TURTLES OF TAIWAN

A Natural History of the Turtles

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PREFACE

To make this book more interesting, I have aimed to give in a popular manner a general survey of Taiwan turtles. In the United States many books about turtles have been published for popular instruction or entertainment. The most popular ones are Pope's *Turtles of the United States and Canada*, 1939, and *The Reptile World*, 1955, as well as Carr's *Handbook of Turtles*, 1952. In Taiwan there has been no definitive work on turtles since Stejneger's classic book *Herpetology of Japan and Adjacent Territory* (1907). At that time Taiwan was a part of the Japanese Empire and known throughout the West as Formosa.

To stimulate a wider range of interests, the present book, like Pope's and Carr's books, is designed to appeal not only to the specialist but also to the general public. With the description of each species, several colored or black and white photographs are included. The photographs, especially the colored ones taken from life, will be very helpful to the students and interesting to the general reader. Since they are much better than pen drawings to show the diagnostic characteristics of the species, any specimens seen later may be more easily identified.

In writing this book, I am deeply indebted to the

world-Wide known herpetologist Dr. C. H. Pope and his wife, Sarah H. Pope, as well as Dr. D. A. Rossman, for their patient corrections, and expert suggestions and comments. I also wish to thank Dr. R. F. Inger, Curator of Reptiles, Field Museum of Natural History, Chicago, Dr. R. G. Zweifel, Curator, The American Museum of Natural History, N.Y., Dr. D. A. Rossman, Curator of Lower Vertebrates, Louisiana State University Museum of Zoology, Mr. E. V. Malnate, Research Associate, Academy of Natural Science of Philadelphia and Mr. C. S. Wang, Instructor of Zoology, National Taiwan University for their kind help in providing me with valuable reference material. Sincere thanks are given to Sgt. F. H. Yeh for taking the photographs and to Miss S. Chen, a zoology student at National Taiwan University, who worked in the Department of Biomorphics here during the summer vacation of 1966, for drawing the pictures. Finally, I have to extend my heartfelt thanks to the Biology Research Center, Taiwan, for the financial support of this study.

Shou H. Mao

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PART I

GENERAL ACCOUNT

EVOLUTION

The fossil content of the strata of the earth's crust tells us that the first reptiles appeared in the late Pennsylvanian, a time of active mountain building. The reptiles were the first terrestrial vertebrates with the following characteristics: the presence of a scaly covering which aids in preventing loss of moisture from the skin; and the development of the shelled eggs which is unique in adaptation to terrestrial conditions. In the new terrestrial environment, they radiated rapidly, owing to lack of competition from higher groups (birds and mammals). Many types of reptiles flourished in the Mesozoic, but they have since suffered a great decline. This fact is reflected by the recent classification; more than 170 fossil families are recoginized, and this is nearly four times the number of the living ones.

The primitive cotylosaurs arising in the Pennsylvanian are called stem reptiles, because all of the vertebrates above the amphibian level were gradually evolved from them. The cotylosaurs were small-brained creatures, and before the end of the Triassic they had become extinct. But by a cryptic series of changes, one of their descendants achieved the following features: skull of primitive anapsid type (with no opening in temporal region); body enclosed in a bony box;

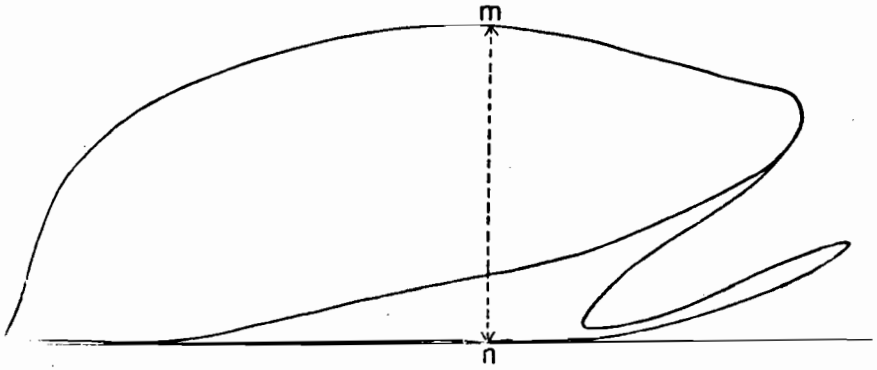


Fig. 4. Method of measuring the shell of a turtle. Length of carapace, a-b; width of carapace, c-d; length of plastron, e-f; length of fore lobe of plastron, e-g; length of mid-part of plastron, g-h; length of hind lobe of plastron, h-f; width of hind lobe of plastron, i-j; width of bridge k-l; depth of shell, m-n. (From Carr, *Handbook of Turtles*, Comstock, 1952, by permission.)

The above diagrams show that the greatest length, width, and depth of the shell are recognized as the standardized measurements. It should be noted that the length of a shell is always measured in a straight line from its anterior end to its posterior one, and the measurement of width is taken in the same way from side to side.

AGE, SIZE, AND GROWTH

It is well known that the turtle is the symbol of longevity to Orientals. An old Chinese saying is "thousand-yeared

wang-pa (soft-shelled turtle), ten thousand-yeared kuei (hard-shelled turtle)" (千年王八，萬年龜). This means that turtles can survive for a long time, which has long been noticed by Chinese. As to the actual evidence, proof of the longevity of turtles is chiefly based upon captive individuals, Major Stanley S. Flower's study of 55 kinds of reptiles in zoos, provided a reliable account of their ages. He recorded 31 turtles, 11 crocodilians, 10 snakes, 2 lizards, and the tuatara. The 31 kinds of turtles were definitely known to have lived twenty or more years in captivity. Five kinds of turtles are listed as having lived a century or more, whereas the oldest reptile not a turtle had survived only 56 years (Pope, 1955).

Dates carved on the shell of turtles by unknown persons cannot be asserted as scientific evidence, for obvious reasons. For example, a box turtle (*Terrapene carolina*) with the legend "G. Washington, 1751" was certainly carved by a joker. Therefore further evidence is needed for the determination of its age (Carr, 1952).

Among the living turtles, the leatherback (*Dermochelys*) is the largest. It may have an overall length of 9 feet. An animal of this size weighs 1500 pounds. The largest loggerhead (*Caretta*) and green turtle (*Chelonia*) weigh between 500 and 1,000 pounds. In the United States, the average shell length of the small turtles, such as the common mud turtles (*Kinosternon*) and spotted turtles (*Clemmys*), is 3 or 4 inches. In Taiwan the smallest one is the golden turtle

(*Chinemys*), its average shell length being from 4 to 6 inches.

The horny laminae of the turtle shell usually make concentric rings around the "areola" (the infantile area of a lamina). As the underlying bone of the shell grows, the lamina increases with it. During periods of rapid growth, the lamina is enlarged by adding the new horny substance, which is deposited under the entire surface of the old lamina, around the edge of which it projects as a marginal ring. When growth slows down, as during hibernation, a wrinkle appears around the margin of the old lamina. This produces an effect suggesting tree rings or fish scales.

The seasonal growth rings or annuli may sometimes be very useful for telling a turtle's age, but under the following conditions it is not guaranteed.

(1) The wearing away of the older laminae and the destruction of the newly formed annuli.

(2) In many turtles the laminae are shed periodically, thus resulting in a smooth surface of the shell.

(3) The smooth shell is caused by nearly constant temperature. For example, in southern latitudes there are no marked seasonal changes.

(4) The physiological change of the animal may also influence the deposition of the horny substance. Minor disturbances of the rings tend to confuse the chronology of major ones. Either too few or too many rings for the elapsed years may result from such factors.

In spite of the shortcomings mentioned above, Cagle found it is a very good tool in determing the growth rate of *Pseudemys*, He found that "(a) in most individuals (in Illinois) not more than one is formed annually, (b) the zone between any two annuli represents one season of growth, (c) the approximate period of time represented by any area between rings is determinable".

Cagle computed the growth rate for periods signified by discernible annuli, employing the equation $\frac{L_1}{L_2}=\frac{C_1}{C_2}$ in which C_1 represents the length of the annulus; C_2 the length of the entire plastral lamina; L_2 the length of the plastron; L_1 unkown, or the length of the plastron at the time the annulus formed. This equation is also widely used by ichthyologists.

REPRODUCTION

The sexes are separate, and fertilization is internal. The male organs include a pair of testes and a pair of vasa deferentia through which the spermatozoa reach the grooved, unforked penis attached to the front wall of the cloaca. The female organs are a pair of ovaries and a pair of oviducts which open into the cloaca.

