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Mangrove Swamp Communities

by Klaus Rützler, and Candy Feller

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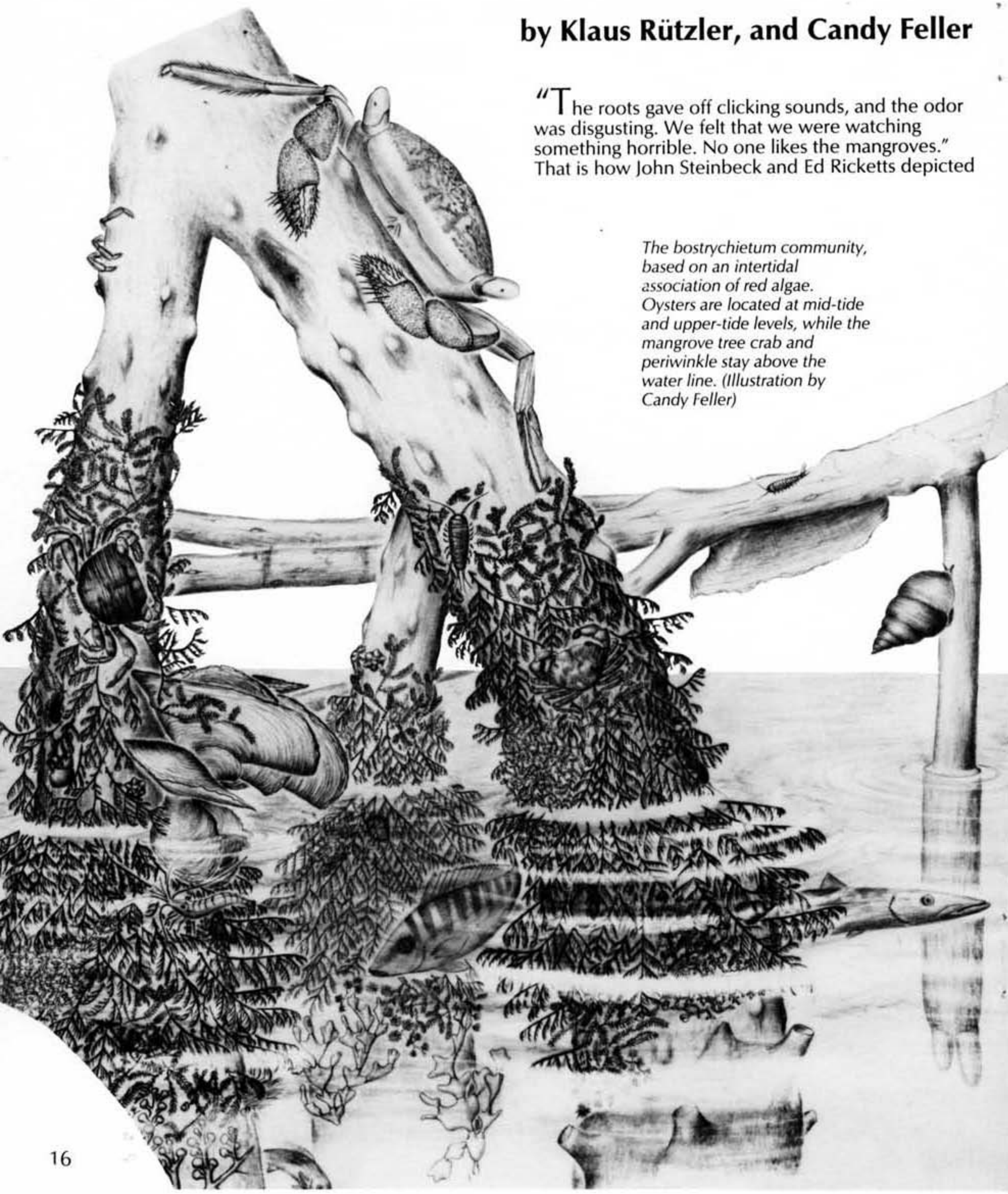
"The roots gave off clicking sounds, and the odor was disgusting. We felt that we were watching something horrible. No one likes the mangroves." That is how John Steinbeck and Ed Ricketts depicted



The bostrychietum community, based on an intertidal association of red algae. Oysters are located at mid-tide and upper-tide levels, while the mangrove tree crab and periwinkle stay above the water line. (Illustration by Candy Feller)

Communities

the mangroves in 1941 in the *Sea of Cortez*. Many people agree with them. So why have two dozen scientists from the Smithsonian Institution, primarily from the National Museum of Natural History, and twice as many colleagues from American and European universities and museums devoted a decade of exploration to one square kilometer of "black mud, . . . flies and insects in great numbers . . ., impenetrable . . . mangrove roots . . .," and ". . . stalking, quiet murder"?

