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A Brief Review on: Architecture, Characteristics and Types of Burrows in Crabs

Shipra Sinha Department of Zoology, kalyan PostGraduate College, Bhilai, C.G

Shalini Balakrishnan Department of Zoology, kalyan PostGraduate College, Bhilai, C.G

KEYWORDS :

Behavioural ecology is the branch of science that studies the ecological and evolutionary aspects of a species or a collection of species with that of its/their immediate environment. It deals with analyses of relationships between an organism's behaviour and the environment wherein the said behaviour has evolved or is expressed. One of the greatest geneticists Theodosius Dobzhansky (1964) famously wrote, "*Nothing in Biology makes sense except in the light of evolution*". The pattern of behaviour helps an animal to adapt to its environment, both intrinsic and extrinsic, efficiently. In modern behavioural ecology a variety of tools and approaches are used - from demographics to molecular phylogenetics. The arthropods are often used as models for studying the behavioral patterns, both in the solitary and social conditions. Ecological and spatial distributions of the arthropods allow them to maintain favorable body temperature within the burrows and also during several key developmental stages, affecting size and development rate. The options offered by modern telemetry technology can also be used by physiological and behavioural ecologists. When direct observation is impossible, telemetry can be used to acquire a wide spectrum of environmental, physiological and behavioural data. The relationships between behaviour and other factors, such as gender, species and size also draw observations and focus on the classical theories of behavioural ecology. Decapod crustaceans have complex life histories and behavioural aspects, such as foraging, mating and reproduction, moulting and growth, habitat selection and migration. New technologies have enabled to use an individual, field-based approach to analyze these problems, although they have been less developed in decapods than in vertebrates. In decapods applications of telemetry to analyze habitat selection, foraging behaviour, energetics, moulting site selection and migrations are also used to study the behavioural aspects. Thus the behavioural study is the dynamic system of intermittent locomotion by which the animals adjust themselves with the change in the circumstances of the surroundings. Movement of an organism is an important cue for stimulus detection; pauses can also reduce unwanted detection by an organism's predators or prey. Most of the ecological studies have focused completely on the behavioural interaction of the crab with the surroundings. Relatively little work has been done on the behavioural ecology of the Indian freshwater crab associated with the behaviour and population related processes. The analysis of the spatial distribution of burrows of the crab in the field can suggest uniform, clustered or random orientation in the population dynamics.

The terrestrial crab, *Barytelphusa cunicularis* has been selected as a model animal to study the spatial and temporal patterns in its population. To understand abundance patterns and population dynamics of organisms in spatially heterogeneous environment, dispersal is usually considered as the key element. The nearest neighbouring technique is a simple technique to study the classification patterns and the distribution of population sampling patterns. The distribution of burrows is classified as clustered, random or regular by using this technique. The behavioural and morphological characteristics of *Barytelphusa cunicularis* are also used as the functional of the dispersal properties of an organism. In general, studies on burrowing behaviour enhance the burrow characters, biological complexity, ecological significance and also reproductive, behavioural and physiological activity of the species. In semi-terrestrial decapods burrows play most important and functional role in the extreme environmental conditions. Burrows generally protect the animal from varying environmental conditions and play a vital role in determining the owner's social environment and its access to food. Structure of burrows plays a significant role and provides a morphological window in the life of an organism. Also the morphological characteristics play an important role in agonistic and aggressive interactions and have also attracted human curiosity and fired human imagination. Possibly the most important contribution of crabs make to science comes from the fact that their rich behavioural repertoire is played out openly and within a small space that can be continuously monitored. In this miniature animal society, we can study in detail the behavioural ecology as well as the mechanisms of behaviour under natural conditions.

