the top leaves of the plant. Increased number of T. urticae and P. citri mites per leaf resulted in a reduction in standard error. The opposite was observed for M. caribbeanae.

Regression analysis between total number of mites/leaf and the relative estimate by adhesive tape indicated a intermediate correlation ($r^2 = 0.68$), which demonstrated that 79.3% of the variation in total mites/leaf can be explained by the use of the adhesive tape (Fig. 3). A combination of several techniques (visual damage rating, population counts, etc.) should be used not only were a single species is the key pest, but also when there are several. These techniques may assess the regular mite outbreaks in the large cassava growing regions of Brazil, Africa, and Asia.

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REFERENCES CITED


OBSERVATIONS ON THE NESTING OF THREE SPECIES OF CERCERIS (HYMENOPTERA: SPHECIDAЕ)

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ABSTRACT

Quantitative data obtained from the nests and provisioning activities of 3 species of Cerceris are presented. Those for C. flavofasciata floridensis compare favorably with information on the nominate subspecies and reveal 4 new genera and 5 new species of prey Chrysomelidae. Data from 2 populations of C. rufopicta confirm previous nesting information on this species, bring to light 2 new genera and 6 new species of chrysomelid prey and introduce a new prey family, Eucnemidae. Biomass data in the form of total prey weight per cell for C. funipennis substantiate previous information on male and female cells. Observations on the Florida population of C. funipennis reveal the use of conspecific nests from previous generations and disclose a new cleptoparasite, Senolaimia rubriventris (Maequart) (Hymenoptera).
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Resumen

Se presentan datos cuantitativos sobre los nidos y las actividades de aprovisionar de 3 especies de Cerceris. Los datos sobre C. flavofasciata floridensis comparan favorablemente con la información sobre la especie nominada y revelan 4 géneros nuevos y 5 especies nuevas de presas de Chrysolomelidae. Datos de 2 poblaciones de C. rufopicta confirman información precedente sobre la nidificación de esta especie, revelan 2 géneros nuevos y 6 especies nuevas de presas crisomelidales, y introducen una nueva familia presa, Eucnemidace. Datos sobre biomasa en la forma del peso total de presas por celda de C. fumipennis verifican la información previa sobre las celdas de los machos y de las hembras. Las observaciones sobre la población florídano de C. fumipennis revelan el uso de nidos conoíferos de las generaciones previas y revelan un nuevo cleptoparásito, Senotainia rubiventris (Macquart) (Sarcophagidae).

Cerceris, the largest genus in the Sphecidae, is behaviorally one of the best studied genera in the family. Most of the Nearctic species nest in aggregations in bare firm soil, the nest dimensions often reflecting the friability of the soil. The entrances are left open during the provisioning and are surrounded by a prominent rim of soil which is removed by weathering. A female often constructs and remains with only one nest during her lifetime (Evans 1971). Thus some of the nests become extensively multi-cellular. In some tropical and subtropical species of Cerceris these nests may be enlarged further by the daughters and, possibly, granddaughters of the founding female (Salbert and Elliott 1979, Evans and Hook 1982, a. b). Burrow storage, aided by an inner plug of soil, is prevalent in the genus (Evans 1971). The North American species of Cerceris provision exclusively with adult Coleoptera (Seuflen and Wold 1969), whereas some of the exotic species store Hymenoptera (Tsuneki 1965, Gess 1980).

Much of the information on nesting in this genus exists in the form of anecdotal descriptions such as those published by Krombein (1952, 1953, 1959, 1963, 1968). Evans (1971) found few differences between some Nearctic species in nest architecture and provisioning behavior but noted significant interspecific diversity in prey selection. Evans and Rubink (1978) reported remarkable inspecific constancy in the prey preferences of several Nearctic species. Alcock (1975) found a “high level of burrow switching, burrow stealing, and communal provisioning” in Cerceris simplex macrasticta Viereck and Cockrell. Some other species of Cerceris, particularly those in the tropics and subtropics, have also been implicated in communal nesting, i.e., several females live together in the same nest and cooperate or share in the nesting activities (Grandi 1961, Tsuneki 1965, Evans and Matthews 1970, Evans et al. 1976, Salbert and Elliott 1979, Alcock 1980, Evans and Hook 1982, a. b). The factors related to communal nesting remain obscure. Evans and Hook (1982a) found no reproductive division of labor in some Australian species of Cerceris despite an apparent division of labor into provisioning and non-provisioning females.

