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FOOD INTAKE AND CONVERSION IN HATCHLINGS OF OLIVE RIDLEY *LEPIDOCHELYS OLIVACEA* FED ANIMAL AND PLANT FOOD

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ABSTRACT

Effect of starvation, onset of feeding after emergence, food preference, food intake, absorption and conversion have been studied in hatchlings of olive ridley, *Lepidochelys olivacea*, fed clam meat (*Meretrix casta*), sea grass (*Hallophila* sp.) and a combination of both, reared individually and in groups. The hatchlings started feeding only on the 6th day after emergence eventhough they had free access to both animal and plant food. Absorption efficiency in terms of calories and protein was higher than that for dry matter in both animal and plant fed hatchlings. Conversion efficiency (K_1) was maximum in *ad libitum* clam fed hatchlings viz., 23.15 ± 2.54% (dry matter); 25.13 ± 0.24% (calories) and 26.38 ± 1.52% (protein). The hatchlings converted calories and protein more efficiently than dry matter of food. Metabolic rate of the hatchlings was also calculated using food intake-conversion values. Survival rates of hatchlings starved from the time of emergence were also estimated. The study indicated that olive ridley hatchlings are obligatory carnivores and may not have the 'digestive climate' to utilize plant food exclusively. Size hierarchy effects observed in the course of group rearing has also been discussed in detail.

INTRODUCTION

Information on food intake and conversion efficiency in hatchlings of sea turtles is extremely scarce (McVey, 1972). In the recovery programme for olive ridley currently being undertaken by the Central Marine Fisheries Research Institute at Kovalam, Madras, a study on this aspect was taken up. The objective of the study was to find out the onset of feeding after emergence, food preference of hatchlings when they start feeding and food conversion efficiency. Needless to say, studies of this nature may have some inherent drawbacks such as (*a*) that the hatchling is not in its natural environment where, in the course of its vigorous swimming movements, it could seek its food or encounter it at the right time to sustain life, (*b*) the quality of food given is an experimental feed and not an item of its natural food, (*c*) stress due to impairment of metabolic activity and other functions while in captivity and (*d*) group or individual rearing being atypical as compared to hatchligs feeding in nature.

Nevertheless, in benign research, it is essential to find out the general food preference of the hatchlings when they first start feeding; whether the intake preference is of plant or animal origin; and whether they are able to survive and show good growth on selected feeds. The young olive ridley is reported to be carnivorous while the adults are predominantly herbivorous, consuming algae and animals such as crustaceans, bivalves, echinoderms and coelenterates (Deraniyagala, 1939, Carr 1952). The present work was undertaken to study the pattern of energy utilization in hatchlings of olive ridley.

In addition, food intake-conversion estimates are considered better parameters for assessing metabolic rates (Kinne, 1960). According to Pandian and Vivekanandan (1976) this kind of assessment provide (1) less restricted maintenance condition during feeding experiments; (2) the possibility of repeatedly observing one and the same individual over a period of time; (3) the possibilities of measuring the effect of quantitative feeding on metabolism (Paloheimo and Dickie, 1966 a, b); and (4) the possibility of measuring total metabolism including the energy expended on part or total anaerobiosis (Blazka 1958, Kutty 1968, 1972). The matabolic rate of *L. olivacea* hatchlings has also been estimated here using food conversion values.

Our findings also throw light on the establishment of size hierarchy in cases where rearing in groups was undertaken.

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Material and Methods

For individual rearing, the hatchlings of *L. olivacea* were collected from a single clutch transferred to the turtle hatchery of the Central Marine Fisheries Research Institute at Kovalam, Madras.

Initial trials were carried out to find out the time of onset of feeding after the hatchlings emerge from the nest. The hatchlings, with a fair amount of unutilized yolk as energy reserve, did not consume any food, animal or plant matter, until the 6th day after emergence. Hence the feeding experiments were started on the 6th day after emergence.

