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Changing Population of *Aphidius colemani* in Relation to Environmental Factors

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Abstract
An experiment was carried out to study the extinction and permanence of host-parasitoid systems with Allee effects, for both parasitism attacking before and after the growth phase of host. Allele effects and parasitism are common biological phenomena observed in nature. Allee effects and parasitism can lead to extinction of both species due to Allee effects at their low population density, multiple attractors, strange interior attractors and even crisis of strange attractor due to high parasitism. This study concentrated on *Aphidius colemani* an important and efficient endoparasitoid of several economically important aphid species under in-vitro conditions. The investigation studied its behavior and population change in relation to host and other environmental factors. *Aphidius colemani* discriminated between parasitized and unparasitized hosts. It is also suggested that this parasitoid performs best between 20 and 25°C and its population declines above or below this temperature.

Key words: *Aphidius colemani*, Environmental factor, Population

Introduction

Aphids represent vast and major pests of many crops throughout the world. Many aphid species are cosmopolitan in habit. Besides feeding on phloem sap, they transmit viruses which render aphids as important crop pest. For many years insecticides have been used against aphids in an attempt to control them with variable success. But insecticide resistance is however, becoming a problem of immense significance. In addition, pesticides are known to have an adverse effect on beneficial insect, including the natural enemies of aphid (Graham-Bryce *et al*., 1979). Natural enemies can suppress harmful organisms without ecological backlashes. An alternative method of aphid control is the utilization of natural enemies, either alone or combination with other measures which could make large financial savings. One major group of aphidophagous insects are the parasitoids. One principal hymenopterous family which parasitizes aphids is the Aphidiidae. This parasitoid have provided some of the most famous successes in the biological control of aphids (Caltagirone, 1981). Each female wasp (depending upon the species) is capable of killing between 150-500 aphids by laying a single egg inside each aphid.

The population of parasitoid and their behavior is important in relation to their value as pest control organism. The main characteristics of this parasitoid which make it successful are its high fecundity, narrow host range and its ability to locate hosts over a broad range of host densities. A knowledge of parasitoid population and their behavior in relation to their host and other environmental factors are important in using them for successful bio-control.

Materials and Methods

The following materials equipment and techniques are used in this experiment.

Plant materials

Faba bean (*Vicia faba*), cowpea (*Vigna unguiculata*) and cabbage (*Brassica oleracea*) plants are used. Seeds were sown in plastic pots using a peat based potting compost.

Aphid culture

Black bean aphids were cultured on faba bean plants. Plants were regularly replaced every one to two weeks with new uninfested plants to ensure that the aphids remained uncrowded and the plants were within the age range 4-6 weeks.

Parasitoid culture

The parasitoids were regularly supplied which were reared on cucumber plants on *Aphis gossypii* Glover. Polgar (1987) concluded that 2-3 days old parasitoid can be stored in a refrigerator for about a month without significantly reducing the number emerging or the sex ratio. If required for immediate use, they were kept at room temperature (20-25°C).

Newly emerged female parasitoids were obtained from the colonies, keeping them in vials and observing adult emergence regularly. Emerging adult females were placed individually in vials, each with a single male and provided with cotton saturated with honey- water solution for food and moisture. It was found that copulation usually occurred within a few minutes. After copulation, each female was introduced into a cylindrical cage with one cowpea plant infested with >100 *Aphis fabae*. After 24 hr of foraging on aphid infested plant, each parasitoid was transferred to a second cylindrical cage with similarly infested plants. This procedure of transferring parasitoids from one cage to fresh plants was repeated at 24 hr intervals until

the parasitoid died. Consequently, all cylindrical cages plus plants were maintained inside incubators at five constant temperature regimes at 10,15,20,25 and 30°C separately. All newly hatched aphid nymphs were carefully removed. The plants were checked regularly for mummified aphids, which were counted and put singly into marked tubes. The number of mummies in each cage was used as a daily estimate of age specific fecundity for the individual parasitoid. Also the number of adults emerging and their sex ratio were recorded daily. For each temperature there were 10 replications and each replicate composed of one cage.

