THE IDENTIFICATION AND IMPORTANCE OF PREDATORS OF *ELDANA SACCHARINA* (LEPIDOPTERA: PYRALIDAE)

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Abstract

Predators of eggs and larvae of *Eldana saccharina* Walker in sugarcane were identified by means of a serological technique. By combining the results of serological tests with estimates of arthropod abundance, the relative importance of the predators was estimated. Such an analysis showed that ants and probably mites were important predators and that predation appeared to be greater on larvae than on eggs. Field experiments showed that the amount of predation on an egg batch depended on the degree of exposure of the batch; concealed batches were less severely attacked than exposed batches. The results of insecticide exclusion experiments supported this finding. By tracing and examining the eggs laid by radioactive females released into field cages, it was found that the level of predation on eggs remained low whether or not arthropods were excluded. Larval predation was similarly examined, and it was found that survival of larvae was greater where arthropods had been excluded. However, a large percentage of larvae were lost irrespective of the treatment.

Introduction

Mortality of *Eldana saccharina* Walker has been considered by several authors including Waiyaki,[12] Girling,[5] and Betbeder-Matibet.[1] These authors suggest that, in common with many lepidopterous pests, the greatest mortality occurs in both the egg and young larval stages. In his study of eldana, Girling[5] suggested that most of the mortality of eggs and young larvae could be attributed to the action of predators — mainly ants. This finding was supported by Betbeder-Matibet[1] and by Waiyaki[12] in their studies of eldana in West Africa and Tanzania respectively. However, both parasitoids and diseases can be major causes of mortality. Moreover, environmental factors, such as desiccation and the condition of the host plant may affect survival.

The objective of the first of the two studies presented here was the identification and assessment of the importance of identified predators of this pest. The objective of the second study was to demonstrate the impact the predator community has on the survival of eldana eggs and larvae.

Materials and methods

The two studies differed in their methodology, so each will be considered separately.

The identification of the predators of eldana

It was considered likely that predation would be heavier on eggs and larvae, particularly young dispersing larvae. Accordingly, efforts were made to identify such predators by a serological technique called cross-over electrophoresis (COE) (Leslie[8]). In this technique, antibodies and antigens move towards one another in a horizontal gel medium, under the influence of an electric current. Where the two solutions meet, visible bands of antigen/antibody complex are produced in a positive test.

Antisera were prepared against eldana egg and larval protein by inoculating rabbits with the appropriate antigen (egg or larval protein). The antisera used in tests had a sensitivity of 1/20 480 against the homologous antigen. Cross-reactions were removed by absorption and dilution. It was not possible to produce an antiserum specific to young larvae alone, so the results reflect predator feeding on all stages of eldana larvae.

Arthropods for testing were collected in the field by vacuum sampling rows of mature sugarcane. The arthropods were taken to the laboratory and stored in a deepfreeze to await testing. For testing, crushed extracts of arthropod gut contents (the antigen) were tested against the egg or larval antisera.

Establishing the importance of arthropod predators of eldana

The insecticide exclusion technique was used. Pairs of field cages 2 × 1 × 2 m were positioned over 2 m row lengths of 12 month old sugarcane and cages were separated by 10 cane rows. In one of a pair of cages, the arthropods were removed by fumigation with methyl bromide at a rate of 40 g m^{-3} for 1½ to 2 h. Additionally sugarcane in the immediate vicinity of that fumigated was sprayed with a solution of cypermethrin at a rate of 40 mℓ in 50 ℓ of water. Both treated and untreated cages were enclosed in shadecloth (to prevent the escape of released adults as well as to inhibit entry of predators) and earth was banked up around their perimeters.

Into cages so prepared were released radioactive eldana adults or black (nearly hatched) eggs, depending on the objective of the experiment. An average of 7 mated females were released into each cage in the egg predation studies while approximately 300 black eggs were placed out in each cage in the larval predation trials.

Radioactive adults for release were obtained by feeding larvae on a diet containing the radioisotope phosphorus-32 (32p). This was incorporated into an artificial diet medium to give a concentration of 1 μCi 32p $m\ell^{-1}$ of medium. Two to three-week old larvae were added singly to approximately 10 mℓ volumes of the labelled diet, where they remained until they emerged as adults. Labelled adults gave counts of between 50 and 150 counts sec^{-1} at a distance of 50 mm from the detector. Such a dose received by the adults was sufficient to permit detection of eggs laid in the field, and had no apparent effects on adult emergence, behaviour and fecundity. The eggs used in larval predation studies were obtained from the general laboratory culture.

