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The Entomological Evidence

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ABSTRACT: The primary task was to investigate and explain the source of blockage in an elbow (B2) and in other parts of the fuel supply unit recovered from the wreckage of a private airplane. A small clump of pollen associated with a disc-shaped gummy mass of plant fibers suggested that bees belonging to the family Megachilidae might have been responsible for accumulating these plant materials. Examination of other parts of the fuel control unit revealed three dead adult bees identified as *Osmia gaudiosa* Cockerell (Megachilidae) and a single dead individual of the genus *Ashmeadiella* (Megachilidae). A survey of the tubing of a heater that had been stored showed that 69% of its tubings and fittings contained nest material and other arthropod debris including those of *Ashmeadiella meliloti* (Cockerell) and *Anthidium* sp. (Megachilidae). Through SEM examination, a single branched hair partly embedded in the clump of pollen was matched with the postgenal hairs of an adult *Ashmeadiella.* These facts left no doubt that the B2 elbow mass was part of a nest of *Ashmeadiella.* This conclusion was consistent with the facts that the wreckage had been available to the bees for nesting during the entire time of the spring and summer nesting season, and that the plant materials (leaves of *Sphaeralcea* and pollen sources) were readily available near the storage yard during that time. Contamination of the wreckage by nesting bees was obviously a post-crash phenomenon. Plant materials as well as dead bees would have been consumed by the intense fire that accompanied the crash if they had been present before.

KEYWORDS: forensic science, December, 1989 Ruidoso, NM plane crash, entomology, bees, pollen, *Osmia, Ashmeadiella,* Megachilidae, nest

Previous papers in this symposium identified and described the botanical evidence regarding the mass that blocked the B2 elbow taken from the fuel control unit. Still to be explained is how these botanical materials found their way into the elbow and other parts of the fuel control unit.

The B2 mass was a hard but flexible, dark disc with a vague swirl pattern. It completely blocked the 4-mm bore of the elbow. It later was found to consist of plant trichomes held together by an amorphous gummy matrix (Bates et al., Liddell; this series). A small clump of pollen representing several species of plants (Graham, Lewis; in press) adhered to one side of the mass. Partly embedded in the pollen clump was a single branched (as discussed below). How and when did these materials accumulate in the elbow? The answer is simple—but only if one is familiar with the biology and nesting behavior of bees.

Eickwort and I, both bee systematists with extensive experience in bee behavior and ecology, were hired independently as expert witnesses by the defense in early 1992. Our primary task was to investigate and explain the source of blockage in the B2 elbow and in other parts of the fuel supply unit. Our secondary task was to inform and convince a jury that what we discovered was correct.

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About Bees

It was assumed that the jury, like most of the general public, was not knowledgeable about bees. People seem to have the impression that all bees are social, living in large colonies dominated by a queen and defended and fed by a large number of sterile female workers. Such persons may also think that there are only a few kinds (species) of bees, namely honeybees, bumble bees, and perhaps sweat bees and/or carpenter bees. In fact, there are 21,000 species of bees in the world and most of them are solitary, that is, a single female, unassisted by workers, constructs her own nests and brings in food (pollen and usually nectar) for her offspring. The nests of solitary bees vary greatly in architecture, construction materials, and habitat. The variations may be species-specific, genus-specific, tribe-specific, and/or family-specific. Hence nest characteristics may permit the identification of the family, tribe, etc., responsible for making the nest.

Bees, like most insects, are holometabolous, that is they pass through morphologically distinct developmental stages during their life cycles, namely, egg, larva, pupa, and adult. The immature stages are restricted to brood cells (chambers) in the nest. Adults are normally found mating or foraging at flowers although females routinely return to their nests to unload their provisions, oviposit, and construct new brood chambers. When adult bees emerge from the immature stages, they normally abandon their natal nests, leaving behind larval fecal material, cast skins, vacated cocoons, and nest components. Not infrequently, immature stages as well as adults die in the nests because of diseases, parasite attack, or unfavorable weather conditions. An investigator can often find in abandoned nests the dead immature stages as well as adults that perished before emergence.

Results

At the time that we were first informed about the law suit and learned about the debris discovered in the wreckage, Eickwort and I immediately suspected that bees were responsible because of the presence of the clump of pollen on one side of the B2 elbow mass. All bees found in temperate latitudes feed their young on pollen as the main source of protein. Bees can be thought of as a specialized group of wasps, the ancestor of which shifted from feeding its young on animal protein to a newly evolved source of plant protein—pollen—roughly 120 million years B.P. Further, both of us independently hypothesized that a member of the leaf-cutter bee family Megachilidae was responsible, for two reasons: 1) Many members of this family are well known to use preformed tunnels (such as abandoned beetle burrows in wood, vacated insect burrows in soil, old mud dauber nests). 2) Species in this family often line their nest tunnels and cells and separate their cells with such material brought in from the outside as masticated leaves, petal snippets, resin, and/or pebbles. In contrast, species in other families tend to use their own glandular secretions to line their cells.

