Life On Guam
Mangrove Flat

by Gaylord Diaz and Dave Hotaling

art L Hotaling and Lita Payne

Life On Guam

...a project to produce relevant class, lab, and field materials in ecology and social studies for Guam junior and senior high schools. Funding is through a grant under ESEA Titles III and IV, U.S. Office of Education—Department of HEW—whose policy, position, or endorsement is not necessarily reflected by the content herein.

"...to ultimately graduate citizens who are knowledgeable and conscientious about environmental concerns of Guam and the rest of the World."

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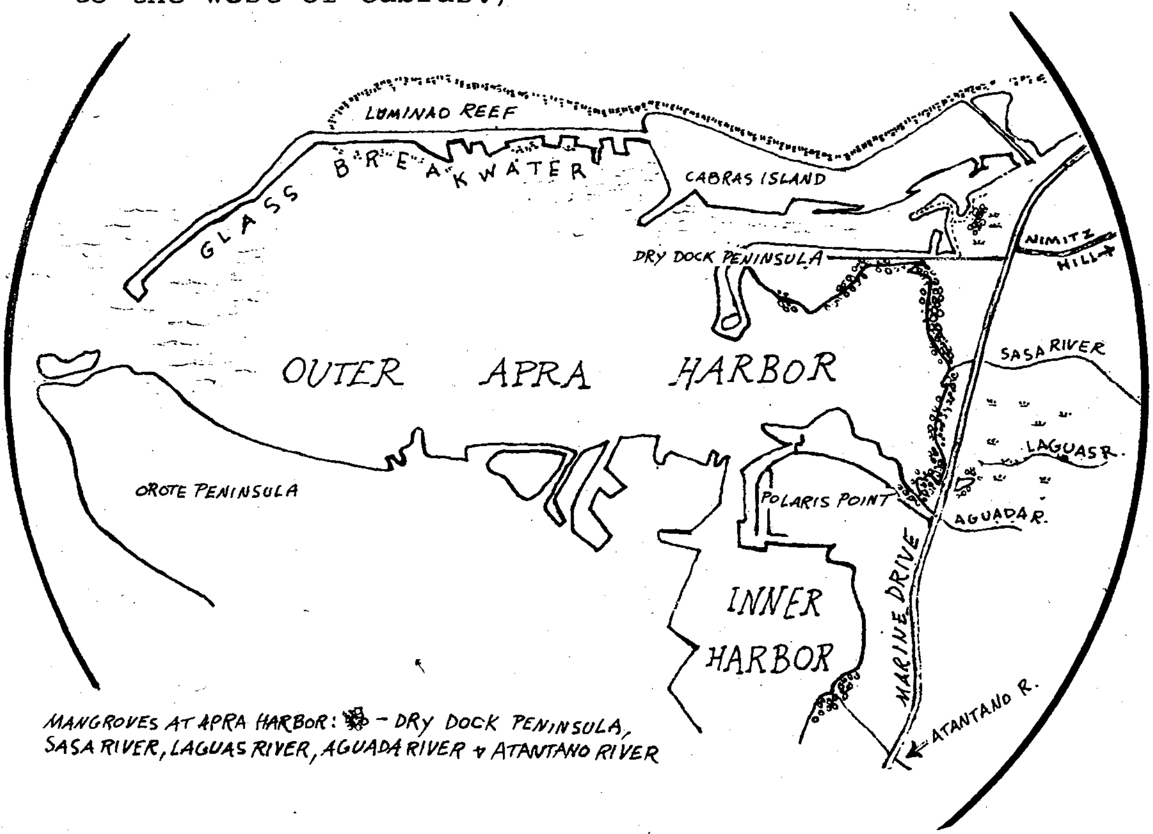
I Introduction

Formation

Land and sea meet at three different kinds of shore: rocky, sandy, and muddy. The first two often face the open pounding ocean.

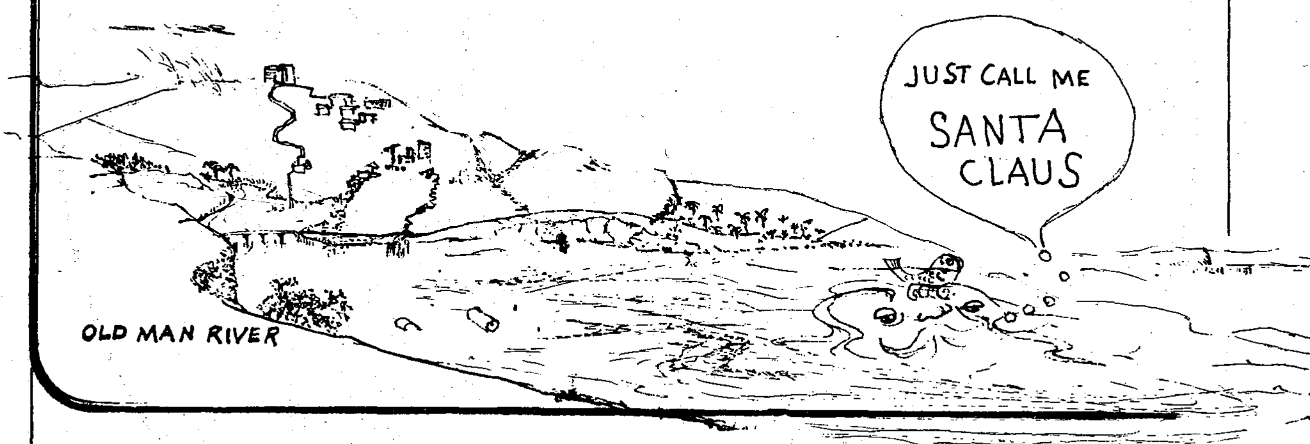
Muddy shores develop only where water is calm and currents are slow, behind some kind of protective barrier. Apra Harbor's mud flats are shielded from the sea by Cabras Island and the long breakwater extending westward from it. This breakwater was built in 1946 and named for U. S. Navy Captain Henry Glass who had eased Guam from Spain in 1898. (Before the breakwater was built, Luminao Reef was a good barrier to the west of Cabras.)



Small rivers bring varying amounts of water and silt to this meeting place of fresh and salt water, the estuary. As in other intertidal zones (between the high and low tide lines), plants and animals here are continually covered and uncovered by water, twice a day. (In other parts of the World wide variations in temperature occur also, but in the Tropics the difference is negligible:) Mud flat organisms, however, do have another special environmental problem. The rivers bring freshwater to the flat. When the tide is out the water coming into contact with the plants and animals is nearly 100% fresh. The incoming tide floods the organisms with saltwater. They must stand up to this big change in salinity, saltiness. Only a few kinds of plants and animals can do it. For that we call them euryhaline, meaning 'wide salt'.

If most plants and animals were subjected to the change in salinity which occurs on the mangrove flat, they'd die. For example, deep-sea fishermen on the southeast Mainland coast are troubled by shipworms. These are marine (saltwater) worms which bore into wood. Eventually they can so riddle a hull that it will sink. The fishermen have solved the problem. Every few months they drive their boats a short way upstream in the freshwater rivers. The freshwater seeps (by osmosis) into the worms, expands them and bursts them.

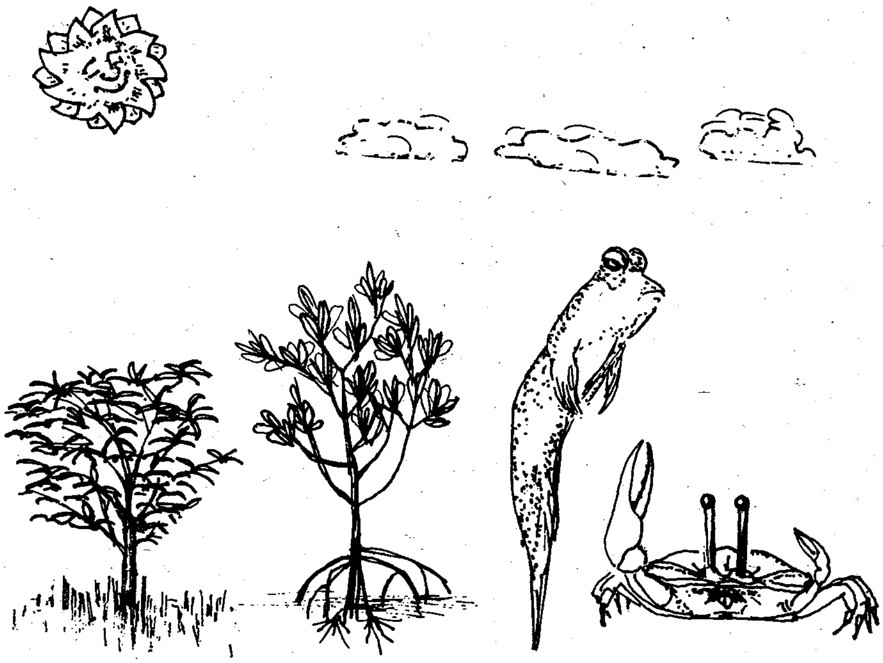
The mangrove flat is otherwise a gifted environment. Incoming tides offer up nutrients and debris that outgoing tides leave behind. The rivers carry down to the flat other gifts: silt, and sewage (including more nutrients).



You may recall from <u>Savanna, Old Fields, Roadsides</u> that 'littoral' means shore or shallow water. The sublittoral part of the mangrove flat is always under water. When the tide's out it is here that fresh and salt water meet and mix. Think about the differing size and shape of the mixing zone, the estuary, at high and low tide. We are going to discuss the flat at the eastern end of outer Apra Harbor. What rivers form this estuary?

Let's take a look at a few of the more noticeable plants and animals on the flat: mangrove trees, fiddler crabs and mudskippers.

Meet Our Hosts



1. What major condition leads to the formation of a mangrove flat?

2. What effect does the estuary have on plants and animals?

3. What special adaptations are necessary to live on the flat?

4. Why do estuaries occur on Guam only around the southern end?

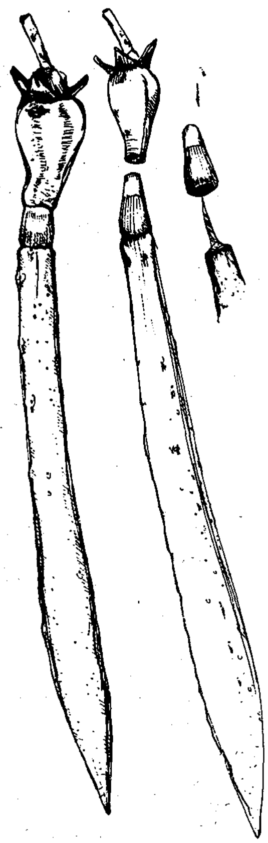
5. How do high and low tide affect the shape and size of an estuary?