In the egg predation studies, caged sugarcane was carefully scanned with a portable Geiger counter approximately 5 days after the release of the labelled adults. The time of sampling was determined by monitoring the development of placed egg batches; when these turned dark orange the cage was sampled. Any batches detected were collected and examined in the laboratory for evidence of predation.

In the larval predation studies, the sugarcane was destructively sampled after a period determined by accumulated day degrees (d°). This value was calculated to provide sufficient time for placed larvae to develop into easily collected late instar larvae.

In both studies, to test the efficacy of the exclusion treatments, batches of eggs were placed as a control in exposed positions in the cages. Superimposed on the above studies was a pretrashing treatment: the sugarcane in pairs of cages was either pretrashed or left with the trash intact.

As part of the study on egg predation an ancillary investigation into the effect of egg concealment on predation was conducted. Egg batches comprising known numbers of eggs were placed in concealed, or alternatively exposed, positions at 3 points on mature sugarcane stalks. The eggs were later collected and examined for evidence of predation.

Results

The identification of eldana predators

A total of 3 442 arthropods were tested as suspected predators of eldana eggs and larvae. Of these 2 318 were tested as potential egg predators, while 1 124 were tested as potential larval predators.

The species of arthropod tested and the number and results of such tests are given in Tables 1 and 2. A wide range of arthropod species was tested. While a large number of species had fed on larvae (69%) only 28% of those suspected of feeding on eggs had done so.

These serological tests cannot be quantified, so on their own can be misleading; it is not known how many destroyed

Table 1

The results of serological tests: eldana egg predators associated with sugarcane

Arthropod type	Results of tests			% positive	Arthropod type	Results of tests			% positive
	Number negative	Number positive	Total			Number negative	Number positive	Total	
Acarina:					Diptera	5	0	5	0
Prostigmata	288	12	300	4,0	Formicidae:				
Araneida:					*Pheidole*	630	2	632	0,3
Lycosidae	25	0	25	0	*Paratrechina*	12	0	12	0
Salticidae	32	0	32	0	*Solenopsis*	109	1	110	0,9
Thomisidae	22	0	22	0	*Polyrhachis*	4	0	4	0
Clubionidae	9	0	9	0	*Plagiolepis*	3	0	3	0
Pholcidae	15	0	15	0	*Crematogaster*	56	0	56	0
Theridiidae	74	0	74	0	*Acantholepis*	36	0	36	0
Drassidae	32	0	32	0	*Dorylus*	219	0	219	0
Linyphiidae	1	0	1	0	Heteroptera	44	0	44	0
Selenopidae	10	0	10	0	Homoptera	89	0	89	0
Agelenidae	3	0	3	0	Isopoda	20	1	21	4,8
Araneida misc	28	0	28	0	Chelonethida	18	2	20	10,0
Blattaria	63	2	65	3,1	Gryllidae	68	0	68	0
Chilopoda	3	0	3	0					
Coleoptera:									
larvae	21	0	21	0					
adults	201	2	203	1,0					
Collembola	152	4	156	2,6	Total	2 292	26	2 318	1,1

Table 2

The results of serological tests: eldana larval predators associated with sugarcane

Arthropod type	Results of tests			% positive	Arthropod type	Results of tests			% positive
	Number negative	Number positive	Total			Number negative	Number positive	Total	
Acarina:					Dermaptera	1	0	1	0
Prostigmata	15	1	16	6,2	Diptera	10	0	10	0
Araneida:					Formicidae:				
Lycosidae	20	2	22	1,0	*Pheidole*	148	12	160	7,5
Salticidae	17	0	17	0	*Paratrechina*	114	0	114	0
Thomisidae	36	5	41	12,2	*Solenopsis*	43	3	46	6,5
Clubionidae	4	0	4	0	*Polyrhachis*	23	1	24	4,2
Theridiidae	11	3	14	21,4	*Plagiolepis*	20	2	22	9,1
Drassidae	28	3	31	9,7	*Acantholepis*	29	5	34	14,7
Selenopidae	6	0	6	0	*Dorylus*	145	94	239	39,3
Agelenidae	1	2	3	66,7	*Aenictus*	33	2	35	5,7
Argiopidae	2	1	3	33,3	Heteroptera	37	5	42	11,9
Sicariidae	12	1	13	7,7	Homoptera	20	0	20	0
Erigonidae	5	0	5	0	Chelonethida	7	1	8	12,5
Blattaria	77	14	91	15,4	Gryllidae	31	10	41	24,4
Chilopoda	13	0	13	0					
Coleoptera:									
adults	43	6	49	12,2	Total	951	173	1 124	15,4

prey are represented by a single positive result. By combining percentage positive tests with estimates of the abundance of arthropods the relative importance of predators can be obtained. The analysis is based on a formula used by Ragsdale *et al.*[10] who calculated what they termed predator efficiency (PE).

