Short Communications

Burrow identification of some estuarine organisms

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The available literature lacks adequate descriptions for the identification of the burrows of common South African estuarine benthic organisms. The burrows of three crab, two prawn, two bivalve and a polychaete species commonly encountered in southern Cape estuaries are described. Details on tidal levels, sediment types and associated macrophytes are included to assist in burrow identification.

In die beskikbare literatuur is daar gebrek aan behoorlike beskrywings waarvolgens die gate van Suid-Afrikaanse bentiese organismes geïdentifiseer kan word. Die gate van drie krapspesies, twee garnaalspesies, twee spesies tweekleppiges en 'n borselwurmspesie wat algemeen in Suid-Kaapse getyriviere voorkom, word beskryf. Om met die indentifisering van gate te help, word besonderhede gegee van getyhoogtes, sedimentsoorte en makrofiete wat met die spesies verband hou.

As part of a larger investigation of organic matter and inorganic nutrient fluxes in the Keurbooms estuary, a detailed biomass distribution study of the main benthic fauna was carried out. Sampling revealed a diverse community of animals, most of which inhabited burrows. Difficulty was experienced in distinguishing burrow types and linking species to each of these. As the literature reviewed did not provide easy access to the information we required, we defined criteria which would link an organism to its burrow. Detailed descriptions of burrow type as a guide to fauna identification are given. The species dealt with are *Arenicola loveni*, *Callianassa kraussi*, *Cleistostoma* spp., *Scylla serrata*, *Sesarma catenata*, *Solen capensis* and *Upogebia africana*.

Burrow descriptions

Arenicola loveni (Blood worm). The burrow is 'U'- or 'L'-shaped with the inhalent and exhalent ends differing in appearance (Figure 1). The depth of the burrow is often in excess of 75 cm, with only the smallest worms penetrating less that 30 cm (Gaigher 1978). The inhalent end ranges from a barely discernible saucer-shaped depression to a 200 mm deep funnel or irregular hollow (Gaigher 1978). The hole is often obscured by macrophyte material and sand particles. The size of the inhalent depression bears little relation to the size of the resident worm (Gaigher 1978). The exhalent outlet is usually 200–300 mm distant, but can be as far as

Figure 1 The inhalent (A) and exhalent (B) ends of the burrow of the bloodworm *Arenicola loveni*. Often *Zostera* and other macrophyte fragments collect in the inhalent depression. Scale: 1 Division = 10 mm.

800–1200 mm (Macnae 1957). It is small, being approximately 2–3 mm in diameter in the center of a small cone of excavated material, and is often different in colour and texture to the surface sediment. The cone consists of 'faecal' sand which has passed through the worm. The cone usually shows some sign of coils, unless produced under water. Casts of juvenile worms can resemble earthworm casts and may be higher up the beach than those of larger specimens. The surface signs of *A. loveni* are variable and are a function of the tidal phase, substratum, locality and size of worm (Gaigher 1978). In addition, casts consisting of watery spurts on the sediment surface, simple sand rope coils or irregular channels showing traces of layering may be present. Burrows are normally found at low water of neap tide levels, extending down to low water of spring tide (Day 1981). In most southern Cape estuaries, subtidal populations of *A. loveni* extend downwards from intertidal levels (Gaigher 1978).

Bivalves. There are several species of burrowing estuarine bivalves or mussels. They usually have well-developed siphons, e.g. *Loripes clausus* and may be buried to a depth of 200 mm. The siphons reach the surface and may be detected as a small hole of 2–3 mm in diameter. A sediment cone is usually absent. One of the more common bivalves found in Southern African estuaries is *Solen capensis*.

Solen capensis (Pencil bait). The mouth of the burrow is formed by the joined siphons and results in an oval hole constricted in the middle (Figure 2). It could also be thought of as being key-hole or figure-of-eight shaped. The diameter across the long axis can exceed 20 mm. *S. capensis* is usually found in sand, but records show that it also inhabits muddy sand. *S. capensis* burrows are generally found from mid-tide levels to channels below low water of spring tide. They usually occur in the marine dominated lower estuarine reaches, often near the mouth.

