

EVALUATION OF A EUCALYPTUS-BASED REPELLENT AGAINST *CULICOIDES IMPUNCTATUS* (DIPTERA: CERATOPOGONIDAE) IN SCOTLAND

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ABSTRACT. A eucalyptus-based insect repellent (PMD) was evaluated against *Culicoides impunctatus* in Scotland in comparison with deet. In human landing catches, both repellents still afforded 98% protection from biting 8 h after application of 0.5 ml to the forearm. A second trial looking at protection between 8 and 10 h after repellent application showed 99.5% protection for PMD and 97% for deet as compared with controls.

In a preliminary laboratory evaluation (Trigg and Hill 1996) a new eucalyptus-based insect repellent (PMD) with principal active ingredient *p*-menthane-3,8-diol was reported to give complete protection from the biting midge, *Culicoides variipennis* Coquillett, for up to 6 h after an application of 0.032 ml to a 90-cm² area of the forearm. In a laboratory trial with the malaria vector *Anopheles gambiae* Giles, PMD was found to be almost as effective as a repellent formulation containing deet (diethyl methyl benzamide). In this paper, a field comparison between PMD and deet against the Scottish biting midge, *Culicoides impunctatus* Goetghebuer is reported.

The trial was undertaken in July 1994 on the Ormsary Estate, Argyllshire, Scotland (56°N, 5°W). The area is dominated by damp, acidic, peat-based soil, rushes (*Juncus acutiflorus* and *J. articulatus*), grass (*Molinia caerulea*), and moss (*Sphagnum* spp.), providing ideal breeding conditions for several species of *Culicoides*, though notably *C. impunctatus* (Blackwell et al. 1994).

A comparison was made between a spray formulation of PMD (50% AI, MASTA, London, United Kingdom) and a spray formulation of Autan[®] (20% deet, Bayer AG, Leverkusen, Germany), when applied to the forearms of 3 human subjects. Repellent was applied to one arm only, at a dose of 0.5 ml delivered from a micropipette and spread evenly from elbow to fingertips. The dose was chosen by team members as a realistic amount as used in practice. Earlier laboratory trials (Trigg and Hill 1996) had suggested that the repellent would give at least 5 h of protection from midge biting; therefore, the dose was applied and left untouched on the arm 5 h before the start of the biting catch. On any one day, one subject applied PMD, one applied deet, and one remained an untreated control, with the treatments being rotated daily over a 3-day period.

Arms were exposed to midges hourly over a period of 3 h. Due to very high numbers of midges in the area the exposure time was limited to 10 min in each hour as longer periods of exposure would have resulted in unnecessary suffering by the subjects involved. Subjects stood spaced at least 3 m apart with their test arm exposed but all other skin surfaces covered. The test arm was observed closely over the 10-min period and all midges that were biting were collected using an aspirator and blown into a tube of alcohol to be counted and identified later. Midge biting behavior is influenced by factors such as light intensity, wind, and temperature. To maintain uniform control biting levels, we found it necessary to use 2 sites throughout the course of each catch. Early evening tests were conducted in a wood; later evening tests were conducted outside the laboratory with a carbon dioxide supply switched on to attract midges, with subjects standing approximately 1.5 m from the supply.

The results of the 3-day trial showed that PMD and deet gave complete protection for 6-7 h, and by the end of 8 h protection remained high, at 98%. An additional 3-day trial was conducted, this time applying repellents 8 h before the start of collections and continuing until 10 h after repellent application.

Both deet and PMD showed strong repellency for up to 10 h against *C. impunctatus* (Table 1) with no apparent difference between them. Although complete repellency was lost, protection afforded for up to 8 h after application was on average 98% for both repellents. In the additional trial to assess the repellent 8-10 h after application protection remained high, at 99.5% for PMD and 97% for deet.

The present study and laboratory investigations (Trigg and Hill 1996) have demonstrated that PMD is an effective midge repellent. The high level of protection is very encouraging, as

Table 1. Total number of *Culicoides impunctatus* (No.) collected by individual subjects treated with either PMD or deet and protection time until first bite in minutes (PT) over 3-day periods.

| Person | Time after repellent application | | | | | | | |
|--------|----------------------------------|-----------|---------------|------------|---------------|---------|-----------|------------|
| | 5-8 h | | | | | 8-10 h | | |
| | Control | PMD spray | | Deet spray | | Control | PMD spray | Deet spray |
| No. | No. | PT | No. | PT | No. | No. | No. | |
| A | 460 (1) ¹ | 1 (3) | 480 | 1 (2) | 420 | 199 (1) | 1 (2) | 25 (3) |
| B | 332 (2) | 18 (1) | 360 | 5 (3) | 360 | 495 (3) | 2 (1) | 0 (2) |
| C | 215 (3) | 1 (2) | 480 | 16 (1) | 360 | 233 (2) | 2 (3) | 0 (1) |
| Mean | 335.7 | 6.7 | 440.0 | 7.3 | 380.0 | 309.0 | 1.7 | 8.3 |
| | | | (7 h, 20 min) | | (6 h, 20 min) | | | |

¹ The day on which each test was done is shown in parentheses.

in many parts of the world (including the west of Scotland) *Culicoides* spp. constitute a major seasonal biting nuisance resulting in severe disruption to outdoor activities (e.g., forestry and tourism). That PMD gave as high a level of protection as deet is also encouraging. The majority of commercially available repellents contain deet, but there are disadvantages associated with its usage, which stem from its activity as a solvent of paints, varnishes, and some plastics and synthetic fabrics. Unlike deet, PMD does not possess these undesirable solvent properties. Further trials conducted against anopheline mosquitoes in Tanzania (Trigg 1996) have also demonstrated PMD to be comparable to deet in terms of efficacy and longevity. These studies suggest that PMD is an effective alternative to deet and will be important in the armory of personal protection against biting insects.

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