6. a. Is seawater heavier or lighter than freshwater?

   b. 'Salt wedge' is a term used to describe the saltwater part of an estuary. Do you see how it applies? Discuss it.

II Mangrove Trees - Mangle

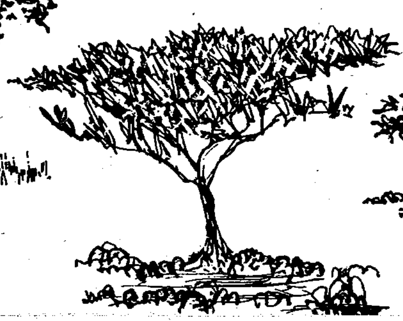
Mud flats and mangroves occur in many latitudes north and south, but only in the tropics do these trees really thrive. Mangrove trees are the dominant plants of the mud flat. They are the most numerous individually and they also are the most important organisms here——you'll see why in a minute. It is fitting that the area be named for them: mangrove flat (also mangrove mud flat or mangrove swamp——the terms are used interchangeably).

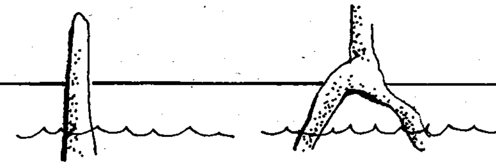


The main mangroves on Guam are Rhizophora the red, Avicennia the black, and Bruguiera. At eastern Apra Harbor, Lumnitzera also grows. Mangrove trees have a special role in ecology——they *build land.* (The Ponapean word for these trees means 'land-builder'.) Their complex roots hold down water currents and catch much debris that tides and rivers bring to them. Also, fallen leaves, twigs, branches and infertile seeds are trapped. Silt, sand, and mud gradually collect. Eventually these materials build up so that the tides no longer cover them. In Florida mangroves built one open shoal into a thick swamp forest in a period of 30 years. Palembang, a coastal port in Sumatra 400 years ago, is now 50 km upstream, largely as the result of mangrove activity.

The red, with its arching prop roots, is the pioneer of our mangroves. It lives furthest out to sea. The many prop roots enable this tree to take hold and survive in the wash of the tides. Its seeds actually sprout while still on the parent. When they do drop, the seedlings have a big head start on life and can root quickly. If the tide is out they drop into the mud; if it's in the seedlings float to a new site. When it builds up the substrate to the point where other mangroves can take root, the red mangrove moves further out to 'greener pastures'.

Black and other mangroves too have roots adapted to life in the mud, but in a different way. Their extensive underground branches put out different structures which stick up through the mud surface. These aerial roots are pneumatophores, specialized organs for gas exchange. Avicennia (black mangrove) grows slim vertical pegs, Bruguiera (mangle machu) makes large 'knees', and Lumnitzera (nganga') produces twisting small knees you might want to call 'knuckles'!





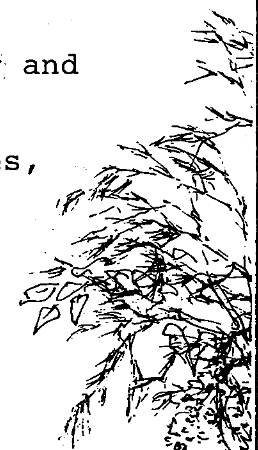
Root cells, like others, need oxygen. Mud contains very little oxygen near the surface, and below that it's anaerobic, without oxygen. Aerial and prop roots are an adaptation enabling a mangrove to live in mud. They contain many pores and breathe in the open air at low tide. Thus oxygen is rhythmically supplied to the buried roots.

Mangroves can grow on many different soils, even rock if it has cracks where the roots can go. The trees will grow in soils containing calcium, or silica, or carbon where peat has formed in mud. Often the peat is formed from mangroves themselves. Generally, these trees do best in mud in very sheltered places.

Succession and Zonation

Each species of mangrove tends to change the conditions of the place where it lives. As it grows, a red mangrove builds up the bottom, takes nutrients from the mud and water, decreases the space available to certain organisms, provides space for others to climb or roost on or hide under, and provides more and more shade. The new conditions make it possible for other mangrove species to move in and 'succeed' the red. This is the process of succession.

As time goes on, the water becomes shallower and shallower. Dry land gradually is formed. Mangroves cannot continue growing here but are replaced by terrestrial species: grasses, herbs, shrubs, and eventually, trees.

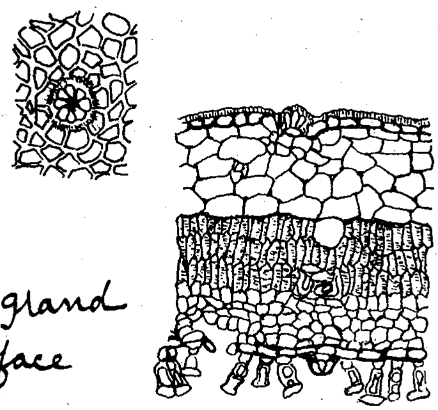


Because of succession different species occupy different parts of the mud flat community. It's possible to distinguish 'zones' in this habitat and the following diagram shows the zonation of one Guam mangrove shore.

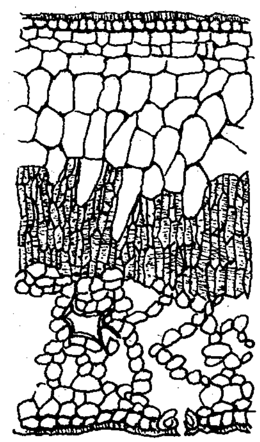
6

The mangrove flat estuary, mainly because of the trees, is a very productive place, biologically speaking. A large amount of the Sun's energy is changed here into plant tissues. (What's the name of the process?) Also, in the same process, a good deal of oxygen is produced by the green leaves and the algae on tree roots and stems. If you include the plants bordering the flat, then you can say that the area probably equals in productivity any three- or four-storied forest anywhere.

Among unsolved mysteries of the mudflat is the relationship of mangrove trees to salt. Workers elsewhere have found that some of these trees contain salt concentrations 10 times higher than others. Leaves of the former, black mangroves, contain glands which actually excrete salt. Leaves of the latter, reds, have no such glands. Perhaps red mangroves would be harmed by salt getting into their tissues, and their roots can keep salt out. Black mangroves take in a lot of salt but their leaves get rid of it. Clearly someone should work on this interesting puzzle——how about you?



Top view and section of black mangrove leaf showing salt-excreting gland in upper surface



Section of *Rhizophora* leaf (no salt gland)

1. Why don't mangroves grow in rough waters?

2. What is zonation?

3. Why does succession on Guam go from red to black mangroves?

4. How are the roots of mangroves different from those of land plants? Explain.

5. How is it that mangroves thrive in salt water?

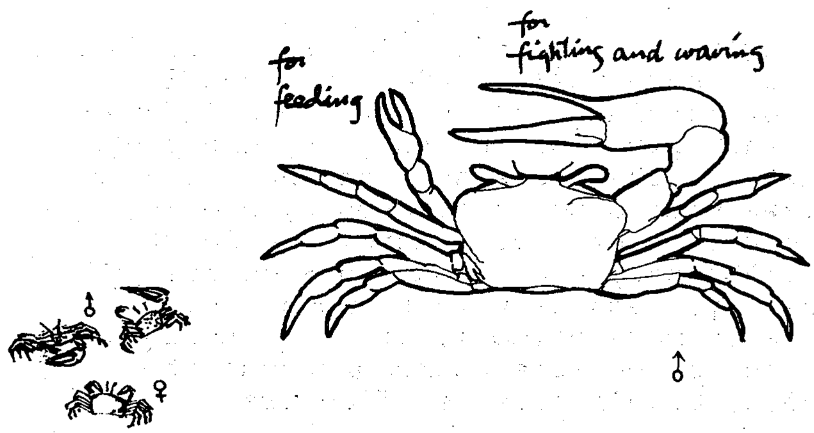
III Fiddler Crabs - Lelente'

Partly because of silt and lack of the right food, many animals can't live in the mangrove flat. (Name some.) Worms, clams, snails, and fiddler crabs are the invertebrates here in abundance. Of these the crabs are the most active, easily seen, and probably most interesting, so we'll discuss them in some detail.

Crabs are noted for several things: strong claws (they're the first of 5 pairs of legs), hard shells, stalked eyes, moving sideways,...and good taste!

<u>General Characteristics</u>

The thing that makes fiddler crabs different from other crabs is the one giant claw on each male. Some males have a large right claw, others a large left.



Walking across a flat full of fiddler crabs is like walking on a magic lake. As you approach, hundreds of them just seem to disappear...they've dashed into the safety of their burrows.

One Day in the Life of Juan Fiddler
Genus - <u>Uca</u>

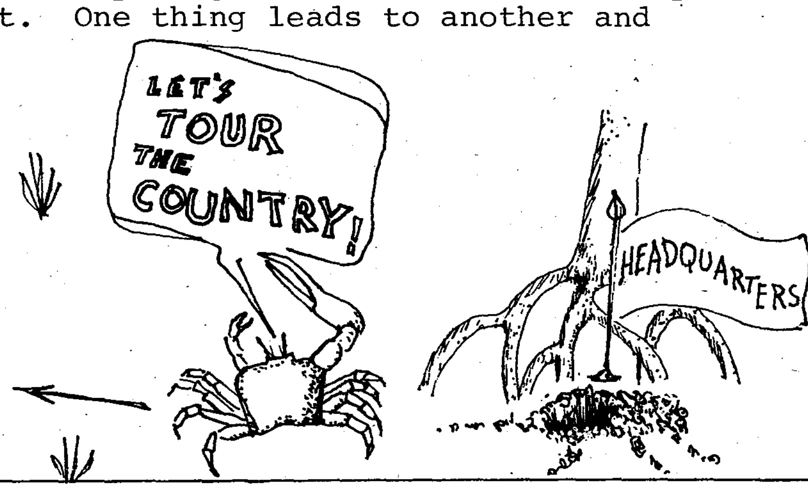
The 'day' begins not necessarily with America's day but when the tide goes out. Then the crabs come out of their burrows and explore the territory. Food is the first thing on the mind of the fiddler. The tide has left behind many tidbits stuck on the mud. These are picked up, tested, and then maybe filtered from the accompanying mud by a current of water passed through some bristles on the mouth. This water can also separate organic particles (food) from inorganic ones by flotation. One kind floats, the other sinks——which does which? Then into the mouth proper goes the food. Rejected materials collect into pellets which are discarded by the mouthparts from time to time. Females feed with both claws.