$$PE = \frac{A \times P}{\sum (A \times P)} \times 100$$

where PE = predator efficiency
A = abundance of predator
P = % positive tests

The data on arthropod abundance were derived largely from Leslie.[8] However, data on mite and ant abundance were obtained from Block,[2] Wilson,[13] and Brian.[3]

Such an analysis has shortcomings. For example, abundance estimates are based on diurnal arthropod activity only. Also, in the case of ants, it is not known what proportion of individuals in a colony is actively foraging at any one time. Nevertheless, this analysis is useful in suggesting which arthropod species are the important predators of this pest; it indicates that mites and ants are the more important egg predators, while ants are the major predators of larvae (Table 3).

Table 3

The efficiency of eldana predators associated with sugarcane

Arthropod type	abundance (No/s×10)† (a)	Number tested	% positive (b)	(a×b)	Efficiency*	
Egg predators						
Acarina	61	300	4,0	244	66,40	
Coleoptera (adults)	2,3	203	1,0	2,3	0,63	
Blattaria	1,3	65	3,1	4,0	1,10	
Collembola	284	156	2,6	(738,4)		
Isopoda	5,3	21	4,8	25,4	6,90	
Chelonethida	0,05	20	10,0	0,5	0,14	
Formicidae:						
Pheidole	300	632	0,3	90	24,50	24,9
Solenopsis	1,8	110	0,9	1,6	0,41	
				368		
Larval predators						
Araneida:						
Lycosidae	1,3	22	1,0	1,3	0,007	0,39
Thomisidae	1,0	41	12,2	12,2	0,070	
Drassidae	0,9	31	9,7	8,7	0,050	
Agelenidae	0,2	3	66,7	13,3	0,070	
Theridiidae	1,0	14	21,4	21,4	0,110	
Argiopidae	0,4	3	33,3	13,3	0,070	
Sicariidae	0,3	13	7,7	2,3	0,010	
Acarina	61	16	6,3	384,3	2,100	
Chelonethida	0,05	8	12,5	0,6	0,00003	
Coleoptera (adults)	2,3	49	12,2	28,1	0,150	
Heteroptera	2,6	42	11,9	30,9	0,170	
Saltatoria	1,1	41	24,4	26,8	0,140	
Blattaria	1,3	91	15,4	20,0	0,110	
Formicidae:						
Pheidole	300	160	7,5	2250	12,10	97
Polyrhachis	9,0	24	4,2	37,8	0,20	
Plagiolepis	1 600	22	9,1	14560	78,20	
Solenopsis	1,8	46	6,5	11,7	0,06	
Acantholepis	4	34	14,7	58,8	0,31	
Dorylus	25	239	39,3	982,5	5,30	
Aenictus	25	35	6,0	150	0,80	
				18614		

* Efficiency = $\frac{a \times b}{\sum(a \times b)} \times 100$

† s = stalk

Establishing the importance of eldana predators

Eleven trials were conducted, 5 in pretrashed sugarcane and 6 in sugarcane that was not pretrashed to study the effect of the exclusion of arthropods on egg predation. Where arthropods were excluded, approximately 10% of placed eggs were eaten, whereas in the control cages (no exclusion treatment) between 55 and 78% of the eggs were consumed by predators (Table 4). No distinct differences in predation were evident between pretrashed and non-pretrashed sugarcane.

Predation on naturally laid eggs was low (about 10%), irrespective of exclusion and pretrashing treatments. The number of batches recovered did not vary greatly between treatments. However, there is an indication that fewer eggs were recovered from pretrashed sugarcane, particularly where arthropods had not been excluded.

