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Pupal premature mortality as host mortality factor in the system *Galleria mellonella* L. - *Pseudogonia rufifrons* Wied. (Lep. Galleriidae - Dipt. Tachinidae)

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Introduction

Insect parasites may induce host death even independently of successfull parasitization.

With regard to hymenopterous parasites this host « premature » mortality was discussed by several authors (Burnett, 1962; 1967; Rahman, 1970; Cate et alii, 1973; Bartell and Pass, 1978; Ryan, 1985). Hosts may be killed by adult parasite females at oviposition (Burnett, 1962; 1967; Rahman, 1970; Bartell and Pass, 1978), or, in a few cases, by parasite larvae, that eventually die (Bartell and Pass, 1978).

In hosts attacked by tachinid parasites, premature mortality may be obviously related only to parasite larval activity and was reported by a few authors. In the system *Galleria mellonella* L. - *Pseudogonia rufifrons* Wied (= *Gonia cinerascens* Rond.), following parasitization host larval premature mortality significantly increased (Mellini and Gironi, 1981; Dindo, 1983), as well as percentages of pharatae pupae, that usually do not let the moth, either the parasite emerge (Mellini and Gironi, 1981; Mellini and Braga, 1982; Dindo, 1983). Dindo and Cesari (1985) and Dindo (in press) showed that, in parasitized *G. mellonella* populations, larvae cannibalize pupae significantly more than in unparasitized populations and described increased cannibalism as a source of host mortality indirectly due to parasitization, i.e. related to parasite larval activity, but unrelated to successful parasite development.

The present study was carried out to determine the effects of *P. rufifrons* on *G. mellonella* pupal premature mortality, independent of both

cannibalism and formation of pharatae pupae. All sources of host mortality within unparasitized and parasitized populations were then analyzed and discussed with regard to their influence on total mortality.

Methods

Galleria mellonella larvae were maintained on a semi-artificial diet (Campadelli, 1973). *Pseudogonia rufifrons* was reared as described by Baronio and Campadelli (1978).

In the present study, 3 groups of 100 *G. mellonella* larvae of the penultimate instar were fed 8 wax leaves each. Group A, mantained as a control, was fed leaves with no parasite eggs. Group B and C were both parasitized, and fed leaves on which there were microtype eggs oviposited by adult tachinid females during the previous 24 hs.

Number of eggs per larva was 4 in group B and 8 in group C (Mellini and Braga, 1982).

After 24-48 hs, the leaves had been completely consumed by the larvae, and the latter were each fed 2.5 g of diet.

All larvae were mantained in complete darkness, at 30°C ± 1°C, and 65% r.h., and pupated in about 2 weeks.

For statistical analysis, the following parameters were calculated for each group:

$$D = \% \text{ host pupal premature mortality} = d/p \times 100$$

$$P = \% \text{ successful parasitization} = t/l \times 100$$

$$Mp = \% \text{ host premature mortality} = m/l \times 100$$

$$Mt = \% \text{ host total mortality} = Mp + P$$

where d = number of pupae that died for all reasons but successful parasitization, cannibalism and formation of pharatae pupae; p = total number of pupae; t = number of tachinid puparia obtained from the pupae of parasitized larvae; l = initial number of larvae (= 100); m = total number of larvae and pupae that died independently of successful parasitization.

Results and discussion

In parasitized *G. mellonella* groups, D (= % host pupal premature mortality) was significantly higher than in controls (Table 1).

TABLE 1

Pupal premature mortality (= D), premature mortality (= Mp), successful parasitization (= P) and total mortality (= Mt) percentages in *Galleria mellonella* populations unparasitized (= A) and parasitized by *Pseudogonia rufifrons* with 4 (= B) and 8 (= C) eggs per larva.

Means ± S. E. for 5 replicates. Means in column followed by the same letters are not significantly different (Duncan's test). Capital letters = 99% level. Small letters = 95% level.

For statistical analysis the Arcsin $\sqrt{\%}/100$ transformation was used.

