

Glandular secretions of the myrmicine ant *Ocymyrmex laticeps* (Hymenoptera: Formicidae)

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The workers of the thermophilic ant, *Ocymyrmex laticeps*, have large pygidial glands, the contents of which are dominated by indole-3-ethanol, a newly discovered substance in insect secretions. The Dufour glands of workers contain a mixture of saturated, unsaturated and methyl-branched hydrocarbons and small amounts of fatty esters.

Key words: thermophilic ant, Dufour gland, pygidial gland, indole-3-ethanol, hydrocarbons, heptadecene, methyl oleate.

INTRODUCTION

Most the 37 species of myrmicine ants in the genus *Ocymyrmex* Forel inhabit hot and arid landscapes in southern and eastern Africa (Bolton & Marsh 1989). They are described as thermophilic, foraging during the hot daytime. They are primarily scavengers (Hölldobler & Wilson 1990: 384), running rapidly over the hot, dry surface, looking for dead and dying arthropods (Marsh 1985). *Ocymyrmex* sp. from the Kalahari Desert has a critical thermal maximum of 55 °C (Turner *et al.* 2000), which even surpasses the record of 53.6 °C of the Saharan species *Cataglyphis bombycina* (Wehner *et al.* 1992). Navigation by *Ocymyrmex* in these circumstances has been studied by Wehner (1987), together with members of the genus *Cataglyphis*, which forage in similar ways. *Ocymyrmex* are thought to forage individually, which is consistent with the view of Ruano *et al.* (2000), who pointed out that individual foraging is linked with high surface temperatures. Except for the studies of Wehner (1987) on navigation, and that of Forder & Marsh (1989) on social organization and reproduction, *Ocymyrmex* has received relatively little attention. A survey of literature since 1980 revealed nothing on the chemical ecology of the genus, and no publications of any kind on the species *Ocymyrmex laticeps* Forel, 1901. We report here on the Dufour gland and pygidial gland secretions of this little-known species.

MATERIAL AND METHODS

Foraging workers of *Ocymyrmex laticeps* were collected and dissected in Kenya. Samples of

individual worker Dufour and pygidial glands were separately placed in soft glass capillary tubes, one gland per tube, and sealed in a small flame for transport to the chemical laboratory, as described by Morgan (1990).

Analysis by linked gas chromatography and mass spectrometry (GC-MS) was carried out using a Hewlett Packard 5890 Gas Chromatograph and 5970B Mass Selective detector with HP59970C ChemStation. The column was a fused silica capillary column (12 m × 0.2 mm) coated with HP-1 (methyl silicone equivalent to OV-1) with 0.33 µm film thickness. The column was linked to the mass spectrometer by a deactivated fused silica capillary (10 m × 0.2 mm). The carrier gas was helium at 1 ml/min. For Dufour glands the oven was held at 30 °C for 2 min, then heated at 8 °C/min to 200 °C and held there 2 min. For the pygidial glands, the GC oven was held at 30 °C for 10 min, then heated at 4 °C/min to 200 °C. The mass selective detector was set to scan the ions from *m/z* 36 to 450 at about 1.7 scans/sec using 70 eV ionization. Samples in their glass capillaries were introduced into the GC with the solid sampling device described by Morgan (1990).

A series of straight-chain hydrocarbons were available for comparison of retention times and mass spectra. Indole and skatole were commercially available. Indole-3-ethanol was prepared from indole-3-acetic acid by reduction with LiAlH₄.

RESULTS

The majority of the components found in the Dufour glands are saturated and unsaturated straight chain hydrocarbons, very similar to those

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Table 1. Mean composition of the secretion of Dufour gland of workers of *Ocymyrmex laticeps* ($n = 5$). The numbers of the compounds correspond to those in Fig. 1.

Number	Compound	Method of identification ^a	Mean	
			%	±S.D.
1	Tridecane	RT, MS	0.1	0.1
	7-Methyltridecane	RT, MS	0.02	0.04
2	Tetradecane	RT, MS	0.6	0.68
3	Pentadecene	MS	1.7	1.7
4	Pentadecane	RT, MS	29.4	25.7
	7-Methylpentadecane	RT, MS	0.02	0.04
	3-Methylpentadecane	RT, MS	0.2	0.5
5	Hexadecadiene	MS	0.1	0.2
6	Hexadecene	MS	1.0	1.1
7	Hexadecane	RT, MS	1.3	1.0
	Dodecyl acetate	RT, MS	0.1	0.2
8	Heptadecadiene	MS	5.6	4.0
9	Heptadecene	MS	36.0	18.3
10	Heptadecane	RT, MS	8.7	2.9
	Octadecadiene	MS	0.02	0.05
11	Octadecene	MS	0.1	0.2
12	Octadecane	RT, MS	0.1	0.3
13	Nonadecane	RT, MS	0.5	1.1
	Isopropyl tetradecanoate	MS	1.5	2.0
	Methyl palmitoleate	RT, MS	0.2	0.3
14	Methyl palmitate	RT, MS	0.6	0.6
15	Eicosene	MS	0.5	1.1
16	Heneicosene	MS	t ^b	–
	Methyl linoleate	MS	2.6	3.7
17	Methyl oleate	RT, MS	6.9	8.6
18	Methyl stearate	RT, MS	1.8	2.6
Mean total amount (ng)			566	

a: RT is retention time, compared with an authentic specimen; MS is mass spectrum, either in our own library or the NIST library of spectra.

b: t is trace amount (less than 0.02%).

found in many other myrmicine species. The principal substances were heptadecene and pentadecane. There was not sufficient material to determine the double bond positions in the alkenes. Small amounts of methyl-branched hydrocarbons, methyl esters of common fatty acids, an acetate and an isopropyl ester were also found (Table 1). These compounds were all identified by comparison of their mass spectra with those in our own spectral library.