The effect of egg concealment on predation is shown in Tables 5 and 6. A comparatively large percentage of batches was attacked when eggs were placed near the base of stalks; relatively fewer were attacked as the height of the batch on the stalk was increased (Table 5). Such differences were more marked when eggs were exposed than when they were not. Table 6 shows percent eggs eaten. Between 6 and 10% of concealed eggs were attacked by predators, depending on the position of the batch, but between 15 and 62% of eggs were eaten if they were in an exposed position.

Table 5

The mean percentage of concealed and exposed eldana egg batches attacked and not attacked by predators

Batch position	Batches attacked			Batches not attacked		
	x̄	SEM	n	x̄	SEM	n
Exposed						
Top	32	1,1	4	68	1,9	4
Middle	55	1,9	4	45	1,3	4
Bottom	76	9,1	4	20	10,0	4
Concealed						
Top	34	5,7	4	66	7,0	4
Middle	32	10,3	4	67	10,3	4
Bottom	46	5,0	4	54	5,0	4

Table 6

The mean percentage eldana eggs eaten in exposed and concealed positions

Batch position	Eggs concealed			Eggs exposed		
	x̄	SEM	n	x̄	SEM	n
Top	6	2,2	10	15	3,9	11
Middle	7	3,1	10	33	6,9	11
Bottom	10	3,1	10	62	18,5	11

Altogether 6 trials were conducted, 2 in pretrashed and 4 in non-pretrashed sugarcane, to study the effect of arthropod exclusion on larval predation. Data on predation of placed eggs confirmed the effective exclusion of predacious arthropods. Where arthropods were excluded, a greater proportion

Table 4

Predation on eldana eggs where arthropods have and have not been excluded in pretrashed and unpretrashed sugarcane

Trial no	Arthropods excluded					Arthropods not excluded				
	No of eggs detected	Number of batches		% eggs eaten		No of eggs detected	Number of batches		% eggs eaten	
		Recovered	Attacked	Laid	Placed		Recovered	Attacked	Laid	Placed
Non-pretrashed						Non-pretrashed				
1	68	2	2	31	17	227	7	2	11	68
2	1 029	24	4	3	8	1 088	26	6	4	62
3	830	12	7	3	9	169	6	0	0	61
4	378	5	2	2	12	606	10	7	5	100
5	929	20	6	8	0	714	22	4	4	88
6	411	15	1	0,2	13	413	10	8	24	79
x̄	524	13	4	8	10	536	14	5	8	76
SD	374	8,5	2,4	11,6	5,8	342	8	3,1	8,6	15,6
Pretrashed						Pretrashed				
1	535	11	0	0	5	105	3	2	54	48
2	446	12	4	1	21	79	1	0	0	29
3	356	17	0	0	6	197	4	2	4	51
4	134	9	2	7	0	471	21	3	3	63
5	—	—	—	—	—	215	7	1	1	84
x̄	368	12	2	2	8	213	7	2	12	55
SD	172	3,4	1,9	3,4	9,0	155	8,0	1,1	23,4	20,3

of larvae were recovered (Table 7). However, many larvae (about 90%) died irrespective of the exclusion treatment. There were no clear differences in survival where sugarcane was or was not pretrashed.

Discussion

Several species of arthropod were identified as egg predators, including ants and mites. The physically smaller ants, such as *Pheidole*, are probably well-suited to searching behind leaf sheaths and similar surfaces for food, as are the mites. The ecology of mites associated with sugarcane in Natal is poorly understood; however, their role as egg predators may be important, because of their abundance, small size, and their feeding habits. As Loughton *et al.*[9] noted in their study of the predators of the spruce bud-worm, mites usually attack more than one egg in a batch.

Some arthropods which were recorded as feeding on eldana eggs would not normally be considered predacious; for example, the Chelonethida (pseudoscorpions), Collembola and the Isopoda. Hinton[6] confirms that the pseudoscorpions and Collembola will attack eggs. However, isopods are considered to be herbivorous or scavengers, and it is likely that eldana eggs were unintentionally consumed by this arthropod.

The serological tests showed that several species of ants and spiders were frequent predators of larvae. As noted earlier, physically small ant species, such as *Pheidole*, should be efficient at searching for and attacking young larvae. Conversely, the physically larger and more aggressive ant species, *Dorylus*, may not feed on young larvae but has been frequently observed feeding on larger eldana larvae in their borings. Some of the spiders identified as larval predators are what can be termed 'hunting spiders', for example the lyocosids, which move through the habitat in search of prey. Such spiders probably attack larvae that have not yet penetrated the stalk. Others such as the theridiids are web-spinning spiders, and they may trap young larvae as they disperse through the habitat. This was the mechanism Rothschild[11] suggested to explain the identification of web-spinning spiders as larval predators in his study of the predators of rice stem borers in Sarawak. It seems probable, therefore, that most larval predation is on young, dispersing larvae, or on those that have not penetrated sugarcane stalks.

