Burying and feeding activity of adult *Holothuria scabra* (Echinodermata: Holothuroidea) in a controlled environment

Svea Mara Wolkenhauer[1]

Abstract

This study investigated the relationship between temperature and burying and feeding behaviour of adult *Holothuria scabra* (sandfish) within a diel cycle. Animals were kept in aquaria in a constant light regime (14 h light/10 h darkness) and temperature was reduced 1°C each day from 24°C to 17°C. A scoring system was used to categorise the animals' burial state and behaviour (e.g. burying, feeding, resting) at two-hourly intervals. Sandfish showed a distinct diel burying and feeding cycle, with most animals exposed and feeding between 13:00 h and 20:00 h, and most buried and inactive between 1:00 h and 9:00 h. Periods of being buried increased with decreasing temperature from 6.7 h per day at 24°C, to 14.5 h per day at 17°C. Feeding activity decreased from 9.8 h a day at 24°C, to 0.8 h per day at 17°C. Temperature was significantly positively correlated with both feeding and burying behaviour. Based on the results of this study, the most suitable time to conduct population surveys of *H. scabra* in the southern hemisphere would be during summer (December to February) from midday to late afternoon.

Introduction

H. scabra show various cyclical patterns of burying, depending on their age (Battaglene 1999; Mercier et al. 1999; Mercier et al. 2000; Uthicke 2001; Yamanouchi 1939; Yamanouchi 1956). Juveniles, probably due to their higher risk of predation, are synchronised by day/night regimes, burying at sunrise and re-emerging at sunset (Mercier et al. 1999). *H. scabra*'s feeding activity can be somewhat independent of its burying cycle, in that exposed animals are not necessarily feeding, and burying animals may still ingest sediment (Mercier et al. 1999; Wiedemeyer 1992; Yamanouchi 1939; Yamanouchi 1956).

An understanding of burying activity is crucial to minimising errors in population and distribution surveys. Additionally, seasonal variation in burying and feeding activity may affect ecosystem function and bioturbation rates attributed to holothurians within their habitat. The aim of this study was to investigate a possible relationship between burying and feeding activity, and temperature of adult sandfish, while excluding other possible factors that may influence the animal's burying and feeding pattern such as tides, current and light.

Methods

Six 100-L aquaria, each with 10 cm depth of substrate, were set up. Based on results from previous studies and personal observations (Wiedemeyer 1992; Wolkenhauer unpubl. data), this was an adequate sediment depth for allowing normal burying behaviour of adult *H. scabra*, since their anus is usually in constant contact with the water column to facilitate respiration.

Artificial lamps were placed over the aquaria to simulate natural summer light regimes (14 h light and 10 h darkness). Each of the six aquaria was stocked with one adult sandfish (~17 cm length, ~300 g wet weight) collected from Moreton Bay, southeastern Queensland, Australia.

Initial temperature was set to 24°C and subsequently, temperature was decreased one degree every day for a week until reaching 17°C at the end of the experiment.

The aquaria were monitored every two hours for seven days, and the activity of the animals was classified on each occasion as various combinations of burial state and behaviour (Table 1).

Table 1. Activity of *H. scabra* in aquaria classed as combinations of burial state and behaviour.

behaviour \ burial state	fully buried	half buried	fully exposed
resting	1	2	3
burying		4	
emerging		5	
feeding levelled (on substrate)			6
feeding upright (on walls)			7
searching			8

1. CSIRO Marine and Atmospheric Research, PO Box 120, Cleveland, 4163 Qeensland, Australia. Email: swolkenhauer@hotmail.com

In order to prepare the data for statistical analysis, I converted scores of different activities of interest into binomial form (true/false) and analysed the responses using a generalized linear model (GLM) with binomial error structure. Each state (e.g. feeding/not feeding or buried/not buried) was therefore treated as a binary response and the probability of this behaviour occurring was estimated as a probability between 0 and 1. Furthermore, harmonic transformation of the time-of-day, using sine and cosine functions representing the daily feeding and burying cycles, were used as supplementary explanatory variables.

Results

Holothuria scabra showed a distinct diel burying cycle (Fig. 1), with most of the animals exposed and active between the hours of 13:00 and 22:00 and most buried and inactive between 01:00 and 09:00. As experimental temperatures decreased, fewer animals were exposed and active, while more remained buried or half buried, showing a significant (p = 0.002) correlation with temperature. However, the trend of burying during the day did not change, but rather the burial duration lengthened. This effect was particularly obvious in the morning (08:00–10:00), with only one animal out of six being buried at 24°C, compared to four out of six animals being buried when the temperature reached 17°C (Fig. 1).

