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Volatiles in the mandibular gland of *Tetraponera penzigi*: A plant ant of the whistling thorn acacia

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1. Subject and source

Workers of the plant ant, *Tetraponera penzigi*, were collected at the Mpala Research Centre in the Laikipia District in Kenya (36° 50′ E, 0° 15′ N).

2. Previous work

There are two genera of the pantropical, arboreal, twig-dwelling ants of the subfamily Pseudomyrmecinae, *Pseudomyrmex* and *Tetraponera*. Mandibular gland contents have been described for three species of *Pseudomyrmex* (Wood, 2005), but no previous studies have been done on the mandibular gland secretion from any *Tetraponera* species. *T. penzigi* is one of the four species of plant ants that are obligate symbionts of the whistling thorn acacia, *Acacia drepanolobium* in Kenya and Tanzania (Hocking, 1970; Young et al., 1997). The composition of the mandibular gland secretion of three other *A. drepanolobium* symbionts, *Crematogaster mimosae*, *Crematogaster nigriceps* and *Crematogaster sjostedti* has been reported (Wood and Chong, 1975; Wood et al., 2002).

3. Present study

Swollen thorn domatia of *A. drepanolobium* containing *T. penzigi* were collected from 10 different trees, pooled and within 1 h were placed in a freezer to kill the ants. After 1–4 h in the freezer, the heads of 50 individual ants were placed in glass vials with Teflon-lined stoppers containing 2.0 ml of dichloromethane. A second sample of 50

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heads for each species was likewise collected for comparison. Decapitation and storing ant heads in solvent is a standard method for extraction of the mandibular gland secretions of ants when they cannot be analysed immediately (Blum et al., 1969; Brand and Pretorius, 1986; Crewe et al., 1970, 1972; Schlunegger and Leuthdold, 1972; Wood and Chong, 1975; Wood et al., 2002; Wood, 2005). The volatile compounds in the extracts were examined by gas chromatography–mass spectrometry (GC–MS) as described by Wood et al. (2002). The relative amounts of each component were calculated from the total ion current and are reported as an average (and standard deviation) of the two 50 ant head samples. Impurities identified in control samples of dichloromethane were not reported, nor were minor components less than 1.0%.

The extracted compounds were identified by comparison of mass spectra in the NIST 1998 computerised mass spectral library and were confirmed by comparison of retention time and mass spectra of authentic samples (Table 1). One compound (retention time 9.04 min) could not be identified using the mass spectral library. It had the following EIMS: $m/z = 112(6), 98(11), 97(71), 96(10), 85(17), 84(31), 83(12), 70(36), 69(41), 68\ (11), 57(31), 56(37), 55(100), 43(69), 42(14)$, and 41(38).

4. Ecological significance

The four ant species exclusively living on the whistling thorn acacia in the area near Mpala Research Centre tend to occur on trees of different size (Young et al., 1997). *T. penzigi* colonies are most often found on trees of small stature (<1 m tall), and are early successional residents that are typically evicted later by competitively dominant colonies of *C. nigriceps*, *C. mimosae* or *C. sjostedti* (Palmer et al., 2000). The process of tree takeover may take several months, during which time *T. penzigi* and the *Crematogaster* spp. coexist on different parts of the same tree.

Periods of active conflict between the co-occurring colonies are typically punctuated by intervals of détente. During these intervals, when individual *T. penzigi* were observed to encounter *Crematogaster* ants at a boundary between the two species, *T. penzigi* flattened itself and remained motionless until the *Crematogaster* ants moved away (Young et al., 1997; Palmer et al., 2002). Normally, ants of different species or colonies will attack intruders. Because the mandibular gland secretion *T. penzigi* is similar to those of the *Crematogaster* ants (Wood et al., 2002), it is possible that *T. penzigi* is using this secretion as a chemical camouflage during these encounters. Ant mandibular gland secretion has been suggested as a source of nestmate recognition odor (Jaffe and Sanchez, 1984a,b) as well as modulators of alarm signals (Hölldobler and Wilson, 1990).

