

The number of reproductive workers in highly eusocial Hymenoptera: monogyny and monandry

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ABSTRACT. Haplodiploidy results in relatedness asymmetries between colony members of highly eusocial Hymenoptera. As a consequence, queen and reproductive workers are more related to their own sons than to each other's male offspring. Kin selection theory predicts multiple optima in male parentage: either the queen or the workers should produce all the males. Nevertheless, shared male parentage is common in highly eusocial hymenopterans. An inclusive fitness model was used to analyze the effect of the number of reproductive workers on male parentage shared by the queen and laying workers by isolating the male component from an inclusive fitness equation using the equal fitness through male condition for each pairwise combination of the three female classes comprised of the queen, laying workers and non-laying workers. The main result of the theoretical analyses showed that the fraction of males produced by workers increases asymptotically with the number of laying workers at an increasingly diminishing rate, tending to an asymptotic value of 0.67. In addition, as the number of

laying workers increases, the share of male parentage converges to that of non-laying workers. The diminishing return effect on male parentage share depending on the number of reproductive workers leads us to expect the number of reproductive workers to be relatively small in a stingless bee colony, even in the absence of productivity costs. The available data confirms this hypothesis, as there is an unusually small number of reproductive workers in stingless bee colonies.

Key words: Reproductive workers; Eusocial Hymenoptera; Male parentage; Inclusive fitness; Kin conflict