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ACTIVITY RHYTHMS OF THE SQUAT LOBSTERS, *GALATHEA SQUAMIFERA* AND *G. STRIGOSA* (CRUSTACEA: DECAPODA: ANOMURA) IN SOUTH-WEST IRELAND

S. DE GRAVE AND J.R. TURNER*

Aquatic Services Unit, Department of Zoology, University College Cork, Lee Maltings, Prospect Row, Cork, Ireland. *School of Ocean Sciences, University of Wales, Bangor, Menai Bridge, Gwynedd, LL57 5EY

This short note describes the *in situ* activity cycles of *Galathea squamifera* and *G. strigosa* (Crustacea: Decapoda) through SCUBA diving observations in south-west Ireland. Both species exhibited nocturnal activity peaks, although they were not exclusively nocturnal. Fluctuating tidal current strength and direction had no discernible influence on either species' activity cycles. It is suggested that shelters, particularly in terms of both predator avoidance and as foraging areas, play an important role in the ecology of both species.

Both the anomuran decapod crustaceans *Galathea squamifera* Leach and *G. strigosa* (L.) are widespread throughout the rocky subtidal of the north-west European coastline. In contrast to the general body morphology and the structure of the mouthparts which have been well studied (Nicol, 1932; Pike, 1947), the biology and ecology of the genus *Galathea* remains poorly studied. These morphological studies have shown that the mouthparts are ill-adapted to living on muddy substrates, essentially restricting the distribution of both *G. squamifera* and *G. strigosa* to rocky areas, where their food is obtained by detrital deposit feeding and scavenging. Turner & Warman (1991) have studied the activity patterns of the genus *Galathea* at Lough Hyne, south-west Ireland and concluded that the genus exhibits nocturnal activity peaks. However, the different species were not distinguished, nor was the potential effect of the aberrant tidal patterns in the area considered. As at least three species (*G. squamifera*, *G. strigosa*, *G. intermedia*) are known to occur at the study site (Holmes, 1985), the present study was initiated to elucidate the activity cycles at a species-specific level. As very few individuals of *G. intermedia* were encountered during fieldwork, this species is excluded from the present contribution.

The study site consists of a rocky boulder scree close to the entrance of the Lough Hyne Marine Nature Reserve (Co. Cork, south-west Ireland). The scree extends between the intertidal and 17 m depth, and consists of a mixture of large boulders and smaller stones and cobbles, interspersed with gravel and sand pockets. *Laminaria saccharina* is the dominant macroalgae until 9 m depth, being replaced further down with sessile fauna and sparse red algal tufts. Due to the sill-like nature of the entrance to the Lough (the Rapids), the normal tidal pattern is distorted into 4 h of inflowing currents with strengths up to 37 cm s^{-1} and 8·5 h of outflowing currents with speeds between 1 and 10 cm s^{-1} (Bassindale et al., 1957). Due to the location of the study site in relation to the Rapids, currents during inflow are in an opposite direction to those during outflow.

In August 1989 an area of the boulder scree was marked off with a transect line. SCUBA divers surveyed the transect four times daily for six consecutive days (Survey I), which was repeated (Survey II) after a non-observation period of seven days to minimize diver-induced disturbances. Each survey dive lasted approximately one hour and dives were staggered by hourly intervals each day, so as to derive a complete 24 h cycle of activity. Both species were

distinguished *in situ* by virtue of their distinctive colouration patterns; *G. squamifera* is brownish-green with no brightly coloured striae (Zariquiey Alvarez, 1968), while *G. strigosa* has a reddish-brown carapace with bright blue striae (S.D.G., personal observation). Before the onset of the actual fieldwork several individuals of both species were captured and their identification verified using criteria in Zariquiey Alvarez (1968). As only visual observations were made, no distinction as to size or sex was made. Numbers seen per species per dive was used as a measure of activity, and is graphically represented in Figure 1. Currents were classified as either inflowing or outflowing.

