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Pathophysiological Effects of *Coccinellimermis* Rubtzov (Nematoda: Mermithidae) on the Respiration of *Coccinella septempunctata* L. (Coleoptera: Coccinellidae)

M RHAMHALINGHAN
Department of Zoology, Government Arts College, Ooty 643 002, Nilgiris

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The rate of metabolism during undisturbed, active and hyperactive conditions and after the emergence of the juvenile nematode parasite, *Coccinellimermis* Rubtzov, in the infected ladybeetles, *Coccinella septempunctata* L. has been investigated. The possible causes for the reduction in oxygen consumption are discussed.

Key Words: *Coccinellimermis, Coccinella septempunctata,* **Metabolism reduction index, Oxygen consumption**

Introduction

Endoparasites bring about several pathological changes in insect hosts (Doutt 1963, Welch 1963). The studies on these pathophysiological and behavioural changes in the insect hosts are essential to shed light on the host-parasite relationship. Information on the effects of parasitism on Coccinellids appears to be very scanty (Hodek 1973). Since *Coccinella septempunctata* L. is an aphidophagous beetle, in view of its economic importance, an attempt has been made to investigate the effects of the juvenile nematode on its metabolic rate.

Materials and Methods

The juvenile of the nematode *Coccinellimermis* Rubtzov is a solitary endoparasite, seen in the haemocoel of the seven-spotted lady-beetle *C. septempunctata* (Rhamhalinghan 1986). Warburg apparatus was used to determine the oxygen consumption of the infected/uninfected beetles. Sixteen infected beetles in two groups of 6 and 10 were used. The first group of 6 beetles belongs to 30–45 days age group and the second group belongs to 50–60 days age group. Oxygen uptake for the uninfected beetles (10 each) of the same age groups as that of the infected beetles has been determined. The readings were taken every 10 minutes for a minimum period of 3 hrs. The rates for the undisturbed, active and hyperactive beetles were determined. During undisturbed state the beetles moved rarely or the movements were very much restricted. The active beetles moved ceaselessly in search of food and water inside the reaction vessel. The infected beetles alone showed hyperactive condition, hours before the emergence of the nematode parasite from their body cavity. They ran madly and took off frequently and dashed violently against the sides of the reaction vessel, as a result of the irritation produced by the nematode during its search for the emergence hole (Rhamhalinghan 1986). In the case of the uninfected beetles, the hyperactive condition was simulated by agitating the reaction vessel for one to three minutes vigorously (Parker et al. 1977). The weight of the individual infected/uninfected beetle was determined after the experiments.

The rate of respiration in infected and uninfected beetles had been collated to expound the dimensions of damage brought about by the mermithids. The metabolism reduction index (MRI) was calculated using the formula:

$$\frac{(C - P)}{C} \times 100$$

where C and P indicate the mean O_2 consumption/mg/hr of the uninfected and infected beetles of the same age group respectively, for a given activity.

For the absorption of CO_2, 20% KOH solution was used. The maximum and minimum temperatures in the laboratory were 17.6 and 16.4°C respectively, the RH being 73 to 78%. The data were analyzed statistically using Students' t-test (Simpson et al. 1960).

Results and Discussion

While the physiological traits of the insects are influenced by several extrinsic factors, the endoparasites form the intrinsic factor that bring about inevitable changes in the insect hosts. Further the total environment of the endoparasites (i.e. the haemocoel and organ systems of the host insects) is very much limited and hence can alter the physiological traits of the internal environment easily either by the absorption of nutrients, destruction of tissues or release of toxic materials. These three primary activities of the endoparasites would lead to the effective changes in the essential constituents of the body of the hosts and their behaviour.

Sluss (1968) observed that parasitic activities of *Perilitus coccinellae* Schrank caused a reduction in the rate of respiration immediately after the hatching of the parasite's egg and before the emergence of the last instar parasitic larva, in *Hippodamia convergens* Guerin. Otherwise there is no change in respiration in that insect. Parker et al. (1977) studied the O_2 consumption of parasitized and non-parasitized beetles of *Coleomegilla maculata lengi* Timberlake. The authors found no significant difference in the rates of respiration between parasitized and non-parasitized beetles. On the contrary, the present investigation shows that there is a significant difference in the rates of respiration between the infected and uninfected beetles.

The rates of respiration change with activity and temperature (Chapman 1972). The uninfected beetles of 30–45 days age group are robust and are actively reproducing individuals. In the actively reproducing beetles of *H. convergens* (Stewart et al. 1967), *C. septempunctata bruckii* Mulsant (Sakurai 1969), and *Semiadalia undecimnotata* Schnieder (Hodek 1973),the oxygen consumption increases. Active ingestion, conversion and utilization of materials require more oxygen. Thus unparasitized beetles consume significantly more oxygen than the parasitized beetles in all the three activity patterns observed (table 1, figure 1). The increases over the parasitized beetles are 8.11%, 29.33% and 7.37% during undisturbed, active and hyperactive conditions respectively in the case of 30–45 days age groups and 8.57%, 23.77% and 8.76% respectively in the case of 50–60 days age group. Thus the metabolism reduction index (MRI) increases during active periods and after the emergence of the parasite (figure 2). As such metabolic rates in the infected beetles measure 7.37% to 30% less than that of the uninfected beetles.