Our studies on the nesting of members of this genus encompass 3 species: C. flavofasciata floridensis Banko, which has been studied briefly (Krombein 1964); C. rufopicta F. Smith (=robertsonii Fox) which has been studied in some detail (Krombein 1952, 1953, Evans 1959, 1971); and, C. fumipennis Say, which has been studied rather well (Evans 1971, Evans and Rubink
1978). Our observations were made in northwestern Pennsylvania (C. rufopictus), central New York (C. rufopictus, C. fumipennis) and southern Florida (C. fumipennis, C. flavofasciata floridensis) during 1970-83. They add much qualitative and quantitative behavioral information to the knowledge of species in the genus. Wasp and prey specimens bear corresponding ethology note numbers.

*Cerceris flavofasciata floridensis* Banks

This species nested in an almost vertical sand cliff, 2.7 m high, at the Archbold Biol. Sta., Lake Placid, FL during 5-11 April 1971. All nests were in the north-facing portion of the cliff, near the bottom. We excavated several nests but will present data only from the 2 largest, 8- and 7-celled.

The burrows, 6-8 mm in diameter, entered the cliff at slight upward angles for 3.5-8 cm, then progressed slightly downward for an additional 24-54 cm before undulating downward for another 12-26 cm (Fig. 1). Two such burrows were 72 and 88 cm in length. The cells were located off the semi vertical or vertical portions of the burrows, 3-16 cm from the burrow walls. Cells successively made within a nest were unearthed 2-12 cm apart.

Fig. 1. Nest of *Cerceris flavofasciata floridensis*, as viewed from the side, showing burrow, terminal storage chamber and cells. Cells are numbered in the order in which they were built and provisioned, based upon their contents.
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The oval cells (N = 15) averaged 7.7 (6-9) x 13.3 (11-17) mm in height and length. Those containing older larvae and cocoons were invariably larger (9x15-17 mm) than those with eggs or younger larvae. Nine completed cells, i.e., those containing an egg or larva, held from 12 to 30 (x = 19.7) prey. Individual prey (N = 121) averaged 12.5 (5.5-57) mg in body (wet) weight, whereas the total prey weight of a single cell ranged from 168 to 322 (x = 252.4) mg. Three associated wasps weighed (wet) 41.5, 36, and 61 mg.

Although many prey in the cells faced head inward, often ventral side upward, some were positioned head outward or sideways. In certain cells the prey seemed to be "fitted" around the centrally located, pedestal prey bearing the wasp's egg or larva. The stout, slightly curved, hyaline egg, 3.5 mm long, was loosely attached longitudinally to the ventral side of the thorax of the prey.

Prey (*new host record) in the cells comprised adult Chrysomelidae, with their numbers in parentheses, as follows: *Bassareus croceipennis LeConte (82); *Cryptocephalus binomis rufigenialis Schaeffer (122); *C. bifrons Newman (37); *C. guttulatus Olivier (4); *C. notatus fulvipennis Haldeman (1); *Griburius aequus Olivier (4); *Pachybrachis discoides Bowditch (3); *Ememoa gibba (Fabricius) (1); *Anomoea nitidicollis crassicornis Schaeffer (4); *Coccinoptera dominica franciscana (LeConte) (1).

All 7 cells in one nest contained cocoons or wasp larvae in various stages of development; however, one cell in another nest contained red ants and prey fragments, 2 cells each held one maggot (Sarcophagidae) feeding on the prey, and 2 other cells had decomposed prey with neither a wasp's egg nor larva.

Cerceris rufopicta F. Smith
(* = Cerceris r. robertsonii Fox)

We excavated 10 nests of this species, 2 of them being 8 and 10 celled, in sand pits and blow-outs at Auburn, NY (24 July 1970, 21-27 July 1989) and Presque Isle St.Pk., PA (28-30 July 1970, 5-10 July 1971). Seven cells of 2 nests at Auburn averaged 21.7 (17-24) cm in depth below the surface, whereas 34 cells of 7 nests at Presque Isle St. Pk. averaged 22.9 (16.5-38) cm in depth. The cells themselves averaged 8.2 x 14.0 (7-10x10-18) mm at Auburn and, 8.3 x 12.7 (7-10x11-15) mm at Presque Isle in height and length.

