DIEL PERIODICITIES OF ADULT EMERGENCE OF SOME CHIRONOMIDS (DIPTERA: CHIRONOMIDAE) AND A MAYFLY (EPHEMEROPTERA: CAENIDAE) AT A WESTERN AUSTRALIAN WETLAND

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Abstract

Diel periodicities of adult emergence for three species of Chironomidae and one Caenidae from a Perth wetland were recorded during spring and summer. All chironomid species emerged mainly at dusk, regardless of sex, with the peak rate of emergence occurring during a 30 to 60 min interval beginning within 30 min of the time of light extinction. Light intensity appeared to be the major factor regulating the time of emergence. The emergence of the mayfly occurred at dawn during both spring and summer and may be controlled by an endogenous circadian rhythm.

Introduction

For many aquatic insects adult emergence occurs towards the end of the life-cycle with the emerged adult surviving for a fraction of the time taken for larval development. In many species mating and oviposition occur immediately after emergence, and death occurs soon afterwards. Since the survival of the adults is determined, at least in part, by predation and ambient environmental conditions (Iwakuma and Yasuno 1983; Jackson 1988), the timing of emergence may be crucial to overall reproductive success and dispersal ability.

Diel periodicities of adult emergence timed to coincide with optimum environmental conditions and/or minimal predation have been demonstrated for a wide range of aquatic insects. In general, species from colder latitudes or seasons emerge during daylight, when higher air temperature is more supportive of activity (Morgan and Waddell 1961; Sjoberg and Danell 1982). Species from warmer regions or seasons tend towards crepuscular or nocturnal emergence when water loss and predation are likely to be minimised (Morgan and Waddell 1961; Oliver 1971).

The mechanisms determining emergence periodicity are incompletely understood but light intensity and/or temperature are, with few exceptions, the key regulating factors (Oliver 1971). However, the overwhelming majority of these studies have been performed in northern temperate and subarctic habitats, and little information is available to determine whether the above generalisations apply to the emergence periodicities of aquatic insects in the southern hemisphere. This study examines diel emergence patterns of three species of Chironomidae (Diptera) and one species of Caenidae (Ephemeroptera), and the possible regulating factors in a wetland in south-west Western Australia.

Materials and methods

North Lake (115°49'E, 32°4'S) is a shallow wetland of approximately 27 ha located 14 km south of Perth, Western Australia. The lake is eutrophic and supports dense populations of chironomids and mayflies during the warmer months of the year (Pinder *et al.* 1991). The study was carried out in water 30 to 40 cm deep at the northern end of the lake.

Submerged benthic funnel traps were used to monitor adult emergence. These were constructed from white translucent prefabricated plastic funnels (24 cm basal diameter, 20 cm high and 2 cm apex diameter). The lid of a plastic screw top jar was attached to the apex of each funnel so that a jar could be easily removed and replaced. The traps were placed on the sediment and secured by metal pegs and then the jars were submerged so that the upper half contained air when attached.

On five occasions between October 1990 and February 1991, eight emergence traps were set and samples collected at 2-h intervals over a 24-h period. On three of these occasions (once in November and twice in January), trapped insects were recovered at half-hourly intervals during the period around dusk and on one occasion in February samples were collected at half-hourly intervals at dawn only. All samples were returned to the laboratory to be counted, sexed and identified using the keys and descriptions of Freeman (1961) and Glover (1973) for the Chironomidae and Suter (1979, 1986) for the Ephemeroptera. Identifications of the Chironomidae were confirmed by Dr Peter Cranston of the CSIRO Division of Entomology.

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Whenever the traps were emptied a range of environmental parameters were also measured in close proximity to the traps. These included dissolved oxygen (YSI model 58 oxygen meter), water temperature and solar radiation above water (Li-COR 185B quantum radiometer/photometer).

Results

The adults of three species of Chironomidae all belonging to the subfamily Chironominae, *Tanytarsus bispinosus* Freeman, *Cryptochironomus griseidorsum* Kieffer and *Polypedilum nubifer* (Skuse), and one species of Caenidae, *Tasmanocoenis tillyardi* Le Stage, were recorded in sufficient numbers for patterns of emergence to be discernible. Of the chironomids, *T. bispinosus* occurred in sufficient numbers on all five occasions, *P. nubifer* on four occasions and *C. griseidorsum* once. The mayfly *T. tillyardi* was sufficiently abundant on four of the occasions on which emergence was monitored.

