DIEL PERIODICITY OF ECLOSION OF ADULT CHIRONOMID MIDGES IN A RESIDENTIAL-RECREATIONAL LAKE[1]

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ABSTRACT. The diel emergence periodicity of chironomids in a shallow residential-recreational lake in southern California was investigated on 4 occasions between May and October 1977. Emerging adults were sampled at 2-hr intervals during a 24-hr period with submerged emergence traps.

Diel periodicity of emergence was exhibited by 6 species of chironomids. Emergence of *Tanytarsus* (2 species) continuing throughout each diel period, accelerated considerably 2–3 hr before dusk with most emerging within 2–3 hr after sunset. Emergence activity of *Chironomus decorus* Johannsen, and *Chironomus frommeri* Atchley and Martin, was essentially nocturnal between dusk and midnight and having a pronounced peak within 2–3 hr after sunset. All adults of *Dicrotendipes californicus* (Johannsen) emerged between dusk and 1–2 hr after sunset. Adults of *Procladius freemani* Sublette showed a distinct bimodal eclosion pattern with peaks occurring during the crepuscular periods.

The diel emergence periodicity of all 6 chironomid species correlated with the diel light changes but fluctuations in water temperature exerted no observable effect on their emergence activity.

INTRODUCTION

The phenomenon of diel periodicity of adult emergence in aquatic insects has been investigated by several workers (Barnard and Mulla 1977, Corbet 1964, 1966, Disney 1969, Morgan and Waddell 1961, Remmert 1965). A considerable amount of this work was concentrated on midges of the family Chironomidae inhabiting freshwater and marine environments (Caspers 1951, Coffman 1974, Danks and Oliver 1972, Morgan and Waddell 1961, Oliver 1968, Palmén 1955). In man-made warm-water recreational lakes of southern California and elsewhere chironomid midges are the predominant macroinvertebrates, often emerging in large numbers and causing severe nuisance and economic problems for the lakeside residents and users (Ali and Mulla 1977, Mulla 1974). Reported here are the emergence rhythms of chironomid adults in a shallow recreational lake in southern California surrounded by residences and recreational facilities.

MATERIALS AND METHODS

This study was conducted at Village Grove Lake located at 250 m elevation in the City of Corona in Riverside Co., CA. The study area has been previously described (Ali and Mulla 1978). The lake is 4 ha at the surface and has an average depth of 1.25 m.

Emergence of adult chironomids was assessed with sheet-metal cone emergence traps, modified after Mundie (1956) and described by Mulla et al. (1974). Each trap, 60 cm high, covered ca. 0.3 m^2 of lake bottom. A 0.5 liter Mason jar was screwed on the top conical end of the trap prior to lowering it onto the lake bottom. The emerging adults from the area enclosed by the trap were collected in the air pocket of the Mason jar. Ten traps were set randomly in the lake, and adult emergence was sampled over a 24-hr period on 4 occasions (26–27 May, 26–27 July, 9–10 August, and 4–5 October) in

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1977. On each occasion, sampling commenced at 0900 hr and terminated at the same time on the following day with collection jars replaced at 2-hr intervals. A flash light was used at night.

At the end of each 2-hr sampling period, the trap was pulled gently to the water surface and the collection jar was unscrewed under water and capped while inverted in the water. The cap, a fine mesh screen, retained adult midges but allowed water to drain from the jar. A new jar was immediately screwed on the trap and lowered a few meters from the previous sample location. The time of sampling was labeled on the retrieved jars. Water temperature at a depth of 10–15 cm below the surface was measured at one location during each sampling interval. The time of sunset, sunrise, and twilight periods were subjectively recorded. Adult collections were brought to the laboratory for identification and counting.

RESULTS AND DISCUSSION

Adults of 8 midge species, *Tanytarsus* n. sp. 2 and 3 after Sublette (Darby 1962), *Chironomus decorus* Johannsen, *Chironomus frommeri* Atchley and Martin, *Dicrotendipes californicus* (Johannsen), *Procladius freemani* Sublette, *Procladius culiciformis* (L.), and *Tanypus grodhausi* Sublette were collected. Of these, the first 6 species were present in sufficient numbers to study emergence rhythms. Two specimens each of *P. culiciformis* and *grodhausi* were taken in July and only 2 adult *T. grodhausi* were recovered in August.

The mean numbers of adults of the different species emerging/m^2 during the 2-hr sampling intervals of each of the 24-hr sampling periods are shown in Fig. 1. Adults of *Tanytarsus* n. sp. 3 predominated over those of n. sp. 2, however, the diel changes in both species were similar, therefore their numbers are combined and collectively shown in Fig. 1. Midge emergence during the observation dates was predominated by *Tanytarsus* spp. (Fig. 1), constituting 64–90% of the total adults collected during this study.

