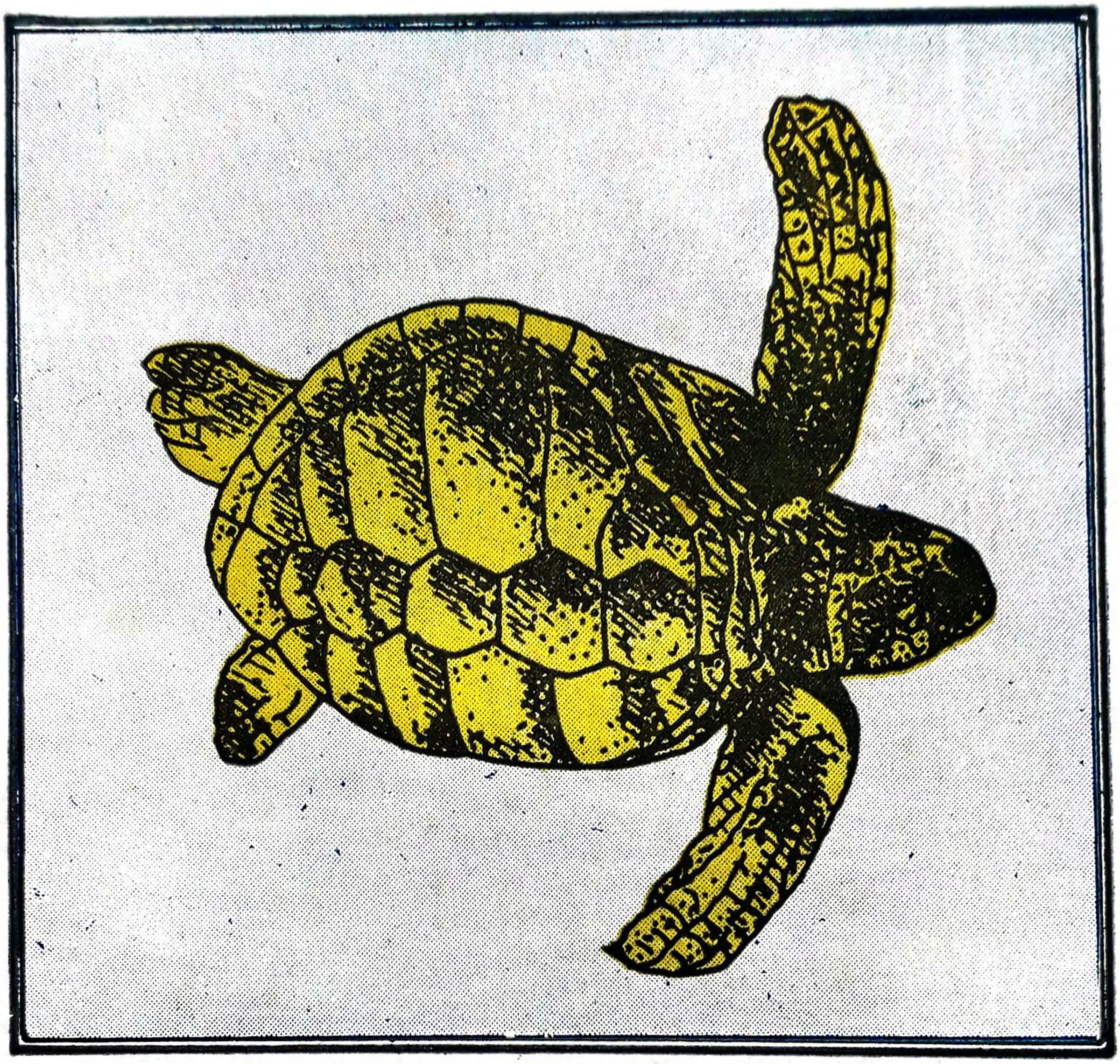
PRANIKEE



A STUDY OF ECOLOGY, BREEDING PATTERNS, DEVELOPMENT AND KARYOTYPE PATTERNS OF THE OLIVE RIDLEY, *LEPIDOCHELYS OLIVACEA* OF GAHIRMATHA, ORISSA

Volume - IX

PRANIKEE

A STUDY OF ECOLOGY, BREEDING PATTERNS, DEVELOPMENT AND KARYOTYPE PATTERNS OF THE OLIVE RIDLEY, *LEPIDOCHELYS OLIVACEA* OF GAHIRMATHA, ORISSA

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B. K. Behura
Editor

PREFACE

Turtles have always been important animals in Indian folklore and mythology. The most famous of all is the " Kurma Avatara " or " Turtle incarnation " of Lord Vishnu. According to this story, in the continuing struggle between the Gods and the Demons to rule the earth, there was an agreement to churn the ocean in order to obtain the " nectar " for immortality. Whichever group obtained the nectar would become immortal and invincible and would rule the earth. The " Mandara Mountain " was the churning stone, the king of snakes " Basuki " was the rope for churning. The Gods held the tail and the Demons the head of Basuki. As the churning started, "Mandara Mountain " began to sink. To save the situation, Lord Visnnu assumed the form of a giant sea turtle, the Kurma and supported the mountain on his back and thus prevented it from sinking. Eventually the nectar emerged and became the property of Gods who eventually ruled on the earth.

Thus, as one of the incarnations of Vishnu, turtles have been revered in Indian culture. In Orissa, people do not eat turtle meat and therefore, they are well protected. But, sea turtles and their eggs used to be exploited for Calcutta market until the early 1970's until they we declared as protected species. Gahirmatha, Orissa has now become famous as the largest rookery of olive ridley turtles. We had the opportunity to work in this area and this volume is a compilation of our work.

The Late Prime Minister Shrimati Indira Gandhi was very much concerned about our environment and took a personal interest in the protection of turtles in Orissa. When she learnt about our work she had sent instructions that all possible help should be provided to us. We are indebted to her for her encouragement. The then Chief Minister of Orissa, Shri J. B. Patnaik also took a personal interest in our work and provided us with all possible help, called several high level meetings and provided funds to us to ensure continued protection of the turtles. We express our gratitude to him.

My colleagues Dr. S. P. Bhunya and Dr. B. C. Guru have been associated in this work. The research team included Dr. S. K. Dutta, Dr. Jyotsnabala Kanungo, Dr. Maheswar Behera and Mr. Dolagobihda Dey. It was due to their team efforts that we could obtain valuable information on different aspects of this important population.

Professor Marie T. Dimond, Professor Emeritus, Trinty College, Washington first drew my attention to the necessity of this work for the conservation of this endangered species. She has generously provided expertise during her trips to this department. I express my sincere gratitude to her.

I would like to thank the Ministry of Environment, Government of India, New Delhi for the grant (No. 14011/5/84-EG-7-ER) and Department of Forests, Govt. of Orissa (WL (A) 7/89-6238, dated 18.11.1989) for the grant which made this study possible.

I would like to extend my thanks to officials of the Forest Department for their interest and help in this study. During the course of this work many people have provided help directly and indirectly, I thank themall.

I hope this volume will be useful to the turtle lovers of this world.

(P. Mohanty-Hejmadi)

INTRODUCTION

Sea turtles have drawn considerable attention in recent years for their vulnerability and the fact that all the five species, namely the leatherback *Dermochelys coriacea*, the hawksbill *Eretmochelys imbricata*, the green turtle *Chelonia mydas*, the olive ridley *Lepidochelys olivacea* and loggerhead *Caretta caretta* were given protection in September 1977 as an amendment to the schedules to the Indian Wildlife (Protection) Act (1972).

Sea turtle populations have decreased all over the world due to human consumption of eggs in large numbers, predation on eggs and hatchlings by non-human predators, poaching of adults for meat and other products, and disruption and alteration of nesting beaches.

Out of the five species of sea turtles, in recent years considerable attention has been paid to the olive ridley which used to be the most numerous of the turtles and used to be widely distributed in the tropical coastal waters of Pacific, South Atlantic and Indian Oceans. In India, they nest in the east as well as along the west coast. The large mass nesting beaches in the Cuttack district of Orissa, especially the rookery at Gahirmatha, host the largest aggregation of olive ridleys in the world. Traditionally, adult olive ridleys were caught throughout the coastal belt in Orissa for commercial purposes. A major portion was taken to Calcutta market as Oriyas do not eat turtle meat due to the high respect given to " Kurm avatara " one of the incarnations of Vishnu in the form of a tortoise in Hindu mythology; but in Bengal it is quite popular. During the nesting season in the past, the forest department of Orissa was issuing licences for the collection of eggs at the rate of Rs. 15/-per boat load of eggs containg roughly between 35,000 to 1,00,000 eggs upto 1975 when the sorrounding area of Bhitar Kanika was declared a wildlife sanctuary. Thereafter, complete protection has been given to the nesting females and their eggs.

A recovery programme at a modest scale has been started by the Forest Department of Government of Orissa since 1975 and a research station has been set up at Gahirmatha. Under a grant from the department of Environment under the Eastern Ghat Project; the current work was started in November 1985 to study the ecology, breeding patterns, development and karyotype patterns of the olive ridley, *Lepidochelys olivacea*. This is the first such comprehensive study at Gahirmatha, the largest rookery of olive ridleys. In addition, laboratory studies have been undertaken to hatch the eggs under controlled conditions, to manipulate sex differentiation and raise the hatchlings under controlled conditions to develop husbandry methods for "turtle farming".

The data collected from 1985 to 1989 are presented here with the hope that it will be a source of information for the workers on turtles as well as for the public.

1. IDENTITY

1.1. *Nomenclature* :

Valid name—*Lepidochelys olivacea* (Eschscholtz, 1829)
Common names :—

Olive Ridley (Preferred English)
Tortuga golfina (Spanish)
Pacific Ridley
Warana (Surinam)
Tortue Olivatra (French Guiana)
Xibirro (Brazil)
Samudrik Katha (Bengali)
Gadha Kachua (Hindi)
Pul amai/Sith amai/ Kadal amai(Tamil)
Samudram thabelu (Telugu)
Samudra Kachhima/Chilakainchaa (Oriya)

1.2. *Taxonomy* :

Phylum—Chordata
Subphylum—Vertebrata
Super class—Tetrapoda

Class—Reptilia
Sub-class—Anapsida
Order—Chelonia
Sub-order—Cryptodira
Super family—Chelonioidea
Family—Cheloniidae
Sub-family—Carettini
Genus—*Lepidochelys*

Synonymy of Genus

Lepidochelys—L. Fitzinger, 1843
Cephalochelys—J. E. Gray, 1873
Colopchelys—S. W. Garman, 1881.

1.3. *External Morphology and Coloration*

Adult

1) Five to nine lateral scutes (usually 6-8)
2) Four inframarginal pores
3) Color—Carapace : dark olive green
Plastron : yellow
4) Two pairs of prefrontal scales on head
5) One claw in each flipper (adults)

Hatchlings

Color—Dark grey or black both above and below.

1.4. *Size*

Adults

1. Carapace length (straight) upto 80 cm
2. Head upto 13 cm wide
3. Weight—upto 60 kg

Hatchlings

1. Carapace length up to 4 cms.
2. Weight upto 17 gms.

1.5. *Cytomorphology* :

Chromosome analysis from the spleen cells of a sea turtle *Lepidochelys olivacea* (0) has been done for the first time (Bhunya and

Mohanty-Hejmadi, 1986). Cytological slides were prepared from the spleen cells of the male hatchlings (5-20 days old). The hatchlings were sacrificed 4 hours after treatment with colchicin (400 mg/kg b. w.) following the usual air drying schedule. Morphometric analysis of the chromosomes was done in accordance with Levan *et al.*, (1961) and Bhunya and Sultana (1979).

Thorough examination of metaphase plates revealed the chromosome number to be 2n=56 with 12 pairs of macrochromosomes of which 6 pairs are m-type, 1 pair Sm-type, 1 pair St-type, 4 pairs t-type and the remaining 16 pairs are acrocentric microchromosomes (Table 1) Sex chromosomes could not be discerned.

Table 1. *Morphological data of the Karyotype of L. olivacea*

Chromo-some number	Absolute length in μm	Relative length (% TCL)	Centromeric index	Type
1	7.22	10.7	43.3	m
2	6.11	8.7	12.8	m
3	4.62	7.0	21.6	st
4	3.76	5.7	26.4	sm
5	3.61	5.4	—	t
6	3.50	5.3	42.8	m
7	3.27	4.9	—	t
8	3.00	4.5	50.0	m
9	3.00	4.5	50.0	m
10	2.27	4.2	46.0	m
11	2.50	3.8	—	t
12	2.22	3.3	—	t
⋮				
28	1.00	1.5	—	t

Including the present one, four cheloniid species have been cytologically worked out so far and the diploid number has been reported to be 58 in *Caretta caretta* (Nakamura, 1949) and 56 in *Chelonia japonica* (Makino, 1952), *C. mydas* (Waddell and Siegel, 1965) and *L. olivacea*. It is apparent that probably numerical changes of chromosomes did not play much of a role in species differentiation in chelonia. The existence of sex chromosomal heteromorphism in chelonia is a controversial issue (Ogama 1937, Nakamuri, 1947, Bickham *et al.* 1983). The male karyotype of *L. olivacea* in the present study did not reveal any heteromorphic pair. However, no conclusion can be drawn until female karyotype is studied On comparision of the karyotype of *L. olivacea* with confamilial species as well as species of other families under order chelonia, a good degree of resemblance is evident in the first three pairs of chromosomes. Such a type of karyotypic conservatism among chelonian species has also been pointed out by Takagi and Sasaki (1974). The present result also reinforces the theory of karyotype conservation in chelonia.

2. DISTRIBUTION

Although commonly referred to as the Pacific ridley, the olive ridley is not exclusively found in the Pacific Ocean. It can also be found in the Atlantic and Indian Oceans. This species prefers warmer latitudes and remains in the tropical and subtropical regions. Some of the nesting grounds of the olive ridley in the world are given in Table 2.

Nestings occur throughout the year at Gahirmatha with a variation of the number from 1 to 10. This shows the presence of these turtles in the Indian Ocean throughout the year. However, mass nesting (Arribada) usually occurs two times in a nesting season from late December to April (Kar, 1984 and the present study).

3. BIONOMICS AND LIFE HISTORY

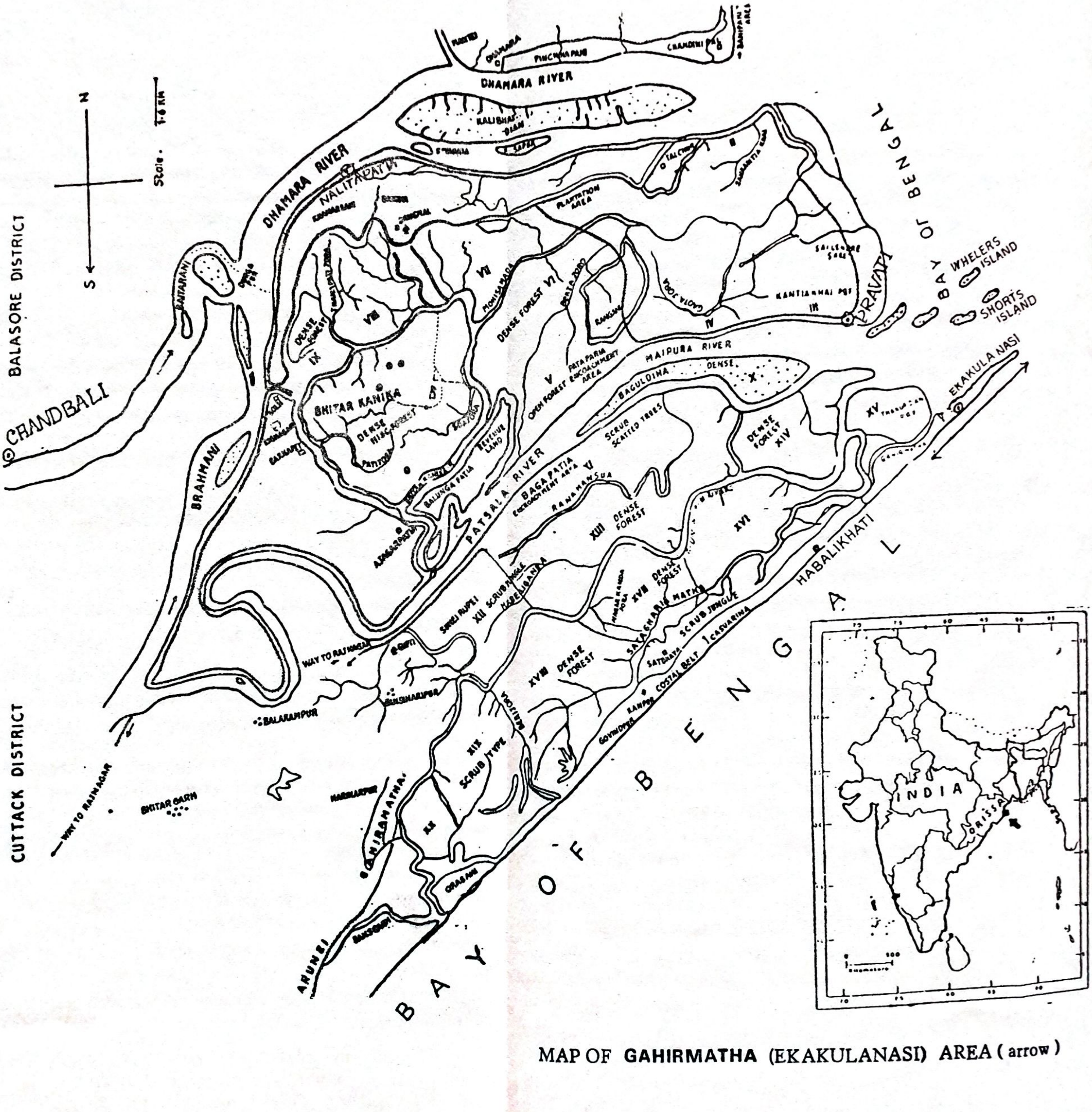
3.1. *Sexuality* : Olive ridleys are heterosexual with sexual dimorphism being evident in adults. Adult males have a long, thick tail that extends well beyond the posterior margin of the carapace, long heavy claws pointed downward and a plastron comparatively smaller. Adult females have a short tail that does not extend beyond the hind margin of the carapace, and claws are parallel to the long axis of the foreflipper.

Table 2. *Nesting ground of L. olivacea*

Name of the Country	Name of the Breeding ground	Approximate no. of arrival each year.
Mexico	Jalisco	20,000 — 50,000
Mexico	Baja Peninsula	1,000 — 10,000
Mexico	Sinaloa	10,000 — 1,00,000
Mexico	Colima	1,000 — 10,000
Mexico	Michoaca'n	10,000 — 20,000
Mexico	Guerrero	10,000 — 20,000
Mexico	Oaxaca	20,000 — 50,000
Colombia	West Coast	—
Costa Rica	Playa Nancite	—
Srilanka	Southwest section	—
Ecuador	Guayaquil Monta	10,000 — 1,00,000
Pakistan	Hawks Bay & Sandpit	1.000 — 2,000
Malaysia	East Coast	—
India	Orissa (Gahirmatha)	5,000 — 3.00,000
India	Andaman	—
India	Andhra Pradesh	—
India	West Bengal	—
India	Laccadives, Maldives	—
India	Gujrat	—
India	Maharastra	—
India	Goa	—
India	Kerala	—

Source : 1) Sea turtle hunts throughout the world, 1982. Centre for Environmental Education, Washington.

2) Whitaker, & Kar, (1984).



MAP OF **GAHIRMATHA** (EKAKULANASI) AREA (arrow)

Sexual dimorphism in hatchlings and juveniles is not discernible by external examination but only through histological examination of the gonads.

3. 2. *Breeding Ground Topography* : Gahirmatha, the largest rookery for the olive ridley sea turtle extends over an area of 11 km on the eastern coast of India on the Bay of Bengal(Fig.1). The nesting beach runs in a northeast to south-west direction. The beach is constantly changing in its topography due to silting. The 11-km beach has been subdivided into 100 meter sections and the Forest Department has put up poles at every 100 meter interval (110 poles in all). This enables identification of specific areas of this beach.

During the monsoon season the breeding site becomes completely covered with water. This causes a topographical change from year to year.

Seven kilometers of the beach starting from Habalikhati is backed by high continuous sand dunes reaching heights of 20 to 30 meters with *Casuarina, Ipomia, Spinifex* and mangrove vegetation. Three hundred meters of the vegetation with sand dunes were washed away by high tides during 1985. Due to sand deposition the beach elongated by an additional kilometer during 1985-86. After pole No. 70, the breeding ground is wider with discontinuous small sand dunes with vegetation up to the pole No. 93. From pole No. 93 to Nasi the beach is devoid of sand dunes and vegetation. It provides a wider space for breeding with the sea and the Maipura river mouth coming close to each other.

In comparison to what happened in 1985, in 1986 the breeding ground became narrow. During spring tide, the high tide covers one third of the beach. The width of the beach from the vegetation area to the high tide level during spring tide varies from 16 m to 120 m, The ground is very wide towards NASI. The turtles emerge probably due to thegentleness of the slope from pole No. 80 to pole No. 100. The Forest department cleared most of the vegetation in this area and the sand cliffs in most of the places have been flattened for smooth crawling of the turtles. The height of the beach varies from 2 to 4 m from sea level.