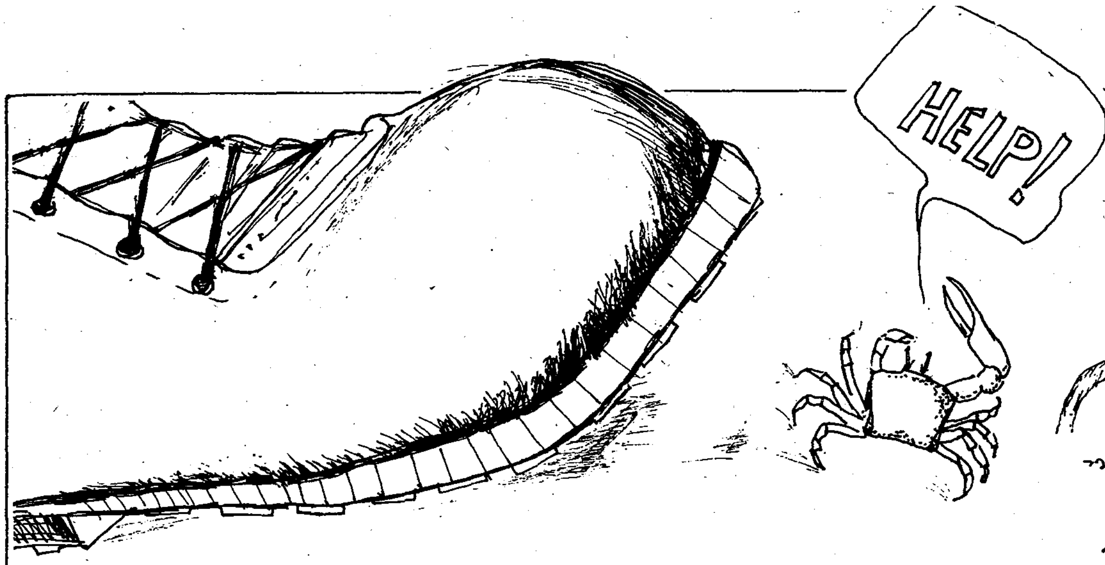
While feeding, the crabs look around for company. They also signal visually and audibly, wander, threaten, fight, hide, and mate.

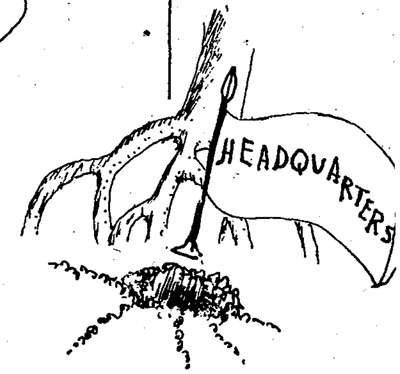
The name 'fiddler crab' was given these little fellows perhaps because of the male's waving or sawing motions, perhaps merely because the large claw reminded someone of a violin. One way a male signals is by rising on 'tiptoe', moving this claw upward and outward, then bringing it back in and settling down to normal position. The female on the other hand, rises on tiptoe to prevent the male from clasping her.

Sound plays a big role in the social life of fiddlers, but we're not just sure how! Sounds are made in several ways: by rubbing various parts of different claws against other parts of the body, by drumming or banging claws or other legs against the ground, by clashing claws with opponents, even by blowing bubbles. The sounds aren't very loud. We don't know if other crabs can 'hear', but they do respond, males, aggressively, females perhaps romantically. Sounds are produced more commonly at night than in daylight. You may be able to record some of the sounds made by Guam's littlest fiddlers.

In wandering about, males inevitably come across other males defending their burrows. Mutual dislike is readily apparent. One may threaten the other by raising the 'elbow' of the large claw, by lowering the whole claw, by making small sweeping movements with it, by lunging with the entire body at the opponent. One thing leads to another and







they have at it. Rubbing, bumping, pushing, gripping, all take place. Battle is generally joined for only a few seconds and ends in a draw about 75% of the time. Both parties quickly resume their previous behaviors, wandering and waving. If there is a loser and it's the wandering intruder, he'll move off in a kind of creep. If the burrow owner loses he may delay waving again for a minute or two. Once in a great while one crab is actually flipped over. Even so, he suffers only a temporary loss of dignity.

Courtship is simple. The male 'beckons' more or less continually while feeding. If a nearby female is attracted, she moves toward the male. He will stop fiddling around, move close to his burrow and descend into its darkness. She may follow for further action.

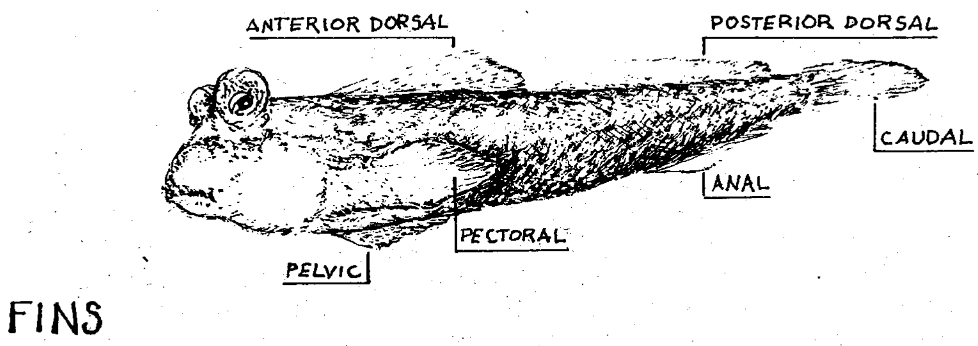
The activities of exploring, feeding, fighting, courting and mating all take time. And the tide is returning. Time and tide wait for no crab. On each incoming tide the fiddler touches up the burrow. Using the claws and other legs the crab shapes the mud into balls and deposits them several centimeters from the opening of the home. After refinishing the home suitably wide and deep, the crab enters it and seals it with a plug of mud. Soon the once teeming flat is empty, not a fiddle in sight. Not long after, the flat itself disappears, covered by incoming tide.

IV Mudskippers - Macheng

General Characteristics

Mudskippers are very talented fish. They can live in salt and fresh water, can breathe out of water, see every which way, use 'crutches', dig burrows, build chimneys, skip on land, jump and climb trees!

The Guam mudskipper is Periophthalmus koelreuteri. The Latin genus name, peri + ophthalmus, means 'all around eyes'. The head is short and thick, the body long and tapered. There is a single row of teeth on each upper and lower jaw.



External anatomy of a mudskipper

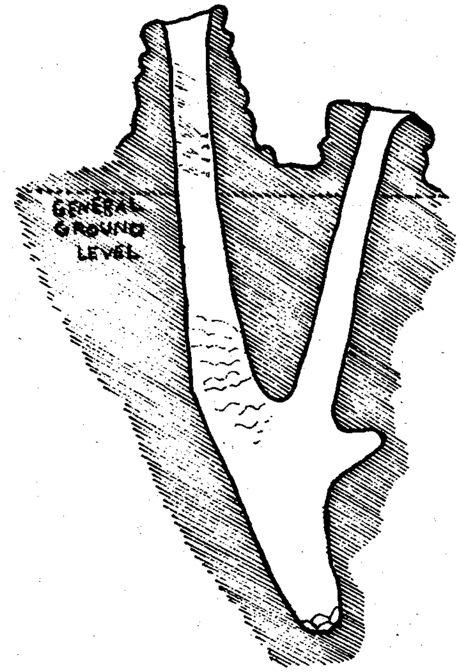
Habitat

Mudskippers often nest among the dense, arching roots of mangrove trees. Prop roots of the red mangrove and the pneumatophores, air roots, of the black mangrove are resting stations, and also provide the mudskipper with a rich food supply.

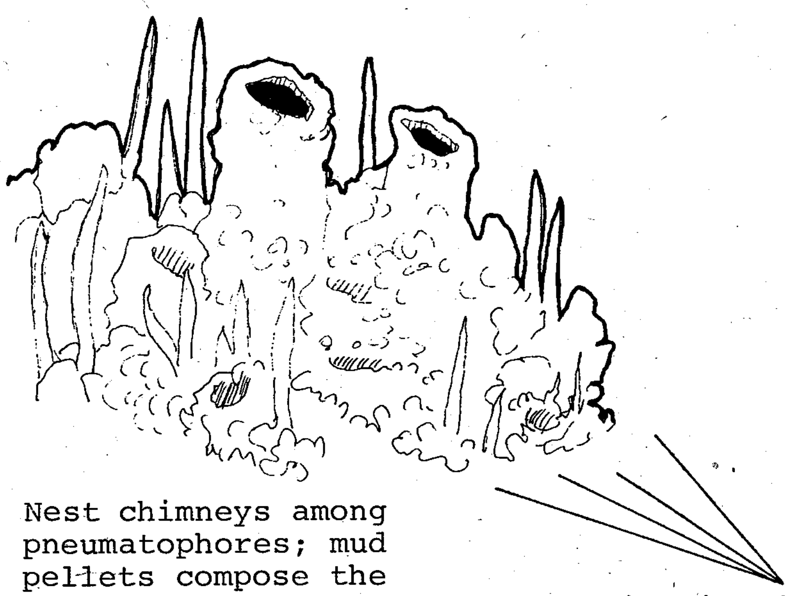
Nests

Mudskipper nests are scattered about, evidence of territoriality (Human Impact, p. 15). As a general rule, shady places are chosen to build in, usually near mangrove trees.

The nest is Y-shaped, with one chimney of mud higher than the other. Both chimneys meet in a main room with the floor 25-50 cm below the mud surface. Mud pellets are carried in the mouth from below to the nest opening and there formed into the chimneys.

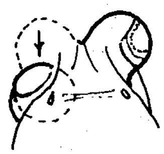


Vertical section of the nest of a typical mudskipper; several pellets of mud lie on the bottom.



Nest chimneys among pneumatophores; mud pellets compose the chimney walls.

Distribution of nests.



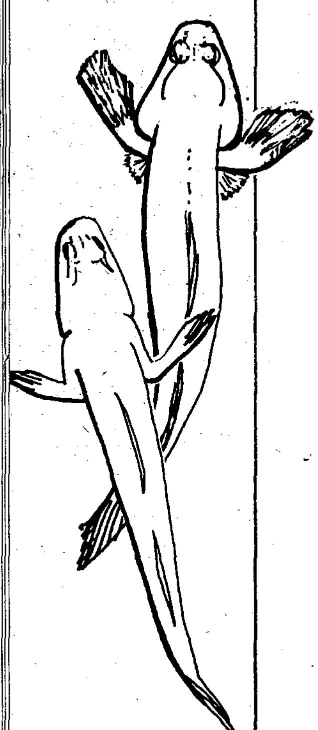
Seeing

The bulging and rotating eyes help the fish see mates, food, and danger, and in any direction. The eyes can be raised and lowered like periscopes. The lower half of the retina is rich in cones for color vision, perhaps for watching rival displays. The upper half is composed largely of rods, for black and white vision, i.e. locating prey on the mud. Apparently mudskippers can see up to 9 meters.