Figure 2 The key-hole or figure-of-eight-shaped burrow entrance of the pencil bait, *Solen capensis*. Scale: 1 Division = 10 mm.

A second species, *S. cylindraceus*, is found in soft mud substrata further upstream in estuaries, and does not produce 'keyhole' burrow entrances. Its burrow opening is usually difficult to detect, with the only indication of its presence being a small pock mark in the sediment (Gaigher pers. comm.).

Callianassa kraussi (Sand or pink prawn). It is found associated with sand throughout the intertidal zone and sub-tidal channels. The burrow diameter may reach 10 mm and is often in the center of a large cone of medium-grained sediment (Figure 3). The cone size varies considerably and may reflect the stability of the sediment within which the burrow is made. Where the sediment has higher cohesive properties the cone may be small. Furthermore, tidal and wind-driven water movements may flatten protruding cones (Branch & Pringle 1987).

Very often sediment within an estuary is layered, with superficial mud covering a deeper layer of sand. In this case it is possible for *C. kraussi* and the mud prawn *Upogebia africana* to live beneath the same surface area, but be separated vertically Figure 4. However, Gaigher (pers. comm.) has observed sand prawns living together with mud prawns in marginal or unstable areas of soft or muddy substrata, where the sediment lacks stratification.

According to Hanekom (1980), *C. kraussi* may live as deep as 1 m below the surface. Burrows exceeding 2 m in length have been reported (Branch & Pringle 1987).

Upogebia africana (Mud prawn). The burrows are up to 12 mm in diameter. The hole may either be level with the background substratum or have a ridge surrounding it (Figure 5). As it does not have a sand cone as seen in *C. kraussi*, the burrows can be easily distinguished even when they occupy the same area. As its common name implies, it is found in mud or sandy mud, is often associated with macrophytes in the upper reaches of the intertidal zone and is found in subtidal as well as intertidal mudflats from mid-tide to low water of spring tide. Hill (1967) describes *U. africana* burrows penetrating to depths of 20–60 cm below the surface. They normally consist of two vertical shafts, connected at the bottom by a short horizontal passage which varies in length from a few centimetres to 20 cm.

Cleistostoma spp. (Crab). Burrows are up to 12 mm in diameter in mud or sandy mud. Coarse particles (pseudo-faecal pellets) are often scattered around the entrance giving a granular appearance (Figure 6). They occur at high-water mark, often associated with *Spartina* or *Triglochin*. *Upogebia africana* is also found in this substratum and often *Cleistostoma* spp. seek shelter in the upper portion of a *U. africana* burrow.

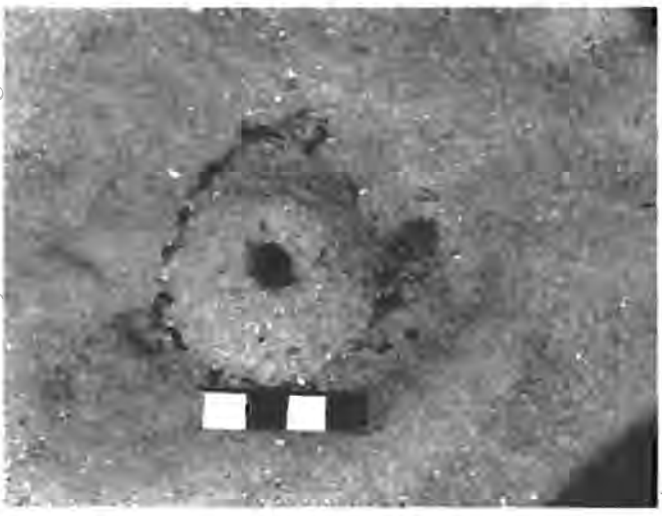

Figure 3 The burrow opening of the sand prawn *Callianassa kraussi*, showing the typical cone formation found in poorly cohesive substrates. Scale: 1 Division = 10 mm.

