1980s MARINE TURTLE POISONING FILE

PART 2 OF 3 G.H. BALAZS

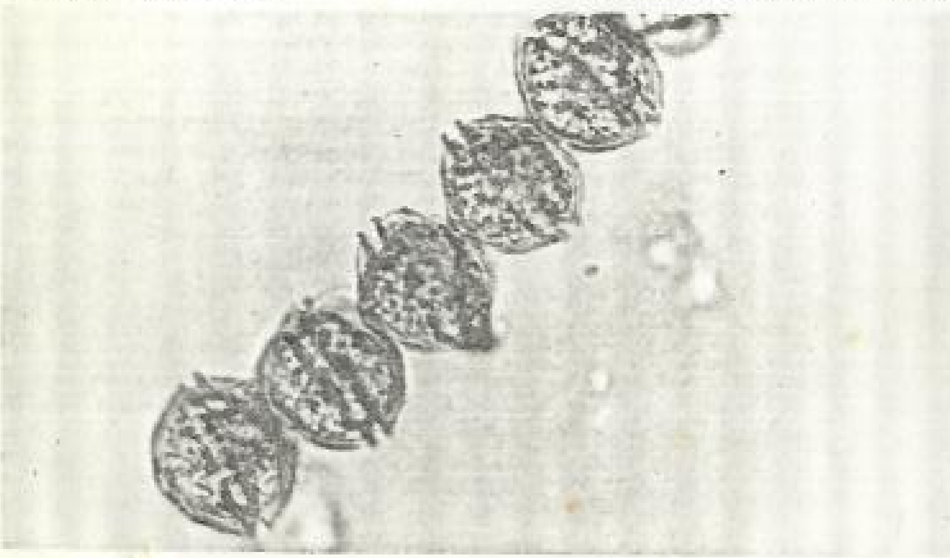
6. Monitoring procedures should include vital respiratory and cardiovascular signs, C.V.P., E.K.G., E.E.G., etc., arterial blood gases and pH.
7. Because of the possibility of consciousness persisting despite the absence of skeletal or respiratory movement, the repeated administration of a minor tranquilliser, e.g. diazepam 10 mg i.v. would seem humane.
8. Symptomatic medication may be required, e.g. analgesics, anti-diarrhoea preparations, etc.
9. On general principles, large doses of steroids (100 mg hydrocortisone i.v. 6th, hourly) could be beneficial in the severe cases.
10. Control of the epidemic. The public must be warned of the danger associated with the ingestion of shellfish. This can be achieved by the communications media (radio, T.V., newspapers) and by direct approaches to the fishing co-operatives and distributors.
11. Tracing the source from the patient to the distributors and fishermen to prevent further contaminated shellfish being supplied for public consumption.

PREVENTION

1. The unexplained presence of dead sea creatures (eels, sea birds, mollusc eating fish, etc.) is a good indication that something in the sea is poisonous.
2. Red tides (dinoflagellates) and luminescence of the water are also warning signs.
3. Cooking, and the discarding of cooking fluids afterwards, diminishes the amount of poison ingested.
4. Wherever there is any question of this, shellfish should be subjected to toxicity tests in the public health laboratories.
5. There is no way in which shellfish can be shown to be safe by visual inspection. Discolouration, folk tale techniques, and smell are unreliable guides.

"If in doubt, throw it out."

Photomicrograph of G. catenella



Wedneil Publications
Newport, Australia

1978

253pp

TURTLE AND TORTOISE POISONING

ORDER	:	Chelonia
SPECIES & SYNONYM	:	*Caretta caretta* – Loggerhead turtle *Eretmochelys imbricata* – Hawksbill turtle *Chelonia mydas* – Green turtle *Dermochelys Coriacea* – Leatherback turtle *Pelochelys bibroni* – Soft shell turtle

GENERAL

In Australia the marine species of Chelonia are termed turtles and the freshwater or land species are called Tortoises. Both have been used as food, and some of those in the north Australian waters weigh over 200 kilograms. One would have thought that the unpleasant consequences of ingestion would have made them obsolete as foodstuff, but still this animal is consumed by some ships crews, natives, etc., and is particularly reported around the Malay Archipelago and New Guinea.

There is no way of determining whether the turtle is poisonous except by trial and error. Some authors believe the poison to be similar or identical to ciguatera. Autopsy findings include hepatocellular damage, to the extent of acute yellow atrophy of the liver, necrosis of the kidney, haemorrhages and ulceration of the bowel.

CLINICAL FEATURES

- Symptoms commence a few hours to several days after ingestion of the turtle.
- Anorexia, nausea, vomiting, abdominal pain and diarrhoea in many cases.
- Abnormal sensations around the lips, mouth, tongue, throat, etc., may extend to include dryness or increased salivation and difficulty in swallowing, mouth ulcers and infla- mation may supervene and become extensive – lasting for weeks or months be healing is completed.
- Weakness, sweating, pallor, vertigo, headache.
- A generalised red itchy rash may later peel.
- Difficulty in breathing, tightness in chest, may extend to severe respiratory distress, central cyanosis (bluish tingue to lips) and death.
- Liver damage may result in jaundice, liver enlargement and tenderness, coma and death.
- Other manifestations may mimic ciguatera poisoning (page 186).

- Mortality rate is over 25%.
- Renal failure may result in a decreased urinary output and then the development of uraemia over the next few days.

FIRST AID

1. If the patient is fully conscious, induce him to vomit by inserting fingers in his throat. Syrup of Ipecac U.S.P. 8 ml orally may aid in this. Treat any other potential victims (e.g. other people who ate the turtle) in the same way.
2. Rest and reassurance.
3. Resuscitation if needed. This will usually be in the form of mouth to mouth respiration (page 187) in those patients who develop severe respiratory distress, unconsciousness with cyanosis (bluish colour), etc.
4. Hospitalisation and observation is always needed until recovery.

MEDICAL

1. First Aid as above. Gastric lavage (apomorphine 2–8 mg s.c.) or other emetics if the laryngeal reflex is unimpaired.
2. With respiratory involvement, the ideal treatment is to perform endotracheal intubation and control respirations. The use of an endotracheal tube will also prevent the aspiration of vomitus, particularly likely under the conditions of a bulbar paralysis with gastrointestinal symptoms. If this is not achieved, then maintain respiration by any method at your disposal.

   Assisted intermittent positive pressure respiration (e.g. with a Bird respirator) may be of value when there is only a mild impairment. If there is a rising arterial CO_2 level or an increasing respiratory rate, assistance with respiration is required but oxygen supplementation is not needed.

   When there is a more severe degree of respiratory depression with symptomatic distress and/or cyanosis, an increasing arterial CO_2 and a decreasing arterial O_2, it would be prudent to completely control respirations by the use of endotracheal intubation and mechanical ventilation. Monitoring of serial arterial O_2, CO_2 and pH levels is required. The patient should be maintained on the regime for at least 6 hours and then gradually weaned from the respirator over the next 12–24 hours.
3. Ensure fluid and electrolyte replacement and administer medication by intravenous means (record vital signs, serial haematocrit, S.G., electrolytes, C.V.P., E.K.G., urinary output and analysis, etc.).
4. Sedation should be achieved with non-respiratory depressants, e.g. diazepam 10 mg i.v. repeated as required. Small doses of opiates may be needed for pain.
5. Steroid cover, e.g. hydrocortisone 100 mg i.v. 6 hourly during the danger period is possibly of value – but is non-specific in its effect.
6. Treat the bowel disorder symptomatically.
7. Monitor the clinical, biochemical and electroencephalographic manifestations of hepatocellular damage, and correct these by the customary medical dietetic and antibiotic techniques.
8. Monitor the clinical and biochemical manifestations of renal failure and correct these by dialysis as required.

PREVENTION

Refrain from eating turtles.

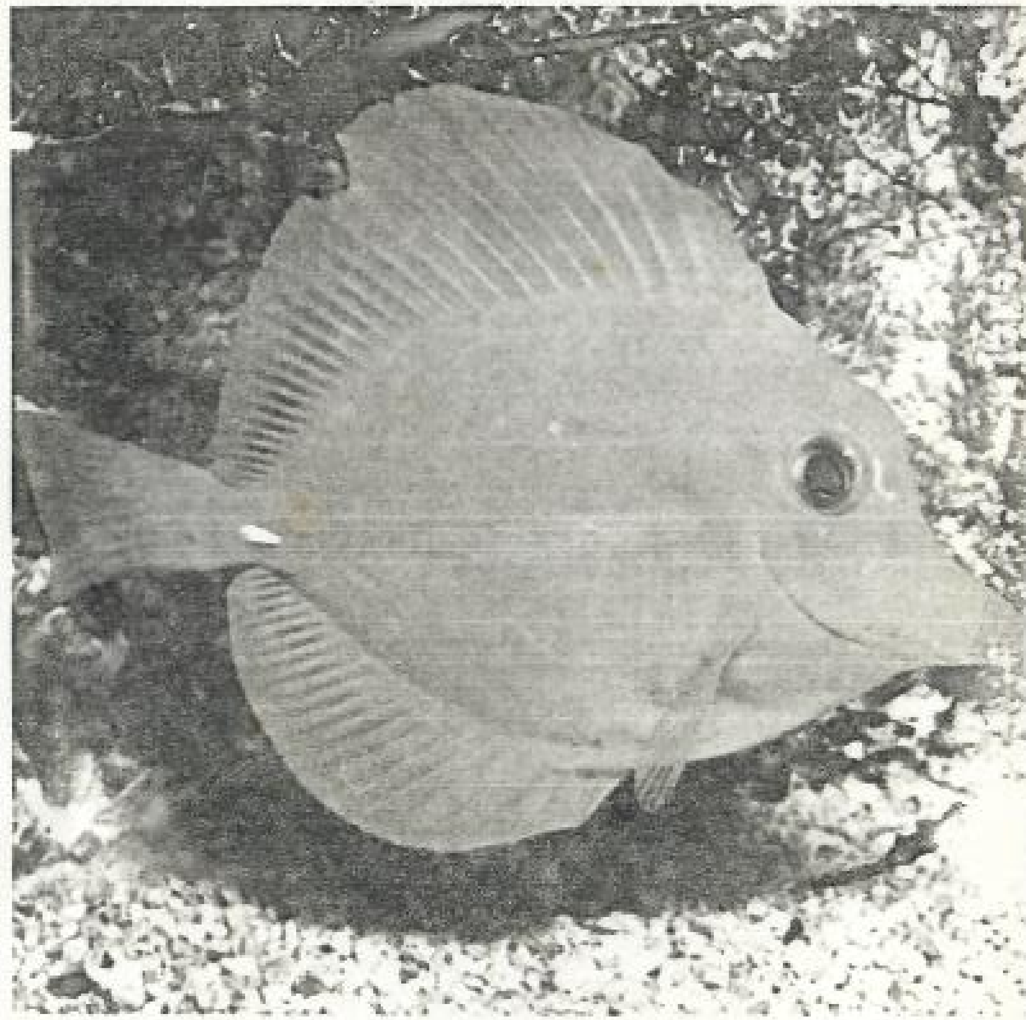
CHAPTER 6

RESUSCITATION FOR RANK BEGINNERS

Cover Photograph: P. Lane — Shark
Cover Photograph: K. Gillet — Blue Ringed Octopus

DANGEROUS MARINE ANIMAL OF THE INDO-PACIFIC REGIO

by DR. CARL EDMOND



Photograph: E. Frie

DIVING MEDICAL CENTRE MONOGRAPH ON IDENTIFICATION FIRST AID AND MEDICAL TREATMENT

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C. KENNETH DODD, JR.

Sea Turtles in Indian Waters

Seaturtle Investigation: S. Valliappan assisted by Solomon Pushparaj.

Tuticorin, 12th—17th June, 1973. Sponsored by Madras Snake Park Trust, Madras—22

Introduction:

Upon inquiring we found that there are no existing laws protecting the five genera of seaturtles and their eggs in India and no control on the exploitation of these endangered animals. Although it is not a major export industry the present pressure on these international animals is too great to allow their continued survival. In order to provide a sample of what the seaturtle industry is in India we deputed two members of the Madras Snake Park Trust staff for a one week investigation in Tuticorin, a centre for the turtle industry in India (South). The following is their report:

Sea turtles found around Tuticorin (in order of abundance)

English name	*Scientific name*	*Tamil name*	*Translation*
1. Green sea turtle—	Chelonia mydas	a) Paeraamai	Big turtle
		b) Thaenaamai	Honey turtle
2. Hawksbill —	Eretmochelys imbricata	Nanjaamai	Poisonous turtle
3. Loggerhead —	Caretta caretta	a) Panguni	
		b) Perunthalaiyan	Big headed turtle, a Tamil month, (Mar. 14th April, 14th) when they are most common
4. Ridley's	Lepidochelys olivacea	Paingiliaamai	Beautiful parrot turtle.
5. Leatherbacks —	Dermochelys coriacea	a) Ongal	'which has grown huge'
		b) Aezhu vari aamai	Seven lined turtle

People interviewed: Local fishermen, fish exporters, State and Central Fisheries Departments, fish market people, fishing trawlers, local public, harbour people.

A. General notes:

The fishermen (even their kids) are very fast at naming sea turtles from pictures. According to them 90% of the turtles caught are the Green sea turtle. They associate the

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presence of turtles throughout the year with the abundance of food in the waters around the coral reefs near this coast. There is a chain of about 20 small islands and atolls extending 160 km. along the coast from Tuticorin to Rameswaram, 5-6 km. off shore. The average water depth is 2 fathoms between shore and islands and 3 fathoms in channels between the islands. According to the fishermen this is ideal depth for sea turtle feeding and mating. The fishermen know the reefs very well and are careful not to smash their boats. They call the reef 'Paarai' which means rocks. They say the habit of the sea turtle is to use the high tide to get over the reefs to find feeding places and come back with the receding tide. By this time the fishermen have placed their heavy large holed nets of a bottom set type (Paaichchuvalai) accross the channels between islands and reef or parallel to the reefs. The normal tide variation is 1.4 metres ; the bottom between mainland and islands is mostly muddy. The fishermen believe that the turtles feeding in this area go to the islands with the least human interference for nesting because they don't see much egg-laying. Others feel that though they feed in this area the turtles go elsewhere, probably along northern beaches, to nest. There is very little sale of eggs in this area. The fishermen note very little seasonal variation in numbers, sea turtles are always around. They say that the stretch of beach between Tiruchendur and Indinthakarai is a turtle nesting area and they believe that Ridley's sea turtle come in great numbers to lay eggs there. They mention that "a Ridley found will be a female full of eggs". They believe that Ridleys come ashore a few days before actually laying and digs a few test holes. Some years ago great numbers of nests could be seen along beaches near Manappad ; it is also said that the beaches of Ceylon, Laccadives and Minicoy islands are well known nesting areas.

The fishermen call the 'turtle grass' on which the Green Sea turtle feeds "kadal paasi", they also note that barnacles are found on turtles that feed at one place for a long time. We removed barnacles from the sides of the head, mid-plastron and mid-carapace, but only a few turtles had them.

With reference to the Hawksbill turtle its meat is sometimes poisonous, perhaps because of some seasonal change in feeding habits. Some fishermen say 2-3 Hawksbill in every hundred are poisonous throughout the year. In 1972 about 20 persons died in Thazai village from Hawksbill meat poisoning. Experienced turtle catchers are able to identify poisonous meat. There are three maintests :

Not poisonous

1. Blook drips off knife blade quickly.
2. A drop of blood on the skin does not itch.
3. When the meat is washed with a bit of lime added it does not change colour.

Poisonous

1. Blood thickens on knife blade.
2. A drop of blood on skin itches and the spot becomes inflamed.
3. The additon of lime changes the meat to a green colour.

The symptoms of Hawksbill poisoning are swollen lips, vomiting, "cleft tongue" in 2-3 hours after consuming the meat. Some fishermen maintain that the best months for turtles are July-September which corresponds with the highest tides, June, July and August. They observe that when Green Turtles are mating nothing bothers them and they can be easily hauled out. They are said to lay eggs 4-5 times a year. There is some association with cobras which also carefully choose a place to lay their eggs. Most fishermen have not seen baby turtles, but only yearlings.

The previously mentioned islands along this coast are of a rigid calcareous framework, covered with sand. The vegetation is thorny scrub with hares, saw-scaled vipers, sand boas, bearded lizards, larks, wading birds and crabs being the main flora and fauna. Except for Krusadi Tivu all the islands are uninhabited but their waters are frequented by small fishing boats. Hare Island (now no longer an Island but attached to the mainland to form the Tuticorin Harbour Project) was once the site of much sea turtle activity but which has ceased because of all the underwater blasting and construction. This is a well-known pearl fishing area which is carried out for one season every two years. The other islands in the chain are said to be very similar to Hare Island, most of them average 3-6 kms in size. Beach temperatures we recorded were high; 48°C Low 30°C.

B. The Market at Tuticorin

Every Sunday morning between 6 and 8 a.m. 20-30 sea turtles (mostly Green Sea) are slaughtered at the Tuticorin fish market. These are all animals caught either by chance or by those fishermen who specialize in turtle catching. They are kept in pens (20' by 20') in a marshy area (water 3'-4') at Roche Park near town or sent by rail from near by coastal towns, addresses inked directly on the plastron. About ten years ago there was a big export market to Ceylon (evidently for re-export). Since then Ceylon stopped sea turtle import rnd more recently put a total ban on sea turtle killing. After sometime West Germany and the U.S.A. were the main countries buying the frozen meat shipped in ship's reefers. At that time the dealers would buy large numbers of turtles from the fishermen and the take was about 4000 per year (at present it is 1500, mostly local use). Some dealers even constructed big holding tanks 40' by 40' for storing live turtles. At present there is little export market but the dealers and fishermen, based on their correspondence with Japanese and American dealers feel that the business will boom again for them.

So far the trading has been irregular but once the regular ships start arriving with the nearly finished Tuticorin Harbour Project the business will also become regular they say. They say they still have good contacts in U.S.A., Japan, W. Germany and Europe. Japan seems most interested in the shells, possibly both for the outer shell for polished

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Conclusion No

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Anyway, on Sunday morning there is a long 'Q' for turtle meat and one by one the animals have their throats out by a boy who also carries a cup to collect the blood. Blood is carefully collected and a 250 ml. glass costs 1 rupee and drunk on the spot like an elixir. An average green turtle gives 10 to 12 glasses of blood and that from the lungs, heart, liver is considered particularly good in curing certain consumptive diseases. The meat is sold at Rs. 4 per kg. and an average turtle yields 40 to 50 kg. The shell can be sold for Rs. 50 so the average turtle on the market is worth Rs. 250 or more. It is purchased from the fishermen at the rate of:

Rs. 10-15 for sizes 45 to 55 cm. length.
Rs. 25-30 for sizes 60 to 70 cm. length.
Rs. 45-60 for sizes 90 to 100 cm. length.
Rs. 65-75 for sizes over 115 cm.

The 90-100 cm. length Green Sea turtles are most common weighing 50-60 kilos, roughly 70% are females, 20% males and 10% young. The head, flippers, liver, fat, meat and guts are all eaten. People prefer the medium sized turtles, saying that young turtle meat is too lean and big turtles too coarse. The shells of Green turtles are sold at Rs. 20 per kg. and the plastron (lower shell) at Rs. 40 per kg. Hawksbill shell sells for Rs. 100 to 150 a kg. and exported mainly to Japan. Leatherback carapace is cut into small pieces and boiled to prepare an oil to paint boats against leaks. There is no local demand for shells, but some dealers store them for possible foreign orders.

Conclusion Notes:

It has been observed by various Snake Park associates and correspondents that besides Tuticorin many other coastal and island towns have a sea turtle industry. These include coastal Orissa, Bengal and Kerala, the Andamans, Maldive and Minicoy Islands. In addition it may be assumed that wherever there is a fisherman population sea turtle eggs are harvested. In Madras in December and January large quantities are sold by door to door vendors for up to 15 paisa each or at 5 paisa each wholesale from the fishermen. The taste for the meat is restricted to certain religions and castes, for example in Tuticorin it is only the *Catholic* Christians who go in for turtle meat.

It is imperative that we accept the findings of the I.U.C.N. on the endangered position of the world's sea turtles, and urge our legislators into protective action. Simultaneously we hope to work on public opinion and developing interest in the habits and ecology of the marine turtles to help their position. All sea turtles should be placed on Schedule 1 of the Wild Animal Protection Act, 1972 giving them complete protection. Since they do offer a valuable source of protein eventually they can be carefully exploited.

In their present depleted state however it is only logical that we afford them full protection while studies are being made and population surveys are made in different parts of the world.

The Madras Snake Park will continue its research into sea turtles as part of our general interest in reptiles and especially in seeking recognition and protection of the commercially exploitable species. Total protection of the sea turtles will only be a minor inconvenience to a very few people and of great potential benefit in the long run.

NORMAN W. BEBERMAN, M.D.
ANDERS G. J. RHODIN, M.D.
Orthopaedic Associates, P.C.
Telephone: 345-1144

Burbank Professional Building
Nichols Road
Fitchburg, Mass. 01420

April 12, 1984

Dear Dr. Balazs,

I saw your note in the latest Marine Turtle Newsletter about sea turtle poisoning in Tonga, and wanted to write you. Though I have never personally seen any cases, and do not know of any unpublished ones, I thought you might be interested in the short bibliography I have compiled over the years concerning this subject. My interest in sea turtle poisoning stems from not only my medical background, but also my interest in Papua New Guinea where I spent several months involved in both medical work and herpetological collecting. As you may be aware, I am also involved in turtle research. I have enclosed some of my recent sea turtle papers for your interest.

Perhaps there are some of the following articles that you were not previously aware of. Some of them are somewhat difficult to obtain. Should you need copies, then I have them here and can send you xeroxes.

Bierdrager, J. 1936. Een geval van massale schildpadvergiftiging in Nw. Guinee. Geneesk. Tijdschr. Nederland-Indie 76:1933-1944.

Deraniyagala, P.E.P. 1939. The Tetrapod Reptiles of Ceylon. Vol. I. Testudinates (p.191)

Dewdney, J.C.H. 1967. Turtle meat poisoning -- the New Ireland epidemic, 1965. Papua New Guinea Med. J. 10:55-58.

Likeman, R. 1975. Turtle meat and cone shell poisoning. Papua New Guinea Med. J. 18:125-126.

Likeman, R. 1977. Turtles and botulism. Papua New Guinea Med. J. 20:93.

Romeyn, T. & G.T. Haneveld. 1956. Turtle meat (Eretmochelys imbricata) poisoning in Netherlands New Guinea. Doc. Med. Geogr. Trop. 8:380-382.

Siegenbeek van Heukelom, A. 1936. Doodelijke vergiftiging na het eten van een schildpad, gevangen bij Billiton. Geneesk. Tijdschr. Nederland-Indie 76:1945-1947.