Thirty healthy individuals were selected, 24 of which were equally divided into 4 groups and reared individually in separate plastic troughs of 10 litre capacity and the rest taken for intial chemical analysis. The first group was starved while the II, III and IV groups were fed respectively on meat of clam (*Meretrix casta*), sea grass (*Hallophilla* sp.) and a combination of both these. Thus six replicates were run for each of the four groups. Groups II to IV were fed *ad libitum* on their respective diets. In the IV group it was observed that the hatchlings consumed maximum quantity of clam meat and almost ignored the sea grass. Hence after the 15th day of the commencement of feeding, clam meat was restricted to approximately 5% of live body weight of the hatchlings in this group and sea grass was given *ad libitum*.

The turtles were fed once a day at 1000 hrs and feed remains and faeces were removed by siphoning and pipetting at 1600 hrs. After removing leftovers and excreta, water was changed completely with filtered sea water. For starved groups also water was changed simultaneously. Faeces were removed again on subsequent day morning before feeding. and were collected in No. 21 bolting silk, washed with minimum quantity of distilled water and then transferred to petridish. The loss of some constituents due to leaching cannot be ruled out. Faeces for the whole experiment was collected in the same petri dish which was stored in an electric oven at 60°C. Feed remains were also dried in an oven at 60°C for 24 hrs and the weight was subtracted from the total amount offered. To find out slight decrease in weight in clam meat and sea grass during feeding period weighed samples were placed in an aquarium and collected after 6 hrs and dried for 24 hrs at 60°C. Based on this, appropriate corrections were applied to the quantity of food consumed by the animal. Sea grass was washed thoroughly before feeding to remove associated animal matter, if any, att ched to it. Clam meat was chopped and fed while sea grass was given in small tufts.

Salinity of sea water varied between 32-35‰ and the water temperature was 27.8 ± 1.7°C throughout the experimental period which lasted 61 days for individual rearing and to 63 days for group rearing.

Chemical analyses were performed on material dried to constant weight at 60°C. The entire dry material was minced and ground to fine powder and dried again for an hour before packing in airtight bottles. It was then stored in desiccator. Aliquotes were taken from such samples to determine caloric value and protein.

Caloric content was determined by Parr Oxygen bomb calorimeter (Parr Instrument company, Technical manual, 120) and protein by modified Biuret method (*see* Sumitra Vijayaraghavan and Vijayakumaran, 1976). Since consumption of food (C), production (P) and faeces (F) are measured it is possible to estimate the rate at which the turtle metabolised and released energy or respiratory metabolism (M) i.e., $M = C - (P + F)$ (*see* Petrusewicz and MacFadyen 1970). Metabolism is expressed in terms of oxygen uptake (ml O_2/g/live weight/hr), considering the expense of 4.8 cal as equivalent to 1 ml of O_2 uptake (Engelmann 1966). For want of data on quantities of ammonia, urea and other soluble excreta produced, for calculation of metabolic rate, a 10% reduction was made in the absorbed food as the correction factor for finfish (Solomon and Brafield 1972, Pandian and Vivekanandan 1976) and this is taken as a measure since there is no data on sea turtles.

Experimental design adopted was the 'Sacrifice method' of Maynard and Loosli (1962). Absorption efficiency was estimated by relating the quantity of food absorbed (food consumed—faeces) to the quantity of food consumed. Conversion efficiencies K_1 and K_2 were estimated relating the growth of the animal to the quantity of food consumed and absorbed, respectively Pandian 1967).

Another experiment was conducted simultaneously to study the effect of quantity and quality of food, clam meat and sea grass, on group rearing of turtle hatchlings. Three batches of twenty numbers each of 6 days old hatchlings were reared in three 4' dia. polythene liner tanks containing 400 litres of sea water. Hatchlings in each tank were from different clutches. The clam meat was given in plastic trays just below the surface and the sea grass was tied in tufts and floated on the surface. One group was fed *ad libitum* with clam meat once daily in the morning. To the second group a restricted ration of 5.26 % body weight clam meat was fed and to the third group 3.4 % body weight clam meat plus *ad libitum* sea grass was given. Feed remains were removed in the evening and the entire water was changed thereafter.

