Studies of a *Goneplax rhomboides* population off Quarry Bay

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Introduction

This work was conducted during a course in sublittoral marine ecology sponsored by the Lundy Field Society and the Department of Marine Biology, University College of North Wales, Menai Bridge, Anglesey. The observations reported here result from a team effort involving Mr. A.R. Andrews, Miss M. Cooper, Mr. J. Creak, Mr. M. Davies, Dr. P.M. Hardy, Mr. J.B. Markham, Mr. C. Roberts, Mr. D. Tierney, Mr. J.G. Wilson and myself. The main objects of the exercise were to familiarise ourselves with various types of burows in the mud and employ a number of techniques to study them. This involved the preparation of polyester resin casts of selected burrows, mapping the distribution of burrows and observing the area by night as well as by day.

Although *Goneplax rhomboides* (L.) was responsible for most of the conspicuous burrows in the area several distinctive burrows occupied by the Red Band Fish *(Cepola rubescens* L.) were found. The squat lobster *Munida bamffica* (Pennant) was occasionally seen in the entrances of burrows but these burrows appeared to be vacated *Goneplax* burrows.

Methods

A 48 metre tape measure was pinned into the mud substratum 17m below C.D. off Quarry Bay. Those burrows that occurred within 1m either side of the tape were mapped using pencils on prepared perspex 'slates'. Interrelationships between holes in the mud were ascertained by creating a current of water in the burrow and noting those openings through which mud clouds emerged. Where one or more entrances to a burrow were particularly large and crater-like this was noted. Conspicuous burrows were clearly divisible into two types. Hand collection of specimens from each type of burrow indicated they were *Goneplax* burrows and *Cepola* burrows. Previous to mapping burrows along the 48 x 2m belt transect, the mapping technique was practised in an adjacent area delimited by a contiguous grid of $1m^2$ quadrats covering an 8 x 8m area. Polychaete, bivalve and other burrows considerably less conspicuous than those of *Goneplax* and *Cepola* were ignored.

The orientation of the belt transect was N – S. The speed and direction of the current was measured throughout a tidal cycle using an Ono CM2 direct reading current meter. Thus the orientation of burrows could be investigated in relation to current.

Casts of burrows were taken using polyester resin marketed by Trylon Ltd. as AP 101 PA lay up resin, plus liquid catalyst. The resin was mixed 98% to 2% catalyst by volume, passed immediately from the boat to a diver who then poured it from the plastic bucket used as a container into burrows in the mud. Casts were raised after 24 hours. Casts were then measured and photographed and the diagrams in Fig. 3 were traced from photographs.

Since *Goneplax* were not seen on the mud surface during the day, the transect was also swum at night.

