COMPARISON OF THE REPRODUCTIVE INVESTMENT IN COCCIDOPHAGOUS AND APHIDOPHAGOUS LADYBIRDS (COLEOPTERA: COCCINELLIDAE).

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The prey of coccidophagous ladybird beetles has a slower rate of development and is less mobile than that of aphidophagous ladybirds. These differences are paralleled by a suite of characters suggesting that coccidophagous species live at a slower pace than aphidophagous species. Data in the literature tend to indicate that coccidophagous ladybirds live longer and have a lower fecundity than aphidophagous species. Thus the expectation is that coccidophagous species allocate proportionally less resources to their gonads than aphidophagous species. The reproductive investment in *C. montrouzieri* and *A. bipunctata* support this prediction. The fat in gonads represents 27.4 % of the total body fat in *C. montrouzieri* and 37.1 % in *A. bipunctata*.

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INTRODUCTION

Worldwide there have been 155 attempts to control aphids by introducing ladybirds, and only one was supposedly substantially successful, whereas of the 613 such attempts to control coccids resulted in 53 complete or substantial successes (DIXON 2000). Coccidophagous ladybirds are therefore very successful biocontrol agents compared to aphidophagous species. DIXON (2000) suggested, therefore, that the study of ladybird successes and failures in biological control programmes might enable us to identifying the specific attributes of successful biological control agents.

Reproductive potential is generally regarded as an important attribute of natural enemies (e.g., DEBACH 1973; MESSENGER et al. 1976; VAN DRIESCHE & BELLOWS Jr. 1996). STEWART et al. (1991) measured reproductive investment as the egg weight multiplied by the ovariole number and related this to adult weight for 8 aphidophagous ladybirds. There is a very strong positive correlation between reproductive investment and adult weight. Gonads make up a fixed proportion of the body weight, and there is a trade-off in the number of eggs a species can lay per day and egg size. MAGRO (1997) performed the same kind of study on 3 coccidophagous ladybirds, where the reproductive biomass is again a fixed proportion of the total body mass. However, the reproductive biomass in coccidophagous ladybirds makes up a smaller percentage of the total body mass than in aphidophagous species. That is, coccidophagous ladybirds invest proportionally less in reproduction than aphidophagous ladybirds.

DIXON (2000) states that there is a slow-fast continuum in the life history characteristics of ladybirds. When the reproductive investment of coccinellids is considered along with other parameters such as rate of development, relative growth rate, the rate of metabolism, speed of movement, reproductive rate and rate of ageing, coccidophagous species appear to have a slow pace of life and aphidophagous species a fast pace of life. These different paces of life reflect those of their prey.

As fat is the chief form in which energy is stored (WIGGLESWORTH 1972), we decided to verify the above conclusions by comparing the allocation of fat to gonads and soma in an aphidophagous and a coccidophagous ladybird. This paper reports the preliminary results of this study.

MATERIAL & METHODS

Biological material

Two similar-sized ladybird species were studied. *Cryptolaemus montrouzieri* Mulsant is a well-known Australian coccid predator, which has been introduced all around the world to control mealybugs. Adults weigh on average 11.1 mg (MAGRO 1997). *Adalia bipunctata* (L.) is a European aphidophagous ladybird. Adult weight is on average 15.8 mg (STEWART et al. 1991).

Both species came from our laboratory stock cultures: *C. montrouzieri* was reared on potato sprouts infested with *Planococcus citri* Risso and *A. bipunctata* on *Acyrtosiphon pisum* Harris reared from bean plants.

Measure of reproductive investment

The reproductive investment was measured in terms of mg of fat.

The analyses were made on 15 females of *C. montrouzieri* and 14 of *A. bipunctata*. Females were between 15 and 30 days old and were laying eggs regularly.

Each female was weighed (Sartorius Supermicro SC2 balance), dissected and its body cut in three parts: head and thorax, ovaries and abdomen without ovaries. Each part was dried at 35°C until it reached a constant weight. The dried tissues was put in Petroleum spirit (boiling range 40–60 °C) for 9 hours and then the solvent was replaced and the extraction continued for another 9 hours. The tissues were then removed and the solvent evaporated off overnight, after which the tissues were weighed.

Fat contents were estimated as indicated by equations 1 and 2:

$$Ovfat = Ovdw - Ovdws \qquad (1)$$

$$Tfat = Tdw - Tdws \qquad (2)$$

where *Ovfat* is the fat content of gonads, *Ovdw* is the dry weight of the gonads and *Ovdws* is the dry weight of the gonads after fat extraction. *Tfat* is the total fat content of the body, *Tdw* is the total dry weight of the body and *Tdws* is the total dry weight of the body after fat extraction.

Mean values for both species were compared using a t test.

RESULTS & DISCUSSION

Figure 1 presents the results of this study in terms of the mean percentage as well as the standard deviation of fat invested in the gonads of the two ladybirds.

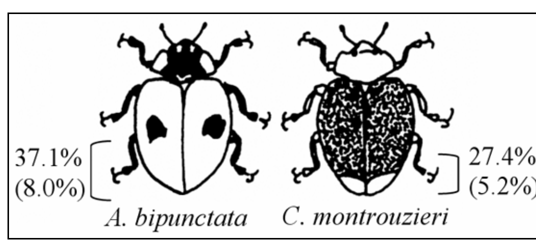

Fig. 1. Mean reproductive investment in an aphidophagous ladybird - Adalia bipunctata - and a coccidophagous ladybird - Cryptolaemus montrouzieri. Results presented in terms of fat in gonads as a percentage of total body fat. Standard deviation values are between parentheses.

Figure 1 indicates that *A. bipunctata* invests more of its energy reserves in reproduction than *C. montrouzieri*: the percentage of fat in the gonads of the aphidophagous species is greater than in the coccidophagous species (aphidophagous: 37.1%; coccidophagous: 27.4%; $P<0.05$). This supports the idea that aphidophagous species invest proportionally more of their fat reserves in reproduction than coccidophagous species of ladybirds.

CONCLUSIONS

The present work strengthens the conclusions of STEWART et al (1991) and MAGRO (1997) as the aphidophagous ladybird allocated proportionally more of its energy reserves to reproduction than the coccidophagous ladybird.

This conclusion is important from two points of view:

The evolutionary point of view: Organism are energy limited (KREBS 1994). Limited resources should be allocated in a way that maximises fitness. That is, reproduction is maximised within the constraints of other energy requirements. Therefore it is relevant to ask: Why do coccidophagous species invest proportionally more of their fat reserves in soma than aphidophagous species? DIXON (2000) argues that coccids in nature are generally much less abundant than the aphid prey of aphidophagous ladybirds and therefore it would appear to be advantageous for coccidophagous ladybirds to allocate more of their energy reserves to searching for prey.

In terms of biological control: A high reproductive investment, although important, does not seem to be an essential characteristic of a successful biological control agent.

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