RESULTS

Hatchlings survived on yolk material for the first 5 days and did not accept the food offered. During this period the live weight increased from 17.45 ± 1.53 g on the day of emergence to 18.13 ± 1.65 g. on 6th day. The water, protein and caloric content did not vary significantly during the 5 days of non-feeding(Table 1).

The turtles consumed 16.39 ± 1.64 mg/g live wt/day of dry food when fed *ad libitum* on clam but only 1.37 ± 0.21 mg/g live wt/day when sea grass was given *ad libitum*. On mixed food the feeding rate was 14.43 ± 0.75 mg/g live wt/day/of which only 0.2 ± 0.1 mg was contributed by sea grass (Table 2). Absorption efficiency of dry matter of food ranged from 87.85 ± 8.04 % for plant food to 99.56 ± 0.23 % for clam fed *ad libitum*. Conversion rate was maximum being 3.75 ± 0.30 mg/g live wt/day on clam fed *ad libitum*. The mixed food gave a conversion rate of 2.88 ± 0.28 mg/g live wt/day. Interestingly the loss of weight in sea grass fed turtle (—3.03 ± 0.64 mg) was more than that in the starved ones (—2.74 ± 0.40 mg/g live wt/day) and a possible explanation is given elsewhere in this account.

When calculated in terms of calories and proteins, rates of feeding, absorption and conversion and efficiencies of absorption and conversion followed a similar pattern (Tables 3 and 4) as was observed in the case calculation on dry weight basis. Absorption efficiency (%) did not vary much among the groups when calculated in terms of calories or protein but the efficiency of dry matter absorption was significantly low in the group fed with sea grass (87.85 %; t = 3.226;

TABLE 1. *Body weight, composition of water, protein and energy in the newly emerged and 6th day hatchlings of* L. olivacea ; *each value represents average of* 4 (*for chemical analysis*) *and* 25 (*for initial body weight*) *individuals* ; ± *indicates SD*

	Live weight (a) (g)	Dry weight (g)	% Water	Protein % in dry weight	Energy K. cal/g dry weight
Newly emerged hatchling ..	17.45 ± 1.53	4.40 ± 0.39	74.78 ± 3.25	51.9 ± 2.41	5.86 ± 0.13
6th day hatchling ..	18.13 ± 1.65	4.52 ± 0.41	75.12 ± 1.56	55.0 ± 2.04	5.73 ± 0.21

TABLE 2. *Rates and efficiencies of feeding, absorption and conversion (on dry weight basis) in hatchlings of* L. olivacea *offered animal and plant food ; each value represents average of* 5–6 *individuals ;* ± *represents SD.*

Parameter	Starved hatchling	Clam fed hatchling	Seagrass fed hatchling	Clam + sea grass fed hatchling
Feeding rate (mg/g live body weight/day) ..		16.39 ± 1.64	1.37 ± 0.21	14.43 ± 0.75 Clam: 14.23 ± 0.73 Sea grass : 0.2 ± 0.1
Absorption rate (mg/g live body weight/day) ..		16.29 ± 1.65	1.20 ± 0.18	14.34 ± 0.74
Absorption efficiency (%) ..		99.56 ± 0.23	87.85 ± 8.04	99.41 ± 0.20
Conversion rate (mg/g live body weight/day) ..	—2.74 ± 0.40	3.75 ± 0.30	—3.03 ± 0.64	2.88 ± 0.28
Conversion efficiency K_1 (%) ..		22.98 ± 2.52		20.71 ± 1.28
Conversion efficiency K_2 (%) ..		23.15 ± 2.54		20.83 ± 1.29
Conversion factor ..		4.39 ± 0.43		4.84 ± 0.30

p < 0.05) compared to the clam fed group. Conversion efficiency (K_2) also was significantly more in both clam fed and mixed food fed groups when calculated in terms of calories and protein compared to the same values for dry matter.