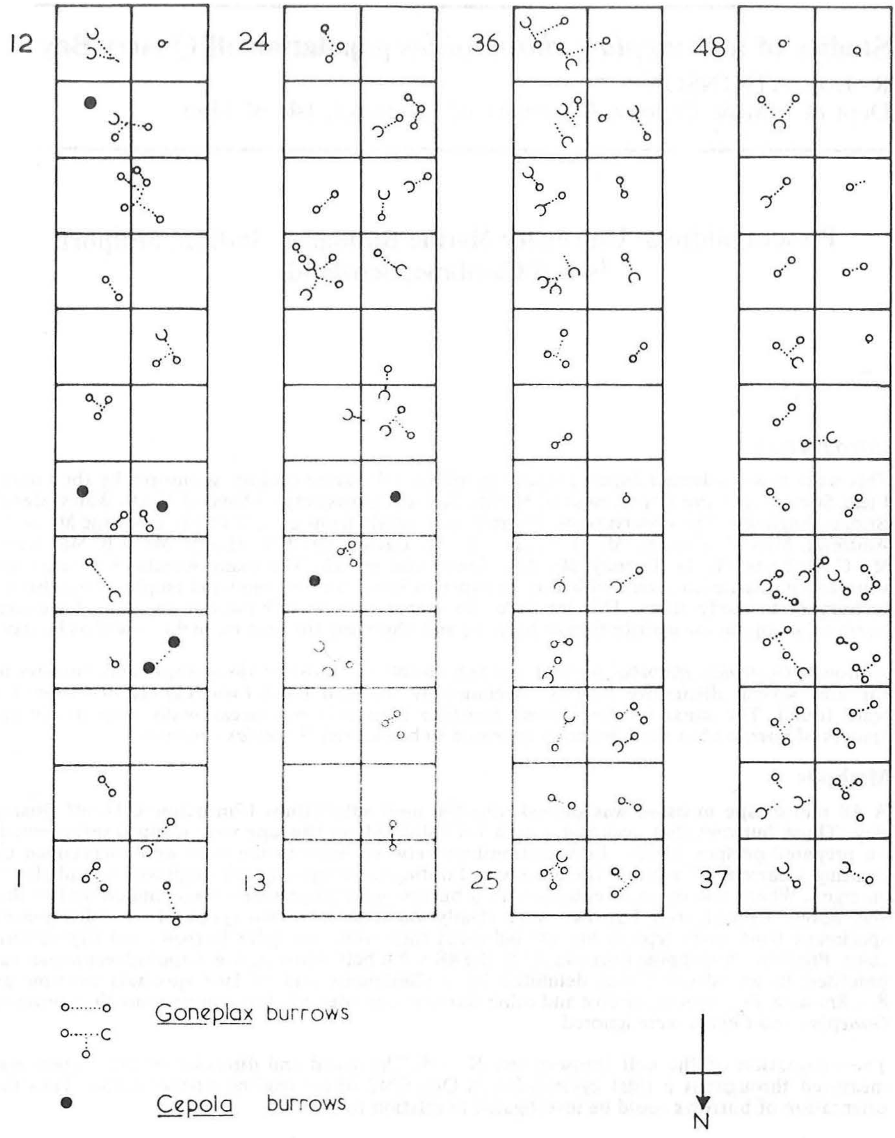

Fig. 1. Distribution of Goneplax burrows along a 48 x 2m belt transect (divided in the figure for ease of presentation). Dotted lines indicate probable course of tunnels. C-shaped indicate where burrow openings were particularly large and crater-like.

Results

Fig. 1 presents a distribution map of burrows along the belt transect. Analysis of *Goneplax* burrows reveals slight aggregation which becomes evident at the 2 x 8m quadrat size when the Index of Dispersion (see Blackman, 1942; Pielou, 1969) is employed (chi squared = 13.79. $0.05 > P > 0.01$ at $n - 1 = 5$ degrees of freedom). The mean density is 0.93 burrows per m^2. 6 or possibly 7 (if system 4m along transect line is constructed by two fish) *Cepola* burrows occurred at one end of the transect.

Of the 89 *Goneplax* burrows, the percentages with 1, 2, 3, 4 and 5 openings are 18, 54, 24, 3 and 1 respectively.

Linear tunnels with an opening at each end were analysed for orientation. Side tunnels had to be ignored since their point of connection with the main tunnel of a burrow could not be fixed with certainty without casting. The result is presented in Fig. 2 where (a) indicates the orientation of burrows in relation to magnetic N and (b) indicates the speed and direction of the current during a tidal cycle, the current meter being deployed at the north end of the transect.

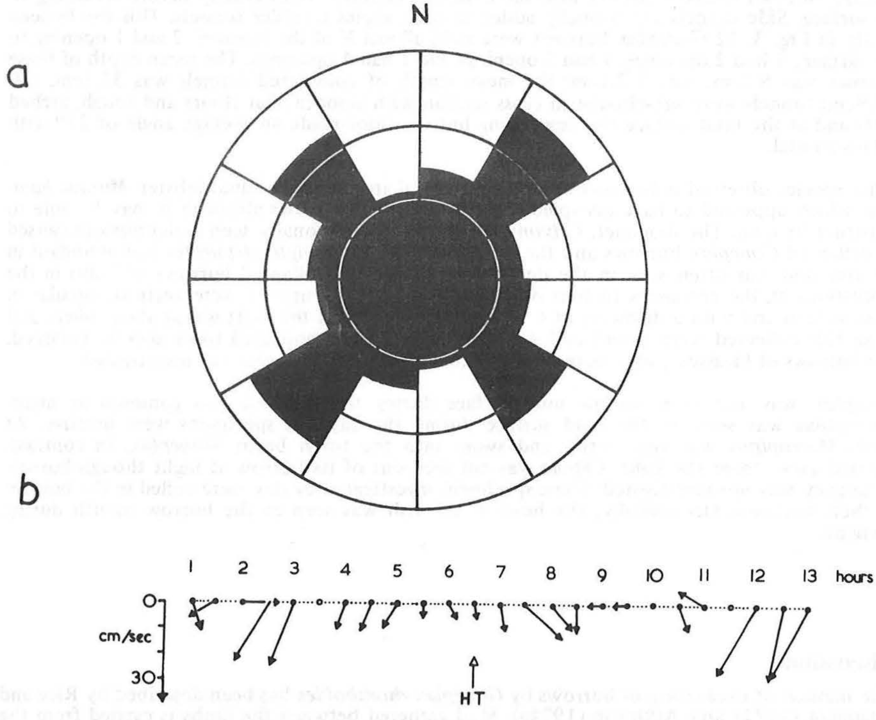

Fig. 2 (a) Orientation of burrows (black). Each division of radius = 5%.

