, one man can make upwards of 300 sumac trap sticks per day.

The general life histories of bees and wasps have been fairly well worked out. However, for many species there is little detailed information known about their biology and ecology. While some of the species have been studied in other areas, very little information is available on any of the species under Wisconsin conditions.

The nesting habits of *Dipogon sayi* were described briefly by Peckham and Peckham (1898). The biology of this insect given by Medler and Koerber (1957) is based on information obtained from trap-nests.

The Megachilinae have been more extensively studied because of their importance as pollinators of legume seed crops. Peck and Bolton (1946) gave considerable information on the nesting habits, habitat preferences, and parasites of *M. relativa* and *M. inermis*. Their study was conducted in northern Saskatchewan using artificial nesting holes bored into logs and stumps. In most respects, the data presented by Peck and Bolton are in agreement with that found in Wisconsin. However, they list (in Table 6) *Chrysis* as a parasite of Megachilinae. *Chrysis* was never found to parasitize Megachilinae in Wisconsin. All of the chrysidids which were taken in this survey occurred as parasites in the nests of *A. antilope*, *R. foraminatum* and *Trypoxylon* spp.
Hobbs and Lilly (1954) studied the distribution, abundance, and habitat preferences of Megachilinae in Alberta but gave no information on nesting biology. *M. brevis* Say, *M. relativa*, and *M. inermis* were reported as being rare in Alberta. In Wisconsin, *M. relativa* is abundant except in the southern part of the state. *M. inermis* is fairly common in the north but does not occur in the south. Manuscripts on the biology of *M. relativa* and *M. inermis* in Wisconsin are now in preparation.

Michener (1953) presented a very detailed account of the biology and ecology of *M. brevis* Say which is the most common Megachile in Kansas. Only two nests of *M. brevis* were taken in Wisconsin.

Practically no information is available on *M. mendica* which is the most abundant species in the trap-nests in southern Wisconsin.

*Ancistrocerus antilope* was reported by Cooper (1953) in New York and Medler and Fye (1956) in northern Wisconsin. Both authors used trap-nests to collect data on the nesting biology of this wasp, but neither gave information on habitat preferences or distribution of *A. antilope*.

Rau and Rau (1918) described the nest and nesting activity of *Rygchium foraminatum* in natural holes in logs and hollow stems. Apparently little is known on the distribution, abundance, or habitat preferences of this species.

*Chlorion harrisi* is fairly well known. Its nesting habits were described by Rau (1935). It is recorded as nesting in hollow sticks and holes in logs and using various saltatorial orthoptera for provisioning its nests. *C. harrisi* has not previously been studied in Wisconsin, and some new host records were obtained.

Peckham and Peckham (1898) described the nesting habits of *Trypoxylon rubro-cinctum* and *T. striatum*. They record *T. rubro-cinctum* as nesting in hollow straws and *T. striatum* from beetle galleries in logs and posts. Our trap-nest data agree very well with the accounts given by the Peckhams. Krombein (1954, 1956) recorded *T. rubro-cinctum* and *T. striatum* in wooden block trap-nests.

Data that were obtained on the other species of insects listed in the footnote of Table 1 were fragmentary, and further studies should be made before details of biology, distribution, and habitat preference are discussed.

**Summary**

The trap-nest method was used to determine the distribution and abundance of bees and wasps in Wisconsin. The insects used the hole of the trap-nest to build a linear series of cells and provision the cells with food for their progeny.
The most common species found in the trap-nests were:

Megachilinae—*Megachile relativae* Cress., *M. inermis* Prov., and *M. mendica* Cress.

Eumeninae—*Rygchium foraminatum* (Sauss.) and *Ancistrocerus antilope* (Panz.)

Pepsinae—*Dipogon sayi* Banks

Trypoxyloninae—*Trypoxylon striatum* Prov., *T. rubro-cinctum* Pack.

Sphecinae—*Chlorion harrisi* Fern.

The species were found to have certain preferences for habitats and hole size. The distribution and abundance of some of the species was associated with habitats at the various trapping sites.

The trap-nest technique affords many as yet uninvestigated opportunities for studying the biology, ecology, and distribution of solitary bees and wasps. There are many species which would probably use trap-nests made from different materials or with smaller or larger holes. Intensive investigations are required in order to provide needed information on species rarely encountered in nature, and the trap-nest technique would be a valuable aid to this research.

**REFERENCES CITED**


