Melanophila unicolor Gory, 1841 (Buprestidae), the furnace beetle, in southern Africa

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Recently, large numbers of *Melanophila unicolor* Gory, 1841 were attracted to furnaces and cooling copper at a smelter at Tsumeb, Namibia, where the beetles are colloquially known as 'furnace-beetles'. The smelter is surrounded by indigenous savanna woodland. The beetles were alleged by workers to inflict a painful bite. Specimens were sent to us for identification; the results are reported in this communication.

There has been considerable confusion over the years about which species of *Melanophila* occur in southern Africa and little documentation that the adult beetles demonstrate the same heat-seeking behaviour reported for the northern hemisphere species. There is one published account of these beetles in South Africa being attracted to a steel foundry (Holm & Bellamy 1985), and a few museum specimens record them collected at camp fires and near industrial furnaces of some kind. However, all South African members of the genus possess the same infrared receptors that are a major taxonomic character differentiating them from related genera, thus they can be presumed to be thermophilous.

Melanophila primarily is a Holarctic genus consisting of 12 species with, until the present study, possibly more than one species known from southern Africa. All Holarctic species are associated with freshly-burnt conifers which provide food for the wood-boring larvae (Evans 1964), although one North American species, *M. occidentalis* Obenberger, 1928, regularly breeds in a variety of broadleaf trees and shrubs (Barr & Linsley 1943). The southern African records are from savanna areas where conifers are absent, suggesting *Melanophila* in South Africa regularly utilises non-conifer hosts.

From specimens examined in two South African museums (National Collection of Insects, Agricultural Research Institute, Pretoria, and Ditsong National Museum of Natural History, Pretoria) and those collected recently at Tsumeb in Namibia that we identified using keys and descriptions in Cobos' (1987) revision of the genus, we concluded that only one species, *M. unicolor* Gory, occurs in southern Africa (Botswana, Namibia, South Africa and Zimbabwe – this study, and Angola and Mozambique – Bellamy 2008). However, there are various names applied to the small number of specimens in the above museums which are either synonyms of extralimital species or refer to species known from other regions.

Names that have been attributed to southern African specimens are *M. nigrita* (Fabricius, 1798), *M. lugubrina* (Fåhraeus, 1851) and *M. cuspidata* (Klug, 1829). *Melanophila nigrita* is considered a synonym of the widespread Palearctic species *M. cuspidata* and *M. lugubrina* is considered synonymous with *M. unicolor* (Cobos, 1987). Thus in our interpretation of the genus, there are two Palearctic species also found either in West Africa (*M. cuspidata*) or North Africa (*M. gestroi* Obenberger, 1923), but only one southern African species, *M. unicolor* (Fig. 1).

Adults of both sexes are strongly attracted to burning trees, where mating takes place and where females lay eggs under the bark of smouldering wood. They appear to be able to tolerate far higher temperatures than most other insects and have been seen to perch adjacent to glowing timber and sit on metals hot to the human touch (Evans 1964, 1966a, b, 2005). The actual temperature that they experience or for how long they can tolerate these high temperatures have not been measured; however, there is one anecdotal report of *M. unicolor* (as *M. nigrita*) being able to tolerate temperatures of up to 60 °C (Holm & Bellamy 1985). It is surmised that the females approach as close as possible to the burnt or burning wood because the heat destroys plant secondary metabolic products in the wood that may supress or restrict development of the wood-boring larvae. The species probably also gain a competitive advantage by being the first to find and exploit newly available resource ahead of other species of wood-boring beetles (Evans 1971). Larvae only develop in wood of trees freshly-killed by fire

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Fig. 1. Dorsal view of *Melanophila unicolor* (Gory). Pronotal sculpture and the shape of the elytral apices include diagnostic characters of the species.

(Evans 1964), although adults of the Holarctic *M. acuminata* (DeGeer, 1774) have been observed ovipositing on conifers cut for lumber (Evans 1962). In southern Africa and North America, adults have been reported to bite when they land on a person. Workers at the copper smelter in Namibia claimed the bite is painful, and Linsely & Hurd (1957) state that the beetles are 'heartily disliked' by workmen at cement plants in southern California. This may be related to their apparent insect-eating habits – adults have been observed feeding on scorched insects in the field (Ricksecker 1885) and readily consume insect prey in captivity (Evans 1962), a highly unusual but understudied deviation from the diet of their pollen- and foliage-feeding relatives.

Melanophila beetles detect smoke and infrared radiation from burning trees using two independent systems; antennal smoke detectors (Schütz *et al*. 1999) and thoracic infrared sensors (Evans 1964, 1966a, b, 2005). It has not been established, though, how information acquired by the systems is neurally integrated.

Infrared wavelengths are longer (about 750 nm – 1 mm) than those of visible light and are produced by warm objects radiating heat. Some insects are capable of sensing infrared wavelengths from radiant heat with special sensors that process them into a sensory signal in the brain. Heat sources of importance to insects in nature are produced by warm-blooded animals such as birds and mammals, and some of their parasites use the infrared rays they produce as orientation cues. Mosquitoes also use it as one of a suite of cues to locate their hosts (Jones 2013). However, the most remarkable example of infrared detection has been recorded in members of the jewel beetle genus, *Melanophila* (Evans 1964, 1966a, b, 2005; Vondran *et al*. 1995; Schmitz *et al*. 2007).

