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NOTES ON THE GREEN TURTLE (*Chelonia mydas*).

By F. W. MOORHOUSE, M.Sc., late Marine Biologist of Queensland.

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1.—INTRODUCTION.

Turtles are found the world over; some are restricted to certain very limited areas only, while others are cosmopolitan and are found mainly in the tropical and subtropical waters of all the oceans. Along the Barrier Reef, from south to north, there are present in considerable numbers at least three species of turtles—the green turtle (*Chelonia mydas*), the loggerhead turtle (*Thalassochelys caretta*), and the tortoiseshell or hawksbill turtle (*Chelonia imbricata*).

As little is known of the life-history and habits of the green turtle (*Chelonia mydas*), and as these animals are being taken in large numbers from the many islands along the coast of Queensland, more particularly in the Torres Strait, where the natives make them an important article of their diet, observational and experimental work on the laying period and on the rate of growth of the young turtles was carried out from October to February, 1929-30, with a view, not only to the adding to our knowledge of these animals, but also to the recommending of restrictions on the taking and killing of the adult animals if such was considered necessary.

Heron Island, situated at or about the southern extremity of the Great Barrier Reef and 55 miles north-east of Gladstone, was chosen as

the centre of these inquiries. The island is somewhat cigar-shaped and approximately 1 mile in circumference, surrounded by a moat of varying width and depth which never dries even at the lowest tide. The whole of the south sandy beach is protected by beach limestone, but the north shore is composed of white coral sand, there being no limestone deposits present.

The writer remained on the island from 31st October, 1929, until 16th February, 1930. Since turtles arrive mainly after nightfall and at any state of the tide, parades of the island were carried out each night with but one exception, due to extraordinarily inclement weather. In the early part of the work parades were made from nightfall till midnight and again from 2 to 5 a.m., but as the season progressed and the actual counting of the eggs became unnecessary, owing to the fact that the hatchings would occur after our departure, parades were at intervals, generally three times a night, viz.:—7.30 to 8.30; 10.30 to midnight; and again at 3.30 to 5 or thereabouts. During parades, only those turtles that came up on the island and laid their eggs were counted (excepting the marked animals which were counted each time they came up, whether they laid or not). This was done because a study of the habits of the turtle in general was one of the objects of the investigations.

Canning of turtle soup had been carried on at Heron Island for some years, work commencing early in November and finishing in February. During the 1928-29 season, so scarce did the turtles become towards the end of the season that periodic visits had to be made to the neighbouring islands in order to obtain sufficient animals to keep the factory in active operation. In view of the facts that the last season's animals were wiped out and that there was a considerable number present this season, one deduction is that turtles seen in any one season on any given island do not necessarily return the following year to lay, but that there is a period of rest between layings—that layings seasons are separated by some years. This is offered tentatively and can be proved or disproved only after some years of investigations.

2.—MARKING OF ADULT TURTLES.

In order to recognise the turtle under observation each was labelled. The labels were of copper sheeting about 1 inch square attached to the carapace by a wire passed through a hole bored in one or other of the PYGAL plates. The right bottom corner of each label was removed, the better to orientate the label during reading, and each label had a number punched on it. The original numbers were from 1 to 50, but as the 5 was difficult to distinguish in subsequent readings, labels 5, 15, 25, and 45 were discarded and the following—61, 62, 64, and — substituted. The labels proved a very satisfactory method of marking, but five animals were not seen again after labelling. It is more than probable that the labels of these animals were torn off by the male during copulation.

Turtles arrived on the island on 31st October, though it is reported that some had visited the island during the two previous nights. The first animal was labelled on the 4th November, but the marking of the animals did not start in earnest till 13th November because the animals coming up in the early part of the season were taken by the proprietors of the factory (a) for canning purposes, or (b) for sale to the freezing works at Gladstone.

With a view to finding the percentage hatch of young per nest, the eggs were counted as they were laid, the nest was marked by a stake bearing the same number as the label, and finally the animal was labelled. The label was added in order, as stated earlier, to show the returnings, if any, of these animals. By 23rd November fifty animals had been labelled, all the nests had been marked, the eggs of most counted, and the number recorded.

Amongst the first marked were five animals that had been turned over and left on the beach by visiting fishermen. On each of the two nights following, one of these five animals came back to the island and on both occasions was turned. On the second turning over she was actually transported to the factory to be killed but was later liberated. A report was received that on 15th November, ten days after her labelling, this animal had been seen laying on North-West Island, some 16 miles from Heron Island. Her subsequent layings were carried out on Heron Island.

Turtles are powerful swimmers, though they cannot maintain a high speed for any length of time, but on land they are not at all at home. When turned over on their backs on shore, they are quite helpless. The turning is easily carried out by first gripping the carapace at the pygal region and then lifting at the moment the turtle has completed her forward pull with the fore flippers. While in the turned position they make numerous futile attempts to right themselves and the fore flippers are waved a bout and frequently beaten against the plastron with resounding slaps. Care must be taken, however, not to venture too near the swinging flippers, for nasty wounds have been inflicted by the horny toe arming each. It was our custom to turn the turtles before boring the hole to take the label, but it was found that this was unnecessary labour, for the turtle took no notice of the process if it were carried out as she filled in her nest after laying.

During the marking of the last few animals, the earlier marked had commenced to return for their second laying. Many of the animals had a total of seven layings, though the returnings in some cases were as numerous as twelve. In many returnings the animal walked about the beach, and after perhaps digging a nest or two, went back to the water to return on the following night at some other point on the beach to lay. Some of the animals in their neariberings covered 600 yards besides digging one or two nests.

3.—BREEDING SEASON.

The breeding season in this southern area of the Barrier Reef commences in late October and extends at least into mid-February. During this time the females have been observed to lay seven different lots of eggs, and it is quite possible that since turtles were still returning on 16th February, when investigations ceased, that seven is by no means the maximum number of layings per season.

The males, distinguished from the females by their very long tails, have never been seen on the beach at any time of night or day, though they frequently come close in-shore.

Copulation appears to occur right through the season; pairs were seen floating on the surface of the smooth seas during October and November and again in January (Plate I., fig. 1). During copulation the couple float at the surface and frequently appear to go to sleep, for with care it is possible to row right up to the beasts.