The study started in the early 1980s, and focuses on an intertidal mangrove island known as Twin Cays, just inside the Tobacco Reef section of the barrier reef of Belize, a tiny Central American nation on the Caribbean coast (see article page 76). The principal purpose of this research is to document the biology, geology, ecological balance, economic importance, and aesthetic value of a prominent coastal ecosystem using the example of a diverse and undisturbed swamp community.

Properties of Mangrove Swamps

Mangrove swamp communities dominate the world's tropical and subtropical coasts, paralleling the geographical distribution of coral reefs. Mangroves on the Atlantic side of the American coasts occur between Bermuda and almost to the mouth of the Rio de la Plata (Argentina), and throughout the West Indies. Like reefs, mangrove swamps are environments formed by organisms, but unlike most coral communities, they thrive in the intertidal zone and endure a wide range of salinities.

"Mangrove" refers to an assemblage of plants from five families with common ecological, morphological, and physiological characteristics that allow them to live in tidal swamps. Worldwide, at least 34 species in nine genera are considered to be true mangroves. P. B. Tomlinson's recent book, *Botany of Mangroves*, defines this group of plants by five features: 1) they are ecologically restricted to tidal swamps, 2) the major element of the community frequently forms pure stands, 3) the plants are morphologically adapted with aerial roots and viviparity (producing new plants instead of seeds), 4) they are physiologically adapted for salt exclusion or salt excretion, and 5) they are taxonomically isolated from terrestrial relatives, at least at the generic level. "Mangrove swamp" or "mangal" refers to communities characterized by mangrove plants.

Mangrove trees are used for water-resistant timber, charcoal, dyes, and medicines. They resist coastal erosion during storms and possibly promote land-building processes by trapping sediment and producing peat. The protective subtidal root system of the red mangrove serves as nursery ground for many commercially valuable species of fishes, shrimps, lobsters, crabs, mussels, and oysters. An assorted fauna of birds, reptiles, and mammals is also at home in the mangrove thickets and tidal channels.

Human disturbances have made a heavy impact on many mangroves near populated areas as a result of dredging and filling, overcutting, insect control, and garbage and sewage dumping. The intertidal environment of mangroves is endangered by pollutants in the water, air, and soil. Accidental oil spills appear to be particularly damaging. Oil and tars not only smother algae and invertebrates, but also disrupt the oxygen supply to the root system of the mangrove trees by coating the respiratory pores of the intertidal prop and air roots.

A Mangrove Laboratory in Belize

Belize (formerly British Honduras), boasts the longest barrier reef of the Northern Hemisphere, extending 220 kilometers from the Mexican border in the north to the Gulf of Honduras in the south. Behind this barrier lies an enormous lagoon system averaging 25 kilometers between the mainland and open ocean. Mangroves border most of the coastline, extend upstream from countless river mouths, and fringe or cover most lagoon cays.

One of these is Twin Cays (Figure 1)—an island divided into two by an S-shaped channel. Twin Cays has become our study site and experimental field laboratory. Although we usually spend the nights and conduct laboratory bench work on nearby Carrie Bow Cay—site of the National Museum's coral reef field station for the last 15 years—most days and many nights are spent in the mangrove channels, lakes, ponds, mud flats, and even the trees. A self-contained weather station established on one of the mud flats transmits data on wind, sun, rain, temperatures, and tides to a portable computer on Carrie Bow Cay.

The bibliographies on mangroves show that during the last 200 years more than 6,000 papers have been published describing biological and geological details from almost as many different swamps over the world. Our ongoing study aims to