Out of a total stretch of 11 km, the breeding ground was mainly restricted to 1.5 km. towards NASI (the north eastern tip of the rookery). In May during the spring tide, water comes to the vegetation area and the sea connects the mouth of the river Maipura at three different places between poles 71 to 73, 84 to 85 and 107 to 108. Small water reservoirs are found at different places of the beach during low tide. A narrow canal of two meters wide and 0.95 to 1.22 m, deep was formed on 23rd May, 1986 at night during high tide between poles 107 and 108 which was also a portion of the thick mass nesting area. Several nests and hatchlings were washed away due to the strong current. The NASI end of the beach looked like a small sand dune surrounded by water during high tide.

In 1986, the total length of the breeding ground was 11.2 km from Habalikhati to Ekakula. In 1987 the NASI end was found extended for another 400 meters further due to sand deposition deep into the sea extending the total stretch of the beach to 11.6 km. Vegetation also increased on the sand dunes along the area from poles 74 to 98.

In 1989, approximately 200 meters at the northern tip of NASI area was submerged reducing the length of the breeding ground to 11.2 kms. Small but discontinuous sand dunes with vegetation were noticed from pole 98 to NASI tip during 1989. The breeding ground north to NASI tip was getting broader towards the Short's island due to deposition of silt and sand. It appears that NASI area may become continuous with this island with further deposition of silt and sand in course of time.

3. 3. *Maturity* : No reports are available about the sexual maturity of olive ridley but it is well beyond age four as sexual dimorphism was not evident in 47 month old olive ridley (Rajagopalan. 1984).

3.4. *Mating* : Mating occurs on the surface in the shallow waters adjacent to the nesting beaches. Mating occurs prior to 55 to 60 days before mass nesting. Mass mating takes place at Gahirmatha during October and November.

3.5. *Fertilization* : Fertilization is internal.

3.6. *Nesting Process* :

Beach description :—Olive ridleys generally prefer to nest on small isolated beaches. They prefer fine hard sand with sufficient moisture and avoid the vegetation area. They come in large numbers to the areas of higher elevation in comparison to the flat areas.

Sand size analysis :—Analysis of sand size at different regions of Gahirmatha rookery has been done before the commencement of mass nesting by the test seives of different mesh numbers of 18, 30 and 44. The areas selected for sand size analysis were in the high tide line, the vegetation area, the breeding ground facing the sand dune vegetation and the open breeding ground of northeast portion without any vegetation.

Table 3. Percentage of sand separated from different Mesh nos. of different regions of Gahirmatha.

Area	Depth of sand	Mesh no. 18	Mesh No. 30	Mesh No. 44
Hightide line	Surface	0	18.65	16.7
	15 cms	0	1.65	3.85
	30 cms	0	3.9	4.7
Vegetation area	Surface	0	0.52	0.78
	15 cms	0	0.30	0.45
	30 cms	0	0.85	1.70
Breeding ground facing vegetation	Surface	0.2	6.0	8.6
	15 cms	0.2	4.0	5.3
	30 cms	0.3	6.5	6.4
Breeding ground without any vegetation	Surface	0.8	11.5	10.0
	15 cms	0.6	15.3	14.5
	30 cms	1.2	16.5	14.8

From table 3, it is clear that the breeding ground contains larger sand grains in comparison to those of the high tide line and the vegetation area. The north-east portion of the rookery comprising of about 2.3 kilometers is devoid of any vegetation and its sand size is larger than that of the sand size of the breeding ground facing the vegetation. The sand size may hold a clue to the preference of the turtles for the north-east portion for mass nesting.

Beach and nest temperature : The temperature of the beach and the nests were recorded 4 times a day at a 6 hour interval at different depths in 1986. Both average beach and nest temperature increase in time with the increase in atmospheric temperature. However, the nest temperature is higher at times perhaps due to the metabolic heat produced by the developing eggs (Table 4). A sample of temperature recorded at 6 hour interval of the nest and beach are presented in tables 5-6.

Moisture content of the soil : The percentage of moisture content of the new beach, thick mass nesting area and thin mass nesting area was 11.3, 4.16 and 3.06 percent by weight, respectively.

Atmospheric temperature and humidity : During the whole nesting seasons from 1986 to 1989 it was recorded that the difference between the highest and the lowest atmospheric temperature for any day was between 5 to 11°C, respectively. The lowest variation (upto 5°C) was during the cooler period during January and the highest (upto 11°C) variation was during April when the days tend to be very hot. Similarly, the difference between the highest and the lowest humidity observed was 10 to 30%.

3.7. *Nesting season :* The olive ridley turtles prefer a dry season for laying their eggs. In Gahirmatha, they lay their eggs during December to April. However, it has been observed that single turtles do come to lay their eggs throughout the year. At Gahirmatha the mass nesting which is popularly known as ARRIBADA meaning "the arrival" in Spanish; occurs twice once during January to February followed by the second mass nesting, usually during March. The nesting process has been observed from 1986 to 1988.

Mass nesting in 1986 : Nesting occured from January 15th onwards. But unlike the previous years (1983 onwards since our laboratory has been involved in collecting eggs from Gahirmatha, Table 7), the number of turtles coming to nest were less in number. In general, there are two peaks in nesting. One is in January and another around March with

Table 4, Beach and Nest temperature in °C during the incubation period of second mass nesting*

Days of incub.	Depth of soil			Average	Depth of nest			Average
	15 cm	30 cm	45 cm		15 cm	30 cm	45 cm	
5	28.4	28.0	28.2	28.2	27.6	27.6	28.3	27.9
11	29.4	28,6	29.0	29.0	29.4	29.4	29.2	29.3
20	30.4	30.9	30.9	30.7	30.8	31.0	30.9	30.9
23	30.4	30.5	30.5	30.4	30.6	31.1	31.9	31.2
26	31.1	31.6	32.0	31.5	31.9	32.4	32.4	32.1
31	31.2	32.6	33.1	32.3	32.8	33.9	34.4	33.7
33	31.9	32.8	33.1	32.6	33.3	34.4	33.5	43.7
35	33.2	33.7	33.7	33.5	34.4	35.4	34.4	34.7
37	33.6	33.9	34.3	33.9	34.5	36.2	35.0	35.2
46	33.5	34.4	34.7	34.2	35.2	37.1	35.8	36.0

(Hatching)

* Nesting 16.2.1986 Hatching 10.4.1986

Table 5. Nest temperature in °C

Time	Egg surface		Middle Temp.		Bottom Temp.		Average	
	18.1.87	29.1.87	18.1.87	29.1.37	18.1.87	29.1.87	19.1.87	29.1.17
6 A.M.	25.0	23.6	24.0	24.6	24.0	25.6		
Noon	25.5	24.4	24.5	25.5	24.0	24.0	25.33	24.29
6 P.M.	26.0	25.5	25.4	25.0	25.8	25.0		
Mid night	25.0	24.0	25.4	25.3	25.8	25.0		

Table 6. Beach Temperature in °C

Time	14 cm Deep		30 cm Deep		45 cm Deep		Mean	
	18.1.87	29.187	18.1.87	29.1.87	18.1.87	29.1.87	18.1.87	29.1.87
6 A.M.	25.5	23.4	24.2	23.8	25,6	24.8		
Noon	26.0	24.3	24.6	24.0	25.6	25.0	25.49	24.97
6 P.M.	27.0	25.0	25.2	25.5	25.6	25.5		
Mid night	26.0	24.0	25.2	25.5	25.4	25.3		

sporadic nesting in between. More than 100,000 turtles nest during each peak. A remarkable feature for 1986 was the drastic drop in the number of turtles coming to nest, As presented in table 8, the number of turtles which emerged to nest is less than 100 for the period from January 15 to February 15, 1986. Out of these less than 50% laid eggs. Similarly for the period from February 15 to March 15, only 267 emerged out of which less than 50% nested.

Table 7. Yearwise Nesting figure for *L. olivacea* at Gahirmatha

Year	Total Emerged
1983	2,00,000
1984	5,00,000
1985	2,88,000
1986	48,101
1987	6,31,193

In other words, unlike that of previous years, only sporadic nesting occured from January to March 15, 1986. However, a mass nesting of 47, 760, although in a smaller scale which may be referred to as "*Mini-Arribada*", occured in the period between March 15 to April 15, 1986; out of which more than 50% nested.

In otherwords, the breeding pattern for 1986 deviated from the normal pattern from 1983 to 1985 in the absence of the first peak in mass nesting and with only *one peak in the second nesting period but with reduced numbers. Apparently the same pattern was observed in 1982.*

Table 8. Nesting of *L. olivacea* in 1986

	Total emerged	Total nested(%)
January 15 to Februrry 15	74	30 (40.54)
February 15 to March 15	267	116 (43.44)
March 15 to April 15	47,760	32,976 (69.04)
Total	48,101	33,122 (68.85)

First Mass Nesting during 1987 : The mass nesting took place on 5th January and continued upto 14th January (Table 9). It happened unexpectedly early in comparison to that in the previous years. Approximately 2, 45, 157 turtles emerged with a peak of 47,900 turtles nesting on 9th January. Mass nesting started between the poles 90 to 104 and gradually extended to Ekakula, filling the beach of around 5 kms with eggs. The following is the detailed profile.

Thick mass nesting—	Pole 85 — Pole 104
Moderate mass nesting—	Pole 72 — Pole 85
Thin mass nesting—	Pole 53 — Pole 72

Table 9. First mass nesting of *L. olivacea* 1987

Date	No. Emerged
5th January, 1987	5,000
6th January, 1987	32,605
7th January, 1937	41,329
8th January, 1987	37,943
9th January 1287	47,991
10th January, 1987	37,043
11th January, 1987	21,112
12th January, 1987	14,149
13th January, 1987	7,537
14th January,1987	448
Total :	2,45,157

Second Mass nesting during 1987 : In March, the turtles nested in record-breaking numbers, not only more than that of the first mass nesting of 1987, but also the largest number since 1976, The nesting took place from 8 to 14 March 1987. A daily account of the nesting is presented in the table 10. The second mass nesting covered a six km stretch of beach.

One of the peculiar features was that the emergence started at 1:30 PM on March 8 in bright sunlight. This is contrary to the usual behaviour of the turtles, which usually emerge to nest either after sunset or during the day with an overcast sky. The mass nesting continued until the next morning. On 9 March, the emergence started in the evening, reaching a peak at 9.30 PM, when the heach became totally covered with turtles. The mass nesting occurred in the same area where the turtles had laid eggs during the first mass nesting. The hatchlings resulting from the first mass nesting were ready to emerge when the second nesting took place. The result was that the hatchlings as well as some of the developing eggs were dug out of the sand by nesting turtless. A considerable number of hatchlings were either thrown into the air or buried in the sand due to the nesting activity of the turtles. Thus, a large number of hatchlings died due to the second mass nesting.

The number of turtles nesting reached a maximum on the third day. In the frenzy to find a nesting place, the turtles migrated further and further away from the water line and even climbed the sand dunes. What was interesting was that the turtles cut into the wire fence of the 30'x20' hatchery set up by the Wildlife Division by cutting it with their beaks. Some of them even nested there, digging out the transplanted nests, The concentration of turtles was such that 3 to 5 turtles were found digging in the same place with their backs towards the same spot. This was a comical sight. as the simultaneous digging resulted in filling of one's body pit by another. The result was that none could dig a proper nest for laying. Due to the destruction of nests resulting from the high concentration of activities, the beach became littered with broken shells and dead hatchlings.

The next day the mass nesting started a little later at 8 PM and reached a peak between 9.30 and 10.00 PM. On the 12th mass nesting started in the evening at 6.00 PM, and a little later on the 13th, with fewer turtles. The numbers decreased considerably on the 14th, when only 12 emerged to lay eggs.

In 1988, no mass nesting took place. Only 901 turtles emerged sporadically throughout the season out of which 700 were found nesting. This phenomenon had also occurred in 1982 when only 200 to 300 turtles emerged sporadically. Thus there is no predicatable profile for mass nesting and the reason for lack of mass nesting twice durlng 1982 to 1988 is difficult to explain.

In 1989, the first mass nesting took place from 14th to 22nd January with a peak of about 80,000 on 16th. Approximately, 3,00,000 females emerged during this period. But it is a matter of concern that second mass nesting which takes place in March did not take place.

Table 10. Second mass nesting of *L. olivacea* 1987

Date	Emergdd	%Nested
3 March	15,000	98.0
9 March	60,000	93.3
10 Marah	131,000	95.0
11 March	100,280	9.50
12 March	67,744	25.6
13 March	12,000	98.7
14 March	12	83.8
Total :	386,036	95.1

3.8. *Behaviour* : Olive ridleys are generally mass nesters, Arribada (Spanish word which means "arrival") is the special phenomenon observed in the olive ridley and Kemp's ridlev turtles when large number of turtles aggregate in a particular beach to lay their eggs. Generally mass emergence takes place two hours after and before the high tide. Nesting takes place at night but some turtles were observed nesting in bright day light just before the commencement of 2nd mass nesting during 1987. The total process starting from emergence to return after laying lasts for about 1.30 to 2 hrs. (Table 11).

Emergence from Sea : Before emergence out of water, the turtle waits a while, lifts her head up and then crawls out. The turtle presses her muzzle against the sand throughout her crawl to the nest site. They change their direction or may return when they are disturbed by light or other animals.

Table 11. Observations during nesting in *L. olivacea*

Time (in minutes)

No. of observations	Distance of nest to HTL* / Water in meters	No. of attempts for digging the pit	Attempts for laying total clutch	Clutch size	No. of beats for compacting the nest	CCL in cms	Emergence to nest site	Digging pit	Laying eggs	Filling the pit	Return to water	Total time (emergence to return to water)
1	45/65	85	105	182	92	73.5	15	22	31	14	8	90
2	63.5/68.5	95	98	143	48	69.5	20	15	24	24	17	100
3	30/54	88	102	152	132	72	20	18	22	14	17	91
4	80/100	100	92	95	152	72.5	13	47	17	15	14	106
5	54/66	96	98	132	43	74	15	23	26	14	15	93
6	20/45	109	62	126	70	70	5	20	16	16	5	62
7	34/42	93	83	121	72	73	37	33	22	14	8	114
8	28/33	109	119	153	52	76	35	22	28	15	8	108

* High tide line

Selection of nest site : The crawl for site selection is not in a straight line. It moves in a zigzag manner to find a suitable place for nesting. Some of the turtles were observed crossing a distance of about 300 to 400 meters to select a nest site. They always prefer a high place for digging. During mass nesting when thousands of turtles come to the same place, the choice for a good site is not available due to competition among themselves. Some of them even come to the vegetation area and try to clear the area to nest

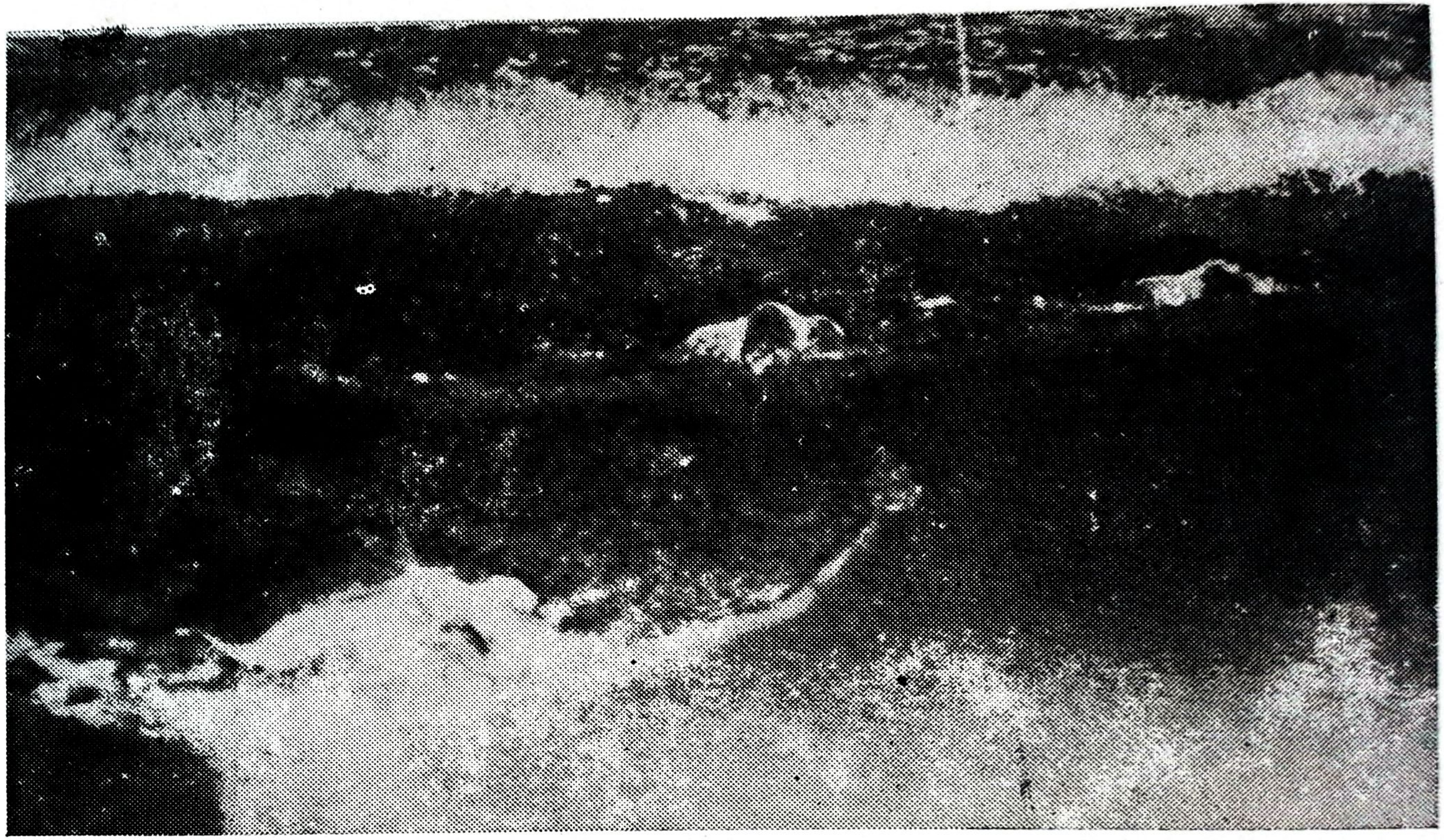
Clearing the nest site : Once the nest site is selected, the turtle moves around sweeping the sand by its fore flippers. With the hind flippers working in an alternating rhythm with the front flippers, she makes a shallow pit of 10 to 15 cm before digging the nest proper.

Excavation of Egg Cavity : After 3 to 5 minutes of nest site preparation, the fore flippers stop and the hind flippers begin to scoop out the egg pit. The hind flippers continue to work alternately to dig the pit which may be oval, flask shaped or cylindrical. It presses the edge of flipper, scoops out the sand and throws the sand laterally away from the shell and then rests Then the other flipper snaps forward throwing the sand from the pit to the front and the side, and then repeats the process.