Silas, E.G. & A.B. Fernando. 1984. Turtle poisoning. In: Silas, E.G. et al. (Eds.), Sea Turtle Research and Conservation. Bull. Cent. Mar. Fish. Res. Inst. 35:62-75.

I hope these references will be of some use to you. Best of luck in the completion of the project. I would be very interested in seeing your manuscript when it is completed.

Sincerely,

Anders Rhodin

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Southwest Fisheries Center
Honolulu Laboratory
P. O. Box 3830
Honolulu, Hawaii 96812

April 20, 1984

Dear Dr. Rhodin:

I certainly want to express my appreciation to you for sharing your list of mostly obscure, but undoubtedly valuable, references to turtle poisoning. Four of the citations were completely unknown to me. Our librarian here is working to obtain copies for me. If problems arise, I will call upon you, but don't want to put you to the trouble unless necessary. At some point in the future, I would like to prepare a manuscript on the subject. It has been inadequately addressed - at least here in the Pacific. Even the recent FAO Synopsis covered it lightly. I would be pleased to collaborate with you, if you are willing. Attached is a copy of the report I received from the medical officer in Tonga. Please do not copy this to others at this time.

Again, thank you for your letter, and also the reprints.

Best regards,

George Balazs

becoming increasingly big business. Shell ornaments are popular, especially among people of Bengali origin.

Near the jetty at Katchal island where I utilized the stopover period of a inter-island ferryboat to take a quick plunge in the sea, I excitedly beheld the first colony of garden eels (troglodyte eels) that I had seen, on a sloping sandy bed in about 15 ft of water. As I approached them, they simultaneously retreated tail-first into their sandy burrows, swaying like stalks of vegetation in the gentle swell. Dr. Hans Hass has recorded the presence of troglodyte eels from deeper water off Great Nicobar island, but whether or not these were of the same species as the ones I saw, I am unable to confirm.

Close to the town of Wandoor in South Andaman, the intertidal fauna is particularly rich. Large chitons cling to spray-moistened rocks; sea cucumbers of at least five species are found in the shallows. A small pale white octopus crawled over rocks exposed by the tide.

South of the hamlet of Pulo Babi on Great Nicobar island, I twice observed avian predators — perhaps Nicobar Serpent Eagles — snatch up octopi from a reef exposed at low tide. In one instance the bird was forced to drop its prey after partaking of a bite or two, because of the mollusc's weight. Despite having a chunk missing from its mantle, I found the octopus to be alive and active after its fall.

I was fortunate enough to see civet cats (Paradoxurus tytleri) on two occasions: Once at day break on uninhabited Tarmugli island at a distance of ten feet as it leisurely climbed to the top of a tall tree, and another individual at dusk as it searched for titbits among crevices in the exposed reef on Rutland Island, much as I had observed wild pig do in Little Andaman. On both occasions the civets displayed a degree of apparent unconcern about the proximity of a human being that was startling to me.

It is to be hoped that the rapidly expanding population in the Andamans and Nicobars and the influx of refugees and settlers, with the resultant need for living space and resources like timber, will not result in the undermining of its irreplaceable forest wealth or cause the disappearance of the the surviving negrito tribes and of their culture.
Satish Bhaskar.

TURTLE MEAT KILLS THREE

Tuticorin, June 17, 1980 (UNI)

Turtle meat took three lives — one directly and two indirectly -- today. Two suckling infants aged six months and one year died after their mothers had taken turtle meat, and a seven-year old girl who took the meat also died today, official sources said.

Seventy nine people (all fisherfolk) including several women of the fisherman colony of Trespuram who had taken turtle meat on Sunday (June 15, 1980) were treated at the Government headquarters hospital here. 57 were treated as out-patients and 22 were still in hospital.

From the 'Indian Express' Wednesday, June 18, 1980.

It appears likely that the turtle in question was a Hawksbill seaturtle (Eretmochelys imbricata), a species which has been indicated recurrently as causing deaths in India and Sri Lanka. The following instances have been recorded:

On 6th and 7th August 1977, nine persons — two adults and seven children of varying ages — died in the village of Manappad, southern Tamil Nadu from eating, on 3rd August, the meat of a seaturtle whose head was described as being somewhat aquiline, and as resembling a parrots beak. The seaturtle was also known locally as "Natcholy Ammai" which means "turtle with a mouse-like head" and had a yellow plastron whereas that of the seaturtle species that was usually consumed (in all likelihood, the green turtle, (Chelonia mydas) was always white. On this occasion, some of the fishermen's advice against consumption of the meat, on the basis of it being of an occasionally poisonous variety, went unheeded. In 1970, deaths occurred at the village of Periathalai, 7 miles from Manappad, from the consumption of turtle meat.

In 1972, about 20 persons died in Thazai village from Hawksbill meat poisoning. (Valliappan and Pushparaj, 1973).

Deraniyagala (1953) cites instances of deaths in Sri Lanka in June 1921 at Mandaitivu (24 persons) and on December 3, 1941 at Habaraduva "Its toxicity is though to be due to the diet of the animal at the time; ... accordingly fishermen chop its liver and throw it to the crows before cooking its flesh. If the crows refuse it, the animal is discarded. Another test is to mix the raw flesh with slaked lime which turns greenish if the flesh is poisonous".

Valliappan and Pushparaj cite additional tests that some Tuticorin fishermen employ: the turtles blood drips off quickly if the meat is nonpoisonous and thickens on the knife blade if poisonous. A drop of blood on the skin itches and the spot becomes inflamed if the meat is poisonous.

Among symptoms of Hawksbill meat poisoning are:

Neurological symptoms like vertigo, twitching of the muscles leading to convulsions, coma and finally death. Ulceration throughout the buccal cavity, severe itching sensation in and sloughing of the upper layers of the tongue. A sensation of obstruction in the chest, respiratory failure followed by cardiac failure.

In the absence of knowledge of the exact type of poison involved, patients were given high doses of tetracycline, massive doses of vitamin C and corticosteroids and were put on plenty of fluids and diuretics. Where treatment was started before the collapsing stage, cases responded very satisfactorily to the administration of 'Siquil' as an antiemetic, "Anthisan" tablets for food allergy and "Terramycin" injection for the infection. In all cases where death occurred, one to four days elapsed from the time the meat was consumed.

The above data were kindly supplied by Berchmann Moraes and Dr. B.V. Balaji of Manappad, and by Drs. S.C. Thanupillai, G.C.I.M. and Dr. Ramasubramaniam of Udangudi.

S.B.

* * *

MUGGER (Crocodylus palustris) RELEASES IN ANDHRA PRADESH & TAMIL NADU

Andhra Pradesh

On 7th April 1980, the Andhra Pradesh Crocodile Conservation project released 33 mugger crocodiles (11 males and 22 females hatched in June 1977) into the Kinnerasani reservoir situated within the Kinnerasani Wildlife Sanctuary. This sanctuary is located 300 km north-east of Hyderabad. The released crocodiles all ranged from 1 to 1.3m in size. Follow up monitoring survey of the released crocodiles was carried out in August 1980. Some have shown a upstream movement of over 15 km during this monsoon time.

During previous surveys in this reservoir only a few (less than five) resident muggers were reported. No breeding has taken place in past years. Since, the released muggers are all of Gir (Gujarat) origin and are a very slow growing strain (1.2m in three years!) it was decided not to mix them up with the resident Andhra Pradesh wild breeding stock occuring in the Krishna and Godavari rivers and some other tributary rivers. The remaining 58 Gir muggers of 1977 origin are being released in Pakhal Wildlife sanctuary and again in Kinnerasani sanctuary. These releases are planned for the coming winter (November 1980 to February 1981).

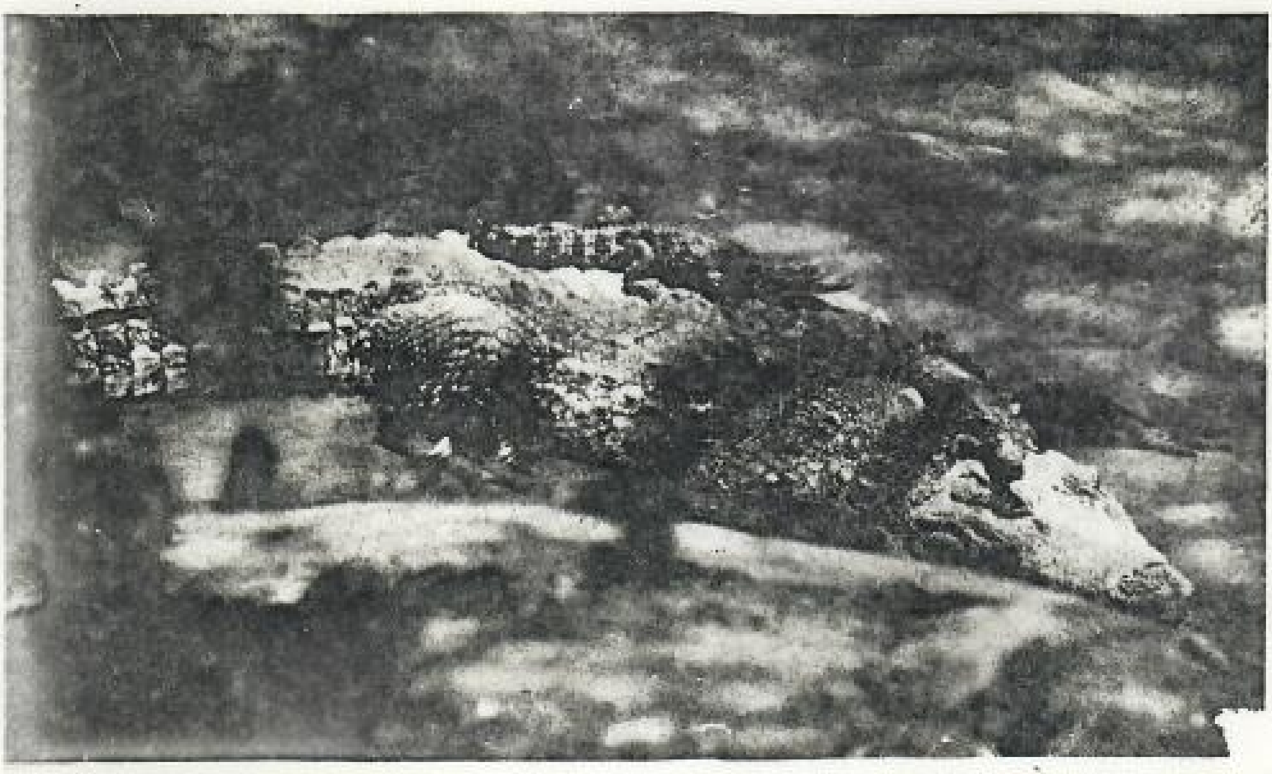
Tamil Nadu

The second large scale mugger release by the Tamil Nadu Crocodile Conservation Project was carried out at Hoggenakal in May 1980. (The first release was

SUBSCRIPTION

Local : Rs. 10 annually
Foreign : $ 2 annually (surface)
$ 4 annually (air-mail)

Cheques should be made to the Madras Snake Park Trust



Newsletter of the Madras Snake Park Trust, Guindy Deer Park, Madras-600 022. Edited by Zai Whitaker.
Information may be used elsewhere with acknowledgement given to Hamadryad, Madras Snake Park Trust.

NOTES ON A RARE CASE OF TURTLE POISONING

By INOCENCIO A. RONQUILLO and PRISCILLA CACES-BORJA
Of the Philippine Fisheries Commission

ABSTRACT

A rare case of turtle poisoning which occurred in a Muslim community at Cotabato, Mindanao, is reported. The meat, eggs and entrails of a sea turtle normally found in the locality were boiled and eaten, after which 11 individuals, as well as dogs, who ate the entrails died. Description of the turtle thru letters showed that its possible species is *Eretmochelys imbricata*, the hawksbill turtle. Although a previous case of poisoning was reported from a nearby locality, yet no accurate data were taken for comparison.

The symptoms noted showed the neurotoxic action of the poison which was similar to other cases previously reported in the literature. The epithelium of the buccal cavity was severely affected.

Samples of the turtle meat were salted and sent to the Manila Health Office for analysis, but it failed to show the symptoms of poisoning when fed to rats.

A review of literature of cases of turtle poisoning was made. A previous case in Cebu, Philippines (1917) was cited although Taylor (1921) believed that it was the green turtle, *Chelonia mydas* L. which caused the poisoning. The symptoms exhibited in these two Philippine cases were more or less identical.

This paper is a report on a rare case of turtle poisoning which occurred in Rosa community, Dinaig, Cotabato, Philippines.

On February 5, 1954, there was a gathering of Tirrurays, a Moslem community in Barrio Rosa, Dinaig, Cotabato, in connection with spiritual rites for a deceased. In this celebration, the guests, including their dogs, were served with meat, eggs and entrails of a sea-turtle, commonly eaten in said locality and known as *payukan*. The local name for this turtle is hawkbill turtle, *Eretmochelys imbricata* Pennant. The turtle's meat was prepared in the usual way as used by the natives wherein pieces of meat were boiled. Of the people who partook of this boiled turtle's meat, a total of 11 individuals, eight males and three females, died. Likewise, many dogs, which ate the entrails of the turtle, died also.

The approximate carapace size of the turtle was about one meter in length and about 61 cm. in width. As described (per comm.), this turtle had thin scutes which indicated that it had been previously caught while still young, its scutes having been removed and then thrown back into the sea, because it is locally believed that it would develop another set of scutes. The scutes of this turtle are commonly known as the *tortoise shells of commerce*, and it is the common practice in the locality to return the tortoise to the sea after removing the scutes by heating the carapace over the fire until the shell is loosened.

In another adjacent community in Kimini, Cotabato, the same kind of turtle, with a new growth of scutes, had caused a similar poisoning during the same season. Inasmuch as this is the only turtle wherein scutes are removed for commercial purposes, we believe that the identity of the species is, more or less, accurate. Furthermore, the egg diameter (2.5 to 3 cm.) is the normal size of this turtle.

Symptoms.—A few hours after partaking of the cooked meat, the victims complained of hot sensations at the region of the abdomen, accompanied by cold sensations at the extremities. A strong feeling of nausea ensued which caused some of the victims to vomit a portion of the food they ate. This condition persisted until the following day when dizziness then set in, accompanied by degeneration of the sense of balance, together with blurred vision and a feeling of sleepiness. To some of the victims, vomiting and diarrhea had been very severe. After 3 to 4 days in this condition, the mucous membrane of the mouth and throat of the victims became red and swollen, becoming sore later. These membranes assumed the appearance of having been scalded with hot water. The tongue, particularly, became heavily coated with a whitish membrane. Because of this condition of the mouth, throat, and tongue, the victims had extreme difficulty in eating and even in drinking. Some patients complained of frequent urination of highly colored urine. Of the victims who partook of the feast, six children, ranging from 1½ to 4 years old, one young man, aged 35, and three older people, 50 to 60 years old, died.

Eight days after the poisoning, the District Health Officer of Cotabato, who was called to attend to the cases, advised the patients to gargle warm water with normal saline solution to prevent further infections of the mouth.

Those who were still alive at the time were very weak and were given a liquid diet of boiled rice, and tea or coffee. Those who were seriously ill were given muscular injections of caffein and sodium benzoate.

The Health Officer sent samples of the turtle meat to the Manila Health Office for analysis. Furthermore, he gave the clinical data for which we are greatly indebted. The meat was fed to laboratory rats, but these did not show any symptoms of poisoning. The meat was heavily salted and dried. However, it was washed to remove most of the salt before boiling in water. Both meat and water were given to the animals. Reports from the Public Health Research Laboratories, Manila, indicated negative results as far as active ingredients were concerned. Rats fed with the meat, which was boiled after washing, were not affected at all. It is possible that the salt used to preserve the meat might have destroyed the poisonous nature of the flesh.

This information was verified by the Municipal Health Officer of Cotabato.

Inquiries made in Zamboanga City indicated that there is no known case of turtle poisoning in that City where green turtles (*Chelonia mydas*, L.) are butchered regularly throughout the year. The Muslim population there relish the meat of this reptile without any mental reservation. That no reported case of turtle poisoning in that city where a lot of marine turtles are being butchered more than in any other part of the Philippines is therefore interesting.

Review of Literature:

The earliest record of turtle poisoning was from the New World. It took place at Saint Jacques, Windward Islands, North America, way back in 1697, as reported by the monks, Damplier and R. P. Labat, in 1724. Labat stated that Jean Montididier, also a monk, bought a tortoise plastron of probably *Eretmochelys imbricata* Pennant, and in spite of his warning, ate as much as he could. As a result, after four days, he was covered with boils. These were accompanied by a terrible diarrhea and high fever for which he suffered for eighteen to twenty days. Father Labat himself, who took caution in partaking of the turtle's meat, had a little diarrhea for six days, accompanied by three boils.

Cleland, sometime in 1845–47, cited from Banfield's "Confession of a Beachcomber" that in some localities in northern Queensland, Australia, the flesh of the hawksbill turtle, *Eretmochelys imbricata* is said to be imbued with a deadly poison, so that care should be exercised in the killing and butchering of this animal, lest a certain gland, located in the neck, be opened. The poison is so toxic that flesh cut with a knife which has touched the critical part, becomes impregnated with the poison. One old seafarer acknowledged that he nearly "pegged out" after a hearty meal of the liver of the hawksbill.

"Banfield also states that the flesh of the luth or leathery turtle, *Dermochelys coriacea,* also causes symptoms of poisoning.

Chevellier and Duchesne (1851) reported that the hawksbill turtle, *Eretmochelys imbricata,* is not good to eat; that it has a special purgative quality according to Damplier and Labat, (*op. cit.*), and that, when eaten, one may be "certain of being covered with boils," if there are some impurities in the body. But if eaten sparingly, the flesh can cure some diseases. When the flesh of this turtle is salted, it loses its purgative effect,

Tennent (1861) reported that the flesh of sea turtles caught in the southwest coast of Ceylon during certain seasons is avoided because they are poisonous. Tennent cited a case of poisoning at Pantura, near Colombo, Ceylon, where in October, 1840, twenty eight persons who partook of a sea turtle were seized with sickness immediately after which a coma supervened and 18 died during the night. Those who survived related later that the flesh of the turtle was fatter than that of the ordinary. He also stated that similar fatal occurrences had been attributed to turtle curry, although there was room for believing that the poison might have been contained in some other ingredients.

The first Philippine report on turtle poisoning was made by Taylor (1921) and cited that the turtle alluded to in Sir Tennent's report (*op. cit.*) was a *Chelonia virgata* [*Chelonia japonica* (Thunb.)]=*Chelonia mydas* (Linnaeus). Taylor (*op. cit.*) cited a case of turtle poisoning in the Philippines, presumably by *Chelonia mydas.* It occured in November, 1917, in Bantayan Island near Cebu. Fourteen deaths were reported out of 33 cases. The victims suffered from pain in the throat and lips vomiting, and drowsiness. Two of those who died had their symptoms very much delayed, coming out after 8 days of partaking of the turtle's meat. Nevertheless, they had symptoms of poisoning similar to those who died earlier and they died after 6 days. It was also reported that relapse in this case occurred even after cure had set in. The

tendency to drowsiness from the moment symptoms appeared was also manifested, and even if improvement under treatment appeared later, still the victims died. It was noted that there is a great similarity of symptoms between the poisoning of 1917 in Bantayan Island and that of the present case. Read (1917) had scattered references to turtle poisoning but without proper identification of the real species.

The similarity of these two recorded cases of turtle poisoning in the Philippines indicates a strong credence that there is really a poisonous substance at times in the meat of some sea turtles which are caught in the Philippines that causes death, although the particular species is not clearly verified in all cases.

It should be noted that like the report of Chevellier and Duchesne in 1851, the flesh of the poisonous turtle, when salted, loses the purgative effect. The flesh of the turtle in the present case showed the same findings when a piece of its meat was sent to the Public Health Research Laboratories in Manila for analysis, just as a sample of meat from the 1917 poisoning was also sent in for examination. In both cases, the meat was heavily salted and dried, and the examination of the flesh failed to reveal the presence of any known poison.

It was noted that, inasmuch as the diarrhea following the eating of turtle's meat had a very dehydrating effect, most of the victims who died in the present case were both young and old. Although one of the dead was 25 years old, this supported the observations of Chevellier and Duchesne: "It is necessary to be of strong, robust nature to resist this evacuation." That the flesh samples delivered at the Government Laboratory in Manila did not have any trace of poison or any effect on experiment rats may be answered from the report of Chevellier and Duchesne (1851) that, if the flesh of the hawksbill turtle has been salted, the purgative effects of poison are lost.

Deraniyagala (1939) noted that the flesh of the leather back turtle, *Dermochelys sp.,* is also reported to possess faintly toxic properties during some seasons when taken on the east coast.

From the review of the literature, it is more or less, concluded that the sea turtle which caused the mass poisoning in Barrio Rosa, Municipality of Dinaig, province of Cotabato, is of the spicies *Eretmochelys imbricata.*

ACKNOWLEDGMENT

We are indebted to Mr. Amado B. Diaz, Municipal Health Officer, Cotabato, Cotabato, for supplying some pertinent information, leading to the indentification of the species of the turtle, and also the report on Sitio Kimini. We are also indebted to Dr. Brune W. Halstead, M.D., for sending us copies of the rare articles on turtle poisoning.

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DEPARTMENT OF MILNE BAY
Provincial Hospital
ALOTAU
Milne Bay Province
Papua New Guinea

15 January 1985

Mr George H Balazs
Wildlife Biologist
National Marine Fisheries Service
P O Box 3830
2570 Dole St
Honolulu
Hawaii 96812
USA

Dear Mr Balazs,

RE: SEA TURTLE POISONING

I have never treated a case of this in over 6 years as superintendent of this hospital which caters for 135,000 mainly rural coastal people. I must therefore conclude that it is rare here. However, I have circulated a questionaire to our 32 rural health centres to inquire as to whether they have seen any cases and will try to let you know the results in true course. The only local references I know of to this topic are found in the Papua New Guinea Med J. 1967; 10: 55-58. Dewdney JCH. Turtle Meat poisoning. The New Ireland Epidemic, 1965; also 1975: 18:125-26. Likeman R. Turtle meat and cone shell poisoning (letter).

2 citations here

Since you may find these references hard to obtain, I enclose photocopies. Unfortunately they are not particularly comprehensive. I would be grateful to receive any papers which you have written or have on this subject.

Yours truly

Peter Barss

PETER BARSS (DR)
Medical Superintendent

PB/ls

A Case Report

BY J. C. H. DEWDNEY.