Both Eickwort and I were well acquainted with the fact that certain megachilids use specific substances for cell separators and nest linings. *Megachile* used leaf or petal cuttings; *Osmia,* masticated leaves; *Anthidium,* cottony plant fibers; *Dianthidium, Heriades, Chalicodoma,* plant resins. In addition, a review of Krombein's study on trap-nesting bees (1) gave us a broader and more detailed view of the nesting habitats and materials of the Megachilidae.

With a hypothesis that the obstruction in the B2 elbow was part of a megachilid nest, our next step was to test the hypothesis by looking for additional data. These data came from the following different sources.

Other parts of the fuel control unit taken from the wreckage. In the discovery session with the plaintiffs' lawyers and their expert witnesses (none trained in entomology) in constant presence, Eickwort and I recovered from four bores, three dead bees belonging to the megachilid genus *Osmia* in their cocoons (Fig(s). 1, 2) (later identified as *O. gaudiosa* Cockerell by Eickwort) and one dead bee of the megachilid genus *Ashmeadiella* (Fig(s). 3, 4) surrounded by its cell and cocoon. These bees had died before they had a chance to emerge.

An abandoned heater with many exposed, open tubes of various diameters. This equipment had been collected from the junk yard at the Sierra Blanca Regional Airport, Ruidoso, New Mexico, in March 1992 where the plane wreckage had been stored. Because the heater had not been part of the wreckage, Eickwort and I examined it without the presence of the plaintiffs' representative and found: *Ashmeadiella* nest with a dead adult female (later identified as *A. meliloti* [Cockerell] by Eickwort), cell partitions and a food mass (pollen agglutinated with a gummy substance) with a dead larva of *Ashmeadiella,* an *Anthidium* nest (identified by its cottony fibers), wasp nests (made of dried mud), spider skins (exuviae), and miscellaneous insect parts. A total of 69% of the 16 heater tubes had nests or arthropod debris of one sort or another.

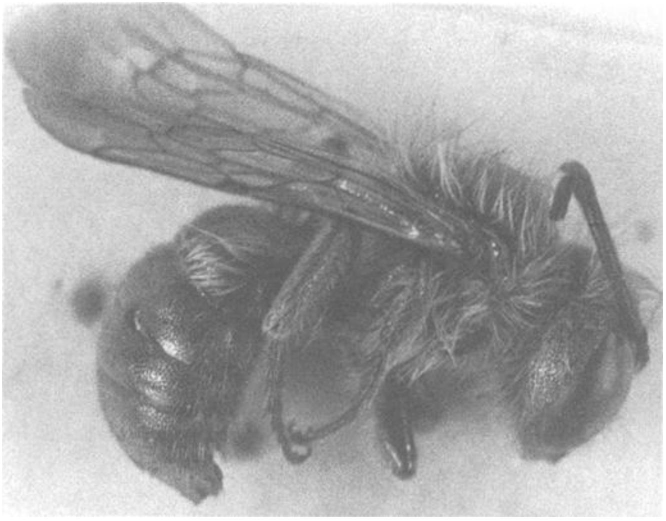

FIG. 2—*A dead male of* Osmia gaudiosa, *removed from one of the cocoons from the fuel control unit, length about 9 mm.*

FIG. 3—*Thorax and legs of* Ashmeadiella *sp., from the fuel control unit of the airplane wreckage.*

FIG. 1—*Two cocoons and other nest debris of* Osmia gaudiosa *extracted from the fuel control unit of the airplane wreckage. Cocoon length approximately 10 mm.*

FIG. 4—*Metasoma ("abdomen") of same.*

The mysterious single branched hair (Fig. 5) in the pollen mass. One of the diagnostic characteristics of adult bees permitting them to be distinguished from wasps is the fact that bees have branched or feathery hairs on some parts of their body whereas wasps have only simple body hairs. Although the single branched hair emerging from the pollen clump of the B2 elbow looked suspiciously like that of a bee, so many plant hairs were involved in the B2 mass (Bates et al., this series) that we were uncertain as to whether this single hair was of plant or bee origin at first. Eickwort solved the mystery in late May 1992 by conducting an SEM study of the hairs of *Asmeadiella* and found an exact match of that single hair with the postgenal hairs (Fig. 6) from the lower part of the head. As adult bees get older, their hairs tend to break off. The hair in the pollen mass had accidentally been lost by the female as she was unloading the pollen from her foraging trip.