The use of antennal smoke-detectors is unknown in any other insect species, and the paired, mesothoracic, infrared detecting pit organs are more complex than any other similar biological system yet discovered. They are well-known in blood-feeding insects such as bedbugs, in so-called pitviper rattlesnakes, some boas and pythons, as well as in vampire bats (Evans 2005). In the U.S.A., *Melanophila* beetles have been recorded to fly across a barren, desert landscape to an oil-fire over distances of some 80 km from the nearest conifer forests. Smoke detection and infrared attraction by the Holarctic species, *M. acuminata*, have been thoroughly investigated, and from general reports and anecdotal information it appears as if all species in the genus have the infrared detectors on the thorax (Sloop 1937) and use them to aid in detecting fires (Evans 1964, 1966a, b, 2005).

In the U.S.A. and Europe *Melanophila* species have been attracted to forest and oil fires as well as industrial heat-producing processes such as smelter plants and burning rubbish in refuse dumps. An early record from Britain quotes '…scorched by the burning peat and half choked by the blinding smoke, we added quite a novel episode to our experiences in collecting beetles, for on the ground on which it was too hot to place one's hand, many *Melanophila* were running. They were settled…on pine stumps actually glowing…or flying through drifts of acrid peat smoke' (Sharp 1918). An equally delightful anecdote from California in the 1940s quotes beetles being attracted to a football stadium during matches

Fig. 2. Ventral view of *Melanophila unicolor* (Gory) illustrating infrared sensory pits adjacent to mesocoxae.

'… where they occasionally swarm in sufficient numbers to annoy patrons by … or even biting the neck or hands. It is possible that in this case the beetles are attracted by the smoke from some 20 000 cigarettes, which on still days sometimes hangs like a haze over the stadium…' (Linsley 1943).

The paired infrared sensory pit organs lie adjacent to the coxae of the middle legs (Fig. 2). They are 450 μm × 200 μm in diameter and consist of about 70 domed sensilla at the bottom of the pit (Fig. 3). Each sensillum is a domed-shaped structure covered by very thin cuticle (1 μm), and each is accompanied by a multiporous wax gland that continuously produces wax filaments which completely fill the pit with a three-dimensional network of coalesced wax fibres. These are thought to protect the sense organs from dust particles and to help reduce water loss through the thin cuticle in the area (Vondran *et al*. 1995; Schmitz *et al*. 2007).

The sensilla are derived from common mechanoreceptors (sensilla trichodea) (Vondran *et al*. 1995; Schmitz *et al*. 2007). Maximum sensitivity is for wavelengths of about 3 μm (range of 2.5 μm to 4.0 μm) and an energy level of $6.0–10^{-5}$ W/cm^2. This sensitivity range is equivalent to

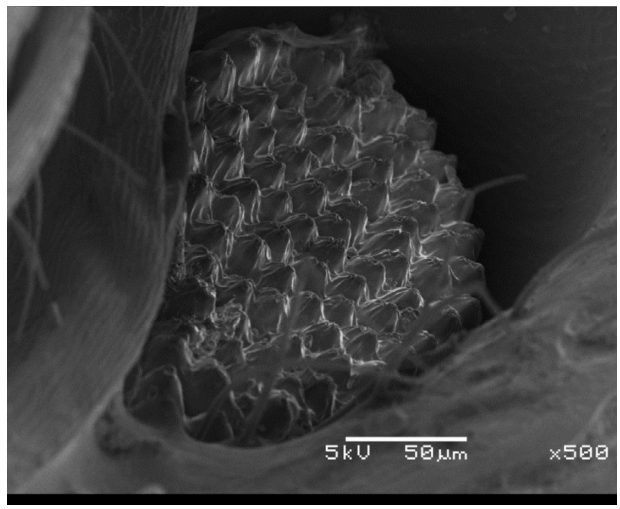

Fig. 3. Scanning electron micrograph (×500 magnification) of an infrared sensory pit on *Melanophila unicolor* (Gory), illustrating surface structure.

the radiation energy of a forest fire generating temperatures of between 425 °C and 1150 °C and perceived over a distance of many kilometres. The sensory pits are exposed during flight which probably allows the beetles to steer tropotactically (using each of the pits to independently and alternately assess the signal) and orientating towards the infrared source.

The antennal smoke detectors are responsive to various volatile chemicals that are emitted by burning wood (pyrolysis), of which guaiacol elicits the greatest response (Schütz *et al*. 1999). Guaiacol results from pyrolysis of lignin and, when bound to oxygen, turns yellowish-brown; it is the substance that imparts the typical colour of, and smoky taste, to smoked food. However, burning wood produces a suite of different volatiles, many of which are, no doubt, specific to the particular tree burning, and which the beetles may use to identify preferred larval host tree species.

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