

Intrusion of Anchialine Species in the Marine Environment: The Appearance of an Endemic Hawaiian Shrimp, *Halocaridina rubra*, on the South Shore of O'ahu (Hawaiian Islands)¹

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ABSTRACT: A single specimen of the endemic anchialine shrimp *Halocaridina rubra* Holthuis was collected on the reef under a brick in a freshwater extrusion in the lower intertidal at Kawaiku'i Beach Park, Niu Valley, O'ahu, Hawai'i, on 25 December 1998. Repeated collecting efforts at low tides failed to produce more shrimp. The associated fauna includes an anadromous eleotrid fish, *Eleotris sandwicensis* (the 'o'opu 'akupa), isopods *Apanthura inornata* and *Talitroides* sp., alpheid shrimp (*Alpheus crassimanus*), an oligochaete, and gobioid fish (*Bathygobius fuscus*). Fresh water seeping out across the sand and visible in the area at low tides may have been the source of the specimen. This find may represent a rare occurrence of *H. rubra* in the reef flat habitat or the intrusion of anchialine species may occur with some frequency after heavy rains when the groundwater flow increases.

THE ENDEMIC RED SHRIMP *Halocaridina rubra* Holthuis ('ōpae 'ula) (Family Atyidae) is found in brackish-water anchialine pools on most of the high Hawaiian Islands, except Kaua'i, although it has not been seen on Moloka'i recently. On O'ahu it is known from wells at Kahuku, sinkholes at 'Ewa Beach, and a pool on Popoia Island off Kailua. Thus this species occurs in both the anchialine pool habitat and the water table beneath the pools. These shrimp have first and second pereopods with setiferous chelae that scrape algae and cyanobacteria from rocks and other substrates. They are not predaceous nor are the chelae utilized in defense. *Halocaridina rubra* appears to be successful in the anchialine habitat, where predators are

absent. In general, *H. rubra* and predaceous fish and crustaceans do not co-occur, except for the snapping shrimp, *Metabetaeus lohena*, which is rare in most pond systems. *Metabetaeus lohena* is not an effective predator capable of substantially reducing the numbers of *H. rubra* in most populations (Bailey-Brock and Brock 1993).

MATERIALS AND METHODS

The beach park at Kawaiku'i, near Niu Valley, is part of a typical East Honolulu fringing reef. It is heavily influenced by streams and urban runoff from the coast highway and nearby ridge and valley residential areas. The largest brackish-water habitat on the eastern part of the island is at Hawai'i Kai, which historically was an extensive system of fishponds. It is located 3 km east of the study area. A smaller system at Wailupe, about 1 km west of the study area (Abbott 1946), was filled in for development in 1950. The beaches receive groundwater runoff visible as small seeps and trickling sources along the beach and in the upper intertidal at low tides. Salinities mea-

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sured during a previous study fronting the beach park were 15–26‰ at low tides (Bailey-Brock 1984). East Honolulu had received heavy showers on the night of 24 December 1998. A refractometer and AGE salinometer were used to measure salinity of effluxing groundwater at the site.

The study site is just east of the beach park boundary in front of a private home. The area was visited on 25, 27, and 29 December 1998 and on 1, 2, 3, 5, 6, 7, and 13 January 1999. Collection methods included turning over rocks in a sand-gravel substrate to check for shrimp and passing a hand net through the water in depressions created by removal of these rocks. On one occasion nets and sieve traps were set up in groundwater trickles and left until the tide started to rise. Fish specimens were measured from head to the tip of the caudal fin (total length [TL]). Gut contents of two species of fish were examined. The digestive system was removed by making a shallow incision from vent to pectoral girdle after first removing the fused pelvic fins. Gut contents were retrieved from three regions of the digestive tract and examined microscopically for anchialine shrimp remains.