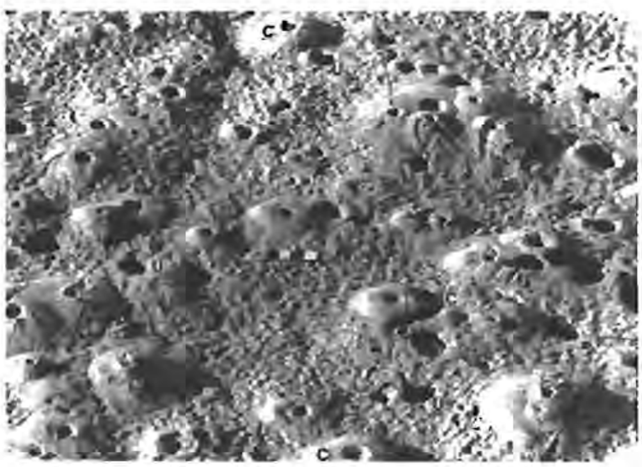

Figure 4 An oblique view of burrows in a mixed community of mud prawns, *Upogebia* (U) and sand prawns, *Callianassa* (C). Scale: 1 Division = 10 mm.

Figure 5 The burrow entrance of the mud prawn *Upogebia africana* showing the ridge formation which is often present when in mud. Scale: 1 Division = 10 mm.

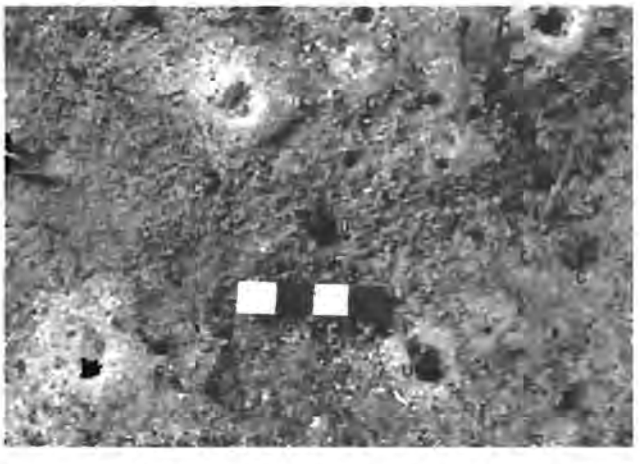

Figure 6 Crabs, *Cleistostoma* spp. (C) associated with the burrows of the mud prawn *Upogebia* (U). Pseudo-faeces (P) indicate the crabs' presence. Scale: 1 Division = 10 mm.

Figure 7 The oval entrance to the burrow of the marsh crab *Sesarma catenata*, surrounded by the spoil of excavation. Scale: 1 Division = 10 mm.

The two species found in estuaries are *C. edwardsii* and *C. algoense*. The former is found in solid and sandy mud from high water of springs to below mid-tide level. The latter is restricted to areas in which the mud is semi-fluid and water-logged (Macnae 1957).

Scylla serrata (Knysna or swimming crab). The burrows of adults are usually flatly oval and often occur in *Zostera* beds. They are also common in channel banks and the interface between mud and sand. They reach 200 mm across the mouth and enter the mud substratum obliquely, extending horizontally for some 3–4 m beneath the surface (Day, Millard & Harrison 1952). They are the largest burrowing organism in the estuarine environment. Juveniles make burrows similar to those of adults, but on a smaller scale.

Sesarma catenata (Marsh crab). Small burrows are circular while large burrows (20–40 mm) are off-round or oval (Figure 7). They occur in mud or sandy mud from

Table 1 Comparison of surface features of the burrows of estuarine organisms

Species	Diameter (mm)	Shape	Substratum	Macrophyte	Tidal levels
Arenicola loveni	2 – 3	Round	S; SM	Z	LWNT–subtidal
Callianassa kraussi	12	Round	S; SM	Z	HWST–subtidal
Cleistostoma spp.	12	Round	SM; M	N; Z; J; T	HWST–LWNT
Scylla serrata	200	Oval	SM; M	Z	Mid-subtidal
Sesarma catenata	30	Oval	SM; M	A; N; Z; J; T	HWST–midtide
Solen capensis	20	Keyhole	S; SM	–	Mid–subtidal
Upogebia africana	12	Round	SM; M	N; Z	Mid–subtidal

