

LOCOMOTIVE BEHAVIOUR OF JUVENILE *CHICOREUS RAMOSUS* IN A FLUME FLOW

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ABSTRACT

Juveniles were very photo negative and moved in random directions only in darkness. In a flume flow without presence of prey, juveniles seemed to prefer an angle of 45° towards the current. A high proportion of juveniles (78 %; n = 49) climbed elevated points on the bottom irrespective of the presence of prey organisms above them. It is concluded that locomotive behaviour in relation to light, current and bottom structure stimulate juvenile *Chicoreus ramosus* to climb corals and hide among spines of the bivalve *Spondylus versicolor*.

INTRODUCTION

Juvenile *C. ramosus* are rarely found in nature. Their small size and hiding behaviour makes them difficult to spot. But, juveniles have been found hiding among the spines of *Spondylus versicolor* which lives attached to corals, *Dendrophyllia* sp. (Somneuk Patamakanthin pers. comm.). The fact that juveniles are found on exposed bivalves which they only can reach by climbing a coral seems contradictory to their hiding behaviour. An alternate hypothesis suggests that the veliger larvae settle directly on *Spondylus versicolor*, and stays there until their size makes hiding under the spines impossible.

The purpose of this work is to test these hypotheses experimentally. Juvenile behaviour is studied in relation to light, current and bottom structure.

MATERIALS AND METHODS

200 laboratory reared juvenile *Chicoreus ramosus* were kindly provided by Jintana Nugranad, Coastal Aquaculture Development Center, Prachuab Khiri Khan. They were less than 4 months old and only specimens with a shell shorter than 2 cm were used. Before and between experiments the juveniles were kept in a 60 l flow aquarium and fed bivalves (*Isognomon ehippium*) *ad libitum*.

The flume was an 8 m vertical recirculated flow tank with a canal width of 60 cm. Upstream was placed a double set of collimators made of 12 cm long plastic straws with a diameter of 5 mm. After the collimators water moved through a 5.2 m canal before entering the 1 m test section, which was covered by a transpar-

ent acrylic plate on which all experiments took place. Water left the canal through a vertical 6" pipe 1.3 m downstream the test section and was recirculated by a double set of propellers driven by a 1 HP electric motor. The construction of a similar but shorter flume is described by Muschenheim *et al.* (1986). Water in the flume was exchanged continuously, one volume per hr. Water temperature was between 27 and 30 °C.

To determine juvenile phototactic behaviour a fluorescent tube (Philips 18 W daylight) was placed across the flume perpendicular to the current either upstream or downstream the test section. This created a light gradient with a light intensity of 6 lux in the centre, 16 lux on the outer perimeter closest to the light source, and 3 lux on the outer perimeter away from the fluorescent tube (Fig. 1). Because of the glass window in the left side of the test section there was a weak light gradient perpendicular to the current (5 and 7.5 lux in the east and west side respectively).

In each test, one juvenile was transferred to the centre of the test section, and the direction of movement was recorded with a black and white, light sensitive video camera (Procec type 1030) placed above the test section. Recording was done on a Toshiba 711 video recorder.

Juvenile migration was later drawn on a transparent sheet covering the monitor. Direction of movement from the central starting point to a 7 and 14 cm circumference, was recorded in degrees. The direction upstream (north) was defined as 0 degrees (Fig. 1). The circumferences were later divided into 12 sections each 30°, and all data fitted into these 12 possible directions of migration.

To test the effect of current without interference of light the same procedure was used but the fluorescent lamps were replaced by a red light directed upwards toward the white ceiling. This created an indirect illumination of the test section with an intensity of less than 0.5 lux. When current was introduced, a free stream flow speed of 2 cm/s was used.

In the experiments with climbing behaviour, a 25 cm 1" PVC pipe was split in two and one piece placed in the test section with the inside of the tube facing down. 49 juveniles were transferred to the tank, one at a time, and placed on the acrylic plate with their whorls and siphonal canal touching the PVC tube. The fraction of snails climbing the tube was registered.

Later 2 glass cylinders (5 cm high) were placed in the tank and 5 juveniles at a time were placed at each cylinder foot. It was registered how many juveniles climbed the tube in absence and presence of 5-7 *Isognomon ehippium* bivalves on top of the tube.

At last 26 juveniles were individually placed in the flume, 30 cm down stream of a glass tube with prey on top. The ability to find this elevated prey was recorded.

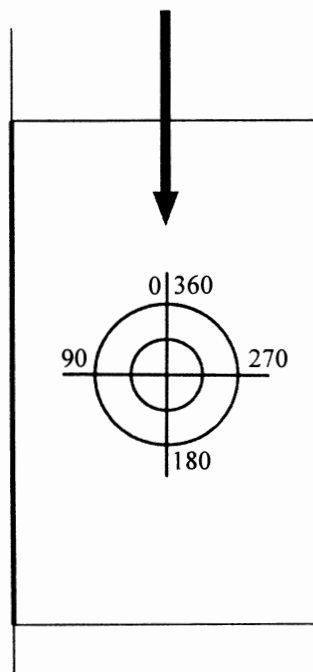


Figure 1. Diagram showing the test section, with the 2 circumferences viewed from above.

