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## Caribbean Marine Occurrence in Mangroves of a Typically Fresh-water Synbranchiform Fish

JAMES C. TYLER AND ILKA C. FELLER

**The capture of the swamp eel *Ophisternon aenigmaticum* in the hypersaline waters of a mangrove island 15 km off the coast of Belize, Central America, is the first marine record for any of the New World species of Synbranchiformes, with dispersal from the mainland through sea water sometime in the past 7,000 years the likely explanation for its island occurrence.**

Synbranchiform swamp eels typically are found in tropical and subtropical fresh-water. Some individuals of a few of the eleven Asian and African species of synbranchiforms occasionally enter brackish estuarine water, and one species, *Macrotrema caligans* (Cantor) from the Malay Peninsula, routinely is found in coastal marine waters as well as freshwater (Cantor, 1849; Weber and de Beaufort, 1916; Smith, 1945; see Rosen and Greenwood, 1976, for the only comprehensive systematic treatment of the Order). In the New World there are no reports of any of the four described species of synbranchiforms in even brackish water (literature search and pers. comm., April 1994, from S. Favorito-Amorin, who is revising the systematics of the Order on a world-wide basis, and J. Graham, based on his collecting experiences relative to his work on the respiratory physiology of Central American species).

As part of a long-term investigation of the effects of nutrient enrichment on the growth of *Rhizophora mangle* (L.) (red mangrove) at Twin Cays, Belize (near the Smithsonian Institution marine station at Carrie Bow Cay and about 15 km east of the nearest place, Sittee Point, on the mainland of Belize, Figure 1), cores of peat of 7 cm diameter and 30 cm length are removed temporarily from the substrate near the bases of individual dwarf red mangrove trees (Figure 2) in order to apply nutrients to their root systems (Feller, 1995; see Ruetzler and Macintyre, 1982, and Ruetzler and Feller, 1987, for habitats and geology of these sites). On one such occasion (13 March 1994), an eel-like fish wiggled out of a core. It proved to be a 127 mm total length specimen (US National Museum 329295) of *Ophisternon aenigmaticum* Rosen and Greenwood (Figure 3), a relatively common species known only from the freshwaters of Central America (Mexico to Guatemala), northeastern South America, and Cuba.

Rosen and Greenwood (1976) believed that the Central American, South American, and

Cuban populations of *O. aenigmaticum* eventually might be found to represent distinct species, but they had insufficient specimens from Cuba and South America to investigate this possibility. S. Favorito-Amorin (pers. comm., April 1994) is describing several new species of synbranchids, including some in what can be considered the *Ophisternon aenigmaticum* complex from Central and South America, and she believes there are other such species complexes in these regions. Therefore, our identification of the Twin Cays specimen as *O. aenigmaticum* is *sensu* Rosen and Greenwood. We note that the Twin Cays specimen has  $67 + 48 = 115$  vertebrae, whereas the 41 specimens reported by Rosen and Greenwood (1976:10, table 2) have between 70–82 abdominal vertebrae (total numbers of 100–138); however, the morphometric data for the Twin Cays specimens are entirely comparable to that for *O. aenigmaticum* given by Rosen and Greenwood (1976:54, table 3).

The original description of *O. aenigmaticum* was based on 59 lots, all from either the American Museum of Natural History or the University of Michigan Museum of Zoology, but with only abbreviated locality data given. We have examined the full locality data from the catalogue entries for all of these AMNH and UMMZ specimens, and others that have been added to those collections subsequent to the Rosen and Greenwood paper, in order to establish whether any of them might indicate brackish versus fresh-water occurrence. On the basis of the distance inland (nearly always more than 20 km) or the elevation of these localities, or of stated ecological parameters, the great majority of them are clearly fresh-water habitats. There is no mention in any of the catalogue data of other than fresh-water conditions, even for those few locations relatively close to marine coastal areas, which one would expect if any of the habitats being sampled by these fresh-water oriented collectors (mostly C. L. Hubbs, R. R. Miller, R. M. Bailey, and D. E.