Diel periodicity of emergence was exhibited by all the midge species collected during each sampling occasion, but the peak emergence time differed among the various species (Fig. 1). Emergence of *Tanytarsus* spp. continued throughout each diel period, accelerating considerably 2–3 hr before dusk with most emerging within 2–3 hr after sunset. Morgan and Waddell (1961) reported a similar emergence pattern of *T. samboni* Edw. in Loch Dunmore, Scotland, where this species emerged throughout the day and night achieving a maximum emergence activity between 2000 and 2200 hr, when sunset time was 2120 hr.

Emergence of *C. decorus* was initiated after dusk, continuing beyond midnight with most eclosing between 2100–0100 hr, and the peak emergence occurring 2–3 hr postsunset. This species did not emerge during daylight hours except in May when 6 specimens were recovered (Fig 1). *C. frommeri,* making its first appearance in August, was also strictly nocturnal with emergence behavior similar to that of *C. decorus.* There are no previous records on diel emergence patterns of *C. decorus* and *C. frommeri.* However, other species of this genus, such as *C. edwardi* Krusem, *C. krusemani* Goetgh, *C. longipes* Stag. (Morgan and Waddell 1961), and *C. halophilus* Kieff. (Palmén 1955) are principally nocturnal, emerging within a few hours of sunset.

Adults of *D. californicus* occurred in small numbers in May and August and were absent in October. The only conclusive data on *D. californicus* gathered in July showed a clear diel emergence periodicity; it emerges between dusk and 1–2 hr postsunset (Fig. 1).

P. freemani adults emerged during darkness. Although the numbers appearing in May and October were too small to show a definite trend, their July and August collections revealed a distinct bimodal eclosion pattern (Fig. 1). Emergence was initiated at dusk and subsided at 2100–2300 hr, resuming again at

0300–0700 hr, extending over the dawn period. A bimodal pattern of diel emergence was reported for other chironomid species, such as *Stictochironomus unguiculatus* (Malloch), *Tanytarsus norvegicus* (Kieff.), *Orthocladius consobrinus* (Holmgr.) (Danks and Oliver 1972), and *Psectrocladius psilopterus* Kieff. (Morgan and Waddell 1961).

The diel emergence periodicity in insects is caused by a complex interaction of various environmental stimuli and endogenous rhythms. This behavior is typically regulated and maintained by an "internal clock" (the endogenous rhythm) which is "set" by responses to external stimuli or exogenous factors (Corbet 1964). Most studies on chironomids indicate that either water temperature and/or light intensity are the major environ-