Sea grass fed turtles spent 1.7 cal/g live wt/day more than the starved ones for the exercise of feeding and digestion. In terms of O_2 consumption also the sea grass fed group spent more energy (0.176 ml O_2/g live wt/hr) than the starved ones. The metabolic rates of clam fed and mixed food fed groups were 0.419 and 0.379 ml O_2/g live wt/hr respectively.

Final body composition of water, protein and calories are given in Table 5. Percentage of water and protein content did not show any difference among the 4 groups. Energy value (K.cal/g dry weight), however, reduced from 5.73 in 6 days old hatchling to 5.08 in *ad libitum* clam fed turtle and to 4.48 in starved turtles. The reduction was maximum in starved turtles.

Group rearing

Mean increase in total live weight per individual, conversion rate and conversion efficiency (K_1) in terms of dry weight for the groups fed on clam meat and sea grass are given in Table 6. At a feeding rate of 13.67 mg/g live wt/day (which is equivalent to 5.26% live weight) K_1 was maximum (20.56%). This is comparable to the value obtained in the individual rearing (20.71%) on mixed food where feeding rate was 14.34 mg/g live wt/day. In the *ad libitum* clam fed group the feeding rate was considerably higher 20.53 mg/g live wt/day than in individual rearing (16.39 mg) but the conversion efficiency was very much reduced (16.07% compared to 22.98% in the former group). Lowest conversion efficiency (15.10%) in group rearing was recorded in the group fed lowest ration (feeding rate 9.47 mg equivalent to 3.6% live body weight). Survival was 100% on *ad libitum* feeding and 70% and 65% respectively for other groups fed 5.26% live weight per day and 3.6% live weight per day.

One of the most striking observations made on hatchlings reared together under laboratory conditions is the increasing range of size (Table 7 and figure 1) with advancing age. The coefficient of variation (cv) which was 6.32% in the 6 day old hatchling, increased to 32.40%, 34.60% and 19.16% in clam fed *ad libitum*, clam restricted (5.25% of body weight) ; and clam (3.4% of body weight) and sea grass (*ad libitum*) fed hatchlings respectively after 63 days.

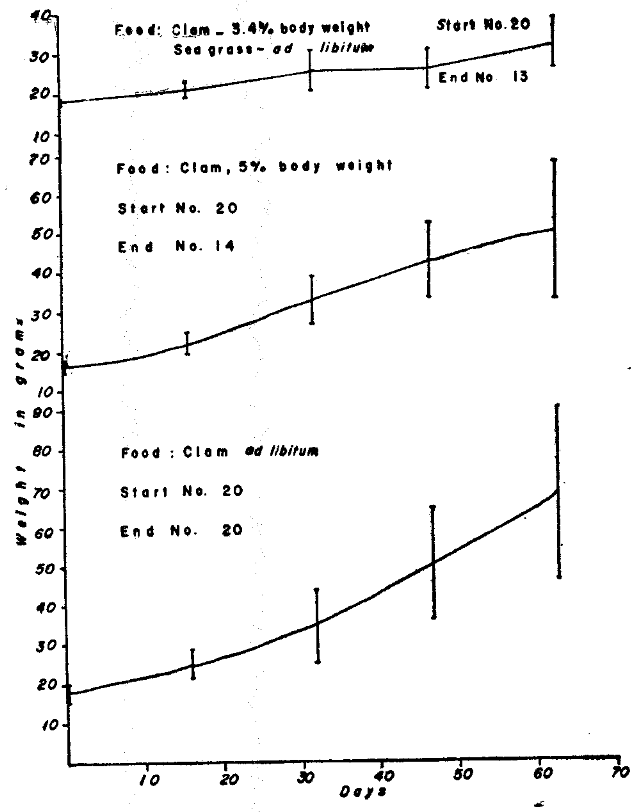

Fig. 1. Increase in weight in hatchlings of olive ridley *L. olivacea* reared in groups of 20 and fed with different quantities of clam meat and sea grass.

