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Results of the Archbold Expeditions. No. 87 Biological Notes on Some Floridian Wasps (Hymenoptera, Aculeata)

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Most of these notes are based on observations I made during residence at the Archbold Biological Station, Lake Placid, Florida, from April 13 to 25, 1963. Also included are notes made on several species during an earlier period of residence, from June 23 to July 5, 1962. Some observations were made on the grounds of the Station which is 5 miles south of Lake Placid; others, in the sandy scrub areas adjacent to Lake Annie just north of the Station property, and on the sparsely vegetated sand flats along the Peace River at Arcadia, 35 miles west of the Station. The original field notes and associated specimens, each appropriately labeled, e.g., 41863 C, have been placed in the collection of the United States National Museum, Smithsonian Institution.

As always, it is a pleasure to acknowledge the gracious hospitality and excellent laboratory and field facilities offered by Mr. Richard Archbold and others of the staff at the Station. I am further indebted to the following specialists for identification of material as noted: Dr. L. J. Brass, Archbold Biological Station (plants); Drs. W. J. Gertsch and W. Ivie, the American Museum of Natural History (Araneae, 1962); Dr. H. K. Wallace, University of Florida, Gainesville (Araneae, 1963); Dr. H. E.

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Evans, Museum of Comparative Zoölogy at Harvard College (bembicine cocoon and *Anoplius bequaerti* Evans); Dr. D. R. Davis, United States National Museum (Olethreutidae); and my colleagues in the Entomology Research Division, Mr. H. W. Capps (lepidopterous larvae), Dr. A. B. Gurney (Orthoptera), Dr. R. W. Hodges (Crambidae and Epipaschiidae), Mr. C. W. Sabrosky (Sarcophagidae), Dr. M. R. Smith (Formicidae), Dr. A. Stone (Chaoboridae), Mr. G. B. Vogt (Chrysomelidae), and Dr. W. W. Wirth (Chironomidae).

The maximum daily temperatures during my stay in April ranged from 81° to 97° F., and the minimum temperatures, from 36° to 70° F. There was no rainfall during my visit, and during the two weeks preceding my arrival there had been only a meager 0.25 inch. This unusual drought had several unfortunate consequences. One was that there was no nesting by any of the vernal species of ground-nesting wasps. They were active during the latter part of March (personal observation, F. E. Kurczewski), but apparently they must require a much higher soil moisture content than the multivoltine species, which were the only ground-nesting species active during mid-April. The other serious consequence of the dry conditions was the difficulty that ground-nesting wasps had in excavating their burrows, and which I shared when I tried to dig up the nests.

FAMILY MUTILLIDAE

Dasymutilla pyrrhus (Fox)

On April 18, while digging up a nest of *Anoplius marginalis* (Banks) along a level sand road north of Lake Annie, I found a bembicine cocoon (41863 C) 10 cm. below the surface. The ovoid cocoon, 18 mm. long and 8 mm. wide at the middle, was composed of sand grains woven to silk; it had a series of pores around the middle. At the anterior end of the cocoon was a small breach, sealed over with agglutinated sand. On opening the anterior end of the bembicine cocoon, I found a soft, light tan, silken, mutillid cocoon (fig. 1, upper), inside of which was a fully colored *Dasymutilla* pupa. The cocoon of the mutillid was about 2 mm. shorter than that of the host. As is customary for members of this family, the mother mutillid had apparently chewed a hole in the host cocoon, oviposited on the resting host larva inside, and then sealed over the breach with some agglutinated substrate. A female *pyrrhus* 11.5 mm. long eclosed on April 22, but did not become active until April 25.

I did not recover any prey remains associated with the host cocoon. However, two species of bembicine wasps—*Bembix sayi* Cresson, which preys on flies, and *Bicyrtes quadrifasciata* (Say), which preys on stink bugs—were active near this site in mid-April. A third bembicine, *Stictiella serrata*

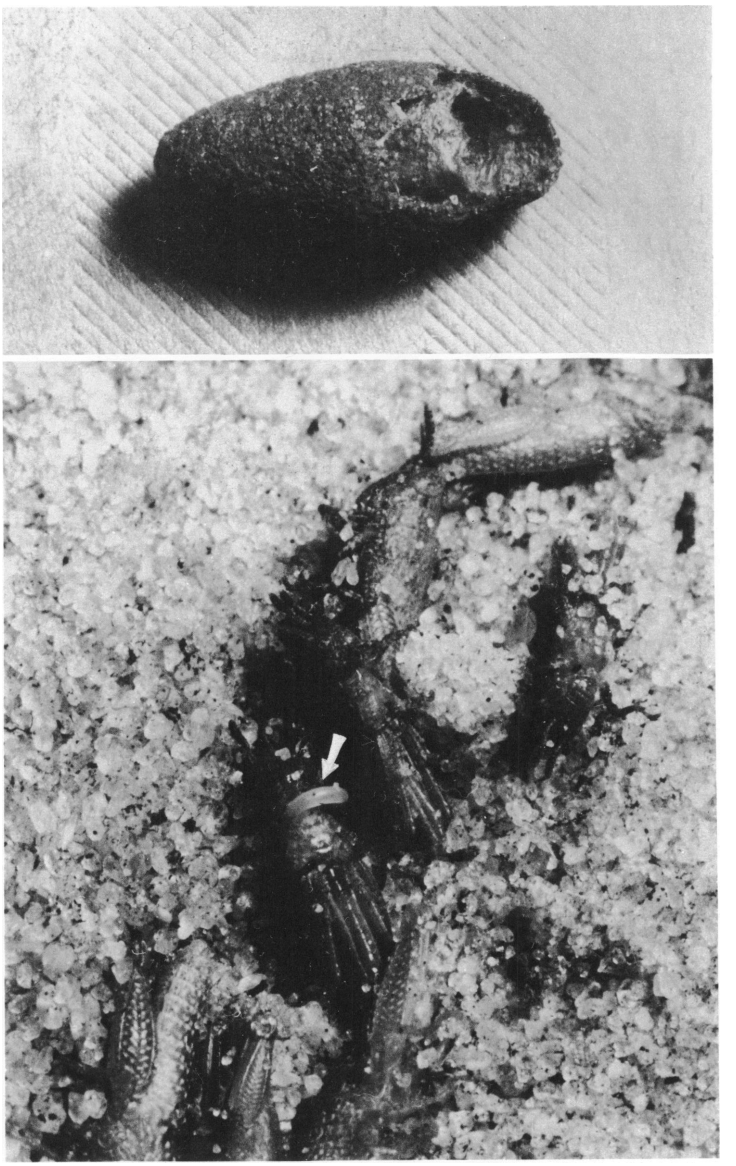

FIG. 1. *Upper:* Bembicine cocoon (41863 C) partially opened to show cocoon of *Dasymutilla pyrrhus* (Fox) within, April 22, 1963. × 3. *Below: Aptenopedes* sp. nymphs in rearing tin, the prey of *Tachysphex similis* Rohwer, from cell 1, nest 41563 B, April 15, 1963. Note wasp egg in center. × 4.

(Handlirsch), which preys on adult Lepidoptera, was concurrently active a mile away on the Station grounds. H. E. Evans examined the host cocoon and thought that it was most probably a cocoon of *Bembix sayi,* though somewhat smaller than average; he also stated that it was virtually indistinguishable from the cocoon of *Bicyrtes quadrifasciata* and rather unlike that of *Stictiella serrata.* I think that if the host had been either the individual of *Bembix* or that of the *Stictiella,* the wings of the prey stored for the host wasp larva would have been very noticeable. Inasmuch as I noticed no prey remains, most probably the host of this mutillid was the individual of *Bicyrtes,* the larva of which could be expected to devour all, or almost all, of the prey stored for it.