There was a significant (p < 0.001) correlation between feeding activity and temperature. Daily periods of feeding decreased by 9 h from 9.8 h at 24°C to about 0.8 h at 17°C.

Modelling the daily feeding and burying cycle showed that the probability of feeding increased directly with increasing temperature, irrespective of time of day (Fig. 2). However, the probability of exposure increased only slightly with increasing temperature during the early hours of the morning, whereas during daylight, the amplitude as well as duration increased rapidly with increasing temperature (Fig. 2).

Discussion

This study shows that adult *Holothuria scabra* have a diel burying cycle as described for juveniles (Battaglene et al. 1999; Mercier et al. 1999). Furthermore, the length of time spent buried shows a significant relationship to temperature. Purcell and Kirby (2005) also found more adult sandfish buried for longer periods during the day with decreasing water temperature. However, they did not specify any temperature range and did not investigate actual timeframes of the animals being buried based on a 24-hour cycle since the observations took place

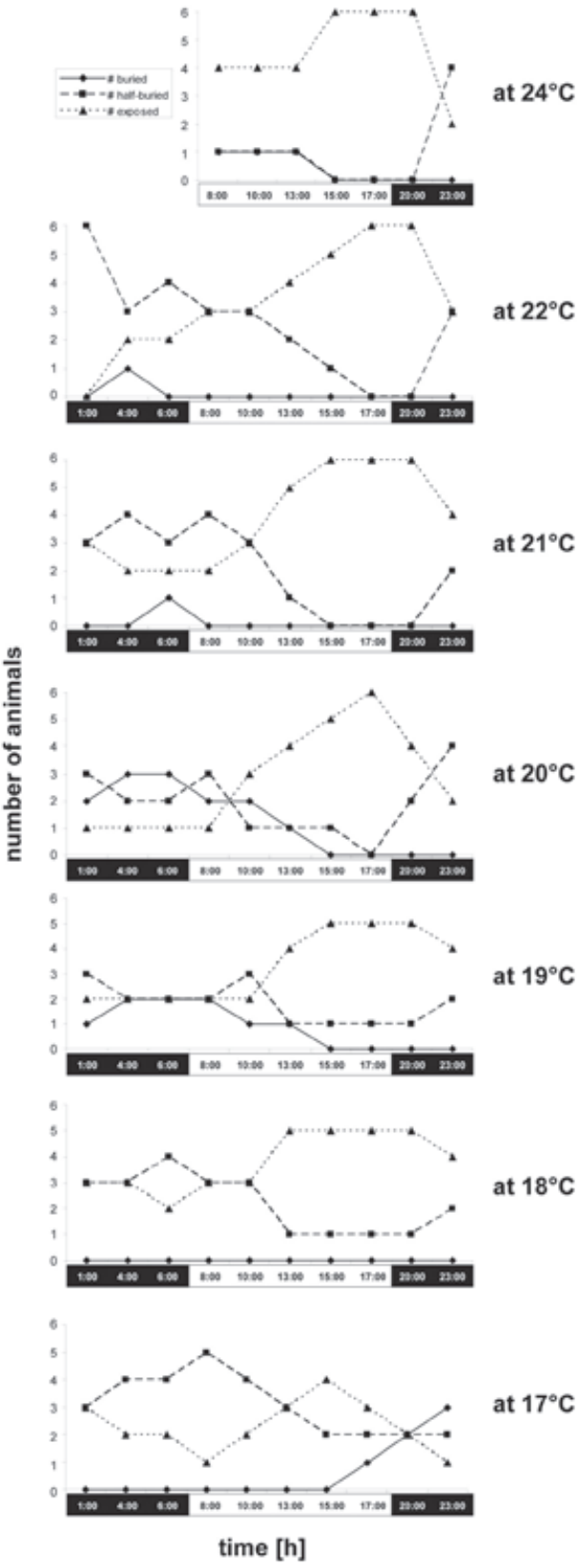

Figure 1. Diel burying cycle of *H. scabra* with decreasing temperature. Open and solid bars on X-axis represent light and darkness.