Feeding

Detection of food occurs chiefly, if not entirely, by sight. You can anticipate a pounce for food by the immobile attitude as the mudskipper intently observes its prey. Then, the jump! Worms, fiddler crabs, and insects are the common diet of mudskippers observed in Guam mangrove swamps.

The prey is usually attacked in a series of rapid leaps. It is caught on the ground, in the air, or on water, but seldom under water. After being caught, the prey is submerged in water, which helps prevent its escape. Should the prey offer a resistance struggle, the mudskipper will jerk it quickly sideways, tending to really shake it up.



Mudskippers also feed on detritus. They take a mouthful from the mud surface and slosh it around awhile, sifting the organic bits from the mud. The mud is then squirted out and the food is washed down with a swallow of water.

Feeding is accompanied by the expulsion of air and water from the gill chambers. It is followed by a movement to the water for a refill.

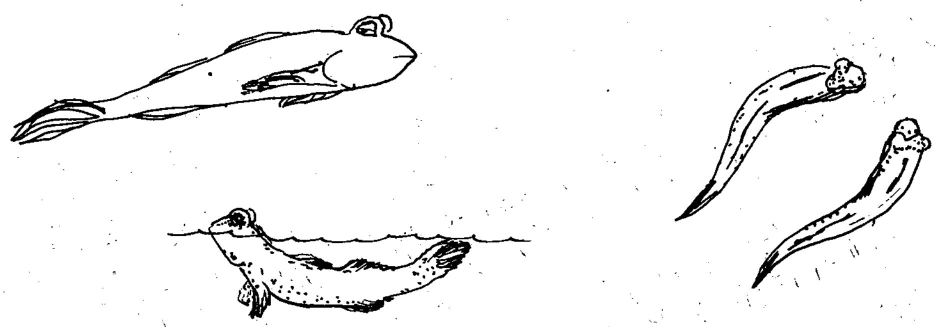
Respiration

If you're a fish which spends time on land, you need a special respiratory system. The mudskipper has one. On coming ashore, the fish closes the gill chamber and gulps air. This expands the chamber, which is kept closed, and forces the trapped air to mix with the water already in the chamber. Thus oxygen-rich water is available to the gills while the fish is on shore leave.

Locomotion - In Water

Mudskippers move through water by slow paddling, fast swimming and skimming.

Paddling - The pectoral fins work together with the tail as they propel the mudskipper slowly along near the surface.



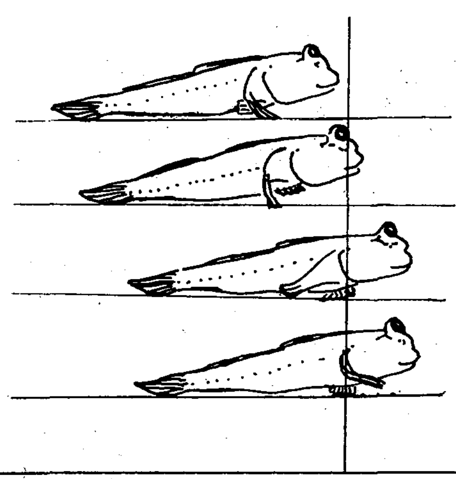
Swimming - On plunging into the water the fish stream-lines itself by folding pectoral, pelvic and dorsal fins against the body and expelling air from the gill chamber. Fast waving of the tail alone pushes the fish ahead.

Skimming - Rapid sideways movements of the tail again give the forward force. A sudden downward movement of the tail thrusts the body up from the water at a slight angle, head first. So the mudskipper skims above the surface in the same way as a flying fish. The tail fin and tail hit the water first. Each low leap follows a quick dip for swimming (page 15).

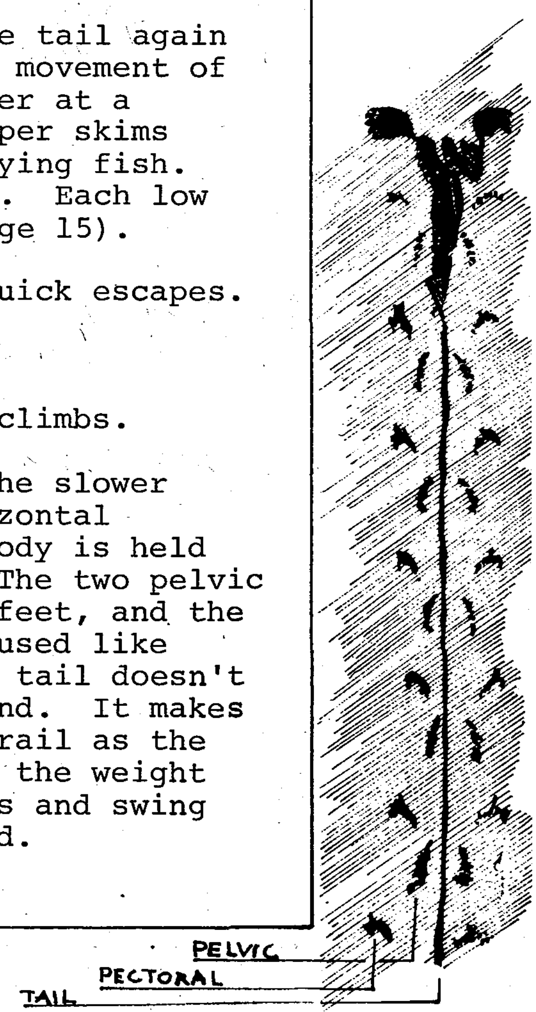
Fast swimming and skimming are used for quick escapes.

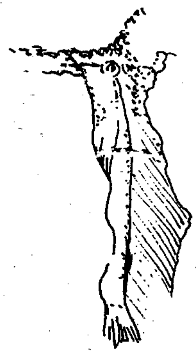
On Land

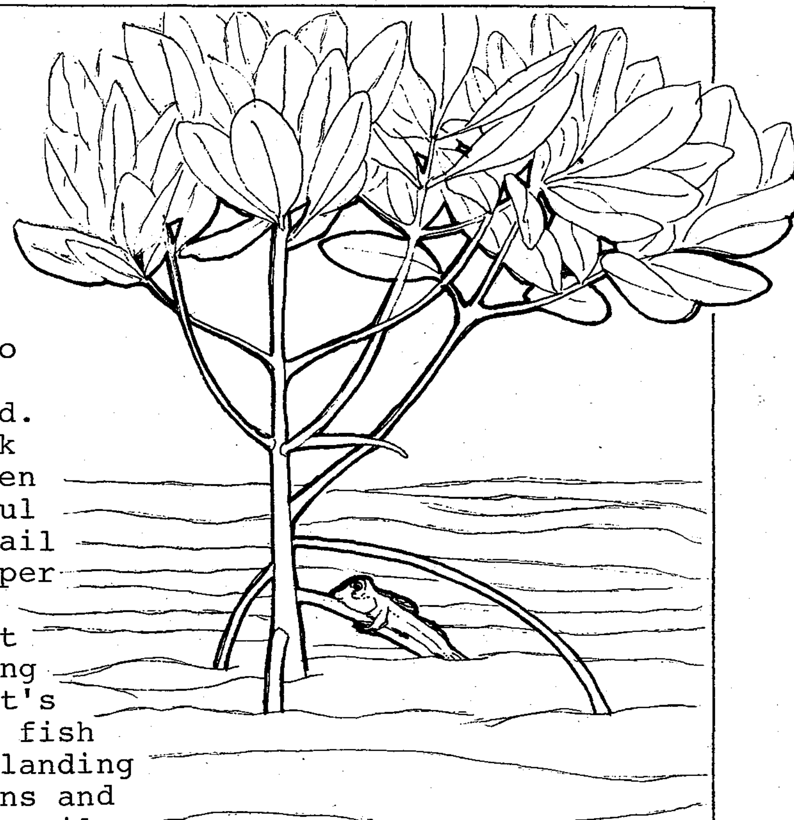
Here the fish crutches, skips, jumps and climbs.



Crutching is the slower method of horizontal motion. The body is held quite rigid. The two pelvic fins act like feet, and the pectorals are used like crutches. The tail doesn't leave the ground. It makes a continuous trail as the pectorals take the weight off the pelvics and swing the body foward.





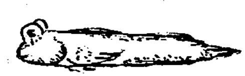


Skipping appears to be another escape-reaction, to reach the safety of the water or burrow. It is also used in feeding. At the beginning of a skip the tail is turned to one side and pressed slightly into the mud. This anchors the back end of the body. Then with a sudden powerful straightening, the tail projects the mudskipper forward. The pelvic fins are in motion at the same time, lifting the body upward as it's forced forward. The fish makes a three-point landing on the two pelvic fins and lower portion of the tail.

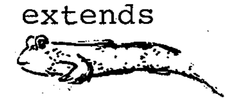
The mudskipper enters its burrow head first. (Depending on the state of the tide the fish may have to get up to the rim of the chimney by jumping or climbing.) After descending several centimeters it turns around and approaches the chimney rim again.

In jumping, and in climbing mangrove roots, mudskippers rely strongly on the pectoral fins. The pelvic fins also are used in clinging to roots.

<u>Attitudes and Displays</u>

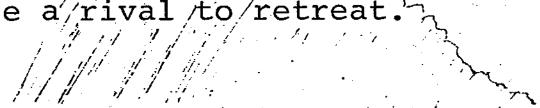


A mudskipper is capable of different postures and displays. When relaxed the fish folds the pectoral fins back against the body. The tail extends straight back.



On the alert the mudskipper bends the tail downward getting a sort of grip on the substrate. The pectoral fins come forward, down and out to grip the surface. The fish is ready for instant movement.