In higher vertebrates, fertilization usually takes place within a limited period of time after copulation, for the spermatozoa will lose their activity in a few hours or a few days at most. In some turtles the spermatozoa may be stored in an inactive state in the female genital tract and

edge of the beak is smooth, but sometimes it is provided with serrations which undoubtedly function as teeth. In adaptation to living on hard food, the inside of the mouth has a flat or ridged crushing-surface in some species. During feeding the forelimbs are usually used for holding down the food.

As to the food, we may say that most turtles, except the marine ones, can eat any plant and animal matter which they get. In my laboratory I found they ate cockroaches, shrimps, fishes, dead frogs, dead rats, chicken viscera, beef, Chinese bread, rice, and various kinds of vegetables. Once I threw a frozen ball of chicken viscera, which had been in a freezer for several days, into a concrete tank in which more than ten turtles were kept. At least five turtles immediately attacked the frozen ball with the help of their front limbs. Sea turtles usually live on seaweed, but small marine animals such as sponges, jellyfishes, mollusks, crustaceans, and fishes are often found in the stomach. In Nanfangao, a fishing port, I saw an old woman fed a baby green turtle with chopped sea fish. The turtle was raised in a big plastic basin. It was very skillful in eating the chopped fish which was held on a pointed wire about five inches long.

DISTRIBUTION

Turtles constitute a small group of animals today. Their distribution, if compared with that of birds and mammals, is quite simple. The suborder Cryptodira includes land, freshwater, and sea turtles, the most flourishing group of

living kinds. They inhabit all continents except Australia. Africa may be considered as the headquarters of the land tortoises. Eastern North America and southeastern Asia are the headquarters of the freshwater groups. All sea turtles inhabit tropical and subtropical seas, and are often found hundreds of miles from land. During the breeding season they venture to sandy beaches in warm regions for egg laying. Occasionally they wander into the temperate seas as far as fifty degrees north and forty degrees south of the equator. The suborder Pleurodira, the primitive side-necked turtles, comprises the families Pelomedusidae and Chelidae. The former inhabits Africa, Madagascar, and South America; the latter Australia, New Guinea, and South America.

RELATION TO MAN

During the Yin Dynasty of China, the people practised divination by using the shell of the turtle or the scapula of the ox. According to Chang (1953), the processes they employed were as follows: generally one side of the plastron was drilled shallowly; sometimes the carapace might also be used. The complex fissures, called "Chao (omen)", appeared on the opposite side of the plastron or carapace after roasting the drilled part. Consulting the Chao, the diviner could tell the will of the demons or gods. The things divined and the reality which would appear in the future were often carved beside the Chao. All of the records present on the

carved shells and bones found in the waste of the Yin Dynasty are called "Oracle Inscriptions". Most historians agree that the oracle inscriptions indicate the already high level of Chinese culture at that time. Fig. 5 illustrates a piece of plastron with roasted fissures and carved record.

Fig. 5. A piece of ink-rubbing inscribed on a tortoise shell showing the roasted complex fissures and the carved record (From Chang, Fascicle 3: Inksqueezes of the Restored Specimens of Inscribed Tortoise Shell with

Annotations, Part I (i). Institute of History and Philology, Academia Sinica, 1957, by permission.)

The carved record on this shell is translated as follows:

1. On right side.

The divination was held on Ping Chen (a day). K'o (a man) prayed: "Shall I have a good crop?"

2. On left side.

The divination was held on Ping Chen. K'o prayed: "Shall I have not a good crop?"

The hint of the gods for this divination was excellent. Held in April.

Pope identified fragments used in divination as belonging to the now extinct Chinese turtle *Pseudocadia anyangensis* (Carr, 1952). Bien (1937), working on the turtle remains from the archaeological site of Anyang, Honan, recognized the remains as belonging to *Ocadia sinensis* and *Geoclemys reevesii*.

Most of the North American Indians paid respects to the turtle. The tortoise usually won the greatest interest, especially the ones with 12 or 13 laminae of the shell. Many Indian tribes made ceremonial rattles out of turtle shells, and sometimes tied them in clusters to the knees of dancers. Although in China and foreign countries there are many inscrutable legends about the turtle, they are certainly beyond the scope of this book.

Man's taste for turtle meat may be traced back to when he evolved as man. The frequently captured turtles in certain areas are often recognized as a delicacy by the people who live there. For example, the diamondback terrapin (*Malaclemys*) is the favorite food of the American, and the snapping turtles(*Chelydra* and *Macrochelys*) are also highly esteemed in the United States. The Mosquito people of Nicaragua roast the mud turtle (*Kinosternon*) in its shell and eat it; some Mexicans recognize the three-keeled Central American mud turtle (*Staurotypus*) as palatable. In China and Japan soft-shelled turtles stand first on the list of the turtles which are used as delicious food. At present, one chin (16 ounces) of beef in Taiwan is only NT$40.00 (NT$40.00= US$1.00), but by contrast one chin of the soft-shelled turtle costs as much as NT$80.00. In China the people think that fresh-water, hard-shelled turtles are sacred. Occasionally some of these turtles are seen in the markets. They may be bought by pious Buddhists to act as a "scape-goat" and released into a temple pond as a meritorious act. The sea turtles, especially the green turtle, are commonly eaten by the people near the seashore in various parts of the world. The sea turtles habitually deposit eggs beneath the surface of open beaches, thus people often collect their eggs in the breeding season. Man probably ate their eggs before he ate the turtles. In ancient days the Galápagos Islands were inhabited by millions of giant tortoises of several kinds. Soon the early whale-hunters learned that they were valuable and good for meat; they were then shipped to various

parts of the world for meat and zoos. The cheloniologist Georg Baur, visiting the Galápagos Islands in the 1880's, estimated that the early whaling ships had carried from these islands no fewer than ten million giant tortoises.

Besides using them as food, turtles serve man in many other ways. Turtle shells are often used in making ornamental objects. The most valuable one is the "tortoise shell" which is peeled off with heat from the back of the hawksbill (*Eretmochelys*). In reality the shells have been put to countless uses. Turtle oils are extracted from turtle fat and used for various purposes around the world. Millions of baby turtles are sold annually as pets in the United States; and what is more, thousands of turtles are sent to schools for laboratory dissection. It seems that certain species of turtles are useful in destroying harmful insects and other invertebrates; however, further evidence will be added in elaborating this aspect.

observed, hence it may be regarded as an individual variation.

Habits --- In a wired small pond of Yuanshan Zoo, Taipei, three kinds of turtles *Ocadia sinensis*, *Clemmys mutica*, and *Chinemy reevesi* are being raised. I visited there several times to learn about the habits of these creatures. I often found several *O. sinensis* basking on the tops of the stones near the bank, although there were many visitors around the pond. Once I saw at least five turtles of this kind immersing their bodies completely in the shallow water, extending their long necks and heads out of the water. It was a very beautiful sight.

Economic importance --- The people on this island think that all of the land turtles are sacred, signifying longevity, hence they are rarely eaten or used in other ways.

Distribution --- This species ranges from southern China to Taiwan. Most of the specimens in our collection were obtained from northern Taiwan (Tao Yuan Hsien and Hsin Chu Hsien); a few of them came from Chia Yi Hsien (southern Taiwan).

MEASUREMENTS AND PROPORTIONS

The 16 specimens in the following table were chiefly collected in northern Taiwan.

Ocadia sinensis	Sex	No. of specimens	Extremes (mm)	Average (mm)
Length of carapace	♂	8	114-150	132
	♀	8	125-202	164
Width of carapace	♂	8	78-101	90
	♀	8	89-132	111
Length of plastron	♂	8	100-132	116
	♀	8	118-191	155
Length of hindlobe of plastron	♂	8	38-49	44
	♀	8	44-74	59
Width of hindlobe of plastron	♂	8	41-60	51
	♀	8	53-89	71
Gular seam	♂	8	12-18	15
	♀	8	16-22	19
Humeral seam	♂	8	7-13	10
	♀	8	9-18	14
Pectoral seam	♂	8	20-25	23
	♀	8	20-38	29
Abdominal seam	♂	8	25-33	29
	♀	8	27-47	37
Femoral seam	♂	8	16-23	20
	♀	8	19-38	29

Although the various average measurements of the females are smaller than those of the males, the depth of the shell in the female is larger. This means that the female generally possesses a thicker body. The averages for tails show that the tail of the female is much reduced.

