

Nesting Habits of *Osmia grinnelli* Cockerell (Hymenoptera: Megachilidae)

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Abstract.—The nesting habits of *Osmia* (*Cephalosmia*) *grinnelli* Ckll. are described for the first time. Nests were made in wooden trap blocks attached to fence posts and to wooden stakes placed among desert shrubs in Utah's San Rafael Desert. Data on nest construction, cell provisioning, cocoon formation, diapause, sex ratio, and nest associates are presented. Females preferred to nest in larger holes (8.3 to 9 mm wide) rather than in smaller holes (1.9 to 5.9 mm wide). Biological characteristics of *O. grinnelli* are discussed and compared with related *Osmia*. The first host association for the parasitic bee, *Stelis* (*Pavostelis*) *carnifex* Ckll., is recorded. Predaceous beetle larvae (*Trichodes* or *Nemognatha*) were found in some cells.

The subgenus, *Cephalosmia*, has 5 included species (Rust, 1974). Information on the nesting habits of four is available (see Rust, 1974 for *O. californica* Cr., *O. montana* Cr., and *O. subaustralis* Ckll., and Parker, 1980 for *O. marginipennis* Cr.). Only the nesting habits of *O. grinnelli* Cockerell are unknown. Recent trap nesting studies in Utah's San Rafael Desert produced many nests of *O. grinnelli*. This paper provides data on the nesting habits and nest associates of this bee. Information on immature mortality, adult weight, sex ratio, and pollen provisions is included.

Trap nests.—Three kinds of traps were used in this study. The first was a layered trap (L.T.) from pine boards (10 × 13.7 × 1.9 cm) with 5 hole sizes (1.9, 3.2, 4.0, 5.9, 8.3 mm) drilled into the 1.9 cm wide end pieces; the holes extended as deep as 85 mm. Each hole size was replicated twice (10 holes/board) and a single trap had 3 boards taped together for a total of 30 holes/trap, Figure 1. The traps were protected from weather by a coating of polyurethane. In the field, the traps were nailed about 1 m above the ground on fence posts, dead and live trees with the entrance to the holes east facing and the long axis of the trap vertical to the ground. Other types of traps were made from 15 × 15 × 15 cm wooden blocks (B.T.) that had 49 holes 9 mm wide and 7.5 × 7.5 × 7.5 cm wooden blocks that had 42 holes 6 mm wide. Holes in both sizes of blocks were drilled through one plane of the block. One end of the hole was covered by a sheet of aluminum foil and the hole filled with an empty 6 or 9 mm wide paper waxed-lined soda straw. The block traps were attached to 1 m long wooden stakes (2.5 × 5.0 cm) by a bolt that extended through the length of the holes and the wooden stake and was held in place by a winged nut. The traps were placed 30 m apart in a line across each habitat sampled.

Five layered traps and 20 block traps (10 with 6 mm and 10 with 9 mm wide holes) were placed at each site; 10 sites in different habits (sand desert shrub, salt desert shrub, mixed desert shrub, and pinyon-juniper zones, see Harris, 1983 for details) in the San Rafael Desert were sampled.

Nesting site.—Nests of *O. grinnelli* were recovered from three sites in southern Utah. The first site was in a sand desert shrub zone at the road junction on Utah's U24 leading to Goblin Valley State Park. This site was a broad wash with numerous shrubs and forbs (*Wyethia*, *Poliomintha*, *Cryptantha*, *Artemesia*, *Astragalus*, and *Oenothera*). The second site was similar but was located in low hills 4 mi W of site one. The third site was in a pinyon-juniper zone near interstate highway I70, 25 mi W Green River, Utah.