From 4 to 9 (x = 7.0; N = 8) prey were placed in individual cells at Auburn, whereas from 3 to 20 (x = 8.9; N = 31) prey were put in cells at Presque Isle. The total weights of the prey in a cell averaged 134.8 (82-177; N = 5) mg at Auburn and 122.9 (60-217; N = 14) mg at Presque Isle. Individual prey from Auburn and Presque Isle averaged 16.8 (7-33; N = 47) and 13.9 (4.9-31; N = 187) mg, respectively, in body (wet) weight. Associated wasps from these localities weighed (wet) 33-39 (x = 36; N = 2) and 34-44 (x = 39.6; N = 5) mg.

One, 2 or 3 prey were stored either head inward or outward in the 15.5-37-cm long burrows, with some burrows having 2 or 3 such storage areas. Prey in the cells were placed mostly head inward but some were sideways and others head outward. Prey from the cells at both localities were lively, able to move around and even walk when taken from the cell.

The prey on which the wasp's egg was laid was usually slightly larger than an average-sized prey and weighed 19.0 (14-23; N = 11) mg. Such
prey were placed in the cell head inward and ventral side upward or on the side. Eggs were white and elastic, measured 3.3-3.7 x 0.8-0.9 mm, and were loosely attached.

The prey (*new host record) comprised adult Chrysomelidae, with the number of specimens in parentheses, as follows: *Cryptoccephalus quadruplex* Newmann (38); *Fidius viucida* Walsh (65); *Colaspis auulla* Fabricius (10); *C. brunnea* (Fabricius) (82); *Tymnus tricolor* (Fabricius) (63); *Pachydactis relicus* Fall (87); *Metachroma angustulum* Crotch (1). One record of *Deltomotopus amoenisornis* (Say) (Euenomidae) from a cell at Auburn represents a new family of prey for this species of wasp.

One 2-celled nest from Auburn contained a cell with 2 maggots (Sarcophagidae) and prey, whereas a 3-celled nest from Presque Isle St. Plk. had 1 maggot (Sarcophagidae) feeding on the prey in each of 2 cells. One cell in a 5-celled nest at Auburn contained prey fragments and small red ants.

**Cerceris fumipennis** Say

This species nested in hard-packed sand near Auburn, NY (17 July - 4 August 1970, 13 July - 3 October 1973) and in very hard-packed sand-clay of a firetrail at the Archbold Biol. Sta., Lake Placid, FL (16-30 April 1973). We excavated 7 nests at Auburn and 6 at the Archbold Biol. Sta. One nest at Auburn contained 17 cells, Cells at Auburn were unearsted 11-17 (\(\bar{x} = 15.0\); N = 7) cm beneath the surface, and those at the Archbold Biol. Sta., 12-17 (\(\bar{x} = 14.9\); N = 13) cm. The cells were 8-15 x 15-26 (\(\bar{x} = 10.9 \times 20.5\); N = 27) and 8-10 x 15-21 (\(\bar{x} = 9.2 \times 17.7\); N = 15) mm high and long at the 2 localities, respectively. Larger cells invariably contained older larvae and cocoons.

Cells at Auburn held 2-15 (\(\bar{x} = 5.4\); N = 39) prey, whereas those at the Archbold Biol. Sta. held 2-5 (\(\bar{x} = 3.3\); N = 13) prey. Cells exhibited distinct bimodality in prey weight per cell as follows: 128-233 (\(\bar{x} = 169.3\); N = 7) and 306-430 (\(\bar{x} = 345.3\); N = 6) mg at Auburn; and, 98-259 (\(\bar{x} = 205.5\); N = 4) and 409-440 (\(\bar{x} = 423.5\); N = 4) mg at the Archbold Biol. Sta. At Auburn male and female wasps, respectively, were reared from these cells. Individual prey at these localities weighed (wet), on the average, 61.9 (18-109; N = 36) and 93.2 (20-188; N = 27) mg, respectively. Wasps associated with these prey weighed (wet) 74-95 (\(\bar{x} = 84.5\); N = 2) and 85-149 (\(\bar{x} = 121.7\); N = 6) mg, respectively.

The prey on which the egg was laid was about average-sized: 63.0 (50-97; N = 6) mg at Auburn; and, 51.2 (61-98; N = 5) mg at the Archbold Biol. Sta. The egg, 3.5-4.5 x 0.8-0.9 mm, elastic and hyaline, weighed 2 mg and was attached tightly and longitudinally to the venter of the prey's thorax (Fig. 2).

