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**GROWTH STUDIES ON THE RIDLEY TURTLE, *LEPIDOCHELYS OLIVACEA OLIVACEA*
ESCHSCHOLTZ, IN CAPTIVITY AND THE EFFECT OF FOOD PREFERENCE ON GROWTH**

by

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CONTENTS

	Page
I. Introduction	1
II. Materials and Methods	4
(a) Rearing	4
(b) Feeding experiments	4
(c) Growth increment studies	5
(d) Experiments on food selection	6
(e) Experiments on the effect of diet on growth increment	6
III. Results	6
(a) Food preferences	6
(b) Effect of diet on growth increment	8
IV. Discussion and Conclusions	9
V. Summary	12
References	13

ABSTRACT

Studies on rearing, feeding habits, food preferences and growth-rate of the ridley-turtle, *Lepidochelys olivacea olivacea* along the west coast of Thailand were reported and the effect on growth-rate of several types of meat-and vegetable-diet were measured in holding experiments in the laboratory. Their breeding patterns in Thai waters are recorded. The recent depletion of turtle populations in this area, its possible causes and remedies are discussed.

I. INTRODUCTION

Five species of sea turtles belonging to two families, Cheloniidae and Dermochelyidae have been recorded from waters around Thailand (Taylor, 1970). The family Cheloniidae consists of four recognized genera, each comprising one single species: Green turtle, *Chelonia mydas japonica* Thunberg, 1787 (*Tao-Ta-Nu* in Thai); hawksbill turtle, *Eretmochelys imbricata bissa* Rüppell, 1835 (*Tao-Kra* in Thai); loggerhead turtle, *Caretta caretta gigas* Deraniyagala, 1933 (*Tao-Ya* in Thai); and ridley turtle, *Lepidochelys olivacea olivacea* Eschscholtz, 1829 (*Tao-Ya* in Thai). The family Dermochelyidae has only one single

genus with one single species: Leatherback turtle, *Dermachelys coriacea schlegeli* Garman, 1884 (*Tao suang* or *Tao-ma-fuang* in Thai) This is the largest of the five species.

The green turtle and the hawksbill turtle are common in the Gulf of Thailand in varying degrees of abundance. For example, they occur in a ratio of 4:1 at Kram Island and 5:3 at Kra Island (Penyapol, 1957). The loggerhead turtle is the only other species of sea turtle recorded from this area. All five species of turtles occur along the Indian Ocean Coast of Thailand. Of these, the hawksbill and loggerhead turtles have become rare in recent times, while the other three species are still more common.

The peak egg-laying season for sea turtles is found to differ from area to area, and the condition of the sea may have some influence in determining this. Currents seem to apparently play a significant role in transporting sea turtles to the general vicinity of the nesting beach in Costa Rica (Richard and Hughes, 1972). The green and hawksbill turtles lay eggs throughout the year in the Gulf of Thailand as has been reported already for Sarawak (Penyapol, *loc. cit.*). However, in Phuket area along the west coast of Thailand (the area of present investigation), egg-laying was found to be maximum during October to April for the leatherback turtles and from October to February for the other four species, while only stray cases are reported during the other months.

Suvatti (1950) recorded that the maximum carapace length of the egg-laying loggerhead turtles was about 105 cm. The carapace length of egg-laying green turtles ranges from 75 to 105 cm, and of hawksbill turtles from 55 to about 90 cm. (Penyapol, *loc. cit.*). Kaewnugool (1969) reported that the total length of the largest egg-laying leatherback turtle was about 225 cm.

Petpaidit (1950), Penyapol (*loc. cit.*) and others studied the egg-laying process of turtles in Thai waters. A turtle may lay eggs several times during a season at intervals of approximately 2 weeks. There is a record of three nestings in one season by a loggerhead turtle. However, it would appear that a green turtle might not necessarily nest every year, but returns to the same place again for nesting (Caldwell, 1960). Carr and Carr (1970), after 15 years of tagging studies, recorded 447 remigration returns of the green turtle at Costa Rica; female turtles returned to nest every 2 years and some every 3 years, the latter being the more frequent cycle. Longer absences of up-to 9 years were also recorded. In Sarawak, most of the green turtles tagged were found not to return to the same beach to lay eggs until at least the fourth year after tagging (Harrison, 1956).

Egg-laying normally takes place during the night, but the turtle occasionally lays her eggs during the daytime also. During this process, the ovigerous female emerges from the sea during high tide on a quiet and undisturbed beach and selects a suitable place for her nest, usually just beyond the high water line. Here, she digs a hole in about 15 minutes using her hind limbs. If the wall collapses owing to dryness of the sand, she selects another place nearby and tests the sand. If this also fails, the turtle returns to the sea.