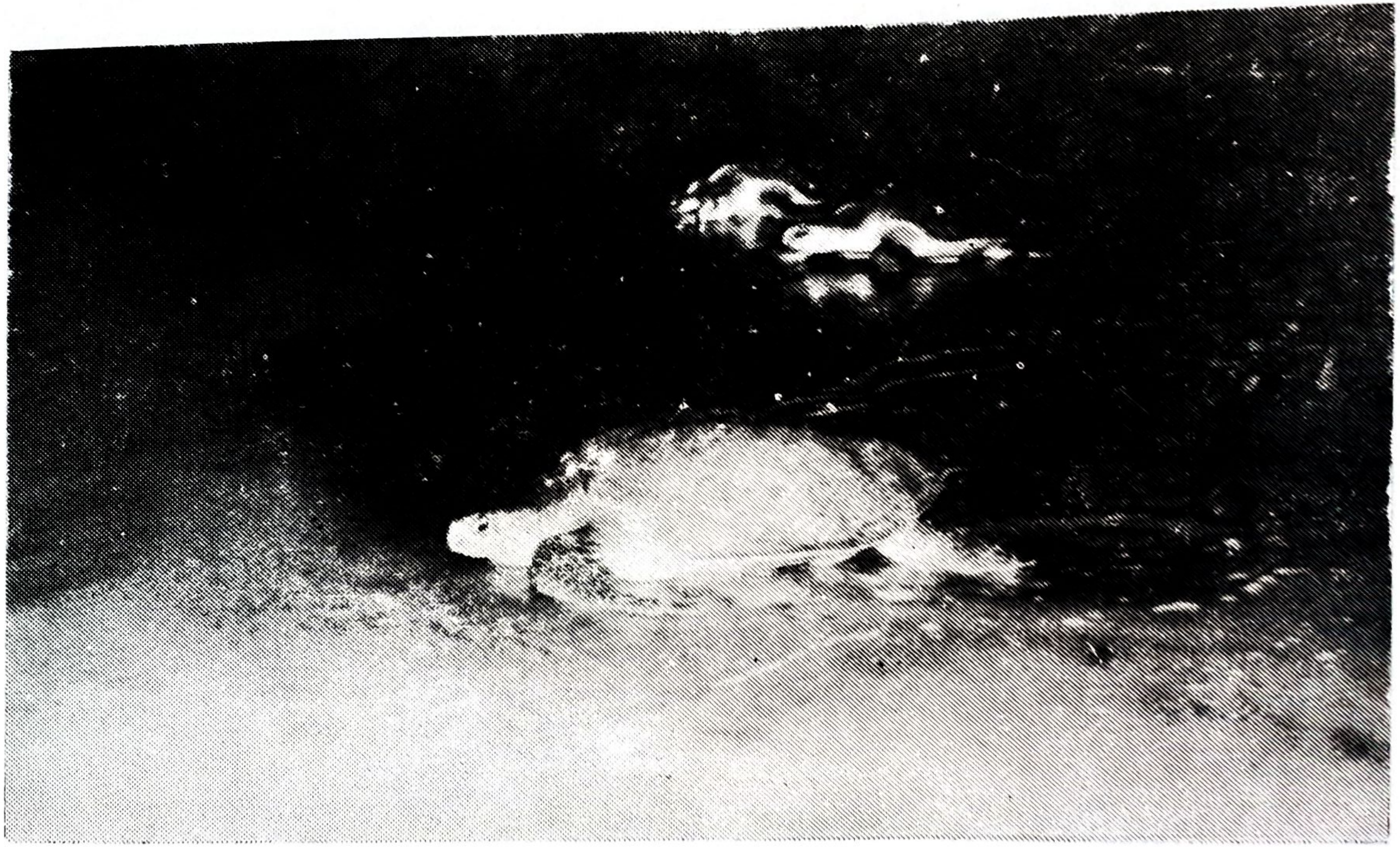
Oviposition : Once the pit is completed the turtle rests a while and then it lowers its tail into the cavity with the everted cloacal portion. The eggs are generally extruded singly or two at a time. As the eggs emerge, the hind flippers curl and the head and neck are retracted and beat down-wards. Mucus is frequently secreted between the egg extrusions coating the eggs.

Nest filling : Filling the nest cavity begins immediately after the last egg has been laid. The hind flippers then scoop sand alternately from the side of the pit and dump it on the opening.

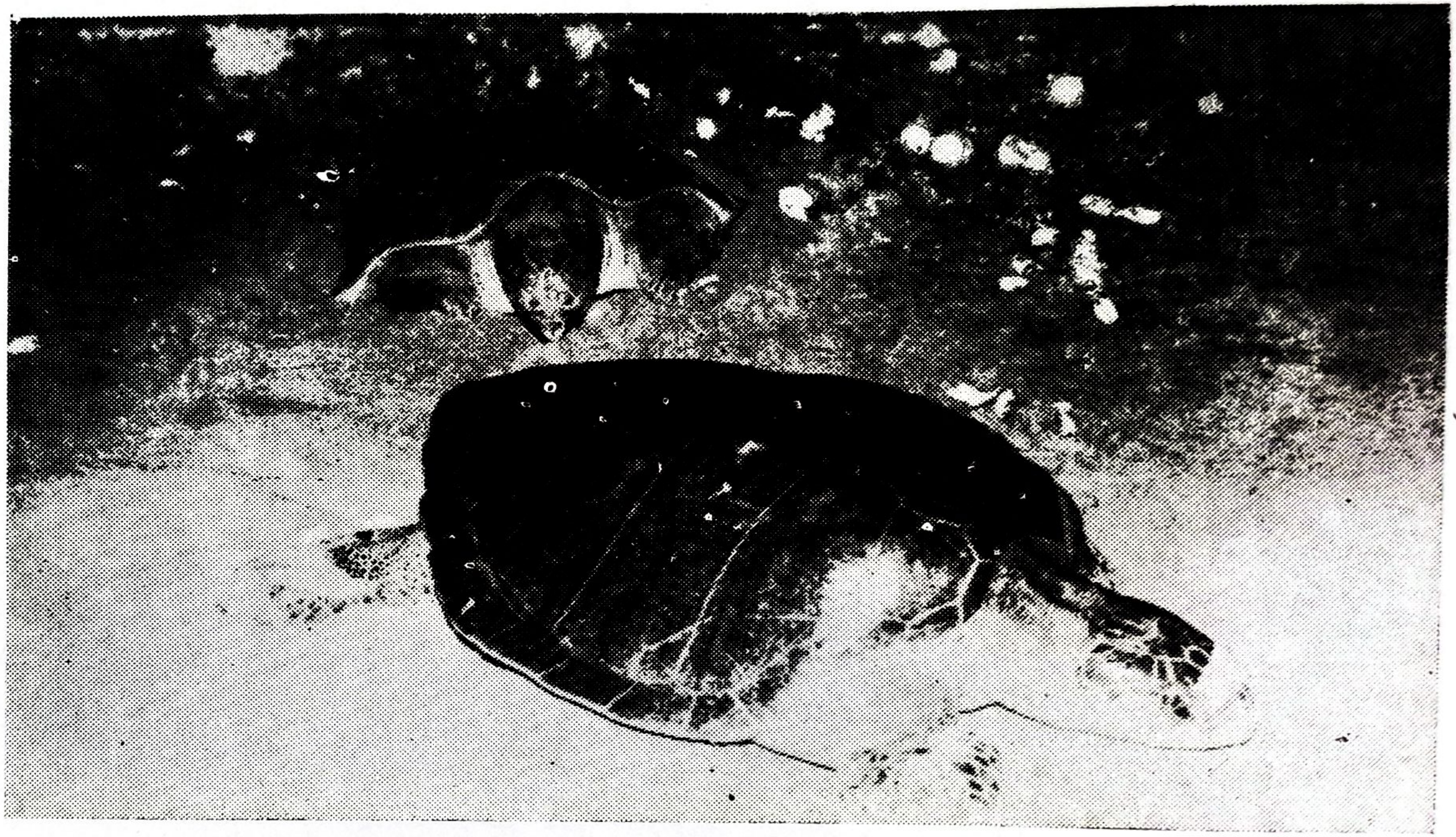
Filling the body pit and concealing the site : The front flippers begin throwing sand backwards at first alternately and then together. The hind flippers collect sand from the side and press it towards the centre and the animal compacts the nest by thumping by its plastron. This thumping also slowly propels the turtle forward. It obliterates the nest by



A. Olive ridley turtles emerging from sea

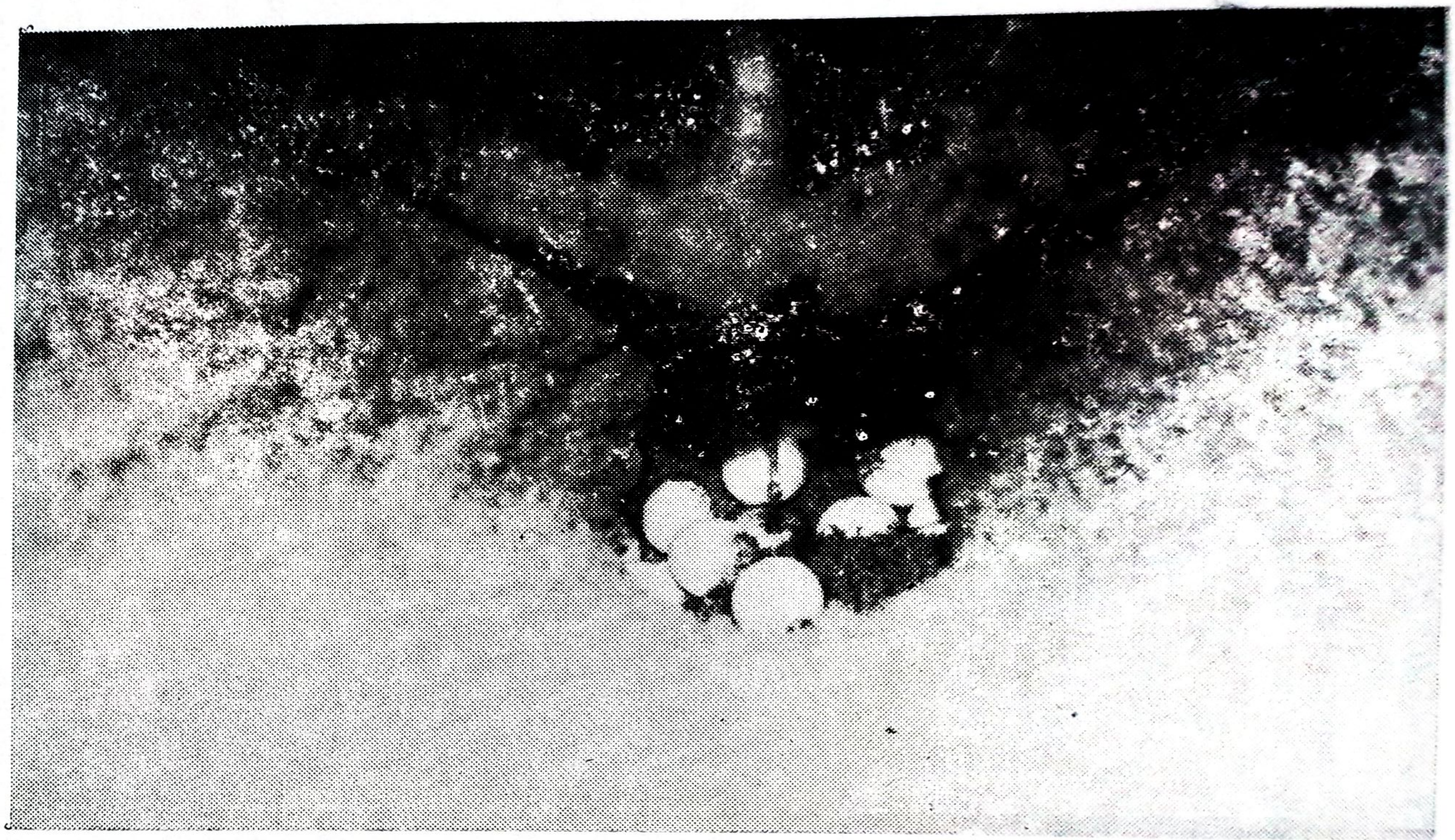


B. Turtles crawling on wet sand



C. One nesting and another sniffing for nest selection

D. Nesting female



E. Rear of nesting female showing the egg nest throwing sand by the fore flippers. *Very often it moves away from the nest and turns round and round throwing sand with its flippers to make a false nest away from the pit which is probably* a means to fool the predators.

Return to the Sea : After filling and concealing the pit the turtle rapidly returns to the sea. Generally it does not press its muzzle against the sand during its return.

Unusual nesting records : *Case 1.* (14.2.86) A few unusual nesting turtles were observed : Once a turtle emerged from the sea crawled the mid beach and crossed the sand dune and came to the river side. Generally turtles emerging from the sea never cross the sand dune. This one laid eggs on the river side. After closing the nest it started walking along the river bed in a zig zag way. The river was comparatively calm but the roaring sound was coming from the other side but the turtle could not see the sea and did not enter the river immediately. It surveyed and crawled about 400 meters within 2 hours before finally entering the river.

Case 2. (18.2.86) Another peculiar observation was noted for a turtle having only one hind flipper. In general, the turtles dig the nest by the two hind flippers using them alternately. Instinctively, this one also tried to dig by using two flippers. Due to muscular activity of the amputed portion everytime sand rushed into the pit dug by the good flipper. This way it could not dig a proper pit. It rejected the spot and selected another nest site. There also it met the same fate. It tried to dig a pit again and again at different sites and altogether it tried 13 times and failing to dig a proper pit; it returned to the sea.

Case 3. (10.3.87) During second mass nesting in 1987 towards the end of the night, a turtle emerged which had both of its hind flippers amputed. It did not come to the beach when the beach was filled with laying turtles. It rested at the high tide line, then started digging on the wet and compact sand. Alternately, it used both the leg stumps for digging. She could not make a pit. However, after 30 minutes of digging it started laying. As there was no pit, the eggs rolled to the sea. After laying she went through movements of closing the nest (although there was not a single egg there) and returned to the sea. This indicates that nesting activity is more of an instinct rather than any conscious activity to see that the eggs are properly laid. In this case the turtle preferred to go through all the movements from emergence to return without even digging a proper pit.

3. 9. *Lunar cyle and mass nesting* : The occurrence of mass nesting is known to be correlated with the lunar cycle and usually takes place two or three days before or after the moon enters its last quarter (Marquez and Von Dissel, 1982). The mass nesting data at Gahirmatha since 1983 shows that the mass nesting generally occurs at the 3rd and the last quarter of the lunar cycle *i. e.* within the full moon and the new moon (Table 12). In 1983, 1984 and 1985 the first mass nestings occurred on the 6th, 7th and 8th day after the fullmoon, respectively. The second nesting of 1984 and 1985 occured exactly 6 days after the full moon with the exception of 1983 when nesting occurred 4 days before the fullmoon. In 1986, only one mini mass nesting occured on the 6th day after the full moon. In 1987, the first and second mass nesting occurred 10 days and 7 days before the fullmoon, respectively.

Table 12. Correlation of mass nesting with lunar cycle

Year	Occurance	
1983	Ist Mass Nesting	5 days after the fullmoon
	2nd Mass Nesting	4 days before the fullmoon
1984	1st Mass Nesting	6 days after the fullmoon
	2nd Mass Nesting	6 days after the fullmoon
1985	1st Mass Nesting	6 days after the fullmoon
	2nd Mass Nesting	6 days after the fullmoon
1986	Mini Mass Nesting	6 days after the fullmoon
1987	1st Mass Nesting	10 days before the fullmoon
	2nd Mass Nesting	7 days before the fullmoon

3. 10, *Size of olive ridley at Gahirmatha* : The adult females nesting on the beach and the dead males reaching the beach were measured (Table 13).

Table 13. Size of *L. olivacea* at Gahirmatha

Sex	Carapace length in cm. (mean)	Carapace width in cm. (mean)	Plastron length in cm. (mean)
F (57)*	64—80 (76)	55—73 (65)	50—60 (58)
M (9)	67—78 (74.5)	54—68 (63)	44—55 (52)

* Number

3. 11. *Eggs* : Fresh olive ridley eggs are white and spherical with soft, papery shells coated with a mucilaginous secretion. Abnormal eggs ranging from very small ones to fused eggs were also observed. The clutch size ranged from 36 to 182. The size of normal and abnormal eggs is presented in table 14.

Table 14. Egg size of *L. olivacea*

Type	Diameter in cm	Length in cm	Weight in gm
Normal eggs	3.4—3.8	—	28—30
Fusion of 3 eggs (6)*	—	10.9—12.1	94.4—104.9
Fusion of 2 eggs (8)	—	7.0—8.5	60—80
Abnormally large egg (3)	8.0—9.0	—	50—60
Chain of eggs (1)	—	46	130

* Number

Distribution of eggs in the nest was studied in a few clutches, The following are the distribution in two samples :

Table 15. Distribution of eggs in *L. olivacea* nests

NEST NO. 1

Eggs laid on 15.2.1986 night. Transplanted and incubated in the hatchery on 16.2.86 at 7.30 A.M.

Distribution of the eggs in the nest

Distribution	Number
Bottom centre	1
Bottom 2nd circle	6
Bottom side	12
Middle side	13
Top side	22
Top of the clutch	15
Centre of the nest	55
Total:	124

NEST NO. 2

Eggs laid on 18.2.1986. Trasplanted and incubated in the hatchery on 19.2.1986 at 7.30 A.M.

Depth of the nest — 46 cm
Egg diameter — 3.8 cm
Egg weight — 32 gm

Distribution of eggs in the nest

Distribution	Number
Bottom centre	1
Bottom 2nd circle	6
Bottom side	15
Second side	13
Third side	13
Fourth side	22
Top of the clutch	14
Centre of the nest	32
Total :	116

Predation : Gahirmatha beach is surrounded by mangrove forest which has wild boars, hyena and jackals. Dogs also enter the area from the nearby villages. These animals dig out the nests and cause considerable damage to the eggs. In addition, kites and sea gulls eat the eggs once they have been dug out by other predators There is a transitional increase in the predator population during the nesting season. At times wild boars were observed chasing the turtles before or after egg laying, and disturbing the turtles during egg laying. Predators can locate nests very easily by the crawl marks of the turtles leading to the nest.

4. EMBRYONIC DEVELOPMENT AND HATCHLINGS

4. 1. *Collectin of eggs* : Eggs were collected soon after laying during the nesting seasons in 1986 and 1987 from Gahirmatha beach (20° 42'N, 87°5'E). The eggs were put in baskets covered with moist cotton and transported to the laboratory at Utkal University located 320 km away from the nesting ground.

4. 2. *Incubation of eggs* : Eggs were incubated under laboratory conditions between 48 to 96 hours of laying. Before incubation, the eggs were washed with tap water without changing its orientation, drained and incubated in bowls in sand or wrapped in moist cotton. Later during the study, incubation in sand was discontinued as it proved to be inefficient and messy in comparison to incubation in moist cotton. The eggs were incubated in *Remi* brand B. O. D. incubators at different temperature regimes namely warm (33.0°C), cold (28.0°C) and intermediate (29°C/30°C/31°C/32°C). A constant temperature was maintained±0.5° throughout the period of incubation, The treatment of eggs collected during 1986 and 1987 is presented in Table 16.

4. 3. *Embryonic phase* : Embryological studies on the olive ridley are rather limited. Crastz (1982) described the general aspects of olive ridley embryological development in a series of 31 stages. But in his description a detailed description of anatomy is lacking. Yntema's (1968) embryological stages of the North American fresh water snapping turtle *Chelydra serpentina* has been generally accepted as standard for development of turtles in general. A study of embryonic development was carried out by incubating eggs at different temperatures in the laboratory.

Table 16. Clutchwise details of laboratory incubation of eggs

Year 1986

Clutch 1 (February)

	N	T	E	Total
H	22	10	8	40
C	40	20	7	67
R	20	—	6	26
			Total :	133

Clutch 2 (February)

	N	T	E	Total
H	20	10	—	30
C	58	20	—	78
R	30	—	—	30
			Total :	138

Clutch 3 (March)

	N	T	E	Total
H	40	—	—	40
C	54	—	—	54
R	45	—	—	45
			Total :	139

Clutch 4 (March)

	N	T	E	Total
H	—	—		—
C	33	—	70	103
R	—	—	—	—
			Total :	103

Clutch 5 (March)

	N	T	E	Total
H	14	—	112	112
C	—	—	—	—
R	—	—	—	—

Total : 112

Year 1987

Clutch 6 (February)

	N	T	E	Total
H	26	29	7	62
C	42	18	4	64

Total : 126

Clutch 7 (February)

	N	T	E	Total
H	19	6	5	30
C	8	18	5	31
R	60	—	2	62

Total : 123

N : Normal left for hatching
T : Transfer Eggs for shift Expt.
E : Eggs opened for Embryos (Staging and histology)
H : Hot temperature
C : Cold temperatuae
R : Room temperature

Early development of Eggs : Within two to four days of the start of incubation the parchment-shelled indented eggs became turgid due to liquification of the albumin because of water absorption which enables the vitelline sac to rise, After a week, the vitelline sac expanded to such an extent as to embody most of the egg contents and to lie adjacent to the shell above and below. When these eggs were candled, yellow yolk material appeared to occupy approximately the lower third of the egg, the transparent fluid and the embryo occupying the upper two-thirds. Externally, a fertilized egg has a chalk white spot on the upper surface due to the attachment of the vitelline membrane to the inner surface of the shell. This mark expands with the growth of the embryo and its attachment to the shell. Small water drops resulting from the metabolism are found on the shell surface of the developing egg. These drops are not found on the unfertilised eggs.

Incubation period : The period from pipping (breaking of shell with egg tooth) to crawling out of the egg shell varies from one to four days. In hot temperature (33±0.5°C) the range of incubation period of different clutches was 45-51 days, in room temperature it was 56-59 days and in cold temperature (28±0.5°C) it was 72-74 days. The eggs incubated below 27°C did not hatch at all unless they were transferred to a higher temperature just before hatching. Two percent of the total embryos that pipped died before crawling out the shells.

Table 17. Effect of temperature on incubation period in *L. olivacea*

Temperature of incubation	Days of incubation		
	Range	SD	Mean
33±0.5°C	45—51	2.16	48±0.8
29—32	56—59	1.3	57.5±0.6
28±0.5°C	72—74	1.0	73±0.5

Thermal Tolerance : Eggs did not develop at 35°C and above. Therefore, it was concluded that 35°C is the higher lethal temperature for the eggs. At a temperature lower than 27°C, eggs did not hatch indicating that it is the lower lethal temperature.

Stages of Development : Based on days of incubation and crown-rump length, the embryos developing at 28±0.5°C could be divided into 29 stages. All these 29 developmental stages at cold temperature were compared to Yntema's stagings (Y) for *C. serpentina* at 20°C and Crastz's stagings (C) for *L. olivacea* at 30°C Table 18 and Figures 2-4.

