Tidal Rhythms in Activity in the Intertidal Gastropod, *Polinices incei* (Philippi)

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Abstract - When removed into the laboratory, the intertidal snail *Polinices incei*, retains a tidal rhythm in activity for several days when maintained under conditions of constant light. There is, in addition, a gradual decline in activity following collection and a batch to batch effect of some note. When a 12:12 light regime is maintained there is apparent also a c. 24 h rhythm in activity which may supercede the tidal one under some circumstances. The simplest explanation of the results is that there exist both tidal and diel rhythms. These results are compared with those observed by others for a variety of marine organisms, the adaptiveness of the behaviour pattern is discussed, and the implications of the work for further behavioural studies is explored.

We are engaged in studies of the behavioural responses of selected marine gastropods to low levels of environmental contaminants (Chapman et al. 1985; Hughes et al. 1987; Kitching et al. in press). Much of our work examines activity levels and movement patterns in the sandy shore gastropod, *Polinices incei* (Philippi): a species the movement patterns of which have been described in a related project (Kitching & Zalucki 1982; Zalucki & Kitching 1982).

In preliminary work developing techniques for these studies, we have observed a distinct rhythmicity in the levels of activity in *P. incei* after their return to the laboratory. These observations together with cognizance of the extensive literature on tidal and diel rhythms in marine organisms (see, e.g., Büning 1973; Zann 1973; Palmer 1974; McLachlan et al. 1979; Naylor 1982; Petpiroon & Morgan 1983) led to the experiments reported in this paper. We present these results both as a contribution to the general literature on marine rhythmicity and because they represent essential background to our own work on bioassays.

Materials and Methods

Two experiments are reported here: the first tested for the presence and nature of rhythmicity in levels of activity in continuous light; the second examined the interaction between the tidally-correlated pattern with a superimposed diel pattern of light and dark periods.

For both experiments active individuals of *P. incei* were collected at low tide on Main Beach of North Stradbroke Island (153°30' E 27°30'S) and were returned to the laboratory in aerated containers within 3 h of capture. In the laboratory they were placed, 15 to a tank, in 50 l aquaria each containing about 4 cm of sand and 25 l of fresh sea water collected at the same site as the snails. Two such aquaria were placed under a 45° plane mirror and the activity of the animals monitored continuously using a National™ time-lapse video camera and recorder. These aquaria were maintained at room temperature which was 25 ± 2°C. The water was aerated gently continuously but was not circulated. Animals were not fed during the experiments.

In the first experiment the aquaria were illuminated adirectionally throughout the experiment (intensity approx. 200 lux). Two runs of this experiment were performed using independently collected groups of animals. Data from the first 7 days of each was used (Day 0 through Day 6).

The second experiment was also run on 2 independently collected groups of snails but was continued in each case for 14 days. During this period the aquaria were subjected to a 12:12 light:dark regime. In fact during the ‘dark’ periods the tanks were subjected to a red light (intensity approx. 20 lux) to allow videotaping of the sand surface.

Each experiment was analysed by recording the number of snails active within each experimental group at 15 min intervals. The maximum values obtained in this fashion within each hour

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Fig. 1. Hourly maximum levels of activity following collection in groups of the intertidal snail, *Polinices incis*, under conditions of constant light. The 2 parts of the figure represent 2 runs of the experiment. Day 0 of Run 1 was 10th June 1984; Day 0 of Run 2 was 21st July 1985. Arrowheads along the top of each part of the figure indicate the times of high tide for the location from which the animals were collected. Moon phases are also indicated diagrammatically.

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Results and Analyses

Experiment 1

Fig. 1 shows the results of the 2 runs carried out in continuous light. Times of high tide at the collection site are indicated on the figure as is the phase of the moon. There is a very high overall correlation in both runs between the time of high tide and the time of peak activity (RUN 1: $y = 0.42 + 0.99x$, $r^2 = 0.98$. Run 2: $y = 1.99 + 0.94x$, $r^2 = 0.98$) (Fig. 2). Peaks of activity throughout are just an hour or so behind the tidal peaks but the tidal basis for the activity rhythm is very clear. Rank correlations were calculated between all pairs of the variables: days since collection, hours spent moving by snails each tide, number of snails moving each tide, and the height of the tide in metres. Few of these comparisons produced significant results. The numbers of hours active each tide and the number of snails moving each tide were both significantly correlated with the number of days since collection. The results of