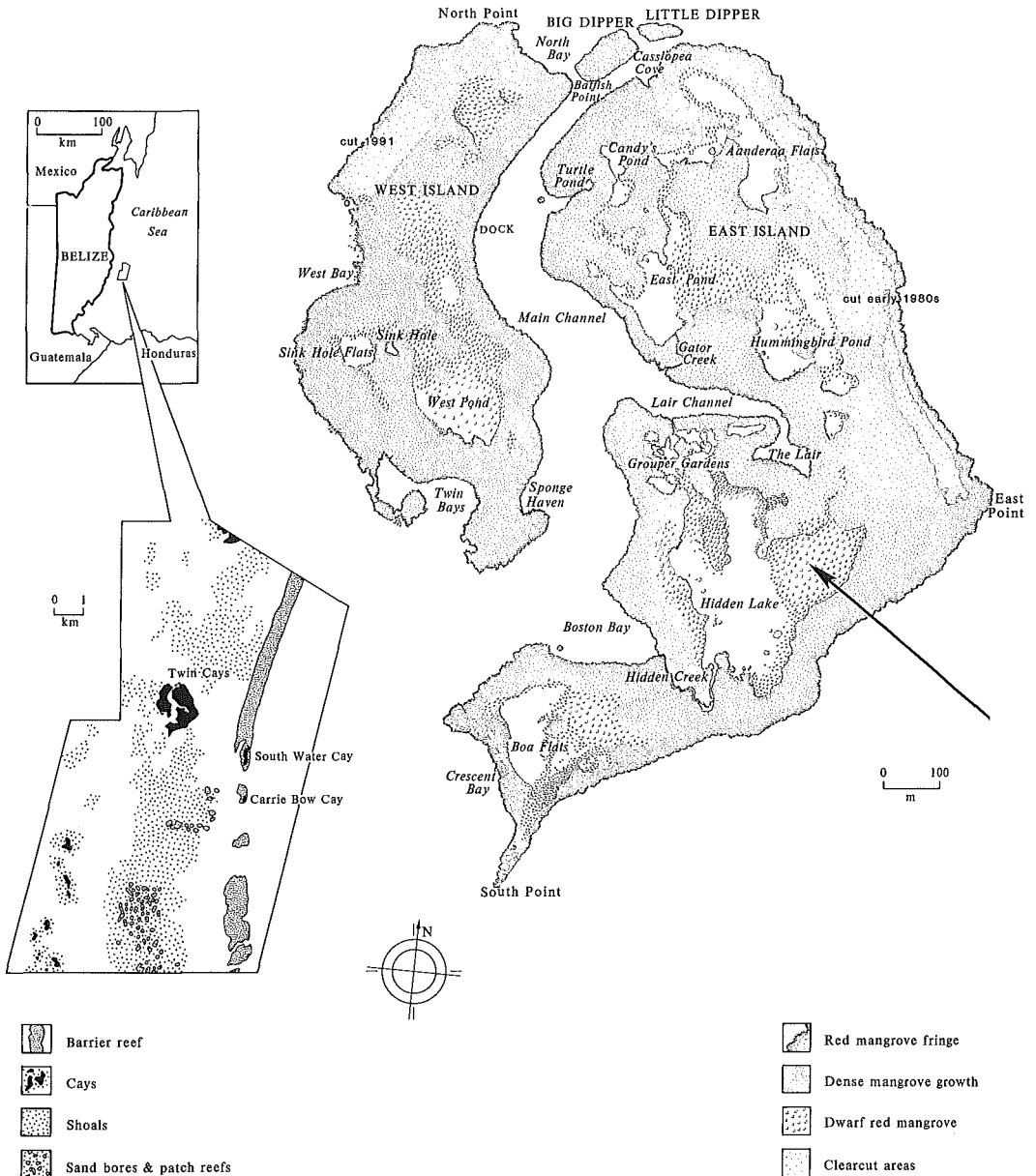


Fig. 1. Location chart for Twin Cays, Belize, the primary mangrove study site for the Smithsonian Institution's Caribbean Coral Reef Ecosystems marine field station at the nearby Carrie Bow Cay. Arrow points into the stand of dwarf red mangroves where the swamp eel was collected.

Rosen) were even brackish. Therefore, we believe that all of these previously reported specimens were collected in freshwater.

The site at Twin Cays in which *O. aenigmaticum* was taken is in a permanently-flooded, shallow marine pond in the interior of the island and is vegetated with dwarf *R. mangle* trees. Water depth at mid-flood tide at the place of capture of the fish is approximately 20

cm. The following data are based on semiannual monitoring of the environmental parameters at this site from 1989 through 1993 (Feller, 1995). Salinity measurements indicate that the pore water in the peat is consistently hypersaline. Mean ( $\pm 1$  SE) pore-water salinity at 15 cm depth is 39.1 ppt ( $\pm 0.4$ ), with a range over a two year period of 38–54 ppt within a 20 m radius of the place of capture. Although



Fig. 2. Photograph of the stand of dwarf red mangroves at Twin Cays where the swamp eel was collected.

salinity of the surface water can vary dramatically following a heavy rain (to essentially fresh in the uppermost few cm) or during low tide in the early afternoon on sunny days (to 42.9 ppt  $\pm$  0.5), pore-water salinity in the peat varies only slightly at the permanently flooded site where the swamp eel was collected. There is no fresh-water lens underlying Twin Cays. Additional hydro-edaphic measurements at this site (redox potential, sulfide concentration, and pH), taken in July 1990, show that the submerged soil is anoxic, with elevated sulfide concentrations. Mean redox potential at 15 cm depth was  $-144.0$  mV ( $\pm 11.1$ ), and sulfide concentration was  $0.792$  mM ( $\pm 0.162$ ). In unvegetated areas even a few m away from the

root zones of the trees, the soil was more strongly reduced, with a mean redox potential of  $-158.3$  mV ( $\pm 29.6$ ) and increased sulfide concentrations ( $2.905$  mM  $\pm$  0.920). Pore-water pH was essentially uniform throughout this ponded area at  $6.6$  ( $\pm 0.0$ ).