TURTLE MEAT POISONING— THE NEW IREAND EPIDEMIC, 1965

ALTHOUGH turtles are [illegible]ll around the coast of New Guinea, and are eaten with relish by the indigenes, reports of turtle meat poisoning are few. Lagi (1932) working as an Assistant Medical Practitioner in Papua heard reports of an incident there in which most of the inhabitants of an off-shore island became ill after eating turtle, and some of these people were thought to have died. Campbell (1960) in questioning many people from different districts in the Territory found only one man able to recall an outbreak of illness following the consumption of turtle meat. In this incident, which occurred near Samarai, seven people were said to have died. Rapson (1966) recalls an epidemic of illness following turtle meat eating on the island of New Hanover (New Ireland District) some ten years ago. The turtle responsible for this illness was dead before being brought ashore. No detailed information is available regarding any of these three episodes.

The reefs around the New Ireland coast provide good hunting grounds, both for turtles and turtle catchers. Late in 1965 a villager caught one of these reptiles and brought it ashore. This was the first act of a tragedy which was to cost five lives.

CHRONICLE.

Saturday, 18th December, 1965.

Villager Soi-Nabien, caught a turtle on the reef fronting the village of Namarodu, a Patpatar-speaking group of beach hamlets in the Namatanai Subdistrict of New Ireland. The turtle was brought ashore to the hamlet of Kanou, where it was turned upon its back and left until the following Tuesday. The turtle was thought to be quite healthy by the villagers.

Tuesday, 21st December, 1965.

In the morning the turtle, apparently still in good condition, was killed and cut up. Portions of meat, and a paste composed of blood, fat and leaves, were wrapped up in banana leaves and tied into parcels. These parcels were then placed among the hot stones of a mumu in the sand close to one of the houses. Although a roof is commonly erected over a mumu, on this occasion no roof was built. The mumu was sealed about noon. Some hours later rain began to fall and continued through the night.

Wednesday, 22nd December, 1965.

Rain fell for most of the day. The amount of rain which fell in the village is not known, but at Namatanai Government Station, a few miles from Namarodu, over 400 points of rain were recorded in the period during which the meat was in the mumu.

At 'lamp-lighting time', about 6.30 p.m., the mumu was opened. The parcels of meat and paste were distributed, the men and boys taking their portions to the men's house where freshly cooked vegetables were eaten with the turtle meat. The women took their meal elsewhere. Some of the meat was kept for later consumption.

Thursday, 23rd December, 1965 (First day of illness).

About 6 a.m. some of those who had eaten turtle became ill with vomiting, and others fell sick as the day wore on. Despite this, however, some villagers ate more of the cooked meat. The illness on this day was markedly vomiting and retching; one to four bouts per person, little abdominal pain and no diarrhoea. Those who had suffered repeated bouts of vomiting stated that they became very weak and had difficulty in traversing the few yards between their houses and the beach where dejecta are customarily deposited. One elderly man continued vomiting repeatedly and was subsequently admitted to the Namatanai hospital.

Friday, 24th December, 1965 (Second day of illness).

Six new cases appeared on Friday. These were more seriously affected than those of the previous day. Five of the new cases had vomiting, abdominal pain (not very severe) and diarrhoea, with weakness of limbs. The sixth case, a baby two months old, commenced vomiting, apparently became comatose, and died in the village a few hours after the onset of illness.

Saturday, 25th December, 1965 (Third day of illness).

The elderly man who had been vomiting intermittently since Thursday was admitted to the Namatanai hospital together with the five survivors of those who fell sick on Friday ; one of these, an eleven-year-old boy died about 6 p.m. An infant who began vomiting on Saturday morning became comatose and died in the village. One man, father of the child who died on Friday, commenced vomiting and remained in the village.

Sunday, 26th December, 1965 (Fourth day of illness).

A woman who had been admitted to hospital the previous day died. The man who commenced vomiting on Saturday was brought to hospital dyspnoeic and semi-comatose. Those already in hospital appeared to have improved. No new cases appeared.

Monday, 27th December, 1965 (Fifth and last day of illness).

The man admitted to hospital the previous day died. No new cases appeared on this or subsequent days.

Tuesday, 28th December, 1965.

Mid-morning a message was received in the District Medical Office at Kavieng, 160 miles from Namatanai, reporting the deaths of five villagers following the eating of turtle meat. I arrived at Namatanai that evening and examined the body of the man who had died the previous day. The Namarodu people still in hospital were examined and found to have recovered from their poisoning. Inquiries into the nature and extent of the outbreak were commenced.

Wednesday, 29th December, 1965.

I visited Namarodu village, was shown the site of the mumu, the carapace of the turtle and collected reports of the incident from the villagers. A meatless feast was being busily prepared in honour of the dead. All villagers appeared to be well.

MORBIDITY AND MORTALITY.

The 1965 census population of Namarodu was 144 persons. One-third of these shared the cooked turtle. Of the 41 people (23 males, 18 females) who admitted to eating turtle, 15 became ill—ten males and five females. In addition two infants died in the village at the time of the epidemic. Their mothers denied that these children had been given any part of the turtle, but for reasons mentioned below, the deaths of these infants are regarded as arising from ingestion of the contaminated meat. Seven people were admitted to hospital, and of these, three died. Including the two infants, the sex and ages of those who died were males of two months, six months, 11 and 34 years respectively, and one woman of over 40 years. Morbidity and mortality are summarized in the Table below.

DISCUSSION.

Cause of the epidemic.

The occurrence of the symptoms of food-poisoning shortly after the ingestion of an unusual item of diet arouses a suspicion that this food, in some way, may have caused the illness. When, further, one learns that the food was meat which, after a comparatively short time in a hot-stone cooker, was left in a rain doused pit for many hours, then eaten without re-cooking, that suspicion becomes extremely strong.

Table showing number of Namarodu villagers who ate turtle meat, became ill, were admitted to hospital, and died, December, 1965.

(Total population of village at 1965 Census = 144 persons.)

Age group (Years).	Number eating turtle-meat. M.	F.	Number becoming ill. M.	F.	Number admitted to hospital. M.	F.	Number of deaths. M.	F.
0-11/12	2*	-	2	-	-	-	2	-
1-14	5	9	1	1	1	-	1	-
15-44	11	5	5	2	1	2	1	1
45-	7		4	2	2	1	-	-
Totals by sex	25	18	12	5	4	3	4	1
GRAND TOTALS	43		17		7		5	

* Unproven.

The environment within the banana-leaf wrapped parcels left in a cooling mumu would appear to be an ideal culture medium for micro-organisms.

Incidence of the illness.

Of the 41 people who admitted eating the turtle meat, only 15 became ill. It appears probable that some parcels of the food did not contain a sufficient load of the pathogenic agent to cause sickness. Possibly because of their position among the hot stones such parcels received a more thorough heating before rain cooled the mumu ; their contents may have provided a less favourable environment for microbial growth ; or perhaps their contents did not become contaminated prior to the tying up of the parcels. An attempt was made to ascertain whether those who became sick had eaten from parcels other than those eaten by their more fortunate neighbours. Due to informants contradicting one another and themselves, this enquiry was not pressed.

Mothers of the dead infants averred that their children had not been given any of the turtle meat, and other villagers agreed that such food would not be given to babies prior to the eruption of teeth. Asked to explain the children's deaths, villagers replied that the turtle meat had poisoned the mother's milk and this was the reason for the illness and death of the infants. It seems more probable that the infants were, in fact, given some of the cooked food, possibly the blood and fat paste, but the mothers' fear of admitting breach of a taboo, and perhaps their fear of police action against them, prevented their complete frankness.

The man, father of one of the dead infants, who himself died in hospital on the fifth and last day of the incident, had almost certainly eaten turtle at least 36 hours after the meat had been removed from the mumu, so it is highly likely that some meat was kept in his house after the Wednesday night feast, and was given to his son on the Thursday.

Clinical features of the epidemic.

Villagers who ate portions of the cooked turtle within a short time of its removal from the mumu, either experienced no ill effects or suffered a relatively minor illness in which vomiting was the main complaint ; abdominal pain and diarrhoea were either minimal or absent. Those who ate meat on the day following its removal from the mumu, or later, presented a more serious picture, including repeated vomiting, abdominal pain, diarrhoea, musclar weakness and inco-ordination of movement, dysarthria, changes in or loss of conciousness, respiratory depression and finally death. Post-mortem exam[illegible] of the man who died on the final day of the incident showed no extensive lesions of the alimentary tract and findings were consistent with death from respiratory failure. None of those who had eaten the meat complained of mouth and throat symptoms described by Romeyn and Haneveld (1956).

The toxic agent.

The increasing severity of the illness with the lengthening of the interval between the meat's removal from the mumu and its being eaten, together with the clinical features reported and the post-mortem findings suggest a microbial toxin as the agent responsible for this epidemic. However, the picture does not unequivocally typify either staphylococcal or clostridial contami-

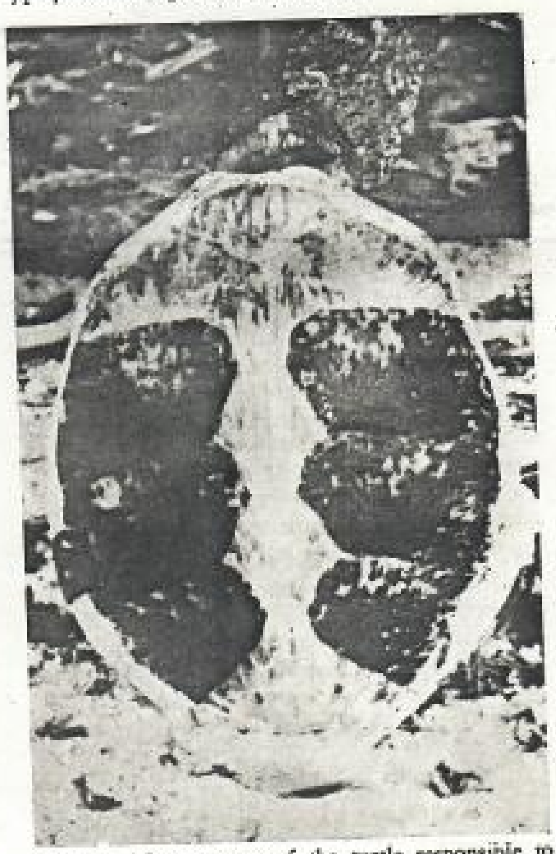

Plate I.—The carapace of the turtle responsible to this epidemic.

nation. The absence of mouth and throat symptoms points to an agent other than that responsible for the epidemic in Netherlands New Guinea (West Irian) reported by Romeyn and Haneveld (1956).

The carapace of the turtle responsible for the Namarodu tragedy was photographed (*Plate* I). Unfortunately some of the scutes had been removed before this photograph was taken and this has made positive indentification of the specimen difficult. Copies of the Kodachrome transparency have been seen by authorities in New Guinea, Australia, England and the U.S.A., and resemblances noted to the species *Caretta caretta*, *Eretmochelys imbricata* and *Chelonia mydas*—three of the four turtle species found around the New Guinea coast.

SUMMARY.

An outbreak of poisoning following ingestion of poorly-cooked turtle meat is reported. Of the 43 persons eating this food 17 became ill and five of these died. The toxic agent was not identified.

Note.—The author would be pleased to send a Kodachrome transparency of the incomplete carapace to anyone wishing to attempt a definitive indentification of the species of turtle involved in this epidemic.

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"NEW GUINEA MOUTH"

NEW GUINEA.

Beriberi assumed epidemic proportions on the goldfields. Transport was exceedingly difficult, and only the most portable articles could be carried in. The great majority of the natives therefore lived on polished rice and tinned meat, and this, together with the depressive factors of great altitude (7,000 to 8,000 ft.), constant cold and rain and heavy work, make beriberi inevitable. It was not long before cases of ulcerative stomatitis made their appearance, and it is interesting to note that so common has this symptom been on other goldfields that is is commonly known as 'New Guinea Mouth'.

Verbal and written representations to the miners by medical officers were not successful, so a special diet was made obligatory by law, and the incidence of beriberi began at once to decline."

Report to the League of Nations, 1926-1927.

PAPUA.

"As was the case last year, the deficient rainfall during this year has resulted in a similar deficiency of native food. In all, 20 cases of ulcerated mouth disease (early scurvy) passed through the Native Hospital, Port Moresby, and 17 through the Native Hospital, Samarai. This 'ulcerated mouth' disease has undoubtedly a scurvy basis although the organisms found are almost entirely large spirochaetes usually mixed with fusiform bacilli much as in Vincent's Angina and Noma. The first signs are that the gums bleed if rubbed; they next ulcerate along their margins and the breath gets foetid. Ulceration then spreads on the inside of the cheek, usually adjacent to the molars, and anaemia and general weakness become marked. In some instances the ulceration spreads markedly and may even lead to necrosis of the palate or portions of the jaw-bone. If untreated, death occasionally occurs due either to extensive spread of the disease or to general weakness and debility. Cases not too far gone recover as a rule readily with some form of anti-scurvy treatment, as they did in this instance. Other signs of scurvy are not frequently seen."

W. M. STRONG,
Chief Medical Officer,
Annual Report 1931-1932.

mission has been difficult to interrupt since spraying started in 1970, there was an average of only four malaria cases per month during the latter half of 1974.

Malaita District has experienced minor outbreaks of transmission in scattered areas every year since spraying started in 1970. This was repeated during 1973 and more seriously in 1974. During mid 1974 East Kwaio, an operationally difficult area, showed signs of resolving, only to break out again in November and spread up and down the coast and also across the mountain barrier to west central Malaita. This outbreak of mainly *P. falciparum* malaria, which was resolving by April 1975, was an object lesson in the need for very speedy action once the parasite gets the upper hand in a semi immune population (as a result of spraying).

During 1973-74 further efforts were directed towards improving the standards of field operations, but delays in supplies and transport problems continued, as always, to threaten the success of the programme. Great efforts were made to improve on the supervision of treatment of all proven malaria cases to avoid the well known relapsing propensity of S.W. Pacific *P. vivax* strains. Remedial measures were intensified around all foci. Mass Drug Administration was extensively used with good results in the Gilbertese communities in Western District, Nggela and N.E. Makira but equivocal results in North Guadalcanal.

Objectives and plans for 1975 include the elimination of all *P. falciparum* Parasitaemia from the Solomons; a special effort in Malaita; an improvement in the detection of imported cases into Western District and an all out onslaught on the north coast of Guadalcanal. Additional supplementary measures will include the use of ultra low volume peridomestic space spraying with malathion and the use of Abate Larvicide. These will be directed at specific foci with the objective of red[illegible] vector densities to a very low level during the low transmission season.

The prospects for the eventual eradication of malaria from the Solomon Islands remain good. It cannot be emphasized too strongly however, that the task is not an easy one and that it requires the wholehearted backing of all agencies in the Ministry of Health, full support by other agencies and last but by no means least, full acceptance and co-operation by the people.

I am grateful to His Excellency, the Governor of the British Solomon Islands, for permission to publish this Progress Report.

Dr. J. G. Avery,
Chief Medical Officer (Community Health), Ministry of Health and Welfare,
HONIARA. British Solomon Islands.

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TURTLE MEAT AND CONE SHELL POISONING

Sir

Two unusual cases which presented at Kavieng hospital during 1974 illustrate an interesting and disturbing lack of local knowledge about dangers from marine animals.

1. Turtle Meat Poisoning

A meal of turtle was eaten in Panapai village, close to Kavieng, on the afternoon of Sunday 11th August. During the night several children were sick. At about 6.00 a.m. the next day a child of 6 years was brought to the hospital, after having become unconscious following vomiting. There was no response to pain, a flaccid paralysis and dilated pupils. Lumbar puncture and a malaria parasite slide were performed to exclude more common diagnoses, but in spite of supportive measures including intravenous fluids, hydrocortisone and phenergan, the child died quite suddenly at midday. This child was alleged to have eaten the unlaid eggs of the turtle.

During the night 2 more children died in the village. The next morning the teacher brought 18 other children who had eaten the turtle. Fifteen were symptom free; 3 had had attacks of vomiting, and were kept under observation for 24 hours. In the absence of further symptoms, they were discharged.

Despite careful inquiries we were unable to ascertain the details of the catching and cooking of the turtle, but the shell was recovered and identified as the ERETMOCHELYS IMBRICATA or Hawksbill Turtle. It was not possible to discover whether the poisoning was due to staphylococcal or clostridial contamination, or a toxin in the meat itself.

Several persons associated with this incident recalled the poisonings at Namatanai in December 1965 which resulted in 5 deaths, and on New Hanover in 1957 and isolated incidents had occured at various other places in the New Ireland District over many years. Nobody however knew definitely which species of turtle were dangerous or when. The only positive comment was that "If the turtle comes to you, do not eat it. If you go after it and catch it, it is good for eating." It is by no means clear what was meant by this.

Reviewing the literature (Dewdney 1967, Halstead 1959, Bell 1972,) it appears that several species of turtle, notably the Hawksbill, the Green Sea Turtle (CHELONIA MYDAS) and the Leatherback Turtle (DERMOCHELYS CORIACEA) do became poisonous to eat at times, possibly by a process analogous to ciguatera poisoning in fish. The presence of neurological symptoms generally favours this diagnosis rather than a bacterial intoxication, although this undoubtedly can occur. In spite of the risks and local uncertainty about the nature of turtle meat poisoning, turtles continue to be eaten in large number here, and so presumably intoxication will continue to occur from time to time.

2. Cone Shell Poisoning

A 35 year old man was admitted unconscious after having been diving on a reef in the Kavieng harbour the previous night with the aid of a flashlight he had picked up a coneshell, which he had placed in his trouser pocket. The shell was later identified as CONUS GEOGRAPHICUS. A short while later he felt a sharp prick in his thigh, but thought little of it. While cycling home he felt weak, and went straight to bed. His family later noticed that he was not moving his chest when he breathed, and was not rousable, so they brought him to hospital. On examination he had generalized flaccid paralysis, and was breathing satisfactory but only with his diaphragm. Other observations were normal. No mark could be seen on his thigh.

No treatment was given beyond careful observation. The following morning he was fully fully conscious, although drowsy, and could move his legs. He was out of bed the next day and discharged two days later.

I subsequently showed the shell to every local member of the hospital staff. Only two said they were aware that it was dangerous; one of these was from Manus District, the other, a mixed race person. This suggests poisoning by Cone Shells is very rare since otherwise one would expect local folk lore to have stored the information.

In the majority of cases of stings or bites which present to hospital (3-4 a month in Kavieng), no positive identification is made, because the victim is injured while wading, the injury is to the leg or foot is under water and the attacking creature is not seen. Occasionally an identification can be made if the patient has subsequently speared the animal (e.g. a stone-fish) or if some part of the sting or proboscis is left in the wound.

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A NOTE ON THE DISTRIBUTIO[illegible] PREVALENCE OF ANOPHELES SUBPICTUS GRASSI

Sir—

Anopheles subpictus has been recorded from the following localities - (1) the Port

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explicable by hypervitaminosis A. Moreover, Cooper pointed out that sharks from the Gilbert islands, where the shark poisonings occurred, are not so rich in vitamin A. As mentioned before, the liver of the gray reef shark, *Carcharhinus menisorrah*, from the tropics has been used as raw material for extraction of ciguatoxin.

Halstead (*175*) found that aqueous extracts of the liver and gonads of the gray reef shark and of the liver and intestine of the spotted eagle ray, *Aetobatus narinari*, were toxic to mice. However, it is not certain whether the toxicity can be directly correlated to the cause of poisoning.

4-7-4. *Killifish* (*322*)

The mummichog, *Fundulus heteroclitus* (Fig. 2-51), and the banded killifish, *F. diaphanus*, seem to become occasionally toxic to warm blooded animals. It was observed that administration of killifish to the fox, the cat, the crow, and the egret evoked hemafecia and diarrhea, followed by prostration or ataxia. It has been stated that the animals once poisoned would not eat the fish any more.

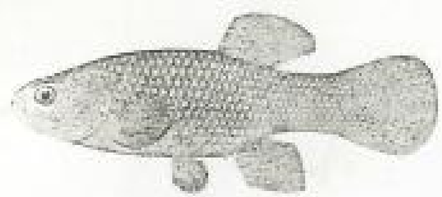

Fig. 2-51. Mummichog, *Fundulus heteroclitus*. (From Halstead (*175*)).

5. OTHER VERTEBRATES

5-1. Turtles

Outbreaks of poisoning from eating turtles have a long history in the Philippines, Sri Lanka, India, and other southeast Asian countries (*323,324*). Although turtle meat has been extensively used for food in these countries, poisoning as a result of it has seldom been recorded. This leads to the speculation that the turtle may become poisonous by its diet or by other factors, but no firm evidence is available. When sea turtles are caught, they are shared and eaten by many people, because they provide a great deal of edible parts. If the turtles are poisonous, mass intoxication is therefore liable to occur.

People in the southern islands should be wary of poisonous sea turtles. Hashimoto and coworkers (*146,325*) learned of four poisonings in the Ryukyus. One was caused by a toxic species caught near Taiwan and the rest around the Yaeyama islands.

The symptoms include diarrhea, vomiting, open sores in the mouth, chills, *etc.* It takes a long period of time for complete recovery. Death occurs mostly among children and old people. Three poisonings in the Philippines and Ryukyus will be described below.

The first poisoning broke out on February 5, 1954, at Dinaig, Cotabato, in the Philippines (*324*). The cooked meat, eggs, and viscera of a turtle called 'payukan' were served at a gathering of Moslems. The turtle was the edible species often eaten by the inhabitants. Its carapace was about 100 cm in length and 60 cm in width. A total of ten persons (six children aged one to four, a man aged 35, and three old persons aged 50 to 60) were killed. A large number of dogs also died from eating the viscera. Two to three hours after ingestion, the patients felt fever in the abdomen and chills in the extremities. Some of them suffered explosive diarrhea and vomiting. The following day, they had dizziness, loss of equilibrium, optical disturbances, and drowsiness, which continued for three to four days. Thereafter, the patients complained of soreness, swelling and pain in the mouth and throat, and difficulty in swallowing. The symptoms persisted for a long period of time.

The second poisoning occurred in Summer, 1954, on Kuroshima island of the Yaeyamas (*146,325*). A turtle, which came to the shore to lay her eggs at night, was turned over and left there overnight. In the morning it was dissected and the meat and viscera were distributed to many people in the village. Most of them seemed to have eaten it after it was cooked in a soup. About 80 people were poisoned with six deaths among the children. The symptoms consisted of vomiting, diarrhea, headache, and languor, followed in some patients by swelling and loss of hair. A breast fed infant was also affected.