No other host records are known for this mutillid. Evans (1957) mentioned that *pyrrhus* [recorded as *lepeletierii* (Fox)] was common in a colony of *Bembix sayi* at Lake Placid, Florida.

FAMILY VESPIDAE

Stenodynerus (Stenodynerus) fundatiformis fundatiformis (Robertson)

Females of this solitary ground-nesting species are 9–9.5 mm. long; males, 7–9 mm. I had an opportunity to study several individuals, and the following notes are based on observations of six wasps or their nests (62662 A; 41463 A; 41563 D, E; 41763 B; 41963 A). In June, 1962, I observed the excavation of a burrow by one female on a bare, slightly sloping, sandy area adjacent to Lake Annie. I made other observations in April, 1963, in an area of flat, bare, firmly packed soil, several square meters in extent, along the edge of a hard-surfaced road on the Station grounds. Evans (1956, p. 268) published a few notes on the nest and prey of this wasp in loose to firm sandy soil at Welaka, Florida.

I watched one female (41963 A) searching for a nesting site on bare spots of hard-packed soil. She flew in a hovering flight a couple of centimeters from the surface. After examining a number of sites, she finally settled on one and began to nibble at the ground with her mandibles, flying about 2 cm. away to deposit the excavated soil. She abandoned the site and disappeared after three minutes of digging.

On June 26, 1962, I watched burrow excavation in some detail by a *fundatiformis* female (62662 A) in coarse, moist sand near Lake Annie. I do not know how long this female had been digging when at 11:15 A.M. I discovered her leaving the nest with a load of sand. The entrance was circular, about 4.5 mm. in diameter, and the burrow appeared to descend vertically for at least several centimeters. At 11:18 A.M. the wasp returned and entered the burrow head first. Fifteen seconds later she backed out with a load of sand in her mandibles, flew off head first about half a meter

above the ground, dropped the sand 1–2 meters from the burrow as she hovered in midair, and then flew back at once to the burrow. She continued these flights for the next 20 minutes at a rate of three loads a minute. I was absent from the area from 11:40 A.M. to 12:55 P.M. When I returned, she was still bringing out sand, but at the faster rate of four loads per minute. She dropped the sand over an arc from east-northeast to east-southeast. At 1:10 P.M. she remained in the burrow for a couple of minutes, then backed out without a load of sand, and made a brief reconnaissance flight over the immediate area. Then she re-entered the burrow, brought out a few more loads of sand, and after another brief hovering flight over the area flew off at about 1:17 P.M. At 1:33 P.M. she returned without prey and began to visit a circular groove I had scratched in the damp sand around her nest entrance. Apparently she was gathering moisture and applying it to the rim and upper 5 mm. of the burrow. After three minutes of this activity, she again brought up a few loads of sand. Between excavation activities she seemed to be applying saliva to the burrow rim, probably to agglutinate the sand and thus prevent it from sifting into the burrow. At 1:54 P.M. she flew off to a nearby bush and then disappeared for some minutes. When she returned at 2:07 P.M., apparently without prey, she again began to excavate more sand. At 2:18 P.M. she crawled out, reversed her position, and, venter up, backed into the burrow. This behavior may have been to oviposit, but when I dug up the nest a couple of days later, I found no egg. At 2:23 P.M. she crawled out of the burrow head first, hovered over the entrance for a few seconds, re-entered the burrow, and then began to bring up one load of sand per minute until 2:28 P.M. At 3:07 P.M. she came out head first and did not return until 4:00 P.M. She entered the burrow head first and had not emerged by the time I left this nesting site at 4:20 P.M. On the following morning she flew in and out of the nest several times, but I did not see her during the afternoon when I was digging up a nest of *Cerceris blakei* Cresson 2 meters away (Krombein, 1963). Late in the afternoon of June 27 there was a heavy shower, and another the following afternoon. I did not see this specimen of *fundatiformis* at all on June 28. The heavy rain of the preceding day may have caused her to abandon her nest.

In April, 1963, I watched two females (41463 A, 41563 E) excavating their burrows in the hard-packed soil along the edge of the road. One of these wasps brought out loads of this heavier soil almost as rapidly as the female I had observed in June, 1962, working in coarse sand. The second wasp maintained a slower tempo of excavation most of the time. Both wasps flew off and dropped their loads of excavated soil, as reported for the female seen in 1962. One of them usually flew 2–3 meters from the

nest to drop the load, but occasionally she did so just a few centimeters from the entrance. The other wasp apparently flew a longer distance to drop her soil, because she was frequently gone from 60 to 90 seconds. For five or six days I noted these two wasps excavating soil from their nests.

When I dug up these nests, I recovered a wasp egg from a cell in each of them. The egg was suspended from the ceiling of the inner end of the cell. One egg was ready to hatch, because the body segmentation was visible through the transparent chorion. The other egg had been laid more recently; it was 3 mm. long, sausage-shaped, and creamy white.

After laying the egg, the wasp began to hunt for prey. I was able to time only one such provisioning flight. On April 18 a female (41563 D) left her nest at 2:11 P.M. Twenty-seven minutes later she flew back with a paralyzed caterpillar 7 mm. long. I netted the wasp, released her, and preserved her prey, which was identified subsequently as the larva of a species of Olethreutidae.

The selection of prey was of considerable interest. In the nests that I dug up the following lepidopterous and coleopterous larvae were obtained:

Lepidoptera
- Psychidae, one species
- Geometridae, *Synchlora aerata* (Fabricius)
- Gelechiidae, one species
- Olethreutidae, one species

Coleoptera
- Chrysomelidae, one species of *Chlamisus*

In one cell Evans reported finding lepidopterous larvae belonging to two species of Pyralidae and one coleopterous larva belonging to the Chlamisinae. The cells in nests that I dug up contained either caterpillars only or a mixture of caterpillars and *Chlamisus* larvae. All the lepidopterous larvae were slender forms, but those of *Chlamisus* were bulky, so it was obvious that the wasps were exploring a particular microhabitat to find their prey. Judging from the prey, I think it is rather probable that *fundatiformis* preys on lepidopterous and coleopterous larvae, which seek protection by encasing themselves in various ways. For example, the larvae of *Chlamisus* and Psychidae are case bearers. H. W. Capps advised me that the species of Olethreutidae stored most commonly in the nests that I excavated had an integument characteristic of species that roll leaves. He also said that the larva of the geometrid *Synchlora* feeds on flower heads and adorns its back with bits of the calyx. Many species of Gelechiidae are leaf rollers, and some Pyralidae have the same habit. Locating one of these larvae and extricating it from its case or leaf roll must require considerable time. It was not surprising to find that this one provisioning flight took 27 minutes.

I dug up seven nests of *fundatiformis* (62662 A, 41463 A, 41563 D and E, 41763 B, 41963 A, and an unnumbered nest). The burrow diameter ranged from 3.5 to 4.5 mm. The single burrow in coarse sand (62662 A) curved downward slightly away from the vertical and ended 9 cm. below the surface; there was no cell, since this nest had been abandoned before completion, as noted above. Two other nests (41963 A and the unnumbered nest) also were not completed. Both went straight downward for 4 cm. One angled to the north at 45 degrees and after another 5 cm. ended blindly; this nest had been started two days before I dug it up. The burrow of the other incompleted nest angled off toward the northeast at the 4-cm. level and ended blindly about 3 cm. from the angle.

The only completed nest that I dug up was that of wasp 41463 A, which I first observed on April 14. During several brief periods on April 17 and 18, I watched this wasp bringing out soil from her nest. On April 19 at 8:45 A.M. she was working just within the entrance, apparently excavating soil, because she flew in and out about twice a minute. I captured her at 9 A.M. and then dug up the nest. The burrow went downward at an angle of 80 degrees. About 1.5 cm. below the surface there was a plug of loose, dry soil several centimeters thick, which undoubtedly indicated that the wasp was making a final closure of the nest when I caught her. The several cells in this nest were all about 5 cm. below the ground level. About 3 cm. to the southeast of the burrow axis were two cells in a linear series, each containing a cocoon with a resting vespid larva. About 2.5 cm. to the west of the burrow axis was the third cell containing an active wasp larva which had just finished eating its store of prey; it was injured by my excavation. The fourth and last cell was only a centimeter from the burrow axis. It contained 13 paralyzed lepidopterous larvae and a wasp egg from which the larva was about to eclose. The cocoons, 17 and 20 mm. long, were made of opaque, white silk tougher than that of the species of *Stenodynerus* that nest in wooden borings.

