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Possible natural circaseptan rhythm in the beach beetle *Chaerodes trachyscelides* White

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Short communication

Abstract. Activity rhythms in groups of captive beach beetles (*Chaerodes trachyscelides* White) have been recorded in an actograph over a period of 29 days. Under constant illumination and when no sand was provided for the beetles to burrow in abnormal behaviour occurred. With sand and in constant darkness a strictly nocturnal activity period with apparently circaseptan components superimposed was observed. The beetles in their natural habitat are confined to the debris zone where they feed on washed up seaweed and this debris zone moves up and down depending on the heights of the tides. Circaseptan elements in the beetles' activity may act as adaptations to the weekly alternations between spring- and neap-tides.

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Free-running rhythms with a period of 7 days have occasionally been reported and, for instance, characterized wound healing (Pollmann 1984), urinary volume and 17-ketosteroid excretion in a human (Halberg et al. 1965) and sodium and potassium excretion in rats on a high-salt diet (Uezono et al. 1987). The built-in circaseptan component has also been implicated in many immune, cardiovascular, and other phenomena (platelets showed weekly periodicities in glutathione content: Radha and Halberg 1987), so that Hajek et al. (1993) even called it "an important prognostic factor in oncology". Yet, despite a search for pacemakers of such rhythms that started as early as 1982 or even before (Levi and Halberg 1982), no known environmental counterpart for 7-day-rhythms has been demonstrated to date (Kaiser et al. 1990). We now believe we may have found a natural "trigger" of circaseptan rhythmicity.

We carried out activity recordings on the New Zealand beach tenebrionid *Chaerodes trachyscelides* White for 4 weeks, using 50 beetles kept together in a sand--filled container. Activities of individual beetles could not be measured as the sand (without which these beetles would not exhibit normal behaviour, similar to the situation described in burrowing decapods by Atkinson and Naylor 1973) absorbed the microwaves of the actograph. The instrument used to monitor the beetles' movements was an "Actograph Type B" (Laboratory Sciences Ltd.), which consisted of a cylindrical bowl with a lid that contained the microwave emission and detection equipment. The actograph was connected to a chart recorder (OmniScribe, Houston Instruments) and any movement inside the actograph resulted in lateral displacements of the recording pen.

The results obtained were therefore those of a group of beetles and, thus, actually more representative of the natural situation. The experiment was run for 6 days under 12L:12D (dark period: 20.00-08.00 h), constant temperature, followed by constant darkness for approx. 1 month. Despite some difficulty with the chart recorder on one night (dotted in Fig. 1.), it was possible to assess the beetles' activity over a period of 29 days.

To test the beetles' activity under continuous illumination rather than darkness was impossible as constant light had an inhibitory effect and prevented the beetles to leave the sand even during the night hours. Beetles without the opportunity to burrow in the sand, however, were continuously active and stopped only when the light was switched off, showing, in other words, exactly the opposite behaviour to what is seen under natural conditions in the field.

Chaerodes trachyscelides is a strictly nocturnal beetle that never starts to be active before the dark period commenced. The amount of activity and therefore the approximate number of beetles remained constant throughout the night, but on the 10th-11th day activity began to start earlier, gradually returning to previous starting times between the 12th and 15th day. This phenomenon of an earlier (and longer) activity and subsequent return to previous starting times was seen twice more within the 29 days of observation (Fig. 1).

The advanced activity start times occurred roughly during spring-tides (unusually high) and neap-tides (lower than usual), when sun, moon, and earth are aligned creating a greater 'force' or the sun is positioned at right angle to the moon resulting in a weaker pull, respectively. In the field, *C. trachyscelides* inhabits the