The completed nest hole is about 25 to 35 cm. wide and 60 to 80 cm. deep. The oviduct is protruded into the nest and at the same time a small amount of mucus is discharged into the bottom of the hole, when the egg-laying begins. The eggs are ejected in batches of 2-5 and the egg-laying is completed in about 25 minutes. The total number of eggs laid depends upon the age of the turtle and may usually range from 70-130. After the egg-laying is complete, the oviduct is retracted and the nest is then covered with sand, again using the hind limbs as flippers. The sand is compacted by using the chest as a weight and finally it flips dry sand from the sides on top of the nest, this time using the fore limbs to cover the tell-tale moist patch. The completely exhausted female returns to the sea immediately after.

The largest eggs are laid by the leatherback turtle, they are of the size of a billiard ball (about 5-5.5 cm. diameter), while the eggs of the other four species are approximately the size of a table-tennis ball (about 3.8-4.8 cm. diameter).

The mucous secretion might be a kind of protective coating to prevent excessive loss of moisture during incubation in the sand. However, if the nest is flooded during this period, all the eggs will not hatch.

The duration of incubation and embryonic development varies among the species and depends

also upon the heat of the sun at each locality. At Kra Island, the eggs of hawksbill and green turtles hatch in about 45 to 50 days (Penyapol *loc. cit.*). At Phuket, the leatherback turtles require 65-70 days for hatching, and all the other species hatch in about 50-60 days. The eggs lie in many layers in the nest and the sun's rays heat the upper layers more intensely than the lower ones, whereby there is a time lapse of 24 to 48 hours between the hatching of the first and the last eggs in a nest. At Kram Island, at least 90% of the eggs in each nest were found to have hatched (Penyapol, *loc. cit.*), while at Phuket, the hatching rate was only 75-80% per nest.

The baby turtles are at first very weak and remain in the nest for 2-3 days after hatching, after which they climb out and head straight for the sea. The young turtles remain in the open sea until they are about a year old. This period is known as "the lost year", when most of them are eaten by predators, such as birds, sharks and other carnivorous fishes. It has been estimated that only one percent survive to return to shallow waters at the beginning of the second year (Anonym., 1972).

Sea turtles constitute a popular source of seafood in some coastal provinces of Thailand, particularly along the west and east coasts of southern Thailand, and the east coast of the Gulf of Thailand as well as in Bangkok. The eggs, called *kai-ja-la-met* or *kai-tao-thale* in Thailand (*kai* means eggs; *tao-thale* means sea turtle; the word *ja-la-met* in old Thai usage means all sea turtles). Sea turtle eggs normally cost four to five times more than the poultry eggs in the market. A generally decreasing trend in their availability has been noticed in recent times, while the demand is notably increasing. Up to 1947, there were no laws or regulations controlling the collection of sea turtles and their eggs in Thai waters, this resulted in a noticeable decline in the sea turtle population. The Fisheries Act of B.E. 2490 was therefore proclaimed by the Government in April, 1947, as a conservational measure. According to this law, killing of sea

turtles is forbidden, egg-collection along certain (but not all) beaches requires a yearly licence issued to concessionaires who have to hatch a definite number of eggs on a percentage basis and release the baby turtles into the sea. These duties are supervised by the provincial fisheries officers. The regulations at present do not cover the leatherback turtle. Each beach is leased to one licensee, and the eggs of all sea turtles nesting on that beach are hatched on the same beach. In 1965, such "hatcheries" existed in 4 coastal provinces in the Gulf of Thailand and in 3 along the west coast. These hatcheries released a total of 21,350 hatchlings of green turtle and 2525 of hawksbill turtles during that year (Lokagul, 1965). Such hatcheries were reported from only three provinces during the last nesting season: Pattani along the west coast of the Gulf of Thailand and, Phangnga and Phuket along the Andaman sea coast. In Pattani province, sea turtles nested on 7 beaches and each licensee released 200 hatchlings of green turtles and 50 of hawksbill turtles. A total of 3,200 releases were made from Phuket province and 7,800 from Phangnga during this season (data on species basis are not available for these two provinces). An average of approximately 11,000 hatchlings (all species put together) have been released yearly during the last 8 years for the whole of Thailand. This clearly shows a marked decline in the number of total nestings during the period after 1965. The decline may be attributed to the rapid development of commercial trawling operations in the Gulf of Thailand and along the west coast during this decade. The sea turtles migrating to shallower areas for nesting are easily caught in the nets during trawling operations where they get entangled and killed. It is worth mentioning here that bottom trawling operations were started and rapidly expanded only after 1963.

Release of hatchlings by artificial means might be an efficient method to replenish the diminishing natural populations of sea turtles in nature. In 1961, 20,000-30,000 baby green turtles were dropped in to the Caribbean Sea by seaplanes to replenish the rapidly decreasing populations

there, for sea turtles form the main source of meat for the natives of that area (Anonym., 1962).

A preliminary study of the distribution, breeding and embryological development of the green and hawksbill turtles in the Gulf of Thailand was made by Penyapol (1957). Hendrickson (1957) observed the reproductive patterns, early development, growth rate, migrations, and nesting returns of the Malayan and Sarawak populations of green turtle. Carr, Hirth and Ogren (1966) reported on the ecology and migration patterns of hawksbill turtles in the Caribbean Sea.

