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RESEARCH ARTICLE

DEVELOPMENT OF TWO SPECIES OF APHIDOPHAGOUS LADYBIRD BEETLES (COLEOPTERA: COCCINELLIDAE) ON ESSENTIAL AND ALTERNATIVE FOODS

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ABSTRACT

Food plays very indispensable role in the development of an organism as it provides energy to cart out daily activities. Ladybird beetles are commonly known as the Farmer's Friends as they are known to feed on a wide variety of insect pests. According to their feeding habits they can be classified into different types viz., aphidophagous, feeding on aphids, coccidophagaous, feeding on coccids and phytophagous feeding on plants. *Cheilomenes sexmaculata* Fabricius and *Coccinella septempunctata* Linnaeus are the most popular aphidophagous ladybird beetles of the Indian region. Apart from feeding on aphids both of them are also known to feed upon psyllids, white flies, mealybugs, tingids, leaf and plant hoppers, mites and early instar lepidopteran larvae. Our study deals with the survival of *C. sexmaculata* and *C. septempunctata* on eight species of aphids as well as on honey and mealy bugs when provided as alternative foods under aphid scare conditions.

INTRODUCTION

Ladybird beetles are incredibly well-liked cosmopolitan insects solely feeding on aphids, mealybugs, scale insects, white flies, thrips, leafhoppers, mites and other small soft bodied insect pests and are identified to predate on about 39 arthropod species (Omkar & Pervez, 2000; Gautam, 1989). Food specificity is an imperative issue in ecology of ladybirds since long time (Hodek, 1967). Thompson (1951) was the first to advocate that many ladybirds are not generalists but have unambiguous food necessities. It is known that aphidophagous ladybirds devour unusual types of food because aphids are copious for petite time period. So it is obligatory to discriminate between essential and alternative foods. Hodek (1996) has manifested foods that uphold larval development and oviposition are well thought-out as essential while foods that act as only as a basis of energy to protract survival can be tagged as alternative foods. Aphids have been recommended to be essential prey for aphidophagous ladybird beetles. Besides this, there are other arthropod items renowned in literature e.g., Stenorrhyncha (Psyllidae, Aleyrodidae, Coccidae), Acari, Thysanoptera and larvae of Diptera, Coleoptera and Lepidoptera (Schilder & Schilder, 1928; Kanervo, 1940; Hodek, 1967; 1970, Singh *et al*., 1991). Aphidophagous ladybird beetles are also identified to feed on some vegetarian food materials like pollen, nectar and fungal spores (Putman, 1964; Hemptinne & Desprets, 1986; Hemptinne *et al*., 1988). In recent years the list of aphid species and other components in the diet of ladybird beetles has amplified, but most of our studies about miscellaneous foods and their appropriateness are based on feeding experiments under laboratory conditions or on field annotations of individual ladybirds. From a single field observation it is not easy to make a decision whether overwhelming a certain food item is a universal behaviour or not. Therefore, moderately diminutive knowledge is accessible about diet composition of *Cheilomenes sexmaculata* and *Coccinella sepetempunctata* under field situations (Triltsch, 1999). *Cheilomenes sexmaculata* and *Coccinella sepetempunctata* frequently branded as six spotted zigzag and seven-spot ladybird beetles are known to feed on a wide prey range (Omkar & Bind, 1993). The core purpose of our study was to uncover the survival of these ladybird beetles throughout the year when aphids are available and when deficient. Diverse species of aphids that initiate their accessibility from mid July to late March were imparted as essential food and then four treatments of alternative foods were given.

MATERIALS AND METHODS

Insects privileged

C. sexmaculata and C. *septempunctata* were elected as tentative replicas. These species of ladybird beetles are effortlessly accessible in the precincts as well as in the agricultural meadow of India. The beetles can be

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straightforwardly recognized by the charisma of orange, light yellow, red or pinkish colour of elytra bearing six black maculae with two zig-zag lines and a posterior black spot while the latter has seven black spots all over its bright reddish elytra. Although they are aphidophagous, but also feed on psyllids, whiteflies, mealybugs, tingids, leaf- and plant hoppers, mites, and early instars lepidopteran larvae.

Stock culture

Adults of both the species were unruffled from the agricultural turfs bordering Allahabad and carried to the laboratory for maintenance of stock culture. Mating pairs were separated and kept in plastic Petri dishes (9.0x2.0 cm) at 27±1°C; 65±5% RH, 14:10 LD in the environmental test chamber. They were supplied with aphids viz., *Aphis craccivora*, *A. gossypii*, *Hysteroneura setariae*, *Lipaphis erysimi*, *Uroleucon compositae* infested on the twigs of *Dolichos lablab*, *Lagenaria vulgaris*, *Cynodon dactylon*, *Raphanus sativus* and *Carthemus tinctorius*. The surplus aphids were uninvolved after every 24 hours in order to evade microbial onslaught. The eggs attained from the mating pairs were used for accomplishing the trial.