The third poisoning happened at Akashi on Ishigaki island in June, 1960 (*325*). At about 3 am a fisherman caught a sea turtle on the beach near the village. The turtle was dissected in the morning and distributed to ten families, each of which had a share of 1 to 2.5 kg of the edible parts. About 80 people ate it after it was cooked *sukiyaki* style or boiled in soup. Sixteen persons developed an illness with two deaths among the children. The symptoms were similar to those observed in the second poisoning.

Much uncertainty still exists in the identification of poisonous turtles. Halstead (*323*) cites several species that were reported to be poisonous and states that the most suspectable species is the hawksbill turtle. On the basis of the leftover carapace of the turtle, the species responsible for the poisoning in the

..ilippines was identified as the hawksbill turtle, *Eretmochelys imbricata* (*324*). I obtained a photograph of the carapace of the turtle responsible for the second case (Fig. 2-52) and sent it to Dr. J. Hendrickson who identified it as the hawksbill turtle, *Eretmochelys imbricata imbricata* AGASSIZ. The inhabitants of the Ryukyus believe that the toxic species is a hybrid between the hawksbill turtle and another species. On Ishigaki island, Hashimoto and collaborators procured several specimens of turtle which were said to be hybrids and examined them for toxicity, but without ill effects on the test animals.

Fig. 2-52. The carapace of turtle which caused mass poisoning in Kuroshima of the Yaeyamas. (Courtesy T. Nakamori).

5-2. Marine Mammals

The liver of marine mammals, such as the polar bear, the seal, and the whale, when eaten in quantity, may lead to hypervitaminosis A, as mentioned above.

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CHAPTER 3

MARINE ANIMALS WITH TOXIC STINGS OR BITES

1. COELENTERATES

Some coelenterates are capable of paralyzing their prey. They also injure the skin of man, sometimes causing death. Jellyfish, sea anemones, hydroids, and corals, which belong to the Cnidaria, are members of this dangerous group. These animals are equipped with characteristic venomous organs named nematocysts. About 70 out of 9,000 species of cnidarians are listed as injurious to man (*1*). In this chapter protein- or peptidelike toxins produced in the nematocysts, tentacles or polyps will be described, and other toxic constituents in these animals will be considered in the next chapter.

The shape, location, and function of the nematocysts differ from species to species and constitute phyletic characteristics. A large number of nematocysts are distributed largely on the tentacles. The nematocyst consists of a globular, oval or spindle-shaped capsule, which encloses a coiled thread tube (Fig. 3-1) (*2*). On stimulation the nematocysts trigger the release of the coiled thread, and the tips of the extended thread tubes penetrate the epithelium of the victim. The fully extended thread tube has a length several hundred times the diameter of the capsule. The venom in the capsule is injected into the tissue of the victim through the tubule.

In earlier studies, the venom of nematocysts had been extracted chiefly from the tentacles. Therefore, a variety of toxic components having different chemical and pharmacological properties had been obtained. However, a new technique has been developed for isolating the nematocysts from the tentacles as pure as

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Ciguatera in the Ryukyu and Amami Islands*

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Ciguatera is usually a nonfatal illness caused by ingestion of various reef and semi-pelagic fishes living in tropics and subtropics. This poisoning has not only been a serious problem in food supply and public health to inhabitants of islands in the South and South West Pacific but also an obstacle to utilizing fish as a protein source to the increasing population in the world. Among a number of reviews on this problem, the most exhaustive has been recently prepared by HALSTEAD[1].

A group in the University of Hawaii has been most actively studying the biology, chemistry, and pharmacology of ciguatera in the Central and South Pacific, and have clarified the characteristics of principal toxin named ciguatoxin[2~5]. We also made an approach on a small scale to the toxicity of ciguatoxic fishes[6,7] in the Ryukyu Islands which lie between Kyushu of Japan and Taiwan.

The increasing outbreaks of poisoning due to fishes brought into Japan from the southern sea led us to enhance the study and initiate joint research with the group from the University of Hawaii headed by Dr. A. H. BANNER under the Japan-United States Cooperative Science Program. At first, we made field surveys in order to grasp the general situation of ciguatera in the Ryukyu Islands and adjacent Amami Islands. The results obtained by the field survey were supplemented by an investigation with questionnaires distributed to many organizations in these islands.

Through these investigations occurrence of many ciguatera poisonings was found, which had not been indicated in official records. In the present report non-ciguatera fish poisonings, such as tetrodon poisoning, hypervitaminosis A due to livers of large-sized fishes, diarrhea due to castor oil fish, acute gastro-enteritis due to a halophilic bacterium *Vibrio parahemolyticus*, are excluded, though we came across several of these cases. Besides fish poisonings, outbreaks of poisoning from ingestion of turtles, crabs, or coconut crabs were also confirmed.

Intoxications by toxic crabs have been reported previously[8], and the present paper deals with the general pattern of ciguatera and poisonings due to turtles and coconut crabs in the Ryukyu and Amami Islands.

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* Studies on Marine Toxins. XX.

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difficulty in swallowing, and loss of hair. It took a long time for complete recovery. Death occurred only in children, and in one case, an infant was affected through the breast milk. The inhabitants believed that the toxic species was a hybrid between the hawksbill turtle and another species. A photograph of the carapace of a turtle, which poisoned about 80 persons was obtained and sent to Dr. J. HENDRICKSON, Óceanics Institute of Hawaii, who identified it as a hawksbill turtle, *Eretmochelys imbricata imbricata* AGASSIZ. This toxic species was said to be caught only occasionally around the Yaeyama Islands, probably once in 4 or 5 years. As there was no poisoning case in northern areas, the Yaeyama Islands seemed to lie on the northernmost of the distribution of the toxic turtle.

Coconut crab poisoning

Sporadic outbreaks of coconut crab poisoning and some legends on the origin of toxin were found, which had not appeared in official reports. We obtained 5 case histories[16] although more could be collected easily in some districts. The symptoms were languor of the whole body, vomiting, and diarrhea which appeared within several hours after ingestion. Patients usually were forced to lie in bed for several days from exhaustion. Our investigation revealed that 4 out of 19 patients were killed. Pigs were involved in the poisoning by eating remnants of the crab, indicating that they are very sensitive to the toxin.

The coconut crab in question was called "Makkon" or "Makkan" locally and identified by Dr. S. MIYAKE, Zoological Laboratory, Faculty of Agriculture, Kyushu University, as *Birgus latro* LINNAEUS. The toxicity of coconut crab was reported to show a narrow regionality and to be related to the presence of some plants, locally called "Fubogi", "Gāna", or "Dōnattsu". "Fubogi" and "Gāna" were found to be identical. They were identified by Dr. S. KURATA, Department of Forestry, Faculty of Agriculture, The University of Tokyo, as *Diospyros maritima* BLUME BIJDR in the family Ebenacae and "Donattsu" as *Hernandia sonora* LINNAEUS in the family Hernandiacae. Coconut crabs were believed to become toxic when they feed on the fruits of "Fubogi" or dwell under "Dōnattsu".

According to Dr. BAGNIS, Institute of Medical Research "Louis Malardé", Tahiti (Private communication, 1968), a poisoning has recently occurred from the ingestion of coconut crabs in the Tuamotu Islands, French Polynesia. It was also reported by Mr. MOTE, World Life Research Institute, Palau (Private communication, 1968) that there is a belief on toxicity of coconut crabs in Palau. HOLTHUIS[17] referred in his recent paper to the following Balss' report that at Yap Island in the Carolines the native first leave the coconut crab for a few days before eating, so that the toxic substances by then have left its intestinal tract. These informations indicate that the coconut crab may cause poisonings within its range of distribution.

Buck

Any of the native birds, large or small, land or sea, were considered good food, though some species were caught primarily for their feathers. The smaller birds with yellow, red, black, or green feathers, which were used for capes and cloaks, were caught in the moulting season by professional fowlers, who used bird lime made from breadfruit gum (*kepau*) or *kukui* tree gum (*pilali*). The Hawaiians did not believe in killing the birds that grew the golden feathers, hence the few yellow feathers of the *'o'o* [*Moho* (*Acrulocerus*) *nobilis*] and the *mamo* (*Drepanis pacifica*) were plucked without damage to the birds, which were liberated to grow more feathers for another plucking. However, some *'o'o* were killed for their black body feathers. The *'i'iwi* (*Vestiaria coccinea*) and the *'apapane* (*Himatione sanguinea*), too extensively covered with red feathers to survive plucking, were killed, skinned, and eaten.

Birds with larger feathers were caught to provide feathers for fly switches and large ceremonial standards, both termed kahilis. Of these birds, the largest was the Hawaiian goose, or *nene* [*Branta* (*Nesochen*) *sandvicensis*], which was also excellent for eating. Malo (1951, pp. 37-40) lists the names of 32 species of birds which were eaten. Among them are the mudhen, or *'alae* (*Fulica americana sandwichensis*); the wild duck (*koloa*); the night heron, or *'auku'u* (*Nycticorax nycticorax hoactli*); a stilt, or *kukulune'o* (*Himantopus himantopus knudseni*); a wader (*kioea*), the bristle-thighed curlew (*Numenius tahitiensis*); and the plover, or *kolea* (*Pluvialis dominica fulva*).

A number of sea birds were caught with nets and lines, others were taken by hand on rookeries. Expeditions were made to the rocky islets of Kaula and Nihoa to procure sea birds, which were eaten despite a fishy flavor.

Malo states that nets with a wide mouth were set to catch birds on their way to their nests and also that snares were set. He mentions the use of a bird pole (*kia*) but gives no details; and he says that the rather primitive method of pelting with stones was used to catch mudhens, wild ducks, herons, stilts, and waders. Plovers, he writes, were attracted by whistling, but he does not describe the rest of the process.

FISHES

Fishes (*i'a*), like birds, were all eaten, for there were no poisonous ones as there are in some parts of Polynesia. An exception, perhaps, is the porcupine fish (*'o'opuhue*), the gall of which is poisonous; but if the gall bladder is carefully removed without spilling the gall, the flesh may be eaten without danger and has a delicious flavor. A crab (*kumimi*) and a species of sea turtle (*'ea*) are also said to be poisonous.

Malo (1951, pp. 45-47) lists the fishes according to various characteristics. As he sums up their values as food, it is interesting to note his divisions, which are given in the following list (table 1). For the actual names of the individual fish, the reader is referred to Malo.

Table 1.—Malo's Fish Divisions

Characteristics	Number in Division	Remarks
small fry along the shore	14	food
with harp protuberances	23	excellent eating
with flattened bodies	22	good eating
bodies greatly flattened	6	
bodies with silvery color	15	good eating
with long bodies	9	used as food
bodies with red color	15	wholesome food

Malo (1951, p. 47) classes "fish with long fins like wings" together: the flying fish (*loloa'u malolo*), rays (*hihimanu*), *puhiki'i*, *lupe*, *hahalua*, and the *hailepo*. All are used as food but are not of the finest flavor. He mentions that the shark (*mano*) provided the skin for covering drum heads, but Malo does not mention its food value. Of the *mahimahi* (dolphin) and the *kahala* he remarks that they "are quite unlike other fishes" in shape but are excellent eating.

Malo (1951, p. 46) classes the octopus group with fishes and says that the octopus (*he'e*) and squid (*muhe'e*) are highly esteemed for food. He adds that the *he'emakoko* is eaten but that the flesh is bitter.

The turtle he classes as a sea animal, distinguishing between the *honu*, which is excellent food, and the *'ea*, which is poisonous. Sea mammals are classed as "fish which breathe on the surface of the ocean." These include the porpoise (*nai'a, nu'ao, pahu*), the sperm whale (*palaoa*), and other whales (*kohola*). When cast ashore, they were "held to be the property of the king." The flesh was eaten. (See Malo, 1951, p. 47.)

Crustaceans and Shellfish

All crustaceans are esteemed as food except the poisonous *kumimi* crab. Malo (1951, p. 45) alludes to them as fishes having feet with prongs, and he lists 13 by name. Chief among them are crayfish (*ula*), crabs (*papa'i*), and fresh-water shrimp (*'opae*). Echinoderms are eaten, and they are classed by Malo as fish beset with spines. He enumerates them as *'ina, hawa'e, wana, ha'uke'uke*, and *haku'e*.

Shellfish which are large enough to repay the work of extracting the contents are eaten. Malo lists 19 names, among them *pipipi* (*Nerita* sp.), *puho'okani* (conch), *'olepe* (a bivalve), *leho* (cowrie), and *'opihi* (limpets).

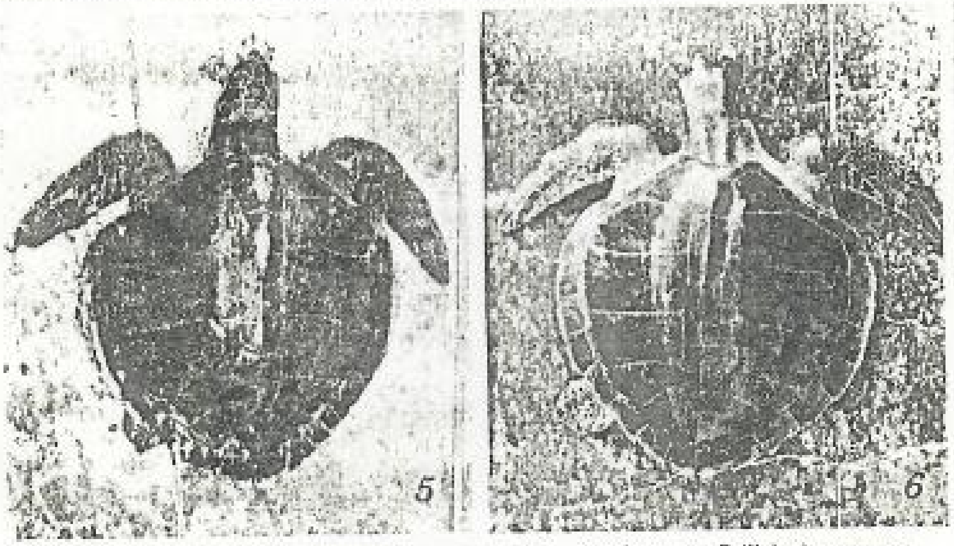
PLANTS

INDIGENOUS PLANTS

Indigenous plants which supplied any form of food were utilized by the Menehune settlers. Anything edible in the form of pith, root tuber, corm, fruit, or not take any food and died within 20 days as he remembered. He put on record the exact localities and dates of capture together with the measurements and photographs. Much to regret, however, all these records have been lost after he retired from the aquarium.

SPECIMEN CAUGHT AT AMAMI OSHIMA IN 1967 (no. 5 in Table 1)

This specimen was reported on the Asahi Press (Kyushu edition, Oct. 10, 1967) as "*A Poisonous Sea Turtle from Amami Oshima*". According to the newspaper, the turtle, about 80 cm in body [i.e., total] length and 20 kg in weight, was caught near Yamato-mura, Amami Oshima, on Sept. 26 by a fisherman who was engaged in squid-angling. The turtle was brought to the Oshima Branch of the Kagoshima Prefectural Office, and because of its resemblance to the sea turtle which had been suspected as the source of severe food-poisoning reported from the Yayeyama Islands and Formosa[6], it was sent to



Figs. 5 and 6. *Lepidochelys olivacea* (ESCHSCHOLTZ). 5—Specimen no. 7 (living), carapace length 47 cm; 6—Specimen no. 8 (living), carapace length 48 cm.

Prof. Y. HASHIMOTO of the Tokyo University for a toxicological examination. The newspaper article is concluded with the statement that this was the first occurrence of this dangerous type of sea turtles in Amami Oshima.

By the description and photograph given on that paper, the present authors readily recognized that it was a Pacific ridley turtle; and it is listed here as a new record from the Japanese waters.

SPECIMEN CAUGHT ON THE COAST OF YAMAGATA PREFECTURE IN 1968 (no. 6 in Table 1; Figs. 3-4)

This specimen was stranded on the beach at Miyanoura village near Sakata, Yamagata Prefecture. It was found dead by Mr. Ichiro SATO of the village. The animal, first mis-identified as a hawksbill, was prepared to a stuffed specimen, which was checked by the last author of the present paper with the Pacific ridley turtle. The carapace was oval in outline and measured 19 cm wide by 21 cm long (percentage of width to length—90.5), and its general coloration was olive. The vertebral scutes numbered 6,

6) The present authors suppose that they referred to the report by HASHIMOTO et al. (April, 1967) on the food-poisoning by turtle meat in the Ryukyu Islands. In this interim report, HASHIMOTO et al. summarized four cases of such food-poisoning, of which at least the one case occurred at the Pratas or Tungsha (東沙) Islands in the northern part of the South China Sea in June of 1952 was possibly due to the ridley turtle in the opinion of the first author of the present paper.

the left costal 7, and the right costal 6. The pattern of head shields was typical of *Lepidochelys olivacea*. The specimen still retained juvenile characters; for instance, a pronounced neural ridge was observed on the carapace, with the postero-median part of each vertebral scute, particularly that of the second scute, projecting backward as a marked prominence, though the costal ridges were already imperceptible. The arrangement of inframarginal scutes and the presence of inframarginal pores were not examined on account of some technial difficulties. The specimen is now kept by the last author at Sakata.

SPECIMENS CAUGHT IN THE EAST CHINA SEA IN 1969 (nos. 7 and 8 in Table 1; Figs. 5–6)

Both specimens were caught by two-boat motor trawlers belonging to the Nagasaki Branch of the Taiyo Fishing Co. while the trawlers were fishing demersal fishes in the East China Sea, and later brought to the Nagasaki Aquarium. They had the broad oval carapace with the neural ridge weakly developed and their head shield pattern was typical for *Lepidochelys olivacea*. The measurements and counts of these specimens are shown as follows:

	Specimen no. 7	Specimen no. 8
Carapace width (cm)	46	47
Carapace length (cm)	47	48
100 × width/length	97.8	97.9
Body weight (kg)	11	17
Number of vertebrals	5	6
Number of costals	*l* 6, *r* 5	*l* 6, *r* 6
Number of larger inframarginals	*l* 3, *r* 3	*l* 4, *r* 4
Inframarginal pores	present	present

Although Specimen no. 7 had somewhat smaller numbers of carapace scutes than the typical Pacific ridley as seen above, the identification leaves no doubt. This specimen also had a remarkable defect on its right hind limb, of which the portion distal to the knee had been lost possibly by a bite of such a large predator as shark (cf. HENDRICKSON 1958; PRITCHARD 1969a). The specimen was kept alive in the aquarium from August 30 to September 4 when it died probably from a bite wound inflicted by other sea turtles kept together in the same tank.

Specimen no. 8 has been raised in the aquarium since September 10, 1969 and is still well at present (February, 1972).

The stations where these turtles were captured are from 60 to 70 m deep. If the turtles were really caught on the sea bottom as it was considered so[7], then these records will show that the Pacific ridley can dive as deep as 60–70 m in natural environments. See also the notes attached below to the description of the specimens nos. 9, 12 and 13.

SPECIMENS CAUGHT IN THE EAST CHINA SEA IN 1971 (nos. 9, 12 and 13 in Table 1)

All these specimens were entangled in the net of a two-boat motor trawler belonging to the Izutsu Fishing Co., Nagasaki, and through the courtesy of Mr. Toshio NIIYA, the chief fisherman of the boat, were donated to the Nagasaki Aquarium where they have been raised since. The measurements and counts of these specimens are given as follows:

	Specimen no. 9	Specimen no. 12	Specimen no. 13
Carapace width (cm)	53.4	55.5	50.2
Carapace length (cm)	55.2	58.0	53.0
100 × width/length	96.8	95.8	94.7
Weight (kg)	20.2	26.3	20.8
Number of vertebrals	7	7	6
Number of costals	*l* 7, *r* 6	*l* 8, *r* 7	*l* 6, *r* 6
Number of larger inframarginals	*l* 4, *r* 4	*l* 4, *r* 4	*l* 4, *r* 4
Inframarginal pores	present	present	present

7) According to the officers of the trawl boats, it is quite unlikely that they were caught in mid-layers while the net was being drawn up. Rather, it is asserted that the turtles were in all probability entangled in the net on the sea bottom during the trawling operation lasting for three hours.

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THE DISTRIBUTION OF CIGUATERA
IN THE
TROPICAL PACIFIC

Albert H. Banner

Philip Helfrich

Final Report
Contract SA-43-ph-3741
"An Epidemiological Survey of Fish Poisoning
in the Tropical Pacific"
National Institute of Neurological Diseases and Blindness
National Institutes of Health
Public Health Service

October 15, 1964

Hawaii Marine Laboratory Technical Report #3
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Honolulu, Hawaii 96822

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DISTRIBUTION OF CIGUATERA IN THE TROPICAL PACIFIC

Albert H. Banner and Philip Helfrich

A peculiar type of food poisoning results from the eating of many types of fish in restricted areas around the coral reefs of the tropics. It is known by the Spanish-Caribbean name of "ciguatera," but is not limited to the New World tropics--it occurs throughout the archipelagoes of the tropical Pacific and across the Indian Ocean to Madagascar. On many of the Pacific Islands the ciguatera is acute, and random reports in the literature have appeared about the conditions on scattered islands. However, because of the breadth of the Pacific with its poor communications, and the lack of interest in the problem by scientifically trained men, no comprehensive picture of the extent of the poisoning, area by area, has ever been presented. In the last eight years the authors have attempted to amass sufficient information to present such a synoptic view.

Types of poisoning by marine animals:

In the literature there have been reported at least five major types of intoxications resulting from eating fish: 1. Poisoning by puffer fish and its relatives (Tetraodontidae); in these fish the toxin is endogenous and the fish are considered toxic almost everywhere they are found (Yudkin, 1944; Mosher, *et al*., 1964). 2. Poisoning by scombroid fishes; here the toxin is the result of bacterial action upon the flesh of newly caught fish (Kimata in Borgstrom, 1961). 3. Poisoning by mullet and surmullet; little is known of this intoxication except that it produces hallucinations (Helfrich and Banner, 1961). 4. Poisoning by one or more species of clupeoid fishes; this type is so little known that nothing definitive has been published. 5. Poisoning by numerous systematically unrelated fishes, ecologically associated in narrow regions on coral reefs; this disease is that known as ciguatera (see list of Hawaii Marine Laboratory literature on this subject in bibliography).

Halstead (1959 and elsewhere) has considered that the moray eels and shark livers represent two additional sources of disease, differing from ciguatera in symtomatology. Studies performed at our laboratory, as yet unpublished, indicate that these two diseases are the same as ciguatera, although there is some evidence that the shark liver may also contain other toxins (Lonie, 1950). There is some evidence that barracuda may carry, in some cases, a toxin of different pharmacological action than that causing the usual ciguatera.