RESULTS

Carbonate and basalt rocks and concrete bricks were turned over at low tide (0.2 ft [6 cm]). A specimen of *H. rubra* was found on the underside of a flat brick in the path of a freshwater trickle on 25 December 1998 at 1500 hours. The edges of the brick were embedded in sand, and water could be seen percolating up through the sand grains where the brick had lain. The sand was relatively free of fine silt and is a mixture of mostly carbonate fragments and fewer basalt grains. Salinity at the collection site was 1.1034‰, and the shrimp has since been maintained in water of this salinity.

The single specimen of *H. rubra* collected on Christmas Day was the only one found despite repeated attempts at subsequent low tides to find more. This specimen is approximately 1 cm long and a pale cream color.

While in captivity, it has been fed and has molted once. Other invertebrates collected in the same general area and the salinity at each location include three specimens of the alpheid *Alpheus crassimanus* (3‰); anthurid isopods *Apanthura inornata* (12‰); gammarid amphipods *Talitroides* sp.; and a yet unidentified species of oligochaete (3.6135‰). Neritid gastropods (*Nerita polita*, *N. picea*), xanthid and grapsid crabs, and crab megalopa were present under many of the larger rocks. Gobies (*Bathygobius fuscus*) were abundant on every collecting trip, and on one occasion (5 January 1999) numerous small eleotrids, *Eleotris sandwicensis*, were seen on the mudflat and under rocks. Fish collected include *E. sandwicensis* (one specimen, TL 1.7 cm) and four *B. fuscus*. The digestive system of the eleotrid contained some unicellular green algae and debris. The gobies (TL 2.7, 4.5, 6.2, and 9.6 cm) had filamentous green algae, mosquito larvae, fish bones, scales and a lens, isopods, and crab and shrimp remains (thorax, carapace, uropods, telson, appendages, and compound eyes) in the digestive system. Crustacean remains were not those of *H. rubra*.

DISCUSSION

This is the first record of *H. rubra* from southeastern O'ahu and a reef flat habitat. It seems likely that *H. rubra* exists in the water table in the East Honolulu region and may be flushed out onto the reef flats as groundwater levels fluctuate or as the shrimp move around in the subterranean portion of their environment. Both the lighted-pool portion of the habitat where most food resources are present and the dark crevicolous portion in the water table below where reproduction apparently takes place have been discussed previously (Maciolek 1983, Bailey-Brock and Brock 1993). On the fringing reef *H. rubra* is probably eaten by predators as it emerges from the substrate, or soon afterward, unless it finds refuge under a rock. It is probably less abundant in the East Honolulu water table than along coastlines where anchialine pools (i.e., plentiful food resources) are pres-

ent. The cream color of this southeastern O'ahu shrimp is like that of an 'Ewa population, which also lacks the red coloration typical of the species. Shrimp of other O'ahu populations are red.

Numerous eleotrid fish ('o'opu 'akupa) were on the shallow muddy sand; all were approximately the same size (TL 1.7 cm). They may have just recently settled out from the plankton and were not yet feeding when collected. The young of this predaceous species develop on the reefs, aggregate at estuaries and freshwater sources, then migrate upstream and become adults in the lower reaches of streams (Kinzie 1990). They have been recorded from coastal fishponds ("sleepers" in Hiatt 1947) and occur in the anchialine pools of Kona, Hawai'i (Maciolek and Brock 1974), and Maui (Maciolek 1986), where they are predators of anchialine shrimp. The eleotrids were not seen on subsequent collecting trips.

CONCLUSIONS

Groundwater seepage along this portion of O'ahu's shoreline provides a brackish environment similar to that of other anchialine habitats in the Hawaiian Islands. The fauna found (eleotrid fish, oligochaetes, isopods, and the atyid shrimp *Halocaridina rubra*) is a typical anchialine fauna found in anchialine pools. The lack of predator-free pools or other refuges along the beach where the shrimp usually lives allows crabs, alpheid shrimp, and fish to prey on the shrimp as soon as it is flushed onto the reef via groundwater. These anchialine species are usually found in predator-free environments and are unable to survive in the presence of predators, so their occurrence on reefs must be ephemeral. The effect of rainfall events increasing local groundwater discharge and permeability of the shoreline must play a role in the occasional appearance of these anchialine species in the marine environment.

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