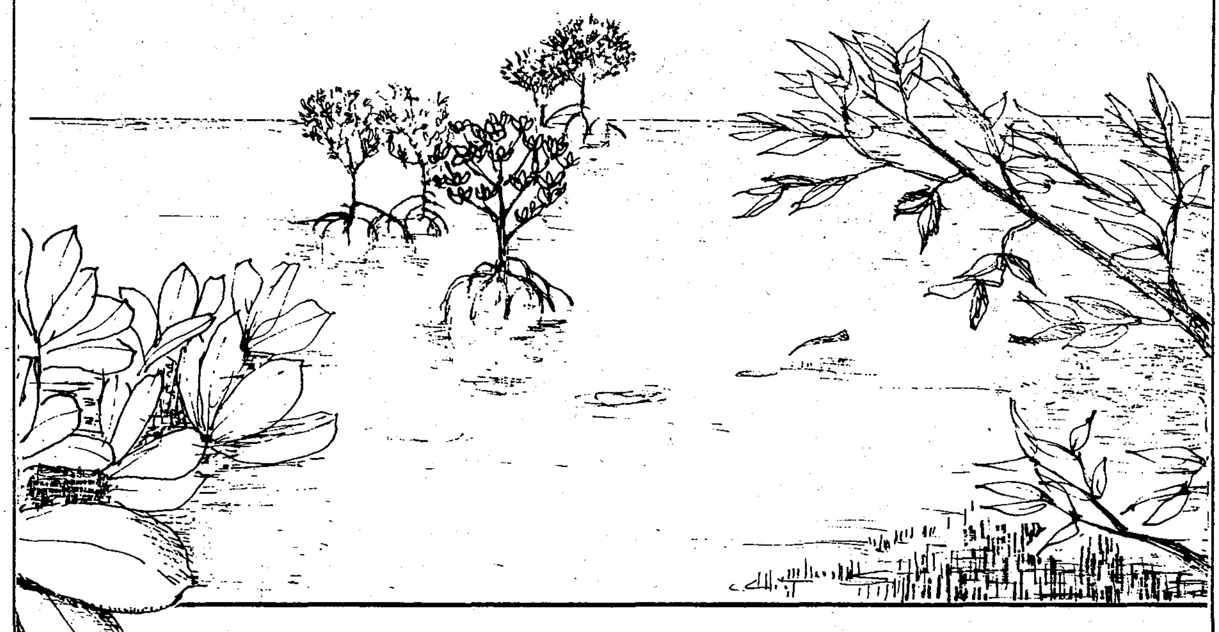
When threatened, the alerted mudskipper raises both dorsal fins. The anterior one has dark and light horizontal stripes and spots. The posterior fin shows a black and orange-to-red horizontal stripe. Often the display will cause a rival to retreat.



When neither of two displaying mudskippers is intimidated they may fight. They jump at each other trying to seize a pectoral fin or the tail and jerk it. If one fish is thrown by the other it 'gets to its feet' and scrambles away as quickly as possible.

Courting and mating behavior of mudskippers on Guam has not been studied and recorded in detail. If it resembles behavior of other mudskippers then it involves the male's first making a burrow. This is followed, at the approach of a female, by his rising on the pectoral fins, arching the back so head and tail are raised, and jumping in the air twice or thrice. All this may be repeated several times. The throat becomes orange during mating season and the male can inflate it for display. As the female follows the male to his burrow he climbs in and disappears under the water. If she doesn't enter also, he'll reappear in a bit and start blowing bubbles. This may be irresistible and she'll plunge in after him.

After mating, some males become extremely defensive of territory surrounding their burrows. If you're another mudskipper you better not get closer than about 25 cm to the burrow, or you'll have crossed the deadline!



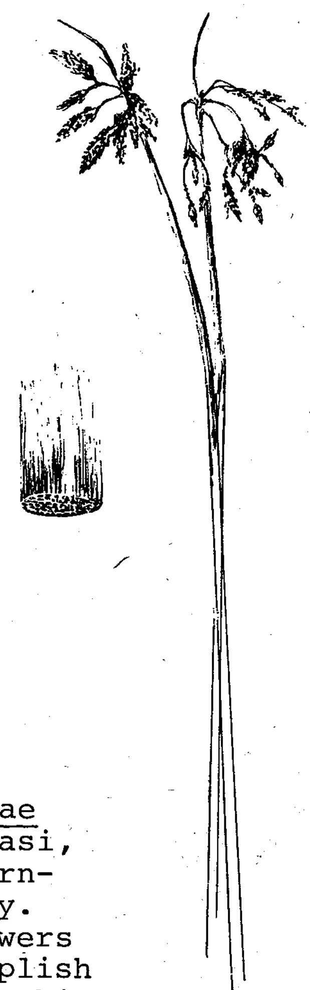
V Picture Gallery

You are cordially invited
to the opening of our exhibition.
Illustrations and information
from Guam's renowned mangrove estuaries,
for your enjoyment
and enlightenment.

Across the stream short Nipa palms
grow on and near the bank.

Phragmites karka
Karisu, reed. A tall grass growing in the freshwater-brackish marsh at the edge of the flat. The lowest flower of each spikelet is usually male, the rest female. In January 1977 the largest karisu stand on the Island was in Agana Swamp. (Where is it now?)

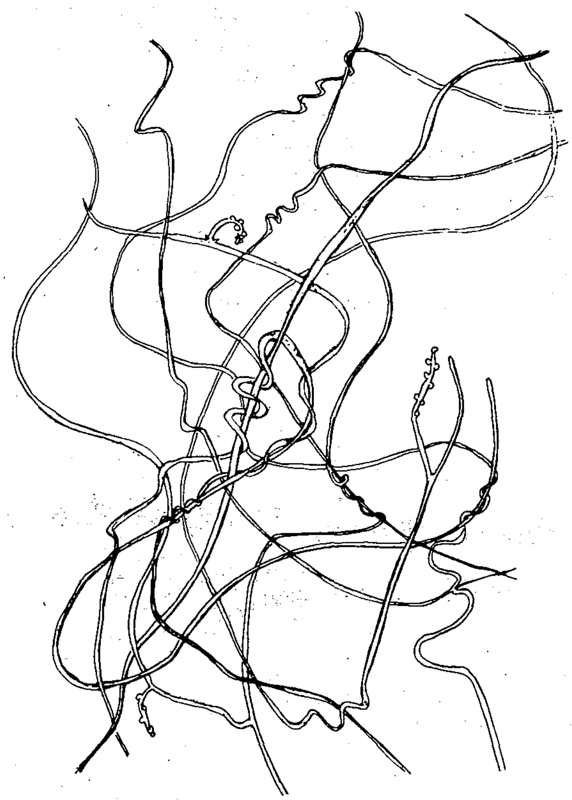
Scirpus littoralis
Bulrush. Grows in mud and brackish water. 2-3 m tall, dark green, gently tapering, circular in cross section. Several brown flower heads on drooping stems nearly at the tip. Leaves are short and tightly wrapped around the base.



Ipomoea pes-caprae
Alalak tasi, beach morning glory. Pink flowers with purplish throats. This fleshy creeper is crawling around the World on tropical shores.

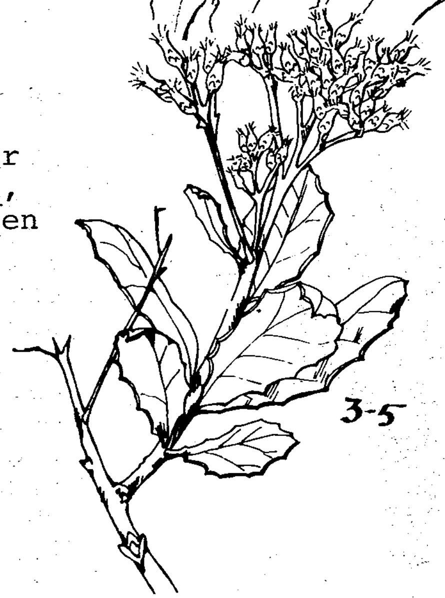
<u>Pemphis acidula</u>
Nigas. A shrub or small tree, according to where it grows. On the windward coast it's just a few centimeters high; on protected shores (e.g. Tanguisson Pt) it's 3-4 m tall, and straight.

<u>Cassytha filiformis</u>
Agasi, mai'agas. Leafless twiner with orange or green stems; attaches to host plants by small holdfasts. A parasite, grows on hosts along the borders of the mangrove flat.



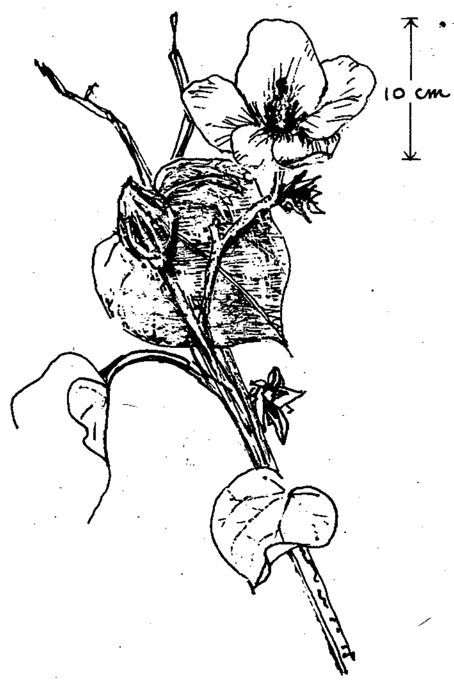
Pluchea odorata
Erect shrub with fuzzy dull gray-green leaves, 8-16 cm long, margins entire or slightly toothed. 12-17 pink to white flowers per head. In Hawaii, the empty dried flower bottoms make leis. From Tropical America.

Pluchea indica
Erect shrub. Leaves smooth, toothed, smaller than P. odorata, bright pale green with very short petioles. Relatively few flowers in compact heads, rose-purple. From India to Australia.

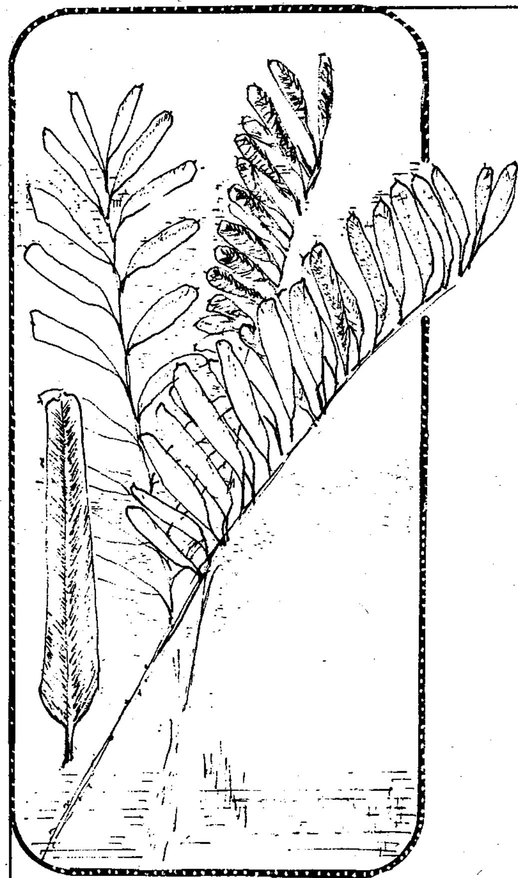


Pluchea fosbergii
This sprawling shrub with yellowish-green leaves is a hybrid, a cross-breed, of P. odorata with P. indica. 97% of its pollen is sterile.

