

Parasitism of the larvae of some Carabidae (Coleoptera)

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SYNOPSIS

An account is given of the species and degree of parasitism by insect and nematode parasites from eight species of Carabidae collected in pitfall traps in arable fields.

INTRODUCTION

Populations of Carabidae were assessed in two arable fields by means of pitfall traps. They included many larvae which were reared in the laboratory for identification and in order to study their life histories and natural mortality factors, particularly insect and nematode parasites. Eastham (1929) has given a detailed account of the biology of *Phaenoserphus viator* (Haliday), a parasite of *Pterostichus niger* (Schaller), and Nixon (1938) has reviewed the genus *Phaenoserphus* but otherwise apart from brief observations on insect parasites emerging from carabid larvae (Elliott & Morley, 1907, 1911; Thompson, 1943; Richards, 1946; Davies, 1955; Basden, 1959; Briggs, 1965) little or no information is available on the extent to which parasitism occurs.

MATERIALS AND METHODS

Larvae were caught in pitfall traps as described by Critchley (unpublished) in two arable fields—Four Acre Field and Hill Bottom—of the Imperial College Field Station. Four Acre Field was kept fallow for most of the time and was cultivated at regular intervals while half of Hill Bottom (one acre) was planted with a Brussels sprouts crop and the other half was kept fallow by tilling. The soil at both sites was a light sandy loam.

Larvae were reared singly in the laboratory in glass tubes, 2.6 cm. × 5.2 cm., containing sterilised moist sand (approximately 8 per cent. water by weight). The tubes were corked to prevent loss of water and kept at 15–23° C. Species studied were those most readily caught in the pitfall traps and included: *Carabus violaceus* (L.), *Nebria brevicollis* (F.), *Notiophilus* spp., *Loricera pilicornis* (F.), *Pterostichus vulgaris* (L.), *P. madidus* (F.), *Calathus fuscipes* (Goeze), and *Agonum dorsale* (Pontoppidan). The larvae were fed once a week on freshly killed blowfly maggots of *Phormia terraenovae* (R.-Desvoidy) from laboratory cultures.

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RESULTS

Observations were restricted to eight species of larvae trapped in two arable fields over two years (Table 1). Less than 50 per cent. of the larvae pupated and one of the more important causes of failure was insect parasitism. The commonest parasites were *Phaenoserphus viator* and *P. pallipes* (Latreille) (Hymenoptera, Proctotrupidae). *P. viator* is gregarious and occurred mostly in winter-active larvae, e.g. *Nebria brevicollis*, *Pterostichus vulgaris*, *P. madidus*, while *P. pallipes* is solitary and usually parasitised summer-active larvae such as *Notiophilus* spp. The parasites were not specific to one host species. Carabid larvae from Four Acre Field were more heavily parasitised than larvae from Hill Bottom, perhaps because there were twice as many larvae (Table 1) which caused greater "density dependent" mortalities from the natural enemies.

Table 1. Causes of mortality of carabid larvae collected from Four Acre Field and Hill Bottom during 1966 and 1967.

Species and site	Dates of capture and rearing	No. examined	% mortality			
			<i>P.viator</i>	<i>P.pallipes</i>	Other factors	% pupation
Four Acre Field:						
<i>N.brevicollis</i>	27.i-3.v.66	294	23	2	43	31
<i>Notiophilus</i> spp.	14.v-19.ix.66	47	—	23	53	23
<i>L.pilicornis</i>	30.v-26.ix.66	32	—	—	63	37
<i>A.dorsale</i>	12.vii-3.x.66	11	—	9	64	27
<i>C.violaceus</i>	31.vii-10.x.66	25	—	—	100	—
<i>N.brevicollis</i>	28.xi.66-8.v.67	346	11	5	52	32
<i>P.vulgaris</i>	17.x.66-14.iii.67	91	2	1	90	7
<i>C.fuscipes</i>	17.x.66-14.iii.67	16	—	25	69	6
<i>P.madidus</i>	7.xi.66-15.v.67	10	10	—	90	—
Hill Bottom:						
<i>N.brevicollis</i>	28.ii-18.iv.66	182	4	—	51	45
<i>N.brevicollis</i>	21.xi.66-7.iii.67	144	6	3	55	37
<i>P.vulgaris</i>	14.xi.66-7.ii.67	4	—	—	75	25
<i>C.fuscipes</i>	28.xi.66-7.iii.67	9	—	11	89	—

Other mortality factors included the following known and possible causes: injury, starvation (or lack of adequate food), parasitic nematodes (Mermithidae), fungi, protozoa, and bacteria. Injury and starvation were factors which could have been induced or enhanced by trapping, incorrect feeding, or unsuitable rearing conditions and probably contributed most to the "other" mortality.