Table 7

The effect of arthropod exclusion and pretrashing on eldana larval predation

Trial no	Arthropods excluded			Arthropods not excluded		
	No of eggs placed	% survival	Total d°	No of eggs placed	% survival	Total d°
Pretrashed				Pretrashed		
1	226	37	202	234	13	178
2	215	17	201	245	12	170
x̄		27	—	x̄	13	—
SD		14,1	—	SD	0,7	—
Non-pretrashed				Non-pretrashed		
1	314	7	229	303	3	229
2	292	18	244	292	15	252
3	301	10	216	318	6	181
4	305	21	190	306	14	240
x̄		14	—	x̄	10	—
SD		6,8	—	SD	5,9	—

The calculated efficiencies of identified predators provide an indication of which arthropods should be considered important predators. Ants and mites evidently are important predators of eggs, while ants are the major predators of larvae. While such arthropods undoubtedly contribute to the mortality of eldana eggs and larvae, there are few quantitative data available on the impact of predators.

In East Africa, Girling[5] pinned egg batches to maize plants and subsequently confined inseminated females to the plants, so that they might oviposit on the plants. The confining cage was then removed and predation monitored. It was found that predation was intense (92% of eggs were eaten), but that some egg batches remained untouched, presumably because they were concealed. Of the eggs that hatched, 93% of the larvae were lost through predation, mainly by ants. Leslie[7] also found that predation on eggs was high. In an insecticide exclusion trial 20% of eggs were consumed where arthropods were excluded, while 60% of eggs were eaten in the untreated trials.

Such studies suggest that a large percentage of eggs are lost due to predation. However, Girling's[5] study of egg predation included the pinning of egg masses to plants. Eggs so placed may be exposed to predation which naturally laid eggs would escape. Although his second set of experiments allowed moths to oviposit on the plants, which resulted in high levels of predation, such studies were conducted on maize plants, the morphology of which is quite different from that of sugarcane. Even so, he found that some naturally laid eggs were not eaten.

In the study by Leslie[7] no record was made of the degree of exposure of the placed batches, but it appears from the results that the batches were in exposed positions on stalks. Thus, while it is possible that under certain conditions predation on eggs may be intense, it seems that in Natal predation upon naturally laid eggs in sugarcane is relatively small. The explanation perhaps is that ovipositing females generally place eggs between closely fitting surfaces in the sugarcane habitat. Such concealment affords substantial protection from predators. It seems that as many as 80% of laid eggs escape predation, a possibility which is supported by the comparative scarcity of positive tests for egg predators in the serological study. Other mortality factors, such as desiccation, mechanical damage or drowning may be more important mortality factors.

The study of the effect of egg conealment on predation showed not only that predation intensity was related to the degree of exposure of eggs, but also that predation was greatest on eggs placed towards the base of stalks. This finding, coupled with the observation that eggs placed on the upper parts of stalks developed more rapidly, suggests some advantage to a moth selecting oviposition sites higher up on the stalk. From observations made on oviposition sites it is evident that such sites are not selected, so there may be important disadvantages in selecting such sites.

While the results of studies of larval mortality show that about 95% of larvae die, the role of predators is not clear. The study here does show that survival is marginally greater where arthropods are removed but further studies are required to confirm this. As in the case of egg mortality, factors such as the inability to find a suitable host, cannibalism, and desiccation may be more important causes of mortality than predation. As Dempster[4] points out, weather alone may frequently act as the key factor in determining population trends.

An aspect of predation that has not been considered is that of the moths. No information, besides anecdotal observations of spiders attacking adults, appears to be available. Because of the moth's mobility and short life-span, predation of adults may not be important. However, the small number of eggs recovered from pretrashed sugarcane where arthropods were not excluded (Table 4) could be explained by predation on adults. The comparatively open nature of the habitat of pretrashed sugarcane may have permitted predators to attack ovipositing females more easily than in non-pretrashed sugarcane.

Conclusion

The studies considered here suggest that predation on eldana eggs and young larvae is low. While the mortality of these stages may be high, factors other than predation seem likely to be a major cause.

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