<u>Hibiscus tiliaceus</u>
Pago. Small tree that bears the official territorial flower, yellow with purplish eye. Grows on the strand, favors sand or mud. Also grows up cliffs. Flowers all year long but each flower lasts only a day.

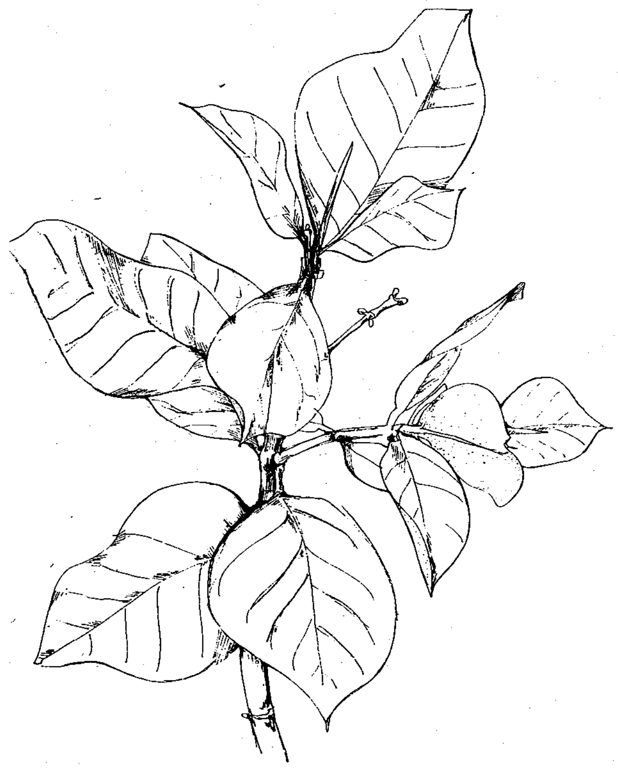


<u>Nypa fruticans</u>
Nipa. A palm, introduced, naturalized. Fairly common in stream mouths, especially on east coast. Except for the ascending tips, stems grow along the ground. Leaves to 5 m long. Fruit roughly like that of pahong, 30 cm diameter. Young seeds edible.



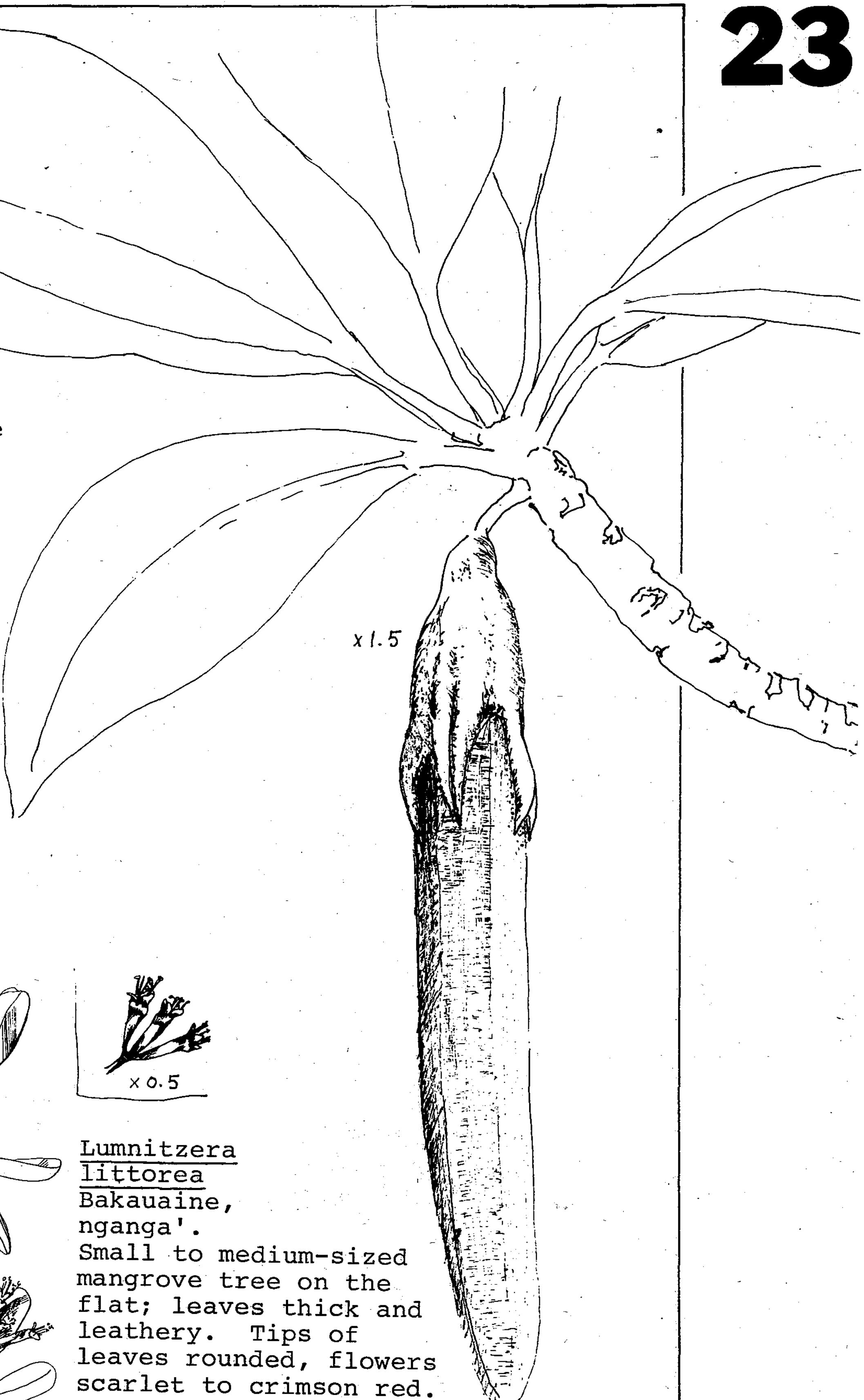
Acrostichum aureum
Lakngayao. A fern growing along the borders of the mangrove flat. It is usually 1-2 m tall. Bottom surface of fertile leaflets entirely covered with spores.

Scaevola taccada
Nanasu, half-flower. Erect, soft-wooded shrub on borders of the mangrove flat. Leaves green, slightly fleshy, 10-20 cm long and 4-10 cm wide, rounded. White flowers look as if they'd been cut in half. Fruit is round, white, about 1 cm diameter, good eyewash.

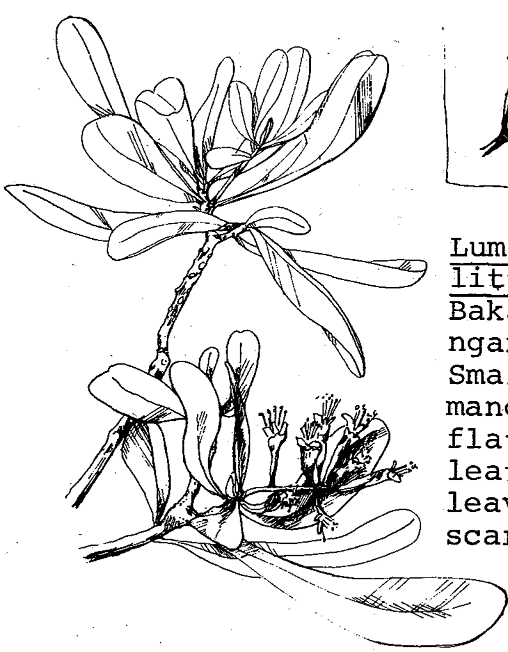


Rhizophora Mangle and mangle hembra. Mangrove tree on 'stilts' - prop and drop roots. Guam's seaward mangrove. Hypocotyls (long slender fruiting bodies) sprout while still on the parent plant. Hypocotyls dotted with lenticels (breathing pores).

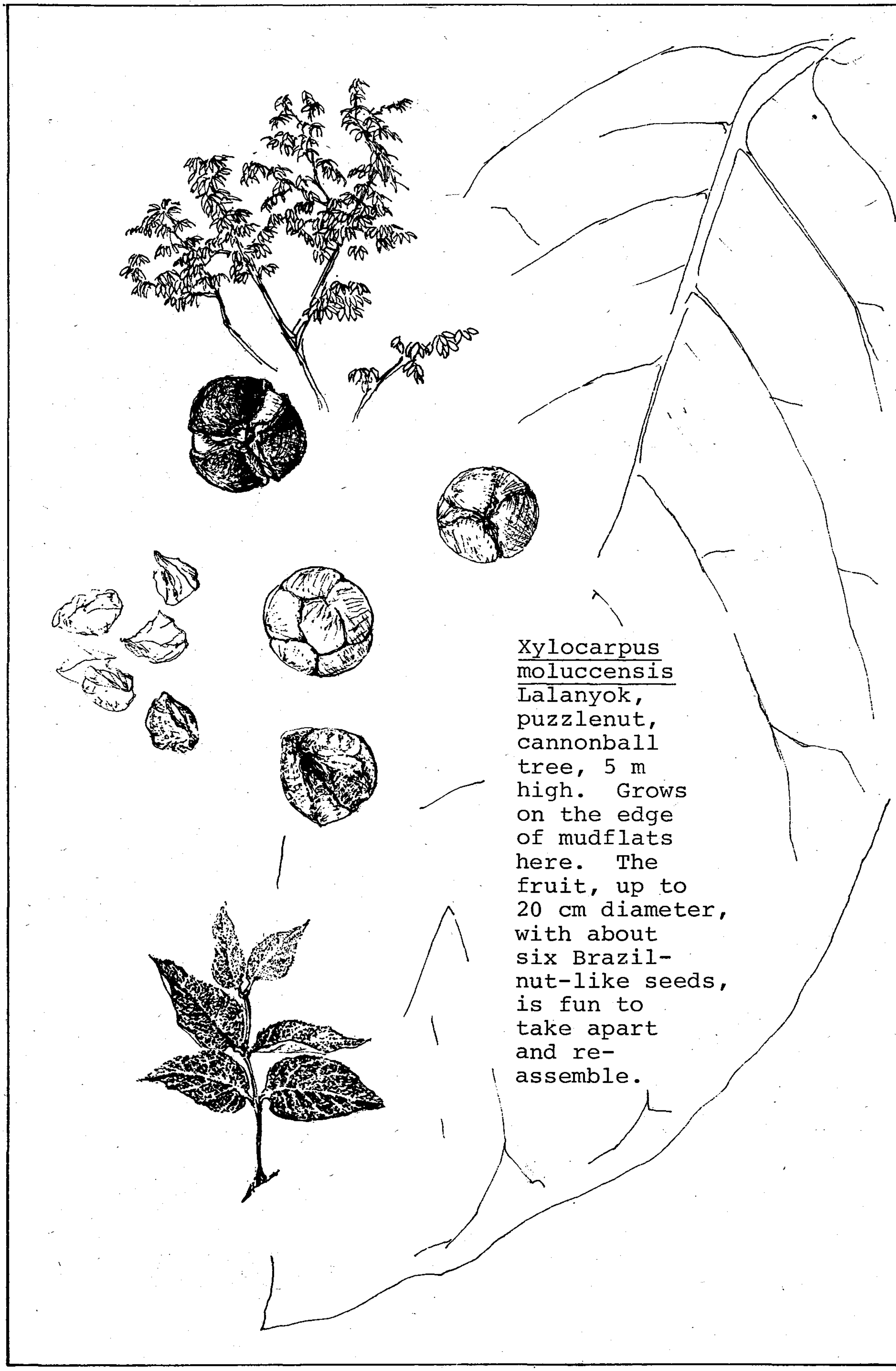
Avicennia alba: The landward (on Guam) mangrove tree with peg-like pneumatophores (air roots) sticking upward from the ground. Leaf upper surface olive green, beneath white. Fruit green, nearly heart-shaped, floats.