For all three species of chironomid, both sexes displayed a unimodal pattern of emergence with the peak period occurring at dusk (Figs 1 and 2). The individuals that emerged during that period represented 75 to 90% of *T. bispinosus*, 45 to 80% of *P. nubifer* and 80% of *C. griseidorsum* total emergence. Relationships between time of emergence and environmental parameters were more easily discerned from the results obtained from half hourly sampling during the maximum emergence period.

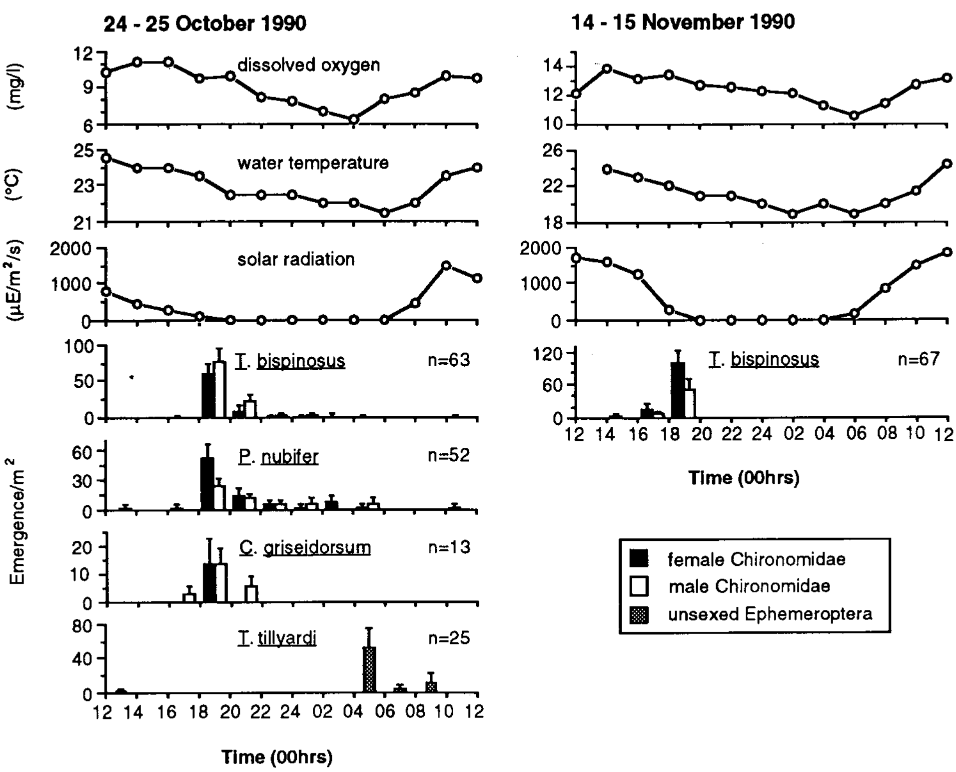

FIG. 1—Diel adult emergence patterns of three species of Chironomidae and one species of Ephemeroptera and diel changes in dissolved oxygen concentration, water temperature and solar radiation, for two dates in spring 1990.

Half hourly sampling revealed that peak emergence of both *T. bispinosus* and *P. nubifer* occurred during a 30 min interval regardless of sex (Fig. 3). For *T. bispinosus* this period began soon after solar radiation was no longer detectable and approximately 40 minutes after the official time of sunset. Sixty four to 70% of all *T. bispinosus* emerged during this 30 min interval.