Experimental setup

The foremost intention of our cram was to find out the survival of *C.sexmaculata* and *C. septempunctata* all the way through the year when aphids are accessible as well as when not in attendance. Larvae hatched from diverse mothers were used and kept singly in Petri dishes to shun cannibalism. Developmental duration was documented on essential as well as alternative diets. Eight species of aphids viz., *Aphis craccivora*, *A. gossypii*, *Hysteroneura setariae*, *Rhopalosiphum maidis*, *Lipaphis erysimi*, *A. nerii*, *Hydraphis coriandri* and *Uroleucon compositae* were specified as essential food. The aphids were collected from *Dolichos lablab*, *Lagenaria vulgaris*, *Cynodon dactylon*, *Zea mays*, *Raphanus sativus*, *Calotropis procera*, *Coriandrum sativum* and *Carthemus tinctorius*. The succession of aphid trails was done on their ease of use in the months from July-March. Four treatments of alternative foods were also preferred which take account of mealybugs from *Hibiscus rosa sinensis*, pollen grains from flowers, sugar syrup and honey. The data acquired on developmental duration was scrutinized by one way-ANOVA using the statistical software MINITAB-13.2 (2000). 'Food'and 'Larval Stage' was used as treatments. One way-ANOVA was also carried out for 'Alternative Foods' and 'Larval Stages'. The data on 'Survival' and 'Mortality' was evaluated by Chi-square test. The experiment was imitated twenty times.

RESULTS

The upshot of aphids when treated as 'Food' and 'Larval Stage' had a significant effect on the developmental duration of both the species (L1: F=196.11; p<0.0001; L2: F=94.31; P<0.001; L3: F=96.03; P<0.0001; L4: F=148.20; P<0.001; Prepupa: F=38.21; P<0.001; Pupa: F=314.94; P<0.001) (Fig.1, 2, 3). However, the outcome of 'Alternative Food' and 'Larval Stages' was found to have a non-significant on the developmental duration of both the species (L1: F=0.24; P>0.05; L2: F=3.19; P>0.05; L3: F=6.05; P>0.05; L4: F=3.52;

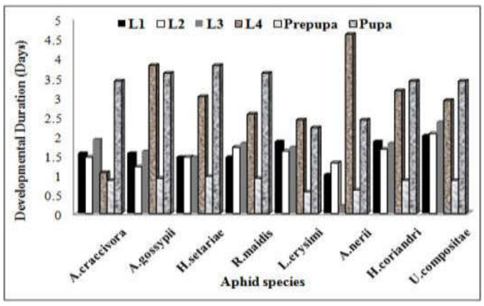

Fig. 1. Graph showing development of *Cheilomenes sexmaculata* on different species of aphids

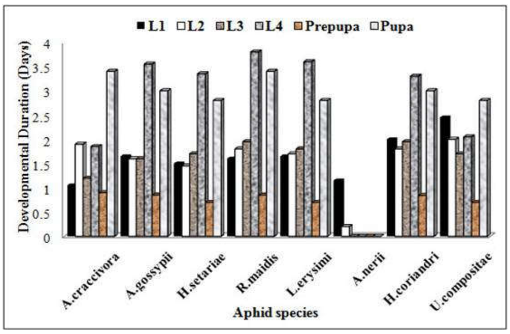

Fig. 2. Graph showing development of *Coccinella septempunctata* on different species of aphids

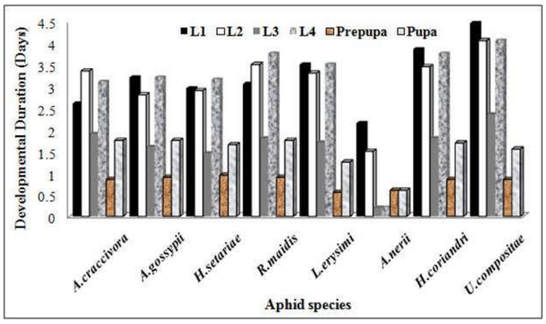

Fig.3. Graph showing overall development of both the two species when fed on different species of aphids

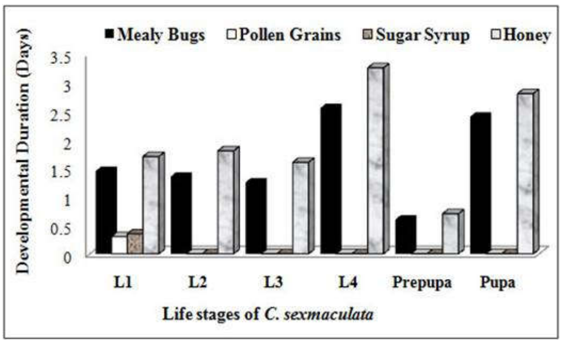

Fig.4. Graph showing development of *Cheilomenes sexmaculata* on alternative foods