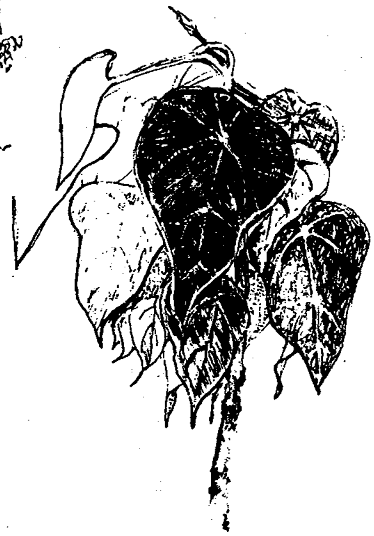
Bruguiera gymnorrhiza
Mangle, mangle machu.
Mangrove tree, leaves thick, dark, leathery, glossy green. Bright red 'hand' (calyx) holds the stubby grooved seedling on the tree until it's ready to drop and take root.



Lumnitzera littorea
Bakauaine, nganga'.
Small to medium-sized mangrove tree on the flat; leaves thick and leathery. Tips of leaves rounded, flowers scarlet to crimson red.

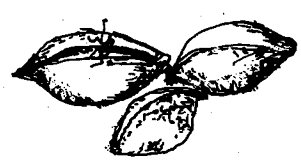


<u>Xylocarpus moluccensis</u>
Lalanyok, puzzlenut, cannonball tree, 5 m high. Grows on the edge of mudflats here. The fruit, up to 20 cm diameter, with about six Brazil-nut-like seeds, is fun to take apart and re-assemble.



<u>Hernandia peltata</u>
Nonnak. Jack-in-the-box tree (probably because each red fruit has a single black seed). This tall tree has a dense and rounded crown. Leaves 12-40 cm long, mostly peltate (the petiole attaches to the bottom of the leaf). Trunk with short buttresses. Bark smooth, silvery-gray-buff. Wood is soft and whitish.

<u>Heritiera littoralis</u>
Ufa-halomtano. About the tallest trees (15 m) bordering the flat. This species is *endangered* (it's so rare it's about to become extinct). Fruit durable, 5 cm long, boat-shaped with keel, floats. Leaves silvery underneath because of tiny scales. (Use a hand lens.)



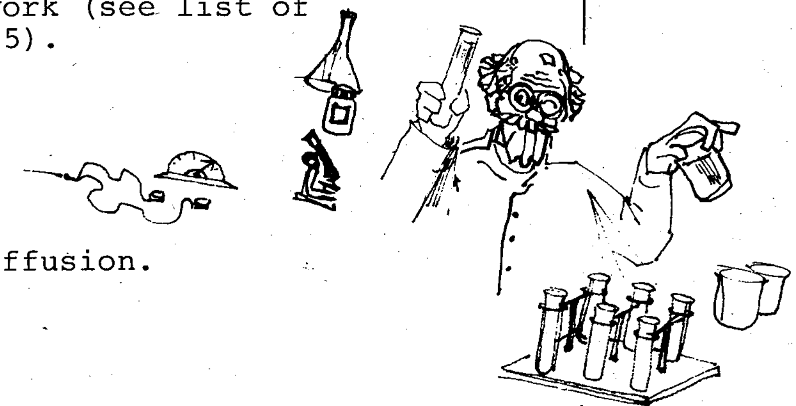
Rogue's Gallery

There's one special dweller of Guam's estuaries we want you to meet, akmangao, the mangrove crab. Akmangao is scarce and hides in burrows a lot. You probably won't see one on a visit to the flat, but here he is anyway, Scylla serrata. ('Scylla' is Greek for 'monster'; 'serrata' means jagged like a saw, probably referring to the border of the shell.)

This specimen is a male——females have smaller claws. These crabs feed on shellfish they find in the mud. They themselves are such good eating that Guam imports them from Palau.

Activities

Here are six classroom experiments for checking out some of the biology, chemistry and physics of Island waters. You may also use your school's Oceanography Kit for further detective work (see list of Suggested Equipment, page 35).



1 Diffusion

Purpose: To demonstrate diffusion.

Materials:

Notebook and pencil
Potassium permanganate ($KMnO_3$) crystals
Water
Beaker

Action: Drop a crystal of potassium permanganate into a beaker of water. Observe this beaker at different times during the period.

Results (in your notebook):

What happens?
Possible explanations?

2 Characteristics of Water Samples

Purpose: To test various water samples for certain characteristics.

Materials:

Notebook and pencil
Hydrometer (to determine specific gravity——S.G.)
pH indicator papers or bromthymol blue
Beakers
Water samples from various sources (for example: ocean, mangrove flat, storm drain runoff, stream, gutter, rainbarrel, pond, ponding basin, puddle, faucet——maybe several different faucets)

Activity 2 - cont'd.

In your notebook make a data table like this one:

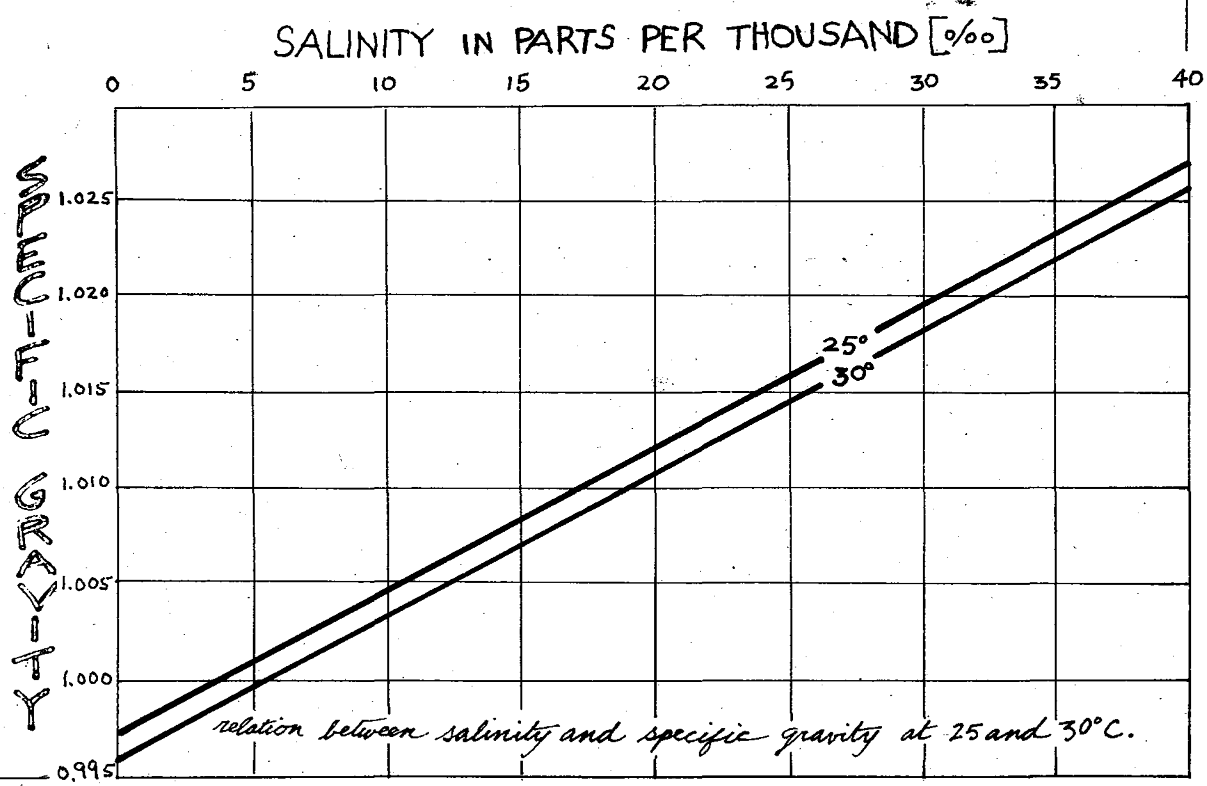
Beaker	pH	S.G.	Salinity in ppt [‰] (parts per thousand)
Pond			
Faucet			
Ocean			
Mangrove			
Etc.			

Action: Divide into groups and each student take a beaker. Label the beakers and pour a different sample of water into each.

Test each water sample for

pH
Specific gravity

Using the table below determine the salinity of each sample of water.



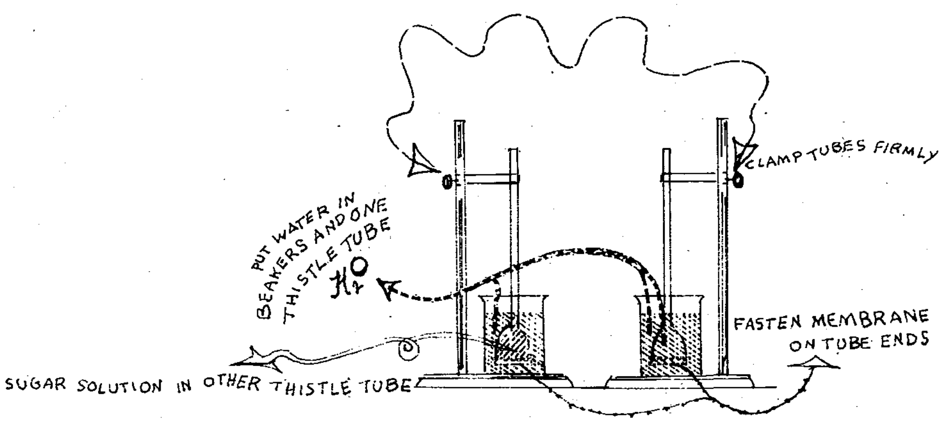
relation between salinity and specific gravity at 25 and 30°C.