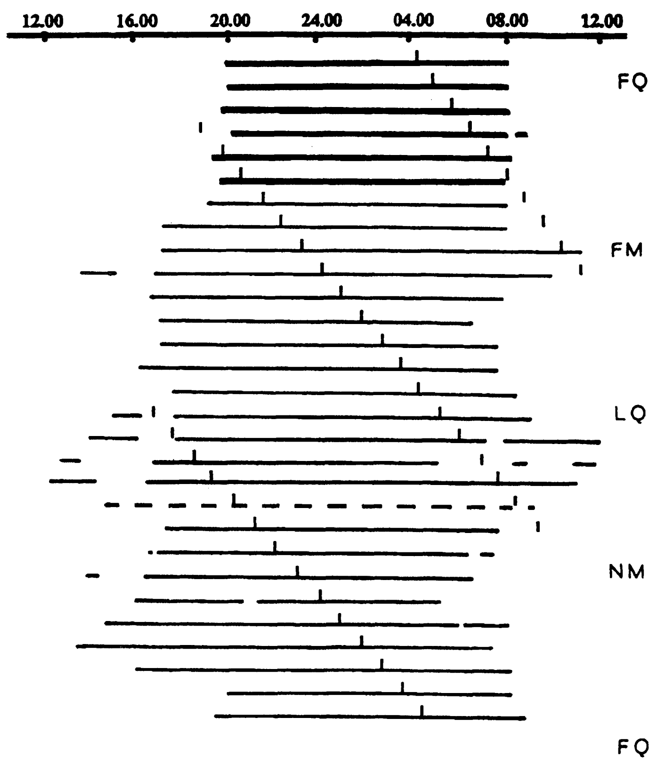

Fig. 1. Periods of activity of 50 *C. trachyscelides* monitored in an actograph. First 6 days under 12L:12D (thick lines), then free-running activity rhythm in constant darkness. The small vertical lines indicate times of high tide and the dotted line refers to a night in which the recorder misbehaved. The abbreviations FQ, FM, LQ, and NM stand for First Quarter, Full Moon, Last Quarter, and New Moon, respectively.

narrow band of sandy beaches, where the likelyhood of seaweed to be washed up is greatest. The beetles hide in the sand down to a depth of 15 cm during the day, but come to the surface at night and feed on the cast-up algae at night. An interesting selection process (Meyer-Rochow and Teh 1991) has resulted in predominantly black beetles occurring on black beaches and white beetles and white sands, but no evidence was ever found for an individual's ability to change colour (Harris and Weatherall 1990).

The thin band of the debris-zone, in which the algae and seaweed accumulate, is not in the same place day after day and night after night, but varies with spring and neap-tides. As a result of the weekly changes and the alternations in the position of the debris band, the beetles would also have to move up and down the beach to stay in the right zone, to avoid being washed away or become stranded above their food supply. It seems that the beetles are being influenced by the varying heights of the tides (seen as an earlier start time and longer nocturnal activity approximately every 7 days) and the dark/light regime, within which the beetles have to operate and which they could use to entrain their nocturnal behaviour as they possess sensitive photoreceptors (Meyer-Rochow and Gokan 1988).

Interestingly, tidal activity rhythms are also present in a marine saltmarsh collembolan insect (Foster and Moreton 1981) and semi-lunar activity rhythms have been reported from the sand beach amphipod *Talitrus saltator* (Williams 1982). Actual seven-day periodicities have been found in a few other marine organisms (Kaiser et al. 1990). For example, the unicellular green alga *Acetabularia* displays a circaseptan rhythm in growth rates (Schweiger et al. 1986) and the luminescence in the dinoflagellate alga *Gonyaulax polyedra* is apparently characterized by a weekly rhythm (Cornelissen et al. 1986). Growth increments in marine bivalves (amongst other variables dependent on water flow, light, and temperature: Clark 1975, Thompson 1975) have been reported to display periodicities of 7-9 days (Pannella 1977).

Could the presence of circaseptan rhythmicities in humans be related to tidal events or even tidal-foraging in the history of mankind? We don't know, but in humans as well as the few other non-marine organisms in which circaseptan rhythms were detected (e.g. bee haemolymph lipid composition: Mikulecky and Bounias 1997), body fluids were frequently involved. At least in *C. trachyscelides* the weekly anticipation of spring- and neap-tides could clearly assist the animal in being at the right spot at the right time and a circaseptan rhythm would, therefore, be an obvious advantage. This hypothesis, however, is based entirely on laboratory observations and a confirmation of it through direct observations at night in the field is, unfortunately, still lacking.

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