The female lays her eggs in a hole which she digs generally above high-water mark. Layings do not occur at each return. In moving up the beach, the animal progresses by stages of six or seven steps, resting for longer or shorter periods between stages. In walking, the green turtle brings the fore flippers to the front and with a heave of the body and a pushing with the hind flippers moves her body forward a few inches on the way up the beach but as much as a foot on the way down, the tail leaving a characteristic stubbing in the centre of the track (Plate III.). The track left in the sand is quite different from that of the loggerhead turtle, which, walking like a four-footed beast, leaves an open set of prints.

As soon as the turtle reaches a suitable site, generally above high-water mark, she commences to remove the surface sand by flappings of her fore flippers while the hind ones pile up the sand behind her ready for the filling in of the nest after laying is completed (Plate II.). Her body is lowered to a level with the general surface, and finally most of the weight rests on the edges of the carapace. Then follows the digging of the egg pit, the hind flippers only being used. As the cupped flipper deposits the sand by the side of the animal the other flipper, which has been resting outstretched, is flicked forward to remove fallen sand and then carefully placed in the hole. As the hole is deepened the animal lifts herself up by her fore flippers so as to allow her hind flippers to dig deeper, the body pivoting on the carapace edges. After completion of the egg pit, which is a cylindrical hole undercut at the bottom, and which is 18 inches deep and 1 foot in diameter, the hind flippers are brought together to shield both tail and orifice and laying commences. The number of eggs at a laying is approximately 120, though as many as 195 and as few as 66 have been counted.

As soon as the laying is completed the nest is filled in, the hind flippers patting and kneading the sand into the nest. Then follows a flinging of sand over the body by the fore flippers, the hind ones



FIG. 1.—GREEN TURTLES IN THE SEA.

[Photo, F. Barclay.]



FIG. 2.—A BEACH CURING TURTLE.

The animal precedes up the beach slowly, resting frequently. She therefore, falls a ready prey to the hunters.

[Photo, F. Barclay.]

pling it evenly as it falls. The animal, still throwing sand, moves forward and soon the original spot is obliterated. Then she returns to the water. From the time of the turtle's coming out of the water till her return two to two and a-half hours have elapsed, though some animals have taken but one hour, while others have taken as long as seven hours in the process.

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Many animals have commenced to dig the egg pit and then left the spot. This is due not to any desire on the part of the animal to hide her true nest but because of (1) the meeting with a tree root or some other obstruction too large to be broken or removed; (2) the falling in of the sand under the animal's weight; (3) interruption due to (a) another turtle in search of a site blundering in on the one digging; (b) man—this applied more to those animals that had suffered the hurt of tagging; or (4) the animal's urinating in the prepared pit.

From the close of November onwards turtles came up in large numbers—as many as fifty-one animals arriving on the one night. Owing to this large number of animals coming to lay, there were few places on the island where no visit had been made, and many thousands of eggs were laid. Some points on the island appeared more favourable than others, though the turtles came as readily across the beach limestone which lines the whole of the south side of the island as they did across the sandy places. Owing to the large number of visits, later arriving animals frequently, when preparing their egg pit or when covering in their nest after laying, dug up old-established nests and scattered the eggs which in the morning were devoured by the sea-gulls. Not only were our nests for observation disturbed, but the marks also were removed and much of the earlier work vitiated. One nest of 81 eggs was destroyed some few days before the expected hatching and, though many of the young thus ejected were again covered none survived.

Considerable variations in the sizes of the carapaces of the laying animals were seen. The measurements were made along the carapace from nuchal shield to middle of the pygal shields for length, and across the carapace from edge to edge passing across the middle of the central neural shield for width. The largest animal was 48 by 42 inches and the smallest 35 by 35 inches. But of the fifty animals that were taken at random thirty-three were between 40 and 43 inches in carapace length, five were less than 40 inches in length, while the remaining twelve were greater than 43 inches. On several occasions, animals were met with that appeared smaller or larger than those mentioned above, but in all cases they were found by measurement to fall within the groups already given. Some small animals were seen swimming in the deep channel to the south of Heron Island's reef-edge, but it was not possible to capture one of them. A search for small turtles was made on the reef flat and in a deep lagoon to the east of the island, but without success.

4.—ENEMIES OF MATURE ANIMALS.

The many enemies of the small turtle will be given later, but mature animals are not immune. Sharks appear to cause much damage, and animals have been seen with a large piece bitten out of the carapace and with flippers missing; probably the result of shark attacks. One female in particular had her flippers so badly mutilated that she could not clamber up the beach. She therefore made a simple nest and laid her eggs in it at the very water's edge.

But all cases of missing flippers are not due to attacks from other animals. A newly-hatched turtle was found dead and its right hind flipper was represented by a small knob; other young have been obtained direct from the nest with the tail missing and with hind flipper, of one side or the other, deformed.

5.—Eggs.

The eggs of the green turtle are spherical in shape and 1½ inches in diameter. They are slightly larger than those of the loggerhead turtle, which are also spherical but 1½ inches in diameter. The number at a laying varies from 66 to 195, the average being approximately 120.

When laid, each egg is not completely filled and therefore is slightly dented. This depression generally disappears after several days of incubation, the filling-out being caused by the absorption of water from the damp sand surrounding the eggs, for eggs placed in sand that had been washed, thoroughly dried, and left under cover, were found to have shrivelled due to loss of moisture.

Similar shrivelling was seen in eggs left open to the sun and air. On opening these eggs the yolk appeared to be intact but all the "white" had disappeared. The white of the egg, of a particularly jelly-like consistency when new-laid, is composed mainly of water and contains very little albumin. When heated it is found not to coagulate. According to reports, retorting new-laid eggs under 15 lb. pressure of steam also fails to bring about coagulation, but if the eggs be exposed to the sun for one day and then boiled coagulation will occur.

The eggshell is parchment-like and is applied in layers, the outermost being impregnated with lime. In some eggs this outer layer flaked off but the contents did not appear to suffer any ill-effects, for development appeared to be normal.

Stages in the development of the embryo, commencing with the first day of incubation and carrying on up to the thirty-eighth day, were taken, but further critical examination of these embryos has not yet been carried out.

Development of the eggs in different nests was not uniform, but in any one nest there was fairly close uniformity. After one day of incubation the eggs, which are translucent when laid, showed the presence of a white patch on the upper pole. There the albumin had become closely apposed to the shell and in the centre of the area the developing

embryo would be seen as a clear patch when the egg was viewed in reflected light. After many attempts to obtain this stage success was at last forthcoming. By carefully cutting on the inner edge of the white patch the whole area was easily removed, and by soaking this for a short time in a salt solution (sea water) the embryo soon floated off. On about the seventh day of incubation the egg was turgid and the jelly-like white a liquid. From this time onwards all embryos were easily obtained.