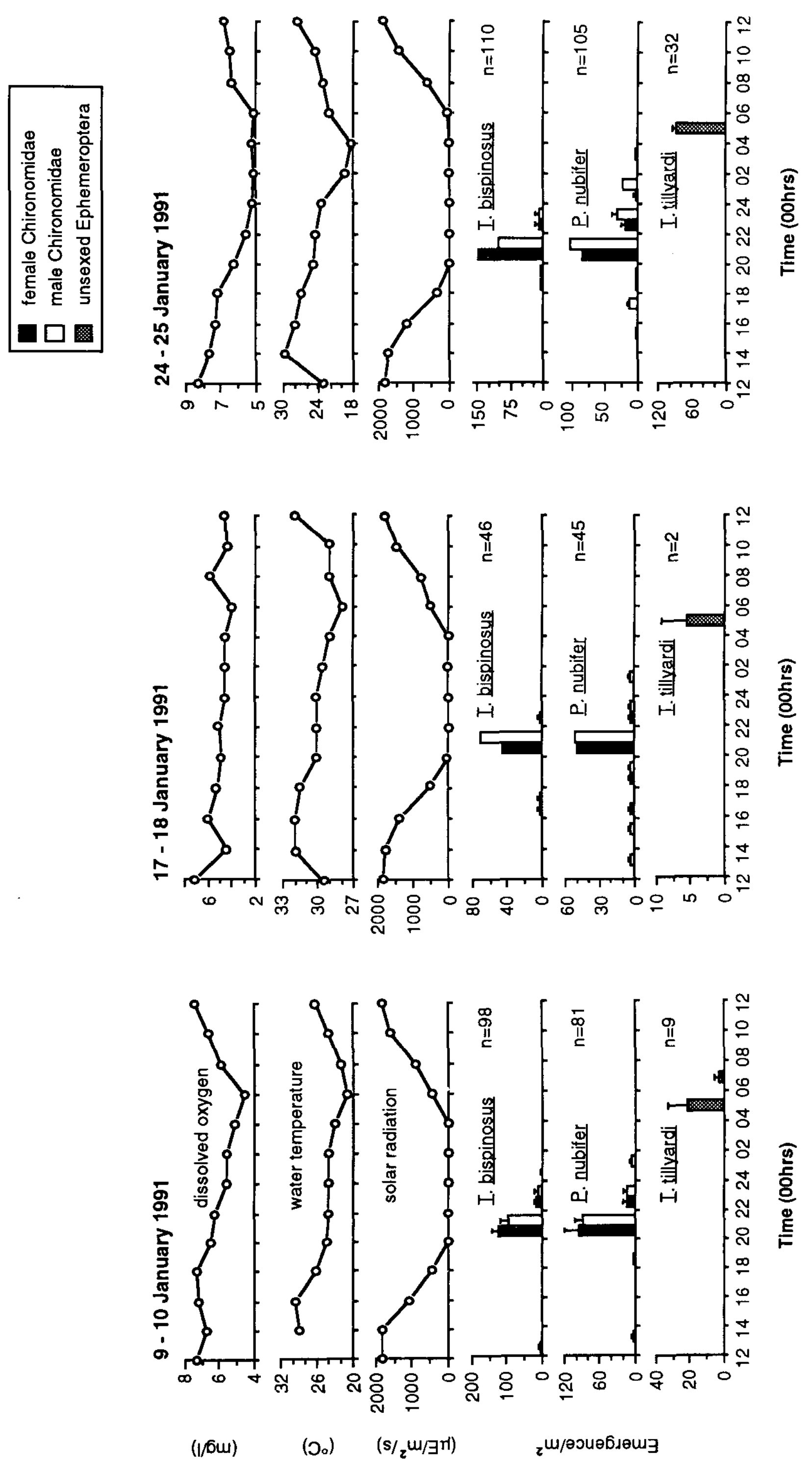

FIG. 2—Diel adult emergence patterns of two species of Chironomidae and one species of Ephemeroptera and diel changes in dissolved oxygen concentration, water temperature and solar radiation, for three dates in summer 1991.