I dug up the next nest (41563 D) at 10 A.M. on April 23. I had been observing this nest since April 15. On April 18 I took a caterpillar from the female, as noted above. While I was digging up her nest, she returned, but she was not carrying prey. Her burrow went straight downward for 5 cm. and then angled to the east at about 45 degrees. At the 4-cm. level there was a branch tunnel to the north at an angle of 30 degrees; it ended blindly after a distance of about 3 cm. Presumably the wasp would have stored another cell at the end of this branch. At 6.5 cm. below the surface I recovered a well-colored pupa in a cocoon; a male eclosed two hours later. Beyond the cell where I found the first cocoon, and along the main burrow at 7.5 cm., was another cocoon containing a newly eclosed female

wasp. At the 6- to 8-cm. level toward the north I recovered still another cocoon; it contained a resting larva injured during the excavation.

The next nest (41563 E) I had also observed since April 15, and I dug it up on April 24. The female had just begun this nest at 12:30 P.M. on April 15, when the burrow was only a centimeter deep. On several days between April 17 and 23 I observed her bringing out soil, resting in the burrow near the entrance, or flying in and out of the burrow. On April 24 while I was digging up her nest she flew around the area. The burrow went downward almost vertically for 6 cm. and then made an angle toward the southeast and continued downward at 45 degrees for 5 cm. About 3.5 cm. from the angle I found an incompletely stored cell containing a wasp egg, five lepidopterous larvae 3–6 mm. long, one of a species of Gelechiidae and four of a species of Olethreutidae, and two larvae of a chrysomelid beetle, *Chlamisus* sp., 3–4 mm. long. A second cell (cell 1 in order of construction), immediately and diagonally below, held a vespid larva about a third grown, nine *Chlamisus* larvae, 3–5 mm. long, and 26 lepidopterous larvae, 3–6 mm. long, of which 21 were of a species of Oleuthreutidae, two of a species of Gelechiidae, two of the geometrid *Synchlora aerata* (Fabricius), and one of a species of Psychidae. These two cells were 8–10 cm. below ground level. At the 6- to 7-cm. depth and in another direction from the burrow axis, I found a cocoon with a vespid prepupa almost ready to pupate and bearing a tiny bombyliid larva. This specimen undoubtedly belonged to a different nest. Since the prepupal period lasts about 10 days, this cell could not have belonged to a nest begun only 10 days before.

The final nest (41763 B) was first noted on April 17. At 4:40 P.M. I saw the female fly into this nest, back out in a few seconds, and then turn around and back into the nest for the night. I saw her enter and leave her nest several times between April 19 and 23. At 3:07 P.M. on April 24 while I was digging up her nest I captured her as she flew in with a lepidopterous larva. Her burrow went straight downward for 2.5 cm. and then angled toward the southeast at 60 degrees for 4.5 cm.; in this latter section an old vespid cocoon formed part of the burrow walls. At the end of the second section the burrow turned toward the north and angled downward at 80 degrees for 7.5 cm. I found the first and only cell at about 9 cm. below the ground level. It contained a newly molted, second-instar vespid larva, 15 small lepidopterous larvae, and five *Chlamisus* larvae. I reared this vespid wasp grub on the prey stored for it, so the caterpillars were not identified.

Evans' data on nest architecture are consistent with my findings. He described his two incompletely stored nests as having from two to five individual cells at the ends of short, steeply descending branch tunnels off the more or less vertical initial section. The cells in the nests I observed were

also usually at the end of individual tunnels. There was one exception (41463 A); in this nest I found two cells in a linear series separated by a partition of dry sand. Apparently, as noted for 41763 B, the wasp may reuse part (or all?) of the tunnel of an older nest.

Detailed data are available for one specimen which I reared in a tin on damp sand at 72° to 76° F. during the feeding period. At 9:30 A.M. on April 19 from cell 4, nest 41463 A, I recovered a wasp egg almost ready to hatch. At 11:45 A.M. the vespid larva had hatched and was sucking blood from one of the caterpillars. By 7:25 P.M. it had molted to the second instar. On April 20 at 7:25 A.M. it molted to the third instar. By 4:00 P.M. on that date it had sucked one of the caterpillars dry and had shrunk another to half its original size. The larva molted for the third time at 7:45 A.M. on April 21, and then it actually began to devour the caterpillars. By 7:00 P.M. on April 21 only eight of 13 remained, and by 10 P.M. another half caterpillar was gone. Another molt took place at 7:30 A.M. April 22, when only four caterpillars remained; at 12 noon, one and a half caterpillars; and at 12:30 P.M. there was only one. By 4:40 P.M., the next time that I examined the wasp larva, it had completed all its feeding. Thus, this larva completely consumed the prey stored for it in only three days and a few hours. I left the rearing tin closed for a few days so as not to disturb the larva while it spun its cocoon. Later I made a small opening in the cocoon wall. Pupation occurred between May 4 and 6, and a small male 7 mm. long emerged from the cocoon on May 20. Almost exactly five weeks passed between oviposition and emergence of this male.

In a cell containing more prey the larval feeding period was longer. A recently hatched vespid larva was recovered on April 24 in the single cell of nest 41763 B, together with 15 caterpillars and five *Chlamisus* larvae. This wasp did not complete its feeding until April 30, so the feeding period may be as long as seven days. The wasp pupated between May 7 and 10, and a male 9 mm. long eclosed on May 23 and left the cocoon on May 25.

Data from these two nests show that the feeding period of male wasp larvae may be from more than three days to seven days, and that the period from oviposition to emergence of adult males may be 31 to 35 days.

I made a few brief notes on other activities of this species. On April 14 I caught a male flying a few centimeters from one of the burrow entrances, but I saw no evidence of mating activities on this or other dates. At the end of the day, usually by 5 P.M., females backed into their burrows, and remained overnight several centimeters from the entrance, with their heads facing outward. I examined some of the burrows by flashlight after dark and found the females in this resting position. Flashing the light on them caused them to retreat farther down in the burrow.

This wasp is troubled to a minor degree by a few parasites and predators. On June 27 I captured a female miltogrammine fly, *Metopia argyrocephala* (Meigen), as she investigated the burrow entrance of 62662 A. Another miltogrammine female, *Senotainia rubriventris* Macquart, was captured while she perched on a small stick a few centimeters from the burrow entrance of 41563 E on April 18. On this same date a large asilid fly made a dash at wasp 41563 E as she returned to her nest and nearly captured her. Two of the prepupae (41463 A, cell 1 or 2, and 41563 E, unassociated cell) each had a tiny bombyliid larva. One of these larvae was on the head capsule, and the other was attached transversely on the dorsum of the third segment behind the head of the other host. I lost both of these tiny larvae as the wasps were being transported back to the laboratory.

Leptochilus tylocephalus tylocephalus (Bohart)

I captured a female wasp (62062 A), 8.5 mm. long, at 3:20 P.M. on June 20, 1962, at the Archbold Biological Station. She had slit open a small blotch mine in a leaf of *Galactia volubilis* (Linnaeus) about 38 cm. above the ground. This vine was twined around a scrubby live oak. Inside the mine was the intended leaf-miner prey of the wasp, a pale green gracilariid larva, 1.6 mm. long. Before I captured her, the wasp had made a slit 3–4 mm. long in the leaf to extract the larva. Several other leaves of the vine contained similar blotch mines. Some of these mines contained a single larva of the same gracilariid species; others had a small slit and no larva and may have been plundered by this same wasp. I tried unsuccessfully to rear some of the remaining larvae to maturity.

