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Oviposition strategy of the parasitic wasp *Dinarmus basalis* (Hymenoptera, Pteromalidae)

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Summary

Host type choice and sex allocation were examined using the solitary parasitic wasp *Dinarmus basalis* (Pteromalidae, Hymenoptera) parasitizing larvae or pupae of the bean weevil *Callosobruchus chinensis* (Bruchidae, Coleoptera) within azuki beans (*Vigna angularis*). The wasps were offered two types of host; one was hard for the mother to lay eggs in, but was more beneficial for the offspring; the other was easy for the mother to lay eggs in, but was less beneficial for the offspring. The two types of host were one large host (17-day old host) in one bean and 6 small hosts (12-, or 13-day old hosts) in one bean. The same number of each host was presented at the same time to female wasps. The wasps accepted more 17-day old hosts than 12-day old hosts, and more 13-day old hosts than 17-day old hosts in each pair-wise choice experiment. The proportions of accepted host types were different from the proportions predicted by optimization models of random prey encounter with known or unknown prey densities. The wasps showed partial preference of host types. Incomplete information about prey densities, and about the costs and benefits of the two types of host may have generated the partial preference. Two predictions of host size-models, that (1) there should be a negative relationship between host size and offspring sex ratio (proportion of male offsprings), and (2) the sex ratio in each size host changes with the relative frequency of each size host utilized, were qualitatively supported.

Keywords: solitary wasp; host choice; sex allocation

Introduction

Host choice models (which correspond to a diet choice model, e.g. Emlen, 1973; Charnov, 1976; Shoener, 1971; Stephens and Krebs, 1986) present an explanation of offspring allocation among different host types. Host-size models (e.g. Charnov, 1979) present an explanation of offspring sex allocation in different size hosts under a given frequency of host size distribution utilized by the female in parasitic wasps.

Suppose there are some types of host that differ in quality: to accept or reject a host is an important decision problem for female wasps. If a female wasp can find enough high quality hosts relative to the number of eggs which can be laid, then she might reject any inferior hosts that she encounters. On the other hand, if she does not encounter enough high quality hosts on which to lay her eggs, the host utilization pattern depends on two factors: knowledge of prey densities, and the fecundity of the female wasp. Under the assumption of incomplete information of prey densities, optimality theory predicts the on–off rule (a host should either always be accepted or always rejected upon encounter (see Stephens and Krebs, 1986)). This means that if the wasp accepts both superior and inferior hosts when there are a limited number of superior hosts, it may utilize both superior and inferior hosts in proportion to encounter rates. Furthermore, if the wasp has complete information of prey densities but a limited fecundity, she
should lay as many eggs as possible on superior hosts. Discrimination among different quality hosts and accurate information on the availability of each host type are important for optimal behaviour in a given environment.

Many parasitoid wasps are known to adjust sex allocation of offspring under various environmental conditions (van den Assem, 1971; van den Assem et al., 1984; Charnov et al., 1981; Jones, 1982; Waage and Lane, 1984; Waage and Ming, 1984; King, 1987, 1988, 1989, 1990, 1991; Werren and Simbolotti, 1989). The fitness of an ovipositing female is influenced by the allocation of male and female eggs on different size hosts under a given level of local mate competition (Charnov, 1979; Charnov et al., 1981; Werren, 1984; Werren and Simbolotti, 1989). This idea has been referred to as host-size models for solitary parasitoid wasps (Charnov, 1979; Charnov et al., 1981). Host-size models qualitatively predict that for solitary species of parasitoids, mothers should oviposit a greater proportion of the sex that has larger relative fitness in a given host size (Charnov, 1979, 1982; Charnov et al., 1981). For most species of parasitoid wasps examined, there is a negative relationship between proportion of sons and host size (e.g., Charnov et al., 1981; King, 1988, 1990; Fujii and Kihn Mar Wai, 1990). These results suggest that developing on a larger host confers more to the ultimate reproductive success of females than to that of males. Charnov et al. (1981) further predicted that the allocation of sex to a particular host-size class depends on the relative frequency with which other host sizes are utilized.

This paper addresses two separate questions by using a solitary parasitoid wasp (Dinarmus basalis) parasitizing weevil larvae and pupae within beans: (1) whether the wasp manipulates egg allocation between two alternative choices of host types according to the prediction of the theory of optimal host choice (Stephens and Krebs, 1986), and (2) whether the wasp’s manipulation of offspring sex ratio in response to host size and its utilization of the alternative size class of host is consistent with the host-size model (Charnov, 1981).

**Materials and methods**

The experiments were conducted in a growth cabinet controlled at 30 °C, 70% RH and 24 L. Dinarmus basalis (Pteromalidae, Hymenoptera) is an ectoparasite on larvae and pupae of several species of grain and bean weevil. This work used the azuki bean weevil Callosobruchus chinensis (Bruchidae, Coleoptera) infesting azuki beans (Vigna angularis) as the host species in these experiments.

The parasitic wasps tend to avoid superparasitism (Khim Mar Wai and Fujii, 1990). However, if superparasitism occurs, the wasps exhibit contest type competition in the developing stage and, therefore, only one adult wasp emerges from one host (Khim Mar Wai and Fujii, 1990). The ages of hosts used in the experiments were 12-, 13-, and 17-day old since oviposition by mother weevils. Twelve-, and 13-day old hosts are larvae, and 17-day old hosts are pupae. Host weight correlates with the age among the three age classes.

To set host choice situations with the same host species, high aggregations were created for smaller hosts (12-, or 13-day old hosts) and sparse aggregations for large hosts (17-day old hosts) in one bean (details given before). When there are many hosts in a bean, the bean is moistened and the texture of the bean is softer because of the respiration of the hosts. The aggregated hosts are superior in terms of oviposition, but inferior for offspring oviposited. On the other hand, the sparse hosts are inferior in terms of oviposition, but superior in terms of resources for offspring oviposited. Therefore, the small size of the young age hosts may be compensated by the host aggregation making them more available to the mother wasps.

We can easily calibrate the number of host in one bean. An arbitrary number of inseminated