Our knowledge of many aspects of the biology of several species of sea turtles is very limited, and nothing is known of their feeding habits, food preferences and the effect of these on growth-rate. For example, we know next to nothing on the biology of ridley turtle, *Lepidochelys olivacea olivacea*. To remedy this situation, a detailed programme to study the biology of the ridley turtle in captivity was initiated by the Department of Fisheries of Thailand at Phuket Marine Biological Center in 1972. The main objectives of this programme were to study the food preferences of this species and their effects on growth-rate in captivity, when fed with different types of food, both separately and in proportional mixtures. It is hoped that an increase in our knowledge of the biology of this species may help us to approach the complex problem of its conservation in nature more objectively and to explore the feasibility of setting up a sea turtle farm in Thailand in the near future.

II. MATERIALS AND METHODS

(a) REARING

Hatchlings of the ridley turtle used in these experiments were procured from one of the concessionaires in Phuket Province on February 2, 1972 and January 25, 1973. In each instance, the baby turtles were transported to the laboratory on the second day after hatching. Few preliminary experiments on artificial rearing were carried

out during the first year, in which 100 baby turtles were raised in 200 × 100 × 80 cm. size, polyethylene aquaria and fed daily with small cut pieces of fish for six months. Forty strong turtles from this batch were used for growth studies. In 1973, 96 healthy hatchlings were directly used for the experiments without preliminary keeping.

Two types of saltwater aquaria were used in these studies: Cylindrical glass aquaria of 10 and 20 litre capacities and rectangular glass aquaria of 30 and 70 litre capacities. In addition, much larger cement tanks of about 2 cubic meter capacity were used for holding adult turtles for experiments not reported here. In all instances, only one turtle was kept in each aquarium. The seawater in the experimental aquaria and tanks was changed once a day to remove leftover food. The physical and chemical conditions of the seawater in the aquaria and their hourly changes are shown in Table 1.

(b) FEEDING EXPERIMENTS

Live plankton, algae and several types of plants and meats were used as food for the feeding experiments as follows:

1. Live plankton: Fresh samples of plankton were collected every day from the pierhead in front of the Center using a small plankton net of 55 μ mesh size. This was used only to feed new hatchlings.

2. Algae: Green alga, *Enteromorpha intestinalis* (L.) Link growing in the seawater outlet channel behind the laboratory were used.

3. Plants: The shore plant, *Ipomoea pes-caprae* (L.) growing at the beach around the Center compound and the turtle grass, *Thalassia testudinum* (Banks ex König) growing at depths of approximately 2 meters near the low-water mark in Makam Bay and Chalong Bay were used.

4. Marine meat: Four types of marine meat, all procured from the local market, were used for feeding.

Table 1. Physical and chemical conditions of seawater in the aquaria.

	Salinity ‰		Dissolved O ₂ ml/l		pH	
	Average	Range	Average	Range	Average	Range
Running seawater in aquaria	32.00	32.16-31.17	3.98	4.71-2.84	8.16	8.20-8.11
Stagnant seawater in aquaria with food						
(at the beginning of the experiment)	32.35	32.75-32.14	2.60	2.72-2.49	7.61	7.69-7.51
" (at the end of 1st. hour)	-	-	2.06	2.19-1.96	-	-
" (at the end of 2nd. hour)	-	-	1.55	1.57-1.54	-	-
" (at the end of 3rd. hour)	-	-	1.15	1.26-1.04	-	-
" (at the end of 4th. hour)	-	-	0.77	0.88-0.65	-	-
" (at the end of 5th. hour)	-	-	0.33	0.41-0.24	-	-
" (at the end of 6th. hour)	32.34	32.72-32.16	0.01	0.02-0	7.58	7.68-7.46
" (at the end of 12th. hour)	32.00	32.30-32.03	0	0-0	7.45	7.69-7.32
" (at the end of 24 hours)	32.16	32.43-31.50	0	0-0	7.38	7.49-7.32

- a. Oysters (*Ostrea* spp.);
- b. Cockles (*Anadara* sp.);
- c. Small shrimps (*Metapenaeopsis* sp.); and
- d. Trash fish (mixture of small fish of no economic value).

No experiments on feeding were conducted using live animals as food. The plants were cut into small pieces of not larger than 5 mm, and the meat was chopped into small bits to feed newly-hatched turtles. Three-to-six months-old baby turtles were fed with cut food particles of not larger than 10 mm. size, while older turtles were fed with larger food pieces (up to 30 mm. size). The animals were fed regularly every day at 9.00 A.M. and the quantity of food left over removed at 3.00 P.M.

The food fed and the quantity left over were weighed to an accuracy of 0.1 g.

In all feeding experiments, except where otherwise stated, the weight of each type of food given was ten percent of the average weight of the experimental turtles.

(c) GROWTH INCREMENT STUDIES

All specimens used in these experiments were weighed every week and the length increment was recorded every month. Carapace length, measured in a longitudinal straight line along the centre of the back with the help of vernier calipers, was taken as the standard unit of length and only this measurement is discussed in this paper. The general trend in the weight and length increments between the various measurements is taken as an index of growth in the discussion part of this paper.