Remarks --- The plastral features of Taiwan soft-shelled turtles (Fig. 14) are exactly similar to the plastral arrangement of a *Trionyx sinensis* pictured by Siebenrock (Stejneger, 1907).

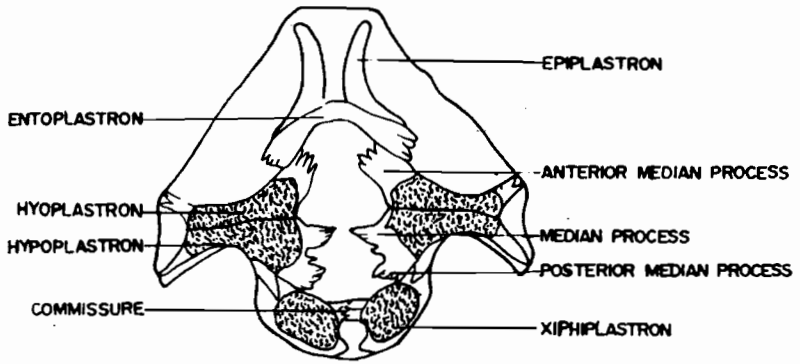


Fig. 14

Trionyx sinensis. (No. 60, ♂). Showing the arrangement of the plastral elements.

FAMILY CHELONIIDAE --- SEA TURTLES

This family belongs to superfamily Chelonioidea. It consists of five species, belonging to four genera. All of them

are marine, inhabiting tropical and semitropical seas. The head and shell are covered with horny scales and laminae, respectively. The limbs, for adaptation to swimming in the sea, have become paddle-like flippers. Only one species in each genus shown below is known to occur in Taiwan. Therefore the key given here is for both genera and species.

KEY FOR IDENTIFICATION OF TAIWAN GENERA AND SPECIES

I. Laterals in 5 or more pairs, the first in contact with precentral; two pairs of prefrontals; bridge with 4 enlarged inframarginals, each of them with a pore near posterior seam ----------*Lepidochelys olivacea*, p 77

II. Laterals in 4 pairs, the first separated from precentral by the anterior central

1. One pair of prefrontals ---- *Chelonia mydas japonica*, p. 87
2. Two pairs of prefrontals ----*Eretmochelys imbricata squamata*, p. 96

6. **Lepidochelys olivacea** (Eschscholtz)---Pacific ridley

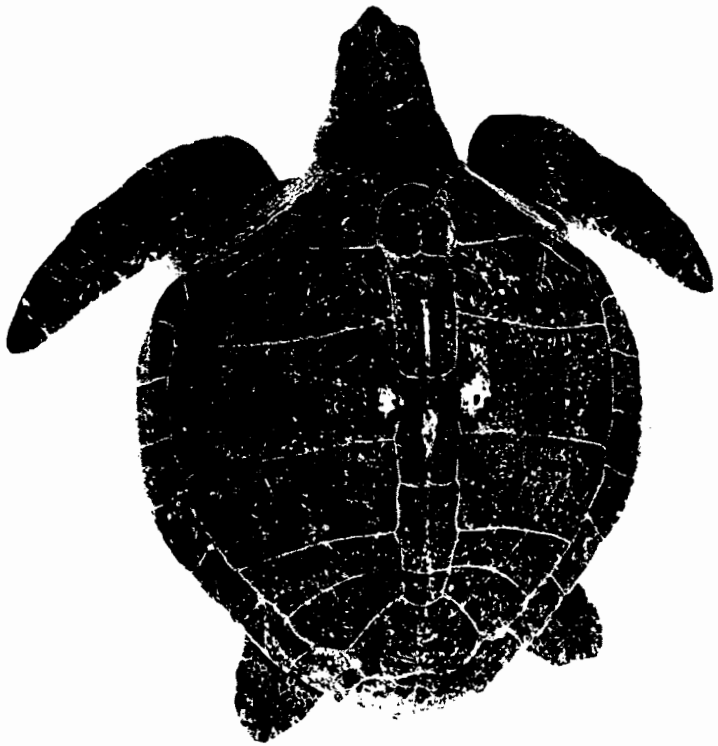
Fig. 15

Lepidochelys olivacea Carr, 1952, Handbook Turt., p.403, pls. 1, 2, 72, fig. 33.

Diagnosis --- Head with two pairs of prefrontals; laterals usually more than five pairs. Dorsal laminae juxtaposed. Inframarginals four pairs, each with a pore near the hind margin. Shell short, chunky, broadly heart-shaped.

Description --- Carapace very broadly heart-shaped, with a median and two lateral emarginations anteriorly; median keel well developed on the first two centrals, poorly developed on the posterior ones, lateral keels absent in present specimens; dorsal laminae juxtaposed, including six or seven centrals, the second from last smallest, and twelve or fourteen laterals, the third largest; marginal laminae twenty-six or twenty-seven in number, slightly serrated posteriorly. Precentral lamina six-sided, much broader than long, usually in contact with the first laterals. Plastron rounded anteriorly, much narrower and shorter than carapace, with a wide longitudinal depression in median region and a poorly developed ridge on each side of it; plastral laminae juxtaposed, thirteen in number, the interanal lamina very small. Each bridge consisting of four large inframarginal laminae, each with a pore near the posterior seam. Head flat dorsally, covered with large scales and characterized by presence of two pairs of prefrontals; nostrils large, on dorsum of snout; jaws strongly hooked, edges of beaks denticulated. Neck covered with small scales above. Each flipper covered with large scales and possessing one claw. Tail rather short.

Color in life --- Carapace dark brown tinted with olive; underside of shell yellow. Top of head dark brown tinted with olive, seams between laminae grayish yellow. Neck dusky grayish olive above; throat reddish yellow; ventral side of neck whitish yellow. Flippers dusky brownish olive dorsally, reddish yellow proximally on ventral side and yellowish olive in the rest. Tail light brownish olive dorsally, yellowish ventrally.



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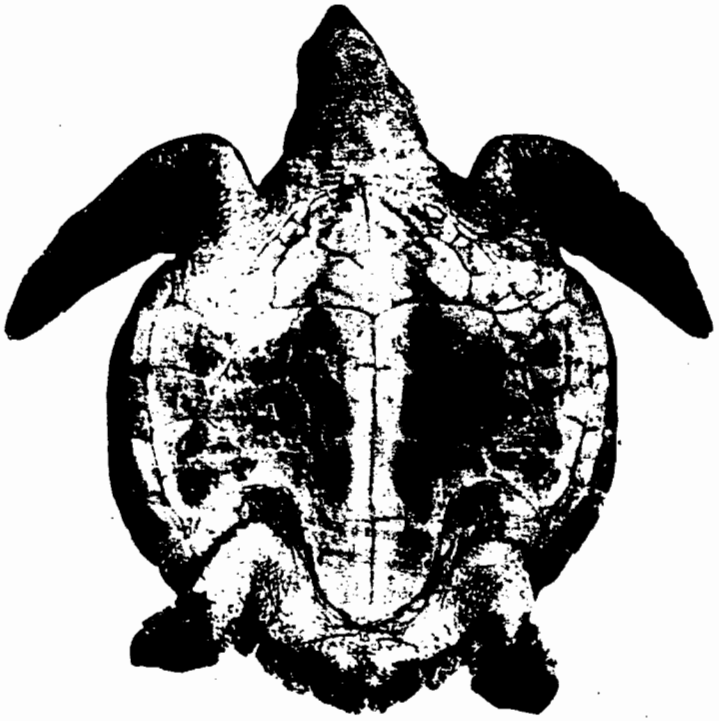

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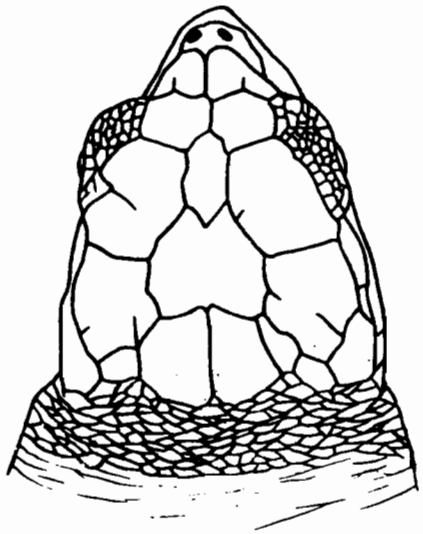