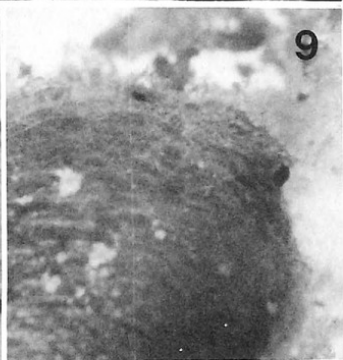
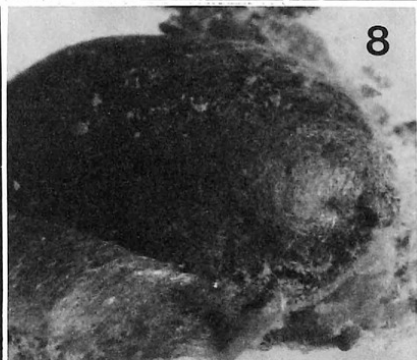
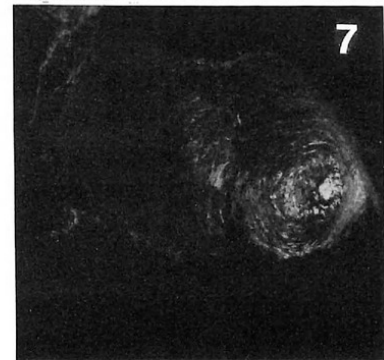
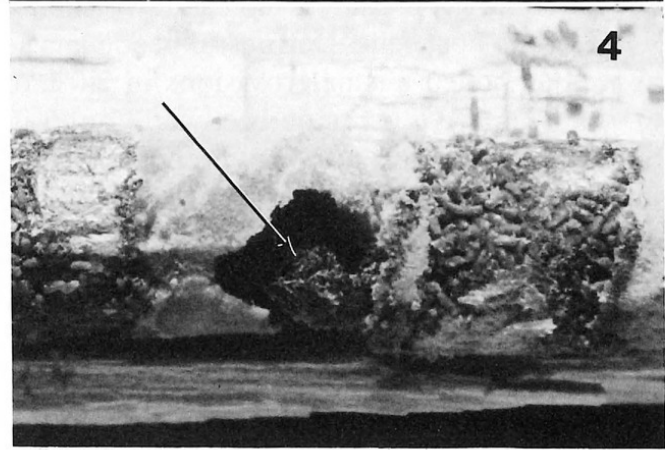
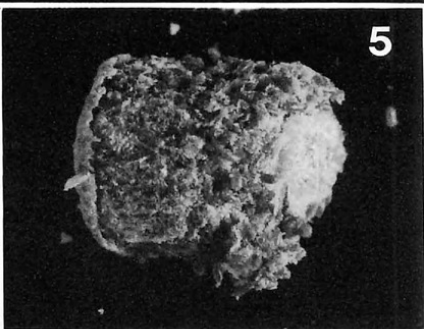
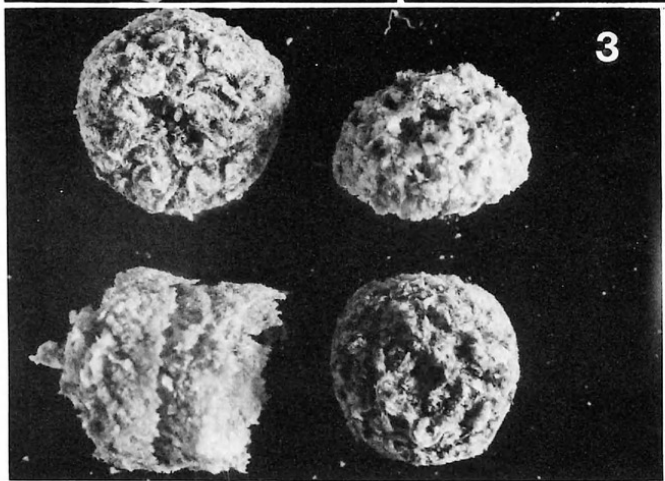
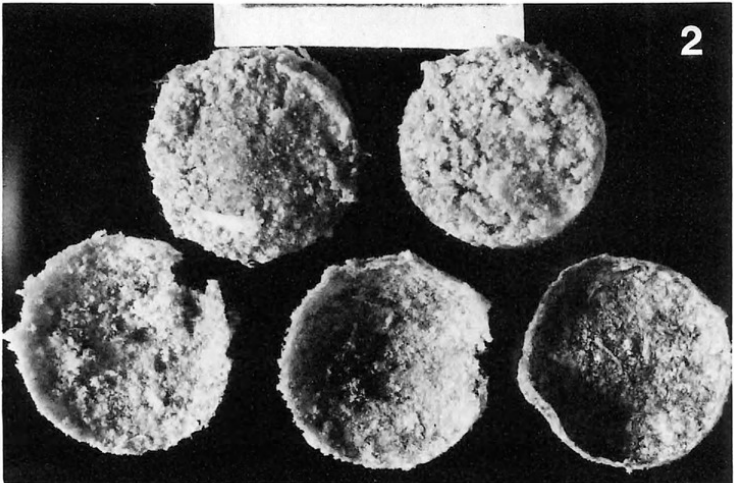
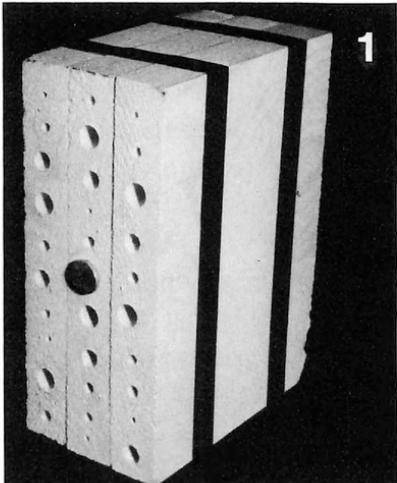
Nest construction.—Fifteen nests with 103 cells were recovered from the layered traps and all but two were made in the 8.3 mm diameter holes. The other two nests were made in 5.9 mm holes. From the block traps, 24 nests of *O. grinnelli* that contained 287 cells were recovered, but only from 9 mm wide holes. Most nests (66%) were started when females applied a thin disk of macerated leaf pulp at the base of the boring. Then, pollen-nectar provisions were added until the food stores filled the entire cell. The thin (1 mm) saucer-shaped cell partition of masticated leaf pulp was made on top of the provision. The surface of the partition was smoothed both above and below (Fig. 2). Cells were of variable lengths and those containing males were shorter (5.5 ± 0.78 mm long, $n = 24$) than those with females (7.7 ± 1.0 mm long, $n = 22$). In most nests, cells were built above one another with no space left between the cell partitions. The number of cells/nest ranged from 1 to 11 and averaged 6.8 ± 2.8 in the layered traps. In the block traps, the number of cells/nest ranged from 1 to 15 and averaged 7.8 ± 2.9 . Generally, the last cell partition was thickened to an average of 3.5 ± 0.7 mm in L.T. and 5.7 ± 2.5 mm in B.T. Most nests (80%) had a vestibular cell (the space between the provisioned cells and the entrance plug) that averaged 8.5 ± 5.7 mm long in L.T. and 65.4 ± 31.1 mm long in B.T. All but 2 nests were closed with a 5.0 ± 2.0 mm thick entrance plug in the L.T. These figures on nest closure were similar in the B.T. (5.7 ± 2.5 mm). The surface of the saucer-shaped plugs was rough beneath but finely smoothed on the outer surface. Some plugs were made from 2 or more compressed disks, Figure 3. The average placement of the plug was 12.5 ± 5.8 mm below the nest entrance in L.T. and 6.5 ± 7.4 mm in B.T.