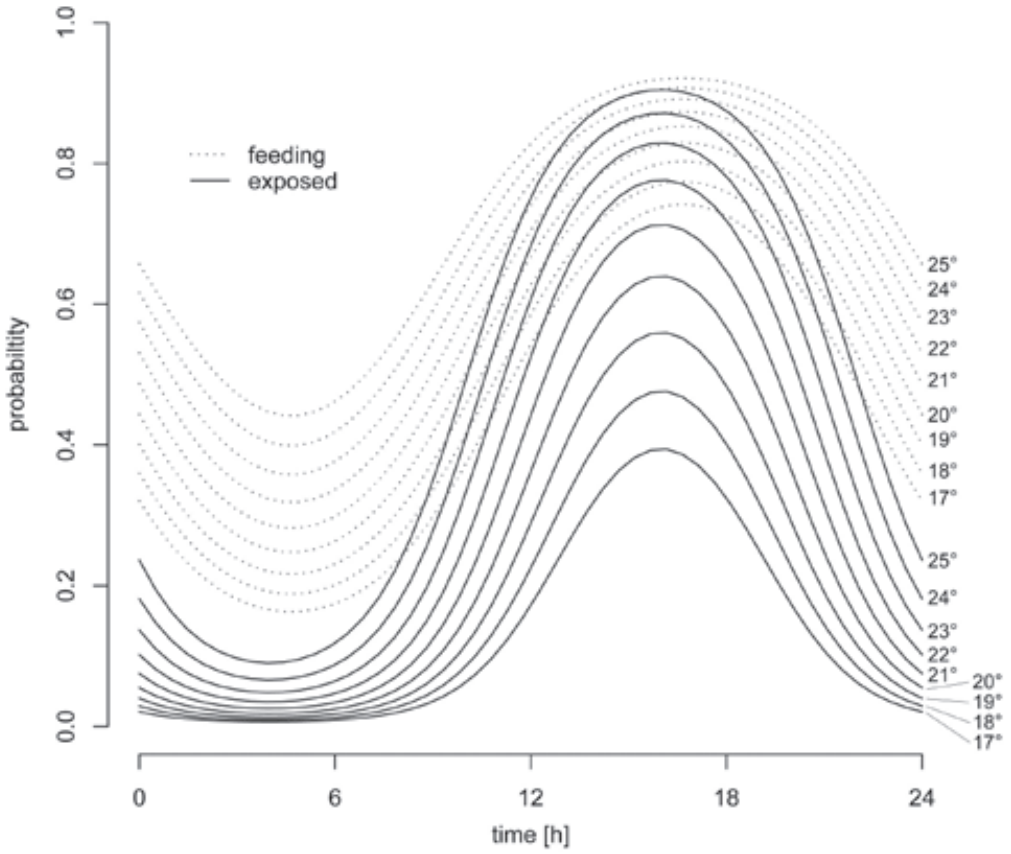

Figure 2. Generalized Linear Model prediction of probability of feeding and burying behaviour (cos-sin function). Dotted line = probability of animals feeding, solid line = probability of animals being exposed. Numbers on the right represent the temperature in degrees Celsius for each line.

only during daylight hours. Mercier et al. (2000) found that most adult *H. scabra* on the surface did not follow their usual burying cycle when the water temperature was increased to more than 30°C.

Other factors that are known to cause sandfish to bury for prolonged periods of time include stress (Purcell et al. 2006), spring tides and strong currents (Skewes et al. 2000), predation (Dance et al. 2003), and desiccation or changes in salinity (Mercier et al. 2000). These factors might counteract or prolong the effect temperature has on their burying cycle in the wild. However, this study aimed specifically to exclude those variable factors to find a potential underlying pattern in response to temperature alone.

Further study is needed to determine how light and temperature interact, and if adult *H. scabra* have a potential tendency to reverse their burying cycle in accordance with reversed light regimes, overruling the temperature effect, as has been shown for smaller juveniles (Mercier et al. 1999).

Temperature also shows a significant decrease on the animal's time spent feeding. Studies on feeding behaviour of other echinoderms show similar effects with temperature (Hollertz and Duchêne 2001; Schinner 1993; Thompson and Riddle 2005). For example, Thompson and Riddle (2005) showed that sea urchins *Abatus ingens* increased their displacement activity with only one degree increase in temperature.

Conclusion

My data indicate that observed differences in burying and feeding behaviour of adult *H. scabra* are strongly related to changes in water temperature. Hence, the ecosystem function of holothurians alters depending on seasons, and should be taken into account when establishing the ecological role of those animals within their habitat. These findings have implications for population surveys for this species when relying on visually counting animals. Surveys should be conducted at consistent diel and seasonal timing if results are to be compared with

previous data. Based on burying data presented here, I suggest the most suitable time to conduct population surveys on *H. scabra* would be during the summer from midday to late afternoon.

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