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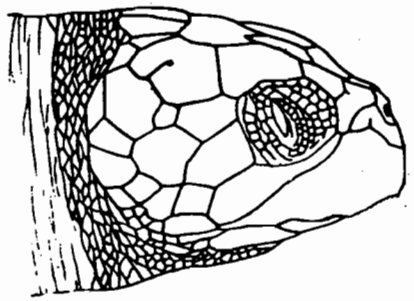

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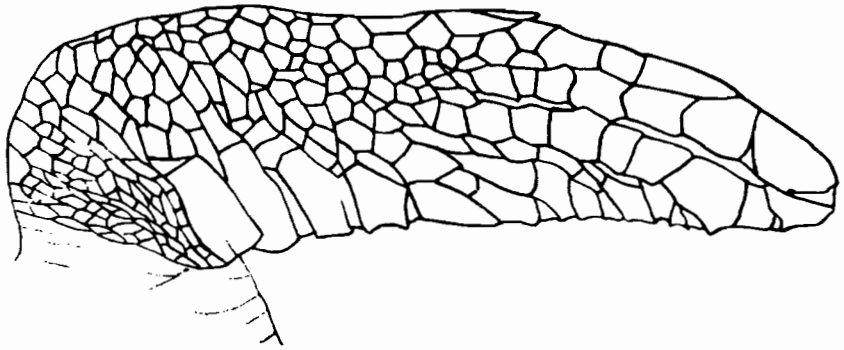

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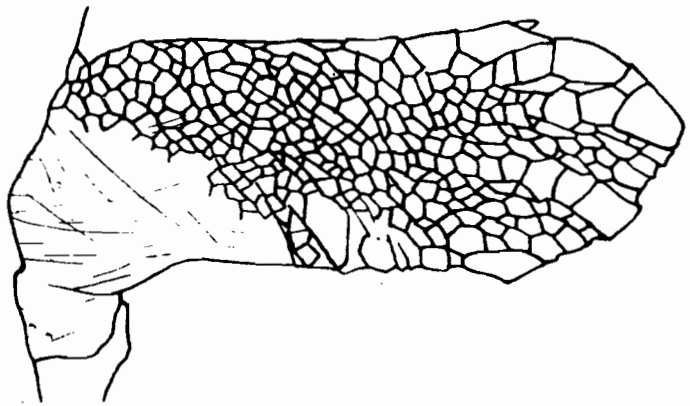


f

Fig. 15.

Lepidochelys olivacea (No. 78, ♀).

a. Dorsal view, x $8\frac{1}{2}$. b. Ventral view, x $8\frac{1}{2}$.
c. Top of head, x 1/3. d. Side of head, x 1/3.
e. Right fore flipper, dorsal view, x 2/7.
f. Right hind flipper, dorsal view, x 2/7.

Variations --- Carr (1952) recorded two east Pacific females; each of them had seven laterals on the left side and nine on the right side. In my two Taiwan females, No. 78 bears six pairs of laterals, and No. 79 seven pairs. Centrals are six in No. 78, seven in No. 79. Marginals are also variable. Specimen No. 78 has thirteen marginals on the right side, fourteen on the left side, while in No. 79 there are thirteen on each side.

Habits ---*Lepidochelys olivacea* usually inhabits shallow water, prefering to sink to the bottom. It is herbivorous. Carr (1952) recorded that "Oliver reported what may have been some sort of migratory aggregation of ridleys in deep water off Guerrero, Mexico, on November 28, 1945. The turtles were adults and were scattered over a tremendous area, since they remained in view of the moving ship from 9:30 A.M. until at least midafternoon. They floated at surface, and birds, probably masked boobies, stood on the shells of about half of them."

On October 11, 1947, on the beach of Isla de Ratones in Honduranean territory in the Gulf of Fonseca, Carr had a chance to observe the nesting behavior of a number of Pacific ridleys. His detailed description in this respect is now summarized as follows:

The turtle left the water at right angles and headed directly for the grass line. She stopped in dry sand among high-tide litter sixteen feet from the grass. She began

throwing sand with fore and hind flippers, changing the orientation of her body slightly until a shallow basin had been excavated around her. After a pause, the turtle applied her tail to several spots in appraisal of the quality of the sand; then she began excavating the nest cavity. The left hind flipper was lifted, brought in beneath the hind margin of the shell, and its edge pushed into the soft sand. It was then curled to enclose perhaps half a teacup of sand, which was carried out laterally and dropped with a little flip. As this fell, the other hind flipper kicked sand straight back. The process was then repeated in reverse. In working this way, the hole became deeper and wider gradually and asymmetrically. The asymmetrical growth was due to the fact that the fore wall received the most active scraping, not only from the curved end and edge of the flipper but also from the strong toenail which projected from the margin several inches back from the end. When the nest was as deep as the flipper could reach, digging ceased.

The tail was dropped vertically into the hole. The cloaca extended considerably beyond the tip of the tail, its opening about four inches below the plastral surface. When she began to lay eggs they came every four to ten seconds, either single or in groups of two, three, or four, most frequently two or three.

After the last egg was laid, she immediately began to fill the hole, raking in sand from the surrounding ramp with her hind flippers. When the hole was full, the turtle began

to pound the sand with her plastron, at first tilting her shell to one side and the other and then, lifting herself with her fore and hind flippers, she dragged in more sand from behind and let herself fall sharply upon it. As the surface hardened, the thumping sound which these falls produced became audible from a distance of thirty feet or more.

When pounding stopped, she began flipping sand backward with her fore feet, meanwhile rotating her body laterally to bring in sand evenly from all sides. She then crawled across the nest twice and started back to the water.

The curious crying by nesting females, apparently a device to keep the eyes free from sand, has been noticed in other species.

Economic importance --- Although the flesh does not taste good, it is eaten by Taiwanese. In Taiwan they are not used in other ways.

Distribution --- It occurs in the warm parts of the Indian and Pacific oceans. In the western Pacific it ranges northward to southern Japan, while in the eastern Pacific it is known from Baja California to Chile. In Taiwan it can usually be obtained at Nanfangao, a fishing port on the coast near Suao, and Lanyu Island, about forty-nine nautical miles off the southeast coast of the main island.

MEASUREMENTS AND PROPORTIONS

The 2 females in the following table were collected at Nanfangao, northern coast of Taiwan. Their body weights are 15.5 and 29 kgms.

Lepidochelys olivacea	No. of specimens	Measurements (mm)
Length of carapace (along its curve)	2	513, 630
Width of carapace	2	469, 554
Length of plastron	2	382, 473
Width of bridge	2	192, 225
Depth of shell	2	172, 221
Depth of shell in length of carapace	2	2.8, 2.9
Width of head	2	85, 102
Length of tail from vent	2	17, 22
Length of forelimb from point of emergence from body (following outer curve)	2	351, 427
Length of hindlimb (tibial border)	2	228, 284
From point of snout to nostril	2	34, 37
From point of snout to lower canthus of eye	2	54, 57

7. **Chelonia mydas japonica** (Thunberg) --- West Pacific green turtle

Fig. 16

Chelonia japonica Stejneger, 1907, Bull. U.S. Natl. Mus. 58, p. 507, figs. 393-395.

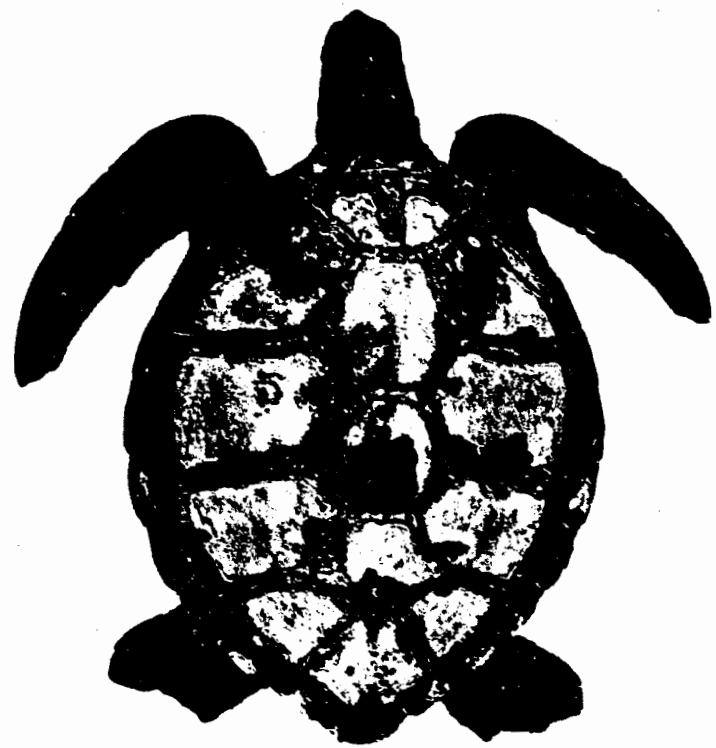
Chelonia mydas Pope, 1935, Rept. China, p. 23, fig. 3 (Ceylon, Queensland, Japan, Hongkong?).