Females at Auburn brought consecutive prey to their nests at intervals of 14-117 (\(\bar{x} = 45.1\); N = 12) min. and spent 2-12 (\(\bar{x} = 7.5\); N = 12) min. inside between entering with prey and exiting.

Prey (no new records) recovered from the cells comprised adult Bu- prestidiae, with their numbers in parentheses, as follows: *Agrius anxius* Gory (171); *Argulus sp.* (1); *Buprestis maculipennis* Gory (23); *Cimyra gracilipes* Melsheimer (69); *Discarca lurida* (Fabricius) (86); *Pocidilota cyanipes* Say (3).
Fig. 2. Prey of *Cerceris fumipennis* with egg attached in position typical of the genus (Photo by D. J. Peckham).
One 5-celled nest at Auburn contained 1 maggot feeding on the prey in each of 2 cells. Of 16 cells in Florida, only 5 had the potential of giving rise to adult wasps in the next generation. Five cells contained small red ants and prey fragments, 5, prey fragments only and 1, prey being fed upon by a maggot which was reared to *Senotainia rubiventris* (Macquart) (Sarcoptagidae).

In Florida 3 wasps were seen to enter nests with other females inside. In each case the entering wasp remained inside the nest for many minutes, then exited, returned with prey, and entered with the other wasp still inside. The female that remained in the nest would often station herself with the head inside the entrance for many minutes, back down and remain inside, or fly out, circle, and reenter. No contact was observed between females occupying the same nest. In 2 of the nests only 1 brood cell each was being provisioned at one time. In 2 of the 3 nests some of the side burrows led to cells that contained prey fragments and cocoon remnants from a previous generation.

**DISCUSSION**

*Cerceris flavofasciata floridensis*, *C. rufopicta* and *C. fumipennis* are, more or less, ecologically isolated from one another. Although pairs of these species were studied at the same localities, they were spatially separated from one another. At Auburn, NY *C. fumipennis* nested in the hard-packed sand of a roadway leading into a sand pit, whereas *C. rufopicta* nested off to the side near the edge of a field. In Florida *C. fumipennis*, likewise, occupied a firm, sand-clay ear path while *C. flavofasciata floridensis* nested in a sand bank some distance away.

Based upon collecting records *Cerceris flavofasciata* and *C. robertsonii* appear to be multivoltine in the warmer parts of their ranges, whereas *C. fumipennis* probably has a partial second brood in the south (Ferguson 1984, pers. comm.). In the Northeast *C. r. robertsonii* may be univoltine because the majority of collection and observational records are from July-August.

The nests of *C. flavofasciata floridensis* were similar in architecture to those described for the nominate subspecies by Krombein (1959). Those of *C. rufopicta* were similar in design to those described by Krombein (1952) and illustrated by Evans (1971). The burrow configuration and nest architecture of *C. fumipennis* were not only similar to those illustrated by Evans (1971) and described by Evans and Rubink (1978), but the depths of the cells from many widely separated geographic localities were remarkably close. Burrow storage, as noted by Evans (1971), was commonplace in all 3 species.

Evans (1971) noted that, in *Cerceris*, cells are of 2 sizes, small ones with less prey giving rise to male wasps and large ones with more prey giving rise to female wasps. We were able to substantiate this, using biomass in the form of total prey weight per cell, only for *C. fumipennis*. In all 3 species the number of prey per cell was inversely related to the sizes of the prey. Evans and Rubink (1978), likewise, noted an inverse relationship between size of prey and number of prey per cell in *C. californica* Cresson.

Prey of all 3 species were placed in the cells usually in a head inward and ventral side upward position, a position typical of species in the genus (Evans 1971). In at least *C. flavofasciata floridensis* some prey were
“fitted” around the centrally located prey bearing the wasp’s egg or larva. Many prey of *C. rufopicta* were lively and able to walk when taken from the cells, and we attribute the variety of positions in which some prey were found (not always head inward, venter upward) to this light paralysis. Prey of *C. flavofasciata floridensis* and *C. fumipennis*, on the other hand, appeared to be rather thoroughly paralyzed as indicated by their acquiescent state. Evans and Matthews (1970) noted that the prey of some Australian species of *Cerceris* were “deeply paralyzed.”

