SPATIAL DISTRIBUTION AND BEHAVIOUR IN BILATERALLY-BLINDED JUVENILES OF THE WESTERN ROCK LOBSTER

PANULIRUS LONGIPES (MILNE-EDWARDS)*

With 1 Text-figure and 1 Table

by

V. B. Meyer-RoCHOW

(Department of Biological Sciences, University of Waikato, Hamilton, New Zealand)

It was shown by Meyer-RocHOW and PENROSE (1976) that in the rock lobster Panulirus longipes antennal sound production begins to appear in the postpuerulus stage; planktonic pueruli are still silent. The coincidence of the onset of sound production with settling on solid substrate in the juvenile rock lobsters prompted us to carry out experiments with bilaterally-blinded postpueruli. When it was found that blinded animals were even less inclined to produce sound than seeing ones the hypothesis that rock lobsters called one another to gather together was abandoned and the results of the experiments were never published. The recent finding by Meyer-RocHoW and TIANG (1984), however, that the rock lobster Jasus edwardsii possesses compound eyes which easily lose their sensitivity and can even go blind following brief exposures to a bright light, meant that a fresh look at the old data on bilaterally-blinded postpueruli would seem worthwhile.

Since the structure of the eyes of both Jasus edwardsii (Meyer-RocHOW and TIANG, 1984) and P. longipes (Meyer-RocHOW, 1975) is very similar, we have no reason to

* Described as a new species by GEORGE (1962), but relegated to the status of an allopatric form of P. logipes by CHITTLEBOROUGH and THOMAS (1969).
suspect that the two species behaved very differently and we, therefore, see no justification in surgically blinding and sacrificing more specimens than those already worked on.

In view of the fact that partially- or completely-blinded rock lobster juveniles are regularly thrown back into the sea by fishermen after sorting procedures are over, observations on bilaterally-blinded specimens are not meaningless. Their behaviour will allow us to predict what consequences the loss of vision in terms of locomotary activity, feeding, orientation etc., could have in the field.

**Materials and Methods**

Puerulus larvae were hand-collected from artificial seaweed buoys (PHILLIPS 1972). Maintained in seawater tanks, they gave postpueruli 3-4 days after capture. Six animals, all of them postpueruli and no longer than 5 cm total body length, had their eyes carefully extirpated just below the basement membrane of the retina so that the endocrine regulators in the eye stalk, i.e. sinus gland and x-organ, remained undamaged. An anaesthetic or cold treatment prior to the operation were not used as it was feared that such measures could upset a circadian rhythm regulating activity in these animals. Five undamaged animals served as controls.

The experimental tank, 150 cm long and 60 cm wide, was filled to 50 cm with seawater, the latter being continually exchanged through the system of circulating seawater in the research establishment. A wire-partition separated compartment ‘I’ (=intact animals) from compartment ‘II’ (=bilaterally-blinded individuals). There were
three ordinary bricks in each compartment, placed next to one another in such a way that several corners and hiding place were created (Text-fig. 1). The temperature of the water was approximately 13°—15°C and the animals were fed small pieces of mussel every other day after observations, but not at precisely the same time of day to avoid unintentionally conditioning the animals. One observation in the early afternoon every two days over a period of one month (April 17th—May 15th) was carried out. An observation consisted of recording the position of each individual by entering it into a map of the aquarium.

Results

Although we were unable to find evidence in support of the hypothesis that sound as a means of intraspecific communication was involved in bringing together individuals, we did notice some interesting differences in the behaviour and spatial distribution of rock lobsters in the two groups. The 'seeing' animals tended to form clusters of 2 or more individuals much more frequently than the blind animals. With one exception, when three seeing individuals were found huddled together in an aquarium corner, the aggregations always took place in the corners created by the three bricks. Single animals, too, almost always were seen in the corners of the bricks or along their edges, but never on top of the stones.

The blinded animals, on the contrary, were rarely found together in one place, but seemed distributed much more randomly in the tank. Blinded animals were often seen directly below the water surface attached to the aquarium wall. They tended not to

Table 1. Summary of the positions of intact and blinded animals based on 16 separate observations made in the early afternoon every other day over a period of 1 month. For further explanations, e.g. number of animals used, mortality etc., see text please.