DISCUSSION

During emergence *L. olivacea* hatchlings retain considerable quantum of yolk energy (16.0% initial yolk wet weight ; 25.9% of dry weight and 26.2% in terms of calories) for post emergence utilization. This forms 17.2% of live weight (or 33.9% of dry weight ; 34.8% of calories) of emerging turtles (Silas *et al.*, 1984). The initial 5 day non-feeding period may be a crucial stage for adjustment and orientati on to the new environment. The first instinct of newly emerged *L. olivacea* is probably to reach the right type of habitat and it does not bother about feeding even if food is available in plenty. This is evident from the present study where hatchlings started feeding only on the 6th day or after eventhough they had free access to both animal and plant food. During this period the hatchling survives on the yolk reserves and it utilizes about 40% of this reserve by the time it starts feeding (Silas *et al.*, 1984). Eventhough the young ones are not consuming food up to the 6th day after hatching, live weight increases. The increase in live weight is not entirely due to water absorption alone since there is only modest increase in per cent water content in the animal. The increase in dry

TABLE 3. *Rate and efficiencies of feeding, absorption and conversion (on the basis of caloric content) in hatchlings of* L. olivacea *fed animal and plant food; each value represents average of 5-6 individuals; ± represents SD.*

Parameter	Starved hatchling	Clam fed hatchling	Sea grass fed hatchling	Clam + Sea grass fed hatchling
Feeding rate (cal/g live body weight/day) ..		74.5 ± 4.4	3.5 ± 2.1	65.0 ± 3.3 Calm: 64.6±3.4 Sea grass: 0.5 ± 0.3
Absorption rate (cal/g live body weight/day) ..		74.4 ± 7.4	3.35 ± 0.2	64.9 ± 3.3
Absorption efficiency (%) ..		99.88 ± 0.05	95.84 ± 2.72	99.90 ± 0.02
Conversion rate (mg/g live body weight/day) ..	—15.2 ± 2.2	18.7 ± 1.8	—17.2 ± 3.6	14.8 ± 0.5
Conversion efficiency K_1 (%) ..		25.06 ± 1.46		22.75 ± 1.55
Conversion efficiency K_2 (%) ..		25.13 ± 0.24		22.80 ± 0.02
Conversion factor ..		4.10 ± 0.15		4.41 ± 0.30
Metabolic rate (ml O_2/g live body weight/hr) ..	0.135	0.419	0.176	0.379

TABLE 4. *Rates and efficiencies of feeding, absorption and conversion in terms of protein in hatchlings of* L. olivaceae *fed animal and plant food, each value represents average of 5-6 individuals; ± represents SD*

Parameter	Starved hatchling	Clam fed hatchling	Sea grass fed hatchling	Clam + Sea grass fed hatchling
Feeding rate (mg/g live body weight/day) ..		8.87 ± 0.88	0.29 ± 0.17	7.73 ± 0.39 Clam: 7.69 ± 0.39 Sea grass: 0.04 ± 0.02
Absorption rate (mg/g live body weight/day) ..		8.86 ± 0.88	0.28 ± 0.16	7.68 ± 0.38
Absorption efficiency (%) ..		99.95 ± 0.02	96.78 ± 2.13	99.3 ± 0.51
Conversion rate (mg/g live body weight/day) ..	—1.5 ± 0.22	2.33 ± 0.16	—1.67 ± 0.35	1.94 ± 0.07
Conversion efficiency K_1 (%) ..		26.37 ± 1.52		25.11 ± 1.57
Conversion efficiency K_2 (%) ..		26.38 ± 1.52		25.26 ± 0.38
Conversion factor ..		3.80 ± 0.21		3.99 ± 0.25