The position of the wasp’s egg on the prey in at least those species of *Cerceris* that store adult Coleoptera appears rather constant (see Tsuneki 1965, Evans 1971, Alcock 1974, our Fig. 2). We noted that eggs of *C. flavofasciata floridensis* and *C. rufopicta* were attached more loosely than those of *C. fumipennis*. Eggs of *C. binodis* Spinola and *C. simplex* macrosticta were laid “diagonally” across the thorax and anterior abdomen of the prey (Evans 1971, Alcock 1974), whereas that of *C. fumipennis*, as observed by Evans (1971), was placed “longitudinally” on the prey. Interestingly, *C. flavofasciata floridensis*, *C. rufopicta* and *C. binodis* use prey belonging to the same family, Chrysomelidae, while *C. fumipennis* captures Buprestidae.

Much has been written about the prey preferences of species of *Cerceris* (Tsuneki 1965, Scullen and Wold 1969, Evans 1971, Gess 1980). All of the Nearctic species capture and store adult Coleoptera. There is much agreement between Scullen’s (1965) species groups of *Cerceris* and type of beetle used as prey. Thus, *C. rufopicta* and other members of Scullen’s Group III use Chrysomelidae while *C. fumipennis* and other species belonging to Group II store Buprestidae. Evans (1971) reported much diversity in prey selection between 10 Nearctic species of *Cerceris* and Eucerceris, a related genus. Evans and Rubink (1978) noted much intraspecific constancy among the prey of 6 of 7 Nearctic species of *Cerceris*. The number of new prey records we present for *C. flavofasciata floridensis* and *C. rufopicta* reflects a previous inadequate amount of such knowledge for these species, whereas our lack of new prey records for *C. fumipennis* reflects the vast amount of work that has been done on this species.

The amount of mortality we report from the cells of *C. flavofasciata floridensis* (33%, 5/15 cells), *C. rufopicta* (40%, 4/10), and *C. fumipennis* (62%, 13/21) is high. We noted maggots of Miltogrammini (Sarcophagidae) and worker ants in the cells of all 3 species. Surprisingly, the highest amount of mortality was for *C. fumipennis* which had 2 or more females each occupying at least 3 nests in Florida and had females guarding these nests with their heads stationed in the entrances! Evans and Hook (1982b) have theorized that females of *Cerceris* stationed in nest entrances are effective in deterring the entry of ants and nest parasites, yet our data do not bear this out.

In Florida it appeared that some females of *C. fumipennis* were renovating and using older conspecific nests, and we attributed this to the difficulty of excavating in extremely hard-packed soil. Individual nests of species of *Cerceris* may be maintained by 2 or more successive generations of wasps (Tsuneki 1965, Evans et al. 1976, Salbert and Elliott 1979, Evans and Hook 1982a, b). In such cases one or more females overwinters in the nest and expands and provisions the nest in the spring. Such nests usually contain one or a few, older females with badly worn wings and mandibles and
perhaps one or more freshly emerged females with complete wings and mandibles (Salbert and Elliott 1979, Evans and Hook 1982a). Evans and Hook (1982b) observed that such nests of some Australian Cerceris contained well over 100 cells and believed that the success of such species was based upon communal nesting, including overlapping generations.

END NOTES

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The correct address of the junior author is not known.

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CUTICULAR LIPIDS FOR SPECIES RECOGNITION OF MOLE CRICKETS (ORTHOPTERA:GRYLLOTALPIDAE)
I. SCAPTERISCUS DIDACTYLUS, SCAPTERISCUS IMITATUS, AND SCAPTERISCUS VICINUS

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Abstract

Whole-body cuticular extracts of Scapteriscus didactylus and Scapteriscus imitatus collected from Puerto Rico, and of Scapteriscus vicinus collected in Florida, were analyzed by isothermal and temperature programmed gas chromatography. Calculated Kovats Indices indicated an homologous series of straight-chain and branched-chain alkanes in the cuticular lipids of each mole cricket. No differences were found between the sexes of species, but small variations in qualitative and quantitative patterns were present among individuals. The profiles of GC peaks were easily distinguishable, providing data for species and region of origin recognition, and supporting morphological and acoustical evidence that the crickets represent 3 species.

Resumen

Se analizaron por cromatografía isotermal y cromatografía de gas