RESULTS

When a white light was placed at 0° without current, all juveniles without exception moved away from the light source (Fig. 2a). They did not move directly towards 180°. The inner and outer circle data were pooled, and showed that 34 snails moved to the “eastern” area (<180°) and only 7 to the “western” area (>180°).

When a 2 cm/s current was generated, the juveniles behaved in exactly the same manner and moved away from the light, following the current direction (Fig. 2b). They still moved in a direction “east” of 180°.

When the white light was moved downstream of the test section all snails moved upstream without exception (Fig. 2c) and again the majority of the snails moved “east” of the 0° direction. The snails turned their siphonal canal away from the light within seconds often without moving from the spot, and then began moving away from the light.

The red light had no effect on the direction of migration (Fig. 3). All snails moved in a random pattern away from the point of release.

When a current of 2 cm/sec was generated in the test section a non random pattern of migration was observed (χ^2 -test, $P < 0.01$). Only very few juveniles moved directly in the direction of the current, and it seemed like the snails preferred an angle of 45° against the current.

The acrylic plate covering the test section was placed loose in the test section depression, creating a few mm wide gap between the plate and the flume tank bottom or sides. When the juveniles reached this gap they would often stop, and if their shell could enter the gap, they would stay there.

The snails would often lift their shell high above the surface and point their inhalant siphon upwards. This prey detection mechanism will on a rough bottom be improved if the snails are able to climb elevated points and raise their inhalant siphon from there. To test if juveniles would climb elevated points half cut PVC tubes were placed in the flume and 38 out of 49 snails climbed the tubes (Table 1).

Typically they would move directly up on the highest point of the tube and move along it for a while, then move down and away. When vertical glass tubes with bivalves on top was placed in the flume 10 out of 40 snails climbed the tubes and were found on the bivalves (Table 1). If bivalves were absent on the tubes,

14 out of 40 snails would climb the tubes. This indicates that there it is a negative geotactic behaviour involved in the orientation of the snails.

When the snails were placed 30 cm downstream of tubes with prey in a 2 cm/s flow, only 2 out of 26 snails would find and climb the tubes.

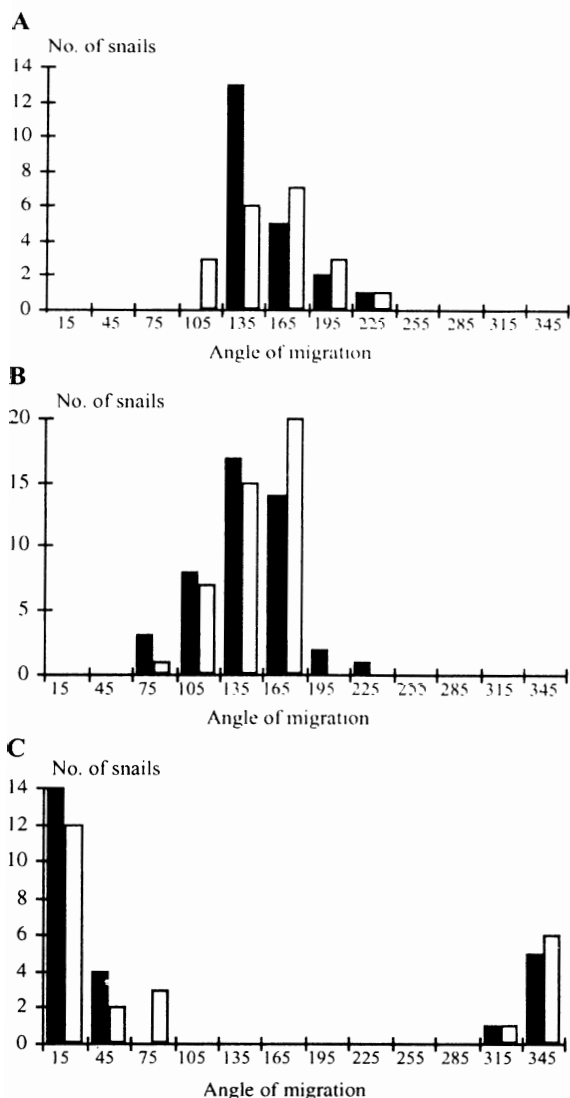


Figure 2. Direction of movement of juveniles with A: one white light placed directly upstream (0 degrees) in still water; B: one white light placed directly upstream (0 degrees) and a current speed of 2 cm/s; C: one white light placed directly downstream (180 degrees) and a current speed of 2 cm/s. Black bars illustrate inner circle and white bars the outer circle.