FAMILY POMPILIDAE

Episyron posterus (Fox)

I found a female (41863 B) 9 mm. long filling in the upper part of her nest on slightly sloping, coarse, bare sand near Lake Annie at 12:35 P.M. on April 18. I captured her and dug up her nest. The burrow went downward at an angle of 30 degrees and ended in a cell 5 cm. below the surface and 6 cm. from the entrance. In the cell was a paralyzed female araneid spider, *Eustala anastera* (Walckenaer), 6 mm. long. The wasp egg was 1.8 mm. long.

I observed prey preferences and nesting behavior of a number of *posterus* females at Kill Devil Hills, North Carolina (Krombein, 1953a, 1953b, 1955, 1958, 1959). They preyed entirely on orbweavers of the family Araneidae, and *E. anastera* was the species most commonly preyed upon.

The nest architecture described for the Florida specimen agrees with the details published for the North Carolina population; the cells of the latter were 2.5–7.5 cm. below the surface.

Anoplius (Arachnophroctonus) apiculatus pretiosus (Banks)

One of these females (41363 A), 9.5 mm. long, was digging a burrow in bare sand on the flats along the Peace River at Arcadia at 10:45 A.M. on April 13. Her paralyzed spider prey was lying dorsum up in a depression just to the right of the burrow entrance, with its cephalothorax toward the entrance. The burrow went downward at an angle of 30 degrees, and the wasp was raking out dry sand beneath and behind her body so that the spider was gradually being covered. Occasionally the wasp came out 5 cm. from the entrance and then scraped sand behind her to level the spoil heap as she walked toward the burrow. By 11:00 A.M. the body of the spider was entirely covered by loose sand, although several of the legs were still visible. From time to time the wasp examined the spider, bending the tip of her abdomen under as she did so, and at 11:02 A.M. it appeared that she stung the spider again. By 11:04 A.M. she was still bringing up only dry sand, and a gusty breeze was blowing loose sand into the entrance faster than she could excavate it. By 11:10 A.M. it was clear that the wasp would be unable to complete her nest, so I captured her and her spider. The latter was a male lycosid, *Arctosa littoralis* (Hentz), 8.5 mm. long.

I have published earlier observations (Krombein, 1953a, 1959) on the prey preference and nesting behavior of *pretiosus* at Kill Devil Hills, North Carolina. Apparently it preys entirely on *Arctosa littoralis*. Nesting details for the North Carolina population show very close concordance with those reported for the Florida individual, even including such details as the beginning of the burrow from a depression in the sand, and the temporary covering of the prey near the entrance by the loose, excavated sand.

Anoplius (Arachnophroctonus) marginalis (Banks)

I observed a female of *marginalis* (41863 A), 14.5 mm. long, digging a burrow on a slightly sloping area of bare sand near Lake Annie at 10:23 A.M. on April 18. Apparently she had been digging for quite a time, because there was a large spoil heap near the entrance. In half a minute she walked about 1.5 meters to a patch of leaf litter to visit her spider prey which was cached in a burrow in this area. She returned to her nest on foot at 10:24 A.M. and began excavating more sand. She came to the surface every three or four minutes and scratched the sand out over a low spoil

heap 7 cm. away from the entrance and about 10 cm. in width.

At 10:37 A.M. she again visited her paralyzed spider in a burrow under an overhanging lichen, and then returned to her nest. In another minute she returned to the spider, grasped it by the chelicerae (?), and pulled it out of the burrow with some difficulty. Then she grasped the spider by the hind coxae so that the cephalothorax was upright, and walked backward toward her nest entrance dragging the spider behind her. She set it down 0.75 meter from the entrance, ran forward to the burrow, came back to the spider at once, and grabbed it in the same transport position.

She dragged it to the entrance, set it down, entered the burrow head first, turned around inside, reached out, and pulled in the spider at 10:40 A.M. During the next 40 minutes, until 11:21 A.M., she backed out to the surface 24 times to scratch out additional loads of excavated sand. She did not reappear at the surface from 11:21 A.M. to 11:50 A.M., so I put an empty tin can over the burrow entrance and mounded sand around it.

When I returned at 12:35 P.M., the wasp was dead on the ground beside the entrance. She had not completed filling in the burrow before the heat under the overturned tin can killed her. Her burrow went in at an angle of about 45 degrees and ended after a distance of 10 cm. in a cell that was about 8 cm. below the ground surface. There was a short auxiliary tunnel 1.5 cm. long and about 3 cm. down from the entrance. Probably this tunnel was where the spider was cached from 10:40 A.M. to 11:21 A.M., while the wasp excavated sand to form the cell.

The spider was 15.5 mm. long and had been placed in the cell. It was quite lively and could move its legs. Since it was apparently recovering rapidly from the paralyzing effects of the wasp sting, I preserved it in alcohol for subsequent identification. The wasp egg, 2 mm. long, was attached obliquely on the right side of the dorsum of the abdomen at the middle. The spider was identified as a female of a new species of *Lycosa* near *ceratiola* Gertsch and Wallace.

I investigated the burrow in which the spider was cached before the wasp transported it to her nest. There was some silken webbing with adherent sand grains associated with this burrow, and it is quite possible that the burrow was the home of the spider. H. K. Wallace advised me that this new *Lycosa* probably lines its burrow with silk and might even spin a kind of flimsy trap door, as do some other species of *Lycosa*.

Evans and Yoshimoto (1962) summarized their own observations on prey and nesting of this species and those by Rau and Rau (1918) and by me (Krombein, 1953a, 1953b, 1958). Evans and Yoshimoto found *marginalis* using both *Lycosa* and *Geolycosa* in Kansas. Rau and Rau reported only *Lycosa* as prey in Missouri. I found it using only *Geolycosa* in North Caro-

lina. I noted that *marginalis* either stung the spider inside or just outside the burrow. Apparently, the wasp always cached the spider inside its burrow after stinging it and spent some time inside with it. Burrow digging was observed by Rau and Rau and by Evans and Yoshimoto. Both pairs of observers noted instances in which the wasp did considerable digging after dragging the spider into the nest. Neither reported finding a short spur off the main burrow where the spider probably was cached while the cell was being excavated.

Anoplius (Pompilinus) bequaerti Evans

I caught a female *bequaerti* (42263 A), 11 mm. long, engaged in prey transport on an area of bare sand near Lake Annie at 11:16 A.M. on April 20. She walked backward, grasping the hind coxae of the spider in her mandibles and holding the cephalothorax upright. The spider was an immature *Lycosa* sp. 5.5 mm. in length.

Aporinellus taeniatus taeniatus (Kohl)

I disturbed a female of this wasp (7562 B), 7.5 mm. long, on the sand near Lake Annie on July 5, 1962, at about 10:00 A.M. Apparently she had been searching for a nesting site. Within a few seconds after I disturbed her, she crawled up a low plant and examined her paralyzed spider prey which she had cached in a leaf crotch. I captured the wasp at this time. Her prey was a jumping spider, *Pellenes* sp., 4.5 mm. long; none of its legs had been amputated.

FAMILY SPHECIDAE

Nitelopterus slossonae slossonae Ashmead

I obtained two prey records for typical *slossonae* at Arcadia in April, 1963. I noted the first female (41363 B), 4.5 mm. long, running rapidly forward over the bare sand at 11:35 A.M. on April 13. She was carrying a small paralyzed spider beneath her. Occasionally the wasp took short forward leaps. She reached her nest several meters away, but she was unable to open the entrance because of the continual drifting in of sand from the gusty breeze. I captured her with her prey, but I was unsuccessful in tracing the burrow because of the dry, shifting sand. Her spider prey was an immature salticid, *Metaphidippus* sp., 3 mm. long.