Diagnosis --- Head with single pair of prefrontals; laterals four pairs. Dorsal laminae juxtaposed. Shell margin not markedly serrated above hindlimb; shell slightly chunky, very high along the median line. Scales on sides of head dark brown with narrow yellow margins.

Description --- Shell very high along the median line. Carapace more or less heart-shaped, broader in front than behind; no median and lateral keels; dorsal laminae juxtaposed, including five centrals and eight laterals; marginal laminae twenty-four in number, slightly serrated posteriorly. Precentral lamina four-sided, much broader than long, not in contact with the first laterals. Plastral rounded anteriorly, much narrower and shorter than carapace, with a wide longitudinal depression in central region and a poorly developed ridge on each side; plastral laminae fourteen in number, the intergular and interanal laminae small. Bridge with four large laminae. Head flat dorsally, covered with large scales and characterized by a single pair of prefrontals; nostril large, on dorsum of snout; jaws not

hooked, the edge denticulated. Neck covered with loosely arranged small scales above. Each flipper covered with large scales and possessing one claw. Tail rather short.

Color in life --- Carapace brown, often with striations and blotches of dull yellow; underside of shell deep yellow tinted with olive. The scales on the upper surface of head dark brown, seams between them yellow; those on the sides of head also dark brown, but with very narrow yellow margins, not giving a yellow cast to the temporal region. Neck dusky olive brown above. Throat and underside of neck yellowish tinted with olive. Flippers dark brown dorsally, brownish tinted with olive ventrally with dark brown scales. Tail dusky brown dorsally, yellowish ventrally.



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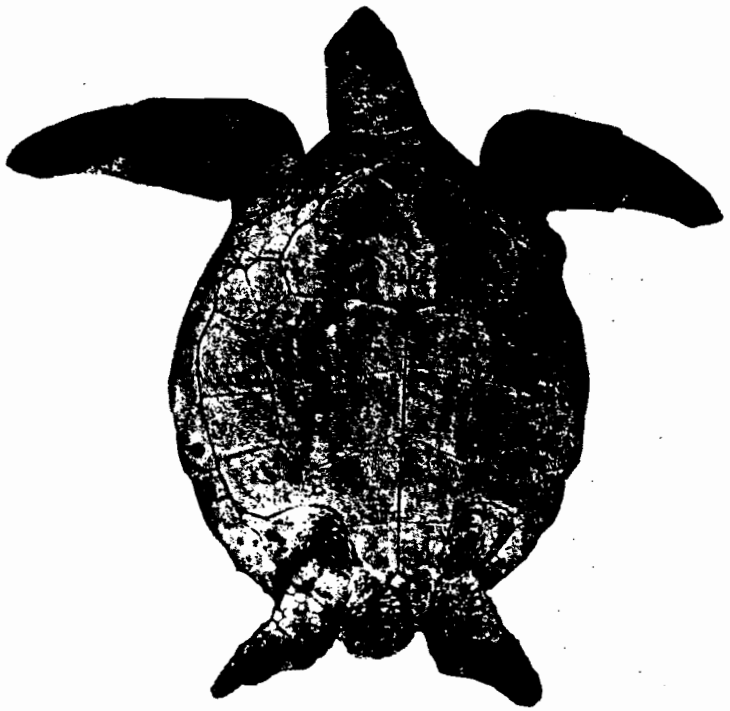

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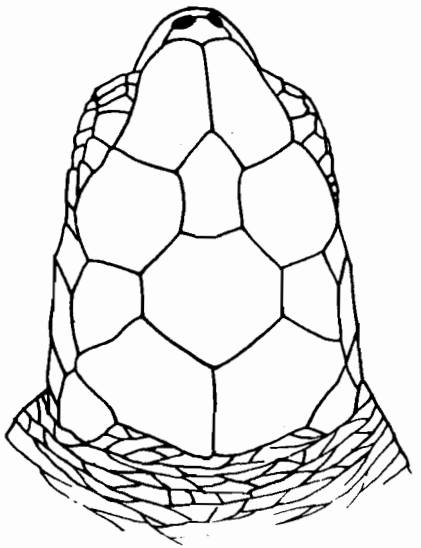

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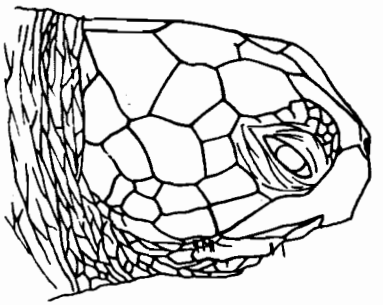

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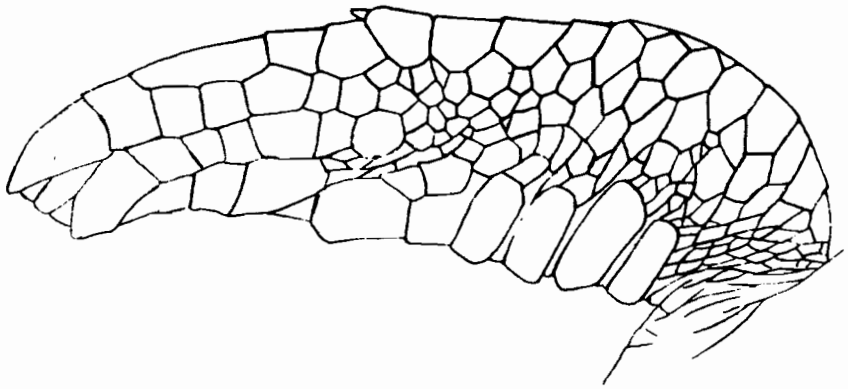

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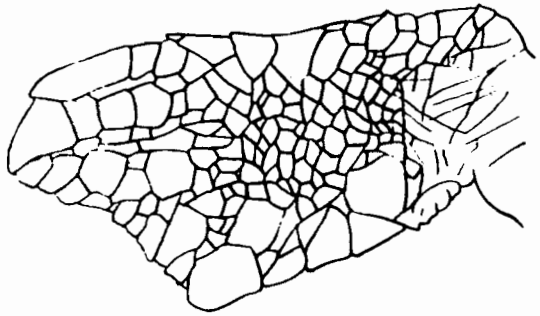

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Fig. 16.

Chelonia mydas japonica (No. 77, ♀)

a. Dorsal view, x 1/6. b. Ventral view, x 1/6.
c. Top of head, x 1/3. d. Side of head, x 1/3.
e. Left fore flipper, dorsal view, x 2/5.
f. Left hind flipper, dorsal view, x 2/5.

Variations --- Interanal may sometimes be absent.

Habits --- In Taiwan many of these turtles are usually captured in December and January; from June to September they are very rare. In other months they may be captured occasionally. According to ***Fauna of Japan*** (1957) they usually lay 90-170 eggs in June and July. The grayish-white eggs are round with an average diameter of 4.5 cm. This animal chiefly depends upon vegetable materials.

Economic importance --- A young fisherman told me that when his grandfather first came to Taiwan from the mainland, the meat of the green turtle was commonly used as food. At present they are still recognized as a delicacy by the people living along the coast. The plastrons are ground to be used as an ingredient of the chicken food, or bought by Chinese medicine shops to form certain medicines. According to ***Fauna of Japan*** (1957), the carapace may be used as a substitute for that of the hawksbill; the fat can be used for making soap. The eggs are palatable.

Distribution --- This species probably ranges widely in the tropical parts of the Pacific Ocean (Japan; Boine Islands; Okinawa; Taiwan; Pacific, South Sea.) It also occurs in the Indian Ocean. According to Chen (1956), in Taiwan it may be obtained from various parts of the Taiwan coast; especially at Nanfangao it is very common.

MEASUREMENTS AND PROPORTIONS

The 2 females in the following table were collected at Nanfangao. One (No. 77) weighed 8.9 kgms.