Group	D	Mp	P	Mt
A	1.75 ± 1.11 Aa	17.46 ± 6.72 Aa	—	17.46 ± 6.72 Aa
B	25.44 ± 3.69 Bb	57.53 ± 8.77 Bb	22.16 ± 6.38 Aa	79.69 ± 4.08 Bb
C	35.52 ± 2.87 Bb	70.56 ± 6.88 Bb	17.42 ± 5.42 Aa	87.98 ± 3.99 Bc

Within a number of prematurely dead pupae (about 40% in group B and 30% in group C) a dead parasite third (= last) instar larva was found. Most of other dead pupae were decomposed, so that no further investigation was possible on them. Within a small number, however, a tachinid second instar larva was found.

In the system *Coleophora laricella* (Hbn.) *Agathis pumila* (Ratz.) (Lep. Coleophoridae - Hym. Braconidae), Ryan (1985) showed that a number of *A. pumila* did not emerge, but died as fully grown adults within the host case. The author suggested that this non-emergence phenomenon might have been due to unsuitable artificial rearing conditions for the parasite, i.e. low humidity or improper photoperiod. In the present study, the death of parasite third instar larvae within the host body was probably unrelated to such environmental factors. All larvae, indeed, including the parasitized ones, were maintained in complete darkness, whereas the proper photoperiod for *P. rufifrons* adults is 16:8. Mellini and Dindo (1982), however, demonstrated that photoperiod itself does not affect directly the parasite development and growth, that are strictly dependent on the host.

This parasite mortality might have been due to endogenous factors, or to precocious host death and a consequent impossibility, for *P. rufifrons,* to develop up to the pupal stage.

Regardless of the reasons causing the observed phenomenon, the importance of host pupal premature mortality as mortality factor within parasitized populations must be emphasized. As it was pointed out by some authors (Bartell and Pass, 1978; Ryan, 1985; Dindo, in press),

all mortality factors but successful parasitization are usually not evaluated when considering parasite effectiveness within a host population. As parasitization percentages might be an understimate of actual effectiveness, other mortality factors possibly related to parasite activity (i.e. pupal premature mortality) should be considered as well.

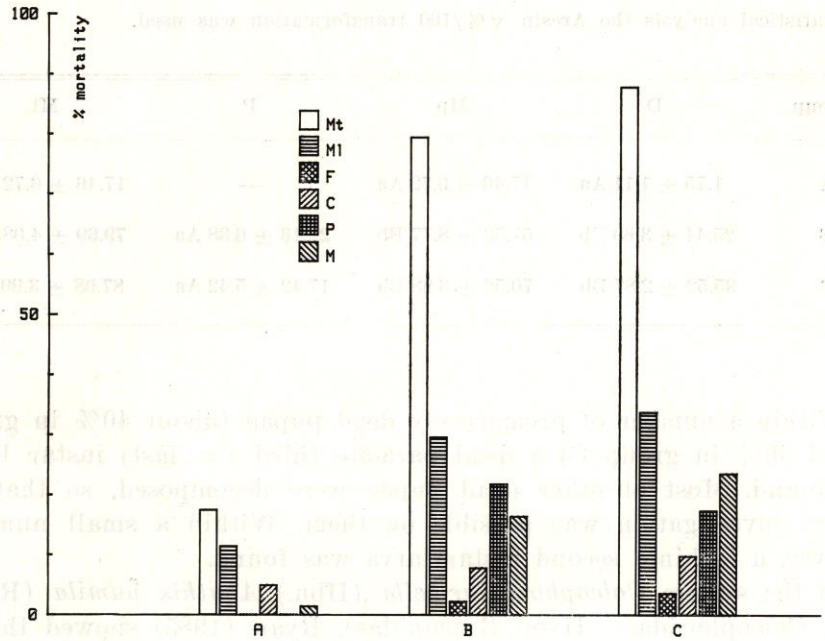

FIG. I

Influence of different mortality factors on total mortality in *Galleria mellonella* populations unparasitized (= A) and parasitized by *Pseudogonia rufifrons* with 4 (= B) and 8 (= C) eggs per larva.