The following stages and conditions of the embryo have been taken—the times are only approximate:—

2 days old—Body of five somites.

10 days old—The heart closed and beating regularly, the flipper buds definite, and the eye well advanced.

13 days old—The allantois a small sac-like outgrowth.

30 days old—Ribs and plates plainly marked off, eye enormously enlarged.

38 days old—Carapace taking on colour; head, lower jaw, and flippers move at will.

Experiments on the planting out of eggs were made at the early part of the season. The eggs were obtained from two sources—(1) From the evidents of animals killed for soup making; (2) from nests made by the females.

From the first sampling, *i.e.*, the eggs from the killed females, five nests were made; four of these were made on 8th November, the other being made on 1st January. The number of eggs per nest, the young that hatched, and the percentage per nest are as follows:—

Nest.	Number of Eggs.	Young hatched.	Percentage.
1	122	12	10/6
2	88	9	10/6
3	107	25	23/6
4	68	31	45/6
5	55		

Not hatched at time of leaving island.

With reference to the low percentages, it should be stated that from No. 1 nest at various intervals during the development period, eight eggs were taken in order to note progress. Each of these was developing normally, so that it is fair to assume that under ordinary circumstances the young would have been hatched from them, thus giving a percentage of sixteen from this nest. No. 2 nest was disturbed by a loggerhead turtle and when found many eggs had been thrown out. As this state of affairs occurs so frequently the percentage must stand. No. 3 nest was composed of eggs taken from the floor of the factory where they were floating around in the water that is freely used during the killing and cleaning of the animals to be used in the soup making. Some, too, had not been extracted from the portion of the water containing them.

so that during the development they were open to the attacks from the innumerable nematodes that are found in the decomposing mass. The necessity for the complete removal of all offal from the eggs that are planted out is therefore illustrated. No interruptions to No. 4 nest occurred, so that, though the percentage hatch is low, the young make a welcome addition to those naturally occurring. The important fact that eggs taken from killed turtles and planted out will develop has been demonstrated.

Since the policy of turning turtles before they have laid is still unfortunately adhered to by all persons met with, factory proprietors as well as ordinary fishermen, the proprietors of factories should see that all mature eggs are removed from the offal of the killed animals and planted out. The amount of time expended in carrying out this work is extremely small and once the planing is done no further attention is required. For the sake of the turtle industry, this should be done.

The second method of planting out eggs, from nests made by the turtles, was carried out because it was generally thought that, since there are so many eggs to each nest and yet so small a percentage hatches out, the earliest hatched animals devour the other less fortunate in the nest. This is certainly not correct, for there is yolk in excess of that required for the developing turtle, and this is drawn into the body cavity just prior to the animal's breaking from the egg-shell. In fact, some almost fully developed young have been seen with the yolk sac still external, and in two instances these animals were taken a day or so after and it was found that the sac had been drawn in through the umbilicus. The yolk sustains the liberated turtle for several days, and young kept in aquaria have been one week without attempting to eat. As soon as they are hungry they commence to dive, being especially attracted by pink objects such as portions of *Tubipora* or *Yoluta* shells. Young loggerhead turtles, however, are ready for food in two days, and they swim at the surface with their mouths open to the full extent and showing white against their otherwise totally brown drabness.

Before the fact that there is excess yolk was discovered, two nests, had been divided up. The eggs were planted out in smaller nests, each containing 12, while 22 and 36 were left in the original nests. In not one instance did the planted-out eggs come to full development, though all opened showed that there had been arrested growth of the embryo, and subsequent death. From the original nests, 17 from the former and 19 from the latter were the total hatchings. The failure is due in all probability to the fact that development had commenced in the eggs



FIG. 3.

After the body-hole is completed, the turtle commences to dig the egg pit. The right flipper has just deposited its sand, while the left one is checked to throw off the fallen sand before it is placed in the hole.



FIG. 4.

As soon as the egg-pit is completed, the flippers are brought together to cover the tail and orifice, and laying commences. The right flipper was drawn back in order to show the tail.



FIG. 5.—A LOGGERHEAD TURTLE.

Note its thick neck and its large head. The turtles are of little commercial use at present, though there are possibilities of utilizing them in the production of turtle oil.

before they were removed to the smaller nests, and that injury was caused to the embryo during the transplanting.

6.—PERCENTAGE HATCH.

The small percentage of hatchings, occurring in the eggs taken from killed females and planted out, has already been shown, so that for those eggs laid in the orthodox manner much better results would be expected to obtain. In the case of those eggs in nests that remain undisturbed this is so, but many instances will be seen later where 0 per cent. resulted.

Nests are usually made above high-water mark, but this mark during the month of November was considerably more than a foot below that for the month of January, so that many nests then out of reach of the tide were covered by the later higher tides, while others were laid bare or washed out by the resulting wave action. No young resulted from these nests, so the six nests under the heading "Destroyed by Sea's Encroachings" in the list to follow produced 0 per cent.

Of the fifty nests marked during the first laying, the following is a summary of results:—

Definitely known Hatchings.	DESTROYED—		Lost Trace of or not known.
	By other Turtles.	By Sea's Encroachings.	
11	10	6	23
(Percentage page 10)	(Percentage ?)	(Percentage 0)	(Percentage ?)

Unfortunately the "Lost Trace of" column contains 46 per cent. of the nests of the marked animals. Of these twenty-three instances, five nests belonged to animals marked early in the season. These turtles had been turned by visiting fishermen and unfortunately left on the beach, so that it is almost safe to assume that they had not laid before being turned. The returning of some of these animals on following nights is recorded, but as they were turned once or even twice again it is probable that all left and laid elsewhere. Actually one animal was seen by a fisherman, who reported that it had laid on North-west Island, 16 miles from Heron Island.

Of the other eighteen nests, the majority had their marking stakes thrown out by turtles, and so were lost trace of. It would appear that they should be included under "Destroyed by Turtles," but that column is reserved for nests in which the eggs were definitely known to have been destroyed. From many of these nests some young were probably produced.

