Diel activity of a boreal water beetle (*Dytiscus alaskanus*: Coleoptera; Dytiscidae) in the laboratory and field

R. B. AIKEN Department of Entomology, University of Alberta, Edmonton, Alberta, Canada

SUMMARY. 1. The diel activity of *Dytiscus alaskanus* (Coleoptera: Dytiscidae) was studied by trapping in the field and by direct observation of behaviour (mounting, chasing, grappling, swimming and surfacing) in the laboratory.

2. In the field, the number of beetles trapped during the dark hours was approximately fifty-fold greater than trapped during daylight hours.

3. In the laboratory, there was a marked increase in mounting, chasing and grappling when the ambient light level fell below 0.4 lm m$^{-2}$. Swimming showed only a slight diel pattern and surfacing none at all.

**Introduction**

Virtually all insects, except perhaps those in caves, respond in some way to temporal periodicity in their environment. One aspect of this periodicity that has received the attention of a great number of authors is diel periodicity (see Saunders, 1982). Activity cycles at different times of the day generally allow exploitation of a greater number of niches and greater partitioning of available resources. Among aquatic insects, diel activity phenomena have been investigated in relation to drift (Hynes, 1970; Waters, 1972; Müllner, 1974; Adler, Light & Kim, 1983), behaviour of pest insects with aquatic larvae and aerial adults (Taylor, Bennett & Lewis, 1979; Allan, Surgeoner & Helsen, 1982) or emergence patterns (Dahl, 1973; Danks, 1978). Most studies of this nature examine the results of the behaviour (especially drift studies) and not the behaviour patterns themselves. Behaviour patterns of aquatic insects have generally received less attention, presumably because of the difficulty in working with them.

*Dytiscus alaskanus* (J. Balfour Browne) is a common water beetle in Alberta (Larson, 1975) that can reach high population densities in early summer (Aiken & Wilkinson, 1985). In this paper, I present data from gross measures of diel activity in this species and from more detailed observations of the incidence of several kinds of behaviour patterns.

**Materials and Methods**

A. **Field sampling**

All beetles were sampled at George Lake, Alberta, in bottle traps modified from the design of Aiken & Roughley (1985). Each bottle was mounted on a small piece of wood with a 2.2 cm hole drilled in one end with the hole protruded approximately 10 cm beyond the bottom of the bottle. Bottles were then mounted on poles of 1.9 cm conduit tubing at approximately 50 cm intervals (using the air/water interface as a reference point) and secured with heavy rubber bands. In the field, a length of 1.3 cm conduit tubing 1–3 m long (depending on water depth), was anchored vertically in the lake bottom (Fig. 1). The
FIG. 1. Vertical arrangement of bottle traps to take D. alaskanus adults at different depths. The number of bottles on a pole depends on water depth.

1.9 cm conduit was fitted over this pole and slid down until it too was resting on the lake bottom. When both poles were in place, they were standing vertically, one inside the other, in the water column with a series of bottles protruding at right angles from the larger diameter pole (Fig. 1). The number of bottles per pole ranged from two to seven depending on water depth. Sixteen poles with a total of forty-eight bottles were set along a 1000 m section of shoreline.

For 3 days in June 1984 traps were cleared and immediately reset every 8 h at 06.00, 14.00 and 22.00 hours and the beetles in each counted.

B. Laboratory trials

In the laboratory, thirty males were placed in a 91×47×39 cm deep, 151 litre aquarium filled with filtered pond water. They were kept in this aquarium for 24 h before testing. The beetles were on a natural light cycle, receiving natural light from a north-facing window. After dark, the tank illuminated from above by three 25 W red incandescent light bulbs. Ambient light levels were measured with a Tektronix Model J16 Digital Photometer placed beside the tank.

Beetle activity was monitored for 15 min every hour for 24 h. The incidence of the following behaviour patterns was noted:

1. Swimming. Any bout of swimming during which a beetle moved more than one body length.
2. Surfacing. Upon coming to the surface, a beetle briefly opened the subelytral air chamber to renew its air supply.
3. Mount. One male climbed on the dorsum of another and extruded the aedeagus as if to copulate.
4. Grapple. Two animals met venter-to-venter, grasped and tried to bite one another.
5. Chase. The pursuit of one animal by another for a distance of more than 15 cm.