Chelonia mydas japonica	No. of specimens	Measurements (mm)
Length of carapace (along its curve)	2	425, 500
Width of carapace	2	351, 425
Length of plastron	2	337, 415
Width of bridge	2	190, 270
Depth of shell	2	137, 165
Depth of shell in length of carapace	2	3.1, 3.0
Width of head	2	62, 72
Length of tail from vent	2	24, 25
Length of forelimb from point of emergence from body (following outer curve)	2	324, 367
Length of hindlimb (tibial border)	2	178, 220
From point of snout to nostril	2	20, 25
From point of snout to lower canthus of eye	2	31, 37

Remarks --- For many years only one species of green turtle (*Chelonia mydas*), widely distributed in the Atlantic, Pacific, and Indian oceans, was recognized. In recent years, two reaces have been distinguished by Carr (1952), namely *Chelonia mydas mydas* (Atlantic form) and *Chelonia mydas agassizii* (east Pacific form).

Carr (1952) stated that, "The relationships of this race (*Chelonia mydas agassizii*) with other Pacific forms have not been determined, and will not be until someone sets out to collect large series of specimens from a great many localities. It seems unlikely that only one recognizable form exists in the Indo-Pacific area; if this should prove to be the case, then all the green turtles there will have to be called *japonica*, since that is an older name than *agassizii*."

Although I have no specimens of the Atlantic and east Pacific forms for direct comparsion with my specimens, in reading Carr's detailed descriptions of the characters of the above two forms and comparing the plates (31 and 32) of those animals appearing in *So Excellent a Fishe* (Carr, 1967) with my specimens, I find the Taiwan green turtle (west Pacific form) can be differentiated from the above two races by some minor differences which are depicted in the following key.

KEY TO *CHELONIA*

1. Coloration above predominantly brownish; shell margin

not markedly serrated above the hindlimb; shell slightly chunky and deep; scales on sides of head brown with broad yellow margins, giving a yellow cast to temporal region; Atlantic and Caribbean---------- *mydas mydas*

2. Coloration above predominantly greenish or olive brown; shell margin often markedly serrated above the hindlimb; shell chunky and often with the laterals straight from the margin to the centrals; scales on sides of head greenish or olive brown with narrow yellow margins, not giving a yellow cast to temporal region; Pacific coast of America---------- *mydas agassizii*

3. Coloration above predominantly brown, shell margin slightly serrated above the hindlimb; shell slightly chunky but very high along the median line and the laterals becoming gradually higher from the margin to the centrals; scales on sides of head dark brown with narrow yellow margins, not giving a yellow cast to temporal region; Pacific coast of Taiwan ---------- ---------- *mydas japonica*

Since the minor differences found in Taiwan-coast specimens compared with the other two races are quite clear, I temporarily follow Carr's suggestion to nominate it as *Chelonia mydas japonica*

8. **Eretmochelys imbricata squamata** Agassiz---
Pacific hawksbill turtle

Fig. 17

Eretmochelys squamosa Stejneger, 1907, Bull. U. S. Natl. Mus. 58, p. 511, figs. 396-400.

Eretmochelys imbricata Pope, 1935, Rept. China, p. 22. fig. 2 (Hainan; Pescadores; Riu Kius; Japan).

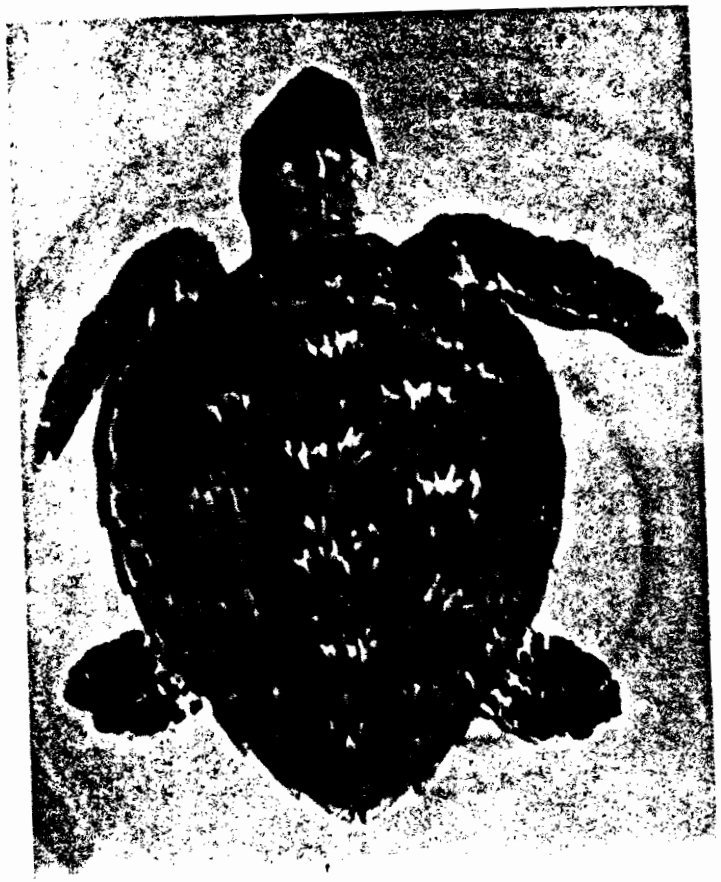
Eretmochelys imbricata squamata Carr, 1952, Handbook Turt., p. 373, pl. 67.

Diagnosis --- Head with two pairs of prefrontals; four pairs of laterals. Dorsal laminae usually imbricate except in the largest and oldest specimens in which they may become juxtaposed. Carpace marbled with beautiful brownish black, yellow, reddish rays.

Description --- Carapace heart-shaped, broader in front than behind; with three keels, the median keel the more developed, continuous from the first to last central, the lateral keel continuous from second to last lateral; dorsal laminae imbricate, including five centrals and eight laterals; marginal laminae twenty-four, strongly serrated posteriorly, precentral lamina four-sided, much broader than long, not in contact with the first laterals; the projecting points of marginals often curved slightly inward posteriroly. Plastron rounded anteriorly, much narrower and shorter than carapace, with a wide longitudinal depression medially and a poorly developed ridge on each side of it; plastral laminae imbricate, thirteen in number, intergular

lamina small. Each bridge consisting of four large imbricate laminae without pores. Head flat dorsally, covered with large scales and characterized by two pairs of prefrontals; nostrils large, on dorsum of snout; jaws hooked, edges of beaks not denticulated. Neck covered with small scales above. Each flipper covered with large scales and possessing two claws. Tail rather short.

Color in life---Carapace marbled with brownish black, yellow, and reddish rays; underside of shell yellow, occasionally most of the laminae with a deep brown maculation. The scales on top of head brownish black, with or without narrow yellow margins; those on sides of head also brownish black, but with broader yellow margins. The beak of upper jaw brownish black anteriorly and posteriorly, the lower edge of it yellow; the beak of lower jaw yellow or reddish ventrally and anteriorly, its lateral sides brownish black, and its upper edge yellow; the large mandibular scale brownish black with narrow yellow margins; Neck dusky brown above; throat and ventral side of neck yellow. Flippers with brownish black scales dorsally, most of the scales with narrow yellow margins, the proximal portions of the hindlimbs yellow; underside of flippers yellow with numerous brownish black-centered scales. Tail yellow dorsally and ventrally.