1. Hawaii Marine Laboratory Technical Series No. 3, University of Hawaii, Honolulu, Hawaii (96822)

Among the invertebrates, there are some clearcut types of intoxication, as from the toxic anemone, "matamalu" (_Rhodactis howesii_), of Samoa or the salivary glands of a sea slug, the "ngau" (_Dolabella_ sp.) of Tonga. About these, however, almost nothing is known scientifically, and about other types of possibly toxic invertebrates, such as the reported toxicity of giant clams and "crabs with hairy legs," even less is known for we can obtain neither specimens nor reliable reports.

Therefore, in the report to follow, we have ignored poisoning by puffers because it seems to occur wherever the fish occur and scombroid poisoning because its occurrence is the result of improper handling of the fish after it is caught. Correspondingly, reports on toxic invertebrates have been omitted because they were too vague and without adequate scientific basis. This report thus concentrates on ciguatera, with notes on clupeoid and mullet poisoning where available.

The Nature of Ciguatera and the Biology of Ciguateric Fishes:

Publications issued and forthcoming from the Hawaii Marine Laboratory have established the nature of the toxic molecule causing ciguatera and its mode of action: it is an oil-soluble molecule of a probably "phosphatic nature" which causes a neuromuscular blockage by inhibiting the action of cholinesterase. We have also been able to confirm most of the steps in Randall's (1958) hypothesis of the environmental origin and transmission of the toxin. Randall suggested that the toxin originated in a fine alga, and was transmitted through the smaller herbivores to the larger carnivores feeding about the reef. We have been able to show that the toxin may be transmitted through the food chain, without harm to the fish ingesting it and that the toxin may be stored in the body of a fish, fed on a non-toxic diet, for over thirty months. However, we have not as yet found any alga that may originally produce the toxin.

Other studies have indicated that initially many, if not most, of the herbivores and carnivores upon a reef become toxic, but that over a period of years the toxicity of the fish gradually decreases until only the very large--and therefore old--snappers, groupers, eels and sharks remain toxic. In the archipelagoes reported upon below, all stages in the increase and waning of toxic conditions were found.

The listing of all of the species to which toxicity is attributed will not be attempted in this paper. Partial lists, giving encompassing distributional records, are presented by Fish and Cobb in 1954 and by Bouder and Cavallo, 1962 (the reader should be warned that these lists, like those of other authors, are not based upon laboratory testing but upon reports of varying reliability). In this paper we are concerned primarily with the larger, more toxic, carnivores such as snappers (Lutjanidae), groupers (Serranidae), eels (Muraenidae), jacks (Carangidae), reef sharks (Carcharhinidae), and barracuda (Sphyraenidae). These groups are generally the most esteemed food fishes and therefore most frequently involved in outbreaks of fish poisoning. The most commonly implicated herbivores, the surgeon fish (Acanthuridae), are also considered.

SAMOAN ISLANDS

Jordan reported in 1902 and in 1929 upon the toxic fish of Samoa, listing nine types (in some cases species, in some cases families).

Our present information on the extent of ciguatera and other intoxications caused by fish in the Samoan Islands indicates they constitute a rather serious problem there. Prior to the fire we received a report compiled by a teacher in Western Samoa based upon reports submitted by his students from their home villages; this compilation listed between 50 and 100 cases, almost all from the island Upolu, with some of them fatal. This report, unfortunately, was lost together with a number of reports on interviews made by the senior author of medical personnel and fishermen. The hospital reports both in Apia and Pago Pago do not reflect the extent of fish intoxication in the islands for most Samoans would rather trust their own remedies.

Manu'a, Rose and Swain's Islands:

No information is available on these islands.

Tutuila (American Samoa):

According to Mr. Thomas Annastas, Fisheries Officer for American Samoa, five areas are toxic off the south and southwestern portion of Tutuila (see Fig. 7). The most common toxic species on these offshore areas are the two snappers, *Lutjanus bohar* (Forskål) ("mu") and *L. gibbus* (Forskål) ("malai"). In three areas *Epinephelus* sp. ("ata-ata") and *Gymnothorax* sp. ("pusi") are also reported to be toxic, while in the area of Cape Taputapu all four fish plus *Holocentrus* or *Myripristes* ("malau") are suspect. In the pass between Aunu'u Island and Utumea Point a huge green turtle (*Chelonia mydas* [L.]) was captured in about 1958 and eaten by almost all persons in the neighboring village; all became sick and one woman and two children died; the symptoms apparently were those of ciguatera.

According to the records of the Government Hospital in Pago Pago, since 1 January 1963 there have been seven outbreaks in which fish were implicated; three were caused by *Lutjanus bohar* (one involving 9 persons, another 2 persons); two by "sea eel," probably *Gymnothorax*, one from an unidentified fish; and one from a barracuda (the symptoms in the last case were confused and may have arisen from hypochondria).

Upolu and Savai'i (Western Samoa):

Our only general information about these islands comes from Mr. A. L. Philipp, the Commissioner of Police, a long time resident of the islands and an enthusiastic fisherman. He reports that *Lutjanus bohar* ("mu") is toxic on the western and eastern extremities of Upolu and off Apia, but "as far as I know they are not poisonous on the island of Savai'i." He further reports that the pelu pelu (*Harengula* or *Sardinella*) is poisonous along the northern coast of Savai'i but not around Upolu. The large barracuda has also been found to be toxic in various places among the islands.

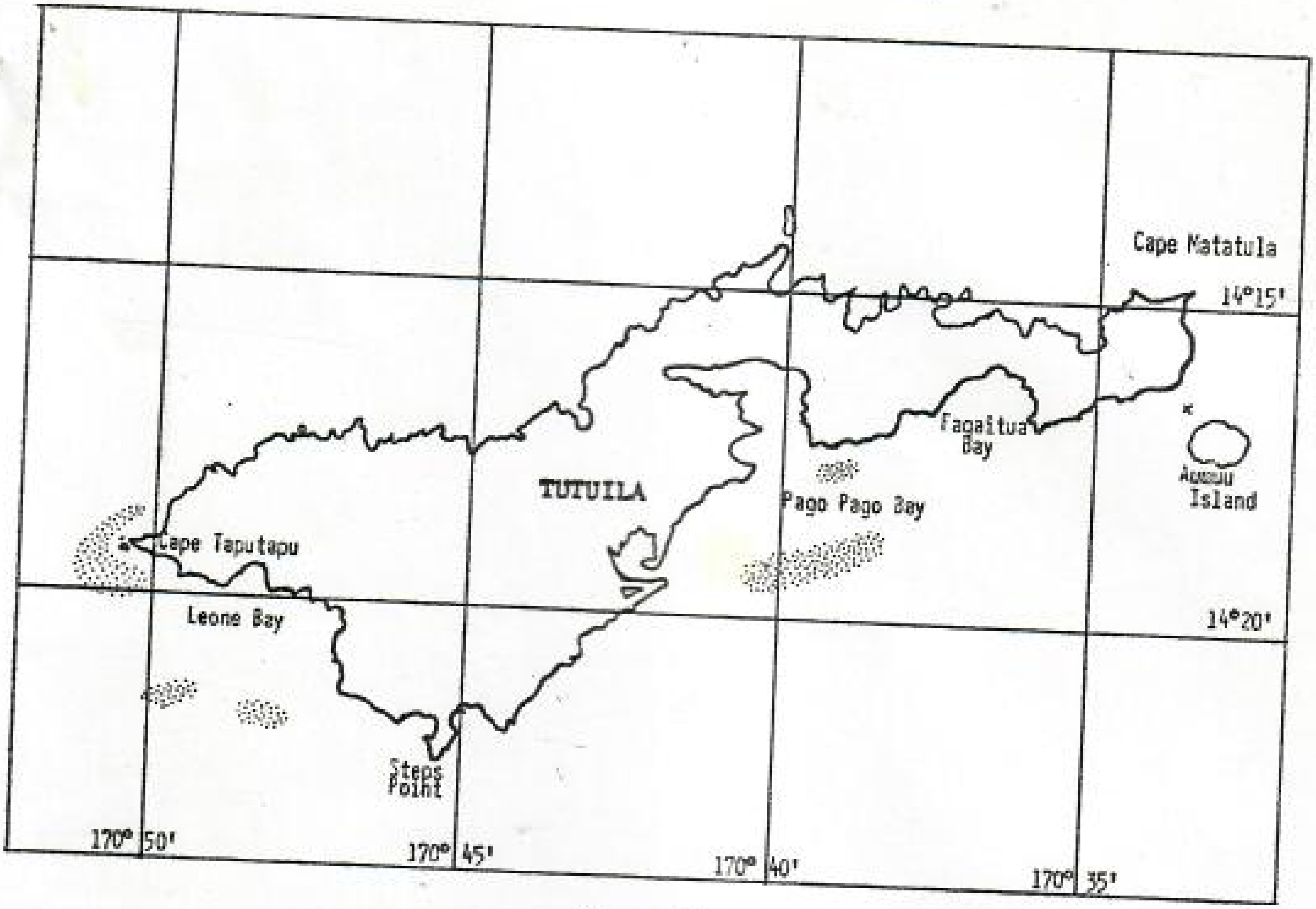

Figure 7
SAMOA--TUTUILA ISLAND: Known toxic areas shaded

A medical practitioner, Kome Kuresa, reported upon the district of A'ana on the northwest coast of Upolu. Here he reports that the "a'a," Lutjanus argentimaculatus (Forskål), is toxic everywhere in the district, both inside and outside of the reef and gives the typical symptoms of ciguatera. He estimates that 120 cases of ciguatera have occurred in the district in the last five years. He also submitted a case report on a person in Mofoali'i village, Western Samoa, being poisoned by an "a'a"; the symptoms were typical for ciguatera.

WALLIS ISLANDS

According to Dr. Guy Loison, Executive Officer for Health, of the South Pacific Commission, toxic fish are unknown in the Wallis Islands (personal communication).

TONGA

The Tongan Islands, including the Vavau and the Ha'apai groups, have long been noted to be without ciguatera and no information we have received indicates otherwise, except for one of the two fatal cases reported by Matheson and Puloka (1961). In this case, a male of 73 years ate a "humu moana," a fish identified by the Tongan Fisheries Officer, Yutaka Sawamura, as Balistes capistratus Shaw. Some of the symptoms were similar to ciguatera, as vomiting, diarrhea, muscular cramps of the lower limbs, and "definite paresis of lower limbs especially below the knees. All the patellar, tendo-achilles and plantar reflexes were absent." However, these symptoms are also found in poisoning by the puffer fishes, to which the family Balistidae is related.

On the other hand, poisoning by sardines has been long known in Vavau. Mariner in his book Tonga (3rd ed., 1827, I:246) reports: "[About] the shores of Vavaoo about the month of July [occurs a] fish, which they call ooloo caoo . . . . The common people consider it a great delicacy, but there is considerable danger in eating it promiscuously, for here and there is found one which produces the most alarming and sometimes the most fatal effects. As there is no mark by which these poisonous ones may be known, it is most dangerous to eat of them . . . . [Footnote:] The symptoms produced by eating this fish when poisonous are headache, nausea, vomiting, diarrhea, with violent pains in the bowels, to which death generally succeeds in the course of four or five hours. . . ."

The fish, by modern Tongan spelling, ulukau, was identified by Mr. Sawamura as Harengula zunasi Bleeker, probably the same sardine as that reported toxic from Samoa and Fiji. The second case of fatal poisoning reported by Matheson and Puloka was from a batch of these fish which incidentally afflicted, non-fatally, at least eight other individuals and killed three dogs and two pigs. As in Fiji, apparently only the viscera of these fish are toxic for two men who ate the raw, but eviscerated, fish from this catch were unaffected, but the two pigs that ate the viscera were killed.

Assemble all poisoning reference — include traditional knowledge i.e. Hawaii, etc.

23 kg in nine and a half years (Flower, 1937). Caldwell (1962c) reported the weight increases of four hatchlings maintained in captivity for three years as follows: the mean weight increase was 135 g the first year, 2,725 g the second year, and 5,000 g the third year. In captivity, hatchling green turtles can grow up to between 22.5 and 25 cm in six months according to Schroeder (1966). Evidently green turtles in captivity readily eat fish and other meat (see also Hornell, 1927; Loveridge, 1945; and Parrish, 1958).

People in the Tuamotu Archipelago have raised hatchlings on coconut meat and fish and they have obtained a length of 50 to 71 cm in 3 to 3½ years. Fishermen on various islands in the Kingdom of Tonga sometimes keep adult turtles in kraals and feed them on turtle grass which washes up on the beach (Hirth, MS).

3.44 Metabolism

Appa Rao and Dutt (1965) examined the chemical composition of muscle of an adult male green turtle. Results indicate that the water content of turtle flesh is close to that of fishes (i.e., 80 g water per 100 g muscle). The fat content (0.76 g per 100 g muscle) is lower than in most fishes. In 100 g of muscle they found 15.35 g protein, 510 mg phosphorus, 210 mg calcium, 34 mg iron, 0.21 mg copper, 0.20 mg cobalt and 0.20 mg molybdenum.

Chiefly because green turtle oil is used for therapeutic purposes in some parts of Mexico (used in treatment of tuberculosis, leprosy, and as a source of vitamins), Giral and Cascajares (1948), Giral, Giral and Giral (1948) and Giral (1955) have begun a study of its chemical properties. Some of the most common fatty acids in the oil are lauric, myristic, palmitic, stearic and palmitoleic. The presence of large amounts of lauric and myristic acids may be characteristic of Chelonia mydas. The sterol of body oil in a green turtle from New Guinea contained 96% cholesterol, 3% B-sitosterol, 0.2% campesterol and 0.15% stigmasterol (Minato and Otomo, 1969).

Biochemical composition and nutrient quality of the flesh may vary among individuals of a population depending on such things as age and sex, stage in the reproductive cycle, kinds of vegetation eaten on the feeding pasture, and physiological stress induced by long-range movements.

Evidently, the flesh (or fat or blood) of some Chelonia is toxic to humans. Halstead (1970) gives a list of references pertaining to sea turtle poisoning. The list contains only one case of poisoning by green turtles and this incident caused 18 deaths in Ceylon in 1840. However, the list also contains other instances of chelonitoxication in which the species was unknown. Most reports of chelonitoxication are from the Indo-Pacific region. The origin of turtle poison is unknown but most investigators who have studied the problem appear to be rather consistent in their opinion that the toxin is derived from poisonous marine algae eaten by turtles (see Halstead, 1970 for review of literature; also Boulenger, 1890; Halstead, 1959, 1969; and Taylor, 1970). The symptoms of chelonitoxication vary with the amount of flesh ingested and with the person. Symptoms generally

after eating the meat and initial symptoms include nausea, diarrhea, epigastric pain and vertigo. There are no known antidotes for chelonitoxin. The treatment is symptomatic. Further studies on chelonitoxication and documentation of green turtle cases are needed.

Ammonia is the major end product in the urine of mydas as it is in marine teleostean fishes. The green turtle also excretes a large amount of hippuric acid and this may be due to its herbivorous diet (Khalil, 1947).

An interesting adaptation of Chelonia mydas to its marine environment, pointed out by Schmidt-Nielsen (1959) among others, is its ability to discharge excess salt by means of salt glands located near the eyes. In this regard the green turtle is similar to the marine iguana and sea snakes. When on land, a turtle discharging salt looks as if it is "crying". Carr and Ogren (1960) suggested that the "crying" of nesting females also serves to keep the eyes clean of sand.

Holmes and McBean (1964) have clearly shown that the "salt gland" in mydas is the predominant route of sodium and potassium excretion. They further hypothesize that sea turtles drink sea water not only to obtain osmotically free water but also to enable the excretion of potassium ingested as food. Such information may be important for future turtle farmers in providing the proper milieu for their captives.

Ellis and Abel (1964a, b) describe how the turtle's salt gland tissue is in some ways different from the salt-secreting epithelia of fish and birds. Abel and Ellis (1966) state that histologically the modified lacrymal glands of marine turtles may be classified as compound branched tubular glands and that the salt-secreting nasal glands of marine birds, the rectal glands of elasmobranchs and the lacrymal glands of marine turtles have many common cytochemical and cytological features.

The marine plants that the turtles graze on probably have a salt concentration similar to that of sea water and no doubt the salt gland of the turtle operates in response to this electrolytic load.

Thorson (1968) measured the body water in sub-adult C.m. mydas and C.m. agassizii and

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The Turtles and Crocodiles of Thailand and Adjacent Waters With a Synoptic Herpetological Bibliography[1]

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ABSTRACT

The entire known turtle and crocodile faunas of Thailand and adjacent waters are treated, based on collections in Chulalongkorn University in Bangkok and in part on specimens in the EHT-HMS collection in Lawrence, Kansas. The number of species and subspecies here reported is 23 turtles and 3 crocodiles. Certain other specimens of turtles in the Bangkok Zoological Gardens purporting to be from Thailand have been examined. Some of these may also have a place in the Thai fauna, but their provenance is uncertain, some certainly not from Thailand.

INTRODUCTION

This is the fourth of a series of publications on the herpetological fauna of Thailand. The three others deal with the Amphibia (Taylor, 1962b), Sauria (lizards) (Taylor, 1963b), and Serpentes (Taylor, 1965a). This work treats of the Thai Testudines and Crocodylia, together with a synoptic bibliography for the series.

The collections on which these works were based were made chiefly during my sojourns in Thailand, 1958-59, 1961-62, while holding Fulbright Fellowships. These were made available through the kind help of Dr. Supachai Vanijuvadhana, then Secretary General of Chulalongkorn University of Bangkok, Thailand, who was himself greatly interested in the Thai faunas. I was in residence a total of more than 26 months, and of this time more than half was spent in exploration in various parts of the Kingdom. A third journey of about two months duration was made in 1964. This time was spent in the field.

For the most part the synonymies and literature lists refer to articles dealing with Thai specimens or specimens from localities in closely adjoining territory. Where available, Thai specimens were used for the descriptions. Unless otherwise designated, the numbers are those of specimens (at least formerly) in the collections of Chulalongkorn University.

I have included a map of Thailand showing the Changwats (provinces). The numbers have no significance—merely referring to the names.

[1] This work was done under National Science Foundation Grant No. GB-4510.

Genus **Dermochelys** Blainville

Dermochelys Blainville, Bull. Soc. Phil., 1816, p. 119. (Type of genus, *Testudo coriacea*.)
Sphargis Merrem, Syst. Amphib., 1820, p. 19.
Coriudo Fleming (type, *coriacea*), Phil. Zool., 2, 1822, p. 271.
Scytina Wagler (type, *coriacea*), Isis von Oken, 1828, p. 861. (Substitute name for *Sphargis*.)
Dermatochelys Wagler, Natürliches System der Amphibien mit vorangehender Classification der Saügethiere und Vögel, 1830, p. 133 (type, *coriacea*).
Chelyra Rafinesque (type, *coriacea*), Atlantic Jour., vol. 1, 1832, p. 64.

Diagnosis: Large sea turtles, the young covered with small polygonal shields, largest ones on the soft leathery carapace and plastron. Adult with smooth skin. Young with 7 dorsal keels on carapace and 5 on plastron, the keels covered by raised quadrangular scutes. More or less symmetrical plates or scutes on head, the occipital usually the largest. Tail very short. Arms large flattened paddles; legs, shorter flattened paddles. Only a single living species known.

Dermochelys coriacea (Linnaeus)

Testudo coriacea Linnaeus, Systema Naturae, ed. 12, 1766, p. 350 (type-locality [restricted], Palermo, Sicily).
Dermatochelys coriacea, Günther, Reptiles of British India, 1864, p. 55.
Dermochelys coriacea, Boulenger, Catalogue of the chelonians, rhynchocephalians, and crocodiles in the British Museum (Natural History), 1889, p. 10; Fauna of British India . . . Reptilia and Batrachia, 1890, p. 50; Siebenrock, Zool. Jahrb., Jena, Suppl., vol. 10, 1909, p. 553; Deraniyagala, Proc. Zool. Soc. London, 1930, pt. 3, pp. 1057-1070; Ceylon Jour. Sci., Sec. B, vol. 16, 1930, p. 45; Ceylon Jour. Sci. Colombo Museum Nat. Hist. Ser., vol. 1, 1939, pp. 38-102, figs. 12-34; M. Smith, The Fauna of British India including Ceylon and Burma, Reptilia and Amphibia, vol I, Loricata, Testudines, 1931, pp. 59-62, figs. 6-8.
Sphargis coriacea, Tickell, Jour. Asiat. Soc. Bengal, vol. 31, 1863, p. 367-370, 1 colored plate.
Dermochelys schlegeli, Stejneger, Bull. U.S. Nat. Mus., No. 58, 1907, p. 485.
Dermochelys coriacea schlegeli, Garman, Bull. U.S. Nat. Mus., 1884, No. 25, p. 303 (type-locality, Guaymas, Sonora, México); Carr, Handbook of the turtles of the United States and Canada, 1952, p. 452; Mertens and Wermuth, Zool. Jahrb., Syst., Band 83, Heft 5, 1955, p. 387; Lekagul, Conserv. News, Bangkok, No. 7, 1965 (1966), p. 19, fig.

Diagnosis: Characters of the family and genus.

Atlantic forms differ from those in the Pacific and Indian Oceans so that two subspecies are recognized, only one of which occurs in Thailand waters.

Dermochelys coriacea schlegeli (Garman)

Sphargis coriacea var. *schlegeli* Garman, Bull. U.S. Nat. Mus., No. 25, 1884, p. 303 (type-locality [restricted], Guaymas, Sonora, México). (The type is figured in Temminck and Schlegel.)
Sphargis angusta Philippi, An. Univ. Santiago de Chili, vol. 104, 1899, p. 728 (type-locality, Tocopila, Chile).
Dermochelys coriacea schlegeli, Carr, Handbook of the Turtles of the United States and Canada, 1952, p. 452; Mertens and Wermuth, Zool. Jahrb. (Syst.), Band 83, Heft 5, 1955, p. 387.
Dermochelys coriacea M. Smith, The fauna of British India including Ceylon and Burma, Reptilia and Amphibia, vol. I, Loricata, Testudines, 1931, pp. 59-62 (*part*.).

The status of *schlegeli* as a subspecies is based largely on the fact that the average known size of the Pacific form of *coriacea* is larger than that in the

Atlantic. There are other small differences recorded but it is not certain that these are constant. No one has been able to make a direct comparison of a series of these huge animals. Carr (*loc. cit.*) reports specimens with a body two meters in length—in fact, one reported from Australia reached nine feet in length. Other specimens are reported as weighing from 800 to 1600 lbs.

Compared with the typical form the head is said to be proportionally longer, the scales of the head less symmetrical, and the arms shorter in proportion to length.

Description: In young animals, body and limbs covered with small, irregular, usually polygonal shields. These larger on carapace and plastron than on other parts. Seven keels on dorsal part of carapace, made of larger raised quadrangular shields; five keels on plastron, the median often presenting a double row. These keels may converge and meet anteriorly and the three median meet posteriorly. Scutes on remainder of surfaces smaller, nearly uniform except for a few larger series on edges of limbs.

