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THE SWIMMING RHYTHM OF *EURYDICE PULCHRA* Leach AND A POSSIBLE EXPLANATION OF INTERTIDAL MIGRATION

J. D. Fish and Susan Fish

Department of Zoology, University College of Wales, Aberystwyth, Wales

Abstract: In tanks containing sediment and sea water *Eurydice pulchra* Leach has been shown to exhibit a swimming rhythm with maximum activity on the ebb tide. Light suppresses swimming activity in the laboratory. There is a semi-lunar component, and maximum activity was recorded on 'falling' spring tides. No activity was recorded in animals collected during neap tides. Swimming behaviour is discussed in relation to migrations up and down the beach associated with the spring-neap tidal cycle.

Introduction

The behaviour of the cirolanid isopod, *Eurydice pulchra* Leach to changes in hydrostatic pressure has been investigated by Singarajah (1966), Knight-Jones & Qasim (1967) and Jones & Naylor (1970). In addition, Jones & Naylor (*loc. cit.*) studied the effect of a range of exogenous components on the swimming rhythm of *Eurydice*. A common finding is that when kept under laboratory conditions in containers provided with sediment, *Eurydice* burrows into the sediment and rarely, if at all, does it emerge to swim in the overlying water. Singarajah (1966) and Knight-Jones & Qasim (1967) found that large pressure increases failed to induce *Eurydice* to leave the sediment, and the activity of the animals in response to changes in hydrostatic pressure was therefore monitored by recording the number of animals swimming above mid-depth in tanks without sediment. The same method was employed by Jones & Naylor (1970) who found that adding sea water at the time of high tide to sediment containing *Eurydice* failed to induce swimming. These observations are at variance with a series of preliminary results obtained during April and October of 1967 with *Eurydice pulchra* collected from the Dovey estuary, Cardiganshire. The present work was initiated to investigate the swimming rhythm of local populations and to compare the results with published data. An attempt has been made to explain the spring-neap tidal migrations shown by this isopod (Fish, 1970).

Materials and Methods

Samples of *Eurydice pulchra* were collected from Ynyslas beach which lies within the estuary of the River Dovey. Small quantities of sediment were passed through a 0.5 mm mesh sieve, and it was ensured that individual sievings were completed in about 30 sec: this precaution was considered necessary because Jones & Naylor (1970) induced rhythmicity in an arhythmic population by subjecting the animals to lengthy periods of stirring.

In the laboratory, the animals were kept in dishes of 30 cm diameter which contained 3 cm of sediment from the natural environment and 10 cm of sea water (33 $^0/_{00}$). The dishes were placed in an aquarium room where they received natural day–night illumination. In all experiments the animals were left undisturbed overnight before observations on their swimming behaviour. Each dish contained twenty adult *Eurydice*, and during the period of observation the number of animals swimming above the surface of the sediment was recorded at half-hourly intervals and the results first expressed as a percentage of the total, and then as the mean percentage swimming activity from three dishes for each half-hourly reading. Throughout the experimental period temperatures ranged from 11–15 °C, and during darkness the number of animals swimming was counted under illumination from a dim red light.

The Swimming Rhythm in the Laboratory

The most conspicuous feature of the swimming rhythm in the laboratory is that when the animals are collected during neap tides, they do not swim when placed in laboratory tanks containing sediment, but that when collected during spring tides swimming activity is readily observed both during day and night. The swimming rhythm in the laboratory shows maximum activity on the ebb tide, and greater activity during darkness (Fig. 1). This pattern of swimming behaviour has been repeated on many occasions; if the animals are observed for several days after collection, the deterioration of the swimming rhythm is clearly seen (see Fig. 3).

