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SHORT COMMUNICATIONS

MORTALITY DURING EMERGENCE OF *PANTALA FLAVESCENS* FABRICIUS IN CENTRAL INDIA (ANISOPTERA: LIBELLULIDAE)

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Mortality during emergence was studied at an open drain in the city of Nagpur (central India). The total mortality rate (MR) was 10.92% (n = 686). Failure to moult (incomplete emergence state, MR = 4.8%) and failure to expand abdomen and harden wings for flight (complete emergence state, MR = 6.12%) were the two major reasons of mortality. The emerging dragonflies failed to moult and were found dead in the following conditions: cuticle of the thorax split and head and thorax of the pharate partly out of the exuviae (MR = 2.04%), head, thorax and wings out but the entire abdomen trapped in the exuviae (MR = 2.76%). After complete moulting some pharates were found floating, dead or completely exhausted in the water body. Some of the dead pharates had a curved telescopic abdomen and crumpled (MR = 0.44%), or stretched wings (MR = 2.33%), while others exhibited a straight, expanded abdomen and stretched overlapping (MR = 1.75%) or stretched spread wings (MR = 1.60%). Death due to overcrowding and predation was negligible. Statistical analysis revealed that mortality is independent of stage of emergence (P = 0.25).

INTRODUCTION

In Odonata, emergence is one of the most vulnerable stages since the individual is unprotected and exposed to destructive biotic and abiotic factors (JAKOB & SUHLING, 1999). Mortality during emergence is mostly underestimated for two reasons: if it is small it may be overlooked and there are some causes of death during emergence which leave no evidence (CORBET, 1999). Mortality during emergence is classified into three observable events, viz.: failure to moult, failure to expand and harden the wings, and predation (THOMPSON, 1991; BENNETT & MILL, 1993; CORBET, 1999). The first two are caused by factors such

as low temperature, rain, wind, low oxygen level, lack of suitable emergence support and overcrowding (CORBET, 1957, 1999; INOUE, 1979; PAJUNEN, 1962; GRIBBIN & THOMPSON, 1990). Depending on abiotic factors and/or levels of predation mortality rate can vary in the same species: from 1% to 100% in *Pantala flavescens* (BYERS, 1941; ROKUYAMA, 1963), 8.5% to 15.8% in *Anax imperator* (CORBET, 1957), 4.5% to 22.4% in *Aeshna juncea* (KURATA, 1974) and 3.0% to 21.8% in *Pyrrhosoma nymphula* (GRIBBIN & THOMPSON, 1990; BENNETT & MILL, 1993).

Most of the studies on mortality during emergence have been undertaken to determine the effect of various physical and environmental factors (CORBET, 1957, 1999; PAJUNEN, 1962; ROKUYAMA, 1963; INOUE, 1979; GRIBBIN & THOMPSON, 1990; JAKOB & SUHLING, 1999). Data is not available on the different state or period at which mortality takes place during emergence in Odonata. The present investigation has been undertaken to document the various states at which mortality takes place in *P. flavescens*.

MATERIAL AND METHODS

From 1st April to 15th May 2004, for 45 days continuously, dead, dying and drowned larvae/pharate adults were collected every morning between 5:30 am and 7:00 am from a long, open drain located in the playing field of St John's School in Nagpur city in central India. In the absence of any emerging plant, the larvae used the cement wall as emergent support. All the exuviae were collected from the wall along with the dead/dying individuals and were taken to the laboratory. Their morphological conditions were noted with respect to state of moulting and photographed. The daily collection of dead individuals was recorded and stored for further reference.

During the period of observation, eight mature F-0 larvae (with legs in the gripping position) were found upturned and dead in the water of the drain. These were not included in the counting because of the ambiguity in the reason for their death. A Chi square analysis was performed on the data as in ZAR (2005).

OBSERVATIONS

The daily mortality of *Pantala flavescens* during emergence is illustrated in Figure 1. Out of 686 emergences noted in the 45 days of observation, 75 individuals failed to mould and hence the overall mortality rate was 10.93 %. In the 45 observation days, 50% mortality was observed on the 11th day (Fig. 1).

The emerging dragonflies which failed to mould were found dead in the following conditions (Figs 2-12):

(1) Larva with the cuticle of the thorax split [mortality rate: 2.04% (N = 14)]

(2) Larva with the head and thorax of the pharate partly or completely out but with the entire abdomen trapped in the exuviae [mortality rate: 2.76% (N = 19)]

During these states the pharate is still trapped inside the larval exuviae and,

consequently, this condition can be referred to as the "incomplete emergence state" and the mortality rate was 4.8% (2.04% + 2.76%) (N = 33).

The pharate adult (out of the exuviae) was found dead/dying and floating on the water in the following conditions:

(3) Pharate with curved telescopic abdomen and crumpled wings [mortality rate: 0.44% (N = 3)]
(4) Pharate with curved telescopic abdomen and stretched wings [mortality rate: 2.33% (N = 16)]
(5) Pharate with straight abdomen and overlapping stretched wings [mortality rate: 1.75% (N = 12)]
(6) Pharate with straight abdomen and spread out stretched wings [mortality rate: 1.60% (N = 11)]

These states can be referred to as the "complete emergence state" and the mortality rate is 6.12% (0.44% + 2.33% + 1.75% + 1.60%) (N = 42). Chi square analysis revealed that mortality is independent of stage of emergence (P = 0.25, i.e. not significant).

