Associative behavior of the fish *Cryptocentrus cryptocentrus* (Gobiidae) and the pistol shrimp *Alpheus djiboutensis* (Alpheidae) in artificial burrows

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**Abstract**

Observations and experiments on the associative behavior of the fish *Cryptocentrus cryptocentrus* (Valenciennes) and the shrimp *Alpheus djiboutensis* De Man from the Red Sea were carried out in artificial burrows. A signal system, bringing about correlated behavior in fish and shrimp, consisted of antennal contact of the shrimp with the fish, tail undulations by the fish, and, finally, emergence of the shrimp. The shrimp emerged from the burrow only in the presence of the fish. A constant antennal contact was maintained by the partners while the shrimp was outside the burrow. Emerging from the burrow, the shrimp pushed the fish towards the entrance. Following visual stimulation, the shrimp always retreated back into the burrow with the fish. However, the further back the shrimp was located inside the burrow, the less intense was its retreat with the fish. In the absence of the fish, visual stimulation of the shrimp had no effect. Cleaning of fish by shrimp was observed within the burrow.

**Introduction**

Associations between alpheid shrimp and gobiid fish are known from the Pacific Ocean (BAYER and ROGEN, 1957), the Indian Ocean (SMITH, 1959), the Persian Gulf (PALMER, 1963), the Red Sea (LUTHER, 1958a, b; ABEI, 1960; KLAUSWITZ, 1960, 1964, 1969; MAGNUS, 1967) and the West Indies (BOHLE and CHAPLIN, 1968; RANDALL, 1968). Some information on behaviour in aquaria has been given by LUTHER (1958a, b). Field studies have been carried out by MAGNUS (1967).

It has generally been accepted that this association is a mutually beneficial partnership (MAGNUS, 1967). The fish uses the burrow excavated by the shrimp as a temporary shelter during the day, and as a permanent resting place at night. The shrimp, which is almost blind, depends on the fish as an alarm system against predators. No data about the behavior of the partners inside the burrow has been available.

**Material and methods**

The fish *Cryptocentrus cryptocentrus* and the shrimp *Alpheus djiboutensis* were collected in the Red Sea from the shallow sandy bottoms of Marsa-Murach (20 km south of Elat). They were kept for 9 months in aquaria at 22 °C, and fed on a mixed diet of living *Tubifex* and "Hydro" (dry food for tropical fish). Artificial burrows were constructed from plastic tubes (3.5 cm diameter, 55 cm long), cut in half along their axes. The cut surface faced the front glass of the aquarium. The tube was perforated (holes 6.5 mm) to allow water exchange and a slight leakage of sand. The entire tube, except one end, was covered with sand; a stone was placed near this open end (Fig. 1.) One fish (4 to 5 cm long) and two shrimps (3 to 4 cm long) were placed in the aquarium. After entering the tube, the shrimps immediately started removing sand and shell fragments from the tube. Shell fragments were placed above the opening, while sand was pushed ahead of it, forming a pile in front of the burrow similar to that observed in the field (Fig. 2). The associated fish, when outside the burrow, was usually found on the entrance-facing slope of the pile.

The shrimps inside the burrow were recorded for 12 observation periods, lasting 25 min each. Emergence of the shrimps from the burrow was recorded 100 times. Vertical lines were marked on the front glass at 5 cm intervals (Fig. 1) to define the positions of the animals in the burrow; the positions were recorded at 15 sec intervals. Sand and shell fragments were introduced into the burrow in order to instigate intensive digging and transport activity of the shrimps.

**Results**

**Activity of the shrimp Alpheus djiboutensis inside the burrow**

Most of the shrimps' activity occurred inside the burrow. This included digging, sand and shell transport...
Fig. 1. General view of artificial burrow with stone near entrance (left). Vertical lines: 5 cm intervals marked on the aquarium front glass

Fig. 2. Fish *Cryptocentrus cryptocentrus* and shrimp *Alpheus djiboutensis* in front of the burrow. Shrimp maintains contact with fish by means of left antenna

and other maintenance activities. Three different types of digging were noted. (1) Rapid movements of the pleopods, with the posterior end of the abdomen directed toward the burrow entrance; as soon as a pile of sand accumulated, the shrimp turned around and pushed the sand towards the opening. This kind of digging was performed only within the burrow. (2) Digging with the first pair of chelae, by inserting them into a vertical sand wall and twisting until the sand loosened. (3) Digging with the second pair of chelae and walking legs; this activity was superficial and was used to uncover food, both inside and outside the burrow.

The pushing of sand grains and small stones outside from the inner parts of the burrow was accomplished by the first pair of chelae. The two chelae were placed together in the form of a spade broadened by the chelae hair. Larger stones and shell fragments were grasped by the first pair of chelae and carried out of the burrow to the area above the entrance (Figs. 3, 6). When the burrow was artificially filled with sand and shell fragments, the shrimp removed first the shell fragments from the entire burrow, then, beginning near the entrance, pushed out the sand. During the entire period of intense digging and transportation, there was no cooperation between the two shrimps. The small "Hykro" particles were eaten where they fell, while the bigger *Tubifex* were dragged inside the burrow before being eaten. Water currents were directed towards the inner parts of the burrow by rapid movements of the pleopods while the abdomen was raised. This activity was performed mainly within the burrow near the entrance, although it was also observed in other areas of the burrow. Self-cleaning of the carapace, antennae, antennulae and pleopodae with the second pair of chelae occurred inside the burrow as well as in the entrance area. Moulting was