NOTES

A NEWLY INTRODUCED, BRACKISH-WATER SNAIL IN THE SALTON SEA BASIN, CALIFORNIA

On 6 March 1976, many snails were observed by an aquatic biology class from Pomona College in Whitefield Creek, a brackish-water creek located in the headquarters area of the Salton Sea State Recreation Area, Riverside County, at an elevation of 68.6 m (225 ft) below sea level. Further observations were made on 29 June and 20 July, 1976. Collected specimens were identified by Dwight W. Taylor, University of the Pacific, as *Thiara (Tarebia) granifera mauiensis* (Lea), a member of the Thiaridae (Prosobranchia: Mesogastropoda) and a native of Hawaii and other Polynesian islands. The first North American record for *T. granifera* was from Lithia Spring, Hillsborough County, Florida; the snail is believed to have been introduced from Hawaii about 1940 (Edmondson 1959). Records for *T. granifera* in western North America are summarized by Taylor (1975), but he lists none from California. D. W. Taylor (pers. commun.) has noted one previous, unpublished, record of *T. granifera mauiensis* in California. Taylor identified specimens collected by J. A. St. Amant, Calif. Dept. of Fish and Game, on 24 December 1969 from near the mouth of the Avenue 82 drainage ditch into the Salton Sea. This location is on the western side of the Salton Sea, 5 km (3 miles) north of Desert Shores, Riverside County, and about 35 km (22 miles) distant along the shoreline from the Whitefield Creek site. A drawing of this snail is provided by Edmondson (1959: Fig. 43.62b, p. 1138).

Whitefield Creek is a short, permanent, spring-fed stream of moderate salinity (3.5 to 4.0 $^0/_{00}$ in March 1976, 4.5 to 5.0 $^0/_{00}$ in June). Diverted towards the State Park boathouse in Varner Harbor in an attempt to prevent barnacle settlement on the patrol boats, Whitefield Creek now runs in a dredged channel throughout its entire length. This channel is about a meter wide, gradually deepening from 50 to 150 cm (20 to 60 inches) as it approaches Varner Harbor, to which it is connected by a culvert. Whitefield Creek flows through a region of typical alkali-sink scrub vegetation. Flowering plants within the stream itself are limited to cattails *(Typha domingensis)*, with occasional clumps of salt-grass *(Distichlis spicata stricta)* and rushes (*Juncus* sp) at the margins. Filamentous green and benthic blue-green algae are abundant. Besides the snails, the only obvious animals present are fish: native pupfish *(Cyprinodon macularius)*, introduced mosquitofish *(Gambusia affinis)*, introduced mollies (*Poecilia* sp), and the recently introduced tilapia, believed by State Park personnel to be *Tilapia zillii*. One muskrat *(Ondatra zibethica)* was seen on 29 June.

In the middle, flowing portion of Whitefield Creek, where the water is about 5 to 10 cm (2 to 4 inches) deep, *Thiara granifera* is common to abundant. The snails themselves are obvious and their tracks in the grey silt on the stream bottom are particularly conspicuous. Densities were not measured, but are estimated at up to 50 m^2. Very tiny specimens were present in March, June, and July, suggesting successful reproduction during at least this portion of the year; this species is ovoviviparous. About 100 m (330 ft) upstream from Varner Harbor, the stream passes under a State Park access road through a culvert with a 20 to 25 cm (8 to 10 inch) waterfall at the downstream end. While snails were abundant just below this waterfall, none was located at any point upstream from the culvert, despite apparently identical conditions of the water (salinity, temperature, clarity, velocity, depth), vegetation, and fish. This small waterfall seems to be a barrier to upstream migration of the snails.

Close to Varner Harbor, the channelized creek bottom is below the level of the rising Salton Sea, to which it is connected by the culvert at Varner Harbor. Measurements in this lower portion of the stream channel indicate marked salinity stratification. In March, with the stream contained entirely within its banks, bottom water of 11 ‰ was overlain by a layer of surface water of only 4 ‰. No snails were observed in this portion of Whitefield Creek in March. In June and July, with the level of the Salton Sea at its highest since 1915 (69.7 m, or 228.6 ft, below sea level) (Anon. 1976), this lower portion of Whitefield Creek had overflowed its banks, creating a series of shallow pools adjacent to the main channel. Salinities of surface waters in the stream and in these shallow pools were relatively low (5.0 to 6.5 ‰) all the way to the Varner Harbor culvert. In these pools, temperatures reached 37 C (99 F) when the main stream was 32 C (90 F) (air temperature in excess of 38 C, or 100 F). Deeper water in the main stream channel as close as 15 to 20 cm (6 to 8 inches) to the surface was much more saline (12 to 14 ‰), as well as cooler, than the surface water. Snails were abundant in the recently created shallow pools with lower salinities, though absent from the deeper, more saline portions of the main stream channel. The highest salinity in which snails were observed was about 10 ‰. These observations on the differential distribution of the snails in this stratified portion of the stream suggest that *T. granifera*, while euryhaline, either is tolerant of only modest increases in salinity, or is limited by the chemical composition of Salton Sea water present in the lower portion of the Whitefield Creek channel. This salinity barrier is about 12 ‰, about one-third the present salinity of the Salton Sea (37.5 ‰ on 29 June, just offshore from the State Park).