DISCUSSION

The final emergence in *P. flavescens* is divided into three observable stages. Stage-I starts from the moment the larva finds a suitable site for moulting till the splitting of the thoracic tergites. During Stage-II, the pharate adult emerges out of the larval exuviae while, at Stage-III, the pharate hardens the cuticle and stretches and spreads the wings to become flight worthy (ANDREW & PATANKAR, 2010).

In Odonata, the average total mortality during emergence can range from 1% to 100% depending on various biotic and abiotic factors (CORBET, 1999). BYERS (1941) observed 1% or less mortality in *P. flavescens* whereas ROKUYAMA (1963)

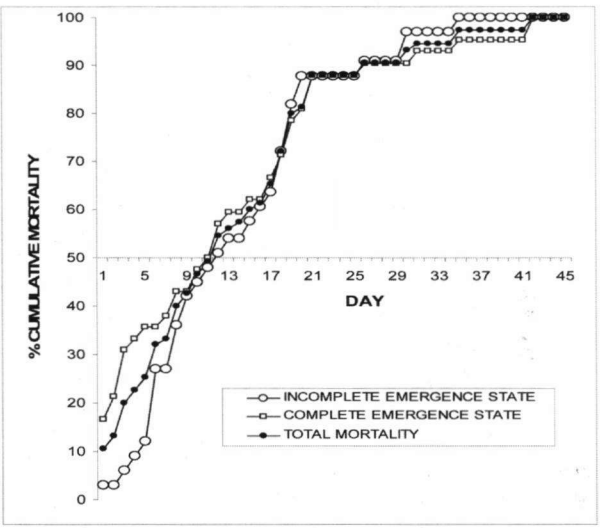
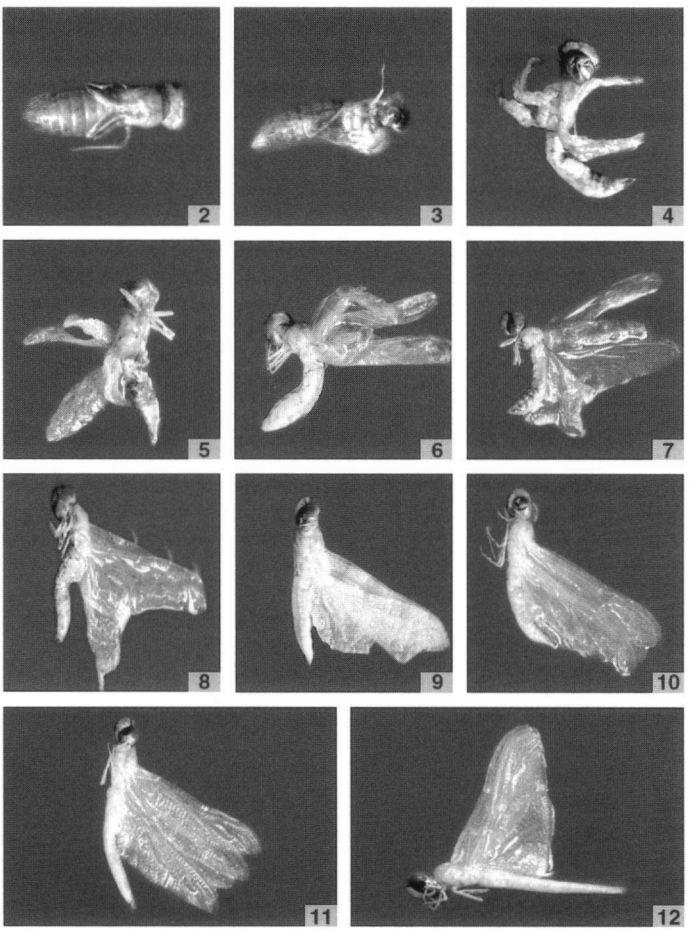


Fig. 1. Cumulative mortality of *Pantala flavescens* during 45 days at an open drain in central India.

found 100% mortality in the same species in Japan due to low temperature. MATHAVAN & PANDIAN (1977) reported that the mortality rate of most libellulid dragonflies in southern India varies between 8% and 14%. In the present study, the mortality rate during emergence of *P. flavescens* in the summer season (April-May) at a site in central India was 10.93%. JAKOB & SUHLING (1999) reported that the prime cause of mortality was incomplete ecdysis result-



Figs. 2-12: The emerging *Pantala flavescens* which failed to moult were found dead in the following conditions: (2) larva with split thorax; – (3) pharate with thorax and head partially out of the exuviae; (4-5) pharate with crumpled wings and curved telescoped abdomen; – (6-7) pharate with spreading wings and curved telescoped abdomen; – (8-10) pharate with completely stretched hindwings and straightening telescoped abdomen; – (11-12) pharate with straight abdomen and overlapping completely stretched wings.