Provisions.—The semi-moist pollen-nectar provisions were tightly packed into the cells. An egg chamber (Fig. 4) was made within the food stores near the bottom of the cell. Over 99% of the pollen in the provisions came from the perennial composite, *Wyethia scabra* Hook. Other species of *Cephalosmia* also provision nests with pollen from composites.

Cocoon.—The three-layered cocoon, typical of *Cephalosmia*, was made first by

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Figures 1–9. 1. A layered trap used in these studies. 2. Cell partitions made from macerated leaf pulp. 3. Entrance plugs; note smooth texture on outer surface. 4. Pollen-nectar provision with egg chambers now filled by developing host larvae (arrow). 5. Cocoon showing pollen and fecal material spun into outer layer. 6. Inner cocoon of *O. grinnelli*. 7. Nipple on cocoon of *O. grinnelli*. 8. Cocoon of the parasitic bee, *Stelis carnifex*. 9. Nipple on cocoon of *Stelis carnifex*.



the larva spinning a thick brownish layer of silk against the cell walls that held the fecal material, pollen, and other cell debris (Fig. 5) away from itself. Inside this network, a second layer was formed that was darker and thicker (Fig. 6). The third layer was clear and coated the inside of the second. The resulting cocoons were often asymmetrical because of the irregularities caused by the cell debris. The conical nipple on top (Fig. 7) consisted of fibrous silk strands that were sealed on the inside by the last layer of the cocoon.