These shields or scales tend to disappear completely in older animals, but traces of the keels remain visible on carapace as nodular ridges. Keels on plastron tend to disappear completely. Arm bones encased in long fleshy paddles which, in the young, approach length of carapace, but become proportionally shorter in adult.

Color: The adult is colored—"Dorsally a slaty black with three or four longitudinal rows of small white spots not larger than the iris extending between each pair of carapace ridges. These spots are more numerous at the base of the flippers. Head black with a few white blotches. Jaws white, clouded with black. Neck with five longitudinal rows of white spots. Ventrally pinkish white or white, usually with dark reticulation representing scale marks. A black lateral band usually extends from the inguinal area to the cloaca. Sometimes in females the black disappears more or less from the plastron. The top of the caudal crest is white. Newly hatched young are an intense blue black marked with white to whitish; the encroaching black imparts a bluish appearance." Deraniyagala (1930a).

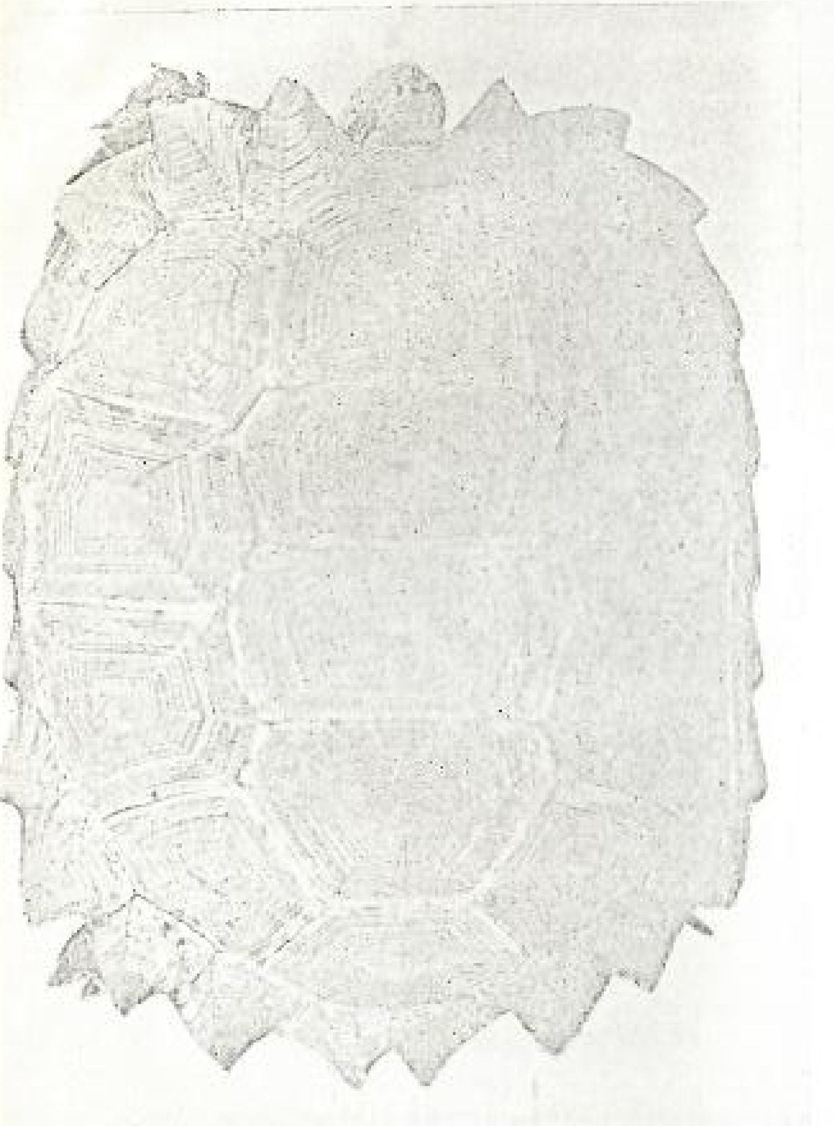
The markings on the adults are similar to those of the young but probably less well defined.

Measurements: Total length, 7 ft. 5 in.; length of carapace, 5 ft. 3 in.; carapace width, 2 ft. 10.5 in.; width of flipper to flipper, 4 ft. 3 in. (From Carr, 1952.)

Remarks: One Thai specimen is figured by Dr. Boonsong Lekagul (1966).

Superfamily **Cryptodira**

Shell with plastron and carapace fused laterally and covered with epidermal horny plates or scales. Head can be withdrawn within shell, the neck



...gure 8. *Testudo impressa* (Günther). Chulalongkorn Univ. No. 1647. Carapace lengt... ...m; carapace width, 140 mm.

Color: Light brown of varying shades, lighter near sutures; about pe... ...ery of each scale, short dark brown radiating lines. Laterally on marginal... ...e indefinite larger dark spots; plastron yellow-brown becoming pal... ...wish near sutures; distal remnants of radiating lines.

Arms nearly black; legs and tail very dark brown.

Measurements in mm: Length of carapace, 166; width of carapace, 140; depth of shell, 73; length of plastron, 161; width of plastron, and bridge (pectorals), 123; width of anterior lobe, 96; width of posterior lobe, 91; length of posterior lobe, 56; length of bridge, 68.

Variation: The described specimen is considerably more than half grown as the species reaches a length of at least 270 mm in carapace length.

Young specimens may be light yellowish brown above, finely speckled with black. Some specimens have strongly defined dark rays on the plastron.

Distribution: In Thailand the species has been taken in relatively few places. It is a mountain species found at moderate altitude. The type was taken in Thailand but the exact locality is unknown.

Malcolm Smith (1916c) reports a series of specimens taken in Thailand but does not give exact localities. It is not a common species. The specimen here described has no specific locality recorded.

Remarks: The sculpturing of the carapace, the strongly serrate character of the marginals, and the rich brown coloration of the carapace combine to make this perhaps the handsomest of the turtles and tortoises of Thailand.

Several excellent figures of this species are given by Dr. Boonsong Lekagul (1966, p. 59).

Superfamily **Chelonioidea**

Head partially retractile, forming an S-shaped curve in a vertical plane; cervical vertebrae short; outer part of the tympanic cavity not roofed over by bone.

Pterygoid bones forming a median suture anteriorly, posteriorly rather widely separated; squamosals and parietals forming a suture. A complete set of marginal bones joined to the ribs. Pelvic girdle not fused to carapace or plastron. Carapace bones covered with horny epidermal shields.

One family, the Cheloniidae, is associated with this superfamily.

Family **Cheloniidae** Gray

Nuchal plate lacking a riblike process. Nine plastral bones. Temporal region of skull roofed over completely. Plastral elements reduced in size with a median vacuity between the 2 lateral halves, and connected to carapace by ligamentous tissues. Costal plates above ribs covering most of dorsal area in one form (*Chelonia*), leaving wide fontanelles between them and marginal bones. In *Eretmochelys* they may reach the marginals in old age. In others the fontanelles may disappear in adult.

The family Cheloniidae Gray consists of four recognized genera each comprising a single species: *Caretta* Rafinesque, *Chelonia* Latreille, *Eretmochelys* Fitzinger and *Lepidochelys* Fitzinger. These may be separated by the following key:

KEY TO GENERA OF THE CHELONIIDAE

1. Five or more pairs of costal shields 3
   Four pairs of costal shields 2
2. Two pairs of prefrontal shields; dorsal scutes on carapace imbricate, tending to become juxtaposed in very old specimens; jaws hooked .... *Eretmochelys*
   One pair of prefrontal shields on head; dorsal scutes on carapace always juxtaposed; jaws not hooked .... *Chelonia*
3. Normally 6 pairs of costals; interegular shield usually present (sometimes divided); usually 27 marginals; carapace reaches a length of 1050 mm .... *Lepidochelys*
   Normally 5 pairs of costals. Three relatively large inframarginal scutes. Last few neural plates may be separated by costal plates which meet on midline. Color usually dull reddish brown; 2 pairs of prefrontals, marginals usually less than 27 .... *Caretta*

Genus Eretmochelys Fitzinger

Eretmochelys Fitzinger, Systema Reptilium, 1843, p. 30 (type of genus, *imbricata*).

Diagnosis: Four pairs of costal shields; an intergular shield; a series of inframarginal shields between carapace and plastron; 3 or 4 axillaries and 1 or 2 inguinal shields; regular plastral scales keeled, anals with highest keels. Head covered with regular shields consisting of a frontal preceded by 2 pairs of scales, a pair of supraorbitals, parietals, occipitals, 2 large supratemporals, and 8 or 9 temporals; arms flipperlike; legs similar, shorter, widened; carapace covered with strongly imbricating shields, all keeled with accessory nonparallel ridges; a nuchal, 5 ventral, 4 costal, and 24 marginal shields; jaw hooked; a large shield following the shield on lower jaw; usually 2 claws on hand and foot.

Only a single species with two subspecies is recognized. These may be distinguished by the following key:

KEY TO SUBSPECIES OF *Eretmochelys imbricata*

1. Carapace somewhat straight-sided and narrowly tapered behind; upper surface of head and flippers with less black coloration. Atlantic Ocean, Caribbean Sea .... *imbricata imbricata*
   Carapace usually somewhat heart-shaped in lateral outline, upper surface of head and flippers almost solid black. Indian and Pacific Oceans .... *imbricata bissa*

Eretmochelys imbricata bissa (Rüppell)

(Figs. 9-10)

Caretta bissa Rüppell, Neue Wirbelthiere zu der Fauna von Abyssinien gehörig, 1835, p. 4 (type-locality, Red Sea).
Eretmochelys squamata Agassiz, Contribution to the natural history of the United States of America, vol. 1, 1857, p. 382 (type-locality, restricted to Singapore); M. Smith, The fauna of British India, . . . Reptilia and Amphibia, vol. 1, Loricata, Testudines, Mar. 1931, pp. 67-69, fig. 12.
Chelone imbricata Boulenger, Catalogue of chelonians, rhynchocephalians, and crocodiles in the British Museum, 1889, p. 183; The fauna of British India, including Ceylon and Burma, Reptilia and Batrachia, 1890, p. 49.
Chelonia imbricata Siebenrock, Zool. Jahrb. Jena (Suppl.) 10, Heft 3, 1909, p. 547 *(part.)*.
Caretta squamata, Günther, The reptiles of British India, 1864, p. 54.
Eretmochelys imbricata, Taylor, Amphibians and Turtles of the Philippine Islands, 1921, pp. 180-182, pl. 15, figs. 1, 2; pl. 16, figs. 5, 6.
Caretta rostrata Girard, U.S. Exploring Expedition, Herpetology, 1858, p. 442, pl. 30 (type-locality, Fiji Islands).
Eretmochelys imbricata bissa, Smith and Taylor, Bull. U.S. Nat. Mus. Washington, no. 199, 1950, p. 16; Mertens und Wermuth, Die rezenten Schildkröten. . . . Zool. Jahrb. (Syst.), Band 83, Heft 5, 1955, p. 385.

Diagnosis: Characters of genus.

Description of species (from No. 1652, Gulf of Siam): Carapace low, covered with strongly imbricating shields; a well-defined sharp median keel; lateral keels dim, indistinct; nuchal wide, nearly double width of adjoining marginals; more than twice as wide as long (from nuchal edge); all vertebrals distinctly wider than long (from overlapping edge of preceding scale); first 3 costals distinctly larger than vertebrals; all costals wider than long. Vertebrals and to lesser extent costals with 2 accessory keels lateral to median, which tend to converge posteriorly on each scale; carapace serrate, lateral and posterior marginals terminating in a sharp, rather spinelike projection; supracaudals with a slight posterior notch.

Carapace rather flattened on a level with border of carapace; a triangular median intergular; measurements in mm of the plastral sutures are: gulars, 21; humerals, 30; pectorals, 32; abdominals, 37; femorals, 37; anals, 46. Plastral shields with continuous keels converging somewhat at each end of carapace, highest posteriorly; a row of 4 flat intercalated shields between plastron and carapace, all a little longer than wide; 5 smaller axillary shields and 2 small inguinal scales, the latter separated.

Arms paddle-shaped, with 2 claws evident on distal anterior edge of paddle; front face of paddle covered with enlarged scutes arranged in several irregular rows; underside (posterior) face with similarly enlarged scutes more irregularly arranged; front face of leg and foot with irregular rows of scutes; posterior face with numerous enlarged, as well as small scutes.

Tail very short, dorsal part with 2 or 3 paired scales; a specialized shield follows postanals.

Head covered with shields (or scutes), consisting of a large shield covering most of upper jaw and beak, small soft plate through which both nostrils are pierced, a pair of supranasals, a larger pair of prefrontals preceding a single frontal flanked by large supraorbitals, a pair of fused parietals, and a pair of occipitals. Eight temporals follow supraorbital; an elongate scute follows the large scute on lower jaw.

FIGURE 9. *Eretmochelys imbricata bissa* (Rüppell). Philippine Bureau of Science No. 147[illegible] Carapace length, 173 mm. Upper figure, ventral view; lower, dorsal view.

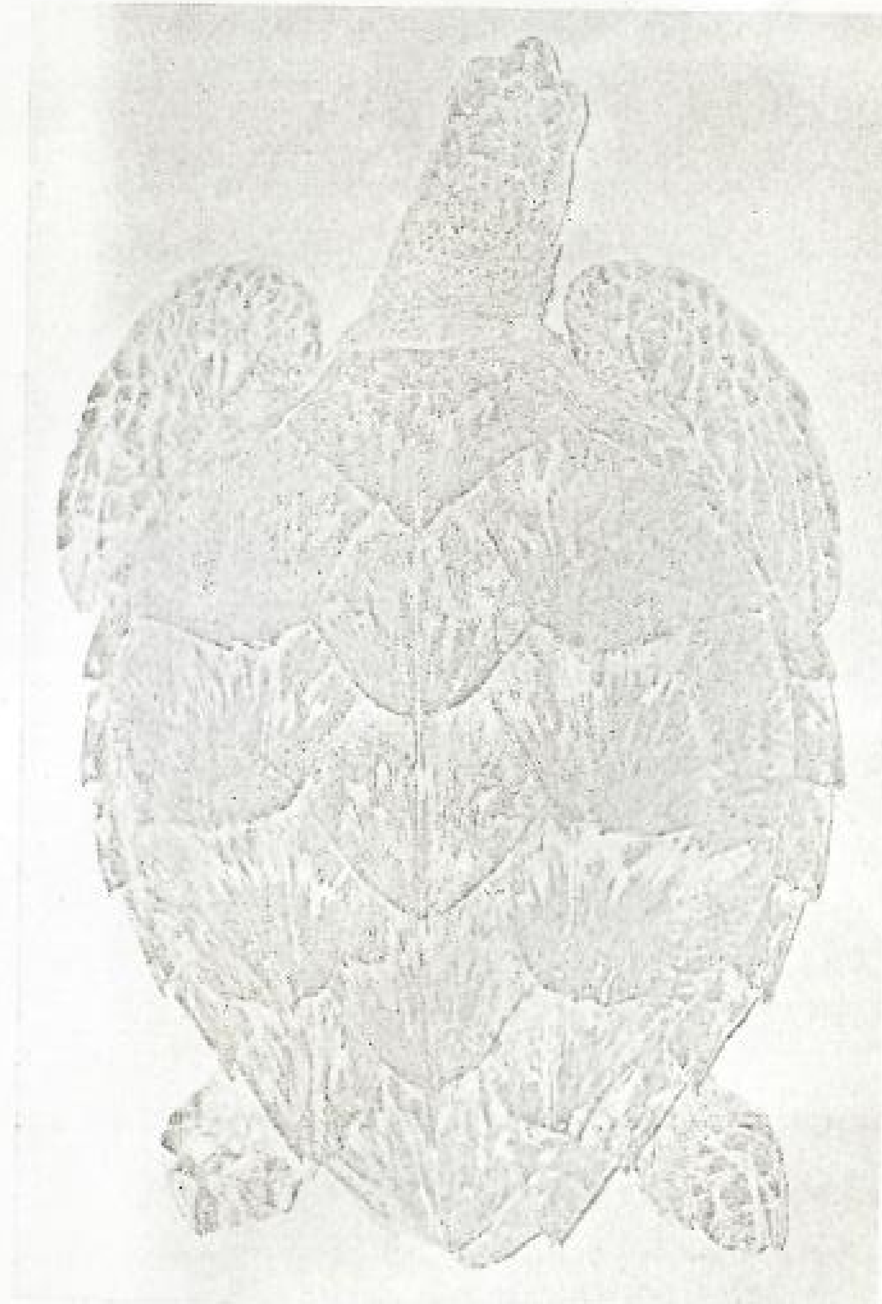


FIGURE 10. *Eretmochelys imbricata bissa* (Rüppell). Philippine Bureau of Science No. 1474 (young). Aparri, Luzon. Carapace length, 245 mm.

Color: Above brown, streaked with amber; plastron light yellowish, darker along posterior part of keels; scales of head, arms, and legs brown, often with yellowish borders.

Measurements in mm: Total length, 244; length of carapace, 173; width of carapace, 130; length of plastron, 134; width of plastron across pectorals, 81; length of arm, 98; length of leg, 53; head length, 47; head width, 30 (from Taylor [1921], Philippine specimen, No. 1474 Bureau of Science Coll.; Manila).

Variation: The dorsal shields, normally imbricate, may become practically juxtaposed in very old animals.

Distribution: In Thai waters the species occurs around the entire coastline but nowhere is it regarded as common as other species of marine turtles.

It is widely distributed along tropical and subtropical coast-lines of the Pacific and Indian Oceans.

Remarks: This species furnishes the "turtle shell" of commerce. It is still collected, but now has to compete with artificial "tortoise shell."

Genus **Chelonia** Brongniart

Chelonia Brongniart, Bull. Sci. Soc. Philom., vol. 2, 1800, p. 89 (type of genus, *Chelonia mydas*).

Diagnosis: Five vertebrals, 4 pairs of costal shields. An intergular scale separating anterior part of gulars. A series of inframarginal scales (4 or 5). Eleven pairs of marginals and 1 pair of supracaudals. Head with regular symmetrical scales. One pair of prefrontals; nuchal transversely widened. Jaws not hooked.

A single species is recognized with at least two subspecies. They occur in the Atlantic, Pacific, and Indian Oceans.

Chelonia mydas Linnaeus

Testudo mydas Linnaeus, Systema Naturae, ed. 10, vol. 1, p. 197 (type-locality [restricted by Mertens and Müller, 1928], Asuncion Island).

Chelonia mydas japonica (Thunberg)

(Fig. 11)

Testudo japonica Thunberg, Kongl. Vetensk. Acad. Handl., Stockholm, 1787, vol. 8, p. 178 (type-locality, Japan).

Caretta thunbergii, Merrem, Tentamen Systematis Amphibiorum, 1820 (substitute name for *T. japonica* Thunberg).

Chelonia mydas japonica, Gray, Synopsis Reptilium or short descriptions of the species of reptiles, pt. 1, Cataphracta, tortoises, crocodiles and enaliosaurians, pt. 1, p. 53; Mertens und Wermuth, Zool. Jahrb. (Syst.), Band 83, Heft 5, 1955, pp. 384, 385.

Chelonia formosa Girard, U.S. Exploring Expedition, Herpetology, 1858, p. 456 (type-locality, Fiji Islands).

Chelonia tenuis Girard, U.S. Exploring Expedition, Herpetology, 1858, p. 459 (type-locality, "Tahiti, Honden, Eimeo and Rosa Islands").

Chelonia agassizii Bocourt, Ann. Sci. Nat., Paris, ser. 5, vol. 10, 1868, p. 122 (type-locality, mouth of Rio Nagualate, Pacific Coast of Guatemala).

Chelonia lata Philippi, Zool. Garten, Frankfurt am Main, 1887, vol. 28, p. 84 (type-locality, Valparaiso, Chile).

Chelonia japonica Taylor, Amphibians and Turtles of the Philippine Islands, Manila, Pub. 15, Bureau of Science, 1921, pp. 184-185, pl. 17, figs. 1-4.

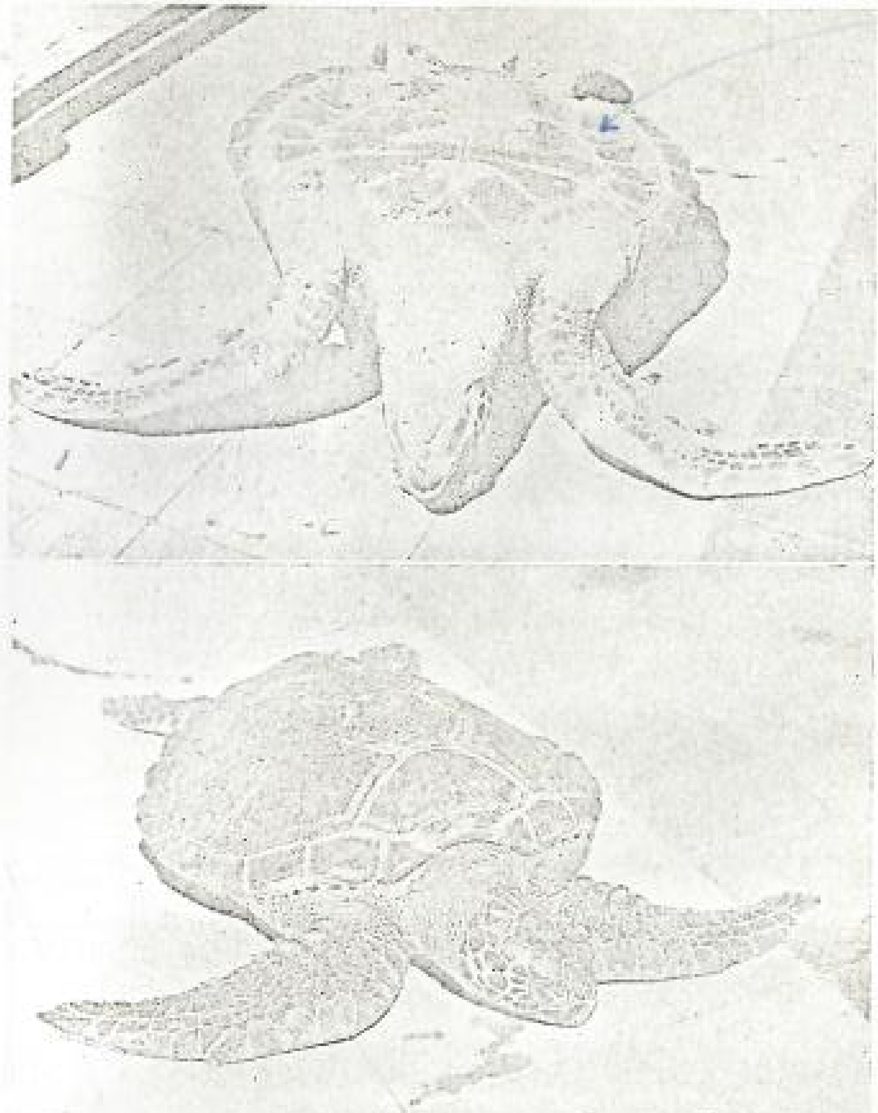


FIGURE 11. *Chelonia mydas japonica* Thunberg. Specimen living in the Manila Aquarium, Manila Bay, near Manila. Carapace length, 735 mm. (Also figured in Taylor, 1920.) Upper, ventral; lower, dorsal view.