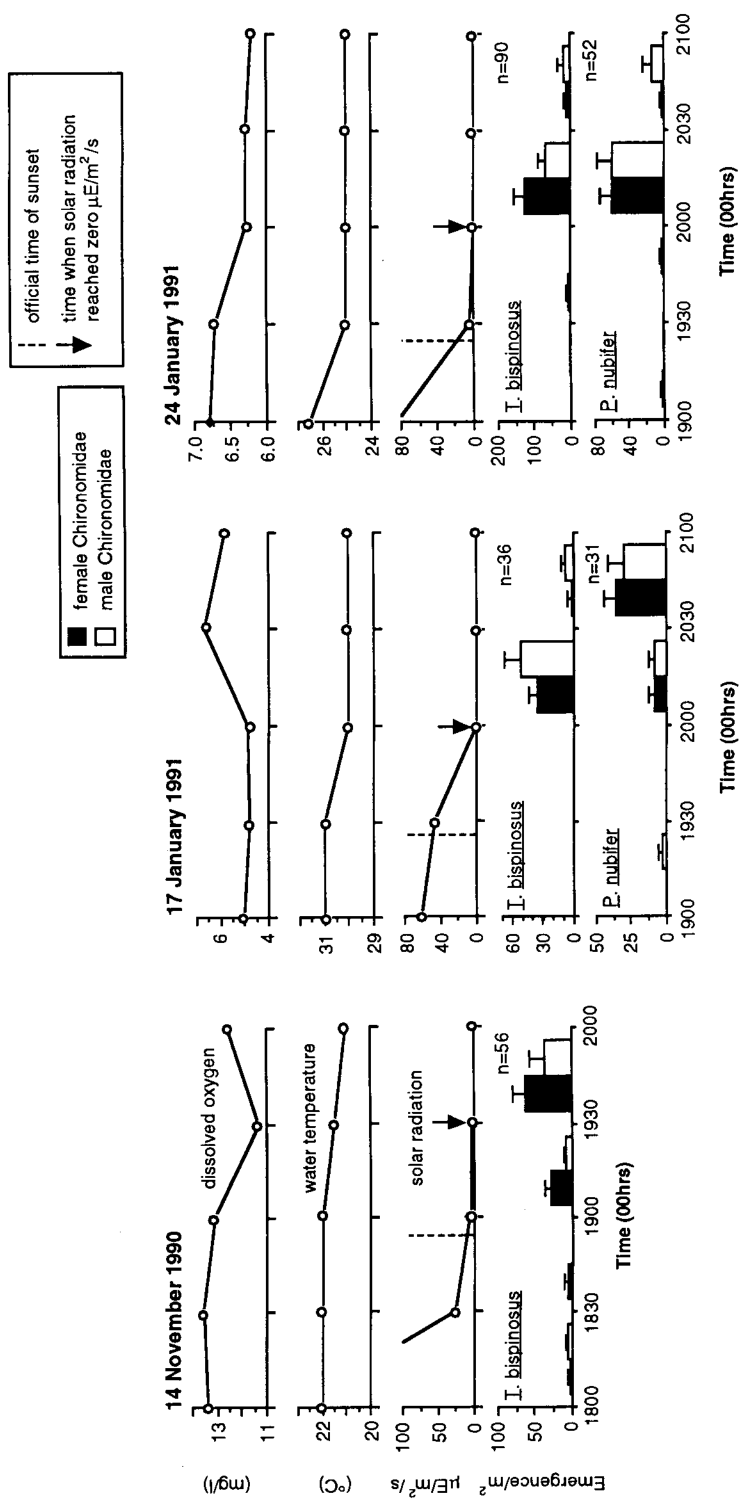

FIG. 3—Adult emergence patterns for two species of Chironomidae and one species of Ephemeroptera and changes in dissolved oxygen concentration, water temperature and solar radiation, at dusk, on three dates in spring/summer 1990/91.

Emergence of *P. nubifer* was measured at half-hourly intervals on two occasions in January. On both occasions maximum emergence (48 and 67%) was within 1 h of the loss of solar radiation. However, the pattern of emergence was different within that period on the two occasions. Whilst maximum emergence of *P. nubifer* occurred in the second half hour after solar radiation reached 0 $\mu E/m^2/s$ on January 17, this event occurred in the first half hour on January 24. On the latter date the water temperature was 5 °C lower than on the earlier date (Fig. 3).

The mayfly *T. tillyardi* emerged primarily between 0400 and 0600 hours in both October and January (Figs 1 and 2). The percentage of total *T. tillyardi* emergence that occurred during this 2 h interval was 73% in October and 89 to 100% in January. Solar radiation was 0 $\mu E/m^2/s$ at 0400 hours on all dates, but rose to between 20 and 500 $\mu E/m^2/s$ by 0600 hours. Emergence of this species was sampled more intensively (half hourly) between 0300 hours and 0800 hours on one occasion in February 1991. On this occasion solar radiation was first detected at 0600 hours and the majority of adults emerged one hour prior to this (Fig. 4).