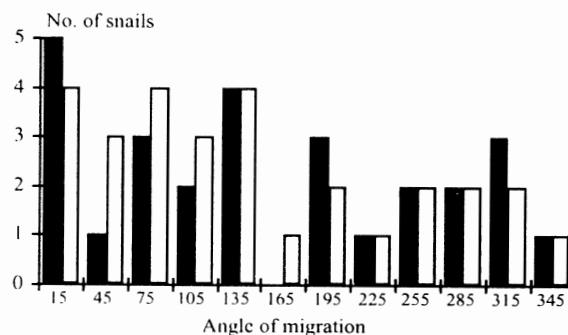


Figure 3. Direction of movement of juveniles in red light in still water. Black bars illustrate inner circle and white bars the outer circle.

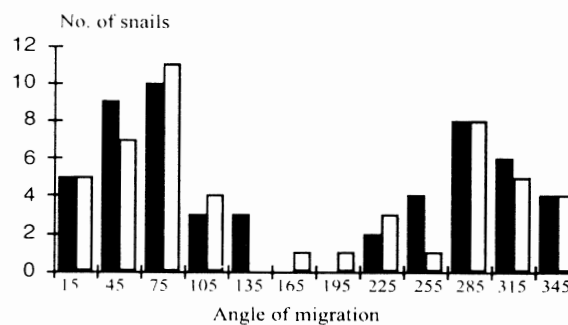


Figure 4. Direction of movement of juveniles in red light and a current speed of 2 cm/sec. Black bars illustrate inner circle and white bars the outer circle.

Table 1. Number of juveniles that climbed elevations with or without prey.

	Not	
	No. Climbed	climbed
	(%)	(%)
Horizont. placed split PVC-tube	49	22
Vertical glass tube without prey	40	65
Vertical glass tube with prey	40	75
Downstream of tube	26	92

DISCUSSION

Juveniles are very sensitive to light irrespective of current. They move directly away from the light source in the direction of the darkest area, even in quite dim light with only 16 lux in the highest illuminated area. This behaviour and the fact that they would hide in crevices, if possible, indicates an escape response. The migration north or south seemed to "drift" towards east. This may be because the glass window in this side of

the test section reflected less light than the opposite white painted wall. A difference of 2.5 lux was measured in the far east and west end of the test section. Many gastropods use chemical sense in detection of distant objects in the environment (Croll 1982). After metamorphosis *Chicoreus ramosus* is carnivorous, and depends on its olfactory organs in prey detection. Most marine bottom currents are of turbulent nature (Brown *et al.* 1991), and the smell from prey species will be dispersed while drifting downstream. This will result in an oblong area downstream of the prey where the prey organism is detectable. Since the width of this area is smaller than the length, a predator will maximize the encounter rate with odour released from prey, when moving perpendicular to the current. The indication of a preferred 45° angle to the current (compass mechanism) indicates a more complex mechanism. These snails are typically found in coastal areas, limited on one side by land and by muddy sediment on the other. Currents will often run parallel to the coast with high current speeds 4 times a day, 2 times in each direction. If the snails move perpendicular to the current they would search the same area back and forth from the coast to the deep water. By moving parallel to the current they would search the same area parallel to the coast. When moving in a 45° angle upstream they would search a larger area in a zigzag manner, and their dispersion would be reduced. Bech (1992) found a similar compass mechanism in adult *Chicoreus ramosus* in an enclosure in nature. The fact that juveniles often climbed elevated points (Table 1) corresponds well with the observed behav-

our of raising their inhalant siphonal canal. By climbing on top of an elevation they are able to raise their inhalant siphon further, and they would still raise their siphon as high as possible by stretching their foot. Prey did not have any positive effect on the climbing behaviour (Table 1). The juveniles were not very successful in finding and climbing the tubes when they were placed downstream of it. The fact that many juveniles would climb elevated points and find prey there, corresponds well with observations in nature where juvenile *Chicoreus ramosus* often are found on the shells of the exposed *Spondylus versicolor* (Somneuk Patamakanthin pers. comm.). Also *Acmaea dorsuosa* and *Nassarius obsoletus* have been reported to be negatively geotactic (Abe 1931; Dimon 1905 in Hyman 1967).

Newly settled juveniles are very difficult to spot in a gravel bottom, but in rearing tanks they move up on elevated points at night, a behaviour that has been used in harvesting snails (Steenfeldt & Bussarawit 1992). When keeping juveniles in captivity they often climb the sides of the culture tanks, which causes mortality due to dehydration when they climb above the water surface (Steenfeldt & Bussarawit 1992). The climbing of tank sides may be an artefact because of the limited space and lack of shelter in the tank, but the high number of snails that climbed the elevations in this experiment shows that there is negative geotactic behaviour involved. Juveniles will only climb elevations in darkness. Dredging and sampling by scuba-diving should therefore take place at night.

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