Scramble competition by males of the velvet ant

*Nemka viduata* (Hymenoptera: Mutillidae)

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Abstract
The mating systems of mutillid wasps have rarely been studied. Here we present information on the mating system of *Nemka viduata*. At a site in southern Spain, many males of this species were seen flying over host (digger wasp) nest aggregations while searching for females. Male activity was greatest in the early morning and late afternoon, when females were more active searching for hosts, and on days when relatively large numbers of females were active. Males were not territorial but instead attempted to find emerging females before their competitors. As many as six males might arrive at a receptive female more or less simultaneously. Struggles to control access to females continued until one male copulated with the female on the ground or carried it off in flight to a location away from rival males. Male size seems to affect the patrolling behaviour (number of patrolled sites), but there is little evidence of an advantage for larger males, as expected in a scramble competition mating system. Scramble competition mating systems often evolve in species in which large numbers of males compete for scarce receptive females, a factor that makes male territorial defence of large areas highly costly.

Keywords
Mutillidae, body size, reproductive biology, scramble competition.

1. Introduction
Little is known of the mating behaviour of the Mutillidae, a parasitoid wasp family within the Vespoidea whose members are often referred to as velvet ants. Most researchers have focused on the taxonomy of the group (Schmidt, 2006) or on the hosts parasitized by mutillids, largely other aculeate hymenopterans (Brothers et al., 2000; Polidori et al., 2009a, 2010a). Wingless
female mutillids search for nests of their hosts, which may be solitary or social species, ground-nesting or wood-nesting. Females usually enter nests when hosts are absent (in the early morning or late afternoon) in order to deposit eggs on the mature larvae or prepupae of their host species (Brothers et al., 2000; Polidori et al., 2009a, 2010a). If discovered near or within a nest, female mutillids may be attacked by the nest owner (Polidori et al., 2009a) but are well protected by their thick cuticle, powerful sting and other adaptations (Schmidt & Blum, 1977).

Male behaviour is less well studied than that of females (Bayliss & Brothers, 1996; Tormos et al., 2010) but there are reports of males of some species emerging synchronously with conspecific females (Hennessey, 2002), after which the winged males may search for freshly emerged, wingless females. This pattern is especially likely in aggregations from which many mutillid females may emerge from host nests over the course of the flight season (Polidori et al., 2009a, 2010a). Some observers have suggested that either males or females of some species may stridulate to attract mates (Manley, 1977; Bayliss & Brothers, 1996) but other than laboratory studies of copulatory behaviour (e.g., Bayliss & Brothers, 2001; Bergamaschi et al., 2010), many details of the mating systems of mutillids remain unknown. Here we present the results of a field study of the mating system of *Nemka viduata* (Pallas) a medium-size velvet ant widely distributed in the Mediterranean region (Invrea, 1964). This species is an ectoparasitoid of the immature stages of at least three species of bembecine digger wasps (Crabronidae: Bembecinae) (Grandi, 1951; Tormos et al., 2003).

In this species, as in most mutilids, males are winged and females are apterous. Daily and seasonal activity patterns, spatial distribution and parasitism rate have previously been studied for females of this species (Alicata et al., 1974; Polidori et al., 2010a). However, little is known of male mating tactics (Tormos et al., 2010), a topic that is central to this paper.

2. Materials and methods

2.1. Study area

The study was carried out at ‘La Mallada Larga’ of ‘Dehesa del Saler’ (Valencia, Spain: 39°20′N, 0°40′W) during the Summer of 2008 (July–August). At the study area, a coastal salt marsh with damp sandy soil, *N. viduata* is a