Diagnosis: Limbs paddle-shaped, with 1 or 2 claws. Shell covered with horny shields; costal plates fused to ribs and carapace, not extending to edge of carapace. Having other characters of the genus.

Description of species: Large marine form commonly known as the Green Turtle. Carapace longer than wide, somewhat arched, slightly serrate posteriorly; 11 pairs of marginals, a broad nuchal and paired supracaudals border rim of carapace; 5 vertebrals wider than long; 4 pairs of costals. Plastron separated from marginals by a series of 4-5 inframarginals; 6 pairs of plastral shields with a single intergular preceding the gular pair.

Head rather large, the snout short; edges of the jaws denticulated, much more strongly so on the lower jaw; upper alveolar surface of upper jaw with 2 strongly denticulated ridges; lower jaw with a short symphysis. One pair of prefrontal shields. Limbs paddle-shaped usually with only a single claw present.

The young specimens usually with a median keel, sometimes with a lateral keel also. Young may have 2 claws. Their color olive to dark brown with some yellow markings on limbs; venter yellowish, with dark areas on hands and feet. The adults are likewise greenish to grayish brown. Some specimens show dark rays. Plastron yellow.

The length of the shell often exceeds a meter.

Measurements in mm: Total length, 735 (head to tail); length of carapace, 555; width of carapace, 470; height of shell, 180; length of plastron, 448; width of plastron across pectorals, 125; width of head, 90; depth of head, 100; tail, from vent, 28.

Remarks: Despite the paddle-shaped limbs the original bony system of limbs and girdle is present with only a few exceptions. The fontanelles between the marginals and costals are never completely covered by bone in this genus.

This species is widely eaten. Sir J. E. Tennant (1861), former civil secretary to the colonial government of Ceylon, reports a case of a turtle of this species being eaten in Ceylon causing the death of 18 persons. This was October 1840.

Taylor (1922) reports a similar case from Cebu Island where a turtle was consumed by 33 persons, 14 of whom died. It is not known whether the meat becomes poisonous only at certain seasons, or age, or whether it is due to some type of poisonous plant consumed by the turtle or by some disease. It is not impossible that the meat had been allowed to spoil before being consumed but there was no evidence that this was true in the latter case.

Genus Lepidochelys Fitzinger

Lepidochelys Fitzinger, Systema Reptilium, 1843, p. 30 (type of genus, *Lepidochelys olivacea* (Eschscholtz)); Carr, Proc. New England Zool. Club, vol. 21, 1942, p. 4.
Chelonia Eschscholtz, Zool. Atlas, 1, 1829, p. 3.

Diagnosis: "Maxillaries not in contact, separated by vomer; frontal bone entering rim of orbit; pterygoids markedly broadened anteriorly, the ectopterygoid process strong; fontanelles in choanal chamber near opening, not hidden by alveolar surface in ventral aspect; external opening of orbits not concealed by overlying bones in ventral aspect; descending processes of prefrontals not reaching palatines; lower jaw with a more or less sharp and strong triangular median element at the posterior border of the bony alveolar surface, which may or may not extend forward as an elevated ridge; four enlarged inframarginal scutes on the bridge; neural bones 11-15; color gray to olive green." (Carr, 1942.)

Lepidochelys olivacea (Eschscholtz)

Chelonia olivacea Eschscholtz, Zool. Atlas, 1, 1829, p. 3, pl. 3 (type-locality, Manila Bay, Philippines).

Three subspecies of *olivacea* are recognized by the Mertens-Wermuth List (1955). These are the typical *L. o. olivacea*, *L. o. kempi* (Garman) and *L. o. remivaga* (Hay). These 3 may be contrasted by the following brief diagnoses:

L. o. olivacea: Bony alveolar surface of each side of upper jaw usually with a gentle elevation extending parallel to the cutting edge but never with a conspicuous ridge; combined width of pterygoids behind expanded anterior portion usually contained no more than 2-2.5 times in greatest diameter of orbit; each inframarginal scute usually with a pore at its posterior border; costal scutes usually in more than 5 pairs; color olive. Indian and Pacific Oceans.

L. o. kempi: Bony alveolar surface of upper jaw with a median ridge extending parallel to the cutting edge; combined width of pterygoids, behind expanded anterior portion, contained about 3 times in greatest diameter of orbit; inframarginal scutes without pores; costal scutes usually in 5 pairs; color usually gray. Atlantic Ocean, Gulf of Mexico.

L. o. remivaga: Described by Hay (1908) from a skull from Ventosa Bay, Gulf of Tehuantepec, Mexico (without a carapace) chiefly by a comparison with that of *Caretta*. "The skull is flat, the snout more or less pointed. The frontal bones enter the rim of the orbit; maxillae are widely separated by the vomer. The pterygoids possess conspicuous ectopterygoid processes. The free border of pterygoid when followed backward becomes a ridge which disappears before it reaches the pedicel of the quadrate. Occipital condyle stands distinctly behind the quadrates. Prootic bones project but little in front of the pedicels. The frontal scute is about as long as the frontoparietal; the latter is not so long as the parietals. Known from Ventosa Bay, Gulf of Tehuantepec, Eastern Pacific Ocean."

Lepidochelys olivacea olivacea (Eschscholtz)

(Fig. 12)

Chelonia olivacea Eschscholtz, Zool. Atlas, 1829, vol. 1, pl. 3 (type-locality, Manila Bay, Philippines).
Caouana olivacea, Gray, Catalogue of the tortoises, crocodiles and amphisbaenians in the collection of the British Museum, 1844, p. 53; Günther, Reptiles of British India, p. 52.
Caretta olivacea, Garman, Bull. Mus. Comp. Zool. Harvard College, vol. 52, 1908, p. 9; Taylor, Amphibians and turtles of the Philippine Islands, Dept. Agri. Nat. Resources, Bureau of Science, Manila, No. 15, Dec. 15, 1921, pp. 182-184, pl. 17, figs. 1-4.
Thalassochelys olivacea, Boettger, Ber. Senck. Nat. Ges., 1886, p. 93.
Chelonia dussumierii Duméril and Bibron, Erpétologie Générale, vol. 2, 1835, p. 557.
Lepidochelys olivacea, Girard, U.S. Exploring Expedition. Herpetology. 1858, p. 435; Mertens and Wermuth, Zool. Jahrb. (Syst.), Band 83, Heft 5, 1955, p. 386.
Caretta caretta olivacea, M. Smith, The fauna of British India . . . including Ceylon and Burma. Reptilia and Amphibia, vol. 1, 1931, pp. 71, 72.

Diagnosis: Characters of the genus. Normally, 6 pairs of costals; intergular shield usually present, sometimes divided; usually 27 marginals. Carapace reaches a length of 1050 mm or more.

Description of species: Carapace with a distinct median keel, more prominent posteriorly; 6 pairs of costals, the nuchal divided; 6 vertebrals, the fifth small; 11 pairs of marginals with 2 supracaudals and 2 nuchals; a small inguinal shield, and a group of small axillary shields, 4 of which touch pectorals and humerals. A small round shield behind the anal shields.

The head scales on a Philippine specimen examined consisted of a pair of anterior prefrontals smaller than the second pair; an azygous prefrontal between 2 supraoculars; frontal large, wider than long, followed by 4 parietals; a large temporal (parietal) follows the supraocular and borders the frontal and parietal; 3 postoculars, upper smallest, middle largest, lower elongate; postoculars bordered by 4 temporals.

Color: Drab olive or gray-olive, somewhat lighter at sutures. Sides and underside of neck whitish. Plastron whitish with somewhat darker areas on plastral scutes.

Measurements in mm (Young living specimen): Length of carapace, 340; width of carapace, 325; height of carapace, 110; length of arm, 260; length of leg, 180; length of plastron, 275; width of plastron, 280; tail from vent, 15; length of head to end of parietals, 90; depth of head, 55.

Remarks: The subspecies is widely distributed in the Pacific and Indian Oceans. The young show indistinct dorsal and ventral keels.

Genus Caretta Rafinesque

Caretta Rafinesque, Specchio Sci. Palermo, vol. 2, 1814, p. 66 (type of genus, *Caretta nasuta* Rafinesque=*Testudo caretta* (Linnaeus)).

Diagnosis: "Five or more pairs of costal shields; intergular shield present or absent. A series of inframarginal plastral shields. Head covered with symmetrical shields; two pairs of prefrontals. Tail short." M. Smith (1931a).

FIGURE 12. *Lepidochelys olivacea olivacea* (Eschscholtz). Specimen living in Manila Aquarium. Topotype, Manila Bay. Carapace length, 340 mm. Upper, ventral; lower, dorsal view.

There is considerable variation in the number of the shields that compose the carapace. The amount of variation is in part geographical as the greatest variation occurs in the Indian and Pacific Oceans.

Caretta caretta (Linnaeus)

Testudo caretta Linnaeus, Systema Naturae, ed. 10, 1758, vol. 1, p. 197 (type-locality restricted to Bermuda).

This species is regarded as comprising two subspecies, *Caretta c. caretta* Linnaeus and *C. c. gigas* Deraniyagala.

KEY TO SUBSPECIES OF *Caretta caretta*

1. Marginal scales on each side averaging 12; neural bones usually 7 or 8, rarely interrupted by costal plates (pleurals). Atlantic Ocean, Mediterranean Sea .... *caretta caretta*
   Marginal scales usually 13 on each side; neural bones 7-12, the last bones of series (1-5) usually interrupted by costal plates (pleurals), which are in contact with each other. Indian and Pacific Oceans .... *caretta gigas*

Caretta caretta gigas Deraniyagala

Caretta gigas Deraniyagala, Ceylon Jour. Sci., sec. B, vol. 18, 1933, p. 66 (type-locality, Gulf of Mannar, Ceylon).
Caretta caretta gigas, Deraniyagala, Tetrapod reptiles of Ceylon, vol. 1, 1939, p. 164.
Caretta caretta gigas, Mertens and Wermuth, Zool. Jahrb. (Syst.), Band 83, Heft 5, 1955, p. 383.
Caretta caretta olivacea, M. A. Smith, The fauna of British India, including Ceylon and Burma. Reptilia and Amphibia, vol. 1, Loricata, Testudines, Mar. 1931, pp. 71-72 (*part.*).

Diagnosis: Differs usually but not invariably from the typical form in having 3 relatively large inframarginal scutes; usually 5 pairs of costals. The last few neurals interrupted by pairs of costals forming a median suture. The color, varying shades of reddish brown.

Description of subspecies: Characters of the genus.

Nuchal scute single; normally 5 costals. Marginals somewhat variable, 11-13 pairs. Plastron with paired gulars, pectorals, abdominals, femorals and anals, the lengths of sutures not differing greatly. Head with 2 pairs of prefrontals; frontoparietal large; 2 or 3 pairs of parietals; 2 supraoculars on each side; other postoculars and temporal scales somewhat variable.

Arms in the form of elongate paddles, each bearing 2 claws (rarely 1). Legs large but shorter than arms, the width and length nearly equal. Both arms and legs with scales and scutes of variable size, largest on inner edge of arm around posterior parts of each.

Carapace somewhat arched, longer than wide, and with posterior parts narrowed. Young with 3 keels above and 4 on the plastron below.

Remarks: Most of these data are from Deraniyagala, who gives a very detailed description of the typical form. The subspecies is widely distributed from Australia to Ceylon along the coast of southeast Asia and the islands of the Pacific Ocean.

I believe that this subspecies is exceeded in size only by *Dermochelys coriacea*.

Superfamily **Trionychoidea** Fitzinger

Head capable of being withdrawn completely within shell, neck forming a sigmoid curve in a vertical plane. Bones of carapace and plastron covered with soft skin instead of horny plates. Phalanges not free, encased in a paddlelike limb; arm with 2 or 3 claws. Pterygoids not forming a suture; basisphenoids forming sutures with palatines. Only a single Asiatic family, the Trionychidae, is associated with this superfamily.

Family **Trionychidae** Bell

Trionychidae Bell, Zool. Jour., vol. 3, 1828, p. 515.

Genus **Trionyx** Schweigger

Trionyx Schweigger, in Geoffroy Saint-Hilaire, Ann. Mus. Nat., Paris, vol. 14, 1809, p. 1 (type of genus *Testudo cartilaginea* Boddaert).

The differences between *Amyda* and *Trionyx* would seem to be not easily discerned. Both names appear in the same publication (Schweigger, *vide supra*), the type of *Trionyx* being *Trionyx coromandelicus* Geoffroy Saint-Hilaire (*Trionyx punctatus granosus* Schoepff). Various herpetologists have used the name *Trionyx* for this group of soft-shelled turtles; others have used *Amyda* which has page priority.

In certain recent publications authors have retained *Trionyx* for the greater number of the soft-shelled turtles of America, Africa and Asia. The group designated *Trionyx* by Geoffroy Saint-Hilaire were the "three toed" turtles with 7 plastral callosities. Malcolm Smith (1931a) regarded this group as equivalent to *Emyda* Rafinesque but shows that this name as used by Gray is a homonym of that of Rafinesque which was proposed as a substitute name for *Emys* Duméril. Smith then proposes a new name—*Lissemys*—for the group having 3 toes and 7 plastral callosities and a "cutaneous femoral valve" with marginal bones.

Diagnosis: Thus *Trionyx* may be defined as lacking a cutaneous valve, marginal bones, and as having 4 plastral callosities. Orbit nearer to temporal cavity than to nasal cavity; arch following orbit narrower than orbital diameter; proboscis as long as eye opening. The dorsal surface of the young bears longitudinal series of small tubercles.

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lar example of micro-evolution between adjacent populations isolated solely by the strength and single-mindedness of the urge of the female—and male—turtles to return to their natal beach for breeding. The various populations appear to have similar shell shapes, but the pigmentation of the scutes of the carapace is sometimes coarsely variegated, sometimes finely variegated, and sometimes relatively plain, each scute simply having a relatively dark central or posterior area, with the areas of relatively recent growth being lighter. The Australian turtle ranchers get a much better price for their stuffed hawksbills than do the inhabitants of Tidung Island.

The flesh of the hawksbill is little favored for human consumption in most areas and indeed is occasionally fatally poisonous; Deraniyagala recorded a case of twelve people in the village of Karuppankudiyiruppu in Sri Lanka dying from eating hawksbill in 1888. However, hawksbills are eaten in Guyana and Campeche, although in neither locality is the shell utilized; and in some few places, such as Cayman Brac and Old Providence Island, the hawksbill is actually considered more tasty than the green turtle.

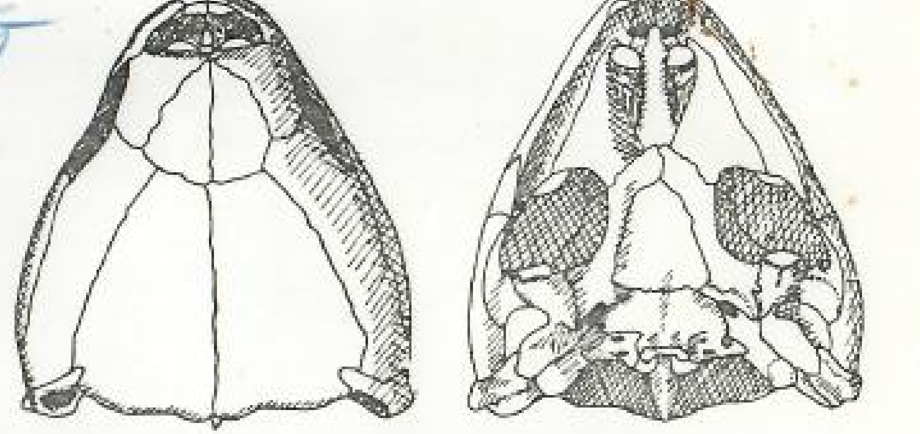
GENUS *DERMOCHELYS*

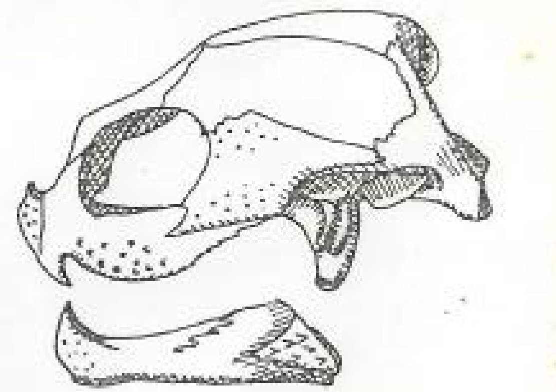
The leatherback turtle, *Dermochelys coriacea*, is the sole species included in the family Dermochelyidae. Indeed, so divergent is this species in so many aspects of its anatomy that it is often placed in a separate suborder, the Athecae, to contrast it with all other turtles that are placed in the suborder Thecophora. However, the leatherback does agree with the other sea turtles in certain aspects—such as the roofed-over skull and many aspects of its nesting behavior—and the family Dermochelyidae is thus considered related to the Cheloniidae rather than representing a completely separate adaptation of turtles toward a marine environment.

The leatherback is easily the largest species of turtle in the world; nevertheless its maximum size has been exaggerated. The literature abounds with unconfirmed records of eight or even nine foot long leatherbacks, but most museum specimens of adult leatherbacks have carapace lengths of only about five feet or a little more (approximately another sixteen inches may be added to give a figure for the total length, or a few more inches still for the total length of the long-tailed male). I have measured more than 2500 mature female leatherbacks on the nesting beach in French Guiana and have found some bigger than any museum specimens I have seen, but I have yet to encounter a six foot leatherback, although the three biggest each had shell lengths of exactly 71½ inches. The median carapace length, at least in the West Atlantic, is about 61 inches. There are few reliable records of the weights of

Any mention under green turtle?

POISONING





Skull of the leatherback turtle,
Dermochelys coriacea.
Redrawn from Carr, 1952.

adult leatherbacks, but Agassiz' statement that he had seen specimens weighing over a ton is usually assumed to be an exaggeration. Having established the weight of a rather small (58") leatherback as 651 lbs., I would suggest that the average is about 800 lbs. and the maximum about 1300 lbs.

The leatherback is immediately distinguishable by the absence of all cornified epidermal structures; it has no scutes on carapace or plastron, no scales on the skin, no claws, and not even flattened horny plates in the jaws. The carapace has the texture of hard vulcanized rubber and is somewhat flexible to the touch; the plastron is very soft. However, the carapace gains a considerable amount of rigidity by being raised into a number of longitudinal ridges. The median ridge, particularly toward the rear, is the highest, but there are two others on each side between the median one and the lateral margins of the shell. The animal has a rather barrel-shaped form with no sharp angle between carapace and

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Date 14th December, 1982

Mr. George Balazs,
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Dear George,

Many thanks for your letter of 1st December, 1982 and note what you say regarding the paper.

Regarding the turtle survey in Sri Lanka, IUCN is in the dark about the matter as they have not been approached. What transpired was that while at Bali, the Sri Lanka conservationists discussed with me the necessity for a turtle survey in Yala. As I had you in mind, I informed them that such a survey would be possible if we were able to obtain the funds. They made no firm commitment but indicated that on their return to Sri Lanka they would take up the matter with those involved and communicate with me - this they have not done up to now. As soon as I hear from them I will let you know.

With all good wishes,

Yours sincerely,

Stanley

G. S. de Silva

PS
In your letter of 3rd Nov. you wanted information regarding poisoning from eating turtle meat. In this regard I have contacted several doctors & the local hospital - but no information is available. Will make further inquiries & let you know.

PSS. Just received ~~[illegible]~~ 2 more turtle posters - many thanks,

PAR AVION

AIR MAIL

LEMBAGA PENGUASA AMANAH
TAMAN NEGARA SABAH

Mr George Balazs

University of Hawaii at Manoa

Hawaii Institute of Marine Biology

P O Box 1346, Coconut Island, Kaneohe,

Hawaii 96744, USA

← Second fold here →

Sender's name and address: ~~Turtle Islands National Parks~~

P. O. Box No; 768 Sandakan,

Sabah, East Malaysia

'TULIP' Air Letter

AN AIR LETTER SHOULD NOT CONTAIN ANY ENCLOSURE: IF IT DOES IT WILL BE SURCHARGED OR SENT BY ORDINARY MAIL.

here →

George—Is Banner still there? If he is, could you ask him if he ever got anywhere with this line of inquiry?

APPENDIX XI

UNIVERSITY OF HAWAII
Hawaii Institute of Marine Biology
P.O. Box 1067
Coconut Island
Kaneohe, Hawaii 96744

January 22, 1969

Dear Dr. Hendrickson,

As you know, there have been sporadic outbreaks, at times lethal, of turtle poisoning in many parts of the world. The most commonly implicated species appears to be the hawksbill, although there are indications that other species may also be toxic. Almost nothing is known about this form of toxicity. To my knowledge, there have been no laboratory studies on the chemistry or pharmacology of the toxin, no adequate accounts of symptoms of human intoxications and no biological explanation as to why certain individual turtles may carry toxins and others caught in the same area can be eaten with impunity. I suspect that Dr. Bruce Halstead in his third volume of Poisonous and Venomous Marine Animals will have an adequate review of all literature on this type of intoxication, but at present what few publications that have ever been issued are scattered and apparently consist largely of newspaper accounts rather than scientific reports. Scientific reports are largely similar to that issued by Hashimoto, Konosu, and Yasumoto in 1967 (in Japanese) which deals with intoxications caused by Eretmochelys imbricata in the southern Ryukyus from 1933 to 1967; it is based largely upon interviews with persons who were poisoned. It is desirable to place the knowledge of toxic turtles on a more firm scientific basis.

Our group at the University of Hawaii is studying marine toxins that may occur in human diet. Our primary emphasis at present is on ciguateric fish, but we are also interested in other types of intoxications from marine foods. We suspect that the toxin in turtles may be related in some way, biologically and chemically, to the toxin in ciguateric fish. We would appreciate your presentation of our request to the International Conference on Turtles for all types of information dealing with intoxications from turtles. We would like to know of outbreaks when they occur, of the symptoms in those intoxicated, of the species of turtle involved, of any local knowledge or beliefs about toxic turtles and above all, if possible, specimens of toxic flesh. If enough information is forthcoming, we will compile it into a publication. If toxic flesh can be obtained, we will guarantee the cost of its shipment to Hawaii either frozen or preserved in ethyl alcohol. We would also appreciate any advice that members of your conference may have on procurement of information or specimens.