P>0.05; Prepupa: F=164.08; P>0.05; Pupa: F=2.03; P>0.05).) (Fig. 4, 5, 6). The data achieved on survival and mortality when different species of aphids were given as food was also statistically significant for the six species except for *L. erysimi* and *A.nerii* (*A. craccivora*: χ^2= 9.800; P<0.001; *A.gossypii*: χ^2=16.21; P<0.001; *H. setariae*: χ^2= 12.21; P< 0.0001; *R. maidis*: χ^2= 12.81; P<0.001; *L. erysimi*: χ^2= 1.08; P> 0.05; *A.*

nerii: χ^2= 0.008; P> 0.05; *H. coriandri*: χ^2= 9.81; P< 0.001; *U.compositae*: χ^2= 9.80; P< 0.001) (Fig. 7).

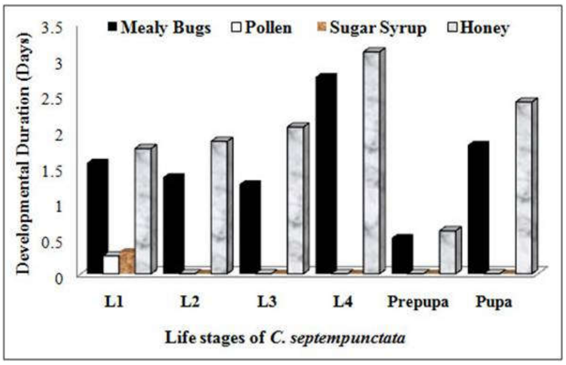

Fig.5. Graph showing development of *Coccinella septempunctata* on alternative foods

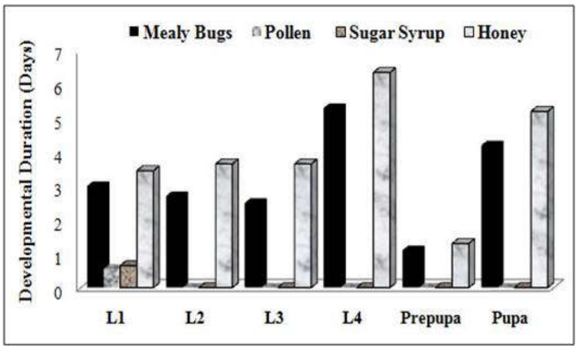

Fig.6. Graph showing overall development of two species of on alternative foods

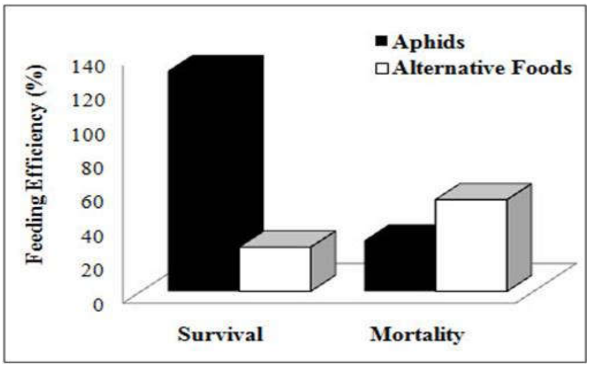

Fig. 7. Graph showing of survival and mortality when larval instars of *Cheilomenes sexmaculata* were fed on aphids and on alternative foods

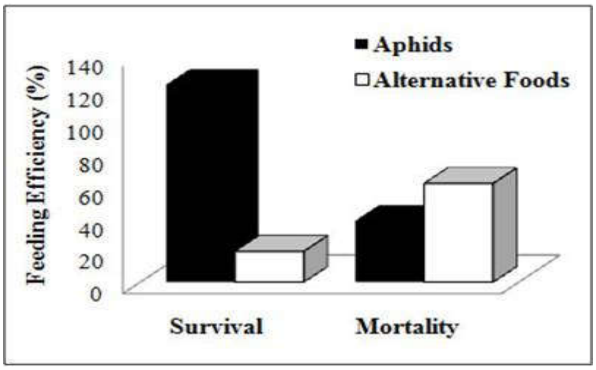

Fig. 8. Graph showing of survival and mortality when larval instars of *Coccinella septempunctata* were fed on aphids and on alternative foods