ing from different factors, among which heavy wind was the most important in the libellulid *Orthetrum coerulescens* and lack of suitable emergence supports in the gomphid *Onychogomphus uncatus*. In the present study, 4.8% of *P. flavescens* larvae failed to moult before the pharate could release itself from the exuviae, i.e. in the "incomplete emergence state". Mortality at this stage generally occurs due to overcrowding (which causes severe competition for emergence support) and/or when the emergence support offers insufficient grip for the tarsal claws of the exuviae (MATHAVAN & PANDIAN, 1977). In *O. uncatus* (JAKOB & SUHLING, 1999), a higher rate of mortality during emergence was found in dense vegetation than on a stony substrate and sparse vegetation. In the present study, the large cement wall of the drain appears to be a perfect substrate for an emergence support of *P. flavescens* larva and mortality due to overcrowding cannot be an issue in the present study. Still, failure to moult at this stage indicates that there may be some endogenous (genetic) factors or injuries or dehydration responsible for mortality at this stage, as postulated by JAKOB & SUHLING (1999).

Failure to expand the abdomen and harden the wings, along with drowning of the completely emerged pharate, accounts for 6.12% mortality in the present investigation. This maybe due to the fact that the cement wall of the drain, which provides good support for the larva, is not a very good support for the emerged pharate (once outside the larval exuviae) and slight wind may dislodge it. After complete moulting too, some imagoes were found floating, dead or completely exhausted in the water in various states. Some of the dead imagoes had a curved, telescopic and pale abdomen and crumpled or stretched wings while others exhibited a straight, expanded abdomen and stretched, hard, overlapping or spread wings. Winds can increase the mortality rate even after complete moulting and emergence. Winds can also cause hardened wings to stick together so that they overlap and cannot spread, leading to death (CORBET, 1999). In the present study 50% mortality was observed by the 11th day (EM_{50} = 14 days).

Predation during emergence is one of the important causes of mortality in Odonata. Well known predators are birds, lizards, crocodiles, frogs, spiders, wasps, ants (CORBET, 1999) and flatworms, fishes and adult dragonflies (JAKOB & SUHLING, 1999). In the Indian subcontinent predation rate varies between 0.06% and 0.78% (MATHAVAN & PANDIAN, 1977). In the present study predation was not observed, probably due to lack of predatory birds, frogs, lizards and fishes at the study site. Ants (*Solenopsis* sp.) were sometimes observed along the wall of the drain and sometimes also in and around the empty *P. flavescens* exuviae, but never as predators.

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REFERENCES

ANDREW, R.J. & N. PATANKAR, 2010. The process of moulting during the final emergence of the dragonfly Pantala flavescens Fabricius. *Odonatologica* 39. – [in press]

BENNETT, S. & P.J. MILL, 1993. Larval development and emergence in Pyrrhosoma nymphula (Sulzer) (Zygoptera: Coenagrionidae). *Odonatologica* 22: 133-145.

BYERS, C.F., 1941. Notes on the emergence and life history of the dragonfly Pantala flavescens. *Proc. Fla. Acad. Sci.* 4: 19-85.

CORBET, P.S., 1957. The life history of the emperor dragonfly, Anax imperator Leach (Odonata: Aeshnidae). *J. Anim. Ecol.* 26: 1-69.

CORBET, P. S., 1999. *Dragonflies: behaviour and ecology of Odonata*, Harley, Colchester.

GRIBBIN, S.D. & D.J. THOMPSON, 1990. A quantitative study of mortality at emergence in the damselfly Pyrrhosoma nymphula (Sulzer) from two adjacent ponds in north England. *Hydrobiologia* 206: 123-131.

INOUE, K., 1979. Review of Japanese dragonflies, pt 6. *Gracile* 24: 1-20. – [Jap.]

JAKOB, C. & F. SUHLING, 1999. Risky times? Mortality during emergence in two species of dragonflies (Odonata: Gomphidae, Libellulidae). *Aquat. insects* 21: 1-10.

KURATA, M., 1974. Alpine dragonflies: a survey and an account of a pursuit of Aeshna juncea. Seibundo-shinkosha, Tokyo. – [Jap.]

MATHAVAN, S. & T.J. PANDIAN, 1977. Patterns of emergence, import of egg energy and energy export via emerging dragonfly populations in a tropical pond. *Hydrobiologia* 56: 257-272.

PAJUNEN, V.I., 1962. Studies on the population ecology of Leucorrhinia dubia V. d. Lind. (Odon., Libellulidae). *Annls Soc. zool.-bot. fenn. "Vanamo"* 24: 1-79.

ROKUYAMA, M., 1963. Late seasons emergence of Pantala flavescens Fabricius. *Tombo* 6: 11. – [Jap.]

THOMPSON, D.J., 1991. Size-biased dispersal prior to breeding in damselfly: conflicting evidence from natural population. *Oecologica* 87: 600-601.

ZAR, J.H., 2005. *Biostatistician analysis* (4th edn), Pearson Education, Delhi.