Results

A. Field trials

As Fig. 2 shows, most of the beetles (95%) were trapped during the dusk to dawn period (between 22.00 and 06.00 hours). The majority of catches were made in bottles sampling the top 5 cm or so of the water column (Table 1). Progressively fewer beetles were taken in deeper traps and none were taken below 1.5 m.

B. Laboratory trials

Light intensities monitored in the laboratory are presented in Fig. 3. Peak light intensity was at 12.00 hours with a general decline thereafter. Sunset and sunrise for the day over which light intensities were monitored were 21.07 and 04.04 hours respectively.

The incidence of acts mounting, grappling and chasing (Fig. 4) increased markedly in the early evening. The critical intensity at which increasing activity is initiated is between 0.4
Dytiscus diel activity

Rhythmicity of swimming and surfacing is not as clear as for other behaviour patterns (Fig. 4) although there is a peak of swimming activity after dark. Surfacing showed no pronounced diel pattern.

Discussion

Field trials show that this animal is strongly nocturnal. Other studies on the activity of dytiscids also show this but have dealt with terrestrial or aerial aspects of the life cycle such as dispersal flights (e.g. Zalom, 1980) and not aquatic activity. In addition, most beetles were taken just below the surface (Table 1). This may represent an effort on the part of the beetles to maximize available light to allow easier detection of food, mates or predators. In June at the latitude of George Lake (approx. 54°N), it is completely dark for only about 2–3 h after midnight.

Light intensity has an important influence on activity of D. alaskanus. There was a change in activity as the light intensities either increased or decreased through the range of 0.2–0.4 lm m⁻².

Paradoxically, there is no diel pattern in surfacing behaviour to renew the air store although there was an increase in all other types of activity measured. One might reason-
ables expect surfacing to increase concomitantly with all other behaviour patterns simply reflecting the energetic demands placed on the animals. That surfacing did not increase may indicate that there is a certain baseline frequency of surfacing that was adequate to satisfy the physiological demands of those activities observed here.

The increase in activity is not one of general locomotion as observed in other aquatic invertebrates (Hiroki, 1982). There is a definite increase in activity that can be loosely described as 'social' (grappling, mounting and chasing), involving interactions between animals and not solely individual activity. The behaviour described could be associated with that used in the course of male–male interaction, mating and reproductive competition. Given the interactive nature of these behaviour patterns, it is perhaps surprising that they occur in darkness (light intensity approximately 0.1 lm m⁻² in the laboratory and probably lower in the field). Studies on the dytiscid eye, however, have shown that it is unique in having a clear zone between the distal and proximal rhabdomeres (Horridge, 1969). Meyer-Rochow (1973) has indicated that this clear zone along with a non-homogeneous cornea serves to crudely focus light on receptors beyond the clear zone. This confers a high sensitivity but low acuity on the dark-adapted dytiscid eye (Horridge, Walcott & Ionnides, 1970; Meyer-Rochow, 1973).

The occurrence of such 'social' behaviour in relative darkness and data on communication systems in these animals may indicate that their mate-seeking and courtship behaviour is rudimentary (Aiken, 1985). Dytiscid beetles have not been shown to produce signals in any modality (e.g. acoustic (Aiken, 1985)) that could be used effectively in mate searching. This together with the occurrence of homosexual mounting seen here and the loss of visual acuity in the dytiscid eye all suggest that *Dytiscus* males may simply try to mate with any moving object of the right size. Aiken (1981) has shown a similar phenomenon in Corixidae and suggested that it may be a workable reproductive strategy in situations of relatively high density where the cost of mating error is not too high.

**Acknowledgments**

I thank J. Scott for drafting the figures. J. M. Cumming reviewed and offered constructive criticism on the manuscript. This study was supported by a University of Alberta Central Research Fund Operating Grant. Special thanks are due to N. J. Newhouse for perseverance during field trials.

**References**


(Manuscript accepted 7 May 1985)
This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.