THE REPELLENT PROPERTIES OF *MYRICA GALE* TO HAEMATOPHAGOUS INSECT PESTS OF MAN

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Abstract—The oil derived from the leaves of a deciduous shrub, *Myrica gale*, has been evaluated as a repellent against the Scottish biting midge, *Culicoides impunctatus*, and other haematophagous pests of man and livestock. Electrophysiological recording of responses from insect antennae (electroantennograms) demonstrated enhanced sensitivity to the odour of *M. gale* oil, compared to other repellents. Behavioural studies in an olfactometer also demonstrated an increased level of repellency to the odour of *M. gale* oil. Based on these and other results, a commercial repellent for the Scottish biting midge was launched in 1995 (Callanish Myrica), and the prospects for increased use of *M. gale* as a repellent are discussed.

INTRODUCTION

Scottish folklore has long held that the deciduous shrub *Myrica gale* L. (bog myrtle, sweet gale - Myricaceae) has repellent properties against the Scottish biting midge, *Culicoides impunctatus* Goetghebuer. *M. gale* is found throughout the British Isles, being particularly common in bogs and wet heaths of Scotland and Ireland. *C. impunctatus* is the commonest biting midge in the United Kingdom, a severe biting pest of man and livestock, and the scourge of the Scottish Highlands during the summer months, having a particular impact on tourism and outdoor industry, especially forestry (Hendry, 1986; Hendry & Godwin, 1988). The midge is on the wing from late April through until September, during which time they undergo two generations, with a generation period of 6 weeks (Blackwell *et al.*, 1992). The female midges are autogenous, not requiring a bloodmeal to oviposit their first egg batch, but bloodmeals are necessary for subsequent egg batches, usually derived from large mammals (Blackwell *et al.*, 1994a; 1995). As potential bloodmeal hosts are relatively scarce in the Scottish Highlands, however, the midges will feed opportunistically on human blood.

Stuart (1990) initially studied the repellent effects of *M. gale* oil against *C. impunctatus*, with promising results. This study reports on a combination of electrophysiological and behavioural techniques undertaken to confirm and quantify the repellent effects of *M. gale* oil against *C. impunctatus*, and presents initial results demonstrating the oil's repellent properties against other pests of man and livestock.

MATERIALS AND METHODS

Source of insects

Non blood-fed, parous female *C. impunctatus* (the Scottish biting midge) were collected from a field study site at in Argyll; non-blood fed female *C. nubeculosus* Meigen (another common biting midge in the UK) and *Aedes aegypti* (L.) (the yellow fever mosquito) were obtained from laboratory cultures at the University of Dundee, and gravid female blowflies (*Lucilia sericata* and *Calliphora erythrocephala*) were obtained from a laboratory culture at the University of Edinburgh.

Electrophysiology

Electroantennograms (EAGs) were recorded from excised heads using silver electrodes, according to established methods (Evans and Allen-Williams, 1992; Blackwell *et al.*, 1994b). The signal was

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amplified and interfaced to an IBM PC for data recording and analysis (Syntech, Hilversum, The Netherlands). Test odours were introduced into a filtered, humidified airstream (600 ml min^{-1}), (0.5s stimulus duration) and the responses were normalised according to a standard stimulus before and after each experimental stimulus. Control values (diethyl ether solvent only) were subtracted from the normalised values to give final, absolute EAG values (n = 10– 15).

For all insects (except *C. impunctatus*), the commercially available insect repellents N,N,-diethyl-3– methyl-toluamide (DEET) and citronellol were also tested along with *M. gale* oil.

Y-tube Olfactometer

Behavioural 'choice' experiments were carried out in a Y-tube olfactometer, following established methods (Blackwell *et al.*, 1994b). Insects (10– 20 per trial for midges and mosquitoes; singly for blowflies n=100 per replicate, 8 replicates per test concentration) were presented with a choice between solvent and a test odour, each connected to a different arm of the 'Y'. Charcoal-filtered, humidified air was drawn through each arm at 150 ml min^{-1}.

For all insects (except *C. impunctatus*), the commercially available insect repellents N,N,-diethyl-3– methyl-toluamide (DEET) and citronellol were also tested along with *M. gale* oil.