Table 18. Staging and measurements of *L. olivacea* and its relation to Yntema and Crastz stages

Stage[1] 28±0.5°C	Days of incubation	C—R[2] length mm	Carapace length mm	Weight in gm	Stage (Y)[3]	Stage (C)[4]
1	2	2.0	—	—	3+	2+
2	3	3.0	—	—	5+	3+
3	4	3.5	—	—	6+	4+
4	5	4.0	—	—	7+	5+
5	6	4.5	—	—	8+	6+
6	7	5.0	—	—	9+	7+
7	8	5.2	—	—	10−	8
8	9	6.5	—	—	10	8+
9	10	7.5	—	—	11	9
10	11	7.8	—	—	11+	9+
11	12	7.9	—	—	12	10
12	14	9.0	—	—	12+	10+
13	15	8.5	—	—	13	11
14	16	8.0	6.0	0.025	14	12
15	17	8.0	6.0	0.030	14+	12+
16	18	8.5	6.5	0.048	15	13
17	21	10.5	7.0	0.062	15+	14+
18	25	11.0	7.5	0.150	16	16

contd.

Stage[1] 28±0.5°C	Days of incubation	C—R[2] length mm	Carapace length mm	Weight in gm	Stage (Y)[3]	Stage (C)[4]
19	28	12.5	9.0	0.248	17	18
20	32	17.5	12.0	0.50	18+	19+
21	37	21.0	15.0	0.82	19+	21
22	42	30.0	21.0	1.87	20	22+
23	48	37.0	22.0	2.60	21	24+
24	51	43.0	33.0	8.52	22+	25
25	55	45.0	33.5	10.45	23	26
26	58	48.0	34.0	12.74	23+	27
27	62	48.5	36.0	13.0	24	28
28	67	53.5	37.5	13.5	25	29
29[5]	74	56.5	39.0	14.5	26	31

1. Staging in the present study 2. Crown-rump 3. Yntema Stage
4. Crastz Stage 5. Hatching

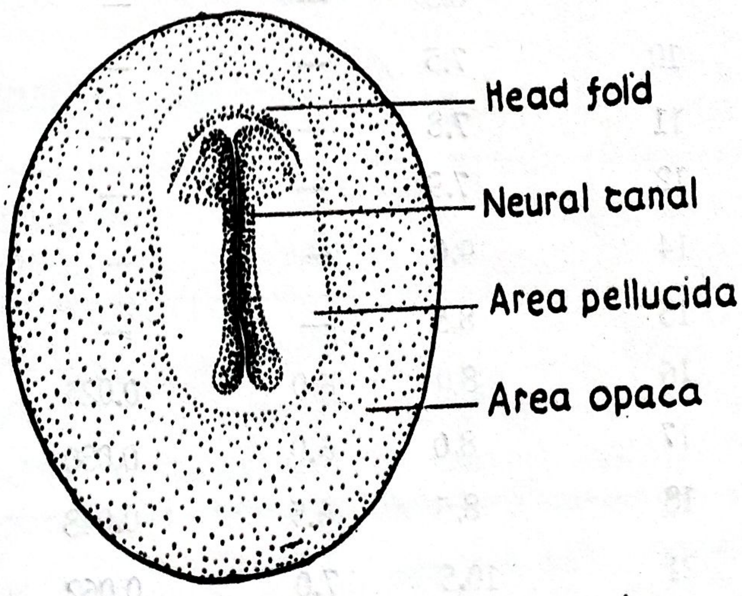


Fig. 2 Two days embryo at cold temperature

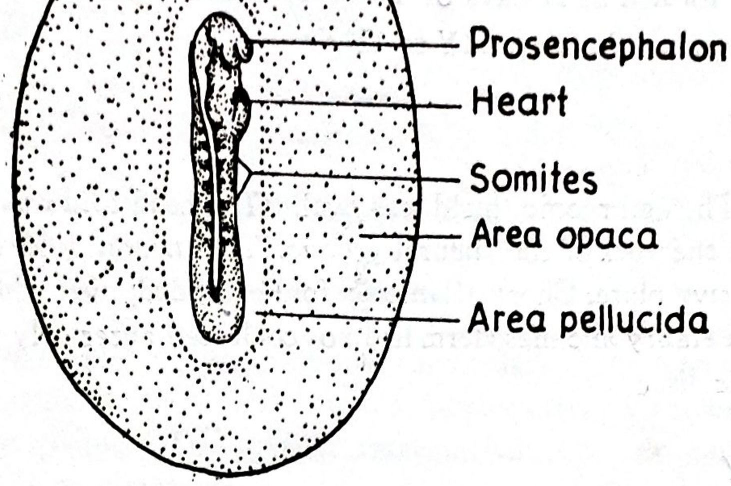


Fig. 3 Five days embryo at cold temperature

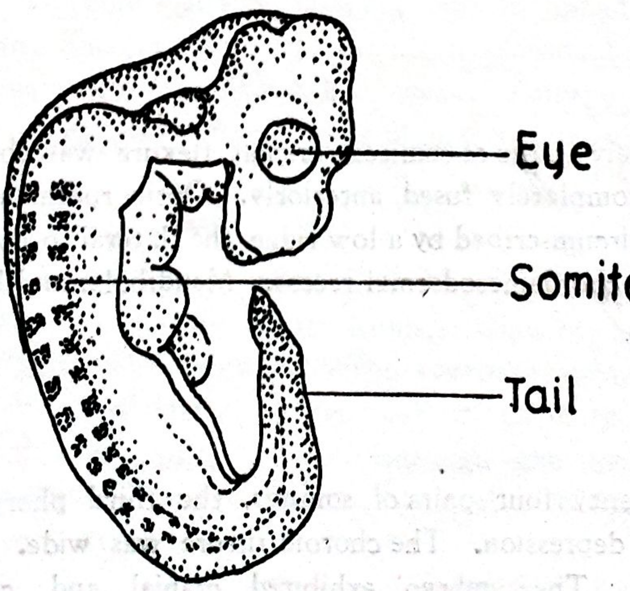


Fig. 4. Fifteen days embryo at cold temperature

Vitelline circulation was observed within two weeks. The allantoic sac, an outgrowth of the hindgut, started expanding at stage 12Y to 13Y. The tail process was formed at stage 10^{+}Y. The first somite stage was observed at stage 3^{+}Y having only one pair of somites. The carapace was distinctly formed at 17 days of incubation at stage 14^{+}Y. The forelimb bud was seen at the stage 11Y to 11^{+}Y.

Stage 3^{+}Y

The embryonic shield was oval. The head fold was a semicircular furrow at the apex of the neural groove. The neural fold extended upto the primitive plate. Chorioallaniotic fold extended over the head process. The extra embryonic mesoderm had not coalesced anteriorly to encircle the embryonic disc.

Stage 5^{+}Y

Seven pairs of somites were seen, amniotic folds covered the hind brain and extended upto the level of anterior intestinal portal. Anterior neuropore remained open in the groove of the neural fold of the head process. The neural folds of the brain were not fused along the midline.

Stage 7^{+}Y

Twelve pairs of somites, cranial flexure was about 180°. Neural folds were completely fused anteriorly. Optic rudiment developed as a depression circumscribed by a low ridge, the lateral body folds bounded a longitudinal chordamesodermal recess. Mandibular and hyoid arches were recognisable.

Stage 10 Y

Twenty four pairs of somites, the third pharyngeal cleft was marked by a depression. The choroid fissure was wide. Otic vesicle was constricted. The embryo exhibited cranial and cervical flexures. Mandibular process extended caudally. Tail was segmented only at the base. Division of somites into myotomes and sclerotomes evident. Hind gut formed. Conus arteriosus was formed. Liver was well marked.

Pronephric tubules developed. The rim of the eye cup attached to the lens epithelium.

Stage Y 13

Head was more twisted. Maxillary process extending beyond the mandibular process and limiting a well marked nasolacrimal groove posteriorly. This leads to a deep olfactory pit. Limbs paddle shaped, sign of apical ridge apparent. Tail elongated between two hind limbs. Lateral demarcation of the laminae distinct. Spinal ganglion formed.

Stage Y 15

The digital plates without grooves and ridges. The frontal process evident. The carapace indistinctly limited posteriorly. The boundary of the plastron not visible. The gonadal ridge developed, Primordial germ cells found in the mesentery.

Stage Y 16

Head was distinct from the body with a narrow neck. Indications of two digital grooves on the digital plate. Carapace clearly limited around its periphery. Frontal and maxillary processes joined. Mandible was more prominent. The lateral edge of the plastron evident as a distinct bend at the ventrolateral aspect of the body wall. Embryo more turtle like. Stomach differentiated to form simple mucosa and muscular stratum circulare.

Stage Y 20

Scales present on the edges of the flippers. Claw of the foreflipper only show slight pigmentation. Scutes on the carapace pigmented. The central scutes darkest, the lateral scutes darker medially and higher laterally. Marginal scutes pale. Few out lines on the head indicated scales. Light pigmentation above the eye, the eyelid reaching the iris. Frontonasal groove obliterated.

Stage Y 23

Pigmentation of the carapace increased, claws dark with pigments. Crests on the central and lateral scutes well marked. Corrugation started in the central and lateral laminae, crests present on the plastron whose tops are pigmented. Scales and plates evident on head. eyelids and limb. Lower jaw was open up to the occlusion point. Triangular mentonian plate evident.

Stage Y 24

Basic hatchling pigmentation and morphology present in the embryo. The head fully pigmented. The transverse fold of the plastron was deep and thoracic scutes were folded under the abdominal scutes, The inframarginal scutes formed a groove. The under surface of the limbs paler than the upper surface. The central laminae forming a dorsal keel.

Stage Y 26

Hatching stage, the umbilical hernia was absent, its position was represented by a soft area in the plastron. The extra embryonic membrane and transverse plastronal fold absent. Body straight.

4.4. *Hatching Success (under laboratory conditions)* : The hatching success was highest at hot temperature (33+0.5°C). A total of 218 (72.6%) hatched out of 300 eggs incubated at different temperatures (Table 19). Out of these the percent of hatching was highest (81.4%) in hot and lowest (65.8%) at room temperature with an intermediate number (70.6%) at cold temperature. After pipping some embryos did not crawl out of the shell and had to be removed by piercing the shell. These embryos were found with large as yet unretracted yolksac.

Table 19. Hatching at different temperature regimes in *L. olivacea*

Temperature of incubation	% Hatching	
	Range	Mean
33±0. 5°C	79.31—83.8	81.4
29—32°C	61.52—68.4	65.82
28±0.5°C	68.46—76.9	70.7

Morphometrics : The crown-rump length (C-R length), straight carapace length and the weight of the embryos of the eggs incubated at 28±0.5C in different days are presented in the Table 20. The C-R length of a 2-day embryo is 2.0 mm. It grows up to 56.5 mm during its incubation period. The first well-formed carapace is visible at the length of 6.0 mm. The weight of the embryos from 16 day incubation up to hatching is 0.025 gm to 14.5 gm, respectively. The C-R length is positively correlated with the weight of the embryos (r=0.46). The C-R length and days of incubation are significantly correlated with the straight carapace length and weight of the embryos, respectively (r=0.99, and 0.93, respectively). Cold temperature slowed the growth of the embryos significantly in comparison to hot temperature. The carapace length, weight and plastron length of the hatchlings at cold temperature were lower than those of the hatchlings at hot temperature (Table 20).

Table 20. Morphometry of the Hatchlings hatched in Laboratory Condition

Temperature	Sex	Incubation Temperature °C	Length of carapace in mm	Weight in gm	Width of carapace in mm	Length of Plastron in mm
HOT	F	33±0.5	42.8±0.2	18 0±0.2	35.6±0.2	34.5±0.24
COLD	M	28±0.5	39.5±0.4	14.43±0.3	33 0±0.4	31.17±0.6

Malformations : Four percent of the total eggs incubated haemorrhaged. Islands of blood could be seen through the shell when these eggs were candled. Two percent of the total embryos were found to be abnormal. A total of 10 embryos with a long neck and reduced carapace suffered perinatal death. Head deformities with fully developed tail and limb buds were also found in 2 embryos. A typical number of scutes was often observed. A rare hatchling was found with only four central scute with an elevated carapace.

Hatching aad hatchlings in nature: Hatchling olive ridleys, like other sea turtle genera, move the buried egg chamber to the surface *en masse* by periodic outbursts of group thrashing which results in the "caving in" of the sand from the top and sides bringing the egg chamber to the top, This process may take frum 3 to 6 days depending upon the depth of the chamber and availability of oxygen. Hatchlings usually emerge above ground in several small batches.

Incubation period: The incubation period is about 50 to 60 days for the first batch of eggs laid around January to February. But the period is shorter for the second batch of eggs because of the increase in temperature.

In 1986, the thick mass nesting took place from first to 4th April. The turtles started emerging from mass nesting area on 18th May and this emergence continued upto 23rd May. The period of incubation was 48-52 days.

In 1987, the mass nesting continued from 8 to 13 March and the mass emergence of the hatchlings took place from 24 to 30 April. The duration of incubation was approximately 48 days.

Time of Emergence from the Nest: The hatchlings generally emerge from of the nests during the night. Such activity starts at about 7 P.M. and continues till the next morning. In the areas close to the waterline the emergence continues to a later period.

Migration to water: During the night 35% of the hatching enter the rivermouth whereas the remaining 65% enter the sea. During the morning hours it has been found that more than 90% of the hatchlings which enter into small water reservoirs leave them ultimately and are found heading towards the sea.

Hatching success: The data for 1986 and 1987 are presented in Tables 21 and 22. In general, hatching success was greater in 1987 than in 1986, In 1987 the average hatching success of the mass nesting area was 47.2%. This percent is certainly high in such adverse conditions of the nests due to sand deposition and inundation by sea water. Quite a number of hatchlings died on their way out of the nests. They were found with their heads up and flippers stretched pressing against the sand

Table 21. Hatching record of *L. olivacea*, Gahirmatha beach, May 1986

Area	Pole area	No. of obs.	Nest Temp. 0°C	No. of Live Hatchling	Post natal death	Prenatal death	Early Embryo death	No. of rotten eggs	Clutch size	Hatching %
Low density	94/95	1	38	7	6	65	15	19	112	6.8
mass nesting	95/96	2	37.5	3	14	86	5	13	121	3.0
area	97/98	3	37.8	21	15	38	10	38	122	1.3
	101/102	4	37.0	28	10	45	15	30	128	7.8
High density	104/105	5	35	23	9	30	10	15	87	26.4
mass nesting	104/105	6	36	—	21	18	30	75	144	0
area with dry	105/106	7	37	5	36	34	15	37	122	4.0
sandy beach	106/107	8	36	13	27	32	5	29	106	12.3
High density	105/106	9	34	48	14	45	5	6	118	40.7
mass nesting	106/107	10	34.5	32	36	7	15	13	103	31.0
area with wet	107/108	11	34	76	35	10	5	4	130	58.5
sandy beach	107/108	12	34	42	28	5	4	4	83	50.6
	106/107	15	34.5	40	17	30	5	20	112	35.7

particles. Presumbly death was due to exhaustion. The average nest temperature during hatching was 35°C.

Table 22. Hatching record of *L. olivacea*, Gahirmatha beach, April/May 1987

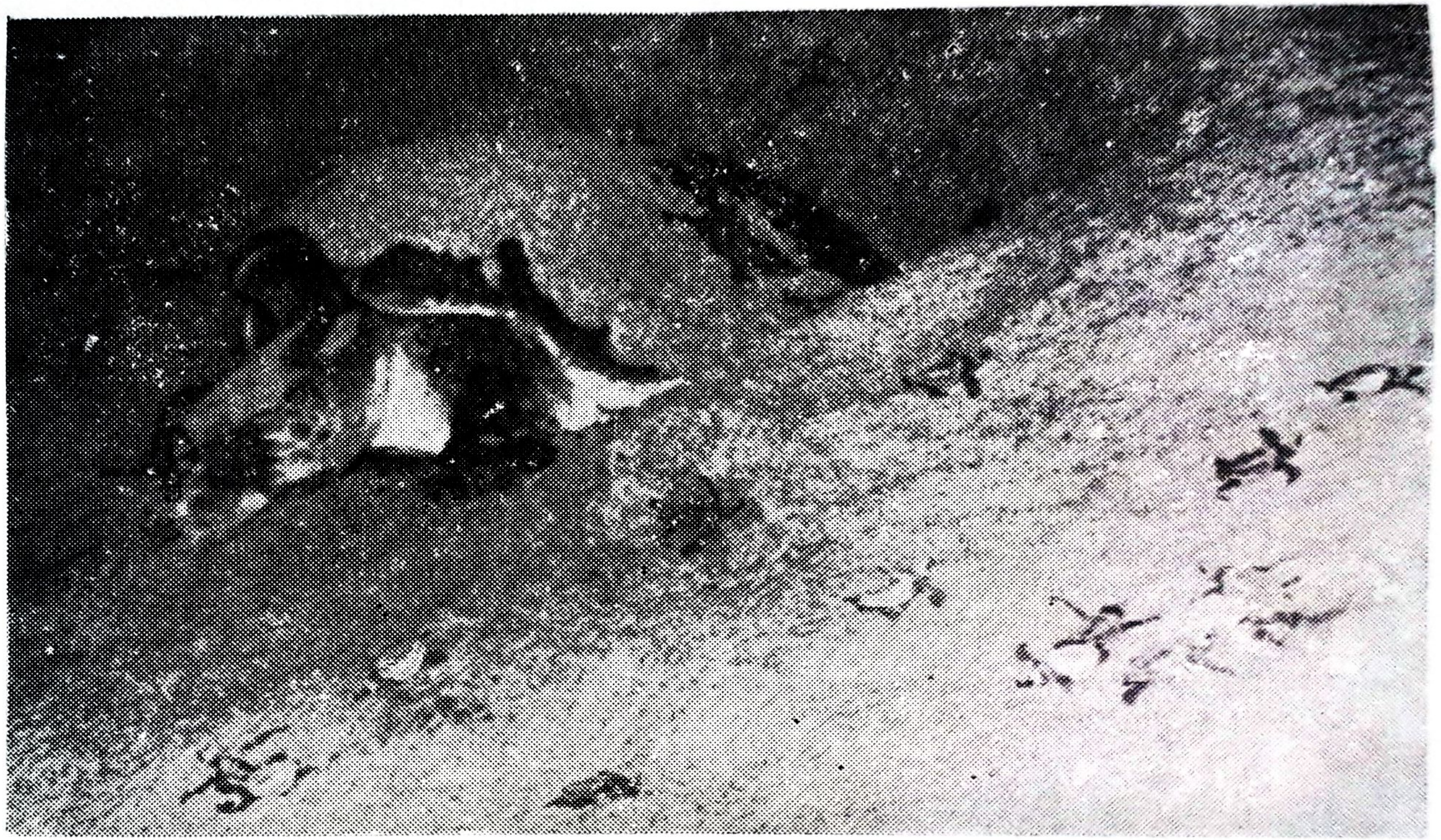
Pole No.	No. of obs.	Nest temp. in °C.	No. of live hatchlings	Prenatal death	Postnatal death	Number of rotten eggs	Early embryo death	Clutch size	*Hatching %*
55/56	1	35.5	84	—	15	—	12	111	75.67
55/56	2	35.0	105	33	—	3	—	141	74.46
57/58	3	35.0	29	4	35	2	10	80	36.25
57/58	4	34.5	51	3	21	—	26	101	50.49
58/59	5	35.0	34	5	9	2	29	79	43.03
59/60	6	36.0	53	32	11	—	15	111	47.74
62/63	7	35.5	30	14	29	3	30	106	28.30
64/65	8	35.5	32	23	—	3	38	96	33.33
Total			418	114	120	13	160	825	

Mortality : In 1986 the dead hatchlings found on the sand of the nesting area were approximately 48,000 (4 in each m²). This type of mortality is due to several reasons.