The information dealing with the eleven nests of the first laying which were not disturbed and from which hatchlings resulted is here tabulated:—

Animal's Number.	Eggs.	Young produced.	Percentage Hatch.	Date of Laying.	Date of Hatching.	Incubation Period.
1	85	50	59	4th Nov.	10th Jan.	Wks. 9 Dys. 4
16	139	67	50	13th Nov.	17th Jan.	9 2
18	68 ^p	89	7	14th Nov.	18th Jan.	9 2
16	106 ^p	77	67.2	16th Nov.	27th Jan.	10 2
19	152	77	50	15th Nov.	25th Jan.	10 1
20	119	63	53	16th Nov.	26th Jan.	10 1
24	119	66	55	16th Nov.	27th Jan.	10 1
25	113	58	51	17th Nov.	28th Jan.	10 2
31	165 ^p	68	66.5	18th Nov.	29th Jan.	9 6
33	90	37	41	19th Nov.	29th Jan.	9 5
48	141	123	86	23rd Nov.	30th Jan.	9 5
*	150	83	55	17th Nov.	24th Jan.	9 5

* In the above list is a Loggerhead Turtle which was observed in order to compare with the Green Turtles. It will be seen that the number of eggs produced, the percentage hatch, and the incubation period follow closely those seen for the Green Turtle, and that since two other marked nests were destroyed the losses in the nests of these animals are as great as are those in the Green Turtle.

NOTE.—*p* alongside the number of eggs (*68p*) signifies that the total was in excess of that given; the animal had commenced laying when found.

7.—YOUNG TURTLES.

The first young turtles seen on Heron Island were found on 6th January just below the surface of sand covering the nest. As these eggs were laid on the 2nd November, this gives the incubation period of these animals as nine weeks two days. But it was not till 9th January that the animals broke through the sand on their own account after nine weeks five days of incubation. In popular writings on turtles it has frequently been stated that the incubation period was from six to eight weeks, according to the fancy of the writer, but the present investigations have proved this a fallacy, the time being from nine and a-half weeks to ten and a-half weeks.

Many hatchings were noted, and in all cases the time was in excess of nine weeks after the laying. Most of the nests from which young emerged in just over nine weeks were in open tracts of sand, unprotected from the summer sun for long periods each day. In those nests on the north side of the island where Casuarinas, Tournefortias, Pandanus, and other forms of vegetation grow close to the water's edge and give much shade, the period of incubation of the eggs has been considerably lengthened, and as much as ten weeks and two days have elapsed between the laying and the hatching. It therefore follows that the development of the eggs in different nests is not uniform, but from the hatchings it is seen that in any given nest there is fairly close uniformity.

The young from any one nest, however, do not all emerge on the same day or night. It was frequently noticed that part only of the young emerged on a particular night, to be followed on the next night or two after by the remaining portion. In some cases the first escaping was but a very small proportion, while in others the major portion escaped at the first break through.

It has been shown that a low temperature due to shade, caused either by vegetation or by clouds, retards progress. Rain also causes a delay in hatchings, for the sand is so hardened by the moisture that the young find it impossible to break through until the sand dries again. One instance out of several such will suffice. After a reasonable interval the young from a marked nest had failed to emerge. Their arrival time coincided with a week of heavy rain, so the nest was opened from one side and thirty animals were seen huddled together in a perfectly formed underground cave, entered by the settling of the egg-shells and of the sand torn down by the baby turtles in their endeavours to escape. When the cave was breached these young emerged, and twenty-five from beneath the floor of the cave also broke through.

As soon as the young turtles emerge from the nest they head for the sea, but should there be a bright light in their vicinity they are attracted to it and walk round and round it, resting for short intervals only. Even after the young have reached the sea they have come to the shore again at the approach of a bright light; on three different occasions animals attracted by the light from petrol lamps have left the water.

Young turtles walk like most four-footed beasts, leaving a characteristic and open track in the sand. The young green turtles thus differ from the adults, which advance by a series of heaves during which both fore flippers are brought forward to pull while the hind ones push.

When they reach the water the young swim straight out to sea, the fore flippers working up and down together, reminiscent of the wing action of a bird in flight. The hind flippers are trailed behind, coming into use only when the turtle rises to the surface to breathe. During this time both the fore and the hind flippers are moved one after the other and the animals appear to tread water.

Turtles are air breathers and therefore it was thought possible that they would survive in fresh water. Young ones were kept in an aquarium of fresh water and, though many appeared healthy, the majority preferred to remain out on the bank. There were many deaths amongst these animals, whereas of those in salt water pools only one death occurred. The fresh water experiment proved a failure.

It may be mentioned here incidentally that eighty-three young Loggerhead turtles were kept in a fresh water-pool for five weeks and all at the end of that period were in perfect health.

In the salt water pools the young often remain motionless on the surface for long periods with their heads and flippers out.

extent. Others remain in a corner with the head resting on a ledge out of water and the limbs tucked about them in various positions.

For up to seven days after hatching the animals make no attempt to eat and it was found, on dissecting several that had been inadvertently killed or drowned, that there was still a large percentage of the yolk within them.