3 Osmosis

Idea: To show osmosis.

Materials:

- Notebook and pencil
- 2 ring stands
- 2 buret clamps
- 2 beakers
- Water
- 2 short stem thistle tubes
- 5% glucose solution (or molasses)
- Dialysis tubing (or cellophane)
- String or rubber bands



Action: Work in teams and set up the two tubes simultaneously. (Why?)

Experiment: Holding a thistle tube with the bulb up and placing your finger over the small opening fill the tube with 5% glucose solution or molasses.

Wet the cellophane membrane with water. With a rubber band or string attach it tightly over a large end of the thistle tube.

Invert the tube into a 250 cc beaker of water.

Clamp securely to a ring stand using a buret clamp.

The fluid levels in beaker and tube must be even. (Why?)

Control: Set up a second tube the same way but using water without the glucose or molasses.

Results: Examine the set-ups at intervals of 15 minutes. Explain what happens.

4 Land Plants and Salt Water

Action: Plant in 3 milk cartons seedlings of any terrestrial plant. After they have grown to about 10 cm, they are ready.

1. To one plant add regular tap water, enough to moisten the soil.

2. To another plant add tap water mixed with a very slight amount of salt.

3. To the third plant, add a strong salt solution corresponding roughly to sea water (using actual sea water is recommended).

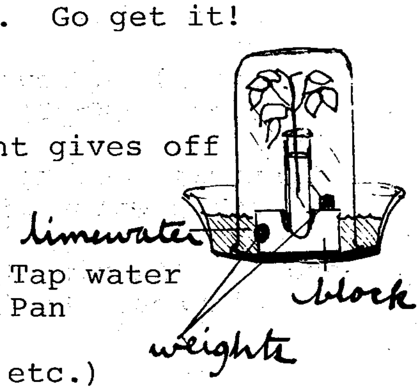
Water the plants once a day, and place them in sunlight or conditions suitable to growth of any plant. Observe their progress over a period of time, and note the plants' reactions.

The experiment could also be performed by several groups of students, each group varying the amount of salt added to a constant volume of water. The results are a dramatic demonstration of the mangroves' adaptation to saline water, and their euryhaline character.

A typical euryhaline experiment could also be performed with either fresh or salt water fishes. The results are again illustrative of the uniqueness of organisms living on the mudflat. Most aquatic organisms are adapted either to fresh water or salt water. Only a few are capable of tolerating varying degrees of salinity.

Somebody living in Osnabrock, North Dakota might have a bit of difficulty in obtaining seawater or a substitute. One benefit of living on Guam is that you're never more than 4 miles away from an excellent source of the real thing. Go get it!

5 Plant Respiration



Purpose: To show that a green plant gives off carbon dioxide (CO_2).

Materials:

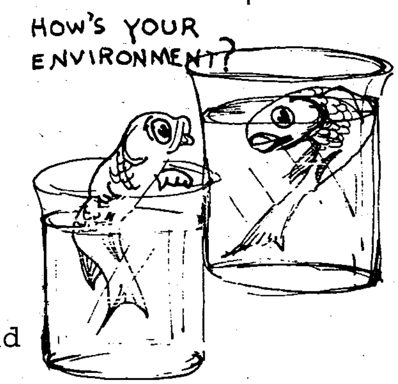
Notebook and pencil	Test tube	Tap water
Young seedling	Limewater	Pan
Beaker		
Weighted block (wood, styrofoam, etc.)		

Activity 5 - cont'd.

Background Jive: Limewater turns milky in the presence of CO_2.

Action: Place the plant in water in a test tube supported in a weighted block. Put this in a pan containing limewater and cover the test tube with a beaker. Keep in a dark place for several hours. Examine the next day.

6 Fish and Different Waters



Purpose: To observe organisms' reactions to various water samples.

Materials:

- Notebook and pencil
- Freshwater fish (same species, age and size if possible)
- At least 4 water samples (e.g. from pond or upstream or stream at low tide, ocean, mangrove flat, faucet, rainbarrel)
- Beakers, labeled, with separate water samples.

Action: Place each of the freshwater fish in a different beaker of water. Observe how the fish react. Discuss results and record in your notebook.

Discussion: Fishes that live in estuaries have the ability to adjust body salt concentration to be isotonic to the surrounding seawater. Fresh and salt water fishes are not capable of making this adjustment of their body salt content. In your notebook write what you would expect to happen in the following cases. Explain each one.

a. Freshwater fish placed in seawater.

b. Saltwater fish placed in freshwater.

c. Estuarine fish taken from freshwater and placed in seawater.

d. Why is man able to swim in both fresh and salt water without adjusting his body salt concentration?

Field Trip

Go at low tide, at least the first time.

Be prepared to get your hands and feet wet and mud to your knees! Bring notebook with notes you've made on the plants in this booklet and birds in the Beach Strand unit, pencil, a hand lens and binoculars if available, a pocket rag for wiping hands and some water to rinse your sneakers. (Don't get the bus muddy.) If your school has an Oceanography Kit, bring it along to check the physics and chemistry of the water on the flat. (See Suggested Equipment, page 35.)

Our goal: the Outer Apra Harbor mangrove flat between the roads to the dry dock peninsula and Polaris Point. (See map, page 1).

Two signs on Marine Drive (nearly opposite Spruance Drive up Nimitz Hill) indicate the dry dock peninsula road: 'Naval Supply Depot...' and 'U.S. Naval Ship Repair Facility...'

There are also interesting mangrove flats on both sides of this peninsula road, and the gravel road going north from it toward the power plants. This gravel road is shown as a dotted line on our map. It's 0.6 km (0.4 mi) from Marine Drive.

To be appreciated, the mangrove flat should have quiet, slow-moving, inconspicuous and observant visitors. You'll probably see a lot more animal life if you come alone or with a companion or two than you will on a school field trip.

To see lots of fiddler crabs, find a place with many small holes (about 1-2 cm diameter) in the mud. Squat down facing them at a little distance from the place and be very still.

While you're waiting for the actors to appear, examine the substrate carefully. What's it made of? What plants grow in it?

Soon you'll be rewarded by the emergence of dozens and dozens of the little males and females. (Here's the time to use binoculars, if you have them.) What different things do the crabs do? Estimate the population size, and density (number of individuals per square meter).

Walk slowly up and down and across the flat, searching as you go.

Keep asking yourself the ecologist's question:

'WHAT'S GOING ON HERE?'

Keep checking for answers.

Note the succession of plants from the outer edge of the flat to dry land.

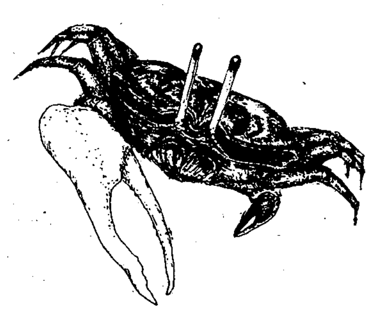
Make a list of all the species you can find. What are they doing? If you don't know names for all of them, that's okay.

Make field notes on and sketches of different organisms you see, noting where they live (=succession). Make the notes and sketches simple but accurate. You'll be able to identify those needing it and read about the species later on.

Afterward:

> How many different kinds of birds did you notice? What were they doing?
>
> What plants did you find?
>
> How many different kinds of trees?
>
> Which mangrove trees did you identify?
>
> Describe the difference between a mangrove and any other kind of tree.

In Ponape the Village hotel was recently built. It contains some 800 mangrove logs. Two hundred of them are at least 15 m long. Compare that with Guam's mangroves. What conditions could cause the difference?



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Suggested Equipment

(in order of mention)

Notebook and pencil

Potassium permanganate

Beakers

Hydrometer

pH indicator papers or bromthymol blue

Milk cartons

Salt

Test tubes

Limewater

Pans

Weighted block (wood, styrofoam, etc.)

Freshwater fish

Seawater, natural or artificial

Hand lens

Binoculars

Oceanography Kit (LaMotte Chemical Company, Chestertown, MD 21620 and other distributors - January 1977 price: $94.95 postpaid).

Glossary

Here are some words and ideas used in the text:

brackish - adj. slightly salty, (not so much as seawater).

buttress - n. a flared-out section at the base of a tree trunk.

calyx - n. the part of a flower at first surrounding young petals.

debris - n. remains, trash.

detritus - n. debris.

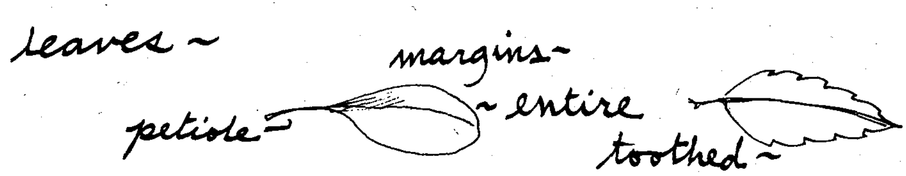
fertile - adj. capable of producing offspring.

gill chamber - n. the space in a fish containing the respiratory structures.

holdfast - n. a structure which clings to another.

introduced - adj. brought in, accidentally or on purpose.

isotonic - adj. equal in osmotic pressure.



naturalized - adj. introduced but now widespread.

nutrients - n. food.

osmosis - try Activity 3.

parasite - n. organism which feeds on another living organism.

specific gravity - n. the density (≈ weight) of a volume of one substance (in our case, seawater) compared to the density of an equal volume of pure water.

spikelet - n. small spike or stick.

spore - n. a small reproductive cell.

strand - n. land along the water's edge.

substrate - n. the ground, the bottom.

terrestrial - adj. land.

twiner - n. a vine.

Index

Here we generally give three names for an organism, Chamorro, English, and scientific (Latin). If you know just one of them you can find the other two and also where in the booklet to read something about the organism. A scientific name has two parts, the genus and the species. Although it's customary to use both parts, some of the time in *Mangrove Flat* we use only the genus. When you go anywhere else in the World and do more reading about these plants and animals, you'll find them listed by scientific names, a great convenience.

Acknowledgements

Many people have graciously contributed time and talent to the preparation of this booklet, especially Olympia Q. Camacho and Jose S. Rivera of the Chamorro Language and Culture Project; James A. Marsh, Jr., L. G. Eldredge, Richard H. Randall and Richard 'E' Dickinson of the University Marine Lab; and most especially, Philip H. Moore, botanist and teacher.