The rate of O_2 consumption dwindles further to 0.53 and 0.49 μl/mg/hr in the parasitized beetles of 30–45 days age group and 50–60 days age group respectively, after the emergence of the parasite. The beetles show least movements and are paralyzed after the escape of the parasite. Various damages to the organs virtually incapacitate them (Rhamhalinghan 1986) which tells upon their metabolic activities. The metabolism is at the lowest ebb and the values are much lower than the lowest value for the undisturbed condition (table 1). When compared to the rate of O_2 consumption of unparasitized beetles in the undisturbed condition,the paralyzed beetles of 30–45 days age group consume 28.38% less oxygen. The same for 50–60 days age group is 30% (figure 2)

The unparasitized beetles of 30–45 days age group consume 5.4%, 18.67% and 10.60% more oxygen than that of 50–60 days age group during undisturbed, active and hyperactive conditions respectively (table 2). The same condition exists in the infected beetles of the two age groups. The parasitized beetles of the first group show an increase of 5.88%, 12.27%, 11.94% and 7.55% O_2 consumption over the second group during

Table 1 *Rate of oxygen consumption in the infected and uninfected beetles of* Coccinella septempunctata *L. belonging to various age groups (O_2μl/mg/hr). Numbers within parenthesis indicate the range*

Age group (days)	Category	Replicates	Undisturbed	Moderately active	Hyperactive	After emergence of parasite
30-45	Infected	6	0.68 ± 0.01 (0.66 – 0.69)	1.06 ± 0.06 (1.00 – 1.14)	2.01 ± 0.10 (1.88 – 2.12)	0.53 ± 0.02 (0.50 – 0.55)
	Uninfected	10	0.74 ± 0.01 (0.72 – 0.76)	1.50 ± 0.08 (1.39 – 1.66)	2.17 ± 0.06 (2.08 – 2.24)	—
50-60	Infected	10	0.64 ± 0.01 (0.62 – 0.66)	0.93 ± 0.04 (0.89 – 1.02)	1.77 ± 0.06 (1.69 – 1.89)	0.49 ± 0.02 (0.47 – 0.52)
	Uninfected	10	0.70 ± 0.01 (0.69 – 0.72)	1.22 ± 0.05 (1.16 – 1.32)	1.94 ± 0.09 (1.81 – 2.06)	—

* The differences between the uninfected and infected beetles are statistically significant at 0.01 level

Table 2 *Oxygen consumption in relation to age and activity in* C. septempunctata

A = 30–45 days age group; B = 50–60 days age group

Categories compared	Age groups compared	Activity pattern	Increase		
			$O_2\mu l$/mg/hr		%
Uninfected	A:B	Undisturbed	A	0.04>B	5.41
"	"	Active	A	0.28>B	18.67
"	"	Hyperactive	A	0.23>B	10.60
Infected	A:B	Undisturbed	A	0.04>B	5.88
"	"	Active	A	0.13>B	12.27
"	"	Hyperactive	A	0.24>B	11.94
"	"	After emergence of parasite	A	0.04>B	7.55