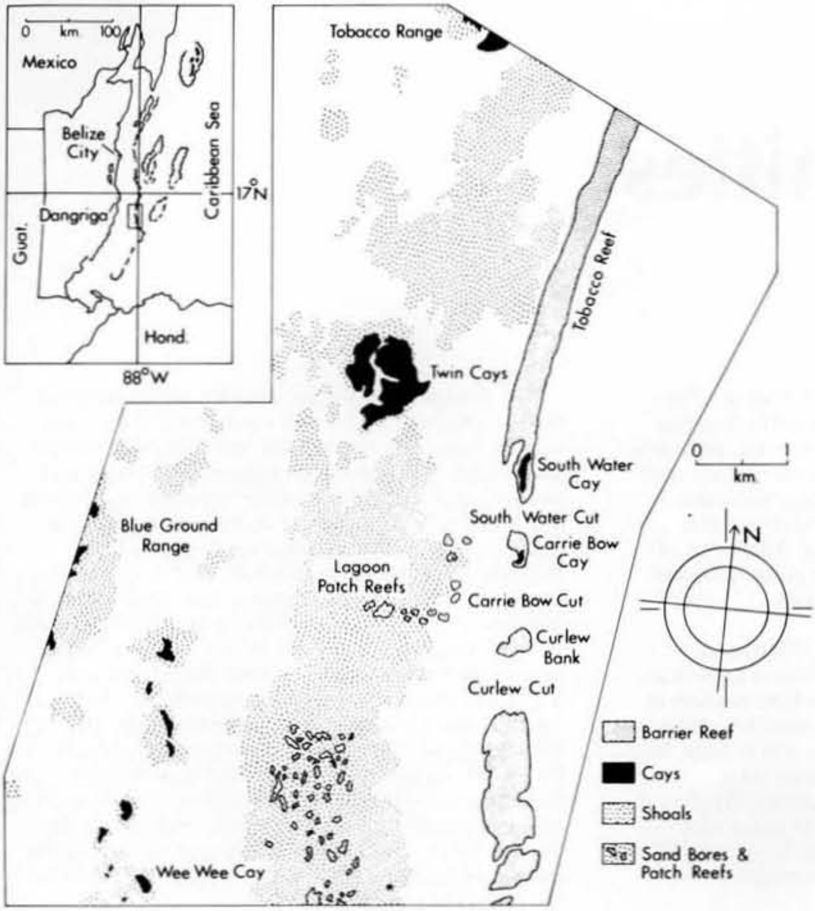


Figure 1. Mangrove ecosystem study area, Twin Cays, Belize. The National Museum of Natural History's coral reef field station is located on Carrie Bow Cay, about 4 kilometers southeast. (From Rützler and Macintyre, 1982, Smithsonian Contributions to the Marine Sciences 12*)*

analyze as many components as possible of a single mangrove swamp and, ultimately, assemble them to a mosaic reflecting structure as well as function of this unique ecosystem.

Geological History of Twin Cays

A popular theory holds that mangroves are builders of land because they trap and hold fine sediments. Early on in our study we discovered that this is not necessarily true. We tried to reclaim nearby Curlew Cay, which had been lost to a hurricane (it is now known as Curlew Bank), by planting an assortment of young red mangroves, but were unsuccessful. So the question arose, if islands are not built by mangroves, how do they get started?

To learn more about the Holocene (recent time—back to 18,000 years before present) stratigraphy under the present island, Ian G. Macintyre of the Smithsonian Department of Paleobiology, along with Robin G. Lighty and Anne Raymond of Texas A&M University, drove pipes 8 meters into the sediment, down to the Pleistocene level (marks the beginning of the Holocene), and retrieved sediment cores that date back 7,000 years.* They also collected rock cores below this level. What they found below the mangroves was a carbonate substrate consisting of a dense limestone formed mostly by finger corals (*Porites*) with abundant mollusk fragments, indicating an environment of deposition similar to today's calm-water patch reefs. The sequence of peat, algal-produced sand, and mangrove oysters in the sediment cores indicates that this mangrove was apparently established on a topographic high formed by a fossil patch reef, and kept pace with the rising sea level. However, there is also evidence that the island repeatedly changed its size and shifted position, generally building with lagoon sediments on the windward coasts, while eroding at the leeward edge, which is characterized by shallow-water bottoms formed by stranded peat deposits.

The mangrove community itself can be thought of as being composed of three components: the above-water "forest," the intertidal swamp, and

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* Although the Holocene can date back as much as 18,000 years, there are only 7,000 years of sediment accumulation in this particular area, as sea level did not flood the Belize lagoon until the upper Holocene.

