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RATE OF LARVAL DEVELOPMENT OF *PANTALA FLAVESCENS* (FABRICIUS) AT ITS SOUTHERN LIMIT OF RANGE IN AUSTRALIA (ANISOPTERA: LIBELLULIDAE)

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The larvae of *Pantala flavescens* completed egg and larval development in less than 51 days in fish farm ponds, at a latitude 2° South of its previously known distributional range in southern Australia. The development rate was less than recorded in earlier studies. Larvae of a second generation were collected from the ponds until May, and were absent until the following February. This evidence indicates that the larvae can complete a life cycle, but their progeny do not overwinter, and that the new population each year is probably derived from migratory adults.

INTRODUCTION

Pantala flavescens is a well known species with a circumtropical and temperate distribution (CORBET, 1979; KUMAR, 1984), commonly occurring between the latitudes 35° North and South (Dr J.A.L. Watson, pers. comm. 1992). *P. flavescens* is a well known migrant (LIEFTINCK, 1962; CORBET, 1983) and the migrations have been well documented (REICHHOLF, 1973; MITRA, 1974; WOJTUSIAK, 1974; CORBET, 1979; LARSEN, 1987). WATSON et al. (1991) reported that *P. flavescens* occurs in all regions of Australia, except southern South Australia, Victoria and Tasmania. The previous most southern record in Australia was Batehaven (35°44'S, 150°13'E) (Watson, pers. comm. 1993). However adults have been recorded from a more southern latitude outside Australia, at Twin Beaches (41°04'S) in New Zealand (CORBET, 1979).

P. flavescens is an opportunistic species which has been reported laying in small mud-puddles, monsoon and perennial ponds, ricefields and large streams

(WARREN, 1915; KUMAR, 1984). CORBET (1983) reports that small waterbodies like fish farm ponds are ideal for the successful development of *P. flavescens* larvae and studies by SANTOS et al. (1988) and BARLOW et al. (1991) show that the larvae become extremely abundant in these ponds when there are high water temperatures and an excess of food.

The egg and larval development of *P. flavescens* has been studied in the middle regions of its range (WARREN, 1915; KUMAR, 1984). WARREN (1915) found that, when kept at room temperature, the eggs hatched in five days and a larva maintained with an excess food supply, completed larval development in 55 days. KUMAR (1984) found in laboratory trials, conducted at temperatures between 28 to 32°C and with excess food resources, that egg and larval development took between 56 and 61 days. SURIBABU (1988) reported that *P. flavescens*, in central India, has a multivoltine life cycle, having observed it completing three generations in one year, in small cemented tanks.

There are no reports of the development of *P. flavescens* larvae at the southern limit of its distribution and this paper demonstrates that under certain conditions, at the southern limit, egg and larval development can be completed in less time than in the middle regions of its distribution.

MATERIAL AND METHODS

This investigation was carried out in earthen fish farm ponds located at the Snobs Creek Freshwater Fisheries Research Station Hatchery (SCFFRSH) near Eildon, Victoria, Australia (37°14'S, 145°55'E). Fish larvae are reared in these ponds for periods of 6-10 weeks. When the fish have grown to a length of 35-55 mm, they are harvested by completely draining the ponds (GOOLEY, 1993).

Two ponds (12 and 13), each with a capacity of 1.8 megalitres (Fig. 1) and another two ponds (14 and 15), each with a capacity of 0.7 megalitres, were sampled during this stu-

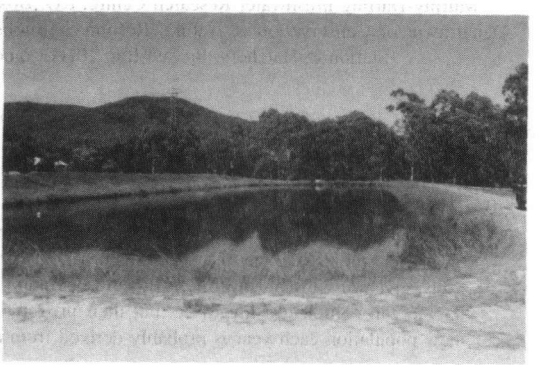

Fig. 1. Fish Pond 13 at full capacity (1.8 megalitres).