(b) Current direction and speed throughout a tidal cycle (0815 – 2015h, 6:8:74). H.T. = high tide. Magnetic north (N) is the same as for (a).

Off Quarry Bay, eddies caused by the main tidal streams cause the current to flow in a southerly direction on both the ebb and the flood tides. The mean current direction on the one cycle measured was 197° (s.d. ± 50°) and the maximum velocity was 30 cm/sec. Of the burrows analysed, 25% were aligned N – S (± 30°), 27% were aligned E – W (± 30°), and the remaining 48% were aligned NE – SW or NW – SE. In Fig. 2a the mid point of a two-entrance burrow is considered to lie at the centre of the circle. Thus no attempt has been made to determine the direction in which the crab excavated, i.e. which entrance is the burrow origin. Normally, the largest entrance to a burrow system is the oldest though this in turn may have been the start of a secondary shaft in an older, now collapsed system (see Atkinson, 1974a). Such large, crater-like openings to burrows indicating the oldest part(s) of the system are indicated in Fig. 1. However, since the oldest parts of many burrows could not be determined an analysis of direction of excavation is not worthwhile in this case. The general orientation of most burrows was somewhat oblique to the mean current direction but since the strongest currents were in SE and particularly SSW directions, some orientation to, or orientation imposed by current may be indicated.

Fig. 3 illustrates typical *Goneplax* burrows and the diagrams are accurate tracings of photographs of polyester resin casts. Fig. 3, a – e are arranged to indicate the way in which a burrow system develops. A detailed description of this process is given elsewhere (Atkinson, 1974a). Briefly, burrows shelve shallowly into the mud and continue horizontally before returning to the surface. Side tunnels are normally added at right angles to older tunnels. This can be seen clearly in Fig. 3. 12 *Goneplax* burrows were cast, all just N of the transect. 2 and 1 opening to the surface, 5 had 2 openings, 4 had 3 openings and 1 had 4 openings. The mean depth of these burrows was 8.2cm, s.d. ± 2.1cm; the mean length of completed tunnels was 32.3cm, s.d. ± 9.9cm; tunnels were sub-circular in cross section with smooth, flat floors and rough, arched roofs and at the mud surface the descending burrow floor made an average angle of 37° with the horizontal.

Other species observed in burrows in the same general area were the squat lobster, *Munida bamffica* which appeared to have occupied vacated *Goneplax* burrows although it may be able to construct its own. The dragonet, *Calyonymus lyra* was occasionally seen in depressions caused by collapsed *Coneplax* burrows and the portunid crab, *Macropipus depurator* was abundant in the area and was often seen in the depressions caused by collapsed burrows and also in the depressions at the entrances to burrows. *Cepola rubescens* burrows were vertical, circular in cross section and with a diameter of 6 – 8cm. The bottom of the shaft was at about 60cm and those fish collected were found coiled in this region which appeared to be slightly enlarged. The burrows of bivalves, polychaetes and anemonies occurred but were not investigated.

Goneplax was not seen on the mud surface during the day but was common at night. *Macropipus* was seen on the mud surface during the day but specimens were inactive. At night, *Macropipus* was very active and swam into the torch beam. *Goneplax,* in contrast, scurried away from the light. *Cepola* was not seen out of its burrow at night though burrow occupancy was not investigated. Some specimens investigated by day were coiled in the bottom of their burrows. Occasionally, the head of the fish was seen at the burrow mouth during daylight.

Discussion

The method of excavation of burrows by *Goneplax rhomboides* has been described by Rice and Chapman (1971) and Atkinson (1974a). Mud gathered between the limbs is carried from the burrow between the folded chelae, aided by the second and third peraeopods on the crab's trailing side. The resulting burrow shelves shallowly into the mud and continues horizontally for a variable distance (normally less than 50cm) before returning to the surface. Secondary tunnels are often added to primary ones, invariable at right angles. Burrow entrances enlarge with increasing use and this eventually results in the collapse of the tunnel. The stability of the sediment probably determines the complexity of a burrow. In Upper Loch Torridon, *Goneplax* burrows normally had 4 or 5 entrances (Rice and Chapman, 1971); in Fishguard harbour 2 or 3 entrances, the latter being similar to Lundy where 2 and 3 entrance burrows also predominated.