(d) EXPERIMENTS ON FOOD SELECTION

In this experiment, the turtles were fed on a mixed diet consisting of the various food items mentioned in (b) 4., except live plankton and cockles, and the food selection was studied. Two batches of turtles of different age-groups, the first consisting of new hatchlings and the second of one-year-old turtles, were used in these experiments. Feeding and measurements were carried out in the same manner as mentioned in (b) and (c). These experiments were started on February 23, 1973 and concluded on July 30, 1973.

(e) EXPERIMENTS ON THE EFFECT OF DIET ON GROWTH INCREMENT

Four types of experiments were conducted to study the effect of various types of diet on growth rate of turtles of 3 different age-groups.

In the first experiments, each batch of turtles was exclusively fed on one type of food only and the growth increment measured. Forty new hatchlings were used in this experiment. They were grouped into four batches. These batches were daily fed separately with fishes, shrimps, oysters or mixed meats (a combination of these meats) respectively, the mode of feeding otherwise remaining the same. This experiment was conducted over a period of 6 months beginning from January 26, 1973.

The same experiment was repeated on another batch of 40 specimens of 6 month-old turtles. These were subdivided into 5 batches and were daily fed separately with fishes, shrimps, cockles, squids or mixed meats (a combination of these meats) each batch getting only one type of food as in the previous case. The experiment started on August 20, 1972 and was concluded on December 15, 1972, a period of four months.

In the third experiment, four one-year-old turtles were fed exclusively on a fish diet, but the quantity of food varied for each one, each turtle getting an amount of food equal to 10, 20,

30 and 50% of its body-weight respectively. This experiment was conducted over a period of six months, beginning from January 20, 1973. The growth increment in each instance was measured periodically.

The fourth experiment was carried out to study the effect of a vegetarian diet on the growth of turtles belonging to different age-groups. Thirty-two new hatchlings and 18 one-year-old young turtles in seven batches were used for this study. They were daily fed in the usual manner as follows:

Hatchlings.

- Batch 1 — Only plankton
- Batch 2 — Only *Ipomoea* (10 g.)
- Batch 3 — Only turtle grass (10 g.)
- Batch 4 — Mixture of *Ipomoea* and turtle grass (10 g. each)

1-year-old turtles.

- Batch 1 — Only *Ipomoea* (30-50 g.)
- Batch 2 — Only turtle grass (30-50 g.)
- Batch 3 — Mixture of *Ipomoea* and turtle grass (30-50 g. each)

For each batch, the mortality-rate and growth increment were periodically recorded. The experiment lasted over a period of five months from February 23, 1973.

III. RESULTS

(a) FOOD PREFERENCES

The results of the experiments on food selection carried out on turtles of two different age-groups show a very similar trend in food preferences. Hatchlings preferred oyster meat to all other types of meat diet (total consumption of 744.9 g. of meat/individual over a period of 158 days) followed in the order of preference by fish (699.2 g./individual) and shrimps (503.2 g./individual). All the three types of plant food were consumed only in negligible quantities when compared with the meat diet, the best preference being shown for turtle grass (141.3 g./individual) over the other two plants (Table 2).

Table 2. Quantity of various types of food consumed by new hatchlings when fed with mixed diet.*

Type of diet	Fish	Shrimp	Oyster	Green alga	Turtle grass	Shore plant
Total quantity consumed during the experiment (g.)	699.2	503.2	744.9	63.5	141.3	78.2
Percentage of total food	31.35%	22.56%	33.40%	2.85%	6.33%	3.51%

* Period of observation: February 23 to July 30, 1973.

Table 3. Growth increments of new hatchlings when fed with mixed diet.*

Length (cm.)			Weight (g.)			Total No. of turtles	No. of turtles died	% Mortality
Initial	Final	Average Increment	Initial	Final	Average Increment			
4.72	10.58	5.86	34.4	276.0	241.6	12	3	25%

* Period of observation: February 23 to July 30, 1973.

Table 4. Quantity of various types of food consumed by one-year-old turtles when fed with mixed diet.*

Type of diet	Fish	Shrimp	Oyster	Green alga	Turtle grass	Shore plant
Total quantity consumed during the experiment (g.)	12,847	11,018	20,930	-	1,066	940
Percentage of total food	27.45%	23.54%	44.72%	-	2.28%	2.01%

* Period of observation: February 23 to July 30, 1973.

Table 5. Growth increment of one-year-old turtles when fed with mixed diet.*

Length (cm.)			Weight (g.)			Total No. of turtles	No. of turtles died	% Mortality
Initial	Final	Average Increment	Initial	Final	Average Increment			
16.82	27.65	10.83	924	5,470	4,546	9	0	0

Period of observation: February 23 to July 30, 1973.

An average total increment in length of 5.8 cm. and in weight of 241.6 g. was registered over the experimental period of 158 days (Table 3). The mortality rate was 25%. In the case of one-year-old turtles a very similar trend was recorded except that the quantity of oysters consumed (20,930 g./individual) was almost double that of

fish (12,847 g./individual), closely followed by shrimps (11,018 g./individual), while the quantity of plants consumed was again very negligible (Table 4). The average increment in length over the experimental period (158 days) was 10.83 cm. and 4,546 g. in weight. No mortality was recorded (Table 5).