Fig. 2. Fish Pond 14 with only sump full (0.1 megalitres).

dy. Ponds 12 and 13 were filled and stocked with fish twice during the rearing season. Between harvesting (completely draining each pond to collect fish) and refilling, the ponds were dried to ensure that all residual fish pathogens and predators (macroinvertebrates) were killed. Outside the fish rearing season ponds 12 and 13 were maintained without water, whereas ponds 14 and 15 were maintained with water in the sump (deep end of the pond), which was approximately 15 percent of each ponds' capacity (Fig. 2).

Dragonfly larvae were collected by performing three to five dredge tows across the width of the pond. The dredge had an opening width of 375 mm and height of 200 mm, and was fitted with a 1.0 mm by 2.0 mm mesh. The samples were washed through a series of Endecott Test Sieves (4.0 mm, 2.0 mm and 0.71 mm apertures). The dragonfly larvae were preserved in 70% ethanol and identified to species (HAWKING, 1986, 1993). Dredge sampling commenced on 26 June 1991 and was conducted monthly, except during the second filling of ponds 12 and 13, when sampling was conducted weekly, and finished on 14th August 1992 (Tab. I). When each pond was drained at harvest, dragonfly larvae were randomly collected by hand for identification. Pond temperatures were recorded by Brannan minimum and maximum thermometers, weekly during and monthly outside the fish rearing season (Fig. 3).

RESULTS

Prior to this study the authors collected specimens of *P. flavescens* larvae during the 1990/91 fish rearing season. One penultimate instar larva was collected from pond 16 on 8 February 1991 and 30 late stage larvae were collected from pond 13 on 13 February 1991, both during pond harvest.

The larvae of *P. flavescens* were not collected during the period from April to November, when only the sumps contained water (Tab. I). The ponds were filled on 15 November 1991 (commencement of the 1991/92 fish rearing season) and larvae of *P. flavescens* were not collected from either the dredge sampling or during pond harvest (8 January 1992). The ponds were subsequently refilled on 18 January and the first larvae of *P. flavescens* (early instars)

Table I

The sampling dates and presence and absence of *Pantala flavescens* larvae in ponds 12 to 15, April 1991 to September 1992

Date	Fish Pond No. 12	13	14	15	Comments
20 Apr 91	*	*	–	–	14 & 15 sumps filled
26 Jul	*	*	–	–	
14 Aug	*	*	–	–	
24 Sep	*	*	–	–	
16 Oct	*	*	–	–	
15 Nov	–	–	*	*	12 & 13 filled
27 Nov	–	–	*	*	
18 Dec 91	–	–	*	*	
7 Jan 92	–	–	*	*	
8 Jan	–	–	*	*	12 & 13 harvested
18 Jan	–	–	*	*	12 & 13 filled
29 Jan	–	–	*	*	
6 Feb	–	–	*	*	
14 Feb	P	–	*	*	
20 Feb	P	–	*	*	
24 Feb	*	*	–	–	14 & 15 filled
26 Feb	–	–	*	*	
4 Mar	P	–	*	*	
9 Mar	P	–	*	*	first exuviae
11 Mar	P	–	*	*	12 & 13 harvested
14 Apr	*	*	P	–	
14 May	*	*	P	–	
9 Jun	*	*	–	–	
14 Jul	*	*	–	–	
17 Aug	*	*	–	–	
2 Sep	*	*	–	–	14 & 15 drained

P larvae collected
– larvae not collected
* Pond not sampled or pond dry

were collected from pond 12 on 14th February 1992 (27 days after filling), and final instar exuviae appeared on the walkway of pond 12 on 9th and 11th March 1992 (51 and 53 days after filling). Larvae in the late instar stages were also abundant in pond 12 at the time of draining on 11th March 1992. However, larvae of *P. flavescens* were not collected from pond 13 during the second filling. These two ponds were not refilled.

The sumps of ponds 14 and 15 were filled on 24 February 1992, to allow oviposition sites for emergent adults from ponds 12 and 13, and were held at that level until they were drained on 2 September 1992. During this period *P. flavescens* larvae were present in samples collected from pond 14, on 14 April and 14 May, but were absent from samples collected on 9 June, 14 July and 17 August 1992, and were not observed in either pond when they were drained.