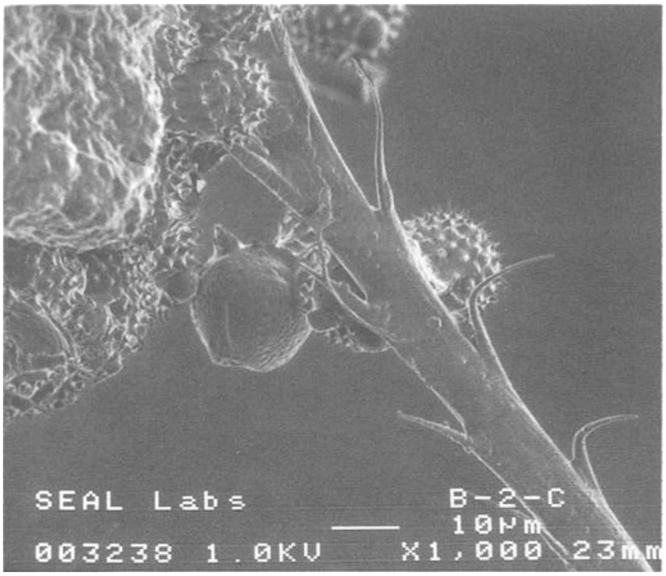

FIG. 5—*Scanning electron micrograph of branched hair attached to clump of pollen from B2 elbow. For explanation, see text.*

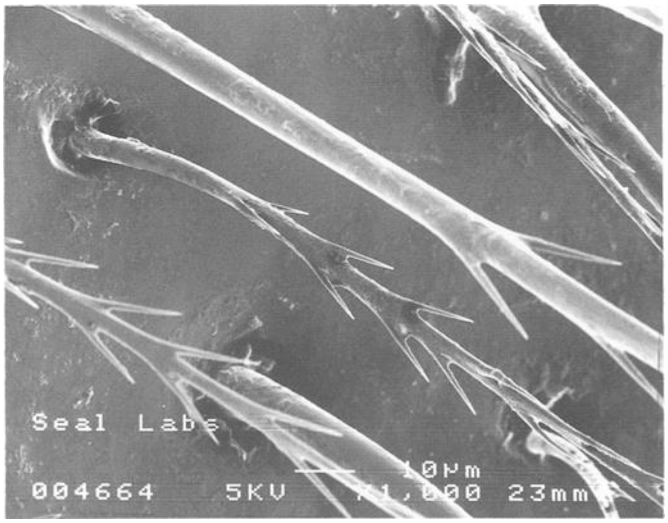

FIG. 6—*Scanning electron micrograph of hairs from postgenal area of head of* Ashmeadiella *showing branching that matched that of hair in pollen clump found in B2 elbow.*

Each of these data by itself supported our hypothesis that megachilid bees had nested in the wreckage, and together they were virtual proof of megachilid involvement. The presence of the branched hair in the pollen clump left no doubt that the blockage in the B2 elbow was indeed the remnants of a nest of *Ashmeadiella*. We could further conclude that the nest had never been completed by the female making it because the pollen had not yet been eaten and there was no indication that the cell had been closed.

Had there been an opportunity for the *Ashmeadiella* and *Osmia* to nest in the wreckage? Examination of the storage area by the expert witnesses on the defense team showed that there was an abundance of *Sphaeralcea* adjacent to the storage yard containing the wreckage. Because of the deterioration of the cardboard storage boxes, bees had ample access to the wreckage. Since the wreckage (including the fuel control unit) had been stored there from May to October 1990, the tubing and fittings were available for nest sites for the entire period of adult activity during that year.

In addition, a trip to the crash site by the expert witnesses for the defense revealed the extent of the fire that had accompanied the crash. The fire had been so hot that it melted aluminum. Not only the nest components but also the dead adult *Osmia* and *Ashmeadiella* would have been completely incinerated had they been present in the plane at the time of the crash. Clearly, then, contamination of the wreckage was a post-crash phenomenon.

Additional Information

This exercise in forensic melittology contributed new information concerning bee biology. We had never known for certain the nature of the gummy material used by *Ashmeadiella* in nest construction. Rozen (2) had suggested that nectar might account for the hardened cell walls of the ground-nesting *Ashmeadiella holtii* Cockerell. On the basis of that suggestion, the defense team compared honey with the gummy matrix of the B2 elbow. Fourier transform infrared spectroscopy fingerprinting provided the answer, and it is reported in the following paper (Liddell, this series). This leads to a new suggestion, namely that the gummy material in nests of *Osmia* and certain other megachilids is likely also to be a combination of masticated leaves and nectar, and that nectar may be a component of nest material of still other megachilids as well. Spiral closures to brood cells appear to be a unique feature of bees, permitting many bee nests to be distinguished from wasp nests (as well as from abodes of other kinds of insects). Although many ground-nesting bees as well as such wood nesters as carpenter bees were known to close their brood cells with spiral closures, such structures had not been reported from the Megachilidae. It seems likely that the swirl noted in the mass of plant materials in the B2 elbow may be a homolog of the spiral cell closure of other bees.

Acknowledgments

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verdict had been rendered. Notes from this seminar were extensively used in preparation of both this paper and the AIBS symposium in San Diego in 1995.

References

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