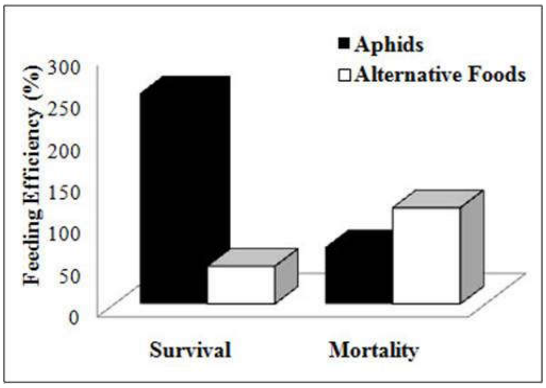

Fig. 9. Graph showing overall survival and mortality both the species when fed on aphids and on alternative foods

The data on survival and mortality after feeding the larvae on alternative foods was found to be statistically non-significant (Mealy bug: χ^2= 0.800; P> 0.05; Pollen: χ^2= 20.00; P> 0.05; Sugar Syrup: χ^2= 20.01; P> 0.05; Honey: χ^2= 3.20; P> 0.05) (Fig. 8). The data attained on the whole on survival and mortality after feeding the larvae on aphids was found to be statistically significant (χ^2= 62.5; P< 0.0001) and on the other hand data was statistically non-significant on alternative foods (χ^2= 9.83; P> 0.05) (Fig. 9).

DISCUSSION

Our study illustrates that *C. sexmaculata* and *C. septempunctata* survive well when aphids are accessible in abundance from mid July to the end of March. Aphids assist to protract larval development and oviposition in ladybirds so can be well thought-out as essential food from ecophysiological point of view. Essential foods however, show varying degrees of favour ability, enabling different developmental rates, fecundity and survival (Hodek, 1993; Hodek & Honěk, 1996). Recent results have verified that a mixed type of diet of aphids boost the robustness of ladybird beetles as reported in *Harmonia axyridis* (Soares *et al*., 2004) qualified to a single species diet. Developmental duration was found to be shorter when the larvae were fed on *Aphis craccivora*, *A. gossypii*, *Rhopalosiphum maidis* and *Hysteroneura setariae*. Analogous conclusions have been prominent in *Coelophora biplagiata* (Swartz) but the order of aphid inclination has found to be reversed in case of Micraspis discolor (Fabricius) (Omkar *et al*., 2005; Ashraf *et al*., 2010, Maurice *et al*., 2011). However, the developmental duration was found to be enhanced when the ladybird larvae were fed on *Lipaphis erysimi*, *Hydrophis coriandri* and *Uroleucon compositae*. This may be accredited to the fact that although some aphid species emerge to be an essential food but bring significant turn down in the fitness of larvae as well as adults. In addition though many aphid species act as if to be suitable prey when once caught but are complicated to catch or structures on plants, such as wax, glandular hairs, impede the movement of ladybirds, especially larvae and difficult to catch prey. The larvae of *Cheilomenes sexmaculata* were found to survive when fed on *A. nerii* although this aphid species is considered to be toxic to other ladybird species. This may be due to that species of aphid that is a suitable prey for one species of ladybird beetle may be unpleasant or toxic for other ladybird species. Some ladybirds appear to assault many species of prey whereas others have been recognized attacking very few species. However, the larvae of *C. septempunctata* failed to survive on *A. nerii* as first instars didn't moulted into the second instars. The overall survival of this species on *A. nerii* was nil and this may be due to the toxic nature of this species. Ladybirds show habitat specialization whether they attack few or many species of prey may be related in particular to the number of species of prey they regularly encounter in their respective habitats (Heimpel *et al*., 2010). Our studies are in quick agreement with those of Maurice *et al*., (2011) carried out on *Coccinella transversalis*. The survival on aphids was found to be highly significant as aphids restrain all the necessary nutrients obligatory for proper development of the larvae as well as adults. Energy from prey is used by adults to fuel their searching behaviour and reproduction. Our study reveals the survival of ladybird larvae on mealy bugs and honey but 100% mortality on sugar syrup and pollen grains. The results of numerous studies on use of non-aphid prey by aphidophagous ladybirds are confusing because one would expect them to develop and/or oviposit eggs only when they have located a patch of nursery prey. Adults of *C.septempunctata* and *C.transversoguttata* augmented in body weight but failed to produce eggs when fed on larvae of weevil (Richards & Evans, 1998). Mealybugs and honey supported larval development on slow scale, this may be due to that the body covering of mealybugs might be not fully palatable by ladybird larvae and honey lacks efficient quantity of protein for larval growth and development but is a rich source of sugars, but few enzymes and pigments are present in it. This issue needs more concern. Pollens fall short to maintain larval development as its surface structure cause clumping and accumulation of insect cuticle that led to death from desiccation in Petri dishes as reported in *Coleomegilla maculata* DeGeer (Michaud & Grant, 2005). The larvae also failed to develop from first instar to next instar and died within 1 or 2 days. No development and growth was observed when sugar syrup was provided as a source of food suggesting as ineffective alternative food as apart from carbohydrates fat and proteins are also required for proper growth of organisms.

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