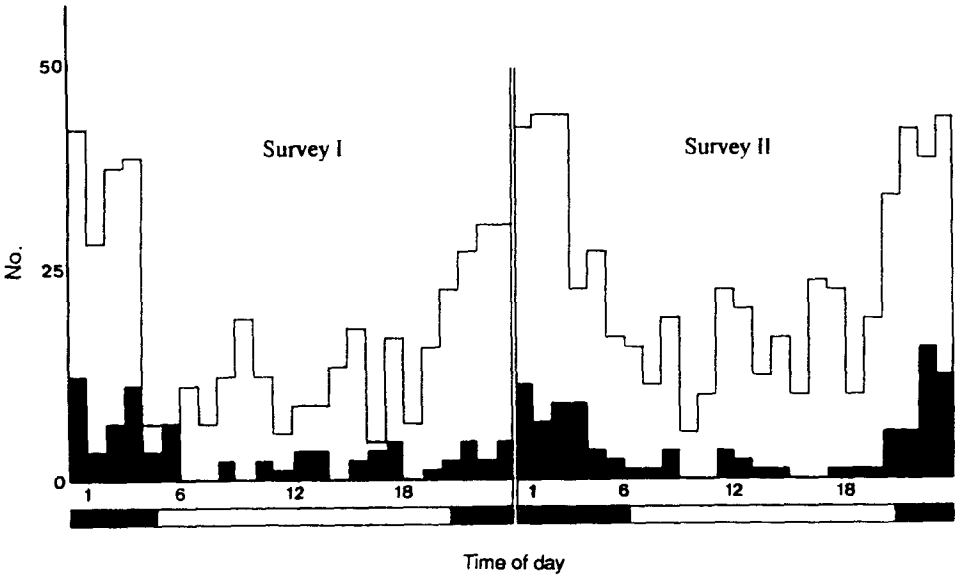

Figure 1. Numbers seen per dive of *Galathea squamifera* (white bars) and *G. strigosa* (black bars). Hours of darkness (black bars) and day light (white bars) are indicated below the time axis.

A one-way ANOVA test revealed no significant difference between both sets (Surveys I & II) of data (*G. squamifera* F_{46} 4·562; *G. strigosa* F_{46} 0·001), hence for each species data from Surveys I and II were combined for further analysis. The activity patterns of *G. squamifera* and *G. strigosa* were not influenced by differences in current (two-way ANOVA: $F_{1,44}$ 0·632 and $F_{1,44}$ 0·886 respectively), but were significantly influenced by day–night differences (two-way ANOVA: *G. squamifera* $F_{1,44}$ 20·362 $P<0·001$ and *G. strigosa* $F_{1,44}$ 59·035 $P<0·001$). Mean number of *G. squamifera* observed during the day was 12·73 (Standard Deviation (SD) 5·44) and during the night 29·72 (SD 15·34), and for *G. strigosa* the respective levels were 1·40 (SD 1·28) and 6·50 (SD 3·55).

These data clearly demonstrate that, in common with many subtidal decapods, *G. squamifera* and *G. strigosa* are primarily active during the night. Nevertheless, both species are not exclusively nocturnal, as a few individuals were seen inside shelters on nearly all daylight survey dives. The prime adaptive force behind nocturnal activity peaks in subtidal decapods is considered to be predator avoidance (Kanciruk, 1980). Potential predators at the study site include *Scyliorhinus canicula, Labrus bergylta, Ctenolabrus rupestris, Conger conger* and *Homarus gammarus* (Samuelsen, 1970; Lyle, 1983; Sayer et al., 1995).

The former three species are diurnally active, while the latter two species are nocturnal foragers. The extent to which any of these species prey on either species of *Galathea* at the study site is not known, but the nocturnal activity peaks of both *Galathea* species may be indicative of a higher predation pressure exerted by the diurnally active potential predators.

Proportionally more individuals (χ^2 8·26, df 1, P<0·005) were observed by day of *G. squamifera* (17·3% day, 82·7% night) than of the more brightly coloured and larger-bodied *G. strigosa* (11·0% day, 89·0% night). These morphological and colour differences may make *G. strigosa* more conspicuous to diurnal predators and contribute to the selective pressures for nocturnal activity in this species.

During the present study, the majority of individuals were observed inside or in close proximity to shelters, particularly during daylight hours when virtually no sightings of individuals were recorded outside the shelters. Most daylight sightings were of individuals roaming around in the atrial region of large shelters, clearly involved in either foraging or feeding. Cooper & Uzmann (1977) demonstrated that juvenile *H. gammarus* spend their entire time within occupied shelters and related this to the abundant food supply of encrusting biota on shelter walls. Similarly, the luxuriant epifaunal growth on the inner surfaces of shelters and the rich biomass in the soft substrate pockets (S.D.G., personal observation) on the boulder scree may be sufficient to provide *G. squamifera* and *G. strigosa* with a plentiful food supply in the proximity of their shelters.

Current speeds during the inflowing tide are of a sufficient force to be able to alter the activity patterns of some species, as they can potentially sweep away moving animals. Howard & Nunny (1983) demonstrated that *H. gammarus* will remain in their protective burrows if current speeds exceed 20 cm s^{-1}, a speed that is exceeded at the study site during inflowing currents. However, neither of the studied species appears to be influenced by the variation in current speed and direction. The fact that both species spend most of their time within the protective confines of shelters and make only limited forays outside shelters is likely to afford them sufficient shelter from strong currents at this site, and indeed may minimize potential effects of variations in current.

In addition, the complex micro-topography of the study site may dampen the differences between the various stages of the tidal cycle. Hiscock (1983) demonstrated that even though surface velocity was 35 cm s^{-1}, the local topography of Whirlpool Cliff and the adjacent boulder scree has a significant effect on both velocity and direction, with simultaneously measured near-bottom velocities ranging from 2 to 35 cm s^{-1} and direction varying from 105° to 232°.

Although the present study has demonstrated a primarily nocturnal activity peak for both *G. squamifera* and *G. strigosa*, a number of questions need to be addressed to elucidate the ecological requirements of these poorly studied, but important components of the subtidal boulder scree decapod community. These questions relate to foraging distances, the role of shelters and the importance of squat lobsters as dietary components in potential predators.

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