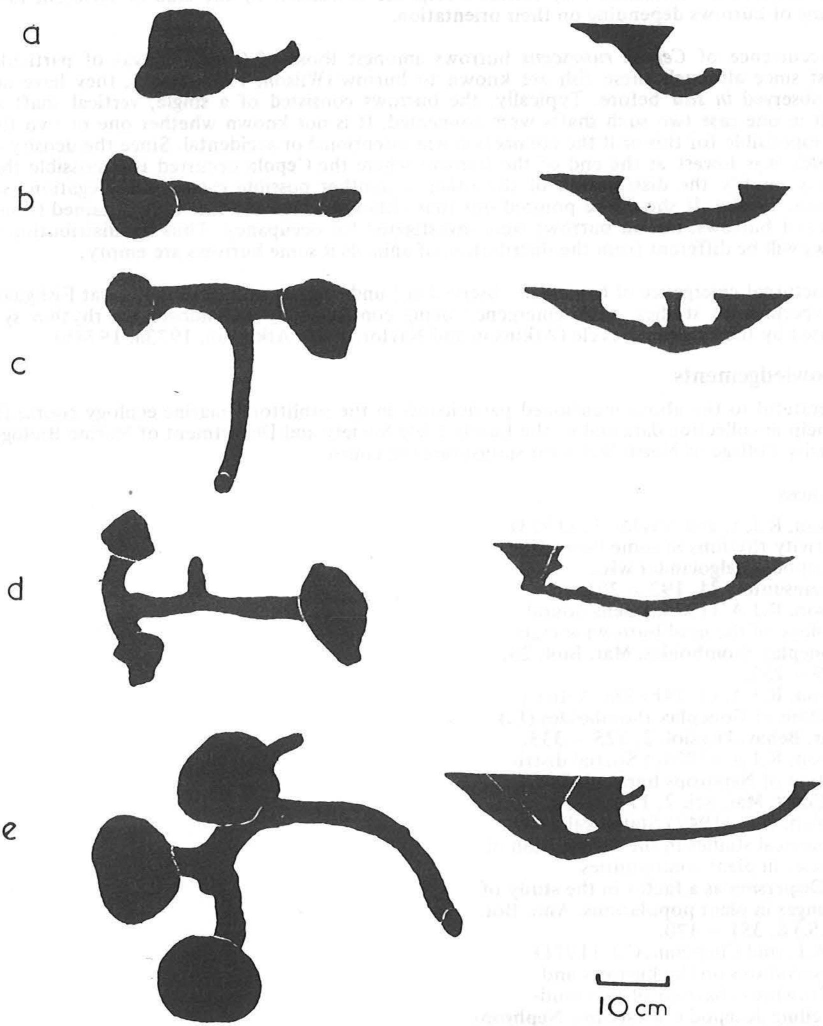

Fig. 3. Plans and side elevations of 5 Goneplax burrows (a – e) showing systems of increasing complexity.

The slight indication of aggregation of burrows may be due to varios factors. The sediment appeared uniform but mud samples taken to test this were unfortunately lost in transit. Good feeding conditions or breeding factors may tend to bring animals together – the present observations were made in August when crabs might be pairing. Since the configuration of burrows is always changing with old tunnels collapsing and new ones added, firm conclusions about pattern are difficult to arrive at. A more detailed experimental approach is needed.

Similarly, the possible correlation between current and burrow orientation needs to be tested experimentally. A correlation may reflect a response to current by the crab or different rates of silting of burrows depending on their orientation.

The occurrence of *Cepola rubescens* burrows amongst those of *Goneplax* was of particular interest since although these fish are known to burrow (Wilson, 1953, 1963), they have not been observed *in situ* before. Typically, the burrows consisted of a single, vertical shaft although in one case two such shafts were connected. It is not known whether one or two fish were responsible for this or if the connection was intentional or accidental. Since the density of *Goneplax* was lowest at the end of the transect where the Cepola occurred it is possible that one may modify the distribution of the other – another possible cause of aggregation (see Atkinson, 1974c). It should be pointed out that although crabs and fish were obtained from a number of burrows, not all burrows were investigated for occupancy. Thus the distribution of burrows will be different from the distribution of animals if some burrows are empty.

The nocturnal emergence of *Goneplax* observed at Lundy agrees with observations at Fishguard and experimental studies, such emergence being controlled by an endogenous rhythm synchronised by the light/dark cycle (Atkinson and Naylor, 1973; Atkinson, 1973a, 1974b).

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