TABLE 5. *Initial and final weights and body composition values of hatchlings of* L. olivacea *starved and fed on animal and plant food, for 61 days; each value represents average of 4-6 individuals; ± represents SD*

	Initial	Starved hatchling	Clam fed hatchling	Sea grass fed hatchling	Clam + Sea grass fed hatchling
Initial weight (g) ..		17.79 ± 1.34	18.96 ± 1.65	18.44 ± 1.71	16.76 ± 1.17
Final weight (g) ..		15.78 ± 1.34	123.04 ± 19.15	15.60 ± 2.42	80.66 ± 3.49
Water (%) ..	75.12 ± 1.56	82.83 ± 1.76	82.62 ± 0.66	82.82 ± 1.12	83.2 ± 1.05
Protein (%) ..	55.0 ± 2.04	64.90 ± 5.96	63.90 ± 5.49	65.25 ± 3.5	65.00 ± 4.05
Energy (K. cal/g) ..	5.73 ± 0.21	4.48 ± 0.15	5.08 ± 0.15	4.66 ± 0.1	4.96 ± 0.09

TABLE 6. *Feeding and conversion rates and conversion efficiencies (K_2) of hatchling of* L. olivacea *reared in groups of 20 individuals on different quantities of animal and plant food*

Treatment	Initial weight (g)	Final weight (g)	Increase in weight (g)	Food consumed mg/g live body wt/day	Conversion rate mg/g live body wt/day	K_2	% survival
CLAM (*ad libitum*)	.. 17.02 ± 1.82	67.83 ± 21.88	50.81	20.53	3.30	16.07	100
CV (%)	10.26	32.40					
CLAM (Restricted ration)	.. 16.56 ± 0.89	50.37 ± 17.43	33.81	13.67	2.81	20.56	70
CV(%)	5.37	34.60					
CLAM (Restricted) + (seagrass *ad libitum*)	.. 18.36 ± 6.10	31.58 ± 6.05	13.22	9.47	1.43	15.10	65
CV(%)	3.32	19.16					

CV — Coefficient of variation.

TABLE 7. *Mean increase in live weight and percentage of survival in hatchling of* L. olivacea, *reared in groups of 20 on different quantities of animal and plant food*

Food	Initial weight (g)	16th day weight (g)	32nd day weight (g)	47th day weight (g)	63rd day weight (g)	No of turtles (initial)	No. of turtles (final)	% survival
CLAM (*ad libitum*)	17.02 ± 1.82	24.72 ± 3.64	34.35 ± 9.05	49.79 ± 14.09	67.83 ± 21.88	20	20	100
CV(%)	10.26	14.72	26.35	28.30	32.40			
CLAM (Restricted)	16.56 ± 0.89	21.74 ± 2.67	32.89 ± 5.94	43.05 ± 6.69	50.37 ± 17.43	20	14	70
CV(%)	5.37	12.28	18.06	22.51	34,60			
CLAM (Restricted) + SEAGRASS (*ad libitum*)	18.36 ± 0.61	20.79 ± 1.99	25.34 ± 4.81	25.60 ± 4.81	31.58 ± 6.05	20	13	65
CV(%)	3.32	9.57	18.98	18.79	19.16			

CV — Coefficient of variation.

weight may be due to the absorption of minerals from the medium. Increase in protein content from 5.91% to 55.0% and the reduction in caloric value 5.86 K cal/g dry weight to 5.73 is explained by the loss of yolk which contains about 33% lipid (Silas *et al*., 1984).