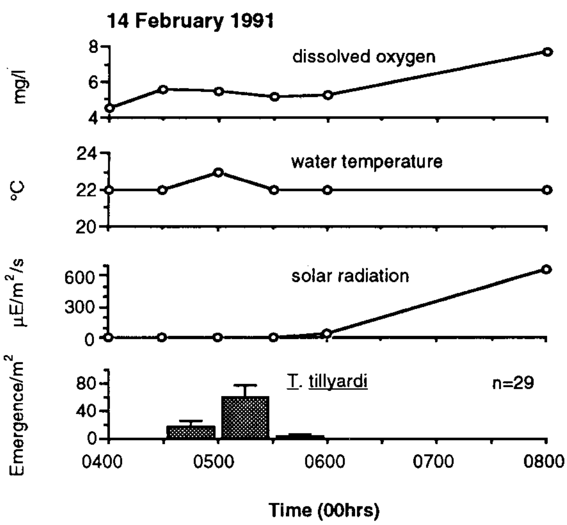

FIG. 4—Adult emergence patterns of *T. tillyardi* (Ephemeroptera) and changes in dissolved oxygen concentration, water temperature and solar radiation, at dawn, on one occasion in summer 1991.

Discussion

Chironomids exhibit a diverse range of diel periodicities of adult emergence, from sporadic or continuous emergence to one or more peak periods which may occur at any time of day (Morgan and Waddell 1961; Oliver 1971). These patterns appear to be species specific and may vary seasonally.

Most studies of emergence patterns in chironomids have examined species with univoltine and bivoltine life histories with seasonally restricted emergence. The warm mediterranean climate of Perth is supportive of multivoltine species which inhabit the wetlands in high densities for all but the coldest months of late autumn and winter. The multivoltine *P. nubifer* and *T. bispinosus* were the most abundant species at North Lake throughout the spring and summer of 1990/91 and both males and females emerged primarily at dusk in both seasons. The crepuscular emergence of both of these species in spring and summer resembles the diel patterns observed for most summer species in northern temperate habitats (Oliver 1971). However, records for species which emerge over more than one season are rare. Ali and Mulla (1979) observed dusk emergence during both spring and summer for two multivoltine *Tanytarsus* spp. in California, as did Morgan and Waddell (1961) for the bivoltine *Cryptochironomus krusemani* Goetgh in Scotland. *Chironomus decorus* Johansson, emerged mostly at dusk and throughout the night during both winter and summer in Florida (Ali 1980).

Light intensity appeared to be the dominant factor regulating the emergence of chironomids from North Lake. Extremely low light intensity between twilight and virtual darkness triggered a short lived, mass emergence, with much lower rates of emergence before and after the peak. In contrast, Wrubleski and Ross (1989) reported a gradual increase in chironomid emergence as light intensity declined.

While light intensity is almost certainly the primary factor regulating the time of emergence, temperature has been shown to have a modifying influence on the response of some chironomids to light intensity. In a laboratory study, Kureck (1979) found that *Chironomus thummi* emerged either during the day or at dusk depending upon temperature, but in both cases changing light intensity was the triggering factor. The response of *P. nubifer* to light may have been modified by water temperature, whereby higher water temperature, reflecting generally higher ambient air temperature, resulted in a delayed peak in emergence to coincide with more favourable air temperatures. Whilst such small scale modifications in emergence time have not been demonstrated for other species, 30 min collection intervals have rarely been employed elsewhere.

Caenids mainly emerge at dusk or dawn (Brittain 1982) and the emergence of *T. tillyardi* at dawn concurs with this generalisation. The onset of peak emergence did not correspond to any measured event and ended before solar radiation was first detected. This suggests an endogenous circadian rhythm, synchronised with the time of sunrise during the final nymphal stage and set to trigger emergence just before sunrise. Endogenous rhythms have also been proposed for other ephemeropterans (Brittain 1982).

Temperature has been implicated as a controlling factor in some species of mayfly (Peters and Peters 1977), but there is no evidence from this study to suggest that temperature has a regulatory influence on the emergence of *T. tillyardi*.

Perth experiences high daytime air temperatures in spring and summer with average maximum temperatures ranging from 20-25 °C and 27-30 °C, respectively and with temperatures often rising above 30 °C in spring and 25 °C in summer. Avoidance of these temperatures in order to minimise water loss is the most likely rationale for the crepuscular emergence of the aquatic insects examined in this study and concurs with emergence patterns of Chironomidae and Ephemeroptera occurring in warm regions in the northern hemisphere (Morgan and Waddell 1961).

Acknowledgments

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