Key: A = *Sarcocornia*; J = *Juncus*; M = Mud; N = *Spartina*; S = Sand; T = *Triglochin*; Z = *Zostera*; HWST = High water of spring tide; LWNT = Low water of neap tide; LWST = Low water of spring tide.

just above high-tide mark to approximately 70 cm below (Alexander & Ewer 1969). They are usually associated with *Spartina, Triglochin, Juncus* or *Sarcocornia* beds. The crabs are easily frightened by sudden movement, but soon reappear to sit in the mouths of their burrows or walk around when conditions return to normal.

According to Alexander & Ewer (1969), two types of burrow are inhabited by *S. catenata.* The first is formed on mudflats and consists of a more or less vertical shaft extending downwards for 15–20 cm. The shaft which may have inclined side entrances, leads into a nest containing free water. It can be inhabited by up to six crabs. The second type of burrow is found in vertical erosion scarps or 'salting cliffs'. Such burrows consist of openings leading into a network of inter-connecting tunnels which may reach back 40–50 cm from the scarp face and contain free water at the lower levels (Alexander & Ewer 1969).

In Table 1 the surface features of the burrows described above have been summarized to assist in rapid identification.

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Natalobatrachus bonebergi (Anura: Ranidae): aspects of early development and adult size

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The early development and adult size of *Natalobatrachus bonebergi* were investigated. Newly hatched tadpoles were normally about 12,5 mm long. Fore-limb emergence occurred at a total length of 35 to 41 mm after 60 to 125 days of development in the laboratory. Body length was 12 to 13 mm at the end of metamorphosis, and reached two to three times this length at sexual maturity. Hind-limb growth corresponded closely in natural and laboratory populations and served to indicate pre- and pro-metamorphic phases. Rapid increase in hind-limb length occurred only after tadpoles had reached 30 mm in total length.

Die vroeë ontwikkeling en volwasse grootte van *Natalobatrachus bonebergi* is ondersoek. Pas uitgebroeide larwes was normaalweg nagenoeg 12,5 mm lank. Voorste ledemaatdeurbraak het plaasgevind by 'n totale lengte van 35 tot 41 mm na 60 tot 125 dae laboratoriumontwikkeling. Aan die einde van metamorfose was liggaamslengte 12 tot 13 mm, terwyl geslagsryp indiwidue twee tot drie keer hierdie lengte bereik het. Groei van die agterste ledemaat was eenders in natuurlike en laboratoriumbevolkings en kon dien om pre- en prometamorfose-fases aan te dui. Vinnige toename in agterste ledemaatlengte het eers voorgekom nadat die larwes 'n lengte van 30 mm bereik het.

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Natalobatrachus bonebergi Hewitt & Methuen, 1913, has a limited coastal distribution in central and southern Natal and north-eastern Cape Province (Poynton 1964). Egg masses are suspended above water on various types of substrate, mostly plants. On hatching, tadpoles drop into the water to complete their development.

Wager (1931, 1952) described hatching and larval development in *N. bonebergi,* but was unsuccessful in rearing tadpoles under laboratory conditions. He was consequently unable to relate developmental changes to tadpole age. The only other accounts of *N. bonebergi* larval morphology and identification are those of van Dijk (1966) and Wager (1986). Van Dijk (1972) referred to the rheophilic, bottom-dwelling habits of the tadpoles and pointed out the lack of information on natural habitat preferences and development.

The present study supplements existing knowledge on *N. bonebergi* early development and hatching, larval development up to metamorphosis and adult size range. Studies were carried out mainly under laboratory conditions but were supplemented with data obtained from natural populations. Data on adult size ratios were obtained exclusively from samples of natural populations.

Intact egg masses of *N. bonebergi* were collected in