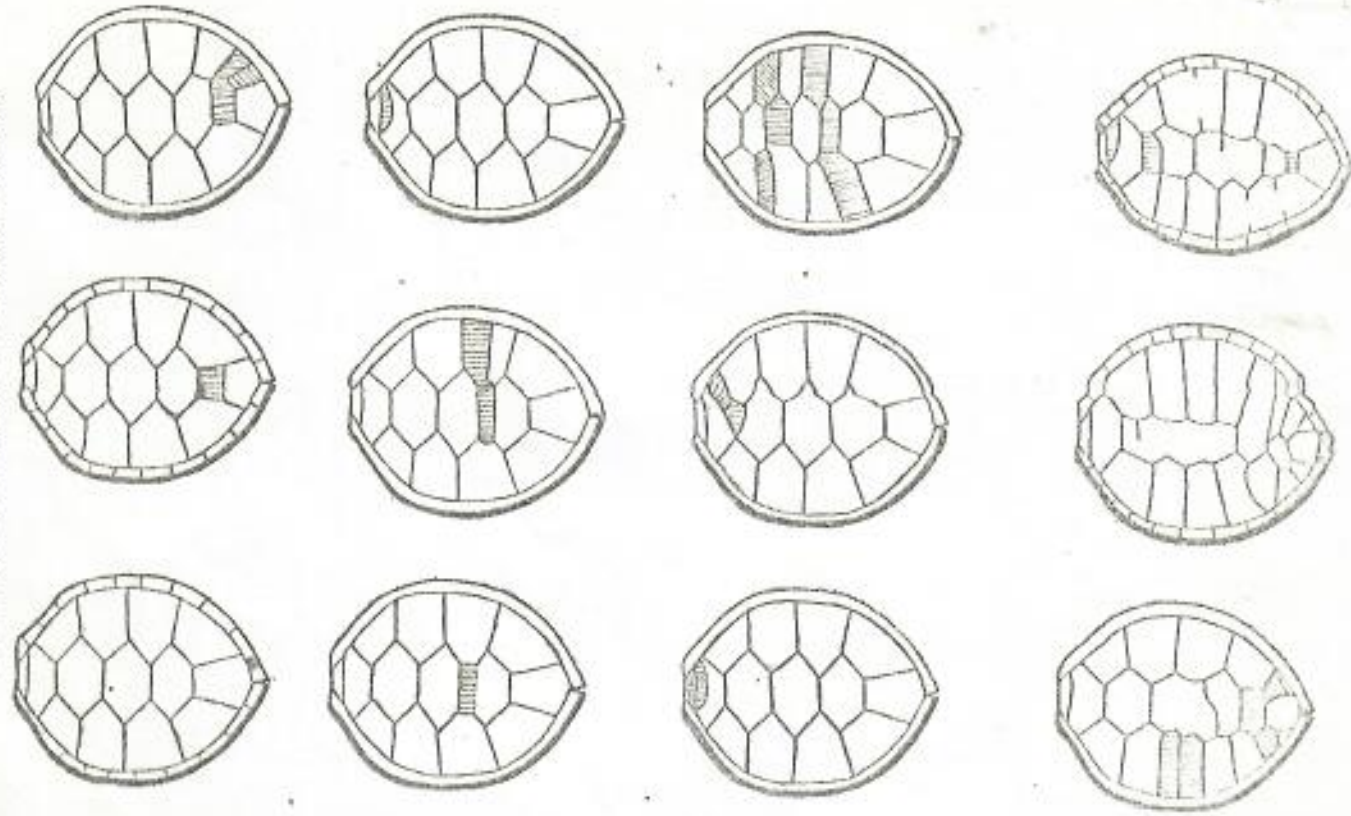
When the young were seen biting at objects in the water—they were especially attracted by the pink coral *Tubipora musica*—it was judged that they were hungry, so food was given to them. Since the adults are herbivorous, it was thought the young were also. Seaweeds were, therefore, placed in the pools and in all cases, though the weed was bitten off, it was rejected shortly after. Most of the species of algae occurring on the reef flat were placed in the pools in the hopes that the right kind would be amongst them, but all were rejected, as also were bread, biscuit, and oatmeal. It so happened that several small fish had been placed in a turtle pool in order to act as indicators to give warning when the water was foul. After a very heavy series of rain squalls the pools were filled with fresh water, and it was noticed that the fish, now showing signs of distress, were being pursued by the turtles. One was caught, torn to pieces, and eaten. After that, the food given to the young turtles was fish, clam, and meat. Young green turtles are therefore carnivorous. The following is its method of obtaining its food:—With mouth open the turtle approaches the food and obtaining a firm grip with its chisel-like jaws it forces the food away with its fore flippers, and tugs at it with all its might. The particles thus torn off are chewed under water, the excess water taken in with the food being forced out through the nostrils. The captive turtle in the observation pools readily took food from the hand and as readily dived for small pieces dropped into the water.

According to Gadow's account of turtles in the *Cambridge Natural History*, one would not expect to find much variation in the shields of the carapace of the green turtle. It came as a great surprise to find in the first collection of young green turtles that out of a number totalling forty-six there were fourteen non-uniform carapaces or 33 per cent. not normal, whereas from eighty-three young loggerheads there were but twenty-three or 27 per cent. not normal.

The normal number of shields on the carapace of a green turtle is thirteen large, made up by five neutrals and four pairs of costals, and twenty-five small, composed of twenty-four marginals and one nuchal. Of the fourteen abnormalities mentioned in the last paragraph there were twelve different departures and two duplicates. These are diagrammatically depicted in Text figure 1, the additional plate or plates being shaded. Two (Nos. 11 and 12) were so irregular as to defy interpretation.

Many hundreds of young turtles were collected. From one nest ninety-five young were obtained and not one animal possessed a set of

TEXT FIGURE 1.

ABNORMAL CARAPACES IN *CHELONIA MYDAS*.

irregular shields, yet from two other nests, of forty-three and twenty-five young, respectively, there were seven and five abnormal sets. The high percentage of abnormalities seen in the first animals collected is then not a coincidence. It is probable that, since there are mature females with shields that differ from the normal, their progeny will be liable to variations also; but the young arrived too late for a verification of this statement to be made.

Adult male green turtles differ from the females in that they possess a very long tail, approximately a foot, or more, in length. It was thought that a similar sexual dimorphism would be seen in the young, but no distinguishing features have been noticed. All young appear alike—omitting the exceptional, *i.e.*, the deformed ones, and the very small ones which, liberated by me from amongst the lowest tiers of eggs, would, under ordinary circumstances, have failed to free themselves.

Besides the abnormalities in the shell just described, several deformed young have been met with. One of these was dead when found. Instead of the normal right hind flipper, that appendage was represented by a rounded knob. A condition similar to this has been seen in the adult of both the loggerhead and the green turtles, but it had been thought that the flipper in these cases had been bitten off by some enemy such as a shark. It is probable that some of these instances are due to arrested growth, though others, without doubt, are caused by attacks from various animals.

A second case was the one whose shell is shown in No. 11 above. This animal had no tail and the hind flippers and that portion of the carapace and body posterior to the hind legs were non-pigmented. This animal lived for a long time in the aquarium and appeared to thrive. Under normal conditions such would certainly fall a ready prey to fish, judging by the number of successful attacks upon it by the other young turtles in the same aquarium. A third turtle had the right hind flipper turned inwards and malformed. This animal was the last to arrive from one of the planted nests. It, too, lived when placed in the aquarium.

Despite these cases there is a remarkable uniformity in size of the carapaces, and, though some small animals occur, the majority have the following dimensions (on hatching):—Nose to tail, 3 inches; carapace (length), $1\frac{1}{2}$ inches; carapace (width), $1\frac{1}{4}$ inches; plastron (width), 1g inches; head (length), $\frac{3}{4}$ inch; thickness of body, $\frac{3}{8}$ inch.

The colour of the carapace when dry is slate grey, but on being wetted this changes to a dark blue. The edges of the carapace and of the limbs are faintly blue at time of liberation, but this darkens with age, leaving after a month but a very thin strip of light colour. The plastron is uniformly white.

The umbilicus is at first very definite, having frequently the appearance of a rounded knob; but gradually this protruding mass is

withdrawn, the shields of the plastron in this region come together, and in about three weeks all trace of the umbilicus has disappeared.

