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The function of dart behavior in the paper wasp, *Polistes fuscatus*

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Abstract Dominance behavior in *Polistes* wasps is a composite trait consisting of various discrete behaviors such as darts, lunges, bites, and mounts. The majority of these behaviors are considered ‘aggressive’, and these aggressive behaviors are considered to form a continuum from mild (e.g., darts) to severe (e.g., falling fights). In this paper we focus on darts, the most common of the dominance behaviors, and investigate their function in unmanipulated post-emergent colonies of the primitively eusocial wasp *P. fuscatus*. Here we show that darts are correlated with the more severe dominance behaviors, and that dominance ranks do not change with the addition or exclusion of darts. We find no correlation, however, between receiving darts and receiving more severe dominance behaviors. This result suggests that darts are not indicative of aggressive reinforcement of dominance, but rather may serve a different function. Our data suggest that the function of darts is to regulate activity on nests. Both foundresses and workers dart inactive workers significantly more often than by chance, and workers respond to a foundress’s (but not a worker’s) dart by becoming less inactive. We also found that active workers who receive a dart from either a foundress or worker respond mostly by switching from one activity to another. Thus, our data suggest that darts are not aggressive behaviors, that foundresses use this signal to initiate activity, and that foundresses and workers both use the signal to regulate worker activity.

Introduction

Polistes wasps are primitively eusocial, display slight caste differentiation, and exhibit a great deal of behavioral plasticity (see Turillazzi and West-Eberhard 1996). In temperate regions, the wasp has a defined four-stage colony cycle consisting of founding, worker, reproductive, and intermediate phases. Of interest has been the founding phase, during which time females initiate a nest alone, initiate a nest in association with another female (Reeve 1991), or wait to adopt an orphaned nest (Starks 1998). These characteristics make *Polistes* a model system for the study of the evolution of eusociality, kin recognition, and reproductive conflicts (see, e.g., Starks et al. 1998; Reeve et al. 2000).

Because *Polistes* wasps construct un-enveloped nests and often contain less than 100 individuals, the behavior of individual wasps across the colony cycle has been well documented (Reeve 1991). Given the potential conflict of reproductive interests, attention has been focused on the dominance hierarchy that develops between cooperating foundresses (Pardi 1948). A dominance hierarchy refers to a social organization where group members have different status levels, and studies show that the level that individuals occupy is linked to reproduction and task performance (Pardi 1948; Gamboa et al. 1978; Strassmann 1981).

Dominance behavior is a composite of multiple behaviors such as darts, lunges, bites, mounts, chases, and falling fights (Pfennig et al. 1983), the majority of which are considered aggressive. Both aggressive and non-aggressive dominance behaviors exist, however, and comprise the suite of characteristics that correlate with true dominance (Pardi 1948). The terms aggression and dominance have a specific meaning in this context, and can be defined as: aggression – hostile or threatening behavior; and dominance – control or command over others. *Polistes* researchers often consider aggression a means of displaying dominance, and thus a wasp’s position in a hierarchy can be determined by observing the relative

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