Apparently *T. granifera mauiensis* has only recently been introduced into Whitefield Creek. This snail and its tracks are conspicuous and, at present densities, would be difficult to overlook. No snails were collected or observed in Whitefield Creek in previous years during visits by aquatic biology classes from Pomona College, the most recent of which was 22–24 March 1974. State Park personnel first noted this snail in Whitefield Creek in December 1974.

T. granifera and other species of the Thiaridae are common in the aquarium trade. In view of the numerous recent introductions of tropical fish and invertebrates in streams, canals, and drainage ditches in the Salton Sea basin (St. Amant and Sharp 1971, St. Amant and Day 1972, Mearns 1975), it seems likely that *T. granifera* was also introduced into Whitefield Creek by aquarists or escapements from nearby tropical fish farms. However, its restricted distribution in Whitefield Creek, limited at the upstream end by the small waterfall and at the downstream end by higher salinity water from the Salton Sea, suggests that *T. granifera* must have been directly introduced into this stream. It is unlikely that the population in Whitefield Creek could have been derived from migration in from some nearby habitat, since there are no connections between this stream and any other watercourse other than through the Salton Sea itself.

Observations in the field and laboratory indicate that *T. granifera* feeds on microscopic algae, other micro-organisms, and small particles of organic matter. These snails are used by tropical fish aquarists to keep down algal growth and to prevent accumulation of organic debris in aquaria. While further study will be necessary to understand the ecological role of this newly introduced snail in Whitefield Creek, it is possible that there may be competitive interactions with the native pupfish, which also feeds on benthic algae and organic detritus (Naiman 1976). However, pupfish were more obvious in Whitefield Creek in 1976 than in previous years, before the introductions of either the tilapia or the snail.

ACKNOWLEDGEMENTS

I thank Dwight W. Taylor, Pacific Marine Station, University of the Pacific, for his identification of this snail. Craig A. Engel, Area Manager, and Richard C. Johnson of the Salton Sea State Recreation Area, were most helpful in discussions of the origins and distributions of organisms in Whitefield Creek. The 1976 Aquatic Biology class of Pomona College provided enthusiastic students for field work. Specimens of *Thiara granifera mauiensis* from Whitefield Creek are in the collections of Dr. Taylor and of the Zoology Department of Pomona College.

REFERENCES

Anon. 1976. *Los Angeles Times,* Section I, page 2. 13 June 1976

Edmondson, W. T., ed. 1959. Fresh-water biology. Second Edition. John Wiley, New York. 1248 pp.

Mearns, A. J. 1975. *Poeciliopsis gracilis* (Heckel), a newly introduced poeciliid fish in California. Calif. Fish and Game, 61(4): 251–253.

Naiman, R. J. 1976. Primary production, standing stock, and export of organic matter in a Mohave Desert thermal stream. Limnol. Oceanogr., 21: 60–73.

St. Amant, J. A., and J. S. Day. 1972. Range extension of *Palaemonetes paludosus* (Gibbes) in California. Calif. Fish and Game, 58(2): 154–155.

St. Amant, J. A., and I. Sharp. 1971. Addition of *Xiphophorus variatus* (Meek), to the California fish fauna. Calif. Fish and Game, 57(2): 128–129.

Taylor, D. W. 1975. Index and bibliography of late Cenozoic freshwater Mollusca of western North America. Claude W. Hibbard Memorial Volume I. Museum of Paleontology, University of Michigan, Ann Arbor, Michigan. 384 pp.

—*Larry C. Oglesby, Department of Zoology, Pomona College, Claremont, California 91711.* Accepted July 1976.

ABNORMAL VERTEBRAL DEVELOPMENT IN NORTHERN ANCHOVY, *ENGRAULIS MORDAX* GIRARD

On July 12, 1975, I collected eight abnormal northern anchovies, *Engraulis mordax* Girard, from the forebay of the Southern California Edison Steam-Electric Generating Station at Huntington Beach, Orange County, California. These fish exhibited various types of abnormal vertebral development, including lordosis (dorso-ventral curvature) and scoliosis (lateral spinal curvature). Such abnormalities have been described in many natural fish populations (Dawson 1964, 1966, 1971), and can be induced experimentally by a variety of stimuli including temperature, salinity, and dissolved oxygen variations; ionizing radiation; dietary deficiencies; and physical and mechanical irritations (Hickey 1972).