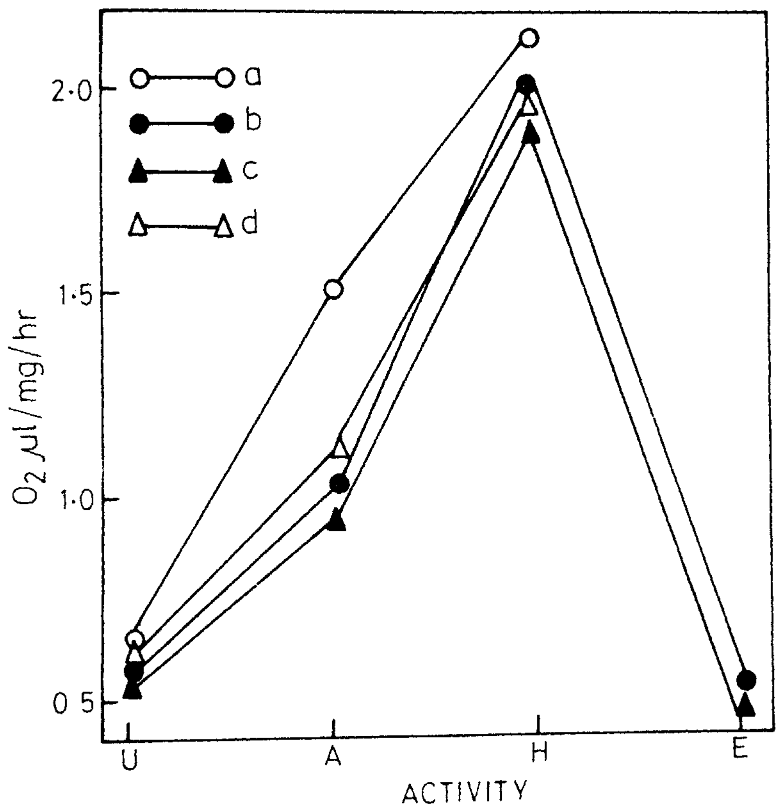

Figure 1 Oxygen consumption in the uninfected and infected beetles, *C. septempunctata*
a and b = uninfected and infected beetles respectively of 30–45 days age group,
c and d = infected and uninfected beetles respectively of 50–60 days age group
U = Undisturbed; A = active; H = hyperactive; E = after the emergence of parasite

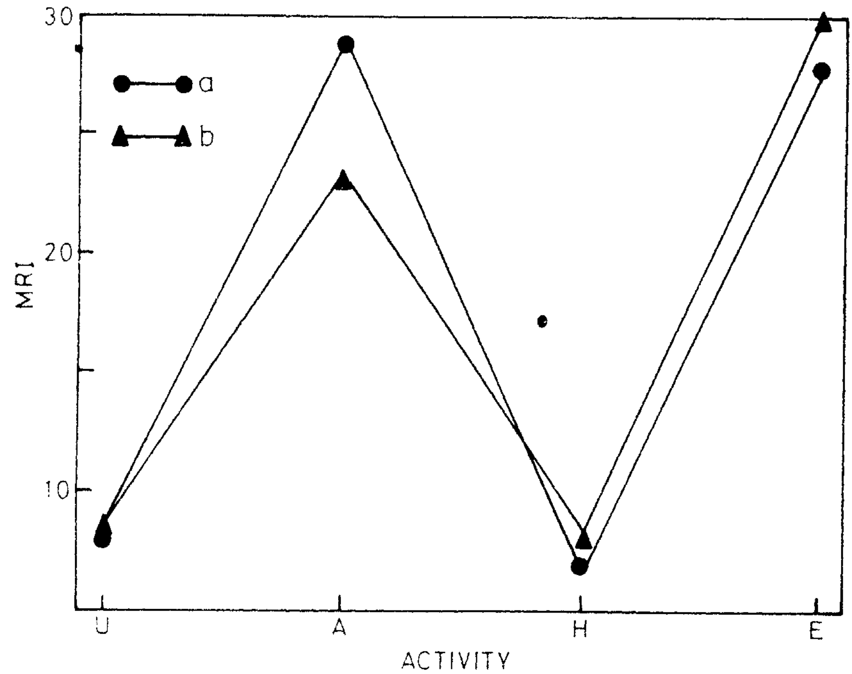

Figure 2 Changes in the metabolism reduction index (MRI)
a = 30–45 days age group; b = 50–60 days age group; U, A, H, E = as per figure 1

undisturbed, active, hyperactive conditions and after the emergence of the parasites respectively.

The hyperactive condition of the infected beetles shall not be compared to the regular running and flight activities of the unparasitized individuals. It is a sudden, short and violent effort caused by the pricking movements of the emerging parasite in the haemocoel (Rhamhalinghan, unpublished observations). Soon after the insect becomes numbed with shock that leads to paralysis.

Pathophysiology of respiration in insects as a result of microbial parasites has been discussed by Benz (1970). The author observed that the parasites would affect respiration either by destroying the tracheal system or by their action on the system of respiratory enzymes. In the nematode infected beetles, the highly branched tracheae around the ovaries and the digestive system have been found to be lacerated wildly (Rhamhalinghan 1986). This may presumably leave the tissues of various abdominal organs devoid of oxygen. Further, air is directly admitted into the body of the host, as a result of the rupture of tracheae (Steinhaus 1949). Hence the fatal reduction in O_2 consumption after the emergence of the parasite.

The temperature being constant, the age of the beetle has a bearing upon the rate of metabolism. This is well exemplified by the difference in O_2 consumption between the two age groups (tables 1, 2).

The O_2 consumption of the beetle must include the consumption by the parasite also. The sharp reduction in the consumption values after the emergence of the parasite indicates indirectly the oxygen utilization by the endoparasite. But one cannot take this for granted since according to Crofton (1966) evidence must be derived from the enzyme systems and the end products of respiration of the nematodes. The discussion with regard to the % utilization of oxygen either by the host or parasite is beyond the scope of the present paper. However, it could be very well ascertained that nematode parasitism causes fatal reduction in metabolic rates in this species.

Another question arises as to what precisely causes this reduction, apart from the tracheal damages. Production of toxic substances may lead to several abnormalities (Welch 1953). Sluss (1968) also suggests that release of toxic materials causes reduction in oxygen consumption. This may presumably be one of the causative factors but not the sole agent responsible for the reduction in metabolism, since in this instance, various operative forces (such as age and activity patterns of the host and the colossal damages incurred by it) are in evidence.

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