As the turtle commences feeding it predominantly consumes carnivorous food and later switches over to predominantly herbivorous diets (Mahmoud and Klicka 1979). Carr (1967) reported that young green turtle must be pelagic relying on floating or close to surface food including small vertebrates. When the turtle reaches 4.5 kg they begin making transition to grazing. These observations lead one to believe that the food preference of the young turtle is influenced greatly by the availability of food in the habitat and that the turtles develop structural adpatations to feed particular type of food after certain age. The present study reveals that given an option of plant and animal food the young *L. olivacea* opted for the animal food. The young turtles may be obligatory carnivores and may not have the mechanism to utilize plant food. It will be a worthwhile study to find out at what stage of growth cellulose digestion is possible. Menzel (1959) and Mathavan *et al* (1976) have reported that certain herbivorous/omnivorous fishes do not possess the ' digestive climate ' necessary for the' true growth ' (Gerking 1952), when they are excluslively fed on plant material and a complement of animal food is necessary for ' true growth '. The young turtles also may not have the ' climate ' to digest the plant material, which is evident from the low absorption efficiency exhibited by the animal when fed exclusively on sea grass. However, a detailed study on secretion of digestive enzymes and presence of microflora in the gut of young and adult turtles is necessary.

It is interesting to note that the metabolic rate of young turtle fed on plant material was high compared to those starved, the reason being the plant fed group expended 1.7 cal/g live wt/day in the process of feeding and digestion of the plant material.

Conversion efficiency (K_2) increased with increase in consumption. The efficiency was maximum when clam meat was given *ad libitum*. Conversion efficiencies recorded for mixed food is essentially that of clam since the amount of sea grass ingested was negligible. *L. olivacea* hatchlings could convert calories and protein more efficiently than dry matter in both mixed food and *ad libitum* clam feed. Maximum utilization, however, was that of protein.

The starved hatchlings could survive upto 36.83 ± 3.54 days while those fed only sea grass survived for 39.60 ± 1.0 days.

In the light of the present study it may be interesting to see whether the conversion efficiency in individual versus those showing accelerated growth in groups could be compared for understanding social behaviour. The establishment of size hierarchy effects in group rearing may be due to direct competition for food or by social interaction as observed by Jobling (1982) in fish and reviewed by Marion Harles (1979) in turtles. In the case of hatchlings of *L. olivacea*, size hierarchies have developed even in the presence of excess food. Group rearing therefore poses many problems as observed in this study. Briefly enumerated they are :

1. Any rationing of food for minimum maintenance requirements may lead to infighting and cannibalism or severe injuries leading to ulceration and infection.
2. In group rearing intensive competition for getting at the food and aggressive behaviour of biting by those which are not able to reach the food may result in injuries even when food is given in excess. But we have not observed cannibalism in such cases.
3. We do not know whether the presence of larger individuals in the groups could inhibit the food consumption in some resulting in their slow growth.

Research of this nature give us an indicative idea of the food preference and utilization in hatchlings once they start feeding activity on their own, despite being also sustained on part of the reserve yolk. This information is useful since, in nature, we have a large gap in our knowledge as to what is happening to the hatchlings once they enter the sea. The olive ridley hatchlings seem to evince a distinct preference for food of animal origin. Such information becomes useful if at a later stage we are to think of turtle mariculture.

We note that the hatchlings can survive on starvation for periods upto or beyond 30 days. In the natural environment it is unlikely that the animal would survive that long. However, the capacity for prolonged starvation could be a built in mechanism for reaching the growout and feeding grounds.

Aggregation in some of the sea turtle is characteristically seen at the time of emergence of hatchlings, and at the time of mating and nesting. Little is known about group behaviour in feeding grounds. Group rearing of olive ridley has clearly shown size heirarchy occuring. This is again indicative that such attempts should be made with optimum numbers in given volume of water or area to minimise or prevent hierarchy. This is a point which may have to be noted in turtle mariculture.

We would urge more research on hatchlings, particularly the first few months of their life in the sea. The transition from carnivorous to omnivorous/herbivorous diet also needs further study.

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