At 10:25 A.M. on April 20 I saw another female of typical *slossonae* (42063 A), 4.2 mm. long, trying to carry her spider up the loose dry sand

of a bank having a slope of 45 degrees. She was carrying the spider forward by one or more legs. The spider was an immature lycosid, *Lycosa* sp., 3.4 mm. long; its left hind leg was missing.

Both of these spiders were previously reported as prey of typical *slossonae* (Krombein and Kurczewski, 1963).

Nitelopterus slossonae barberi Krombein

I made some notes on the nesting and immature stages of one female of *slossonae barberi* (41563 C). I first noted this wasp carrying a spider into her nest on level, bare sand near Lake Annie at 10:39 A.M. on April 15. She emerged at 10:53 A.M., left the entrance open, and departed from the area without making a preliminary reconnaissance tour. She returned a minute later without a spider and entered the burrow head first. I was watching a nest of *Tachysphex similis* at the same time, so I did not see whether the female *barberi* left her nest at once or remained inside. The next time I saw her was at 1:03 P.M. when she again entered the burrow preyless. She emerged a minute later, left the entrance open, and hunted (?) on foot in the immediate vicinity for a few seconds before disappearing in the adjacent vegetation. She had not returned by 1:20 P.M. when I departed. On my return at 1:55 P.M. I saw her enter the open burrow without prey at 2:08 P.M. She came out at 2:11 P.M., made a temporary closure in a few seconds by scuffing loose sand into the burrow from several directions, and then left the area at 2:13 P.M. The entrance was still closed at 2:33 P.M. but was reopened during the next 20 minutes. The wasp finally came out at 3:27 P.M., left the entrance open, and began to hunt again. She came back without a spider at 3:38 P.M. and entered the nest head first. Two minutes later she came out, scratched loose sand behind her to form another temporary closure, and again departed from the area. She had not returned when I left the area for the day at 3:40 P.M.

On the following day the burrow entrance was open at 1:50 P.M. and still open at 3:34 P.M. On April 17 the entrance was closed when I first visited the area at 3:48 P.M., so I dug up the nest. I lost the burrow in the loose sand, but noted that it went downward at a 45-degree angle. I found a single cell 4 cm. below the surface containing three spiders, one of which bore a wasp egg obliquely on the anterior left side of the abdomen. Two of the spiders were 2.0 and 3.5 mm. long, respectively, and none of the legs was amputated. I lost the third spider, but it was also about 3.5 mm. long.

The wasp egg had hatched by 7:30 P.M., April 17. By midnight on April 21 the wasp larva had sucked all the blood from the abdomens of both spiders. I preserved these two spiders for identification and gave the larva

a somewhat larger, immobilized, orbweaver spider. The wasp grub began to spin a cocoon at 7:00 P.M. on April 21, when I preserved it for taxonomic study. The two spiders from the nest were both immature lycosids, one of *Lycosa* and one of *Geolycosa.*

Krombein and Kurczewski (1963) published some biological notes on typical *slossonae* and *s. barberi.* They did not recover any completed cells, but presented evidence to show that two or more spiders are stored per cell. They reported a linyphiid, *Meioneta formica* (Emerton), and a salticid, *Pellenes* sp., as prey of *s. barberi.*

Tachysphex apicalis Fox

I found one nest of this species (42363 C) in the 60-degree slope of a sand pit in the Highlands Ridge sand scrub area of the Station. The female, 8 mm. in length, darted quickly into her nest entrance at 1:15 P.M on April 23. She emerged a few seconds later, and flew back at 1:40 P.M., carrying a paralyzed grasshopper beneath her. She did not set down her prey but entered the burrow at once. I dug her out 10 minutes later as she was completing final closure of the cell. The burrow went in almost horizontally, turned downward at a right angle, and ended in a cell about 4 cm. from the sloping sand surface. The cell contained seven nymphal grasshoppers 7–10 mm. long, obviously all of the same species, but possibly of two different instars. They were identified later as belonging to a species of *Melanoplus,* possibly *puer* (Scudder). The wasp egg was on one of the medium-sized grasshoppers, attached between the mid and fore coxae on the left side, and extending transversely across the sternum beyond the right side. The egg was sausage-shaped and 2.2 mm. long. It was injured 50 hours later by the reflex leg movement of one of the grasshoppers and failed to hatch.

Tachysphex similis Rohwer

I observed burrow excavation by *similis* only once (41763 A). This wasp had just started her nest on a flat, bare patch of dry sand along the hard-surfaced Station road, when I first noticed her at 4:30 P.M. on April 17. When disposing of the excavated sand, the wasp backed about 5 cm. from the entrance, and then walked slowly forward, raking sand behind her into a narrow spoil heap as she traveled toward and into the burrow. While raking the sand behind her, she moved her two front legs synchronously, her abdomen bobbed up and down, and her wings were folded flat over her body. The dry sand was thrown out about 3 cm. beyond the tip of her abdomen. The entrance diameter was about 6 mm. At 4:30 P.M. she backed

out every minute or so to scatter sand, but half an hour later she remained inside as long as three minutes to loosen soil before she pushed it out of the burrow. At 5:05 P.M., instead of scraping sand directly away from the burrow entrance, she went to the end of the spoil heap and scraped some soil first to one side and then toward the other for a couple of centimeters toward the entrance. By 5:20 P.M. she was bringing out darker soil, and at that time she spent four minutes working on the spoil heap. Near the end of the spoil heap she scattered to the sides some of the darker soil brought up most recently. As she worked closer to the entrance, she raked dry, light sand from adjacent areas over the narrow, darker spoil heap as if to camouflage it. She re-entered the burrow head first at 5:24 P.M. and made a temporary closure of dark soil from within, about a centimeter from the ground level.

The burrow entrance was still closed from within at 8:10 A.M. on April 18. The wasp emerged between 8:10 A.M. and 2:07 P.M. because another closure was made during that period, this time from light sand. There was no further activity between 2:07 P.M. and 5 P.M., nor did there appear to be any on April 19. On April 20 I dug up the nest and found that the burrow had been filled with dry sand, perhaps dating from April 18. The burrow went downward at a 40-degree angle to a depth of 4 cm., where it terminated without a cell.

I made some additional observations on a female (41363 C), 6 mm. long, nesting on a bare, flat, sandy area along the banks of the Peace River at Arcadia on April 13. This *similis* flew in and alighted near her burrow at 11:50 A.M. She dropped her paralyzed grasshopper prey about a centimeter from the entrance, cleared the entrance of the temporary sand closure, went inside for a moment, emerged at once head first, grasped the hopper, and pulled it into the burrow head first. She came out a few seconds later and made a temporary closure by scratching sand behind her into the entrance. I captured her at this time and dug up the nest. The burrow diameter was 4 mm. at the entrance. The single, incompletely stored cell was 6 cm. below the surface and about 7.5 cm. from the entrance. The burrow was without an angulation. The cell contained five paralyzed, pale green, grasshopper nymphs, 5–6 mm. long, belonging to a species of *Melanoplus*. None of these nymphs bore a wasp egg, and I found no additional cells.