The existence of a tidal rhythm of semi-lunar frequency was investigated by making collections of *Eurydice* every second day. These were allowed to acclimate to laboratory conditions and the swimming behaviour observed during a night-time high tide

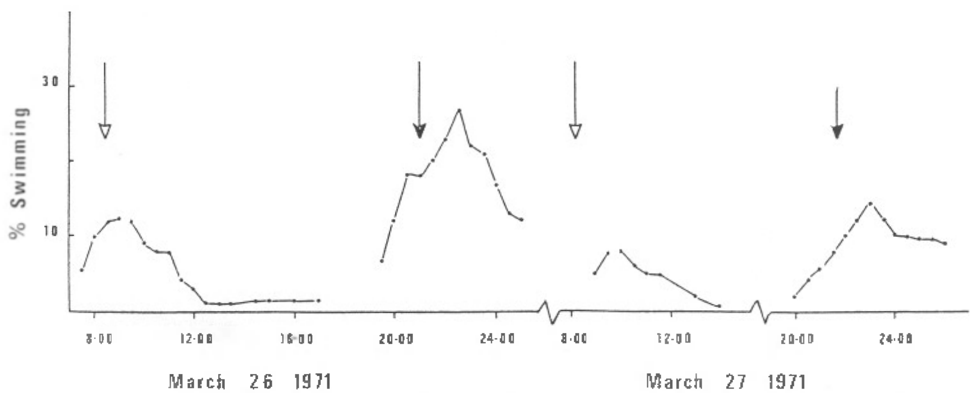

Fig. 1. Swimming rhythms of tidal frequency in *Eurydice pulchra* collected 25th March, 1971 and kept in laboratory tanks with sediment: open arrows indicate the time of high tides during daylight and closed arrows the time of high tides during darkness.

(*i.e.* a tide between 6 p.m. and 6 a.m.). The animals were then discarded and replaced by fresh ones. Fig. 2 shows the maximum swimming activity recorded during each of the observation periods together with the height of the tide, and it is clear that maximum swimming activity occurred on the 'falling' spring tides. No activity was recorded during neap tides.

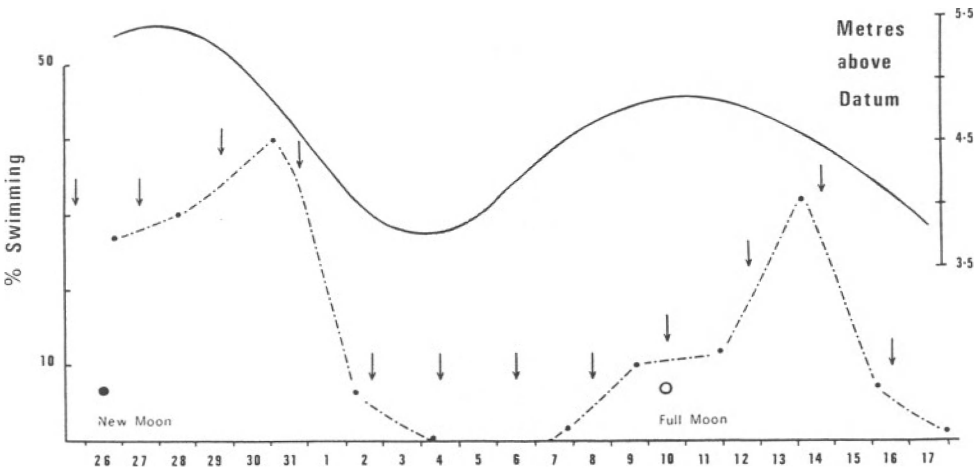

Fig. 2. Semi-lunar periodicity in the swimming rhythm of *Eurydice pulchra*: arrows indicate the times of collection of specimens: maximum swimming activity (●) was recorded on night-time tides. The tidal curve was drawn using the data for Holyhead.