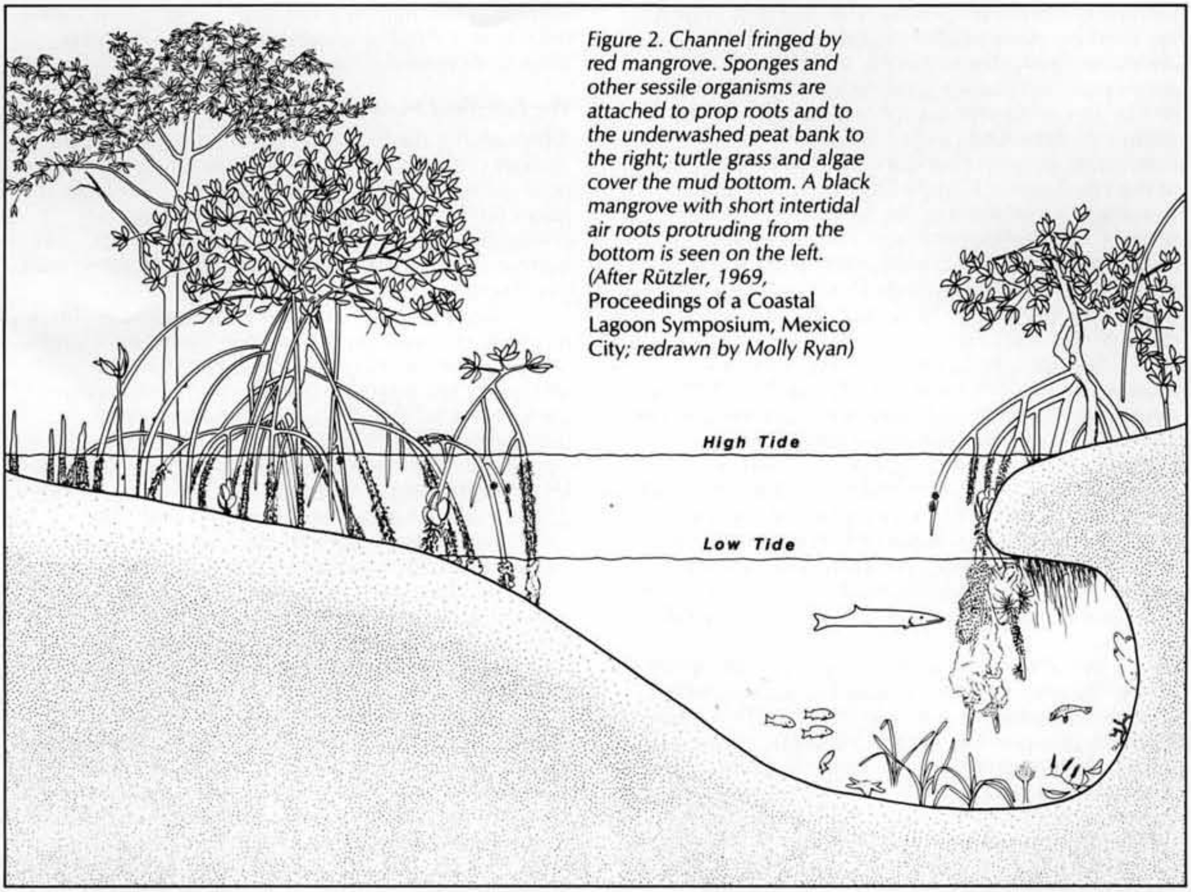

Figure 2. Channel fringed by red mangrove. Sponges and other sessile organisms are attached to prop roots and to the underwashed peat bank to the right; turtle grass and algae cover the mud bottom. A black mangrove with short intertidal air roots protruding from the bottom is seen on the left. (After Rützler, 1969, Proceedings of a Coastal Lagoon Symposium, Mexico City; *redrawn by Molly Ryan)*

the underwater system (Figure 2). In our descriptions, we will start from the bottom and work up.

Environments Below the Tides

The bottom of the mangrove from the intertidal to 3 meters, the greatest depth of the main channel, is composed of what most people would call muck. To us, it displays many varieties, such as carbonate silt, mud, and sand with varying amounts of mucus, organic detritus (products of plant and animal decay), peat, and silicious skeletons derived from diatom algae and sponges. Many fine-grained limestone sediments are produced by physical and biological erosion on the nearby reef and carried into the mangrove by water currents. Sands, on the other hand, are primarily produced within the community by digestion or decay of calcareous green algae (*Halimeda*).

The most abundant and ecologically important plant on the submerged mangrove bottoms is the turtle grass (*Thalassia*). It stabilizes the muddy bottom, offers substrate for egg cases and many small sessile organisms, and provides food and shelter to animal groups ranging from microbes to 2-meter manatees. Jörg A. Ott, a seagrass ecologist from the University of Vienna, determined that turtle grass in the Twin Cay mangrove is more dense, and grows 3 times faster than *Thalassia* in the nearby open lagoon, resulting in an almost 10-fold net leaf production.

Red mangrove stilt roots line all channels, creeks, and ponds and, below tide level, support spectacularly colored clusters of algae, sponges, tunicates (sea squirts), anemones, and many associates. They also provide hiding places for many mobile animals, such as crabs, lobsters, sea urchins, and fishes.

Algae without the ability to root in mud bottoms abound on the stilt roots. Mark Littler, from the Smithsonian Department of Botany, and co-workers Diane Littler and Philipp Taylor found that, curiously, fleshy algae seem to prefer roots that had penetrated the water surface, but had not yet reached the bottom of the channel or lake. Calcifying algae (such as the sand-producing *Halimeda*), on the other hand, are common on the submerged parts of anchored roots and along the channel banks. Experiments demonstrated that the hanging roots offer palatable plants protection from benthic (bottom-living) herbivores such as sea urchins and many fishes, whereas *Halimeda* has its own skeletal protection.

Certain algae and many sessile invertebrates on the subtidal mangrove roots are protected from predators by toxic substances stored in their tissues and produced by their own metabolism. Sponges are particularly well-known for their antibiotic and