Overwintering.—All cells with live *Osmia* had adults in diapause when the nests were recovered in November.

Adult weights and sex ratio.—Female bees from layered traps weighed more (91.9 ± 12.8 mg, range 73.3 to 121.9, $n = 22$) than males (48.1 ± 7.9 mg, range 33.3 to 66.6, $n = 24$). Similar differences between the sexes in body weight were found in those from block traps ($\text{♀} = 99.2 \pm 10.8$, range 77.1 to 116.3, $n = 30$; $\text{♂} = 51.3 \pm 9.3$, range 34.8 to 67.8, $n = 30$). The observed sex ratio in adults from L.T. was 1.16 $\text{♂}:\text{♀}$ whereas the expected sex ratio (female weight \div male weight) was skewed towards more males, 1.90 $\text{♂}:\text{♀}$. Similar sex ratios were found in adults from B.T. (1.19 $\text{♂}:\text{♀}$ observed, 1.93 $\text{♂}:\text{♀}$ expected). Placement of the sexes within cell series was typical of many xylophilous Hymenoptera; females were at the bottom and males were above. The average percentage of males in each cell position from the first to the fifteenth was: 4, 20, 23, 42, 68, 89, 89, 93, 100, 100, 100, 100, 100, 100, 100.

Mortality.—Dead host eggs and dead young larvae were found in 6.6% of the *Osmia* cells. Another 1.0% of the host larvae died after their cocoons were completed.

Nest associates.—Nest predators were the major mortality factor and they destroyed 23.2% of the host cells. The most common predator, the beetle *Trichodes ornatus* Say (Cleridae), destroyed 21.2% of the host cells. Dermestid beetle larvae consumed adult bees in diapause as well as pollen-nectar provisions in 2.0% of the cells. Cocoons of *Stelis carnifex* Ckll. (Fig. 8), a parasitic bee, were found in 5.5% of the host cells. These megachilid parasites overwintered as prepupal larvae. The *Stelis* cocoons were remarkably similar to host cocoons, but they could be distinguished by their flattened and asymmetrical nipple (Fig. 9) as compared to the broader nipple of *Osmia* (Fig. 7). One cell was parasitized by torymid wasps, *Monodontomerus* sp. which had emerged before the traps were collected and another host cell contained an adult of the meloid beetle, *Nemognatha scutellaris* Lec.

Supersedure.—Two nests of *Osmia sanrafaelae* Parker were superseded by those of *O. grinnelli*.

DISCUSSION

The nesting habits of *O. grinnelli* are similar to other members of *Cephalosmia* that use composite pollen for provisions, fill the cell entirely with the food mass (except *O. marginipennis*), and oviposit in an egg chamber in the food mass. The macerated leaf pulp used by *O. grinnelli* to make nest partitions and plugs was similar to material used in nests of *O. montana* and *O. subaustralis* but it differed from the mud and plant pulp mixture found in nests of *O. californica* and *O. marginipennis*. The three layered cocoons characterize cells of all *Cephalosmia*.

The host association for *Stelis (Pavostelis) carnifex* is the first record for this

parasitic bee. Other species of *Pavostelis* are also associated with species of *Cephalosmia*. For example, *S. callura* Ckll. parasitizes *O. marginipennis*, and *S. montana* Cr. is a parasite in nests of *O. californica* and *O. montana* (Parker, 1980, unpubl. data).

Other *Cephalosmia* have been reported to be parsivoltine or with a 2-year developmental cycle (Parker, 1980; Torchio and Tepedino, 1982). All *O. grinnelli* in this study transformed to the adult stage in the same season and none of the cells contained host larvae in diapause.

Floral records for *O. grinnelli* include 6 plant families other than composites (Rust, 1974). Apparently, *O. grinnelli*, like other *Cephalosmia*, collects pollen only from composites for nest provisions, and other floral records are presumably plants visited incidentally, or for nectar only.

Although 100 trap blocks with 5000 6 mm wide holes were available, none of the *O. grinnelli* nests were made in these small soda straw-filled borings. Thus, hole size might be a limiting factor in the nesting requirements of this *Osmia*. Perhaps the lack of suitable nesting sites is why populations of *O. grinnelli* are infrequently encountered (Rust, 1974).

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