8.—ENEMIES OF YOUNG TURTLES.

Since much damage is done to eggs and potential young by turtles that arrive for a later laying, turtles themselves must be included in the list of enemies.

The baby turtles generally break forth from their nest at nightfall. Should they come to the surface before this part of the day, they usually remain beneath the sand. Some have broken through in daylight, however, but in most cases they have buried themselves again. Others have commenced the hazardous journey to the water, but invariably have been taken by gulls and herons.

At night the birds have disappeared, so these enemies are not then to be contended with. But the nocturnal large shore crab, *Ocypoda*, feeds on the beach and many young turtles fall victims to him. These crabs are present in large numbers, but it is only the bigger members of the species that attack the turtles. As it stands over its prey, the crab grips it firmly with one claw while with the other it removes the shields of the carapace, generally commencing with those in the tail region of the shell.

On Heron Island there is another enemy which is perhaps peculiar to this island. This is the common house cat, which has so multiplied that it now forms a real menace to the young turtles, for each cat frequently takes seven or eight turtles for a meal and eats the head only.

In the water, sharks and large fish await young turtles, so that the percentage loss is extraordinarily high.

9.—MARKING OF YOUNG TURTLES.

The marking of young turtles appeared a problem because their backs are but 2 inches in length, whereas those of the adults are 3 feet or more. Owing to the number of adults that have been seen with part of flippers missing, the attaching of labels to flippers did not seem a satisfactory method of marking. Since carapaces are too small to afford suitable places for fixing labels, it was decided to experiment by snipping off the extensions of the pygal plates. When it was ascertained that, though slight bleeding occurred at first, the snipped animals appeared to have suffered no ill-effects, 1,300 animals were marked in the same way and liberated at night. They swam towards deep water and up to the present not one has been seen again.

10.—GROWTH IN YOUNG TURTLES.

A very close uniformity in the carapace measurements of the young as they emerge from the nest is seen in the cases of both the loggerhead and the green turtles. Occasionally in a batch of young there are some decidedly small animals, but they form a very small percentage of the

hatch. They appear to be those from the lowest tiers of eggs and generally are badly formed due to pressure. This is only a temporary malformation and they fill out later. Many of these, however, do not live more than a few days.

The measurements of six representative young were taken at intervals in order to show the increase by growth. Though the list shows that this is not great it is certainly appreciable, and is quite noticeable when newly-hatched turtles are placed in the pools with the older ones, an action that is not recommended, for the new ones continually struggle to escape and thus disturb the now-contented older captives.

NORMAL ANIMALS.

Where Measured.	No. 1.		No. 2.		No. 3.	
	23rd Jan.	10th Feb.	23rd Jan.	10th Feb.	25th Jan.	16th Feb.
Nose to tail (variable)	3 $\frac{3}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$	3 $\frac{3}{4}$
Carapace—						
Length	2 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	2 $\frac{1}{2}$	2	2 $\frac{1}{2}$
Width	1 $\frac{1}{2}$ p	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$ p
Plastron—Width	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Head—Length	0 $\frac{1}{2}$ p	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$
Thickness of body	0 $\frac{1}{2}$	0 $\frac{1}{2}$ p	0 $\frac{1}{2}$	0 $\frac{1}{2}$ p	0 $\frac{1}{2}$	0 $\frac{1}{2}$

ABNORMAL ANIMALS.

Where Measured.	No. 1.		No. 2.		No. 3.	
	23rd Jan.	10th Feb.	25th Jan.	10th Feb.	25th Jan.	16th Feb.
Nose to tail (variable)	3	3 $\frac{1}{2}$	3	3 $\frac{1}{2}$	3 $\frac{1}{2}$	3
Carapace—						
Length	1 $\frac{1}{2}$	2 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$ p
Width	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Plastron—Width	1 $\frac{1}{2}$ p	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$	1 $\frac{1}{2}$
Head—Length	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$
Thickness of body	0 $\frac{1}{2}$	0 $\frac{1}{2}$ p	0 $\frac{1}{2}$ p	0 $\frac{1}{2}$	0 $\frac{1}{2}$	0 $\frac{1}{2}$

The increase in growth of young turtles is shown on the shields of the carapace. The horny matter making up these shields is secreted by cells of the epidermis immediately beneath them, so that the first formed natal piece remains uppermost, the new layers being added from below. Each new addition is a little larger than the one deposited before it, so that, in effect, the shields are very much flattened truncated pyramids owing to the thinness of the added plates. But the new portion is added in different manners in the various shields. That of each neutral shield is so placed that the anterior portion projects more than does the posterior part, so that with increasing growth the original shield is left towards the rear of the shield.

With costal shields the additions are greater to front and outer sides, i. e. to the side that is nearest to the marginal shields, while in the marginals the increase is to the front and to the inner sides more than to the rear.

Since the additions to the anterior portions of the shields are twice as great as those to the posterior portions, the natal shield will come to occupy a position that is approximately a third of the length of the shield from the posterior end. It would be expected from this that, once the yearly growth of a shield is known, then the age of the mature turtle could be found from its shields either by noting the position of the original shield or by sectioning the shield at or about the position of the natal portion. But the older portions of shields are continually peeling off, so that it is not by this method that the age of mature turtles can be found.

It was thought that it would be possible to estimate the age of a mature turtle by taking shield measurement. At birth, for instance, the fourth neutral shield is $\frac{3}{4}$ inch long, whereas a 44-inch animal has these shields 8 $\frac{1}{2}$ inches long. Since the $\frac{3}{4}$ -inch shield increased to seven-sixteenths of an inch in a month, then the 8 $\frac{1}{2}$ -inch shield, having increased by 126 sixteenths, will have taken ten and a-half years to have reached that size, assuming a uniform monthly rate of increase. But if the third costal shield on the right side of the same animal be used, then, since a $\frac{3}{4}$ -inch shield, which in one month grew to $\frac{5}{8}$ inch, has, in a 44-inch animal, increased to 14 $\frac{3}{8}$ inches, the age would be only nine and a-half years. If this method is reliable and if growth is uniform, then 44-inch turtles are approximately ten years of age.

Young turtles seen on Murray Island in January measured 8 inches along the carapace from nuchal to pygal shields. Three had been captured early the previous year and had been kept in a small aquarium made from clam shells, *Tridacna gigas*. Their food was mainly a small herring, boiled trochus, and clam. One-year-old turtles are 8 inches long.

11.—PRESERVATION OF YOUNG TURTLES.

