Head shape and bite loading demands in *Pheidole* ant workers

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Abstract

Workers in the ant genus *Pheidole* show an extreme degree of morphological differentiation, with at least two distinct subcastes: minor workers are smaller and perform most of the colony tasks, whereas majors are larger, display disproportionately massive heads, and specialize in roles as defense and food processing. There is considerable interspecific variation in head shape within worker subcastes of *Pheidole*, which could affect how the stresses generated by the mandibular closing muscle contraction (0md1) spread throughout the head and influence bite force. To assess the role of head shape in stress patterns of *Pheidole* workers, we solve a set of Finite Element Analysis (FEA) while exploring variation in *Pheidole* worker head morphospace. We hypothesize that majors possess head shapes optimized for the generation of stronger bites. In addition, we expect that head shapes corresponding to the edges of morphological space in the genus would show mechanical limitations that could prevent further expanding the occupied morphospace. We vectorized *Pheidole* head shapes based on images of worker heads, considering species that represent mean shapes and the edges of the two main axes of each morphospace, for a total of five head shapes for each worker subcaste. We performed linear static FEA simulating the contraction of 0md1. Our results demonstrate that head shapes of majors are optimized to generate stronger bites given that stress generated on those shapes is distinctly directed towards the mandibles. Head shapes of minors tended to concentrate stresses around the mandibular articulations, with substantially lower and more diffuse stresses spreading throughout the head, indicating that such shapes are associated with weaker bites. Our results agree with the expectations regarding the main colony tasks performed by each worker subcaste, and we find some evidence of biomechanical limitations on extreme head shapes for majors and minors.

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