Table 6. Growth increment and mortality of new hatchlings when fed separately with different types of meat-diet.*

Type of meat-diet	Average food consumed g./turtle	Length (cm.)			Weight (g.)			Total no. of turtles	No. of turtles died	% Mortality
		Initial	Final	Average Increment	Initial	Final	Average Increment			
Fish	1,030	4.15	9.68	5.53	27.4	206	178.6	10	-	-
Shrimp	1,489	4.03	11.03	7.06	27.4	325	297.5	10	6	60
Oyster	2,540	4.08	12.32	8.24	28.2	416.7	388.5	10	4	40
Mixed	1,253	5.00	10.39	5.39	38.7	258.1	219.4	12	-	-

* Period of observation: January 26 to July 30, 1973.

Table 7. Growth increment and mortality of 6 month-old turtles when fed separately with different types of meat-diet.*

Type of meat diet	Average food consumed g./turtles	Length (cm.)			Weight (g.)			Total no. of turtles	No. of turtles died	% Mortality
		Initial	Final	Average Increment	Initial	Final	Average Increment			
Fish	11,454	11.44	20.30	8.86	324.4	1,757.5	1,433.1	8	-	-
Shrimp	8,565	12.55	17.91	5.36	403.7	1,222.5	818.9	8	-	-
Cockle	19,254	12.27	21.46	9.19	400.5	2,097.5	1,697.0	8	-	-
Squid	5,145	13.19	14.15	0.96	460.2	625.0	164.8	8	-	-
Mixed	11,037	11.82	20.31	8.49	352.0	1,857.5	1,505.5	8	-	-

* Period of observation: August 20 to December 15, 1972.

(b) EFFECT OF DIET ON GROWTH INCREMENT

The results of experiments conducted on the effect of various types of diet on growth increment are shown in Tables 6 to 11. When fed exclusively on various types of single diet, hatchlings fed on oyster meat consumed the largest quantity of meat in terms of weight (2,540 g./individual), which was about double the amount of food taken when fed on shrimps (1,489 g./individual), combination of meats (1,253 g./individual) or fishes (1,030 g./individual) as shown in Table 6. The oyster-fed individuals also showed the best growth increment both in terms of length and weight over the others (Plate I). However, there is some disparity if we look for the growth effects of fish and a combination of meats as diet are compared. More combination of meats is consumed than fish alone in terms

of weight. The weight increment shows a direct correlation with this. But, length increment is better in the case of fish-fed individuals.

A 100% survival was recorded in the case of specimens fed with mixed meat and fish. The mortality rate in shrimp and oyster-fed specimens was 60 and 40% respectively.

The same experiment repeated on 6-month-old turtles yielded similar results as regards the quantity of food consumed. In terms of weight, the maximum amount of food eaten was cockles, followed in the order of preference by fishes, mixed meat, shrimps and squids (Table 7). But the trend in growth pattern shows a clear-cut deviation from the previous case. The best growth increment was shown by cockle-fed individuals, followed by mixed meat, fishes,

Table 8. Growth increment and mortality of new hatchlings when fed with plankton, shore plants and turtle-grass.*

Type of diet	Weight (g.)			Total no. of turtles	No. of turtles died	% Mortality
	Initial	Final	Average Increment			
Plankton	31.0	24.5	-6.5	6	6	100
Green alga	26.7	21.3	-5.4	6	6	100
Shore plant	26.7	21.3	-5.3	6	6	100
Turtle grass	28.8	22.0	-6.8	10	10	100
Mixture of above plants	24.3	28.3	-6.0	10	10	100

* Period of observation: February 23 to March 20, 1973.

Table 9. Growth increment and mortality of one-year-old turtles when fed with shore plants and turtle-grass.*

Type of diet	Weight (g.)			Total no. of turtles	No. of turtles died	% Mortality
	Initial	Final	Average Increment			
Shore plant	3,413.3	2,525.0	-888.3	6	6	100
Turtle grass	2,693.3	2,041.7	-651.6	6	6	100
Mixture of above plants	3,294.0	2,510.0	-784.0	6	6	100

* Period of observation: February 23, to July 21, 1973.

shrimps and squids. But the differences in growth increment in the first three cases was much less significant and almost negligible, if we consider the vast differences in the amount of food consumed (almost double the quantity of cockles than that of fish and mixed meat). This indicates that the combination of meats and fish alone in fact show a much better food-conversion efficiency, although the turtle might prefer cockles as food. Again a disparity is seen when we compare the growth increments of animals fed on fish and mixed meat as exclusive diets. More fish is eaten than mixed meat and this is reflected in the greater length increment in the fish-fed specimens. But the weight increment shows an exactly opposite trend. No mortality was recorded during these experiments.