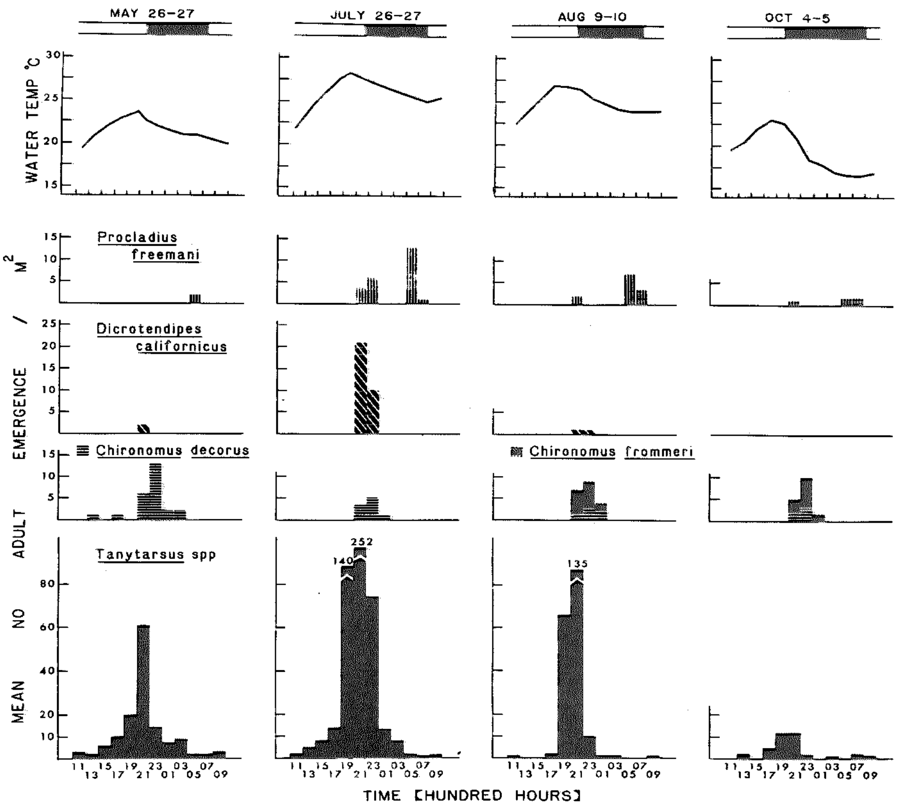

Fig. 1. Diel emergence patterns of chironomid adults in Village Grove Lake (Corona, Riverside Co., CA, May-October 1977). The horizontal bars at the top of the figure indicate diel light distribution. The dark shaded areas enclose the period from sunset to sunrise, while the narrow lightly shaded areas are twilight periods.

mental factors setting diel emergence patterns. Tidal fluctuations may affect the diel emergence of marine chironomids (Caspers 1951).

During studies on high arctic chironomids (Danks and Oliver 1972, Oliver 1968) temperature is regarded as most important in determining diel emergence periodicities; an increase in water temperature near midday induces midge emergence and a decrease at night inhibits it. Changes in light intensity, sunshine, and wind do not affect the diel emergence patterns of chironomids in the far north latitudes (Danks and Oliver 1972). Similar observations were reported by Corbet (1966) and Barnard and Mulla (1977) studying diel emergence of mosquitoes. By contrast, the diel emergence of chironomids in temperate zones is apparently controlled by changes in light intensity (Palmén 1955, 1958, Remmert 1955a, b, Morgan 1958, Morgan and Waddell 1961) with maximum numbers emerging usually between dusk and midnight.

Our data clearly indicate a relationship between time of eclosion and diel light changes. Emergence of *P. freemani, D. californicus, C. decorus,* and *C. frommeri* was nocturnal, occurring mostly between dusk and midnight, while *P. freemani* exhibited a 2nd peak of emergence before dawn. The rate of emergence of these species did not increase or decrease with a rise or fall in water temperature during a diel period (Fig. 1). Similarly, emergence of the predominant midge. *Tanytarsus* spp. although continuing throughout the 24 hr period was maximal during the evening to midnight hours when water temperature was declining thus showing no relationship with this environmental factor.

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BUNYAVIRUS INFECTION RATES IN CANADIAN ARCTIC MOSQUITOES, 1978[1]

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ABSTRACT. From 20,305 unengorged female mosquitoes of 4 species collected in the western Canadian Arctic between latitudes 60 and 69°N from 5 June through 24 July 1978, 9 strains of snowshoe hare (SSH) virus (California encephalitis complex) were isolated from *Aedes communis* (minimum field infection rates 1:159 to 1:3003), 4 strains of SSH virus were isolated from *Culiseta inornata* (MFIR 1:73 to 1:112) and 3 strains of Northway virus were isolated from *Cs. inornata* (MFIR 1:267 to 1:1322).

INTRODUCTION

Isolation of two antigenically distinct Bunyaviruses, snowshoe hare (SSH) virus (California encephalitis complex) and Northway (NOR) virus from mosquitoes collected near Northway, Alaska (62°N, 142°W) during July and August 1970 (Ritter and Feltz 1974), stimulated the search for similar mosquito-borne arboviruses throughout the geographically contiguous Yukon Territory from 1971 through 1974 (McLean et al. 1975) and the Mackenzie Valley of the Northwest Territories during summer 1976 (McLean et al. 1977b). The present report confirms the endemic prevalence of SSH virus in mosquitoes collected during 1978 along transportation corridors throughout the Yukon Territory and Mackenzie Delta, N.W.T., and identifies a third location some 300 miles southeast of Northway at which both NOR and SSH virus have been detected in mosquitoes during the same summer.

METHODS

Unengorged adult female mosquitoes were collected by hand aspirators at 11 locations throughout the boreal forest of the Yukon Territory from latitudes 60 to 66°N, and at 2 locations in the open woodland terrain of the Mackenzie Delta, N.W.T. at latitudes 68 to 69°N, between 5 June and 24 July, 1978.

Mosquitoes were sealed immediately in glass tubes and stored at −70°C in styrofoam containers with dry ice for shipment by air to Vancouver, where they were held frozen at −70°C until tested 1 to 3 months later. Pools comprising 30 to 90 mosquitoes of the same species were examined for virus content by intracerebral injection of newborn mice, and virus isolates were typed by mouse neutralization tests as described previously (McLean et al. 1972). Type-specific antisera were prepared by single intravenous injection of rabbits with Canadian

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