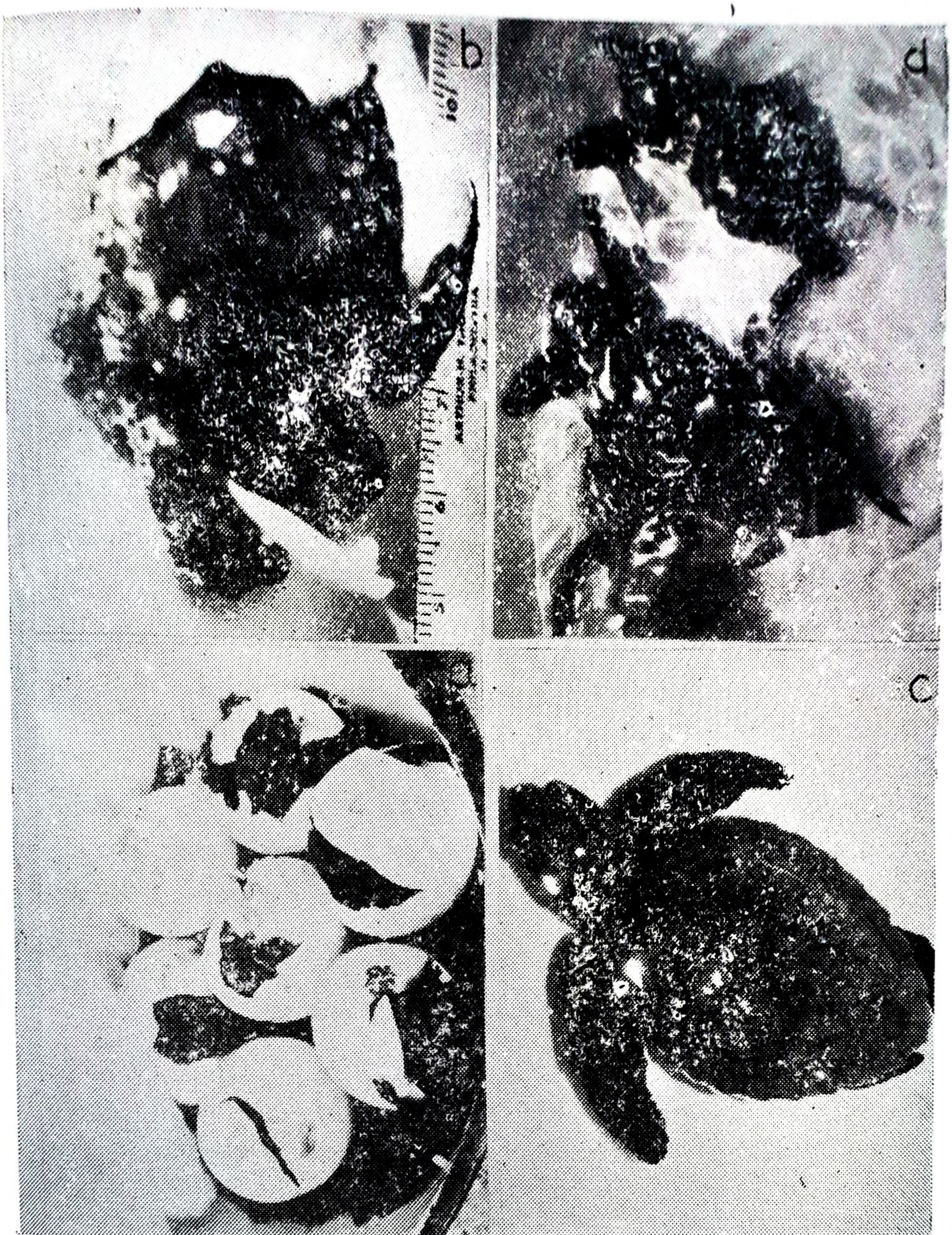
Mortality

- Scorching Heat (5%)
- Predation (60%)
- Uncovering of the nests by tide (5%)
- Uncovering of nests by dog and jackals etc. (30%)

Scorching Heat : Some of the hatchlings which emerge in the morning get scorched by the sunlight and then move randomly on the beach rather than entering the sea. These hatchlings die nltimately when the sand gets hot.



F. A nesting female during second mass nesting. Note the emerging hatchlings in the sand from first mass nesting



G. Hatchling in *L. olivacea*

a. mass hatching
b. hatchling crawling out of shell
c. hatchling
d. hatchling demonstrating juvenile frenzy

Predation: The usual predators are the crabs, crows, kites, sea birds, dogs and jackals etc. The birds pick up the hatchlings and take out the unabsorbed yolk sac from inside the body through the umbilical region. The night predators are the dogs and the jackals. Once the hatchlings enter the sea, fishes including sharks, dolphins and birds are the main predators.

Uncovering of the Nests by the tide: During the spring tide the strong current caused a significant soil erosion of some of the portions of the mass nesting area. Batches of dead hatchlings were found near the tide area. These hatchlings had been washed away and deposited near the high tide lines.

Table 23. Size of tne hatchlings of *L. olivacea*

Condition of Incubation (N)	Carapace length in cm (mean)	Carapace width in cm (mean)	Plastron length in cm (mean)
Nature (45)	3.7—4.4 (3.8)	2.9—3.9 (3.2)	2.9—3.8 (3.0)
Laboratory			
Room (42) (27—32°C)	4.1—4.7 (4.3)	3.3—3.9 (3.4)	3.3—3.7 (3.1)
Cold (20) (28°C)	3.7—4.2 (4.0)	3.1—3.6 (3.3)	2.9—3.3 (3.0)
Hot (31) (33°C)	4.1—4.6 (4.3)	3.5—3.8 (3.6)	3.3—3.8 (3.2)

4.5. *Sex ratio under natural conditions*

The sex ratio of *L. olivacea* under natural conditions has been studied since 1984. A total of 678 hatchlings have been sacrificed which were produced from first mass nesting (January-March) eggs. Only 19.32% of females have been produced from the first mass nesting. Altogether 650 hatchlings were sacrificed from the second mass nesting (March-May) eggs and 90.3% of females were produced from these eggs. Thus, it is concluded that mostly males are produced during the first mass nesting because of the low ambient temperature and mostly females are produced during the second mass nesting due to the higher ambient temperature. The compiled as well as data from random sampling during May, 1986 are presented in Tables 24 and 25, respectively.

Table 24. **Sex ratio of *L. olivacea* hatchlings under natural conditions at Gahirmatha**

Year	Nesting season (dates)	No. of hatchlings	Sex	
			Female (%)	Male (%)
1984	2nd mass nesting (11 March—28 April)	104	104 (100)	0 (0)
1985	1st Mass nesting (18 Jan.—17 March)	104	45 (43.26)	59 (56.7)
1986	2nd Mass nesting (4 April—23 May)	93	78 (94.0)	15 (6.0)
1987	1st Mass nesting (6 Jan.—6 March)	524	68 (12.47)	456 (87.5)
1987	2nd Mass nesting (10 March—23 May)	418	411 (98.32)	7 (1.68)
1989	1st Mass nesting (17 Jan.—23 March)	50	18 (36)	33 (64)

Table 25. Biometry and sexing of hatchlings (May 1986)

No. of obs.	CL mm	CW mm	PL mm	PW mm	FF mm	HF mm	Sex	Wt gm	Yolk wt gm
1	38.0	31.5	31.0	28.0	29.0	19.5	F	15.0	4.0
2	42.5	35.0	35.0	30.0	35.0	20.0	F	16.0	1.5
3	42.0	39.0	38.5	30.0	33.5	20.5	F	15.0	2.0
4	42.0	36.0	35.0	30.5	35.0	22.0	F	16.0	1.5
5	41.0	34.0	34.0	31.0	35.0	21.0	F	15.0	2.0
6	43.5	36.5	35.3	31.5	35.0	22.5	F	16.0	2.0
7	43.0	35.5	35.0	31.5	34.0	21.0	F	16.0	1.7
8	43.0	35.5	34.5	31.5	35.0	21.5	F	16.0	2.0
9	42.5	35.0	36.0	31.5	36.0	21.5	F	15.5	2.0
10	41.0	33.2	33.0	29.0	33.5	21.0	F	15.8	2.5
11	43.0	35.0	36.0	31.0	34.0	21.5	F	16.0	1.7
12	43.0	35.0	34.0	31.0	34.0	20.5	F	16.0	2.0
13	40.0	33.0	34.5	28.0	31.5	18.5	F	13.5	2.0
14	40.0	34.0	33.0	29.5	32.0	20.5	F	13.5	2.0
15	41.5	34.5	34.5	29.0	34.5	22.5	M	14.5	2.5
16	42.5	34.0	33.5	29.5	33.5	21.5	F	14.5	3.0
17	41.0	33.5	34.5	29.5	33.0	20.5	F	15.9	3.5
18	41.5	34.0	33.5	28.5	33.5	22.0	F	14.0	2.0
19	39.5	33.0	33.5	28.5	34.5	21.5	F	14.5	2.5
20	39.0	31.0	31.0	28.0	32.0	20.5	F	14.0	1.7
21	38.5	30.0	31.0	27.5	30.0	20.0	F	13.5	1.5
22	39 0	32.5	32.5	29.5	33.5	20.5	F	15.0	2.0
23	39.5	31.5	32.0	28.0	33.0	20.5	F	15.0	1.7
24	41.0	32.5	32.5	29 0	31.5	21 5	F	15.5	2.0
25	37.0	31.0	31.5	27.0	32.5	20.0	F	14.0	1.5

CL : Carapace length, CW : Carapace width, PL : Plastron length
PW : Plastron width, FF : Fore flipper, HF : Hind flipper

5. GROWTH OF HATCHLINGS

Olive ridley hatchlings were raised under standeredized conditions in the laboratory. The growth of these animals was studied upto 22 months. Growth has been observed in terms of weight, length and width of each hatchlings.

5.1. *Growth in weight*: Generally weight of the olive ridley hatchlings depends on the amount of food intake, number of co-inhabitants and physical conditions. In crowding experiments it has been marked that the animals lose weight, perhaps due to stress and strain, under crowded conditions. Some of the hatchlings do not get enough food in the presence of the dominant ones who eat more and often snatch away the food from others. The weaker hatchlings lose weight and become prone to disease.

In two sets of experiments it has been seen that the animals incubated in cold and room temperature increased in weight in parallel fashion. In the hot tempeaature groups growth was either faster or slower than the corresponding groups of cold and room temperature as presented in Table 26 and Figure 5.

It is also clear from Figure 5 that the exponential (logarthimic) phase of growth starts around 10 months of age in each group.

It has been observed that the group B animals were increasing in weight faster than the group A animals upto February, 1987. But later on this pattern of growth in weight altered from March 1987 till August, 1987. This is due to death of some of the larger ones in group B. In any case, irrespective of the temperature of incubation (hot, room and cold) exponential growth was observed from ten months onwards.

5.2. *Growth in Length and Width*: After plotting age of the hatchlings, carapace length in each group of two batches of animals; it has been observed that the Group A animals increased in length equal to that of Group B upto February, 1987. But later on the Group A animals increased in size faster than that of Group B hatchlings. This increase in length continued till July, 1987. In any case as for the length, the exponential increase in carapace length started around ten months of age in each group (Table 27 and Figure 6).

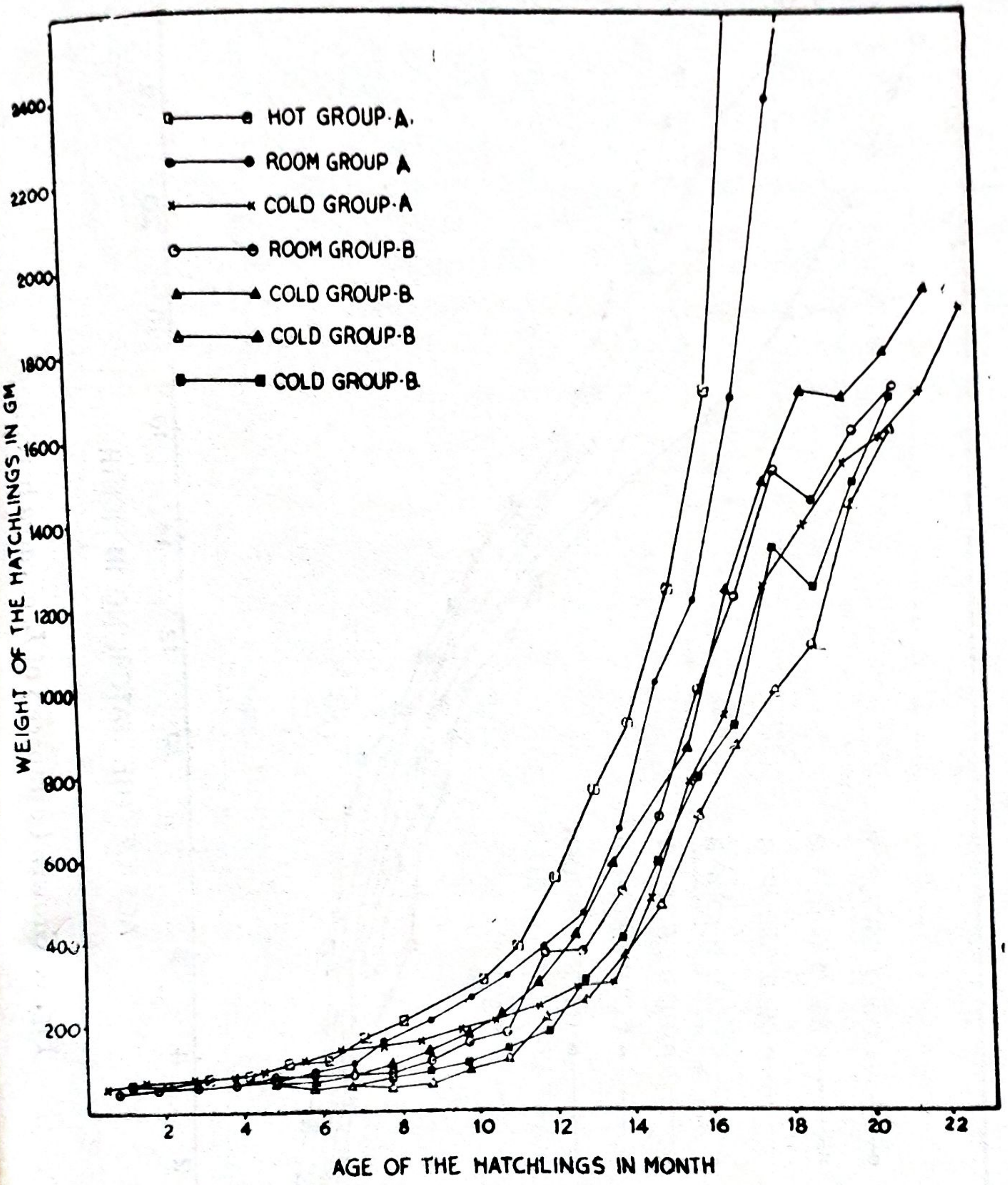


Fig. 5. Growth (weight) of *L. olivacea* hatchlings

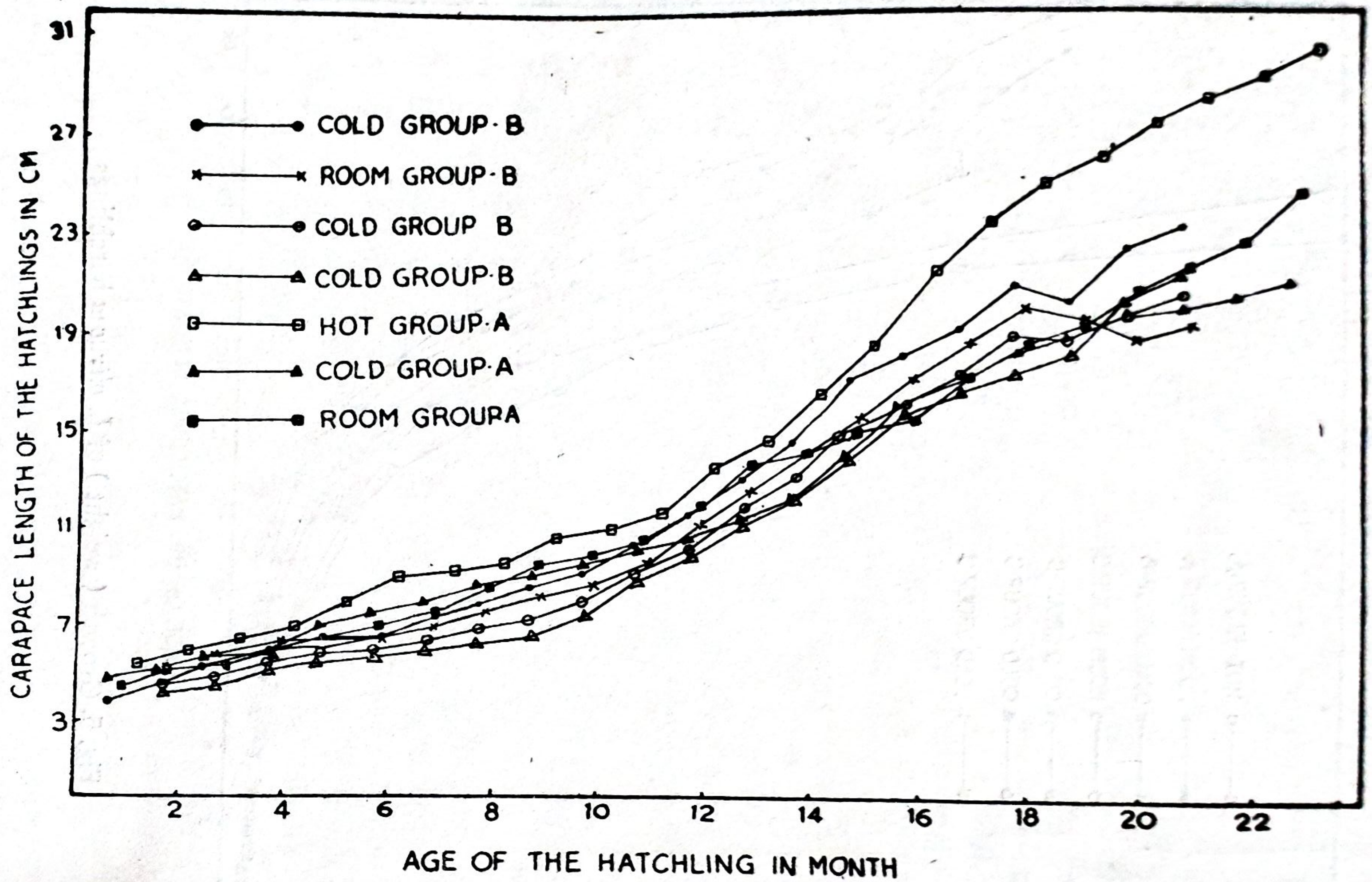


Fig. 6. Growth (carapace) of *L. olivacea* hatchlings

Table 26. Growth (weight in gm) of *L. olivacea* hatchlings

GROUP	NOV. 1986	DEC.	JAN. 1987	FEB.	MAR.	APR.	MAY.	JUNE	JULY	AUG.
A	132.5 ± 10.7	152.5 ± 10.3	188.3 ± 13.7	211.3 ± 10.5	281.6 ± 11.6	348.6 ± 26.8	453.3 ± 51.0	543.3 ± 70.9	790.0 ± 92.5	1143.3 ± 124.3
B	133.7 ± 15.2	157.5 ± 17.5	188.7 ± 26.8	226.3 ± 27.2	240.0 ± 26.8	301.6 ± 56.7	372.5 ± 67.6	422.5 ± 90.6	592.5 ± 94.3	658.0 ± 42.5

Group A—Period of hatching 22 to 24 March, 1986 Group B—Period of hatching 8 to 10 April,1986

Table 27. Growth (Carapace length in cm) of *L. olivacea* hatchlings

GROUP	NOV. 1986	DEC.	JAN. 1987	FEB.	MAR.	APR.	MAY.	JUNE	JULY	AUG.
A	9.2±0.4	9.7±0.3	10.2±0.2	10.3±0.2	11.2±0.2	12.0±0.3	13.4±0.6	14.4±0.3	16.0±0.4	17.8±0.2
B	8.8±0.4	9.6±0.4	10.1±0.5	10.3±0.5	10.8±0.6	11.5±0.7	11.9±0.3	13.4±0.9	14.5±0.8	15.8±0.4

Group A—Period of hatching 22 to 24 March, 1986 Gaoup B—Period of hatching 8 to 10 April, 1986

5.3. *Food* : A wide variety of fresh water fishes were given to the hatchlings. But only shrimps and small fishes were preferred and therefore, were given to the animals. The food was given at the rate of 1/10th of the body weight, once in a day, just after changing the water.