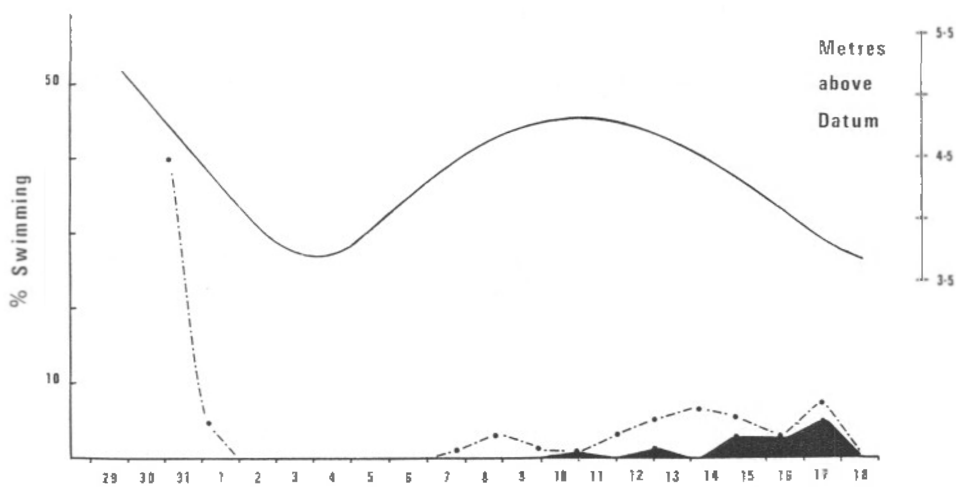

Fig. 3. Night-tide peaks of swimming activity in two samples of *Eurydice pulchra*. Sample A (— - —) collected on the spring tide of 29th March, 1971 and sample B (shaded) on the neap tide of 4th April, 1971. The tidal curve was drawn using the data for Holyhead.

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The semi-lunar component of the rhythm is further emphasized in Fig. 3 which shows the activity of two samples. One sample was collected during spring tides and its activity recorded in the laboratory until the succeeding spring tide, and the other was collected on a neap tide and similarly observed. The spring-tide sample shows an initial high level of activity which falls to zero during the neap tides. During the succeeding spring tides activity was again recorded, but at a much reduced level compared with that of fresh animals (see Fig. 2). The sample collected on a neap tide showed no activity until the spring-tide period but, compared with fresh material, swimming activity was very low.

The Intertidal Zonation of *Eurydice pulchra*

The intertidal zonation of *Eurydice pulchra* on Ynyslas beach has been described by Fish (1970). The zonation is complex because the species shows both seasonal and lunar variations. Fig. 4 shows the number of *Eurydice* collected intertidally at frequent intervals from 24th September to 14th October, 1966. Animals were collected from 16 stations situated at 20 m intervals between the levels of mean high water spring tides and mean high water neap tides. At each station the mean of two 0.1 m^2 samples was recorded and the total number of *Eurydice* present is shown together with the tidal height on the day of collection. The increase in numbers of *Eurydice* on the beach with increase in tidal height shows clearly, and this has been shown to be a movement up and down the beach in phase with the spring-neap tidal cycle (Fish, 1970).

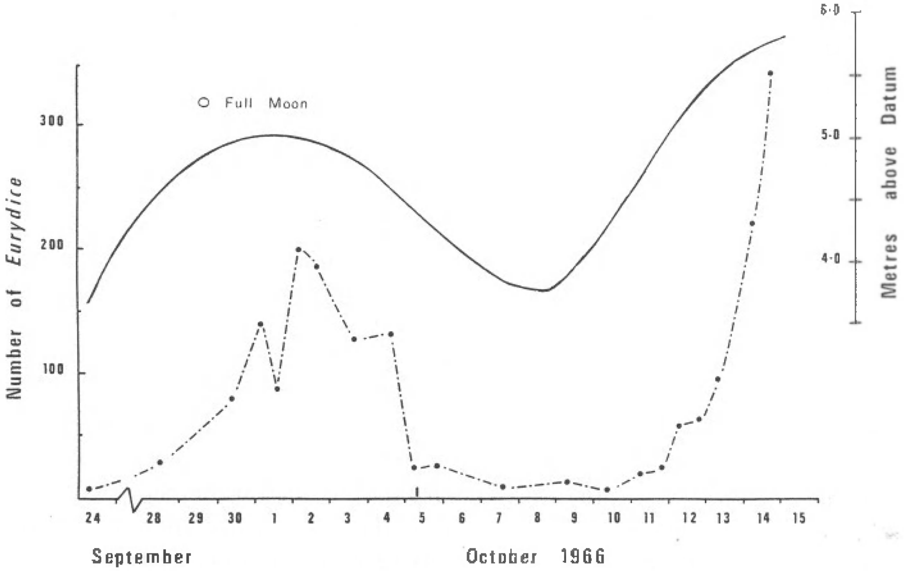

Fig. 4. The number of *Eurydice* (— - —) in samples taken between MHWN and MHWS from 24th September to 14th October, 1966. The tidal curve was drawn using the data for Holyhead.