The distributions of synbranchiforms in general and of the genus *Ophisternon* in particular are of special interest because they were the impetus for the pioneering vicariance model of Caribbean biogeography proposed by Rosen (1975). The disjunct Cuban, Central American, and northeastern South American populations or races of *O. aenigmaticum* formed part of a vicariant distribution pattern. The occurrence of *O. aenigmaticum* in the salt water of Twin Cays

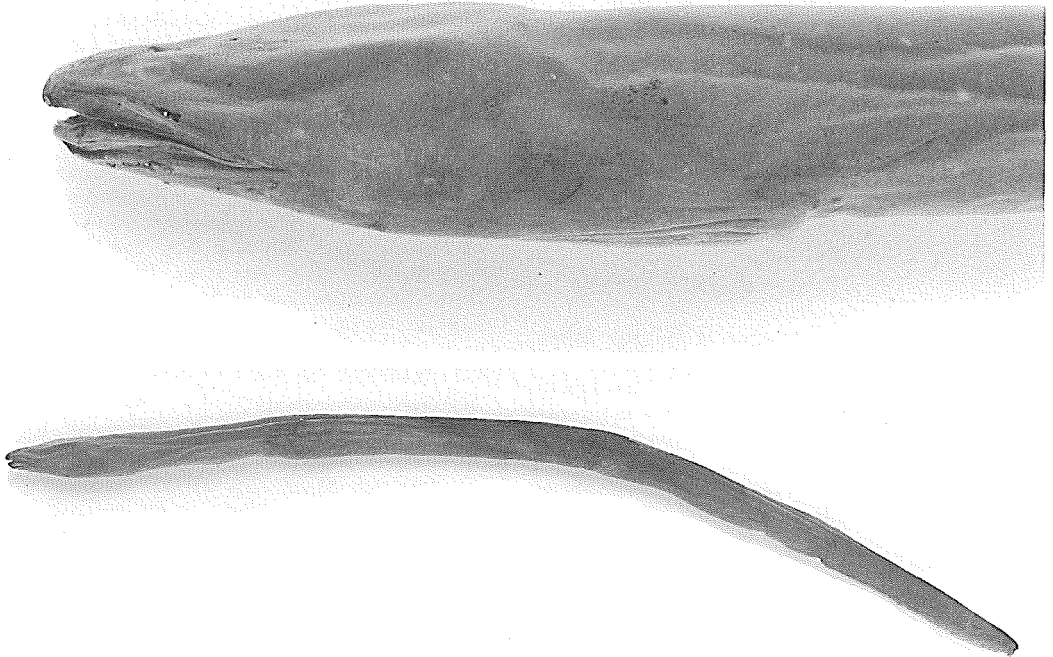


Fig. 3. Photograph of the entire specimen and detail of the head of *Ophisternon aenigmaticum*, USNM 329295, 127 mm total length, Twin Cays, Belize.

may be explained by relatively recent dispersal through the sea from the mainland.

Twin Cays is one of the numerous intertidal mangrove islands that dot the shallower parts of the Belize platform from about 10 km offshore out to the Barrier Reef. Twin Cays has an area of 92 ha and a shoreline of 9.2 km. Like most other Caribbean mangrove islands, it is dominated by *R. mangle*, *Avicennia germinans* (L.) (black mangrove), and *Laguncularia racemosa* (L.) (white mangrove). Twin Cays originated about 7,000 years ago on a topographic high formed by a Pleistocene fossil reef, and the mangrove growth has kept pace with the rising post-Pleistocene sea level (Ruetzler and Feller, 1987:18). Sequences of Holocene mangrove-peat and *Halimeda*-sand facies indicate that Twin Cays has gone through various stages of development and that it has always been broadly surrounded by marine waters, although portions of the deep lagoon (to 20 m) between Twin Cays and the mainland may have been only brackish at various periods during the past 7,000 years when rainfall was heavy and inflow of marine waters over the outer barrier reef was reduced (Ruetzler and Macintyre, 1982, and I. Macintyre, pers. comm., April 1994).

Because Twin Cays is of relatively recent origin and only 14 km off the coast of Belize, but always had been separated from it by broad stretches of sea water or some combination of brackish and fully marine water, it is reasonable to believe that *O. aenigmaticum* arrived there by dispersal through sea water, either by larval transport on currents, active swimming by adults across the lagoon to the innermost of the mangrove islands on the platform, or rafting in flotsam from the coast.

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