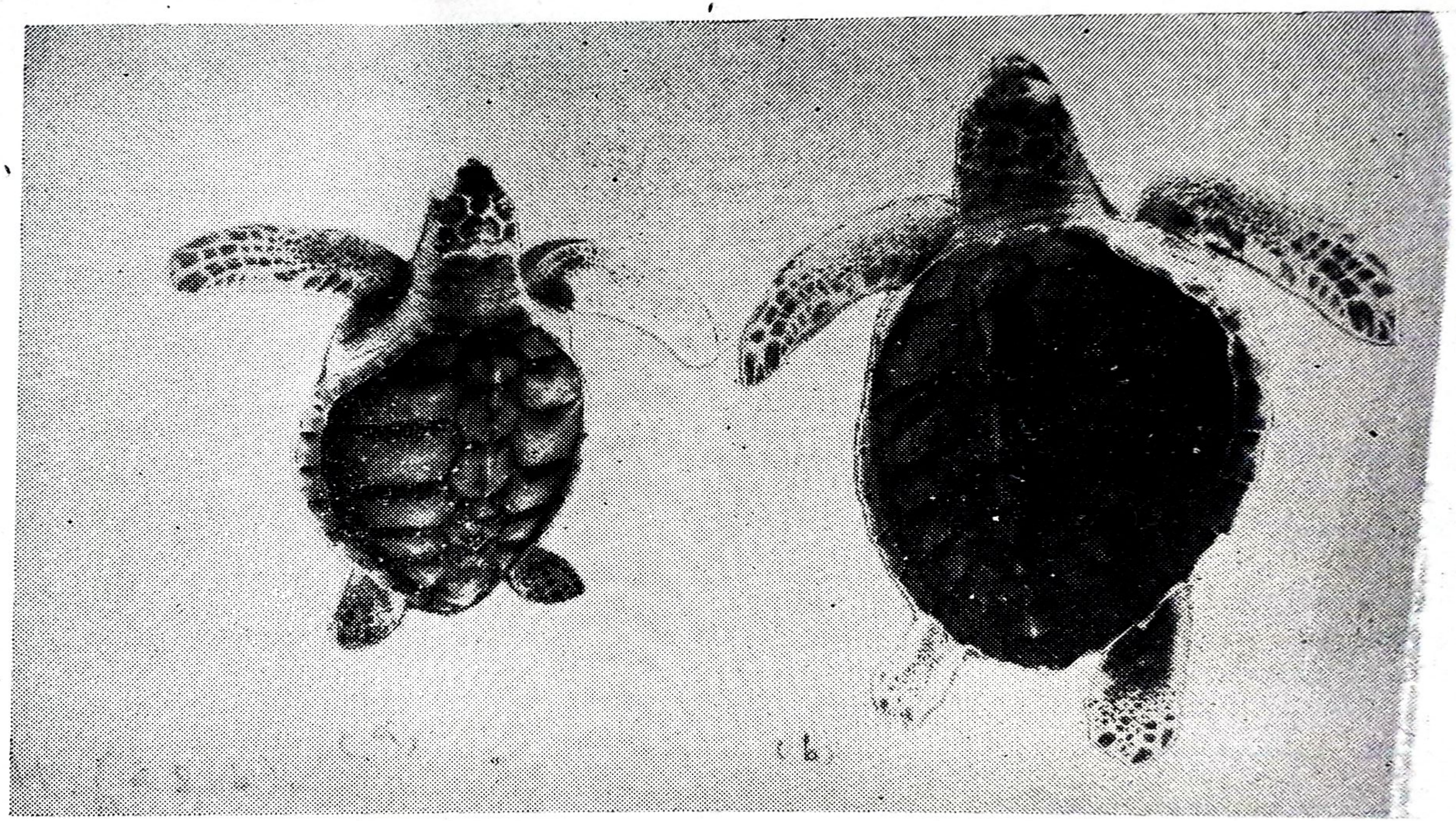
5.4. *Change of scutellation during development* : Change of scute pattern occurs during development in the olive ridley hatchlings. This change is either of fusion type or separation type. Irrespective of position (i.e. anterior or posterior or center) and type of scute (viz. central or lateral), changes start from an average age of 2 months. It has been seen that in every group of the hatchlings (e.g. cold, room and hot temperature), the scutellation may change. Detailed account of this change is described here.

In one cold incubated hatchling (code C_2 C_2, Table 28) two central scutes fused reducing the number of central scutes from 7 to 6.

In one room temperature incubated hatchling (code C_2 R_2) a central scute was formed in the position "4". Another small circular central scute was formed in the anterior most part of one incubated at hot temperature (C_1 H_1). In another hatchling (C_3 R, Table 29), number 4 of the right lateral(RL)fused with no. 5 from the upper half side. In this animal the two new laterals were formed from the last central. In another hatchling (C_3 C) the line separating the 4th and 5th lateral gradually disappeared leading to the fusion of the two into one.

Change of marginal scute was not found in any group of the hatchlings.

5.5. *Morphometrics and growth curves of embryos* : Growth of embryos was recorded based on measurements of weight, Total carapace length (TCL, straight), Crown-Rump length (C-R) and length of the fore flippers and hind flippers of the embryos of both warm (33°C) and cold (28°C) incubated eggs. They followed a more or less sigmoid curve (Figs. 8,9 and 10). The rate of change was slow at first, faster during the middle of the incubation period slowing down before hatching (stage 29). The carapace of the cold incubated embryos increased markedly after the day 31 (19^{+}Y) slowing down again after the day 42



H. Eighteen month old hatchlings
a. white **b.** normal pigmentation

Table 28. Change in scutellation during development in *L. olivacea* hatchlings
(Hatching 24 March to 9 April, 1986)

Code and temperature of incubation	Initial scute patterns LL, C, RL	Change scute patterns LL, C, RL	Age of the animal after change of the scute	Time taken to change the scute	Nature of change
C_1C_1 Cold	$6,5^{1*},6$	No	...		
C_1C_2 Cold	$8,8^2,8$	No			
C_2C_1 Cold	$5,5^1,6$	No			
C_2C_2 Cold	$6,7^1,6$	$7,6^1,7$	$3\ ^2/_3$ months	2 months	Reduction in Central
C_1R_1 Room	$8,6^2,8$	No			
C_2R_1 Room	$6,7^1,6$	No			
C_2R_2 Room	$6,6^1,6$	$6,7^1,6$	4 months	2 months	The no.4 of the Central scute was initially very small. Now it has increased in size and is distinct.
C_1H_1 Hot	$8,7^2,8$	$8,8^2,8$	$6\ ^1/_3$ months	4 months	The no.1 central scute was initially a minute one which later on developed as a circular one.

* = Pre-central RL = Right Lateral LL = Left Lateral C = Central

Table 29. Changes in scutellation during development in *L. olivacea* hatchlings
(Hatching 23 May to 8 June, 1986)

Code and temperature of incubation	Initial scute patterns LL, C, RL	Change scute patterns LL, C, RL	Age of the animal after change of the scute	Time taken to change the scute	Nature of change of scute pattern
C_3R Room	5,6[1],*5	6,6[1],6	6 months	6 months	No. 4 right lateral is in the process of fusion. From the upper side, half of the scute is found fused with the no. 5 RL. Two new laterals are found being seperated from the last central.
C_3C Cold	6,8[1],7	6,8[1],6	...	...	No. 4 & 5 right lrteral is in the proces of fusion
C_5H Hot	7,5[1],7	No	...	...	...
C_3H Hot	5,6[1],6	No	...	...	...

*= Pre-central RL = Right lateral LL = Left lateral C = Central

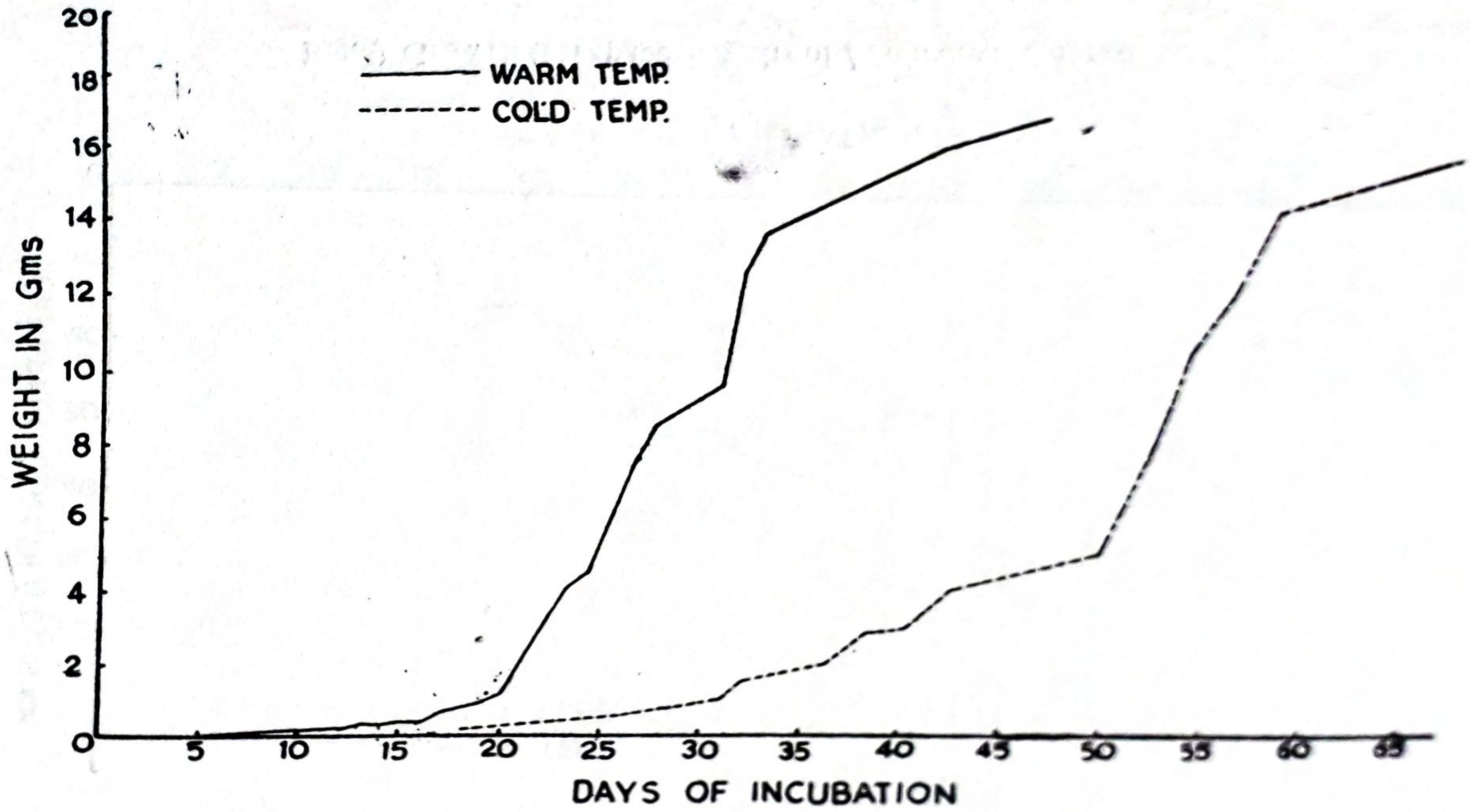


Fig. 8. Growth (weight) of *L. olivacea* embryos

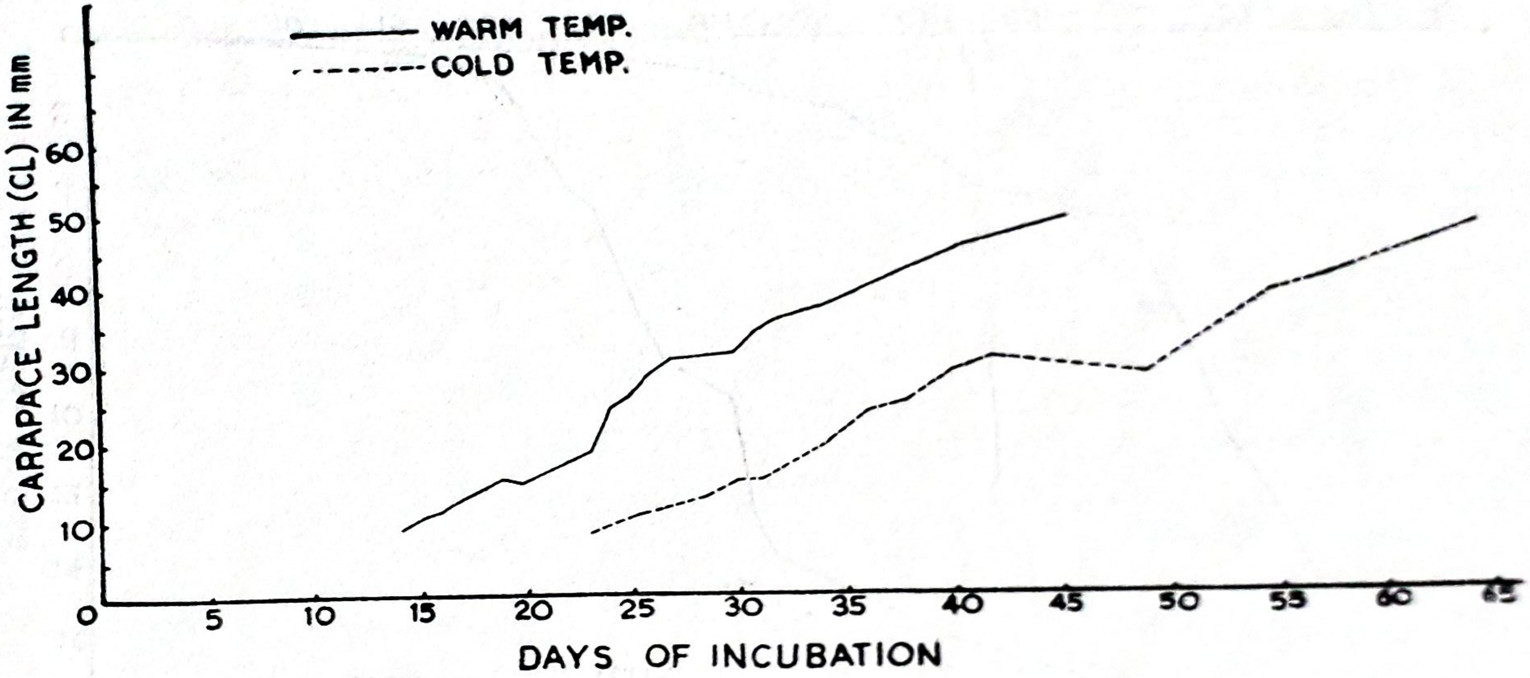


Fig. 9 Growth (carapaee length) of *L. olivacea* embryo

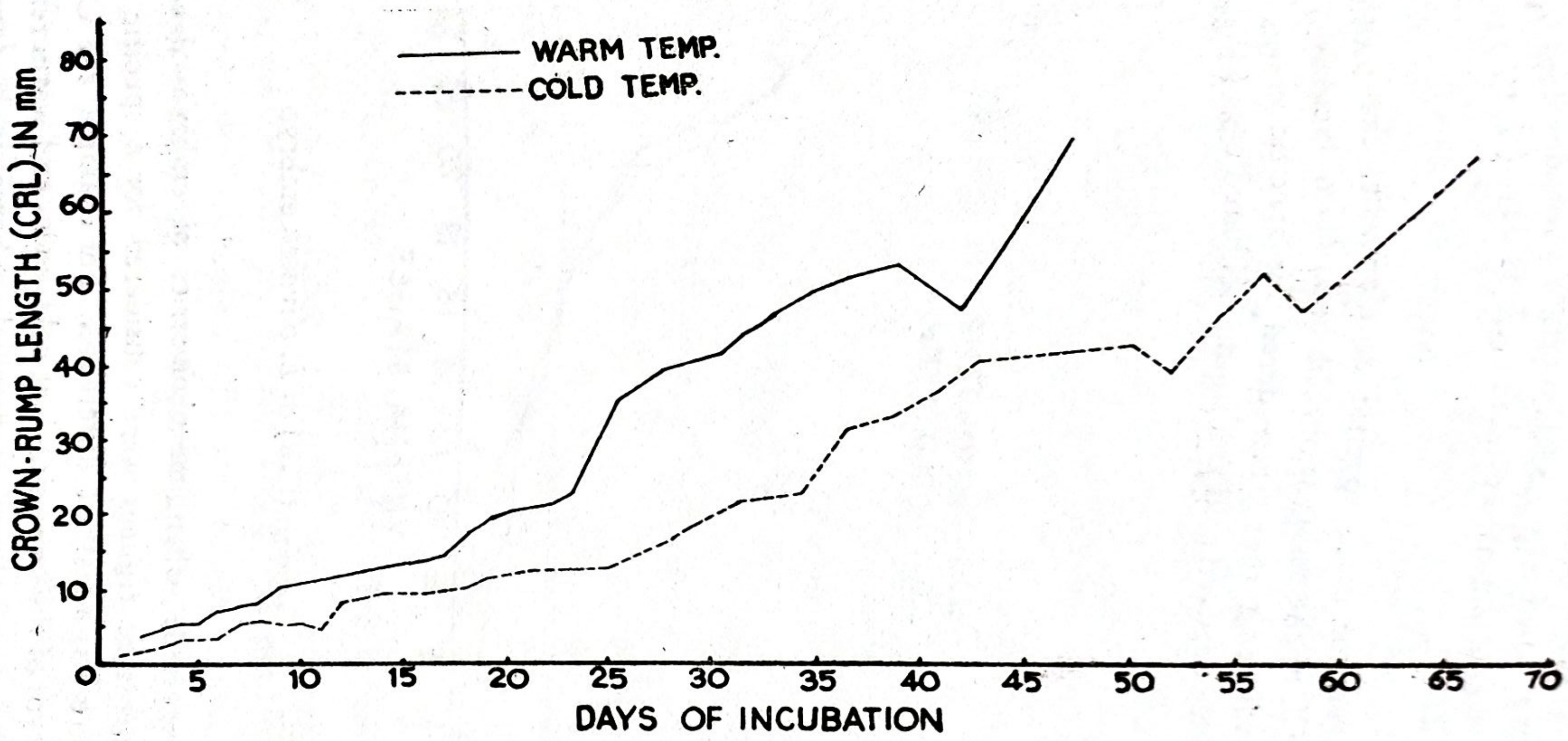


Fig. 10 Growth (C-R length) of *L. olivacea* embryos

(22Y). In warm temperature, the weight increased markedly after 20 days (19⁺Y), slowing down after 32 days (23⁺Y) of development. In cold temperature, weight increased marked after 31 days (19⁺Y) slowing down after 57 days (25 Y).

However, for stage specific development, the profile for C-R lengths and TCL of the embryos of cold and warm incubated eggs were overlapping, indicating that if considered for specific stages there is no marked difference between cold and warm incubated eggs (Figs. 11, 12).

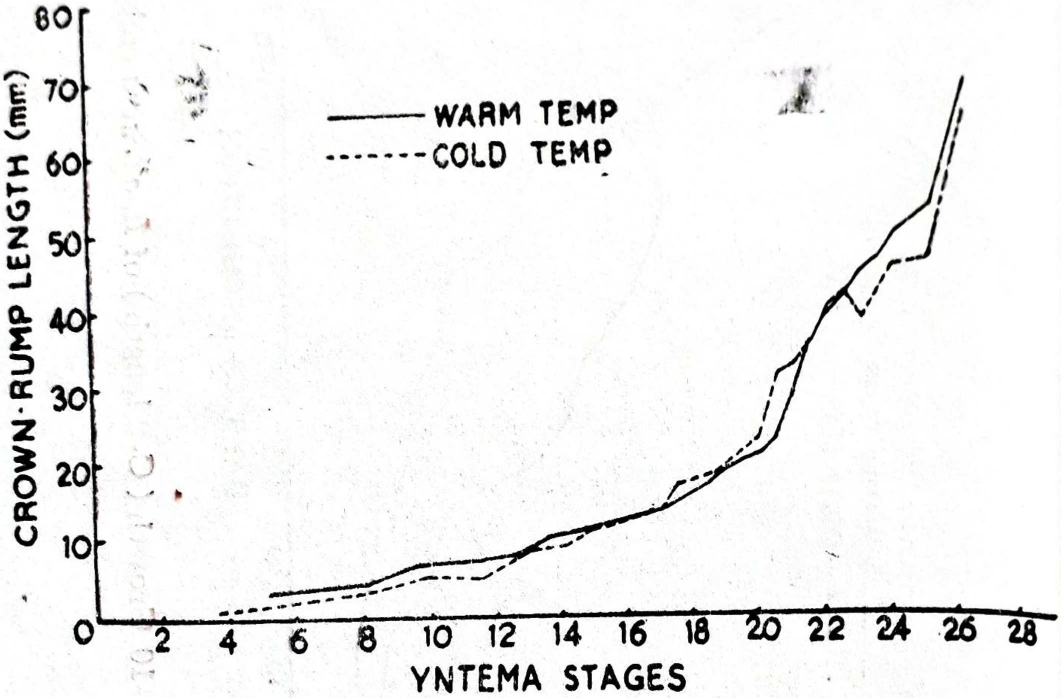


Fig. 11. Growth (C-R) of *L. olivacea* embryo

As expected, when morphometrics of embryos developing at different temperature regimes were considered for a specific period of incubation, there was a marked difference. For example the C-R lengths of 16 day embryos of the same clutch at cold, room and warm temperatutes were 9 mm, 9.5 mm and 11 mm, respectively whereas in 23 days the C-R length of the embryos of these three temperature regimes were 11.5 mm, 14.5 mm and 21 mm, respectively.