Mt = % total mortality; Ml = % larval premature mortality; F = % pharatae pupae; C = % cannibalized pupae; P = % successful parasitization; M = % pupal premature mortality. Number of replicates = 5.

N. B. All percentages were calculated over the initial number of larvae (= 100).

In the present study, for instance, in parasitized populations parasitization percentages represented only a portion of host total mortaltiy (Fig. 1). They do not provide, therefore, an accurate estime of effectiveness of *P. rufifrons* within *G. mellonella* populations.

Larval and pupal premature mortality considerably affected total mortality (Fig. 1). It must be noted that in controls larval mortality was fairly high, though lower than in parasitized groups (see Mellini and Gironi, 1981; Dindo, 1983). This was due to occurrence of NPV

infection. NPV might have affected also the cannibalistic behavior of parasitized larvae, as in parasitized groups the incidence of cannibalism was lower than expected (see Dindo and Cesari, 1985; Dindo, in press).

SUMMARY

Insect parasites may induce host death even independently of successful parasitization. This host « premature » mortality is very seldom considered when evaluating parasite effectiveness within an insect population, although parasitization percentages — i. e. the traditional method of expressing parasite effectiveness — might be an understimate of it.

In the present study, the effects induced by *Pseudogonia rufifrons* on *Galleria mellonella* pupal premature mortality, independent of both cannibalism and formation of pharatae pupae, were studied. In groups parasitized with both 4 and 8 tachinid eggs per larva, pupal premature mortality percentages were significantly higher than controls at the 99% level (Table 1).

Moreover, in both parasitized groups, parasitization percentages represented only a portion of total mortality (Fig. 1). They do not provide, therefore, an accurate estime of effectiveness of *P. rufifrons* within *G. mellonella* populations. For expressing actual effectiveness, all sources of host mortality, apparently related to parasite larval activity (i.e. pupal and larval premature mortality, cannibalism and formation of pharatae pupae) should be considered as well.

Mortalità prematura dell'ospite *Galleria mellonella* L. indotta dal parassitoide *Pseudogonia rufifrons* Wied. con particolare riferimento alle crisalidi.

RIASSUNTO

Gli insetti parassiti possono determinare la morte dell'ospite anche con modalità diverse da quella classica, vale a dire la parassitizzazione sensu stricto. Nell'ambito di popolazioni parassitizzate, questo tipo di mortalità « prematura » può essere di entità pari o spesso maggiore rispetto alla mortalità dovuta alla parassitizzazione vera e propria. Occorrerebbe dunque tenerne conto, nei limiti del possibile, volendo stimare l'efficacia globale di un certo entomofago nel contenimento di una data popolazione di insetti.

Nella presente ricerca è stato considerato il fenomeno della mortalità prematura delle crisalidi (indipendentemente dal cannibalismo e dalla comparsa di pupe farate) nell'ambito di popolazioni di *Galleria mellonella* parassitizzate da *Pseudogonia rufifrons*. Si è rilevata una differenza altamente significativa tra le percentuali di mortalità prematura delle crisalidi (= D) relative ai testimoni da un lato e ai gruppi parassitizzati tanto con 4 che con 8 uova/larva dall'altro (Tab. 1).

Inoltre, in ambo le tesi sottoposte a contaminazione, le percentuali di parassitizzazione (= P) non hanno inciso che parzialmente sulla mortalità totale (= Mt) (Fig. 1). Esse non rappresentano, pertanto, che un indice alquanto approssimativo dell'efficacia di *P. rufifrons* nel contenimento di una popolazione di *G. mellonella*. Un indice più accurato presuppone infatti la valutazione di tutte le cause di mortalità dell'ospite, direttamente e indirettamente legate all'attività dell'entomofago, così come evidenziato

nella figura 1, in cui la mortalità totale è stata scomposta nelle singole componenti (oltre alla parassitizzazione vera e propria, il cannibalismo, la formazione di pupe farate, la mortalità prematura di larve e crisalidi).

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