The results of experiments conducted with purely vegetarian diet show that neither the hatchlings nor the one-year-old turtles could not

survive long on exclusively plant diet (Table 8 and 9).

IV. DISCUSSION AND CONCLUSIONS

The new turtle hatchling normally does not eat any external food during the first one to two weeks after hatching. It survives by absorbing the reserve food from the yolk which is still attached to the umbilical cord and is sufficient for at least a week. All the baby turtles which do not start to eat external food during the first three weeks of their life could not survive and invariably died within four to six weeks. Such hatchling mortality was estimated to be about 4%. Penyapol (1957) reported that starving green turtle hatchlings do not survive beyond 12 days (in captivity). But we do not know how far such mortality from starvation could be held to be true for the open sea.

We have no idea whatsoever about the natural food of baby turtles in the open sea during the first few critical months. *Anonym.* (1972) reported that Australian green turtles are carnivorous in food habit in the early stages, but shift to a predominantly vegetarian diet after about one year. However, *Harrisson* (1955) concluded from experimental feeding that Sarawak green turtles survive on a diet consisting exclusively of fish and/or prawns and not on vegetable matter during the first three years of their lives. *Caldwell* (1960) reported that the leatherback turtles seem to be omnivorous as far as known, while the loggerhead and hawksbill turtles show a preference for meat food. But it is not clear when they become carnivorous in their life or whether they are capable of existence on an exclusively vegetarian diet if given no other choice.

The feeding experiments on new hatchlings using live planktonic larvae, turtle grass and shore plants as food indicate that the ridley turtle could not survive long on this diet. A negligible amount of plant food was accepted, but the animals invariably died within a period of 35 days. The one-year-old turtles also refused to accept plant food and died after a period of 150 days following an actual decrease in body-weight during this period. If offered a choice, both the new hatchlings and one-year-old turtles showed a very clear preference for marine meat over all types of vegetable food, the clearest individual preference being for oysters. The percentage of such preference was 33.4% in the case of new hatchlings and 44.7% for one-year-old young turtles. In addition, it is seen that when fed individually on the various types of meat-diet separately, the quantity of mollusc meat (oyster or cockle) consumed in terms of weight is at least double that of all other types of meat-food. The experiments also clearly show that the ridley turtle never feeds on vegetable diet either just after hatching or after one year of life, and does not show a shift in food habit to the vegetarian diet after one year as in the case of Australian green turtles.

The experiments clearly show that the ridley turtles in captivity are carnivorous and show a definite food preference for marine meat like molluscs, crustaceans and fish, molluscs being their highest preference. *Carr* (1969) observed that the ridley turtles of Costa Rica are inclined towards shrimp as food. According to *Harrisson* (1955), the Sarawak green turtles also prefer shrimps for food. Food preferences of turtles vary considerably from species to species and perhaps also from area to area for the same species. But much research is yet to be done on the food habits of most of the sea turtle species.

The growth increment studies indicated that the growth-rate of new turtle hatchlings is very slow for the first six months. The best growth increment is shown when hatchlings are fed with a molluscan diet (an average increase of 388.5 g. in weight and 8.24 cm. in length during 6 months), followed in decreasing order by crustaceans, mixed meat and fish.

The growth-rate shows an increase after six months and again the molluscan diet (cockles) shows the best growth increment (an increase of 1,697 g. in weight and 9.19 cm. in length during 4 months), followed by a combination of meats, fish or crustaceans. But the growth-rates in the first three cases were almost the same and were about twice that of the turtles fed with shrimps and squids. The amount of cockles eaten during this period was twice that of fish or a combination of meats. This trend indicates that a combination of meats and fish alone in fact show a much better food-conversion efficiency than molluscs. The growth-rate studies further indicated that a maximum increment of 16,210 g. in weight and 38.7 cm. in length occurs in 18 months of growth (the turtle was fed on fish). The average increment for all animals fed on a meat diet for the same period of time was 9,232 g. in weight and 32.0 cm. in length.

The mortality rate of the new hatchlings in captivity was high during the first six months (33.3%), after which it was seen to drop considerably. *Harrisson* (1956) reported a similar

Table 10. Growth-rate and mortality of the ridley turtles in captivity during the first one-and-a-half years after hatching.