The pygidial gland had essentially one component, indole-3-ethanol [2-(3'-indole)ethanol, also commonly known as tryptophol], with indole and skatole (3-methylindole) present as little more than traces. The indole-3-ethanol corresponded in mass spectrum and retention time to the synthetic specimen prepared in the laboratory (M^+ 161 (25 %); m/z 130 (100 %), 103 (6 %), 77 (8 %), other

ions at m/z 143, 115, 63, 57 and 39 were all weak), and to spectrum no. 233852 in the NIST/EPA/NIH Mass Spectral Library, version 2.0a, 2002. The chromatograms seemed to be contaminated with some of the Dufour gland secretion. These substances were found to be the same and in the same proportions as those found in the Dufour gland analyses, but they have been included in Table 2, since we have no firm evidence that they are not truly in the pygidial gland.

DISCUSSION

The hydrocarbon mixture in the Dufour gland was not unexpected, and resembles that found in many other myrmicine and formicine ant Dufour glands. The presence of higher esters is less common. The proportions of the components

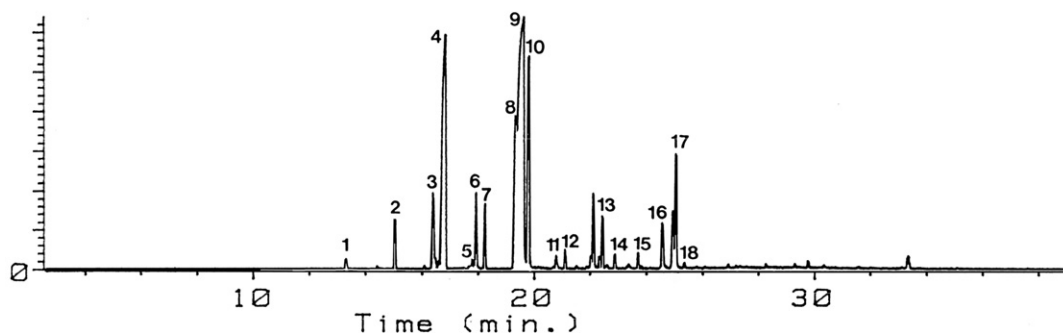


Fig. 1. Typical chromatogram of the secretion of the Dufour gland of a single worker of *Ocymyrmex laticeps*. Numbers correspond to those in Table 1.

were variable, as shown by the values of the standard deviations (Table 1).

The pygidial or anal gland can be found in all ant subfamilies except the Formicinae. It has been described in numerous myrmicine species (Kugler 1978). It has been shown to have an alarm function in three myrmicine genera (*Aphaenogaster*, *Orectognathus* and *Pheidole*) (Hölldobler & Wilson 1990: 239). Dolichoderine ants produce iridoids in their pygidial glands (Attygalle & Morgan 1984), which function as defensive compounds. The aromatic compound 3-hydroxybenzaldehyde was found in

the pygidial gland of the ponerine ant *Rhytidoponera metallica* (Meinwald *et al.* 1983). The very recent first chemical analysis of pygidial gland secretions of a myrmicine ant (Davidson *et al.* 2005) has shown that the secretion of the hypertrophied pygidial gland of *Pheidole biconstricta* contains iridoids, consisting of several isomers of iridodial, dihydronepetalactone and iridomyrmecin, plus actinidine. In this it closely resembles some dolichoderine ants. These compounds are probably defensive or offensive, since they quickly oxidize in air to a sticky, polymeric mass.

Indole-3-ethanol is a new compound in insect secretions. Its structure gives no clue to its function, other than that it is a volatile compound and not subject to polymerization like the iridoids. It is a physiologically active compound, and may therefore have a defensive function. It has been shown to cause rapid and irreversible lysis of human erythrocytes, and induces a sleep-like state and altered body temperature in mice (Seed *et al.* 1978). It has been identified once in a marine organism, a *Halichondria* species of sponge (Li *et al.* 1994). It has been found as a metabolite in many fungi, yeasts and higher plants (Brown & Hamilton 1992; Yuan & Yin 2006). The pygidial gland of *O. laticeps* is large and contained more than 2 μg of indole-3-ethanol. The compound is presumably biosynthesized in the ant by deamination and reduction of the amino-acid tryptophan. Unfortunately the ants did not survive transport to the laboratory long enough for behavioural experiments to be carried out.

Table 2. Mean chemical composition of the secretion of the pygidial gland of workers of *Ocymyrmex laticeps* ($n = 6$).

Compound	Method of identification ^a	Mean	
		%	\pm S.D.
Indole	RT, MS	0.3	0.3
Skatole	RT, MS	t ^b	—
Tetradecane	RT, MS	0.3	0.2
Pentadecene	MS	0.5	0.4
Pentadecane	RT, MS	5.7	3.9
Hexadecene	RT	0.3	0.3
Hexadecane	RT, MS	0.4	0.3
Heptadecadiene	MS	2.7	1.5
Heptadecene	MS	13.1	5.5
Heptadecane	RT, MS	3.3	1.9
Indole-3-ethanol	RT, MS	70.7	13.5
Nonadecane	RT, MS	0.5	0.6
Eicosene	MS	0.8	0.9
Methyl oleate	RT, MS	0.7	0.9
Mean total amount (ng)		3890	

a: RT is retention time, compared with an authentic specimen, MS is mass spectrum, either in our own library or the NIST library of spectra.

b: t is trace amount (less than 0.02%).

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