I watched a third female (41563 B), 5.5 mm. long, nesting on flat, bare sand near Lake Annie on April 15. When I discovered her at 10:00 A.M., she was just removing the loose sand forming the temporary closure to her burrow. Her paralyzed, pale green, grasshopper nymph was lying on the

sand about 2 cm. from the nest entrance. I moved the nymph a few centimeters farther from the entrance, but the wasp discovered it as soon as she came out of the burrow. She grasped it venter to venter, head first, flew with it to the entrance, and dropped it on its side. She entered the burrow head first, came out at once head first, grabbed the antennae of the grasshopper, and pulled it into the burrow. She emerged a few seconds later, made a temporary closure by scratching dry sand backward into the entrance, and departed at 10:03 A.M. She returned at 10:35 A.M. with a larger grasshopper nymph, landed about a meter from the nest, and proceeded by short flights of a few centimeters each toward the nest. She appeared to have some difficulty finding the entrance, but finally entered it alone, and then came to the surface and pulled in the grasshopper at 10:40 A.M. I saw her antennae near the entrance at 10:42 ½ A.M. At 10:45 A.M. she came out of the nest, turned around, and re-entered head first almost at once. She came to the entrance head first at 10:52 A.M. and backed down immediately. At this time it became apparent that she was making a final closure of this nest. She flew out of the burrow at 10:55 A.M. and flew back in at once. I captured her the next time she came out, before she completed the closure.

The burrow went downward at a shallow angle of about 20 degrees for 2.5 cm., then turned downward almost vertically, and ended in a recently sealed cell 3 cm. below the ground surface. The cell contained four pale green, grasshopper nymphs, 5–8 mm. long, the largest of which bore a wasp egg 2 mm. long attached between the right fore and mid coxae and extending across beyond the left side of the nymph. About 4 cm. from this cell and 4.5 cm. from the ground surface was a second, earlier cell. It contained 10 pale green, grasshopper nymphs 5–8 mm. long. The wasp egg was placed on one of the medium-sized nymphs in the position noted above (fig. 1, lower). The egg in this earlier cell would apparently have hatched by the morning of April 17, but I preserved the prey on the preceding evening. The egg in the later cell hatched by the next morning, two and a half to three days after it was laid; the larva died two days later.

The 10 grasshopper nymphs in the earlier (female?) cell were all of a species of *Aptenopedes*. The nymphs in the later (male?) cell were three of this same species of *Aptenopedes* and one of a species of *Melanoplus*. The paralysis caused by the wasp venom was not profound. The nymphs were paralyzed lightly enough to allow them to continue voiding feces and to make jerky reflex movements of their tarsi and palpi.

Krombein and Evans (1955) reported *similis* as preying on a nymph of *Radinotatum* at Marco, Florida.

Trypoxylon (Trypargilum) collinum collinum Smith

On April 19, while examining some dead twigs of scrubby live oaks near Lake Annie, I found an old nest of this species in an abandoned boring of some other insect. There were three *collinum* cocoons, from which the wasps had already emerged, in a linear series in this boring 10 cm. in length. The position and size of the partitions between cells and of the closing plug were not evident. Presumably these partitions were made of agglutinated sand like those I have found in nests of this wasp in borings in wooden traps. The cocoons of this species are specifically diagnostic.

Pluto rufibasis (Malloch)

On April 25 I caught a *rufibasis* female (42563 B), 7.5 mm. long, in the Highlands Ridge sand scrub area of the Station. She was hovering in front of the freshly cut vertical face of a sand bank, as if she were searching for a suitable place to begin a nest in the damp sand. It is known that species of this genus nest in the ground, but it is unusual to find one searching for a nesting site on a vertical surface, since the majority of ground-nesting wasps begin their nests from a horizontal or slightly sloping surface.

Prionyx parkeri Bohart and Menke

I noted a *parkeri* female (41663 A), 15 mm. long, with her paralyzed prey at 11:22 A.M. on April 16 at Arcadia. Her nest was on a slight slope of bare, firmly packed, fine sand. She carried her grasshopper to the burrow dorsum up and head first. She set it down at the entrance, entered her burrow head first, turned around, reached out, and pulled in the grasshopper. The burrow entrance was about 2.5 cm. across and 1.5 cm. high. At 11:24 A.M. she returned to the entrance head first and began pulling loose sand down into the burrow for the next few minutes to make a closure. Realizing that she was making a final closure, I captured her at 11:27 A.M. and dug up the nest. The burrow went straight downward at an angle of 60 degrees and ended in a cell 6 cm. below the ground surface just above a layer of extremely hard soil. There was a single, feebly paralyzed nymph of a species of *Melanoplus,* probably *femurrubrum* (DeGeer), 17 mm. long, lying in the cell on its venter. It did not bear a wasp egg, but this may have been dislodged during my handling of the prey.

Evans (1958) published observations made on this wasp at Arcadia under the name *pubidorsus* (Costa). He found only a single grasshopper venter down in each cell, with the wasp egg attached very lightly just

above the hind coxa. He recorded as prey at Arcadia an adult male *Melanoplus femurrubrum propinquus* Scudder, and nymphs of *Scirtetica marmorata picta* (Scudder). He reported one cell at a depth of 8 cm. and another at a "very shallow" depth. He found only one cell per nest.

Stictiella serrata (Handlirsch)

I made a few brief field notes on one of these wasps on April 23. This female (42363 A) was carrying an adult moth into her nest on a road leading into a sand pit in the Highlands Ridge sand scrub area. The nesting site was on bare, level, firmly packed, fine sand. The wasp came head first to the burrow entrance in a few seconds, scratched sand backward as she emerged to make a temporary closure, and then flew off at 10:58 A.M.

Six minutes later she returned with another moth. She was scared off for a few seconds by ants from an adjacent nest which were investigating her burrow entrance. As she hovered low over the area I could see that she held the moth venter to venter and head first by her mid and hind legs. The wings of the moth were folded tightly against the body. When the wasp alighted at the burrow entrance to scratch open the temporary closure, she held the moth by the mid legs alone. She left the nest head first at 11:06 A.M., again making a temporary closure as she departed. She returned at 11:27 A.M. with another moth, and I captured her as she left the nest after depositing her prey inside.

The burrow had a diameter of 10 mm., went straight downward for 14 cm. at an angle of about 30 degrees, and ended in an almost horizontal, ovoid cell, 2.5 cm. long and half as high, about 8 cm. below the surface. At the inner end of the cell was a wasp grub about one-third grown, and stacked in front of it were 21 moths piled in neat layers on their backs with their heads inward. The moths were 7–14 mm. long as compared with a body length of 12 mm. for the wasp.

About 15 cm. from this nest I found a cell of another *serrata* at about the same depth. It contained 10 moths. If there was a wasp egg or young larva in the cell, I must have lost it. I used the moths from this second cell to feed the larva from the first cell. I preserved the prey from the first cell for identification as follows:

Crambidae
  Crambus satrapellus Zinken, six
  Crambus quinquareatus Zeller, eight
  Argyria argentana Martyn, one
Epipaschiidae
  Jocara sp., one
Olethreutidae
  Eucosminae sp., one

I gave the wasp larva from the first cell several additional moths from which I removed the legs and wings. The larva reached maturity and began to spin a cocoon during the 24-hour period that ended at 8:00 A.M. on April 27, so the duration of the feeding period was probably six to seven days. The cocoon was completed on April 29. The larva died a couple of weeks later from desiccation, because I had breached the cocoon wall to observe the development. The ovoid cocoon, 17 mm. long, was composed of a thick layer of sand grains spun together by silk. Unlike other bembicine cocoons, it lacked a series of pores around the middle; possibly the cocoon construction was abnormal because the larva spun in a rearing tin.

Gillaspy, Evans, and Lin (1962) published some observations on *serrata* made by H. E. Evans at and near the Archbold Biological Station in 1955 and 1961. Their account differs in two details from the observations reported above. Evans found that the moth was held by the mid legs only during flight (one observation), whereas I found the wasp using both mid and hind legs to support the prey during flight (also only one observation). There may be behavioral diversity in prey transport, or the wasp may have to use both mid and hind legs to carry larger specimens of prey, or perhaps my wasp behaved aberrantly because of the ants around the nest entrance.