Age	Diet consumed g./day	Length (cm.)		Weight (g.)		Total no. of turtles	No. of turtles died	% Mortality
		Average	Increment	Average	Increment			
4 days	-	4.33	-	18.8	-	21	-	-
1 week	Little	4.31	-0.02	20.0	1.2	21	-	-
3 weeks	Little	4.03	-0.28	27.8	7.8	21	-	-
1 month	3.2	-	-	36.1	8.3	21	-	-
2 months	6.1	6.34	2.31	59.2	23.1	24	1	4.2
3 "	7.9	7.02	0.68	97.7	38.5	23	1	4.4
4 "	8.7	8.62	1.60	157.2	59.5	22	4	18.2
5 "	10.7	9.20	0.58	197.2	40.0	18	2	12.2
6 "	14.0	10.02	0.82	247.5	50.3	16	2	11.1
7 "	25.0	11.04	1.02	287.4	39.9	10	-	-
8 "	58.0	12.34	1.30	408.7	121.3	20	-	-
9 "	80.0	14.36	2.02	644.3	235.6	20	-	-
10 "	90.0	15.91	1.55	922.5	278.2	20	-	-
11 "	95.0	17.57	1.66	1,243.0	321.0	20	-	-
12 "	100.0	18.77	1.20	1,512.0	268.5	20	-	-
13 "	108.0	20.10	1.33	1,799.0	287.0	20	-	-
14 "	115.0	22.62	2.52	2,617.0	818.0	20	-	-
15 "	134.0	23.53	0.91	2,908.0	291.0	13	-	-
16 "	152.0	26.97	3.44	4,458.0	1,550.0	13	-	-
17 "	180.0	-	-	6,042.0	1,584.0	13	-	-
18 "	225.0	32.02	6.05	9,232.0	3,190.0	13	-	-

trend for green turtle in Sarawak, but the mortality rate there was a little higher (40%). The aquarium conditions also seem to influence the mortality rate of baby turtles. For example, the baby turtles kept in running seawater were seen to have a greater survival rate than those kept in stagnant seawater. Those kept in stagnant seawater were also sometimes seen to develop a fungal eye disease, which was also observed by Harrisson (1956) in the green turtles. The survival rate of new hatchlings is, at any rate, very much higher than what is to be expected in nature where the maximum mortality is caused by predators. The survival rate of the green turtle hatchlings in nature has been estimated to be about 1% (Anonym., 1972). In some places, baby turtles are also caught and eaten by natives.

Therefore, from the point of view of conservation alone, artificial rearing of hatchlings would make a positive contribution towards replenishing the depleting natural populations.

It is here considered appropriate to dedicate our thoughts at this stage, on the basis of the present status of our knowledge of the turtle populations of this area and the demand from the commercial side, to the feasibility of setting up a turtle farm in Thailand in the near future. The time is ripe to think about this possibility in view of the emergency created by the constant reports in recent times on the alarming depletion in the turtle populations in Thai waters, and also in consideration of the overall aspects of the conservation of these species. The Australian sea turtle farm for *Chelonia mydas* has recently

Table 11. Growth increment and mortality of one-year-old turtles when fed with fish diet.*

Average food eaten g./turtle	Length (cm.)			Weight (g.)			Total no. of turtles	No. of turtles died	% Mortality
	Initial	Final	Average Increment	Initial	Final	Average Increment			
43,949	21.88	36.38	14.50	2,200	12,993	10,993	4	-	-

* Period of observation: January 20 to July 21, 1973.

met with great success on a commercial scale (Anonym., 1972). The possibility of cultivating three species of sea turtles should be actively considered for Thai waters: the green turtle, hawksbill turtle and ridley turtle. The green turtle provides the most delicious meat for human consumption, in addition to providing shell, leather and turtle oil. The flesh of the hawksbill turtle is of inferior quality for consumption, but this species is the best source of commercial tortoise shell. The leather and flesh of the ridley turtles is also in demand. The eggs of all species are commercially valuable, although one should note that we know next to nothing on the egg-laying behavior of sea turtles in captivity.

In the case of ridley turtles, mixed meat would be the best food for rearing hatchlings during the first six months and would always be in sufficient supply. Although the above-mentioned experiments show that molluscs, oysters and cockles, show a better growth increment, they should be left out of consideration for practical and economic reasons, because firstly they are costly and secondly they may not always be available in sufficient quantities. In addition, the mortality rate would be higher from this diet. After they are six months old the young turtles may be fed with trash fish which would always be available in sufficient quantity and is comparatively very cheap. Here also the molluscs are not considered for the same reasons as above, but in this case, the fish diet shows almost the same growth-rate.

For turtles older than one year, the daily food requirement would be about 225 kg. of trash fish/1,000 turtles. This would cost

between 110-235 Bht. on the basis of present local market trends in Phuket. The estimated total weight of food required to rear one turtle up to the marketable size (which would take about 2-2½ year) is 150 kgs of fish, a total maximum expense of 225 Bht. per turtle. This would weight about 25 kg, at least 60% of which would be edible flesh.

In addition to the commercial benefits, the artificial rearing of these species of turtles would solve the problem of their conservation in Thai waters in the most practical manner. In the case of those species which might not be commercially cultivated, the possibility of holding the new hatchlings in captivity during the crucial first year should be given serious consideration. As already explained, the survival rate of baby turtles is far better in captivity than in nature, during this crucial stage. Helping the baby turtles to survive this critical period by rearing them in captivity for one year and afterwards releasing them in the sea, should help considerably to replenish the depleting populations of all species of turtles in this area and also help towards their natural conservation.

V. SUMMARY

1. A research programme on rearing, feeding habits, food preference and growth-rate of the ridley turtle, *Lepidochelys olivacea olivacea* along the west coast of Thailand was started in 1972 and the effect on growth-rate of several types of meat-and vegetable-diet when fed singly and in proportional mixtures was measured by conducting experiments in the laboratory.