Results and Discussion

The results of life table statistics of *Aphidius colemani* at five constant temperatures are summarized in Table 1.

Table 1. Life table and related statistics for *A. colemani* on *A. fabae* at five constant temperatures.

Statistics of growth parameters	Temperatures (°C)				
	10	15	20	25	30
Gross reproductive rate (GRR)	87.3	100.71	116.10	80.69	60.10
Net reproductive rate (R_0)	82.33	98.14	107.18	78.43	56.83
Capacity for increase (r_c)	0.17	0.22	0.31	0.34	0.26
Intrinsic rate of increase (r_m)	0.17	0.23	0.32	0.35	0.26
Cohort generation time (T_c) (days)	26.67	20.18	14.98	12.93	15.71
Generation time (T) (days)	26.46	19.79	14.46	12.40	15.35
Finite capacity for increase (lamda)	1.18	1.26	1.38	1.42	1.30
Doubling time (days)	4.15	2.99	2.14	1.97	2.63
Developmental time (in days)	25.0	18.0	13.0	11.0	14.0

From the experimental results, it was found that gross reproductive rate (GRR) and net reproductive rate (R_0) increased as the temperature increased from 10-20°C but then gradually decreased. The highest GRR and R_0 were 116.10 and 107.18, respectively at 20°C (Table 1). The capacity for increase and intrinsic rate of increase were both highest at 25°C. It was found that, as the temperature increased from 10 to 25°C, the mean length of a generation decreased but then increased at 30°C (Table 1). Life table statistics revealed that developmental time of *Aphidius colemani* was minimum (11 days) at 25° C and maximum (25 days) at 10°C (Table 1).

The experimental results showed longest generation times at low temperatures and this confirms the previous observations of Ahmed (1990) and Shijko (1989), who reported similar results for *Aphidius colemani* on *Myzus persicae* between temperature ranges 12 to 24°C. However, the present experimental results showed that when temperature rises above 25°C, the generation time increased.

The r_m values of *Aphidius colemani* obtained from the experiments are summarized and compared in table 2. Some of the previous studies showed that the optimum temperature for parasitism by *Aphidius colemani* was 20-23°C, although the host could be reared between 13-30°C and its optimum temperature was between 20-27°C (Xin, 1986). However, from the results of the present experiment, it is clear that at 25°C *Aphidius colemani* would be a successful biocontrol agent in the field.

The decreasing developmental time with increasing temperature from 25 days at 10°C to 11 days at 25°C was similar to the results with other parasitoids, as reported by Enkegaard (1993), for *Encarsia formosa* Gahan which decreased from 1 month at 16°C to 9 days at 28°C.

Table 2. The r_m values of *A. colemani* and *A. matricariae* at different constant temperatures using *Aphis fabae* and *Myzus persicae* as hosts

Growth parameter	Temperatures°C 10 15 20 25 30
Intrinsic rate of increase (r_m)	0.16 0.23 0.32 0.35 0.26 Using *A. fabae* as hosts
Growth parameter	Temperatures°C 10 15 20 25 30
Intrinsic rate of increase (r_m)	__ 0.10 0.15 0.28 __ Using *M. persicae* as hosts (Shijko, 1989)
Growth parameter	Temperatures°C 12 16 20 24 28 30
Intrinsic rate of increase (r_m)	0.11 0.20 0.31 0.30 0.17 0.09 Using *M. persicae* as hosts (Ahmed, 1990)

Conclusions

This experiment showed that GRR and R_0 were maximum at 20°C, but that r_c and r_m were maximum and T and DT were minimum at 25°C. In addition, developmental time was minimum at 25°C. From the foregoing, it is clear that temperature has an immense influence on the life cycle of this parasitoid, and that the optimum temperature for utilizing this parasitoid as an efficient biocontrol agent is around 25°C, although many other environmental factors could influence their efficiency in the open field.

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