RESULTS

Electrophysiology

The response of *C. impunctatus* antennae to *M. gale* oil is shown in Fig. 1. All test insects were electrophysiologically sensitive to *M. gale* oil, with the haematophagous midges and mosquitoes

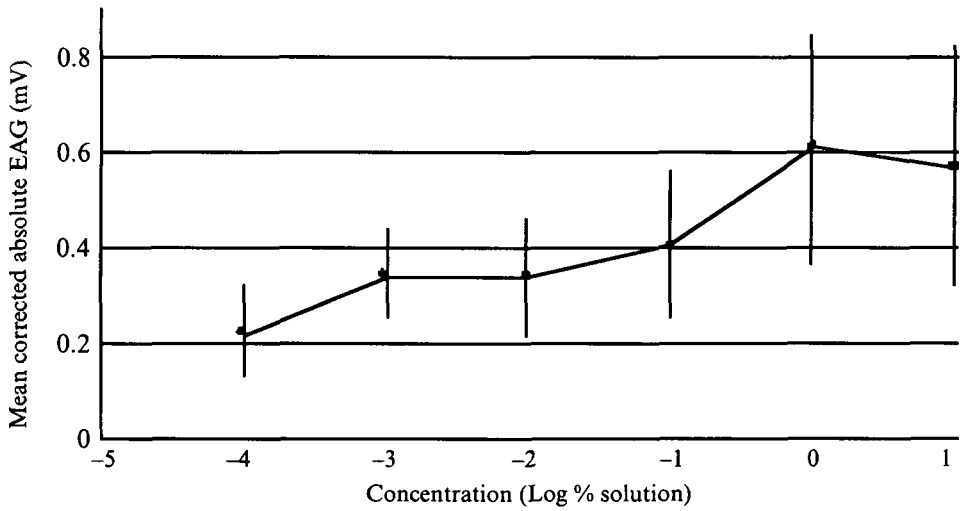

Fig. 1. Mean EAG dose-response curve of non blood-fed female *C. impunctatus* to *M. gale* oil (n=10, ± SE)

Table 1. Electrophysiological thresholds of the test insects for *M. gale* oil, DEET and citronellol (NDT - no detectable threshold)

	M. gale oil	DEET	Citronellol
C. impunctatus	10^{-4}%	-	-
C. nubeculosus	10^{-4}%	10^{-4}%	10^{-3}%
Ae. aegypti	10^{-3}%	10^{-3}%	10^{-4}%
L. sericata	0.1%	NDT	NDT
C. erythrocephala	0.1%	NDT	10%

being 2– 3 orders of magnitude more sensitive than the blowflies (Table 1). DEET and citronellol elicited virtually no responses from the blowflies and although active with *C. nubeculosus* and *Ae. aegypti*, elicited smaller EAG responses than *M. gale* oil.

Olfactometer studies

M. gale oil was significantly repellent with all test insects (Table 2). DEET showed some repellency with *C. nubeculosus*, although the results did not attain statistical significance and citronellol was only significantly repellent at the highest concentration (10%), (Table 2). Neither DEET or citronellol were significantly repellent with *Ae. aegypti*, although DEET did show some degree of repellency at higher concentrations, but this was not statistically significant. Statistically significant repellency to *M. gale* oil was recorded at 1 x 10^{-3}% and 1 x 10^{-2}% for *L. sericata* and *C. erythrocephala* respectively. Neither DEET or citronellol were significantly repellent with the blowflies.

Table 2. Minimum repellent concentrations of *M.gale* oil; DEET and citronellol in Y-tube olfactometer trials (NSD - no significant difference)

	M. gale oil	DEET	Citronellol
C. impunctatus	0.1%	–	–
C. nubeculosus	1%	NSD	10%
Ae. aegypti	1%	NSD	NSD
L. sericata	10^{-3}%	NSD	NSD
C. erythrocephala	10^{-2}%	NSD	NSD

DISCUSSION

The results from the electrophysiological studies demonstrate that all the insects tested are very sensitive to the odour of *M. gale* oil, especially when compared to standard insect repellents such as DEET and citronellol. This sensitivity was also borne out in the results from the olfactometer tests, where all the insect species tested were significantly repelled by *M. gale* oil, surpassing the performance of DEET and citronellol.

Results from field trials (which will be reported in full elsewhere) confirm the repellent nature of *M. gale* oil against *C. impunctatus*, corroborating results obtained by Stuart (1990; pers. comm).

The true repellent nature of *M. gale* oil is an improvement on commercial repellents such as DEET which appear to act only as anti-biting agents, and do not prevent swarms of midges from being a nuisance, even if they are not biting. There has been concern expressed about the relative safety of DEET, which is often sold in concentrations ranging from 30% up to 90%. As a result several commercial repellents based on natural plant extracts such as eucalyptus have been launched in the last few years. A product based on *M. gale* oil was launched in Scotland in 1995 called Callanish Myrica. The potential for *M. gale* as a source of insect repellents may well create a new crop for crofters to grow on land of poor agricultural value should the opportunity arise for use of *M. gale* as a repellent against mosquitoes and other haematophagous pests of man and livestock.

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