Discussion

In dishes containing sediment *Eurydice* shows a well-defined swimming rhythm of tidal frequency with activity maxima recorded on the ebb tide. These results are similar to those described for *Synchelidium* sp. (Enright, 1963), *Corophium volutator* (Morgan, 1965), *Bathyporeia pelagica* (Fincham, 1970) and *Bathyporeia pilosa* Lindström (Preece, in press). Jones & Naylor (1970) investigated the swimming rhythm of *Eurydice* in the absence of sediment and recorded peaks of swimming activity coinciding with the times of high tide.

Light suppresses the swimming activity of *Eurydice* with the result that smaller peaks occur during daylight. This is contrary to the results of Jones & Naylor (1970) who found that *Eurydice* was equally active during day and night high tides.

A tidal rhythm of semi-lunar frequency exists in *Eurydice pulchra* with periods of maximum swimming activity on the 'falling' spring tides. Enright (1963) suggested that the deterioration of the swimming rhythm of a population of *Synchelidium* kept in the laboratory for a few days was caused by the de-synchronization of individuals. This may also account for the decrease in activity of populations of *Eurydice* kept in the laboratory from one spring tide to the next, but the existence of a semi-lunar component lends weight to the suggestion of Morgan (1965) that the deterioration of the swimming rhythm in *Corophium* may be related to an endogenous rhythm of semi-lunar frequency which caused the animals to be less active during neap tides.

The swimming activity of *Eurydice* in the presence of sediment is contrary to the findings of several workers, some of whom were unable to induce swimming by increasing the hydrostatic pressure, even though *Eurydice* is sensitive to small pressure changes when not provided with sediment (Singarajah, 1966; Knight-Jones & Qasim, 1967). Even when the experiments were 'repeated many times', Jones & Naylor (1970) found that *Eurydice* "promptly burrowed and never re-appeared". This observation led them to the conclusion that the main synchronizer of the rhythm, and indeed the only factor apparently capable of initiating the active swimming phase, was wave action (Jones & Naylor, 1970). A similar explanation had been put forward by Enright (1963, 1965) for *Synchelidium* and *Exocirolana chiltoni*. This is unlikely to be the case with the estuarine population investigated during the present study. Ynyslas beach is sheltered from the prevailing winds and is infrequently subjected to wave action. In this context it is significant to note that Morgan (1965) concluded that the activity rhythm of *Corophium* was unlikely to be phased "to so capricious a factor" as wave action. During the present study investigations on a population of *Eurydice* from the exposed open coast at Borth, Cardiganshire revealed similar swimming patterns to the estuarine population, and Salvat (1966) has recorded swimming activity in populations of *Eurydice pulchra* and *E. affinis* from the Bassin d'Arcachon. He recorded high levels of swimming activity in both species kept in laboratory tanks which contained sediment. Activity was highest during night-time high tides, and three days after the start of the experiment there was no clear indication of a swimming rhythm. Salvat

(1966) did not give further details of his experiments apart from the dates over which they were carried out (16th–19th October, 1962) and from these it is clear that he was working during 'falling' spring tides.

The intertidal migrations made by *Eurydice* may possibly be explained in terms of the swimming behaviour. The swimming rhythm in the laboratory shows that peak activity is recorded about 2 h after high tide, and maximum activity is recorded 3–4 days after the Full or New Moon, with no activity during neap tides. Although little swimming activity has been recorded during flood tides, field observations have shown that *Eurydice* is active at the edge of the water during flood tide, and Jones & Naylor (1970) have shown by monthly field collections that *Eurydice* was most active at the waters edge for a period of 2–3 h before high water. It is suggested that during this period of activity the animals will be transported up the beach with the incoming tide. This process will continue throughout the 'rising' spring tides and result in the progressive migration up the beach. With the onset of 'falling' spring tides the increase in swimming activity associated with the early ebb will ensure that the animals remain in the water column long enough to be transported down the shore. Fig. 4 shows that 3–4 days after the Full Moon there is a marked decrease in the number of animals taken intertidally.

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