Yours sincerely,

AHB

Albert H. Banner
Professor of Zoology

Ciguatera and other Marine Poisoning in the Gilbert Islands by M. J. Cooper

Pac. Sci, Vol: XVIII October 1964

"Other Types of Poisoning"

and Valenciennes) and *Abudefduf septemfasciatus* (Kendall and Goldsborough). These fish are customarily eaten only by the old people—who are forgetful anyway. It was not possible to find out if these fish were at times genuinely "toxic," or merely considered so on account of their habits.

Scombroid Poisoning

There is no evidence of any scombroid poisoning in the Gilbert or Ellice islands. This type of poisoning appears to be caused by a bacterium (Kawabata et al., 1956), which may be found in the flesh of certain scombroid fishes. This microbe reacts on certain chemicals in the flesh of the fish when too long a time is allowed to elapse between catching and cooking the fish. The reaction is quickened by tropical temperatures. In the Gilberts scombroid fishes of various species are frequently caught early in the morning and left in the sun, and later the flesh is salted for consumption the next day. No poisoning has been reported, and it is thought that the scombroid fishes inhabiting this part of the Pacific are not infected with the specific bacterium (Banner, personal communication).

"Castor Oil" Fish Poisoning

On a few islands where the sea is very deep, close to the shore is found the castor oil fish, *Ruvettus* sp. Although this is a favorite food, it has the reputation of causing poisoning from the purgative properties of the oil in its flesh (Fish and Cobb, 1954). The choicest part of the fish is considered to be the roe, which is boiled whole, but the flesh is eaten as well. If the fish is cooked soon after catching, no "poisoning" results. However, the Gilbertese, and in particular the Ellice people, are well aware of its purgative properties; indeed, if there is a prolonged shortage of them, perhaps due to rough seas, the amount of epsom salts sold by the stores increases to quite staggering proportions.

Clupeoid Poisoning

During the time that the author was in the Gilberts, clupeoid poisoning was unreported. However, in November 1962 two children are reported to have died and other people have been taken ill after eating "sardines" (*te tarabuti*) caught off Betio, Tarawa. No details are known, except that there were two separate catches involved.

Some years ago at Bairiki, Tarawa, a woman died after eating what was described as "sardines" (possibly *Harengula* sp.). This woman was the only person taken ill among a number of people who ate the catch. At the time she was blamed for her own death, as she threaded her fish on an old piece of corroded brass wire before cooking them, instead of using a piece of coconut midrib: it was considered that she had died from copper poisoning.

Turtle Poisoning

The hawksbill turtle, *Eretmochelys imbricata* (Linnaeus), is considered to be deadly poisonous throughout the Gilbert and Ellice islands. It is not generally eaten, but occasionally one will be eaten in error, either in mistake for the green turtle or by someone who does not know the hawksbill's reputation.

The poisoning caused by the hawksbill is very severe, and the Gilbertese describe it as being similar to ciguatera but very much worse. It is so rare for anyone to eat this turtle, and so to be poisoned, that none of the assistant medical officers who were consulted had ever seen a case. The details of the following cases were supplied by eye witnesses on whom the severity of the poisoning had made an everlasting impression.

On Arorae, about 15 years ago, a group of people ate a hawksbill turtle. All of them became very ill and five of them died. Their symptoms were described as follows: vomiting; very severe stomach ache, and diarrhea; their skin was "very hot to touch; they were very thirsty, but something was wrong with their mouths and they were unable to drink; they were unable to move their arms and legs; finally, their skin peeled off as if they had been cooked." One man was so severely poisoned that he is said to have died less than a day after he ate the turtle, but even in that short time he peeled. The others died at various intervals, the longest surviving about a week.

The symptoms in a more recent incident on Tabiteuea involving an unknown number of people were described as follows: vomiting; severe stomach ache, and diarrhea; gradual paralysis; flaking skin, leaving great sores, especially on the mouth, lips, and in the armpits; intense thirst, but due to the condition of the mouth, inability to drink; finally, the victims died, described as being unable to breathe.

The green turtle, *Chelonia mydas* (Linnaeus), is eaten throughout the Gilbert Islands and has not been implicated in any poisoning.

It should be noted that the hawksbill turtle is primarily a carnivore (Loveridge, 1946), preferring crabs and molluscs, although in captivity they will eat fish as well as seaweeds. On the other hand, the green turtle is primarily a herbivore, grazing many hours a day on beds of *Thalassia* (Loveridge, 1946, citing Deraniyagala, 1939). In captivity the green turtle may prefer animal food (Loveridge, 1946). In the Gilberts young green turtles are sometimes kept until they are large enough to eat, being fed almost exclusively on fish.

The hawksbill and green turtles were and still are Gilbertese family totems. Members of the families concerned will often maintain that all turtles are poisonous.

Invertebrate Poisoning

Several species of crabs are considered by the Gilbertese to be deadly poisonous, but very few species of crabs are commonly eaten. *Te kukua, Zozymus aeneus* (Linnaeus), is reported by Banner and Randall (1952) to be deadly poisonous on Onotoa; although Tarawa people would agree that it is toxic, this species is eaten on Arorae, Beru, and Nonouti. Another species, *Carpilius convexus* (Forskål) generally considered to be poisonous, is similar to a commonly eaten species, *te ntababa*, the red-eyed crab, and in the dark may easily be confused with it, especially by an inexperienced fisherman. Another with the reputation of being deadly poisonous is an uncommon small black and green or yellow crab. Because of its size it would never be taken for food; but it is said to have been used by the practitioners of black magic to poison their victims. However, the Gilbertese are reluctant to discuss such practices and the crabs involved.

In September 1961 a Bairiki, Tarawa, woman died after eating crabs. The crabs had been collected by torch fishermen on the Bairiki reef. When they returned they flung the whole catch on the ashes of a fire, an unusual procedure, boiling being the usual Gilbertese method of cooking crabs. It is said that the woman, being greedy, did not wait until the crabs were fully cooked, but grabbed them half-cooked from the fire and ate them. She was taken ill, removed to the Colony Central Hospital, and died. The assistant medical officer who dealt with the case described her death as being due to acute allergy poisoning. As it was dark when the crabs were cooked and eaten, identifying the species responsible was not possible.

Molluscs are not considered to be toxic by the Gilbertese on any island. Banner and Randall (1952) stated that the Onotoans reported that large tritons, *Charonia tritonis* (Linnaeus), were toxic; however, they could find no specific case of intoxication from this snail (Banner, personal communication). The large conch, *Strombus* sp., has been reported as toxic from certain areas in the Bahamas (Randall, 1958), but apparently this mollusc is not found in the Gilberts. The blood-mouth conch, *Strombus* sp., is one of the most common shellfish in the Gilberts. Vast numbers are collected and eaten, either raw or cooked, but so far none have caused any poisoning. Both small and large spider conches, *Lambis* spp., found on the algae-covered reef flats as well as in deeper water, are commonly eaten by the Gilbertese, but have never been reported toxic. The commercial trochus, *Trochus niloticus* (Linnaeus), is not found in the Gilberts, but smaller *Trochus* spp. are not uncommon; although these are eaten when collected during general gleaning on the reef, they are considered somewhat small for food. Turban shells, *Turbo* spp., are eaten and are commonly used for bait. These snails are picked up on the reef, broken open, a piece is bitten off and put on the hook, and the rest is eaten raw at the time. Cowries of various kinds are found throughout the Gilberts, but are never eaten by the Gilbertese. Many varieties of pelycopods are eaten without any causing illness.

The Gilbertese, surprisingly enough, do not make as much use of the various seafoods on their reefs as do many islanders in the Pacific. Sea urchins, again reported by Randall (1958) as causing a ciguatera-like poisoning, are not eaten by the Gilbertese.

During the Japanese occupation some varieties of seaweeds were eaten by the Gilbertese, but as soon as food supplies returned to normal

TURTLE MEAT (*ERETMOCHELYS IMBRICATA*) POISONING IN NETHERLANDS NEW-GUINEA *

by

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INTRODUCTION

The Papuans are keen on hunting turtles in the seas around New-Guinea as r meat is considered a delicacy. LOVERIDGE (1948) described four species of turtles hese waters. Publications from various countries reported on poisoning—usually s poisoning—by this meat; cases, often ending fatally, occurred in India, Ceylon the Philippine Islands. As regards the East-Indian archipelago, VAN HASSELT 2) mentioned poisonous turtles around New-Guinea. The Public Health Service ne Netherlands East-Indies instituted an enquiry into the matter (*Mededelingen*,) and received several positive answers; some doctors reported their personal rience, others from hearsay. The symptoms were dizziness, nausea and vomiting, few cases with fatal outcome. BIERDRAGER (1936) recorded an instance of mass ning in about 52 people, five of whom died, after eating the meat of a large e (of the Cheloniidae species) on the Isle of Japen north of New-Guinea. The ologist, BONNE (cited by BIERDRAGER, 1936), found fatty degeneration of the and kidneys. SIEGENBEEK VAN HEUKELOM (1936) also described degeneration e liver, pancreas and kidneys.

PERSONAL EXPERIENCE

On August 24, 1954, a number of people in Kaipuri (Schouten Islands) ate turtle- . The government doctor arrived a week later; in the meantime one man had after two days and another after six days. Four others suffered from vomiting, ps and unconsciousness one week after the meal; they took a long time to recover. All cases of turtle-poisoning in Netherlands New-Guinea and Indonesia were ed by *Eretmochelys imbricata* (hawk's bill turtle, vernacular name *tuturuga sisir*). turtle may reach a length of 85 cm and a weight of about 20 kg; the jaws are ed like a bill or beak—hawk's bill—and the head has four prefrontal horn plates. carapace has four overlapping horn plates, in contrast to *Chelonia mydas* (green e or soup turtle).

SYMPTOMS

(1) *General:* The symptoms usually begin about twelve hours after the meal: ling of distress often coupled with vomiting, dizziness and a burning sensation e throat, sometimes also of the tongue, gums and lips. Headache and abdominal

* Originally published in Dutch in *Nederlandsch Tijdschrift voor Geneeskunde*.

nces p. 382

pain, sometimes diarrhoea. Mild cases may show only a few of these general symptoms.

(2) *Mouth and throat* affection becomes manifest after about two days; the tongue is white-furred, the mucous membranes of the mouth and throat are swollen and sometimes swallowing becomes difficult. From two to ten days afterwards red elevations, the size of a pin's head, appear on the tongue; these are the swollen papillae, especially near the point and along the edges. The papillae may still be visible after two months.

(3) *Nervous system:* somnolence occurs at an early stage. The patients may react when spoken to, but they fall asleep again immediately. This somnolence may lead rapidly to death. Occasionally the patients are restless. There is thermolability; some authors mentioned hypotony and hyporeflexia, but others did not observe these symptoms.

Course and prognosis. The severity of the affection is proportionate to the amount of meat eaten, but even in serious cases the prodromal symptoms do not start until 12 hours after the meal, though they are more intense then. Vomiting stops after a few days.

The light cases show the mouth and throat symptoms only; in severe cases the clinical picture is dominated by disturbed consciousness. None of the nine somnolent patients seen by BIERDRAGER (1936) recovered. One of the Kaipuri patients was unconscious for a week and then recovered slowly. In cases of prolonged somnolence the development of ulcerating stomatitis is possible, with intense *foetor ex ore.* KARIADI (*Mededelingen*, 1933) reported such a case; it ended fatally.

Treatment. In the first stage of the disease the stomach and intestinal tract should be emptied by emetics, gastric lavage, clysters and/or laxatives. In the later stages treatment can only be symptomatic, by administration of excitants. The symptoms of the mouth and throat may be alleviated by boracic glycerin and rinsing with permanganate of potassium.

What is the cause of the toxicity of the hawk's bill's meat?

Some authors assume that the turtle's meat is poisonous in certain seasons only; this is probably incorrect as cases have occurred in nearly every month of the year. Possibly only a certain variety of the species is poisonous, as is the case in many kinds of fishes. For the West-Indian *ciguatera*, a well known type of fish poisoning, one of the theories is that the toxin is the result of the dietetic habits of the fish (ARCISZ, 1950).

The hawk's bill is a carnivore; with its sharp beak it tears crabs, molluscs, perhaps also seaweed from the coral-reefs. Several toxic and irritating species exist among the coral fauna and vegetation, as evidenced *e.g.* by coral dermatitis manifesting itself by redness, oedema and cutaneous paraesthesia. Both fish and turtle poisoning might derive its origin from coral fauna or vegetation; extensive coral formations exist near all localities where turtle poisoning has been reported.

Neither a bacterial origin of the toxin nor a relationship with toxic products from the generative organs of the turtle have as yet been proved. Thus the problem of poisoning by turtle meat is still unsolved.

SUMMARY

In Netherlands New-Guinea, two patients died two to six days after eating turtle

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meat; a week after the meal four other persons, developed symptoms, including vomiting, cramps and unconsciousness; recovery was very slow.

Comparison with cases described in the literature reveals that there are two important groups of symptoms, *viz.*, symptoms of the mouth and throat (swelling, redness of the buccal mucous membranes, white coating, and protracted swelling of the papillae of the tongue) and nervous disturbances, especially somnolence.

In the case of nervous disturbances the prognosis is less favourable. All cases were attributable to the carnivorous hawk's bill turtle (*Eretmochelys imbricata*). The toxicity of its meat is probably due to the poisonous coral vegetation on which the turtle feeds.

Treatment is chiefly symptomatic.

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14 May 1974

Toxicity in Sponges and Holothurians: A Geographic Pattern

Abstract. *Toxicity in sponges and holothurians is inversely related to latitude and may reach 100 percent for holothurians in high-diversity coral reefs. Evidence from approximately 700 experiments and from underwater observations suggests that predation by fish has resulted in natural selection for noxious and toxic chemical compounds in species within these taxa.*

A decade ago it was suggested that toxicity is one of several defense mechanisms that benthic marine invertebrates have evolved in response to predation and grazing by coral reef fish (*1*). Further information has appeared on toxicity in coral reef benthic invertebrates [see references in (*2*, *3*)]. McAllister (*4*) stated that only 12 of 770 species of Canadian freshwater and marine fish are toxic to man and most of these are rare. Seven of the 12 toxic species are venomous. In contrast, data from Halstead and Mitchell and from Halstead [cited in (*2*, *3*)], suggested that both venomous and poisonous fish are considerably more common in the tropics than outside the tropics. The data for other marine taxa are insufficient for such a comparison. Because adequate information on toxicity has been unavailable for specific geographic sites, we now report on the extent to which toxicity in sponges and holothurians may change with latitude and with related water temperature and habitat.

Earlier studies (*5*) indicated that a variety of marine fish are sensitive to steroid saponins (holothurin) from certain holothurians and that, although freshwater fish are slightly more resistant to holothurin, they are suitable as test organisms. Our work has confirmed this. Our experiments were designed to determine if a sponge or holothurian is toxic to fish and to obtain a rough approximation of the degree of toxicity (*6*). Marine fish were used in many of the studies to ensure that local fish species are responding to toxins from sponges and holothurians with which they are associated. Toxicity in holothurians was tested separately for the body wall, viscera, and Cuvierian tubules. The data presented here are based on extracts from the body wall since this seems to be the most impor-

Table 1. Toxicity of holothurians at various latitudes. For the techniques used by Bakus see (*3*) and (*6*). Bakus defines holothurians as highly toxic if the fish dies within 15 minutes (usually less than 10 minutes) and mildly toxic if the fish dies in 20 to 45 minutes. Yamanouchi [see (*5*) for techniques] used highly toxic if the mean survival time of ten fish (together) was up to 60 minutes and mildly toxic if it was 116 to 173 minutes. Abbreviations: HT, highly toxic; MT, mildly toxic; GJB, Gerald J. Bakus; TY, T. Yamanouchi.

Locality	Latitude (°N)	Depth (m)	Number of holothurian species				Investigator
			Tested	Toxic	HT	MT	
San Juan Islands, Washington	48	0–100	12	3 (25%)	0	3	GJB
Onagawa, Japan	38	?	5	4 (80%)	1	3	TY
Seto, Japan	35	?	9	7 (78%)	5	2	TY
Santa Catalina Island, California	33	0–10	2	1 (50%)	0	1	GJB
Guaymas, Mexico	28	0–5	6	5 (83%)	5	0	GJB
Eniwetok, Marshall Islands	12	0–3	4	4 (100%)	4	0	GJB
Palau Islands, Pacific Ocean	7	0–10	11	11 (100%)	9	2	TY
Cocos Island, eastern Pacific	6	0–110	7	6 (86%)	6	0	GJB

Table 2. Toxicity of sponges at various latitudes. The investigator was Green; see (*6*) and (*10*) for techniques. Green defines sponges as highly toxic (HT) if the fish dies within 60 minutes, moderately toxic (Mod.T) if it dies in 61 to 120 minutes, mildly toxic (MT) if it dies in 121 to 720 minutes, and very mildly toxic (VMT) if it dies in 720 to 960 minutes.

Locality	Latitude (°N)	Depth (m)	Number of sponge species					
			Tested	Toxic	HT	Mod. T	MT	VMT
San Juan Islands, Washington	48	0–50	34	3 (9%)	3	0	0	0
Santa Catalina Island, California	33	0–40	44	9 (21%)	5	4	0	0
La Blanquilla Reef, Veracruz, Mexico	19	1–20	36	27 (75%)	12	2	5	8
Zihuatanejo Bay, Guerrero, Mexico	17	1–15	11	7 (64%)	1	1	0	5

tant protective structure for most holothurians. Tropical holothurians rarely eviscerate (*7*) and very few species that were studied have Cuvierian tubules for defense. Data are fewer for holothurians than for sponges partly because sponges are more diverse at the study sites.

In Table 1 our results for holothurians are compared with those of Yamanouchi (*5*). Only 25 percent of the holothurians studied in the state of Washington are toxic to fish, and this toxicity is mild relative to that of toxic tropical holothurians. The incidence of toxicity increases toward the tropics and reaches a peak (100 percent of the species studied in the Palau Islands) where coral reefs and associated fish exhibit a high degree of environmental heterogeneity and species diversity, respectively. The relatively high incidence of toxicity in holothurians of Japan may be related in part to the fact that the north equatorial current carries warm water to the southern half of Japan. Table 2 shows the same trend in toxicity, in that only 9 percent of the Washington sponges studied are toxic to fish, whereas 75 percent of the sponges studied on a coral cay near Veracruz, Mexico, are toxic. The three species of sponges that are toxic in Washington are widely distributed. Of 27 species of toxic sponges in Veracruz, 21 live exposed to potential fish predators and the remaining 6 live both exposed and unexposed to fish (that is, under corals). Of an additional nine species of sponges that were found to be nontoxic to fish, six live unexposed to fish, one is both unexposed and exposed, and two are exposed (one of the two produces a purple exudate that is noxious to fishes). If data were available from well-developed reefs of the equatorial west Pacific, it would be expected that nearly all the sponges growing exposed to fish predators and grazers would be toxic or chemically noxious to them, or both. This conclusion is based on the trends shown here and on evidence from experiments in the Virgin Islands and at Eniwetok Island (*2*).

Underwater observations suggest that fish only mildly threaten sponges and holothurians in Washington. On 14 dives to depths of 15 to 20 m at San Juan Island during July and August 1972, we did not observe more than six species of predacious fish living on the sea floor at any site, and we seldom observed any predacious fish in the water column, even when underwater visibility reached 10 m. Moreover, fish that were observed displayed no interest when we attempted to hand-feed them with crabs, the viscera of sea urchins, or toxic sponges or holothurians. We can only assume that they were satiated at these times. It has been shown that asteroids become the major predators of many benthic invertebrates on hard bottoms in cold temperate and higher latitudes (*8*). In strong contrast, there is no marine habitat that supports such a high diversity and standing crop of fish as that of coral reefs, and it is well known that fish predation and grazing on benthic invertebrates is often very intense there, particularly in the equatorial Pacific (*2, 3, 9*). Our field and laboratory experiments with holothurians cut into bite-sized pieces show that starved fish rarely consume the toxic tropical forms, but readily eat mildly toxic nontropical species (*2, 3, 7, 9*). Similarly, our experiments indicate that all fish studied reject highly toxic sponges and are killed by the sponge if force-fed with bite-sized pieces (*2, 10*). A few species of tropical fish consume toxic sponges in nature (*10, 11*).

It could be argued that toxicity in holothurians is due to the physical effect of high temperature on the biochemical production of steroid saponins, because holothurin has been found in considerably greater concentrations in holothurians during warmer than colder seasons in Japan (*12*). This would tend to support the idea that holothurin is a by-product of metabolism, increasing directly with temperature. However, certain tropical holothurians (*3*) and many cryptic tropical sponges are nontoxic to fish (*1, 10*). Very little is known about the chemistry of sponge toxins or the effects of temperature on these toxins.

We recognize that there are many kinds and causes of toxicity in marine organisms. The biological impact of marine fish on benthic invertebrates and of introduced fish is well documented (*1–3, 7, 9, 13*). We believe that fish predators and grazers must play a very important selective role, leading to the production and maintenance of chemical defense mechanisms (that is, allomones) in certain benthic invertebrates of tropical waters, especially those associated with coral reefs. We assume for the present that noxious and toxic chemical defenses in these organisms are often by-products of metabolism, which have been altered and concentrated by natural selection over various periods of time. Although certain of these toxins may have arisen long ago, we believe that natural selection is continuing to select for noxious chemical products and that this process may in some cases give rise to the production of toxins; both of these provide an effective defense mechanism against many predacious fish.

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References and Notes

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6. Small marine fish [*Apogon retrosella* (Gill), *Clinocottus analis* (Girard), *Eupomacentrus* sp. juvenile, *Gibbonsia elegans* (Cooper), *Harengula* sp., and *Lythrypnus dalli* (Gilbert)] and commercial goldfish (*Carassius auratus*) were used as test and control organisms. Marine fish usually weighed about 4 g and goldfish 1.5 to 3.0 g. A piece of holothurian body wall weighing 2 g (fresh weight) is cut into smaller pieces and extracted in boiling 75 percent ethanol for 20 minutes. The extract is dried, weighed, and added to a finger bowl containing 100 ml of seawater or tap water at ambient temperatures. One test fish is added to the finger bowl and the behavior of the fish is timed and recorded. Control experiments are done simultaneously. Portions of sponge weighing 5 g (wet weight) are homogenized with 20 ml of each of the following solvents: water, methanol, ethanol, acetone, and chloroform. Each solvent is used separately.