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TIDE-ASSOCIATED BIOLOGICAL RHYTHMS OF SOME WHITE SEA LITTORAL INVERTEBRATES.

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ABSTRACT

We report the results from two years of laboratory observations of the tide-associated rhythms of activity of White Sea intertidal invertebrates, *Mya arenaria (Bivalvia)* and *Gammarus finmarchicus (Amphipoda)*. The tidal associated activity of these invertebrates could not be estimate as a clear circatidal clock. *Gammarus* activity could be phase shifted by a 0.5 h exposure to turbulent water twice a day for 2-3 days. *Mya's* rhythm could be changed by a single drainage of aquariums lasting about 15 min. This kind of timing system may be a relatively primitive evolution feature.

INTRODUCTION

Rotation of the Earth and revolution of the Moon around the Earth produce the cyclical movements of seawater (tidal cycle) in the ocean. The mean interval of the tide is 12.4 h, so the ebb and flow of the tide are observed on many shores two times a day. Furthermore, the amplitude of the tide is modulated by the relationship with the sun. The amplitude of the tide is maximum around the full and new moons (spring tide) and minimum around the first and last quarters of the moon (neap tide). A variety of behaviors of intertidal and estuarine animals (hatching, swimming, feeding activity etc.) are synchronized with these cycles and show related periodicities: i.e. the tidal and lunar rhythms.

Based on the period, tidal rhythms are divided into two categories: activity may be synchronized to both of the low tides, or to both of the high tides, the period of the tidal rhythm is about 12.4 h (*a single-tidal interval*). On the other hand, the activity may be synchronized to the daytime and night rhythms (*e.g.*, Saigusa, 1981, 1997; Neumann, 1981). For intertidal animals, the activity is also correlated with the *semidiurnal inequality* of the tide height (*e.g.*, Enright, 1972; Saigusa and Kawagoye, 1997). In these cases, the tidal rhythms are synchronized with one of the two low tides or with one of the two high tides, and show a period of about 24.8 h (*a double-tidal interval*). Both patterns should be called a tidal rhythm, because there is clear evidence that synchrony with the tidal cycle is sometimes shifted from a single-tidal interval (12.4 h) to a double-tidal interval (24.8 h) or vice versa (see Saigusa and Akiyama, 1995).

There are currently two major issues in tidal rhythm research: 1) the range where the tidal rhythm is detectable; and 2) rhythmic patterns in the habitats where the influence of the tide is decreased. With regard to the second issue, we need to consider two further problems, and thus, the present research focused on the following three issues: 1) the varieties of tidal rhythms in the marine environment; 2) assessment of the period of the rhythmic patterns; and 3) timing mechanisms of the tidal rhythms.

Some opposing notions have been proposed regarding the timing systems of marine organisms. One of them is the interpretation of the tidal rhythm coinciding with both day/night and tidal cycles. Intertidal and estuarine organisms are exposed to both of these cycles, and they have developed their activities in synchrony with both cycles. Accordingly, a hypothesis was proposed that the activity is