Only *N. brevicollis* larvae were trapped in sufficient numbers to give reliable estimates of insect parasitism. Numbers caught increased from October onwards and reached a peak of activity in January (fig. 1). No first or second instar larvae trapped in the field completed development to the pupa in the laboratory yet larvae reared from eggs laid by adults kept in captivity often developed completely to the adult; the cause of death of the former was never determined. Only healthy looking third instar larvae were therefore used to assess the degree of parasitism from *P. viator* and *P. pallipes* (Table 2). The level

of parasitism varied from year to year and from one field to another but resulted in up to 25 per cent. mortalities in the spring of 1966. As many as 22 first instar larvae of *P.viator* were found in a single host larva of *N.brevicollis* although more were found in larvae of other carabid species. Thus, 37 first instar larvae of *P.viator* were dissected from a third instar *C.violaceus* larva captured on 17.x.66 and 57 from a third instar *P.madidus* larva captured on 14.xi.66. However, rarely did more than 9-10 *P.viator* emerge from a single *N.brevicollis* larva.

The other identifiable causes of death in third instar *N.brevicollis* larvae were those due to injury, causing death before or during pupation, and to nematode parasites. Two

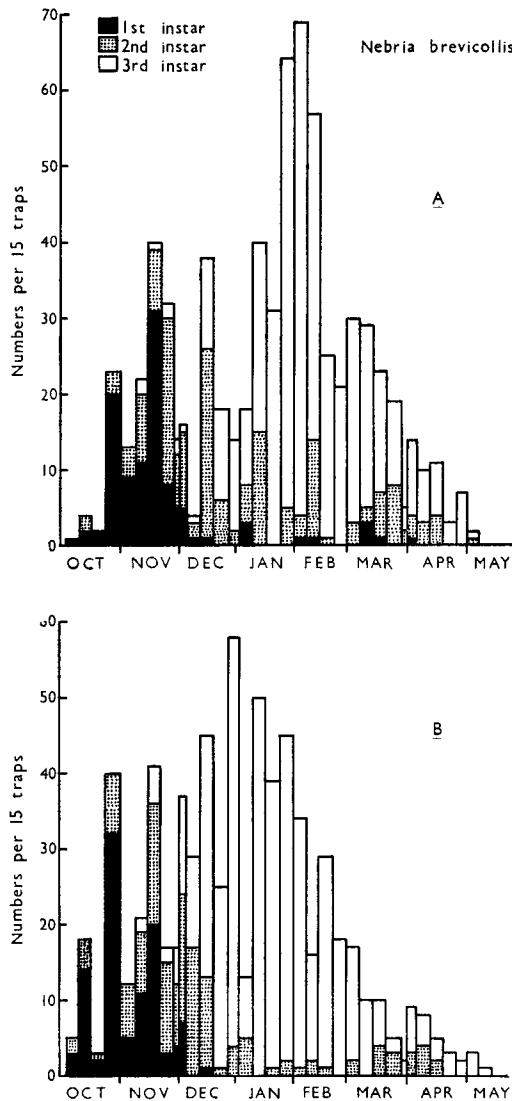


Fig. 1. Relative abundance of *Nebria brevicollis* larvae from (A) the periphery and (B) the centre of Four Acre Field.

Table 2. Mortalities due to *Phaenoserphus viator* and *P. pallipes* in third instar larvae of *Nebria brevicollis*.

Site	Date of capture in 1966	Number examined	Cause of death			Numbers pupating
			<i>P. viator</i>	<i>P. pallipes</i>	Other factors	
Four Acre Field	January 27th	67	24		35	8
	February 1st	112	33	4	37	38
	February 8th	26	7		6	13
	February 15th	16	2	2	7	5
	March 1st	19	1	1	9	8
	March 8th	21			14	7
	March 15th	9			8	1
	March 22nd	5	1		3	1
	March 29th	5			4	1
	April 5th	7			3	4
	April 12th	5				5
	April 19th	1			1	
	May 3rd	1				1
	Total	294	68	7	127	92
Hill Bottom	February 28th	26	7		10	9
	March 7th	21			12	9
	March 14th	15			10	5
	March 21st	19			15	4
	March 28th	18			12	6
	April 4th	23			10	13
	April 11th	26			14	12
	April 18th	34			11	23
	Total	182	7		94	81