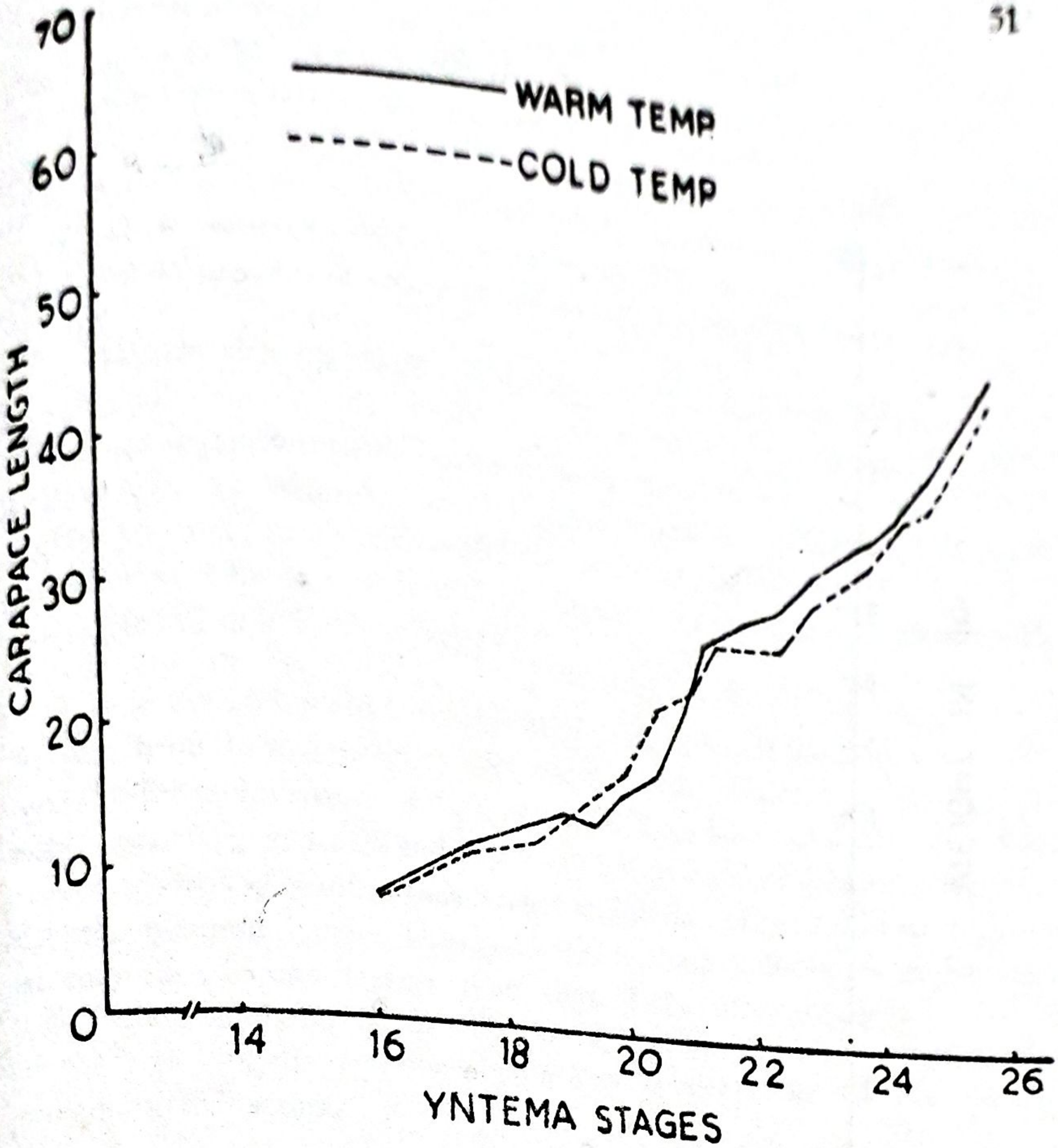


Fig. 12. Growth (Carapace) of *L. olivacea* embryo

A positive correlation existed between total carapace length and plastron length (r=0.63), crown-rump length and total carapace length (r=0.98), and total carapace length and weight (r=0.93). A positive correlation (r=0.46) was obtained between crown-rump length and weight (Fig. 13).

During the early stage of development up to 16 Y (stage 21), the rate of development at warmer temperature (33°C) was about 2 times that at lower temperature (28°C). This decreased upto 21 Y (stage 30) to 1.5 times. From 24 Y (present stage 35) onwards till hatching, the rate of development was the same.

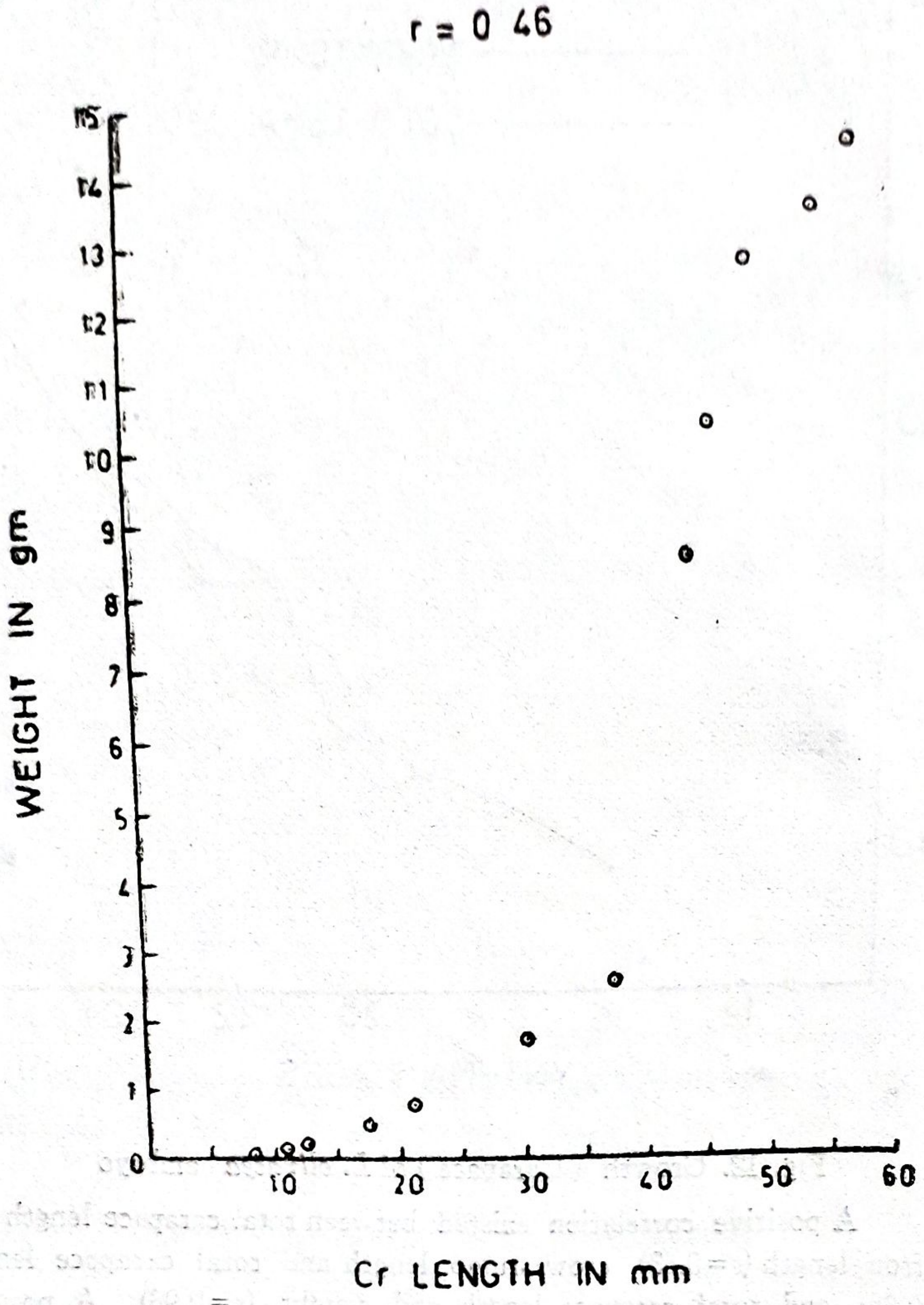


Fig. 13. Correlation between weight and Cr length in *L. olivacea* embryo

5.6. *Serum protein patterns of hatchlings* : Studies on serum protein patterns in young hatchlings of sea turtles have not yet been reported though data concerning biochemical and physiological changes in reptiles do exist (Bennet and Dawson, 1976; Dessauer, 1970). A quantitative assay of serum parameters like total protein, total cholesterol, inorganic phosphorus and phospholipidphosphorus in young female hatchlings of *L. olivacea* has been studied where a serum protein amount of 4.31±0.026 gm/100 ml, was noted for 8-13 day old hatchlings (Mohanty-Hejmadi et al., 1984). It has been reported that proteins make up about 5% of blood plasma in reptiles (Dessauer, 1970). In this study, an attempt was made to note the serum protein patterns of young hatchlings of *L. olivacea.*

Bands showing mobilities in the range of 0.92 to 0.94 were designated as albumin on the basis reported by Mohanty-Hejmadi, 1970. Following the same method, bands showing mobilities in the range of 0.53 to 0.78 were α-globulins, those showing mobilities of 0.14 to 0.28 were β-globulins and bands with mobilities of 0.06 to 0.09 were γ-globulins. Quantitative differences as judged by intensity of staining and band-width were observed in individual gels.

In the 14-day old hatchling all 7 protein bands were observed; one albumin band having mobility 0.94 was noticed. There were 3 α-globulin bands having mobilities, 0.57, 0.70 and 0.74. Two bands of β-globulins with mobilities of 0.20 and 0.28 and one γ-globulins band of 0.08 mobility were noticed. The α-globulin bands having mobilities 0.70 and 0.74 were denser than the albumin band. The band-width of a β-globulin band having a mobility of 0 28 was greater than that of the other bands followed by 0 08 of the γ-globulin band. This is indicative of a high concentration of the two globulin fractions and a low concentration of the albumin protein in the serum.

In the 18-day old hatchlings, five protein bands occured. Out of these, one was an albumin band having mobility 0.92, two α-globulin bands with mobilities 0.54 and 0.78, a β-globulin band of mobility 0.18 and a γ-globulin band having mobility 0.06. Here the band-width of the α-globulin (mobility, 0.54) was greater than that of all the other bands.

In the 24-day old animals, six protein bands were observed. One albumin band having mobility 0.93 occured along with two α-globulins having mobilities 0.53 and 0.75, two β-globulin bands of mobilities 0.14 and 0.21 and a single γ-globulin band of mobility 0.09. The band-width of the α-globulin (mobility, 0.53) was greater than that of the other five bands (Fig. 14).

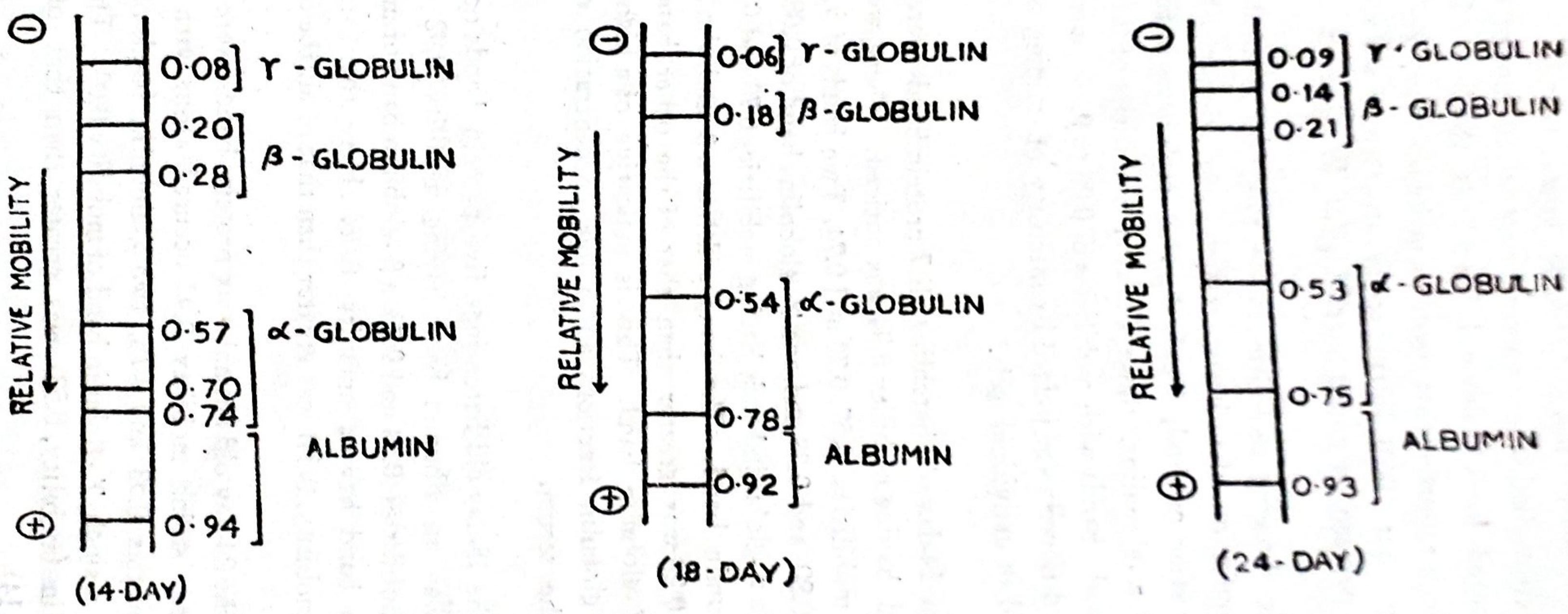


Fig. 14 Electrophoretic serum protein bands of *L. olivacea* hatchlings

6. DEVELOPMENTAL DEFECTS

Abnormal development of reptiles has received little attention (Ewert, 1979). However, it has been reported that in marine turtles, the frequency of occurance of abnormal embryos and hatchlings is very low. Mc Ghee (1979) has reported 0.6% and Blanck and Sawyer (1981) have reported 1% defect during embryonic development in the loggerhead *Caretta caretta*. The common malformation is the variation in scale patterns (Carr, 1952; Hughes, 1970). Other malformations include disproportionate growth of limbs, crumpled neck with reduced carapace, depigmentation of eye, malocclusion of jaws and deformation of head. Although, several workers (Crastz, 1982; Mc Coy, 1983; Mohanty-Hejmadi *et al*, 1985) have described the development of the olive ridley *L. olivacca*, no neports are available on the frequency or nature of malformations for this species. During the study of embryology and development of *L. olivacea*, several malformations were observed which are reported here.

During candling, a total of 78 eggs showed haemorrhage. About 1% of the haemorrhaged eggs revived but the rest of the embryos died within two to four weeks of incubation. Although most of the hatchlings had 6 to 7 central scutes, 5% of the hatchlings had only 5 central scutes. One hatchling (0.33%) had only four central scutes with an elevated carapace giving it a hunch-back appearance.

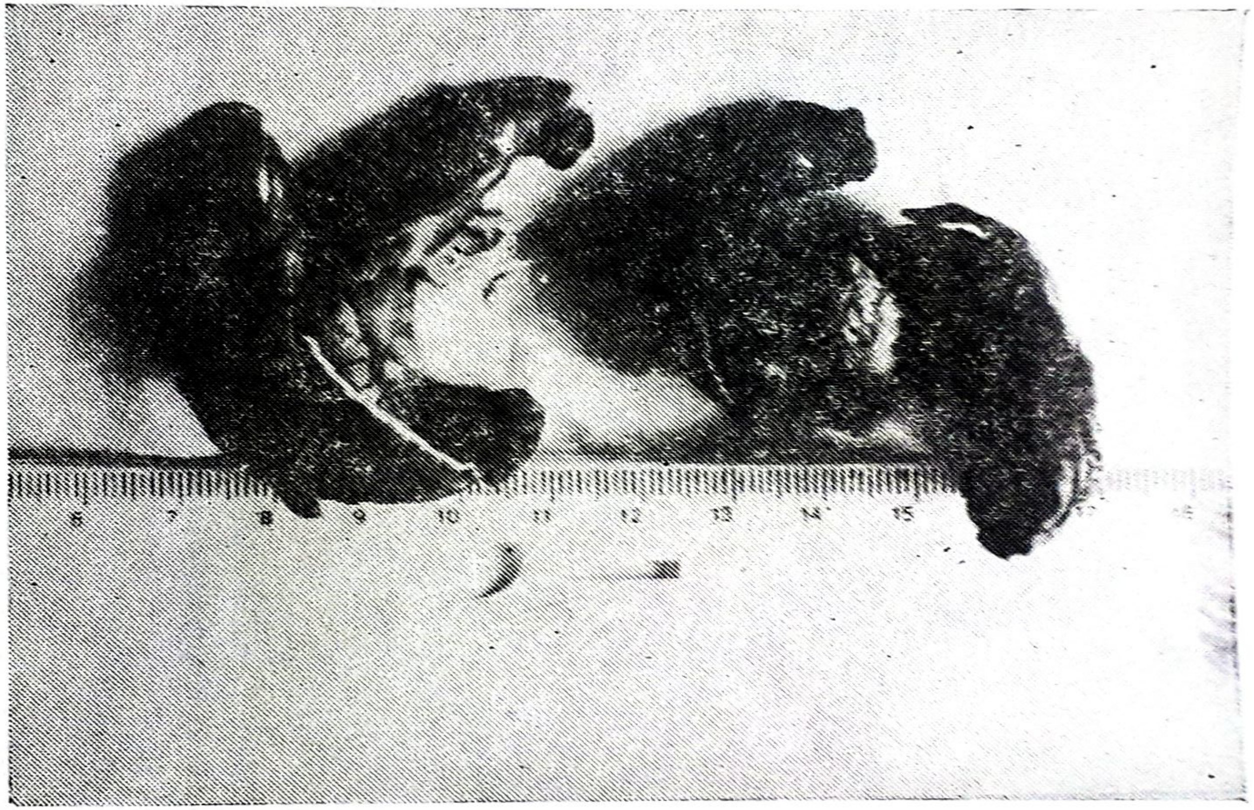
Five embryos (0.9%) which died before stage 22Y (Yntema) had disproportionate forelimbs. Two of these had a long right forelimb with unusual digitation and a paddle-shaped left forelimb. Two embryos (0.39%) which died at stage 16 Y had depigmented eyes. Interestingly enough, five embryos were found dead before three weeks of incubation without any distinct cephalisation out of which two had well developed tail processes. Seventeen embryos (3.4%) which died pre-natally had a long, wide crumpled neck with reduced carapace. By stages 20-22 Y under normal circumstances, the pigmentation of lateral laminae precedes that of marginal laminae, however, during the present study, some embryos developed pigmentation in the reverse order. No difference was observed in the percentage of abnomal development in the three temperature regimes.

As reported in the introduction, the percent of abnormality reported in the sea turtles is very low. In the present study, 5.8% abnormality was observed which is higher than that for the loggerhead (Mc Ghee, 1979; Blanck and Sawyer, 1981). The incubation temperature does not affect the frequency of malformation.

Table—30 Frequency and nature of malformation in *L. olivacea*

Year	Condition of Incubation	Eggs Incubated (N)	Haemorrhaged Eggs (N)	MALFORMATION Limb Deformities (N)	Eye Deformities (N)	Crumpling of Neck (N)	Head Deformities (N)	% of Malformation
1984	HOT	58	16	2	—	3	2	12.0
1984	COLD	98	10	—	1	4	—	5.1
1984	ROOM	80	5	—	—	2	1	3.7
1985	HOT	70	15	1	—	1	—	5.8
1985	COLD	110	14	-	1	3	1	4.5
1985	ROOM	87	18	2	—	4	1	8.0

(N) = Number



1. Twin embryos

7. BEHAVIOUR OF THE HATCHLINGS

Under laboratory conditions, behaviour of the hatchlings was observed under the following categories :

(a) Response to food

(b) Response to change of water

(c) Response to materials other than food

(a) *Response to food* : After the external yolk sac gets completely absorbed, the hatchlings take around 4-6 days to feed by themselves. They will not accept any food during this time. In fact, they reject food even if they are force-fed before 4-6 days. The hatchlings try to catch the food at the bottom by their beaks taking a slight backward and then forward dive in the water. During the first few days (15-20), the aim in catching food is not accurate in the first attempt. But later on, it is gradually perfected.

(b) *Response to change of water*: If food is given just after changing water, then hatchlings get conditioned to feeding. Therefore, a few days later, after water is changed, they " beg " for food by beating their flippers and moving towards any person passingby or standingby. After 2-3 months, the juveniles start responding to food outside the water. When a piece of fish food is hung 1-2 inches above the water surface, the juveniles try to jump at it with their beaks open, beating their fore flippers and lifting the front part of the body.

(c) *Response to materials other than food* : When instead of food any thing else like pieces of paper, wood etc. are given, they also behave similarly. But after they bite the materials 2-3 times, they turn away and do not attempt to feed any more.

Biting one another occurs when food is insufficient or under crowded conditions. Otherwise, this is a very rare phenomenon among them. But in one or two cases, it has been observed that certain hatchlings are comparatively more aggressive. They dominate over their co-inhabitants and take more food and therefore, grow remarkably. This behaviour is checked only by isolating the animals from the rest of the population.

8. DISEASES AND MORTALITY

8.1. *Diseases in laboratory reared turtles* : Since 1983, this laboratory has been conducting sea turtle research. Olive ridley sea turtles designated as an endangered species, are raised in captivity.

In nature, olive ridley hatchlings are highly vulnerable to mortality, primarily through predation. Rearing them in the laboratory was undertaken, so that experience could be gained for future application to the endangered ridleys.

In February, 1986 the first batches of eggs were callected from Gahirmatha. After hatching, they ware reared in the laboratory with sea-water and fish food was supplied to them. They were kept in plastic tubs, the diameter ranging from 12 to 20" depending upon the population size. The second batches were collected during April and the hatchlings were maintained accordingly. Hatchlings from hot, cold and room temperature incubation were also obtained.

During May-June which is the peak of summer, a good number of hatchlings had died during the previous years due to unknown reasons. It was thought that temperature played the main role. This type of mortality with no symptoms was probably equivalent to " Sudden hatchling death " (SHD) Syndrome reported in Loggerhead sea turtles (Clary and Leong, 1984), But in 1986, there was intermittent rain during the summer and no such mass death was noted. In 1987 however, mass death occured again.