The many dangers that have to be faced by the young turtles immediately they are free from the nest have been given, so methods of preservation have been tried.

Those nests that were marked and remained intact were cooped shortly before the young were expected to arrive. The coop was a small-meshed wire-netting cage of 2-foot sides with covered-in top. This was sunk 6 inches in the sand surrounding the nest. No young could escape; therefore the cages were inspected each evening till the young appeared, and for some days after their first appearance, in order to obtain the later arrivals. The young were removed and placed in ponds made above high-water mark, or in floating cages of wire-netting surrounding a wooden frame, which were anchored out in the water of the lagoon.

The ponds were all straight-sided in order to keep the young turtles within bounds, and were enclosed by a wire-netting fence. The

small path at the sides. The tops were covered in in order to keep out herons and gulls. It was a mistake, however, to impound the turtles in straight-sided pools, as they enjoy a walk and by their continued attempts to crawl up the straight sides they were away the little horny toes of the flippers. After this had been noticed, ramps were added to the four corners of the pools up which the young scrambled on their way out. When they had had sufficient time out of the water they dropped back of their own accord. The pools for enclosing young turtles should be so constructed that their long axes are parallel to the beach and the side nearest to the beach should slope gradually down, giving a scoop-like depression. The turtles, when they come out of the water, should be supplied with shade, because the hot sun tends to desiccate them and the shields fall off or blindness follows, resulting in the death of the animal. The food of young turtles is fish, though, after they have been some time on this diet, they appear to relish a little seaweed. Any of the seaweeds found growing on the reef-flat were eaten in very small quantities. The food was suspended by cords at distances sufficient to allow room for several animals to eat at each point. Small fish, such as "hardyheads" (*Hepsetia pongis*), were greedily eaten, but cooked fish was just as readily dived for.

Several attempts to find the destination of the young turtles were made. The turtles, followed by boat, were seen to go as far as the reef edge and there they disappeared. Whether they reached the open sea is doubtful, for, by wading behind others that were liberated at low water, it was found that large fish—"trout," morwong, and sweetlip—darting out from beneath coral ledges near the reef edge snapped them up in a moment. Not one of twelve thus followed escaped. Whether the same state of affairs obtains at night, which is the normal time of escape, could not, unfortunately, be discovered.

The necessity of forming large compounds in which to hold baby turtles until such time as they can fend for themselves is patent. These should be constructed in protected bays where small fish are abundant so that the supplying of food and the changing of water will be done by natural means. Any such compounds must be sufficiently high-walled to reach above high-water mark and must be covered with netting in order to prevent the ingress of birds. In such a place as Heron Island no such protected bay exists, so that large shallow basins would have to be constructed on the plan of that given on an earlier page.

Small floating cages were not a success, for in rough weather when the tide rose over the reef-flat the wave action tossed the young about and eventually drowned them.

12.—DEDUCTIONS AND SUGGESTED RESTRICTIONS.

After the closing of the factory on Heron Island, which, during November, 1920, produced a hundred or so gallon cans of concentrated turtle soup, a tally of all the turtles that came up to lay was kept. Between 1st December and 16th February there were seen 1,755 turtles, and, as mentioned earlier, these were all females.

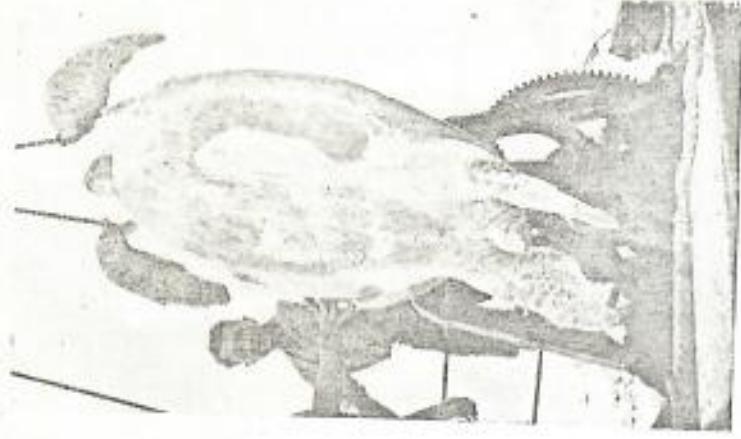


Fig. 6.

A 2½-cwt. turtle being lifted up on to the truck to be taken into the factory.



This is a dummy tank.

No males were ever included in the figures given in this paper, for no males were ever seen out of the water, and no males were ever killed at the factory.

Some of the labelled animals made as many as twelve returnings, but on only seven of these occasions were layings successfully carried out. Many of the animals that were not tagged but possessed such distinguishing features as a badly bitten-away carapace, one or other of the flippers missing, or an undivided horny shield covering the carapace, enabling them to be recognised again, were also seen on many occasions. The interval between layings is approximately fourteen days.

Though some animals were inevitably missed from the count by coming up and returning between our parades, the following definite results are here presented for the first time:—

- (a) A very limited number of animals visit any one island during the breeding season.
- (b) The same animals return again and again, seven being the maximum returnings recorded.

With this information now available these deductions can be drawn:—

1. The idea now prevalent that there are thousands of turtles visiting any one island during the breeding season is quite erroneous and must be replaced by a *limited number of turtles make many visits to any one island during the breeding season.*

2. Had the factory on Heron Island operated right through the 1929-30 season, there would have been seen towards the middle of the season that dearth of animals that has marked previous years when continued canning operations were carried out, mention of which was made in the Introduction of this paper.

3. Since the 1928-29 season's limited number of animals that visited Heron Island was completely wiped out, and yet some hundreds of animals were seen there the following season, then we are confronted with the following probabilities:—

- (a) Turtles do not lay every season.
- (b) Turtles that laid on an island in one season go to some other island the following season.
- (c) Sufficient young mature each season to take the place of those adults killed during the immediate past season.
- (d) There is a combination of (b) and (c)—i.e., some turtles that laid elsewhere during the previous season, together with some lately-matured young, go to any one island for the next season; or
- (e) Turtles that laid some seasons ago, together with some lately-matured animals, visit an island during the season.

Of the five points in No. 3, all that can be said at present is that (c) is the only point that can be definitely ruled out, for the turtles that came up to lay during the season varied, as shown in an earlier portion

of this paper, from 35 to 48 inches in length of carapace, so that all those laying were not newly matured; in fact, only a small percentage of the laying females found on Heron Island was of such a size as 35 inches. It is a tentative hypothesis that 35 inches is the size of newly-matured animals—i.e., in so far as Heron Island observations allow, green turtles first mature when they have reached a length of 35-inch carapace measurement.