The design and architecture of the burrows have always attracted attention of biologists. Although extensive work has been carried out on the biology and fishery aspects of Brachyuran crabs, little is known regarding the burrow characteristics and burrowing behaviour in the Potamonide species, widely distributed in India. Burrow is a very important resource for the crabs; it often protects from aquatic predators and provides a safe refuge for moulting animals and incubating their eggs (Crane, 1975; Montaque, 1980; Zeil and Layne, 2002). Marine crab, *Scylla serrata* (Nandi and Dev Roy, 1991), *Ocypoda ceratopthalma* and *O. stimpsoni* (Baksi et al., 1980) from Hoogly and Malta Estuaries, Sundarban, West Bengal, India, have been studied for their distribution and behavioural ecology. The latter included studies on location, structure, pattern of burrows and burrowing activity. The size of the mangrove crab population depends on its habitat (Macintosh, 1984). In the ecological studies, the burrows of marine decapods have been well described (Lunz, 1937; Pearse et al., 1942; Phol, 1964). Comparable studies related to the nature of crab pellets found on Digha Beach, West Bengal, have been carried out (Chakarbarti, 1971). Quantitative comparison of burrows of brackish water crab, *Chasmagnathus granulata*, between habitats have been conducted (Iribarne et al., 1997).

There are two main types of burrows of crabs, viz., back- and side-burrows (Warner, 1977). In India, the nature of burrowing and grazing activities of different types of crabs on the sandy beach of Western Sundarban, Bengal Delta, has been successfully studied (Baksi et al., 1980). The study on burrowing activity and distribution of *Scylla serrata* from Hoogly and Malta estuaries, Sundarban, West Bengal, has been carried out (Nandi and Dev Roy, 1991). ShivaShankar (1994) studied the nest architecture, foraging and burrowing behaviour in *Heterometrus fulvipes*. In *Ocypodid* crabs, the direction of the burrow opening correlates with the handedness of the animal. The burrow opening spiral runs clockwise or counterclockwise depending upon the small size of the left or right chela (Linsenmair, 1967; Farrow, 1971).

The stability of burrows depends on predation level, social system, food availability and on their substratum properties. The said factors influence the degree of burrow fidelity that varies considerably both between and within the species (deRivera and Vehrencamp, 2001; Ens et al., 1993; Genoni, 1991; Hyatt and Salmon, 1978; Koga et al., 1998; Montaque, 1980; Salmon, 1984, 1987; Wolfrath, 1993). Bertness and Miller (1984), and Bertness (1985) have reported that the burrowing action of crabs have substantial effect on soil aeration and in growth, augmentation and distribution of flora. Murai et al. (1982) observed some behavioral characteristics related to food supply and soil texture of burrowing habitats on *Uca vocanas vocanas* and *Uca lacteal perplexa*. Literature on the ecological distribution of Ocypodid crabs indicates that the distribution, depth and zonation of burrows are closely related to the nature of substratum, food availability, humidity, temperature, desiccation and water stresses of the inter tidal environment (Ono, 1965; Jones, 1972; Lighter, 1974; Crane, 1975; Warner, 1977; Muari et al., 1982; Macintose, 1984).

Some of the decapod burrows were investigated *in-situ* by epoxy resin casting in various mangrove and back-reef environment at the Atlantic Barrier Reef, Belize (Dworschak and Ott, 1993). A model of burrow architecture and trophic modes in thalassinidean shrimp has been studied (Griffis and Suchanek, 1991). Holes or tunnels on the surface characterize the burrow openings of the shrimps, and the number of openings per burrow ranged from two to four. Dworschak (2001) investigated the burrows of thalassinidean shrimp by *in-situ* resin casting, in the Adriatic Sea. Also the number of openings per burrow ranged from 2-4 represented by simple holes or funnels on the surface. Bird et al. (2000) from Southern Australia studied the functional burrow wall morphology in *Biffarius arenousus* (Decapoda: Callianassidae). The shape and size of the burrow also depend on the nature of the animals. Several studies have demonstrated that in *Callianassa tyrrhena*, the U-shaped burrow have shaft making up burrows with numerous short tunnels in the form of lattice (Witbaard and Duineveld, 1989; Atkinson and Nash, 1990; Rowden and Jones, 1995; Nickel and Atkinson, 1995). Dworschak (2000) has described burrow morphology of thalassinidean decapod based on two resin casts made at a tidal flat at Dauphin Island. Felder and Staton (1990), described the relationship of burrow morphology and population structure in the ghost shrimp (Decapoda: Thalassinidea). The shape and dimensions of the burrows of the thalassinidean shrimp has been studied in detail (Dworschak and Rodrigues, 1997). The tunnels are either straight or curved and occur with or without branches. In the cross section, the shape of the tunnel is either circular or elliptical. Observation made during the sampling of burrow morphology suggests that the different shapes of opening might be related to sediment disturbance caused by storm waves and epifaunal organisms. Griffis and Suchanek (1991) studied the burrow morphology in *Upogebia noronbensis* and observed that the species makes Y-shaped burrow with two openings. They further observed that each burrow is occupied by a single organism.