During the 1992/93 fish rearing season dragonfly larvae were sampled only during harvest and larvae of *P. flavescens* were only collected from pond 14 on 24 February 1993 and from pond 12 on 11 March 1993. *P. flavescens* larvae were also collected by the authors from fish farm ponds at Benalla (36°33'S, 145°59'E), 80 km north of SCFFRSH, on 1 March 1993.

The other anisopterans collected during the sampling period included *Aeshna brevistyla* (Ramb.) and *Hemianax papuensis* (Burm.) (Aeshnidae), *Hemicordulia tau* (Sel.) (Corduliidae), and *Diplacodes bipunctata* (Br.), *D. haematodes* (Burm.) and *Orthetrum caledonicum* (Br.) (Libellulidae).

DISCUSSION

This discovery of *P. flavescens* is significant as it demonstrates that, under certain conditions, larval development can be completed at the southern limit of the species in Australia. These records extend the range from 35°S to 37°S, but this is not surprising as Dr J.A.L. Watson in his letter to Dr P.S. Corbet, said "I can see no reason why *Pantala* should not turn up in Victoria in due course, for *Trapezostigma loewii* (Br.), a species with rather similar range and habits, has done so." (CORBET, 1979). This record confirms Watson's prediction that the adults of this species could migrate further south.

Individuals of *P. flavescens* from a population established in late January/early February 1992, during the second filling of pond 12, completed both the egg and larval development phase of its life cycle in less than 51 days. WARREN (1915) and KUMAR (1984) reported that *P. flavescens* completed its egg and larval development in 55-61 days at room temperature in the tropics and at 28 to 32°C, with an abundance of food resources. At SCFFRSH food resources (zooplankton and aquatic insects) were abundant (Ingram, unpubl. data) whereas the water temperatures (Fig. 3) were slightly lower than those in the studies of WARREN (1915) and KUMAR (1984). This suggests that the rapid development at the temperatures observed during this study, was due to the abundance of

food resources available. BAKER & FELTMATE (1987) and PICKUP & THOMPSON (1990) support this observation, stating that increased food availability increased the rate of development of damselfly larvae.

The larvae from the second generation (1991/1992) were collected until 14 May, but were absent from further samples for the remainder of the year. This indicates that this population did not over-winter. During the winter period the water temperatures progressively decreased from 10.0°C, 14 May, to a low of 5.0° by 17 August (Fig. 3). Similarly, CORBET (1988) reported that TROTTIER (1967) had found that the larvae of *P. flavescens* do not survive in ponds in Canada during winter. The absence of the larvae from ponds, outside the normal range, during winter, suggests that the temperatures in the ponds during this period drop below the thermal optimum of *P. flavescens* larvae.

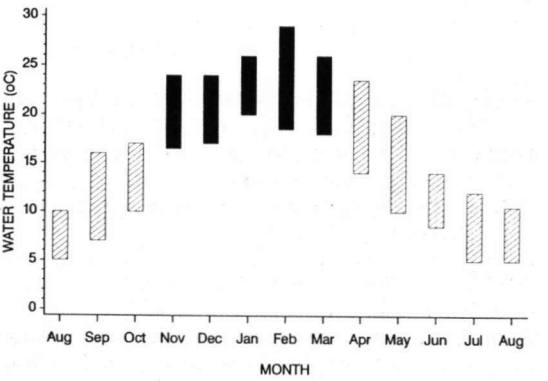

Fig. 3. Monthly maximum and minimum water temperatures for fish farm ponds 12 to 15 from April 1991 to August 1992. – [Shaded bar: only sump full; solid bar: pond completely full].

The inability of *P. flavescens* larvae to over-winter in the ponds, suggests that the larvae found each February are the progeny of transient adults. However, it was not possible to determine the origin of the adults that produced the second generation, whether they were immigrants or adults from the first generation. But the time elapsed from the emergence of adults from pond 12 to the appearance of larvae in pond 14, would suggest that they could be adults that emerged from the first generation.

For three successive years migratory adults of *P. flavescens* have established larval populations in fish farm ponds at SCFFRSH. During the 1991/92 fish rearing season the first generation larvae completed egg and larval development, and a second generation followed but the larvae did not over-winter. It appears that even at the limit of its distribution when the right conditions prevail, such as those available in fish farm ponds, *P. flavescens* can successfully complete larval development. However, they can not maintain permanent populations of larvae during winter, most probably because the temperatures of the water in ponds drops below the thermal optimum of the larvae.

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