EFFECT OF TEMPERATURE AND SOIL MOISTURE ON AUSTRALIAN SOLDIER FLY EGGS

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Summary

Australian soldier fly (*Inopus rubriceps*) eggs were exposed to temperatures ranging from 34 - 42° C for periods of 0.5 - 3.5 hours. All eggs survived at 34 and 36° C. Eggs survived when exposed to 38° C for up to 3 h, 40° C for up to 1 h and 42° C for 0.5 h but half an hour longer at any of these temperatures was lethal. All eggs hatched in silt loam soil held at 20° C with moisture content ranging from 5-25% (40+ to 0.07 bars osmotic potential) but not at 0 or 30%. Eggs appear to develop successfully without absorbing water.

INTRODUCTION

The Australian soldier fly is a pasture and crop pest in the Northern North Island. It has been shown in several pasture management trials that cutting or grazing to a low level during the adult flight period reduces the number of subsequent newly-hatched larvae (Kain and Burton 1975; Gerard and Burton 1976; Robertson *et al* 1978). In New Zealand there are two main adult emergence periods, one in spring (November-December) and the other in autumn (March/April) (Wilcocks 1973). Since mating and oviposition occur shortly after emergence, eggs are present in the field at approximately the same time as adults. They are laid at shallow depths in the soil and hatch in about 2 weeks (Wilcocks 1973). Defoliation of long pasture would expose eggs to high temperatures and possible desiccation and may partially explain the reductions in numbers of newly hatched larvae in the above trials.

Although Moller (1965) and Campbell and Kochler (1971) found eggs held continuously at 25° C did not hatch, Wilcocks (1973) obtained a 59.5% hatching rate at this temperature and concluded that it was near their survival limit. Hitchcock (1970) observed that provided there was some moisture at a time of oviposition, subsequent drying out of the soil did not affect egg viability.

This paper reports on laboratory experiments aimed at finding the effects of short periods of high temperatures and of varying soil moisture on soldier fly eggs and attempts to relate these to conditions found in the field.

METHODS

Freshly laid egg clusters were obtained from mated females caught in the field.

Temperature

Sterilized petri-dishes were filled with agar and 5 egg clusters placed in each so that each dish contained approximately 350 eggs. These were then incubated at 20° C for 4 days, by which time the eggs assumed an

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amber colour, to ensure that all egg clusters used were viable. A series of five temperatures ranging from 34 - 42°C in 2°C steps was set in incubators. Each petri-dish of 4-day-old eggs was then subjected to one of these temperatures for either 0.5, 1.0, 1.5, 2.0, 2.5, 3.0 or 3.5 h as in Table 1. The eggs were then incubated at 20°C until all hatching had ceased. A control petri-dish of 5 egg clusters remained at 20°C continuously so any effect of high temperatures on hatching time could be noted. After hatching, each egg cluster was examined and percentage hatch recorded. Only one dish of eggs was subjected to each treatment, with the 5 egg clusters being considered as replicates.

Soil moisture

Water was mixed with sieved oven-dried soil (silt-loam) to give a range of seven treatments with moisture contents ranging from 0-30% (40+ to 0.05 bars) (see Table 2). Five air-tight plastic vials (9 cm x 4 cm diameter) were filled with soil at each moisture content. Freshly-laid egg clusters were placed below the soil surface and the vial sealed. The vials were incubated at 20°C along with 5 control clusters of eggs on agar. Five days after the control eggs hatched, the contents of each vial were examined.

Unhatched eggs, egg cases and some larvae were removed and the remaining contents of the vial immersed in a concentrated solution of MgSO₄. By viewing the solution surface through a microscope, larvae, egg cases and eggs could be counted. The percentage hatch and condition and development of larvae and eggs were ascertained. Each vial was weighed before and directly after incubation to measure any change of soil moisture levels.

RESULTS

Temperature

At 20°C, fertile eggs on agar assumed an amber colour on the 3rd and 4th day of incubation and larval segmentation appeared at 5-6 days. Larvae hatched on the 10th or 11th day and moulted into the second instar within 5 days.