According to Griffis and Suchanek (1991) in thalassinidean shrimp, *Upogebia pusilla* digging and turning of substrate for burrow construction have direct and indirect effects on bottom sediment. Due to these activities, the remobilization of sediment grains and nutrient cycling is promoted and it thus changes the physical and chemical features of local environment. Candisani et al. (2001) described the burrow morphology and mechanism of encounter and mating behaviour in *Upogebia noronbensis* using resin cast technique. With the help of this method, they obtained the opening of burrow as U-shaped and Y-shaped. The interpretation of the analysis was that the animal size strongly depends on the internal diameter of the burrow, and most of the burrow being as wide as animal carapace (Candisani et al., 2001). The length of the carapace shows a weak positive correlation with the distance between the openings. Nickell and Atkinson (1995) suggested that the burrows of *Upogebia noronhenis* have funnel shaped or Y-shaped opening, which is useful for filter feeding mechanism and have different texture in relation with the remaining parts. It has been reported in *Uca vomeris* that the wetness, smoothness and colour of the crab cuticle shows strong contrast with the mudflat background water (Zeil and Hofmann, 2001). Crab appears wet and shiny inside the burrow. They appear dull outside the burrow due to loss of water through evaporation. Thus the state of wetness affects the specular and polarization characteristics of crab. Therefore, the specular reflections indicate that crabs access the ground water; thus the burrows are resident but not a wandering place for the crab. Rudnick et al. (2005) documented that the timing of burrow activity in Mitten crab may be influenced by the size and number of burrows in an area. Also the crab burrows are more active in the spring and early summer.

Bliss et al. (1978) studied the behaviour and growth of terrestrial crab *Gecarcinus lateralis*. According to Hicks (1985) and Green (1997) during the dry season the activity of the red crab is very low followed by immediate breeding migration. Such changes in activity levels impose specific demands on the physiology and metabolism patterns of red crabs. Adamczewska and Morris (2001) studied the ecology and behaviour during the breeding migration in the terrestrial crab *Gecarcoidea natalis* through radio-tracking, mark and recapture, and counting methods. The fiddler crabs are small. Most of the species of fiddler crabs are diurnal; they spend most of their time in feeding, while the remaining time is divided between burrow maintenance, social interactions, growing and predator avoidance (Crane, 1975; Wolfrath, 1993).

(Sinha.S, 2010; 2013; 2014) The burrow architecture of *Barytelphusa cunicularis* was investigated *in situ*, from the undisturbed areas. A total of 22 burrows were randomly selected. The selected and tagged burrows were filled with thin slurry of cement and Plaster of Paris in the ratio 7:3. The mixture was poured into the mouth of the burrow openings and allowed to harden over a period of 4-5 days. Measurement of total length of burrow cast was carried out using measuring tape. The circumference of burrow casts was measured at every 20 cm starting from the opening of the burrow and its mean was calculated. Temperature at half and full depth of the burrow was also measured using a digital thermometer. Ten complete casts were selected for final measurements. Various patterns and shapes of burrows, like 'L', 'U', 'S', and 'Y' were observed. Nine out of 10 casts had single surface openings. The study of a Y-shaped cast revealed that although the burrow had two surface openings; both were connected to the same vertical structure (shaft) near the middle of the full depth of the burrow. It was revealed that each burrow was occupied by an individual crab. Statistically significant linear relationship between the area of the burrow openings and carapace length or carapace width of the crabs was observed. The depth of the burrow was observed to be proportional to the size of the burrow opening, i.e., greater the area of the burrow opening, higher is the depth of the burrow.

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