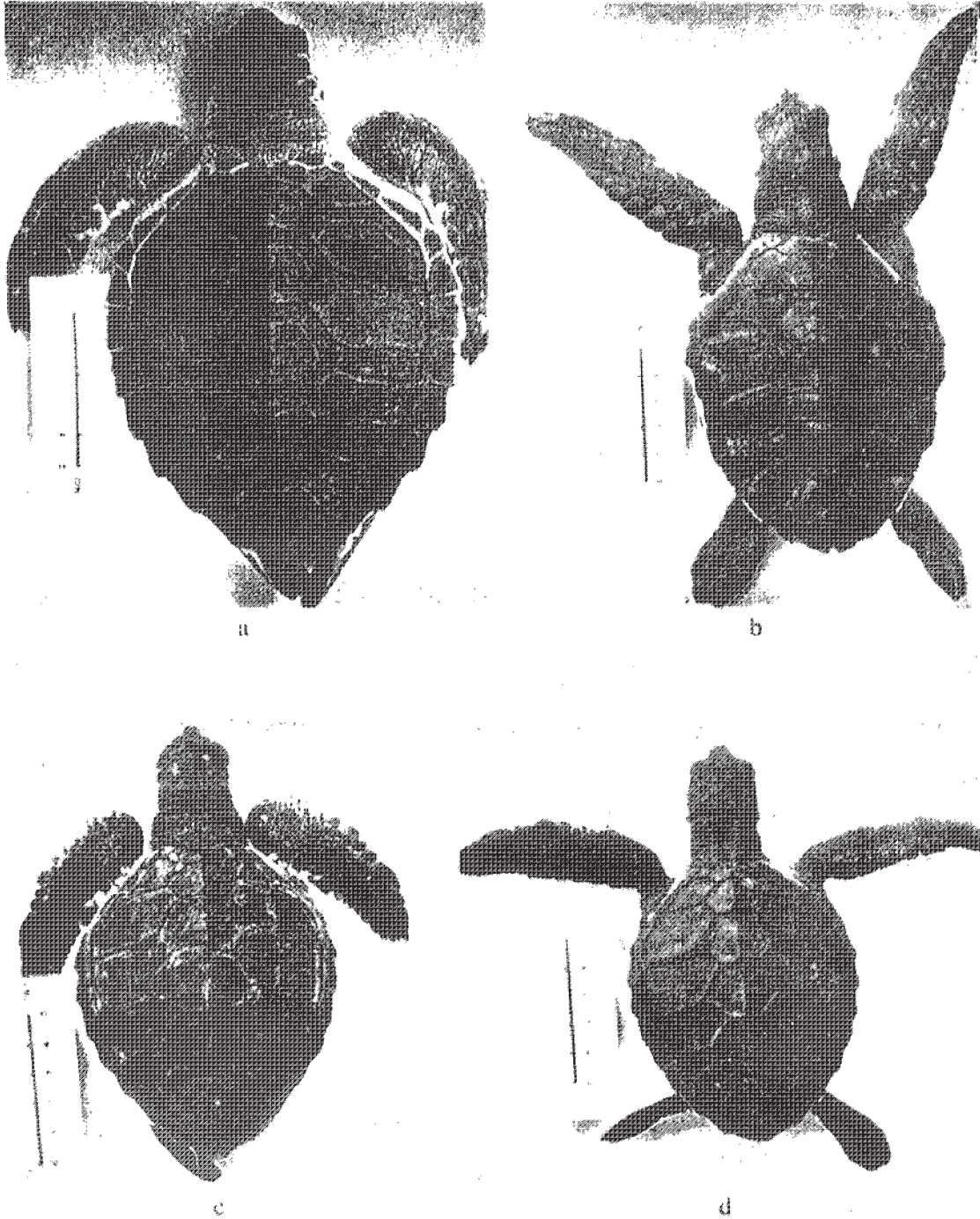
2. Food selection and preference experiments showed that, when fed on a mixed diet, all age-groups showed a preference for meat-diet over vegetable-diet, molluscs (oysters and cockles) being the most preferred single diet.
3. When fed on a single diet, new hatchlings accepted oysters best followed by shrimps, mixed meat and fish in that order. 6-months-old turtles accepted cockles most, followed by mixed meat, fish, shrimp and squids.
4. The amount of most-accepted food (molluscs) eaten was about twice that of all other types of meat diet.
5. New hatchlings showed a very slow growth-rate for the first 6 months, after which the rate increased.
6. The best growth-rate is shown by individuals on a molluscan diet. Fish and mixed meat-diet also showed an equally good growth-rate in 6-month-old individuals.
7. Mortality-rates of various age-groups were compared. New hatchlings (in captivity) showed a 33.3% mortality rate during the first 6 months, which later decreased. Mortality-rates of individuals on various diets were compared. All animals on a vegetable diet died.
8. Feasibility of setting up a turtle farm in Thailand is discussed.

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PLATE I



Six months old turtles fed on various diets: (a) oysters, (b) shrimps, (c) mixed meats, (d) fishes.