All of the compounds identified from *T. penzigi* have previously been identified in the mandibular secretion of the three *Crematogaster* symbionts of *A. drepanolobium* (Wood et al., 2002). 3-Octanone and 3-octanol are major components in the mandibular gland secretions of *T. penzigi* and the three *Crematogaster* spp. The secretions of *T. penzigi* and *C. nigriceps* are the most similar – the only unidentified compound in *T. penzigi*'s secretion was not observed in that of *C. nigriceps*. *C. sjostedti*'s secretion contains six of the eight compounds identified in the secretion of *T. penzigi*, while *C. mimosae* has five of eight compounds in common with *T. penzigi*.

The secretion from *T. penzigi* is much less complex than that from the other members of the subfamily Pseudomyrmecinae that have been investigated. A composite of 50 compounds was observed in the neotropical acacia ant symbionts of the bull horn acacia (*Acacia collinsii*), *Pseudomyrmex flavicornis*, *Pseudomyrmex spinicola*, and *Pseudomyrmex nigrocincta* (Wood, 2005). Five of the nine compounds from *T. penzigi*, 3-hexanone, 3-hexanol,

Table 1
Major volatile compounds in the mandibular glands of *T. penzigi*

Compound	Retention time (min)	% of TIC
3-Hexanone	4.76	13.1 ± 1.8
3-Hexanol	4.91	8.4 ± 3.2
3-Methylbutanoic acid	5.61	1.8 ± 1.1
3-Octanone	7.02	21.2 ± 3.0
3-Octanol	7.08	4.0 ± 2.4
2-Methylhexanoic acid	7.35	5.3 ± 1.2
Phenylacetaldehyde	7.46	3.1 ± 0.2
2-Phenylethanol	7.91	35.6 ± 14.3
Unknown	9.04	7.4 ± 7.7

3-octanone, 3-octanol and 2-methylhexanoic acid, were observed in *Pseudomyrmex* sp. 3-Methylbutanoic acid, phenylacetaldehyde, and 2-phenylethanol were not reported in the *Pseudomyrmex* sp. secretion.

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References

Blum, M.S., Crewe, R.M., Sudd, J.H., Garrison, A.W., 1969. J. Ga Entomol. Soc. 4, 145.
Brand, J.M., Pretorius, V., 1986. Biochem. Syst. Ecol. 14, 341.
Crewe, R.M., Brand, J.M., Fletcher, D.J.C., Eggers, S.H., 1970. J. Ga Entomol. Soc. 5, 42.
Crewe, R.M., Blum, M.S., Collingwood, C.A., 1972. Comp. Biochem. Physiol. B 43, 703.
Hocking, B., 1970. Trans. R. Entomol. Soc. Lond. 122, 211.
Hölldobler, B., Wilson, E.O., 1990. The Ants. Belknap Press, Cambridge.
Jaffe, K., Sanchez, C., 1984a. Acta Cient. Venez. 35, 270.
Jaffe, K., Sanchez, C., 1984b. Insectes Soc. 31, 302.
Palmer, T.M., Young, T.P., Stanton, M.L., 2002. Oecologia 133, 372.
Palmer, T.M., Young, T.P., Stanton, M.L., Wenk, E., 2000. Oecologia 123, 425.
Schlunegger, U., Leuthdold, R.H., 1972. Insect Biochem. 2, 150.
Wood, W.F., Chong, B., 1975. J. Ga Entomol. Soc. 10, 332.
Wood, W.F., Palmer, T.M., Stanton, M.L., 2002. Biochem. Syst. Ecol. 30, 217.
Wood, W.F., 2005. Biochem. Syst. Ecol. 33, 651.
Young, T.P., Stubblefield, C.H., Isbell, L.A., 1997. Oecologia 109, 98.