SEX RATIOS IN NATURAL POPULATIONS OF APHELINUS MALI (HYM.: APHELINIDAE) IN RELATION TO HOST SIZE AND HOST DENSITY

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In an apple orchard at Armidale, the Northern Tablelands of NSW, population sex ratios of Aphelinus mali (Haldeman), an endoparasitoid of the woolly apple aphid, Eriosoma lanigerum (Hausmann) varied from 0.51 (proportion of males) at low host densities to female-biased at high host densities (proportion of males ranged from 0.35-0.39). This shift in sex ratio seems to be caused by the differences in allocation of sons and daughters to hosts of different sizes. In the field A. mali parasitizes all life stages (four nymphal instars and adult) of the woolly aphid upon encountering. According to Hughes' (1979) optimal diet model, such general host acceptance seems to be the best strategy. However, it allows the host nymphs or adults to continue to develop or reproduce until about to mummify (pupate). No mortality was observed when first or second-instar hosts were parasitized in the laboratory. Field collected small mummified hosts yielded male-biased sex ratios whereas large mummified hosts produced mainly females. In the laboratory, progeny from smaller hosts (first to third-instar) produced sex ratios which were not significantly different from 0.5 whereas progeny from larger hosts (third and fourth-instars) produced female-biased sex ratio. During winter (June-August) and early spring (September-October) when the host populations in the orchard were predominantly nymphs, the parasitoid tended to allocate equal resources to male and female offspring. In contrast, at peak population densities in summer and autumn (December-May) when larger hosts were available, the sex ratios were female-biased. The host size of E. lanigerum and A. mali is, therefore, an important component in the dynamics of host-parasitoid interactions.

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et al., 1983). In this context it has been pointed out that one of the factors potentially influencing the success or failure of released natural enemies is sex allocation (Waage & Hassell, 1982). Sex allocation in haplo-diploid hymenoptera has long been considered to have adaptive significance (Charnov, 1979). Fisher (1930) was the first to provide a basic concept for the evolution of sex ratios. He predicted that natural selection favours equal investment of resources in male and female offspring in panmictic populations. This results in a 0.5 primary sex ratio for species in which the cost of producing a son or a daughter is equal, and any deviation from this sex ratio results in a frequency-dependent advantage to the rarer sex (see Werren, 1983).

However, highly variable sex ratios are often found among parasitoids in spatially structured populations (Hamilton, 1967). Several evolutionary models have been proposed to predict sex allocation or sex ratio (defined as the proportion of males among all progeny) particularly, in parasitic wasps (see King, 1987; Waage, 1986). These include (1) Hamilton's (1967, 1979) Local Mate Competition (LMC) theory which predicts that if individuals are distributed in patches in nature and mating occurs among offspring of a single patch (sibmating), female-biased sex ratios should evolve to reduce local competition among male siblings (Taylor, 1981). (2) Charnov (1979) and Charnov et al. (1981) host-quality models also predict that the sex ratios of progeny emerging from smaller hosts tend to be male-biased and those from larger hosts tend to be female-biased. This is made possible because in those solitary parasitic hymenoptera with haplo-diploid sex determination, there is evidence which suggests that adult females of some species can regulate their offspring sex ratio by controlling fertilization: sons develop from unfertilized eggs and daughters from fertilized eggs (see King, 1987). The production of fertilized eggs depends on a variety of physiological and ecological mechanisms, and the operation of these mechanisms influences sex ratio (Clausen, 1939; Flanders, 1946; 1956). However, the model assumes that generally the fitness of a male is less affected by small size than female fitness. This prediction holds regardless of whether mating is local or panmictic (Werren, 1984). (3) Several other factors have been shown to affect offspring sex ratios in some species e.g. superparasitism, female or male wasp density, host density, host sex etc. (see King, 1987). Analytical host-parasitoid models suggest that density-dependent shifts in sex ratio affect the level of equilibrium populations as well as stability of the host-parasitoid interactions (Hassell & Waage, 1984).

A. mali is the major parasitoid of the woolly apple aphid throughout the world. It is regarded as one of the successful examples of biological control of aphids in countries with a Mediterranean climate (Sproul, 1981; van Lenteren, 1990); but has been shown to be ineffective under cool climatic conditions (Miller, 1947; van Lenteren, 1990; Asante & Danthanarayana, 1992).

As part of an effort to evaluate its efficacy against the woolly apple aphid, in this study we examine its sex ratios (emergence sex ratios) under natural conditions using the host quality (size) and host density models. Since there is a seasonal variation in host size (age-specific) (Asante, unpubl.) and host density (Asante et al., 1993) we also examine the relationship between wasp size (length) and its hind tibia, so as to use the hind tibia as an index of wasp size to quantify its fitness in relation to size (Waage & Ng, 1984; King, 1988; Bai, et al., 1992).

MATERIALS AND METHODS

Determination of Host Density

This study was carried out in an apple orchard at the University of New England’s Laureldaile Farm, near Armidale, NSW (30° 14’ latitude and 151° 41’ longitude). The