immature specimens of *Hexamermis* sp. (Nematoda) were found in host larvae trapped in Hill Bottom on 4.iv.66 and 11.iv.66 respectively. Both were tightly coiled in the haemocoel of the host's thorax and were 89 mm. and 102 mm. long. Many *Mesodiplogaster iheritieri* (Maupas) (Nematoda : Diplogasteridae) were sometimes found in dead or dying larvae but these had probably invaded the host larvae through wounds. Ciliate protozoa were occasionally found in association with Diplogasteridae and it is possible that they are symbionts or parasites of the nematodes.

DISCUSSION

Adult Carabidae have few known arthropod predators (with the exception of spiders (Bristowe, 1941)) and probably occupy a position near the top of food chains. Vertebrates are probably the major predators on the adults, e.g. Amphibia (frogs and toads), small mammals, i.e. mice and shrews (Lavrov, 1943; Crowcroft, 1954, in Murdoch, 1966) and birds. Thompson (1943) lists 6 tachinids, 2 proctotrupids and one braconid which parasitise adult Carabidae. Rivard (1964), in a study of the period of egg production in carabids, dissected over 5500 individuals of some 40 species but found only 19 parasitised ones, mostly *Pterostichus melanarius* (= *P. vulgaris*).

The most susceptible stages of the carabid life cycle appear to be the eggs or larvae.

Eggs are generally laid at random in or on the surface of the soil while the comparatively soft bodied larvae are vulnerable to attack by parasites. The two most important insect parasites at Silwood Park were *Phaenoserphus viator* and *P. pallipes*. Dissections of living and dead *N. brevicollis* larvae revealed that first instar larvae of *P. viator* first appeared in late November and early December. Prepupae and pupae emerged from the host larvae from January onwards and after a short pupa period (about 1 week) adults emerged and mating occurred within 24 hours. Adult parasites could be kept alive for several weeks or months on a sugar solution and presumably survive in nature on the nectar from flowers.

Parasitism or attempts at parasitism never occurred when live host larvae were enclosed with adult female parasites. Adult parasites are surprisingly good burrowers in moist sand and it is likely that parasitism occurs in the soil in the comparative confinement of the host's burrow. Twenty three per cent. of third instar *N. brevicollis* larvae examined in 1966 were parasitised by *P. viator* and 11 per cent. in 1967 (Table 1). Possibly there is notably more parasitism in some years, e.g. the decrease in *N. brevicollis* adults from 2300 in 1959 to 200 in 1960 (Greenslade, 1964) could be explained by parasitism. Although larvae of other carabid species were parasitised by *P. viator*, insufficient numbers were examined to give adequate estimates of parasitism.

The biology of *P. pallipes* was relatively difficult to assess because it parasitises both summer- and winter-active larvae. In 1966, 23 per cent. of larvae of *Notiophilus* spp. examined were killed by this parasite but otherwise few *Nebria* larvae were parasitised (Table 2). Davies (1959) bred single *P. vexator* Nixon adults from *Notiophilus biguttatus* (F.) and *N. rufipes* Curtis. Possibly Davies's *P. vexator* was *P. pallipes*, for Nixon (1938) states that "*P. vexator* may later be shown to be nothing but an unusual form of *P. pallipes*".

Very few nematode parasites of Carabidae have previously been recorded. There is a single record of a mermithid, *Mermis albicans* Sieb in *Amara similata* (Gyllenhal) in Europe (Assmuss, 1858, from Rivard, 1964) and one of *Hexamermis* sp. in *Bembidion nitidum* Kirby in Canada (Rivard, 1964). The presence of *Hexamermis* sp. in *N. brevicollis* larvae is therefore noteworthy but these parasites seem to be too scarce to be important in affecting carabid numbers.

SUMMARY

1. *Phaenoserphus viator* (Haliday) and *P. pallipes* (Latreille) are two common insect parasites of carabid larvae in arable fields at Silwood Park.
2. Neither parasite is specific to one host larva species but whereas *P. viator* is gregarious and occurs mostly in winter-active larvae, *P. pallipes* is solitary and usually parasitises summer-active larvae.
3. The level of parasitism was never constant but varied from year to year and from one field to another but caused up to 25 per cent. mortality of a given species.
4. Carabid larvae are parasitised by nematodes, in particular by *Hexamermis* sp., but these occur so infrequently that they cannot be important in affecting numbers.

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