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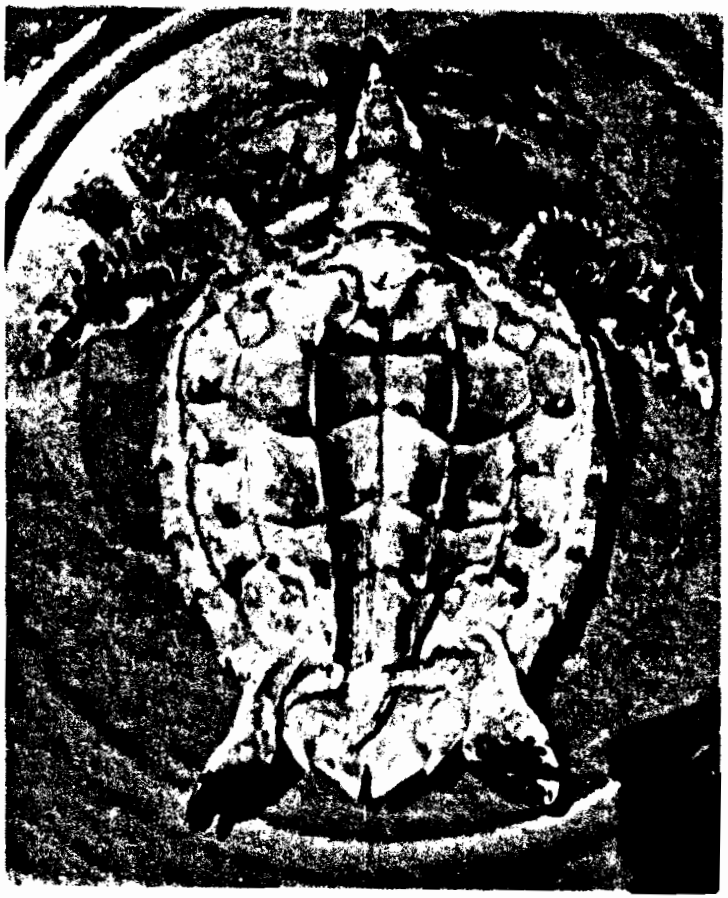

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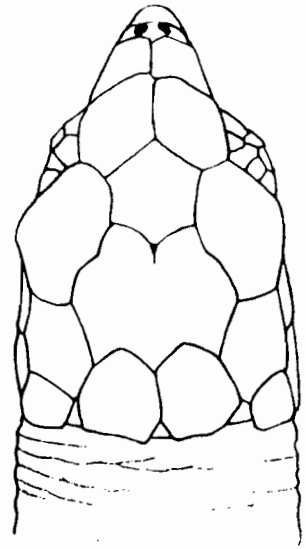

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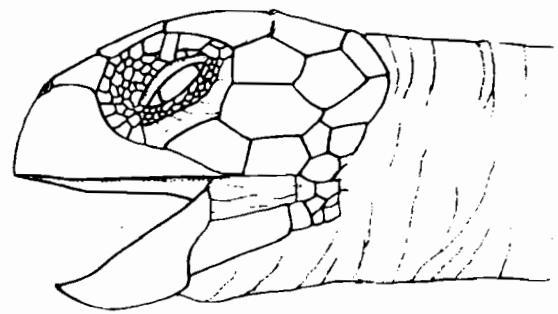

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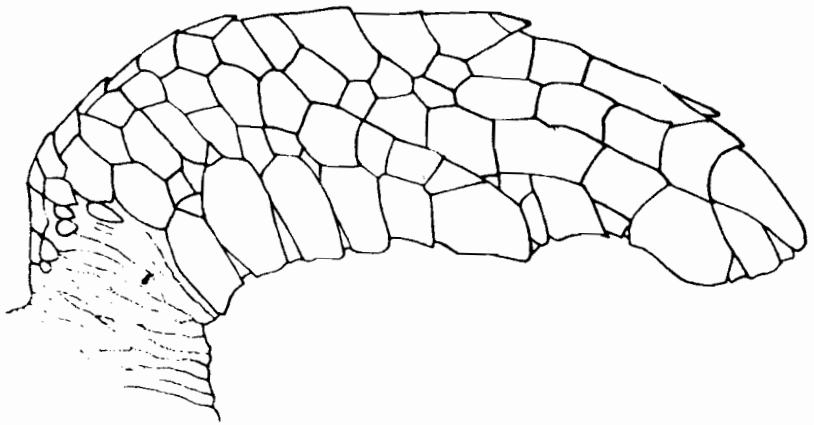

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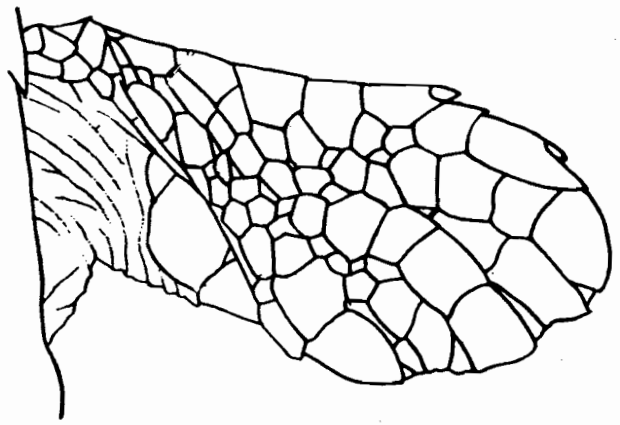

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Fig. 17.

Eretmochelys imbricata squamata(No. 76, ♀).
a. Dorsal view, x 1/3. b. Ventral view, x 1/3. c. Top of head, Nat. size. d. Side of head, Nat. size. e. Right fore flipper, dorsal view, Nat. size. f. Right hind flipper, dorsal view, Nat. size.

Variations --- In my young specimen, most of the laminae on the underside of the shell bear a deep brown maculation, but it is absent in my single adult. Agassiz stated that the laterals in *squamata* possessed ridges which extend downward and forward from the hind projection of each lamina to the marginals (Carr, 1952). This is not the case in my two females.

Habits --- The hawksbill usually lives along the shallow, mud-bottomed coast, with or without submerged vegetation. In the past, some writers showed that they have a very well-developed homing instinct.

The nesting habits of this animal have been reported by Deraniyagala; Carr (1952) cited his statements as follows :

"----- Deraniyagala watched a female deposit her eggs at Bentota, Ceylon, February 28, 1928, at 7 P.M. The turtle selected a site 80 yards from the edge of the water at the edge of the Pandanus brush. After flinging aside loose sand with all flippers for a while, she commenced digging methodically with the hind feet, which were used alternately in grasping and setting aside sand from the growing nest cavity. When the nest had reached a depth about equal to the length of the hind leg (about 500 mm. [19.4 inches]) it was goblet-shaped, with the expanded lower portion about 200 mm. (7.9 inches) in diameter. The cloaca was then lowered into the hole and the eggs were extruded in groups of 2, 3, or 4, with a few seconds' inter-

val between each batch. After laying 115 eggs she began filling the nest, carefully lowering into it footfuls of sand, and again working the feet alternately until the hole was nearly full, when she began pulling in sand with both feet simultaneously. The digging process consumed 45 minutes, oviposition 15 minutes, and the filling and covering of the nest 45 minutes more."

There usually are 130-250 eggs in a clutch; their diameters range from 35-38 mm.

Various kinds of algae, coelenterates, mollusks, crustaceans, fishes, and even meat are the hawksbill's relished food.

Economic importance --- The shell of the hawksbill is often refered to as tortoise shell, which cannot be confused with the shell of the terrestrial tortoise. The tortoise shell has long been highly esteemed in the Oriental countries, perhaps due to its flexibility, fusibility, and richness of coloration as well as its bright shine after polishing.

For four hundred years, much of the best shell has been sent to Shanghai and Singapore for exportation, and in Japan there is also a flourishing trade in tortoise shell. As I know in China they are commonly used for making frames of glasses, necklaces, ear-rings, pads for tea cups and many other artistic articles. It has been said that articles made of tortoise shell become opaque on cloudy or rainy days, more clear and transparent of fine days. According to Li

(1957), the laminae were peeled off by applying boiled vinegar, not by heat as described in foreign books.

In *Fauna of Japan* (1957), it is clearly stated that the meat of the hawksbill is not suitable to eat, but Carr (1952) found that their meat is eaten by the people in several countries of Central America. In Taiwan their meat is also used as food by the people living near the coast. Their eggs are quite relishable.

Distribution-It is widly distributed in Indian & Pacific oceans. It may be collected from various parts of Taiwan Coast.

MEASUREMENTS AND PROPORTIONS

The 2 females in the following table were collected at Nanfangao. Their body weights are 1.02 and 5.2 kgms.

Eretmochelys imbricata squamata	No. of specimens	Measurements (mm)
Length of carapace (along its curve)	2	236, 387
Width of carapace	2	173, 299
Length of plastron	2	166, 297
Width of bridge	2	95, 166
Depth of shell	2	67, 120

Depth of shell in length of carapace	2	3.2, 3.5
Width of head	2	33, 47
Length of tail from vent	2	10, 15
Length of forelimb from point of emergence from body (following outer curve)	2	159, 234
Length of hindlimb (tibial border)	2	99, 125
From point of snout to nostril	2	12, 21
From point of snout to lower canthus of eye	2	21, 36

FAMILY DERMOCHELYIDAE --- LEATHERBACK MARINE TURTLES

Some authors ascribed the leatherback turtles to a suborder Atheca. The name Athecoidea was first given by Cope in 1871 for the leatherback turtles (*Dermochelys*), meaning "without a shell". In reality, under the skin of this giant turtle there is a layer of small polygonal bones (epithecals) which, representing a part of the ancient turtle shell, has been lost by all other modern forms. The bony layer is completely separated from the internal skeleton. In additon, there is a free proneural bone at the anterior

end of the carapace. Owing to the peculiar structure of its shell (the presence of epithecals, lacking horny laminae and thecals), the evolution of the leatherback turtle has long been disputed. According to Romer (1956), a majority of workers today agree that its shell structure is a secondary condition and that *Dermochelys* has arisen from the chelonioid stock, with reduction of horny laminae and thecals accompanied by a secondary development of epithecals.