The other discrepancy involves the matter of provisioning the cell. In two nests Evans found that the egg was laid on the first moth brought into the cell, that 12 and 18 moths were provided, respectively, and that the cells were completely stored and the burrow filled in permanently before the egg hatched. In contrast I found 21 moths in an incompletely provisioned cell and a wasp grub about a third grown in this cell. Apparently *serrata* may occasionally practice progressive provisioning, but we can only speculate as to the cause of this behavior. The weather during my entire stay was hot, sunny, and rainless, so inclement weather could not have been a factor in this protracted storing of prey. Possibly there was a shortage of suitable moths which would have delayed completion of the nest. However, since my wasp made two provisioning flights of six and 21 minutes each, the 21 moths found in this cell could have been obtained in less time than would have been required for the egg to hatch. Obviously, additional observations on this species are needed to determine the normal behavior.

Cerceris flavofasciata floridensis Banks

At 1:00 P.M. on April 23 I saw a *floridensis* female (42363 B) hovering in front of a vertical bank at a sand pit in the Highlands Ridge sand scrub area of the Station. I netted her, ascertained her identity by examination

of the typical clypeal process, and released her. She returned at 1:31 P.M., flew into her nest entrance in the vertical bank, and flew out head first five minutes later. She flew back into the nest a minute later and then flew out in the next minute. She returned at 1:55 P.M., this time with an adult chrysomelid beetle 4 mm. long, a specimen of *Cryptocephalus guttulatus* Suffrian. I released her and kept the beetle. I clocked five additional provisioning flights between 1:55 P.M. and 2:53 P.M. as of 20, 10, two, 11, and nine minutes' duration. The wasp always left the burrow head first and did not make a temporary closure between the provisioning flights. I left the area from 2:55 P.M. to 3:15 P.M. but saw her make one additional provisioning flight, which lasted from 3:34 P.M. to 3:51 P.M. She flew out of the burrow a few seconds later and had not returned when I left at 4:31 P.M.

On April 24 I watched at this nesting site from 9:00 A.M. to 11:40 A.M. I saw some damp sand fall out of the entrance at 10:12 A.M., but the wasp did not emerge. There was some loose, damp sand pushed up to the entrance, but it did not entirely block the entrance. She pushed out some more sand at 10:23 A.M. She completely opened the entrance between 11:40 A.M. and 12:25 P.M. She flew out of the burrow head first at 1:04 P.M. Four provisioning flights of six, 17, five, and two minutes were made in the next 43 minutes. She had not returned when I left the area at 1:50 P.M. The burrow entrance was open between 4:20 P.M. and 4:30 P.M., but I did not see the wasp during that period.

I revisited this area at 8:15 A.M. on April 25 and found the nest entrance plugged with loose sand. I left the site at 11:40 A.M., but by 12:40 P.M., when I returned, the wasp had opened the nest again. I captured her at 12:43 P.M. when she flew back with a small speckled beetle. She was 12 mm. long, and her beetle prey, another specimen of *C. guttulatus,* was 5 mm. long.

The burrow curved slightly downward for 23 cm. The sand immediately behind the vertical face of the bank was quite moist and easy to dig. There was a plug of loose, damp sand near the end of this first section, but it contained no beetles. Probably I caught the wasp on her first provisioning flight of the day, or there would have been beetles in this plug. The burrow then turned and continued downward at a 70-degree angle for 59 cm., turned toward the north and continued downward at 45 degrees for 11.5 cm., then went down vertically for about 20 cm., and ended. I found the first cell about 20 cm. from the end of the vertical burrow at an estimated distance of 90 cm. from the burrow entrance. It was fully stored, and contained 11 stocky chrysomelid beetles 2–6 mm. long and a wasp egg 4 mm. long very loosely attached to one of the beetles. I found a second, partly stored cell about 70 cm. from the nest entrance. It contained nine beetles

of the same size range but no wasp egg. I continued to dig to a distance of 120 cm. from the entrance, and about 17.5 cm. on each side of the burrow, but I could find no additional cells.

The first cell contained the following beetles:

Cryptocephalus bivius Newman, four, 5–6 mm. long
Cryptocephalus binominis Newman, one, 5 mm. long
Cryptocephalus guttulatus Suffrian, two, 4.5 mm. long
Coscinoptera dominicana (Fabricius), one, 5.5 mm. long
Chlamisus sp., probably *nodulosa* Blatchley, three, 2–2.5 mm. long

The second cell contained two specimens of *C. bivius,* one *C. guttulatus,* and six *Chlamisus,* probably *nodulosus.* I preserved seven beetles from the first cell for subsequent identification and combined the remaining beetles from both cells in a rearing tin with the egg.

The wasp egg hatched during the 24-hour period ending at 8:00 A.M. on April 27. Consequently, the incubation period was about three days, if we assume that the egg was laid during the afternoon or evening of April 23, as is probable. This larva had completely hollowed out the beetle prey by May 3, giving a larval feeding period of six to seven days. It was still attempting to spin a cocoon on May 6, and died soon thereafter.

At 11:11 A.M. on April 24 I saw a second female (42463 B) fly into her nest entrance, about 1.5 meters from that of the preceding individual. Apparently she did not carry a beetle. Her nest entrance was 6 mm. in diameter. I tried to dig out this burrow but lost it in the shifting sand, and I recovered no beetles in the immediate vicinity. This burrow probably had not been completed, because it was not in existence the previous day. The wasp returned later in the afternoon searching for it.

I caught another *floridensis* female, possibly 42463 B, as she hovered in front of a different section of this sand bank at 11:15 A.M. on April 25.

Several years ago I published some notes (Krombein, 1959) on a colony of about a dozen specimens of typical *flavofasciata* H. S. Smith nesting in a vertical sand bank at Kill Devil Hills, North Carolina. These specimens had also preyed on various species of chrysomelid beetles of the genera *Cryptocephalus, Chlamisus,* and *Bassareus.* The burrows were 50–75 cm. long, with one or more angulations. No completely stored cells were recovered.

Cerceris robertsonii emmiltosus Scullen

F. E. Kurczewski called my attention to a nest of this wasp after he noticed a female bringing in two beetles in a short period of time prior to 9:30 A.M. on June 27. This nest was on a slightly sloping, sparsely vegetated area of coarse sand near Lake Annie. I watched at the nesting site and caught this female (62862 A), 11 mm. long, when she finally returned to

her nest at 11:00 A.M.

The burrow had a diameter of 5 mm. and was open vertically to a depth of 14.5 cm. At a depth of 34 cm., directly under the entrance, I found a temporary holding cell containing six bronze-colored adult chrysomelid beetles, *Colaspis favosa* Say.

In this nest there were six fully stored cells, listed in the reverse order of their storing, as follows:

Cell 6, 41 cm. below surface and 9 cm. south-southwest of burrow axis; contained 10 whole beetles and a small wasp larva injured during my excavation; cell was ovoid, 12 mm. long.

Cell 5, 42 cm. below surface and 12 cm. from burrow axis; held 14 whole beetles and moldy egg or young larva; cell was ovoid, 14 by 8 mm.

Cell 4, 44 cm. below surface and 5 cm. north-northwest of cell 3; contained a whole beetle, six pairs of elytra, and a nearly mature wasp larva which completed feeding by the evening of June 30.

Cell 3, 44 cm. below surface and 15 cm. west of burrow axis; held seven pairs of beetle elytra, many other beetle fragments, and a nearly mature wasp larva which began to spin a cocoon on the afternoon of June 30.

Cell 2, 44 cm. below surface and 5 cm. south-southwest of cell 3; it contained nine pairs of beetle elytra, and a wasp larva spinning a fusiform cocoon, 14 by 5 mm.

Cell 1, 47 cm. below surface and 20 cm. east of burrow axis; held two whole beetles, nine pairs of elytra, and a large wasp larva which was moribund and not full grown on the evening of June 30.

I carried the excavation to a depth of 56 cm. but found no additional cells. There were no apparent lateral burrows to the cells. Probably the wasp filled in each with the sand dug out to form the succeeding burrow and cell. There were no other nests of this wasp nearby.