A summary of the results from exposing eggs to short periods of high temperature is given in Table 1. Differences are significant ($P < 0.01$). No effect on time of hatching was observed. In treatments where no eggs had hatched, no segmentation was visible indicating that mortality was directly related to the heat treatment. Unhatched eggs remaining in the other treatments had visible segmentation indicating that embryonic development had continued for sometime after the heat treatment.

TABLE 1: Survival of soldier fly eggs exposed to high temperatures for different times.

Time (hours)	Temperature (°C)				
	34	36	38	40	42
1½	++	++	++	++	++
1	++	++	++	++	-
1½	++	++	++	-	-
2	++	++	++	-	-
2½	++	++	++	-	-
3	++	++	++	-	-
3½	++	++	-	-	-
++ 95-100 % survival					
- 100 % mortality					

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Soil moisture

Pooled results from the five replications of each soil moisture level are presented in Table 2. The eggs subjected to 0 % soil moisture were shrivelled but some had an amber colour suggesting that some early development may have occurred. At 5 % moisture content, the larvae were alive and showed no sign of desiccation. All were in the first instar although many had setae of the next instar visible through the larval cuticle whereas all the control larvae on agar were in the second instar. It is unknown whether the apparent delay in entering the second instar by the larvae at 5% soil moisture was caused by later hatching or moisture stress. The larvae had moved away from the egg cases and most were at the bottom of the vial. This downward movement may indicate a survival mechanism if dry conditions are experienced in the field.

Larvae that hatched in soils ranging from 10-25 % moisture content were all in the second instar and still amongst the egg cases. No larvae or eggs were recovered from the 30 % soil moisture level and it appeared that these eggs had been killed.

Water gain or loss from vials after incubation was at maximum 0.12%.

Table 2: Effect OS soil Moisture on hatch of soldier fly eggs.

% Moisture content	Bars	Initial No. eggs	% Hatch
0		350	0
5	40+	514	98-100
10	2	330	99-100
15	0.3	249	100
20	0.12	257	100
25	0.07	271	100
30	0.05	250	0

DISCUSSION

Eggs could hatch successfully after 0.5 h exposure to 42° C, 1 h at 40° C and 3 h at 38° C but half an hour longer at any of these temperatures was lethal (Table 1). Temperatures can reach these levels in the top 2.5 cm of the soil under short, open Waikato pasture during December and March-April, when eggs would be present (Robertson pers comm). Especially with the possibility of repeated exposure several times within one week, high temperatures could account for significant egg mortality.

Eggs hatched successfully in soil at 5% moisture content (40+ bars) and levels below this have not been recorded under short, open Waikato pastures which have supported low numbers of soldier fly in pasture management trials (Robertson, pers comm). It appears, therefore, that desiccation caused directly by low moisture levels may not be a significant mortality factor in the field.

In the field eggs are not laid in a random manner. Rather females oviposit in small cracks in the soil surface or gaps between soil and plant stems. Moisture and physical closeness of the sides of these crevices are probably critical factors in selection of oviposition sites (Wilcocks 1973). Eggs are laid in clusters rather than individually which would also aid survival. Prestidge (1978) found significantly more newly hatched larvae under long rather than short pasture. This may result from preferences of the female for long pasture as an oviposition site (Kain and Burton 1975).

However, once laid, eggs could be exposed to increased heat or desiccation if pasture cover was removed during hot dry weather. In the

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field there would be an interaction between the effects of low soil moisture and high temperatures with one enhancing the other. Other factors such as air movement would be expected to influence desiccation. This may partly explain the observed low recruitment of new larvae into populations after mowing (Kain and Burton 1975) or hard grazing (Dixon and Campbell 1978; Robertson *et al* 1978). Although other factors such as mortality of prepupae, pupae (Gerard and Burton 1976) and newly hatched larvae as well as adult oviposition preferences (Kain and Burton 1975) and dispersal (Dixon and Gerard 1979) may be partly responsible.

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