The superfamily Dermochelyoidea includes this single family which is characterized by the following features: for adaptation to the sea, the limbs have become flippers, the anterior pair is much larger than the posterior; no one of them possesses claws. The shell is provided with seven longitudinal ridges above and five below; the outer part of the shell is covered with a layer of smooth, leathery skin.

Only one living species of leatherback turtle is known nowadays around the world, but Carr (1952) divided it into two races chiefly based upon coloration. He found the Atlantic race (*Dermochelys coriacea coriacea*) is darker than the Pacific form (*Dermochelys coriacea schlegelii*), with less light mottling of the back (usually solid black in adults) and especially of the lower jaw and throat.

The dorsal color of the specimens found at Nanfangao is black tinted with brown, and with many white spots. The jaws are slightly brownish clouded with dark, while the throat is dark brownish, with white spots. Since the

coloration of Nanfangao specimens quite agrees with Carr's differentiation, I follow Carr's trinomial for it temporarily.

9. **Dermochelys coriacea schlegelii** (Garman) ----
Pacific leatherback turtle

Fig. 18

Dermochelys schlegelii Stejneger, 1907, Bull. U. S. Nalt. Mus. 58, p. 485, figs. 373-376.

Dermochelys coriacea Pope, 1935, Rept. China, p. 20, fig. 1.

Dermochelys coriacea schlegelii Carr, 1952, Handbook Turt., p. 452.

Diagnosis --- Shell with seven longitudinal ridges above and five below, covered with a layer of smooth, leathery skin. Upper jaw with two sharp cusps, one on each side; lower jaw with a median cusp. Dorsal color slaty black tinted with brown, and with may white spots.

Description --- Shell covered with smooth, leathery skin, possessing seven longitudinal ridges dorsally, and five ventrally; head and limbs also covered with smooth, leathery skin. Body and limbs covered with small, irregularly polygonal scales in young forms. Head flat dorsally; upper jaw with three deep notches and two sharp cusps, lower jaw with a median curved cusp which is just fitted into the median notch of the upper jaw when closing up the mouth; edges of beaks not denticulated. This sea turtle

usually reaches a gigantic size, and a weight of about a thousand pounds.

Color in life --- In adult, dorsal side of shell black tinted with brown, with many small white spots; underside of shell mingled with black and white spots. Head brownish black with not very many white blotches and spots; jaws slightly brownish, clouded with dark pigment; throat dark brownish with white spots. Dorsal side of flippers black tinted with brown, with not very many white spots; ventral side of them also black tinted with brown, but with many white spots.

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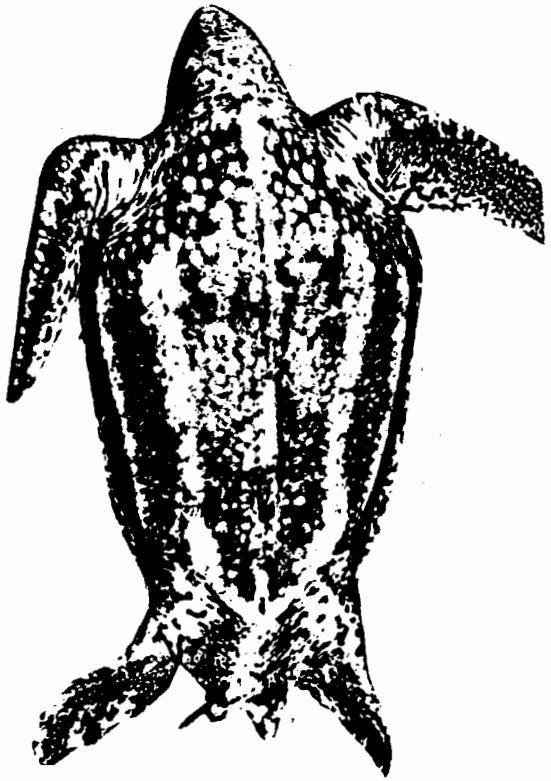

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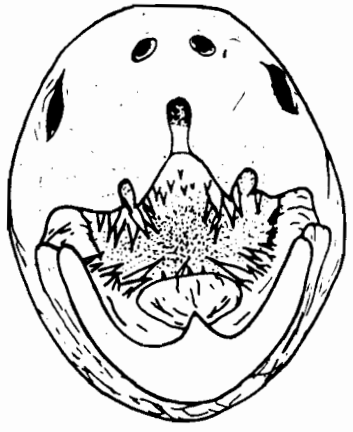

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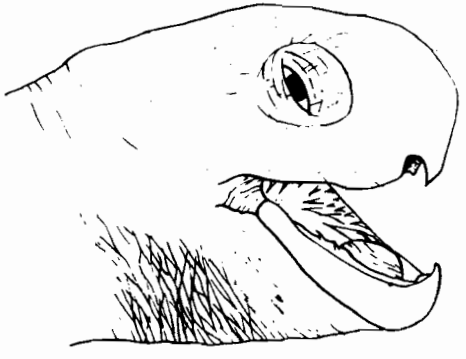

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Fig. 18

Dermochelys coriacea schlegelii (♀).

a. Dorsal view, x 1/15. b. Ventral view, x 1/15. c. Top view of mouth, x 1/3. d. Side of head, x 1/5.

Variations --- Little is known about the variations of this turtle.

Habits --- This pugnacious turtle usually inhabits tropical waters. Owing to its great strength, endurance, and speed, it wanders through the wide sea at will, yet it is often met near coasts. Sounds produced by these turtles have often been heard by fishermen at sea. Deraniyagala reported that on the southern coasts of Ceylon the peak of the breeding season is in May and June, and he also gave a wonderful account of its nesting and laying procedure. Because his statement is too long to be quoted in full, Pope (1955) has summarized it as follows:

"After leaving the water in the moonlight, the female watched by him threw great loads of sand over her glistening back until she was completely coated and therefore much less conspicuous. A copious flow of tears kept her vision clear during this 'sand bath'. Choosing a laying-site, she swept sand about with the flippers and made a hollow by movements of the body from side to side. Next she settled to excavate, with the hind flippers, the egg cavity. The eggs, once laid, were gently covered by flipperfuls of sand. Movements of the hind parts of the body finished the covering, and then obliteration of the site began. All four limbs took part in this; sand was flung high and wide while the body gyrated and moved back and forth in the area. So

effective was this sand-throwing and plowing that Dr. Deraniyagala and two helpers were unable to find the eggs by digging with the hands for an hour."

In Ceylon the eggs are usually spherical, soft-shelled, and white, occaisonally sprinkled with small green spots. They range in diameter from 50-54 mm. The incubation period is from 55-65 days.

The leatherback feeds on jellyfishes, crustaceans, and algae.

Economic importance --- Although its meat has a bad taste, it is sold as food at about NT$ 5.00 a chin on this island. The eggs are eaten wherever available. The oil yielded by the skin and shell is used as varnish on boats.

Distribution --- The leatherback is widely distributed in Indian and Pacific oceans. In the Eastern Hemisphere it has been found northward to Japan and southward to Australia as well as at the Cape of Good Hope, Africa. In the Western Hemisphere it ranges from British Columbia to New Zealand and Chile.

MEASUREMENT AND WEIGHT

The measurement and weight of the reptile (♀) which was photographed at Nanfangao are as follows:

Weight ---------- 252 kgms.

Tip of snout to tip of tail ---------- 1545 mm.

Remarks --- All of the specimens that have been seen at Nanfangao were too big for research purposes. Delivery of a small one has been promised by a fisherman who said that this giant was frequently captured from October to March, and occasionally in other months. During the prosperous season, usually two to five individuals could be seen on the wharf on a single day. Most of them are over one hundred and fifty kgms. The smaller ones are rarely seen at that fishing port.

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