All the beetles were the chrysomelid *Colaspis favosa* Say, 4.5–6 mm. long, except that there was one similarly colored *Paria* sp., 3 mm. long, in cell 6.

Some years ago I published observations on two colonies of typical *robertsonii* Fox at Kill Devil Hills, North Carolina (Krombein, 1953a, 1953b). The nest architecture in *emmiltosus* is similar to that of most of the nests reported earlier for typical *robertsonii*. The wasps in one *robertsonii* colony used as prey the chrysomelid *Rhabdopterus picipes* (Olivier), which is very similar in color and shape to the *Colaspis favosa* used by *emmiltosus*. They stored eight to 12 beetles per cell. In the other *robertsonii* colony, the wasps used orange-spotted chrysomelids, *Cryptocephalus notatus* Fabricius and *Pachybrachis dilatatus* Suffrian.

Crabro (Paranothyreus) rufibasis (Banks)

I watched a female *rufibasis* (42563 A), 9 mm. long, fly swiftly into her nest at 8:57 A.M. on April 25. The nest entrance was on the almost vertical face of the sand pit several meters from the nest of *Cerceris flavofasciata*

floridensis Banks described earlier. The *rufibasis* burrow was 6 mm. in diameter and went down almost vertically after a short horizontal section. I caught the wasp at the 20-cm. level as she tried to escape. The burrow continued downward and ended blindly 54.5 cm. from the entrance. I continued my excavation 7.5 cm. below this point, and 7.5 cm. on all sides of the burrow for its entire length, and found no cells.

Rau and Rau (1918) described nests of a related species, *Crabro (Paranothyreus) cingulatus* (Packard), in a vertical sand bank in Missouri. They reported the burrows as being 6–44 cm. in length, and varying from slightly sloping to almost vertical. Their wasps were storing ephydrid flies, *Paralimna punctipennis* (Wiedeman) [recorded as *P. appendiculata* Loew].

Oxybelus emarginatus Say

Additional observations (41463 B and C, 41563 A, F, and G, and 42163 A–F) were made on several colonies of this species near Lake Annie in April. These observations supplement and extend those made in June, 1962 (Krombein and Kurczewski, 1963). In that paper we reported that the prey was carried by the legs rather than impaled on the sting as is done by most known North American species of *Oxybelus*. We listed as prey a small slender cecidomyid midge, *Anarete buscki* (Felt), and a larger, bulky muscid fly, *Atherigona orientalis* Schiner. The one cell that we were able to dig up was 3.8 cm. below ground level. We found three *emarginatus* nests, one on slightly sloping bare sand, one in a heel print in bare sand, and a third in the side of a pit we dug to obtain the nest of another wasp. Although we captured several *emarginatus* males, we found none of them around the female nests. We also observed that the nest entrances were left open during provisioning flights, a behavioral trait also found in all nests I studied in 1963.

Additional observations in 1963 clearly established that *emarginatus* prefers to begin its nest on the side of a depression in the sand, if it can find one. On April 14 I noticed several specimens of *emarginatus* (41463 B) entering burrows at the base of a shallow hole in the sand a little over a centimeter in diameter. At least one of these was a female, which brought in a long, pale green chironomid beneath its body. I collected two *emarginatus* females 5–5.4 mm. long from this site. I also recovered one of the pale green chironomids 6.5 mm. long from a cell about 6 cm. below the surface.

There were at least two other burrows in another *emarginatus* colony (41463 C) off the side of an ant nest. The ants were a species of *Dorymyrmex,* which makes a crater-like nest. The ant workers are predaceous, aggressive, and possess anal glands which emit a fluid with a disagreeable odor. Despite these apparently objectionable qualities, the *Oxybelus* wasps were

able to nest inside the entrance to the ant nest without molestation by the ants. I captured a female *emarginatus,* 5 mm. long, from this colony. I dug up her nest and found it to be a burrow with several angulations going downward at an angle of about 40 degrees and ending 7 cm. below the surface. There was no cell at the end of the burrow, so the burrow could not have been completed. On the following day I captured seven *emarginatus* males, 4.2–4.7 mm. long, which had begun resting burrows off the sides of the pit that I had dug to explore the female burrow.

On April 15 at 1:20 P.M. several individuals of *emarginatus* (41563 G) began to nest in a small pit which I had dug in the sand only two hours earlier to obtain a nest of *Tachysphex similis* Rohwer (41563 B). The *Oxybelus* burrows were begun on the vertical wall 4–6 cm. below the surface. At 2:56 P.M. I captured one of them, a female 5.3 mm. long. The other two wasps were still burrowing at 3:40 P.M., when I left the area. On the following day between 2 P.M. and 3:20 P.M. I captured four male *emarginatus,* 4–5 mm. long, visiting burrows in this pit.

Two additional colonies (42163) each contained several burrows inside the entrances of larger tunnels probably made by small gopher tortoises. I collected prey from several females nesting in these two colonies, and also several pairs of *emarginatus in copula.*

Males were very active around the nesting sites, a behavioral trait that I did not observe in June, 1962. They excavated short burrows in the sand in the same sites that were used by the females, presumably as shelters, and also frequently mated or attempted to mate with females as the latter flew in with prey. They also perched on grass blades or roots around the depressions, apparently watching for females to return. There were no courtship preliminaries. The males just pounced on the females as they alighted near the nest entrances. Copulation took place while the pair lay on their sides on the sand, or while they hung suspended from a tiny root protruding from the side of the pit. The pairs were never coupled for more than 30 seconds, and the females apparently never relinquished their hold on their prey.

I noted specimens of *emarginatus* visiting flowers of *Geobalanus oblongifolius* (Michaux) Small and *Stipulicida setacea* Michaux near the nesting sites. I did not collect specimens to determine the sex. In North Carolina I found *emarginatus* males visiting honeydew exudates on foliage of scrub and live oaks (Krombein, 1953a, 1953b).

As reported above, on April 14 I recovered a pale green, male chironomid, *Chironomus, sensu lato,* 6.5 mm. long, from nest 41463 B. On April 21 I collected prey from several other females (42163 A-F). All of them were carrying the small, speckled gray, chaoborid midge, *Chaoborus punctipennis*

Say, 2.7–3.2 mm. long. All specimens of prey were transported beneath the body of the wasp rather than being impaled on the sting. For example, I noted one pair of *emarginatus* mating near the nest of the female. They hung upside down from a tiny root, and I could see that the female was clutching a *Chaoborus* midge to her thorax. All of the legs were missing from most of the *Chaoborus* individuals when I recovered them from the wasps. Probably the legs dehisced during handling and transport by the wasp, because I noted later that some legs had dehisced in alcohol from midges that I collected on adjacent vegetation. Certainly, the legs were not deliberately amputated by the wasps, because legs were present on the single *Chironomus* midge (41463 B), and also on the flies obtained in June, 1962 (Krombein and Kurczewski, 1963).

The *Chaoborus* midges on which *emarginatus* was preying on April 21 and 22 did not occur in noticeable numbers before April 19. By April 21 they were present in swarms of both sexes on or near shrubbery 0.5 meter to 4 meters above the ground and only a few meters from the *emarginatus* nests. I did not witness prey capture, but presumably it would be a very simple and rapid process of the wasp pouncing on a resting midge on the shrubbery.

Tsuneki (1951), in his study of *Oxybelus bipunctatus* Olivier in Japan, also included a few observations of *O. strandi* Yasumatsu. He found that *bipunctatus* always carried its prey impaled on the sting, but that *strandi* carried the prey either on the sting or clutched beneath the body by the mid or hind legs. He speculated that *strandi* might adapt the method of prey carriage to the size of the fly, using its legs when the fly was too heavy to transport on the sting. This speculation is unfounded insofar as *emarginatus* is concerned, because all the midges preyed upon were certainly light enough to be carried on the sting.

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