At present in Queensland there is no restriction on the taking of turtles and there is further no regulation forbidding fishermen from taking animals before they have laid the eggs that they have come to the island to deposit. Though the short-sightedness of killing the turtles before they have laid is admitted, even by the hunters themselves, this unwise practice is still followed. If it is continued with, especially early in the breeding season, it must in the very near future deplete our stock of turtles to such an extent as to wipe out this branch of our fishing industry; therefore, a regulation should be framed in order to prevent the extermination of the turtle.

Any regulation regarding the taking of turtles should be such that a breach of it will become patent without the added expense of policing the waters to enforce it. In so far as turtles are concerned the matter appears simple. At Heron Island, turtles are taken on the beach as they come to lay, and since the laying season commences at or about the close of October in these waters, no turtles are seen upon the beach before that date. It is not till the middle of November that all the animals have been to the island to lay the first batch of eggs, so that by preventing the taking of turtles till the close of November all will have had the opportunity to have laid once, while many will have laid their second set. (N.B.—At the commencement of the season turtles were scarce, five or six being the normal number seen each night. The numbers gradually increased till early in January, when as many as fifty-one were seen on the beach in one night, after which the numbers began to decrease again rapidly till towards the close of the season only six or seven were seen each night.)

But the coast of Queensland is some thousands of miles in length, so that what applies in Southern Queensland does not necessarily apply in the north. The writer saw turtle eggs that had been laid in May in the Torres Strait islands, so that either the season is much more protracted in North Queensland or occurs in different months. If, then, regulations are to be framed they must at present state clearly that they apply to that part of the coast of Queensland south from Cairns at least (or latitude 17 degrees South) until such time as the length of the season in North Queensland is definitely known.

The regulation recommended should, therefore, be similar in form to that suggested hereunder:—

“No person, south of latitude 17 degrees South, shall take, or offer for sale, and no person shall purchase, kill, or attempt to export, between the dates of 30th September and 30th November of each year, any turtle of the kind known as the Green Turtle (*Chelonia mydas*). Penalty £10 for each animal found in

This close season is absolutely essential, for it is the only definite means of ensuring the laying of some of the eggs normally produced by the turtle. But if the fishermen and factory authorities could be compelled to plant the eggs from the killed animals, since it has been demonstrated that such action is advisable and profitable, then the yearly production of young turtles can be appreciably increased. It does not appear wise at the present juncture, owing to insufficient knowledge, to frame regulations to limit the number of turtles that shall be taken each season, or the size of animals permitted to be taken.

To illustrate how overfishing is viewed by other countries, a summary of ordinances and regulations introduced by them in order to ensure the natural restocking of their waters with turtle is here appended. Most of these countries carry a large native population.

WEST INDIES.

Barbados (1904).—No person shall take turtles or turtle-eggs from the shores of the island. No person shall set any net or seine within 100 yards of the beach.

St. Lucia (1911).—No person shall take, kill, sell, or buy and no person shall set a net with the object of catching turtles during the months from May to August, both included. Fines range up to £20 for any breach.

Turks and Caicos (1907).—There shall be a close season for turtles from May to September, both included. Neither eggs nor turtles shall be taken during these months. Fine, £20.

Grenada (1911).—There shall be a close season for turtles from April to September, both included. Neither eggs nor turtles found on land shall be taken. Fine, £5.

Jamaica (1914).—There shall be a close season for turtles (months not stated, but probably as for other West Indian Islands). Turtles' eggs shall not be taken. Fine, £5.

Trinidad and Tobago.—Though there is a close season, the months are not given. There is further a restriction in size that it is permissible to take, but measurements are not given. Fine, £10.

EAST INDIES.

Federated Malay States (1915) sets aside areas from which no eggs may be taken. Fine, 100 dollars.

North Borneo (1917) allows eggs and turtles to be collected on condition that a license is held by the person collecting, but this does not apply to the natives, who have a special area allotted to them.

Philippines.—There appear to be no restrictions here.

OTUPEA ISLANDS.

Fiji (1923).—Turtles and their eggs are subject to the same restrictions as the fish; but the fish restrictions are not available.

Seychelles (up to the year 1919).—Turtles here had to be over 30 inches long and were not allowed to be taken during the breeding season. Eggs were not allowed to be taken, there being a fine of

500 rupees or 6 months' imprisonment for a breach. In 1919, however, the above Act was repealed and in its place was substituted the following:—*No turtles shall be taken.*

In conclusion, it must be admitted that much has still to be learnt. There has yet to be discovered the percentage of males and of females arising from each nest, and the percentage of these that actually reaches maturity. Further, a knowledge of where the young spend their lives is required and definite information on growth-rate has yet to be found.

13.—SUMMARY.

1. Of the fifty labelled turtles under observation, many were found to return to the island on numerous occasions and seven was the maximum recorded number of layings per animal. These layings occurred at approximately fortnightly intervals.

2. Copulation is carried out right through the laying season, which in the southern area of the Barrier Reef commences in late October. Animals (including some of the marked ones) were still laying when the writer vacated Heron Island on 17th February.

3. It is tentatively offered that females first mature when they have reached a carapace length of 35 inches.

4. The eggs produced at a laying vary from 50 to 195. The incubation period is from nine and a-half to ten and a-half weeks and the percentage hatch of nests under observation varied from 0 per cent. to 86 per cent. Eggs taken from the ovaries of killed turtles and planted out showed as high as 24 per cent. hatch.

5. Young turtles are greedily eaten by gulls, herons, terns, crabs, large fish, sharks, and cats. No sexual dimorphism was apparent in the young forms.

6. Young turtles were marked by snipping off the extensions of the pygal shields. They can be kept in aquaria of fresh water and are carnivorous in their early youth. Growth is noticeable by the additions to the anterior edges of the shields.

7. It has been shown that a very limited number of animals visit any one island during the breeding season and that these animals return again and again to lay.

8. The Government has been recommended to enforce the following regulation:—

“No person, south of latitude 17 degrees South, shall take, or offer for sale, and no person shall purchase, kill, or attempt to export, between the dates of 30th September and 30th November of each year, any turtle of the kind known as Green Turtle (*Chelonia mydas*).”

This close season is considered absolutely essential, for it is the only definite means of ensuring the laying of some of the eggs normally produced by the turtle.

9. A summary of ordinances and regulations introduced by many countries in order to ensure the natural restocking of their waters with turtles is given.

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