<table>
<thead>
<tr>
<th></th>
<th>intact animals Group I</th>
<th>blinded animal Group II</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two or more animal in close proximity (&quot;together&quot;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) along edge of stone or corner</td>
<td>47</td>
<td>2</td>
</tr>
<tr>
<td>(b) on stones</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>(c) in bottom aquarium corner</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(d) elsewhere</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Animals separated from nearest neighbour by at least one body length (&quot;single&quot;)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(a) along edge of stone or corner</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>(b) on stones</td>
<td>—</td>
<td>11</td>
</tr>
<tr>
<td>(c) in bottom aquarium corner</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>(d) near water-surface</td>
<td>—</td>
<td>13</td>
</tr>
<tr>
<td>(e) elsewhere</td>
<td>2</td>
<td>31</td>
</tr>
</tbody>
</table>
rest in a hiding place. The high incidence of blinded animals, on rather than alongside the bricks and not in the corners available for shelter, demonstrates the restlessness of these animals. This restlessness must have been due to the loss of sight, since these animals were fed and treated in exactly the same way as the seeing individuals. In the blinded population two fatalities occurred during the observation period: the first on the 9th day of observation and the second on the 13th. No fatalities were encountered in the control group.

Discussion

The results can be interpreted in more than one way. It is possible, although unlikely, that individuals see one another and copy one another. This would explain why only seeing animals were found to be gregarious. However, a more likely explanation of the observed aggregations of individuals is that they were not attracted to each other but to a particularly suitable hiding place during the hours of daylight. The suitability of the hiding place itself is probably assessed not alone by vision but by tactile stimulation as well. Support for the notion of a close link between visual and tactile sense also comes from the observation by Meyer-Rochow and Penrose (1976) that intact animals, when touched, are less inclined to stridulate in the darkness of night than during the day. However, since aggregations took place at different corners on different days—a tendency of postpueruli to go where others have already gone certainly exists.

There is considerable evidence that circadian rhythms operate in crayfish and rock lobsters, influencing activity, feeding etc. (Arechiga and Huberman, 1980), but our blinded animals right from the moment they had their eyes extirpated tended to crawl about during the day, not at all making use of the hiding places provided. How is this observation compatible with a circadian rhythm? A circadian rhythm, based on an ‘internal clock’, is likely to allow the animal to ‘sense’ whether it is day or night. The eyes, if intact, would change over more or less automatically to ligh or dark adaptation in anticipation of changing ambient light levels (Meyer-Rochow, 1975; Meyer-Rochow and Tiang, 1984). Now, with an internal clock set at day time, our blinded animals would expect ambient light levels brighter than those during the night. Consequently, we would expect them to actively seek the missing light during the day—which is, of course, exactly what our results document.

Since numerous invertebrates as well as fish use the direction and intensity of sunlight to orient themselves (Fraenkel and Gunn, 1960), it is obvious that the behaviour of sitting on rather than under or alongside a brick and of resting just below the water surface suggest that our blinded individuals deemed themselves in deep, dark water. Their activity can be interpreted as a vain attempt to migrate into shallower zones where they might encounter light. The intensity of ambient light in a rock
lobster's environment, therefore, seems to influence rock lobster behaviour in two major ways: (a) the animal can use day and night light levels as a reference to adjust its internal clock, (b) in conjunction with an intact circadian rhythm the animal can obtain an idea of the depth that it is in. Activities such as feeding and locomotion depend on the correct interplay between internal clock oscillations and the periodic reception of 'Zeitgeber' stimuli for entrainment.

Recently, Zimmer-Faust et al. (1985) have shown that substances released by both sexes in Panulirus interruptus are highly attractive to conspecific males and females alike, resulting in conspecific aggregation. The same authors state “aggregations are probably formed just before dawn and maintained until dusk”. The behaviour is thought to be of survival value. We have now demonstrated that the presence or absence of photoreceptors influences the aggregative behaviour in Panulirus, but whether the control operates via glands in the eye-stalks or in a more direct way remains unknown.

The consequences of our observations are clear: if undersized rock lobsters (=juveniles) due to exposure to bright lights during sorting procedures are returned to the sea with damaged eyes, they may behave abnormally, not seeking to hide during daytime and not remaining in the relative protection of deeper water. By migrating into shallower areas during the day, rock lobsters not only expose themselves to predators but may end up damaging their eyes further until they are completely blind.

Acknowledgements

This research was supported in part by an A.R.G.C. grant and a Queen Elizabeth II.-fellowship in Marine Sciences to the author.

References


**摘要**

外科的に両眼摘出したカノコイセエビ幼生を水槽で飼育し、その空間分布状態および、その行動を正常なカノコイセエビ幼生と比較した。正常なものは日中、かくれ場所に群をなして静止していたが、両眼摘出したカノコイセエビ幼生は日中でも活発に動きまわり、しばしば水面へあがっていった。このような異常行動を体内時計との関連で考察した。