REVIEW OF THE LIFE-CYCLE OF THE AUSTRALIAN SOLDIER FLY

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Summary

The life-cycle of the Australian soldier fly *Inopus rubriceps* is reviewed. Briefly, it appears that eggs take approximately two weeks to hatch, the larval period lasts for one or two years, the majority of larvae taking two years, the pupal period lasts for approximately one month, and the adults live for only a few days.

INTRODUCTION

THE LIFE-CYCLE of the Australian soldier fly, *Inopus rubriceps* (Macquart), has still not been fully worked out under New Zealand conditions. However, there is sufficient information to hand to make a review at this stage worth while. It is intended to deal only with the length and time of occurrence of the various stages, with brief reference to female fecundity. For morphological descriptions of all stages, Irwin-Smith (1920, 1921a, b, 1923), Campbell and Koehler (1971), and Timlin (1969) should be consulted.

REVIEW OF THE LIFE-CYCLE

Irwin-Smith (1920, 1921a) reported two emergence periods for the adult fly in Sydney, one from mid-October to early December, and a second one from early April to mid-May. Near Mackay in Queensland, adults have been observed flying at the end of May (Jarvis, 1925) and at the end of June (Mungomery, 1926). In the Opotiki district of New Zealand, Dumbleton (1949) reported that adults were flying between late March and early April, and in late November.

Saunders (1963), noting the two recorded emergence periods per year made by Irwin-Smith, stated that, on the Atherton tablelands in Queensland, adults have only been observed emerging from April through to June, with a peak emergence in June. Another indication that the time of emergence varied on a geographic basis has been made by Wilson (1969). He reported that, in Queensland, emergence was first noted in mid-March in the Bundaberg district, during the third week of April at Innisfail, but not until the second week of May near Mackay; emergence was still evident but diminishing in June. Wilson (1970) again reported that emergence was first noted at Bundaberg early in March, but not until late April at Mackay.

In the sugar belt area of Queensland according to Moller (1965), the main months during which emergence takes place are April and May, but Australian soldier fly adults have been seen as early as February right through to June. Campbell and Koehler (1971) reported that on the

California Peninsula during 1964 and 1966 only an autumn flight was observed, while during 1965, in addition to the normal autumn flight, a very short spring flight occurred. Timlin (1969) found, from work carried out in the Whakatane district of New Zealand, that the flight period occupied six months from November till May. There were two distinct peaks of emergence, one in February and the second in April.

The writer has recorded both a spring and an autumn emergence period in the Hamilton and Whakatane areas. In both districts, peak emergence occurred in April, and was considerably higher than emergence at any other time of the year.

It appears from the above that the number of emergences per year and the time at which they occur are probably regulated by climatic factors. Also, although emergence takes place over a considerable time interval (Moller, 1965; Timlin, 1969), the peak periods of emergence last for only three to four weeks. Outside these peak times, emergence is usually low and sporadic (pers. obs). Under New Zealand conditions, both a spring (mid-November to mid-December) and an autumn (end of March to end of April) emergence pattern is probably usual.

Irwin-Smith (1920) gave the length of the adult life as between 3 and 10 days, and Wilson (1959) gave it as between 3 and 5 days. Both reports were based on work carried out under uncontrolled laboratory conditions. Campbell and Koehler (1971) recorded that, for adults kept at 20°C, females lived an average of 4.8 days with a range of 0 to 10, and males lived an average of 8.3 days with a range of 0 to 16. At a higher temperature of 25°C, females had an average life of only 2.8 days with a range of 0 to 5.

Mating and oviposition occur shortly after emergence (Campbell and Koehler, 1971). The eggs are laid in clusters (Irwin-Smith, 1921a; Moller, 1965; Campbell and Koehler, 1971) and deposited at shallow depths in the soil (Saunders, 1963). Moller (1965) recorded that females laid their eggs in groups of about 150 to 200. The writer has found that the mean number of eggs per cluster (49 clusters collected from the field) was 42 with a range of 5 to 215.

From collecting copulating females, Timlin (1969) estimated the average number of eggs laid by a female was 187 with a range of 54 to 483. Campbell and Koehler (1971) reared female pupae at $20 \pm 1^\circ\text{C}$, and the adults that emerged laid an average of 230 eggs with a range of 137 to 361. The writer reared 49 females from pupae (at field ambient temperature during March-April 1970, mean maximum = $22.0 \pm 1.3^\circ\text{C}$, mean minimum = $10.8 \pm 1.0^\circ\text{C}$) and estimated the mean total fecundity of a female at 136 eggs, with a range of 33 to 281. There is obviously a wide variation in the fecundity of individual females but as yet no information is available as to the cause.

Irwin-Smith (1921a) recorded that eggs took 17 days to hatch at room temperature. Mungomery (1932) found that eggs hatched in 15 days at a mean temperature of 16.1°C , and both Dumbleton (1949) and Saunders (1963) reported that eggs took 2 to 3 weeks to hatch under field conditions. In the sugar-cane belt of Queensland, with presumably a high mean temperature, Moller (1965) states that, provided there is adequate moisture, the eggs hatch within 7 days. Moller's statement is substantiated with respect to the moisture requirement, by the fact that Campbell and Koehler (1971) found that all eggs subjected to ambient humidity shrivelled and died. However, they recorded the following for eggs kept on moist towelling which was remoistened daily:

<i>Temperature at which eggs were kept</i>	<i>Comments</i>
10° C	No development after 3 weeks.
15° C	Most eggs hatched on the 15th day.
20° C	A few hatched on the 11th day, and the remainder on the 12th.
25° C	Three dead larvae found on the 11th day, all other eggs darkened and decomposed by the 15th.
30° C	All eggs darkened and decomposed with no evidence of hatch.
(Number of eggs in each case was 500).	

However, the writer has hatched eggs in 7 to 9 days kept at 28.5° C on agar. More work is needed here to determine a little more clearly the relationship of time of development to temperature and moisture levels.

Irwin-Smith (1920) noted that larvae of varying sizes occurred at all periods of the year and that most of the larvae found were at a depth of 2 to 3 in. under pasture conditions.

The most detailed work on the length of the larval period reported to date is that being carried out by entomologists of the Bureau of Sugar Experimental Stations, Queensland. Wilson (1969) reported that a small proportion of larvae hatched out in 1967 and reared in a laboratory where the temperature was so regulated to correspond to field conditions, emerged as adults in one year, by May 1968. The majority of the larvae, whether field collected or laboratory reared, remained in the larval stage in the second year. Unfortunately, these larvae subsequently died. Wilson (1970) reported that, from eggs hatched in 1968, some larvae were reared to adults in one year, while the remainder reached the adult stage after two years. One- and two-year life-cycles were observed in both sexes. The number of larval instars appeared to be innately variable, and also to vary according to the length of the larval period. The number ranged from 7 to 10 for larvae maturing in one year, with 8 or 9 predominating, and from 9 to 11 for larvae maturing in two years with 10 predominating. According to Wilson (1970), studies are proceeding to determine diagnostic features for the different larval instars.

Pupae tend to occur just beneath the soil surface, and the pupal stage lasts for at least 18 days (Irwin-Smith, 1920). Campbell and Koehler (1971) have shown that at 20° C the duration of the pupal period is approximately 26 days.

CONCLUSIONS

There are still many points which need clarification, in particular, the temporal variation in emergence pattern, the determination of diagnostic characters to distinguish between the larval instars, and the effect of climatic factors on the speed of development of the various stages.

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