Other commonly reccurring diseases are skin lesions, eyelid infections, emaciation which have also been reported in case of Loggerhead sea-turtles (Leong, 1979).

In skin lesions, the causative agent is not known yet. The lesion appears as a pin-head first on the neck region. Then it enlarges and affects the neck (skin folds) dorsally and laterally in many places. The affected skin looks white and crusty. After 3-5 days, the turtles stop feeding, float with little limb movement and here-after emaciation starts. Then it dies within 5 days, if not treated.

When Gentian violet was tried on the lesions, the next day it shed the crust exposing the delicate dermis underneath. Continuous treatment, however, did ot save them from death or make them take food.

Nevertheless, there were no further lesions on the skin. Force-feeding was tried on these turtles but they refused the food.

An anti-fungal ointment was also tried. It did not seem to cure the disease though there was no further lesions. Thé mortality rate was the same as in the case of untreated individuals.

Terramycin injections (0.01-0.02 ml) daily proved to be fruitful since after much infection, turtles accepted food which saved them from becoming emaciated. This cheeked mortality within one month. There was no record of full recovery of the hatchlings in terms of the lesions but they were active and feeding until sacrificed for cytological experiments. The controls receiving no terramycin died earlier. Emaciation is fatal as has been noticed in Atlantic ridleys (Leong, 1979).

Biting injuries mainly at the angle of body and flippers are not unusual. Gentian violet application cures it. But in one case (3 months old) a pin head-like bite in the left cheek increased in size and became 15 mm in diameter within 15 days. It was treated with rectified spirit and $KMnO_4$ washings. For 22 days it grew like a malignant one. Gentian violet cured it completely within 23 days of daily treatment. During the disease, the turtle was very active and did not lose weight. Some times (in only two turtles), there is eye-infection which appears as a white mass on the eyeball closely attached to it. When scratched by a forceps or blunt scalpel it is detached and comes off with difficulty. These turtles never feed. So naturally, the condition becomes fatal. Force-feeding is not successful. This eye-diaease occurs more frequently if the turtles are kept in fresh water or artificial sea water.

Out of two 4-month old hatchlings growing rapidly, one suddenly stopped feeding and died. The cause was unknown. Autopsy showed that the intestines were solid when touched. Probably, this was due to constipation as reported in Loggerhead turtles (Leong, 1979). Laboratory work indicated that the primary requirements for disease treatment and control were clean water and isolation of sick turtles.

Only in the second batch of hatchlings (eggs collected during April), skin lesions were marked. The first such lesions appeared in the hot group, then in room temperature group and lastly in the cold temperature ones. This indicates that at a particular age they may be prone to certain microbial agents or that after being kept for a certain period under laboratory conditions, they are being infected.

8.2. *Mortality of adults in nature* : Around 100 carcasses were found from Satbhaya Ekakula Nasi along a stretch of 20 kms., killed during the mating season from November to December, 1986. Further, during the period from 20th January to 20th February considerable number of dead turtles were found in the beach. Specifically during the new moon time a large number of dead turtles could be seen floating in the sea. Within a day or two they were thrown on the sea beach. On 8th and 9th February, around 250 carcasses were found on the beach. Out of these, most were females. Most of these were found with pieces of net on their fore flippers and the head. In some, the carapace was broken. Obviously these animals were caught and killed during fishing. Interestingly enough during the period when the coast guard ships "Kittur Chenma", and "Rama Devi" and the Forest Department trawler "Bahal" were patrolling the coast, there were no dead turtles. It is after the patrolling boats went away that considerable number of trawlers (upto 30 at one time) and fishing boats were seen and the dead turtles were found indicating that the mass death during this period was not due to natural causes but due to fishing activity in the area.

Cumulative figures for mortality from 1986 to 1989 are presented in table 30.

Table 30. Cumulative account of dead turtles

Year	♀	♂	Total
1986	285	98	383
1987	280	236	516
1988	1450	246	1696
1989	430	25	455

9. PARASITES AND COMMENSALS

During the field studies on the mass nesting in March, 1987; Commensals and ectoparasites were collected from the carapace and body of nesting turtles (Mohanty-Hejmadi *et al.*, 1989). It is intestering to note that there was no trace of any commensal or ectoparasites on the anterior part of the carapace probably because this area is continuously rubbed by the fore-flippers of the turtles while swimming in the sea. Most were found on the posterior part of the carapace.

The following is a list of animals collected which includes five from the phylum Coelenterata, one each from Porifera and Arthropoda. The classification has been done as far as possible.

1. Phylum : Coelenterata
   Class : Hydrozoa
   Order : Hydroidae
   Genus : *Bougainvillia*

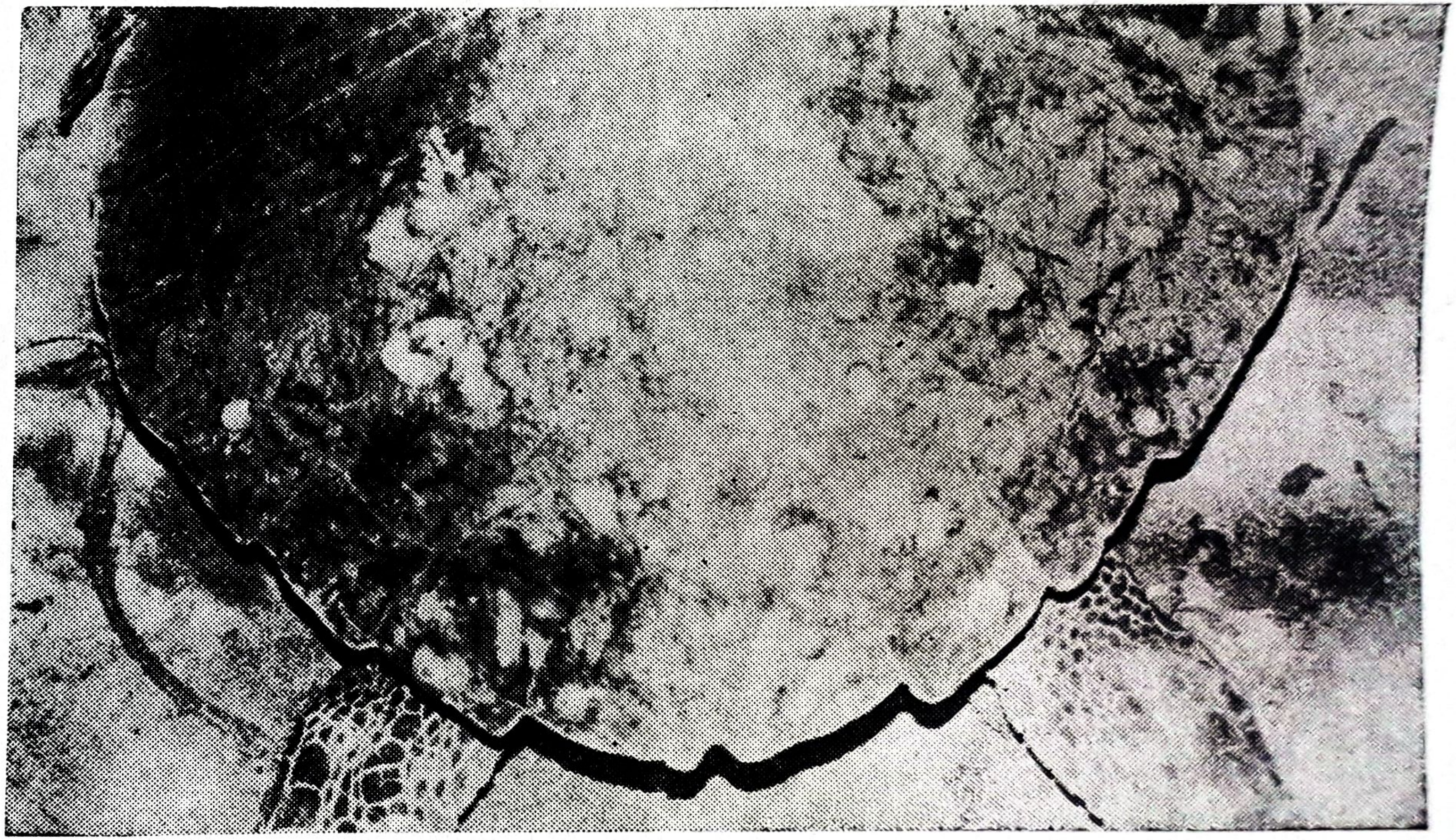
2,3,&4. Phylum : Coelenterata
   Class : Anthozoa
   Sub-class : Zoantharia (Hexacorallia)
   Order : Actiniaria
   Genus ; *Metridium*
   Genus : *Adamsia*
   Genus : Unknown (Yet to be identified)

5. Phylum : Coelenterata
   Class : Anthozoa
   Sub-class : Alcyonaria
   Order : Stolonifera
   Genus : Unidentified

6. Phylum : Porifera
   Class : Demospongia
   Sub-class : Monaxonida
   Order : Halichondrina
   Genus : Unidentified

7. Phylum : Arthropoda
   Class : Crustacea
   Order : Thoracica
   Genus : *Balanus*

In response to our publication (Mohanty-Hejmadi, *et al.*, 1989), Dr. J. C. den Hartog, Curator of Coelenterata RMNH, Leiden; wrote to say that he has doubts about the identification of *Metridium* as it is not known to occur in the Indian ocean. We have sent the materials to him for examination. If our identification is correct this is the first clue regarding the migration patterns of this population. In other words, these turtles spend considerble time away from the Indian ocean.



J. Commensals on the posterior part of carapace of *L. olivacea*

EPILOGUE

Upto the early 1970's, our knowledge on the sea turtles that visited the coasts of India, remained limited. However, the endangered status of the sea turtles, led to a spurt of activities and therefore, we have access to considerable data on the activities of the sea turtles when they visit their nesting grounds. Unfortunately, our knowledge of the habits, migratory patterns and activity of the turtles as well as hatchlings; is negligible. In addition to the present study, there has been some other important work and it is proper that they are discussed briefly here to familiarise workers in this field to the state of the art.

One of the most important work which gives an insight to the turtle trade activities in Orissa is by Biswas (1982) who carried out surveys in the Orissan coast in the 1970's. He reported that the most common and commercially important turtle occurring in the Bay af Bengal is the Olive ridley *L. olivacea* which is one of the most exploited turtles during the breeding and nesting season from November to March. He reported four major nesting grounds for the Olive ridley namely, the Brahmani and Baitarani river deltas, Puri-Balukhanda, Konarka-Chandrabhaga and Chandipur-Burabalanga estuary. The sea facing delta of Brahmani and Baitarani in Cuttack district includes Gahirmatha and Satbhaya nesting grounds. Gahirmatha, at the mouth of Dhamara river where it opens into the sea, remains one of the most important nesting grounds till today.

The Puri-Balukband used to be the most important turtle fishing centre in Orissan coast. Biswas (1982) has reported that the local consumption was negligible however, turtles were shipped to Calcutta market regularly from Puri railway station. Any one visiting Puri, could not miss the turtles being carried upside down on trawley rickshaws towards the railway station. What is interesting is that the address to which they were being shipped (to Calcutta ofcourse), were written on their plastron. Biswas reports that a total of 6190 turtles were despatched from Puri and a total of 149 from the nearby Malatipatpur railway stations during November 1974 to January 1975. At present due to protection of these turtles, there is no official trade in these turtles. Sporadic nesting does continue in the Puri-Balukhand area.

Biswas (1982) also reports that turtles from Vitorkanika (Bhitarkanika) sanctuary used to be brought to Chandbali by boat and then on to Bhadrak railway station from where it used to be shipped to

Calcutta. In addition, boat loads of turtle eggs collected from Bhitarkanika area used to be shipped to Calcutta market. According to Dash and Kar (1987), the collection of eggs continued upto April, 1975 when Bhitarkanika area was declared as a sanctuary; by paying a revenue of Rs. 15/- per boat load containing 35,000 to 1,00,000 eggs.

In 1974, Government of Orissa set up a modest Turtle research station in Gahirmatha. Dash and Kar (1990) have compiled the data collected on different parameters from 1974 to 1983. We started our work in this area from 1984 and the data is complied in the present monograph. During this period several workers have also carried out periodic studies in this area out of which mention should be made of Dr. Silas and his group from Central Marine Fisheries Research Institute, Cochin who conducted a very timely workshop on sea turtle conservation in 1984 (Silas, 1984).

Coming to the present status, although trade in turtle and eggs are not there any more, considerable number of turtles are dying due to fishing activities in this area. Even then, if one considers the number of nesting turtles from year to year, it is reasonable to say that the population nesting in Gahirmatha has not been adversely affected by these activities. However, one of the major concern for the population is the drastic geographical change in the main nesting area the NASI end of Gahirmatha which is now cut off from the main-land. This area is extremely prone to cyclonic storms and inundation. This means considerable damage to eggs and hatchlings. It is necessary to assay these aspects now so that alternative arrangements can be made for mass transfer and incubation of eggs in appropriate places.

A modest Turtle Research Station has been set up at NUANAI near Puri by the Forest Department, Government of Orissa. Here turtles are growing in captivity and drawing a large number of public. Hopefully, this can develop into a full-fledged Turtle farm atleast to raise the consciousness among common people regarding the plight of the endangered sea turtles.

Last but not the least, we have no idea about the migratory habits of this pooulation. As pointed out by Frazier (1987), one of the mysteries is the source of these countless number of ridleys and to quote him "only detailed and long-term studies will provide the answer". I personally feel that satellite-tagging is necessary to solve the mystry for once and all.

REFERENCES

BEHERA, M. 1989. Ontogenic development with special reference to sex differentiation in the olive ridley sea turtle *Lepidochelys olivacea* (Eschscholtz) Ph. D. dissertation, Utkal University, India.

BEHERA, M. and P. MOHANTY-HEJMADI, 1985. Developmental defects in the sea turtle *Lepidochelys olivacea*. Pranikee 6 : 71-74.

BENNET, A. F. and W. R.DAWSON. 1976. Metabolism, pp. 127-223. In C. Gans (ed.) Biology of the Reptilia. Vol. 5. Academic Press, London and New York.

BHUNYA, S. P. and P. MOHANTY-HEJMADI.1986. Somatic chromosome study of a sea-turtle, *Lepidochelys olivacea* (Chelonia, Reptilia) CIS. 40 : 12-14.

BHUNYA, S. P. and T. SULTANA. 1979. Somatic chromosome complements for four passerine birds and their karyological relationship. Caryologia. 32 (3) : 299-309.

BICKHAM, J. W., J. J. BULL and J.M. LEGLER. 1983. Karyotypes and evolutionary relationship of trionychoid turtles. Cytologia 48 : 177-183.

BISWAS, S. 1982. A report on the olive ridley *Lepidochelys olivacea* (Eschscholtz) (Testudines : Cheloniidae) of Bay of Bengal. Rec. Zool. Surv. India, 79: 275-302.

BLANCK, C. E. and R. H: SAWYER. 1981. Hatchery practices in relation to early embryology of the loggerhead sea turtle *Caretta caretta* (Linne). J. Exp. Morph. Biol. Ecol. 49 : 136-177.

BULL. J. J, 1980. Sex determination in reptiles. Quart. Rev. Biol. 55, 3-21.

BULL, J. J. and R. C. VOGT. Temperature dependant sex determination in turtles. Science, New York. 206, 1186-1188.

BULL, J. J. and R. C. VOGT. 1981. Temperature sensitive periods of sex determination in emydid turtles. J. Exp. Zool. 218, 435-440.

BUSTARD, H. R. 1971. Temperature and water tolerance of incubating sea turtle eggs. Brit. J. Herpetol 4, 196-198.

BUSTARD, H. R. 1976. World's largest sea turtle rookery. Tiger Paper 3 : 3.

BUSTARD, H. R. and P. C. GREENHAM, 1968. Physical and chemical factors affecting hatching in the green sea turtle. *Chelonia mydas* (L). Ecology 49, 269-276.

BUSTARD, H, R., K. SIMKISS and J. JENKINS. 1969. Some analysis of artificially incubated eggs and hatchlings of green and loggerhead sea turtles. J, Zool. Lond. 158 : 311-315.

BUSTARD, H. R. and C. S. Kar. 1981. Annual nesting of the Pacific ridley sea turtle (*Lepidochelys olivacea*) in Orissa, India. Brit. J. Herpetology 6 : 139.

CALDWELL, D. K. and D. S. ERDMAN. 1969. Pacific ridley sea turtle, *Lepidochelys olivacea*, in Puerto Rico. Bull, So, Calif. Acad. Sci. 68 (2) : 112.

CARR, A. 1952. Handbook of turtles. The turtles of United States, Canada and Baja California, Cornell Univ. Press. Ithaca.

CLARY, JOHN, C. III and JORGE K. LEONG, 1984. Disease studies aid Kemp's Ridley sea-turtle head start research. Herp. Review 15 (3) : 69-70.

CRASTZ, F. 1982. Embryological stages of the marine turtle *Lepidochelys olivacea* (Eschscholtz) Rev. Biol. Trop. 30 , 113-120.

DAVIS. B. J. 1964. Disc electrophoresis. II. Method and application to human serum proteins. Ann. N. Y. Acad. Sci. 121 : 404-427.

DESSAUER, H. C. 1970. Blood Chemistry of reptiles : physiological and evolutionary aspects. pp. 1-72. In C. Gans (ed.) Biology of the Reptilia. Vol. 3. Academic Press, London and N. Y.

DASH, M. C. and C. S. KAR. 1987. Conservation and management of sea turtle reserves in Orissa coast. Environment and Ecological Zoology. Acad. Env. Biol. India. 303-316.

DASH, M. C and C S. KAR. 1990, Gahiramatha - Turtle Paradise. Imprint Publications, New Delhi, India.

DIMOND, M. T. and P. MOHANTY-HEJMADI. 1983. Incubation temperature and sex differentiation in a sea turtle. American Zoologist, 23 : 1017.

EWERT, M. A. 1979. The embryo and its eggs ; development and natural history. In turtles : Perspectives and Research (M. Harless and H. Marlock, eds.) J. Wiley and Sons, New York, pp. 333-413.

FLWLER, L. 1979. Hatching success and Nest Predation in green sea turtle, *Chelonia mydas* Tortuguero, Costa Rica. Ecology 60, 946-955.

FRAZIER, J. 1987. In search of Kurma, Span Magazine, November issue.

HIRTH, H. and A. CARR. 1970. The green turtle in the gulf of Aden and Seychelles islands. Verhandeligen der Koninklijke Nederlands Akademie, LVIII (5) : 3-44.

HUGHES, G. R. 1970. Further studies on marine turtles in Tongaland., 3 Lammergeyer 12 : 7-25.

KAR, C. S. 1980. The Gahirmatha turtle rookery along the coast of Orissa, India. Marine Turtle Newsletter 15 . 2-3.

KAR, C. S. and S. BHASKAR. 1982. The status of sea turtles in the eastern Indian Ocean. In : Bjorndal, K (Ed.)—The biology and conserva tion of sea turtles. Smithsonian Institute Press, Washington, pp. 365-372.

KAR. C. S. and M. C. DASH. 1984. Mass nesting beaches of the olive ridley *Lepidochelys olivacea* (Eschscholtz, 1829) in Orissa and the behaviour during an arribada. Proceedings of the workshop on sea turtles conservation. In : E. G. Silas (Ed.), CMFRI, Cochin, No. 18 pp. 36-48.

KAR, C. S. and M. C DASH. 1984. Conservation and status of sea turtles in Orissa. Proceeding of the workshop on sea turtle conservation—*Ibid*, pp. 93-107.

LEONG. J. K. 1979. Hatchling diseases in Atlantic ridley turtle (*Lepidochelys kempi*) and Loggerhead turtle (*Caretta caretta*) in the Galveston Laboratory, National Marine Fisheries Service. Amer. Zool. 19 : 982 (Abst.).

MARQUEZ, M. R., A. VILLANUEVA O. and C. PENAFLORES S. 1976. Sinopsis de datos biologicos subre la tortuga golfina, *Lepidochelys olivacea* (Eschscholtz, 1829) en Mexico-INP. Sinop. Pesca, 2 : Instituto Nacional de Pesca, Secretaria de Indsutria Y commercio. Mexico.

MARQUEZ, M. R. and H. G. VAN DISSEL. 1982. A method for evaluating the number of massed nesting olive ridley sea turtles, *Lepidochelys olivacea*, during au arribazon, with comments on arribazon behaviour. Netherlands J. of Zool. 32 (3) ; 419-425.

Mc Coy, C. J., R. C. Vogt and E. J. Censky, 1983. Temperature controlled sex determination in the sea turtle *Lepidochelys olivacea*. J. of. Herpetology, 17 : 404-406.

Mc Ghee, M. A. 1979. Factors affecting the hatching success of Loggerhead sea turtle eggs (*Caretta caretta*). M. Sc. Thesis, Univ. Central FLA, Orlando.

Miller, J. D. 1982. Development of marine turtles, Ph. D. Dissertation' Univ. New England, Armidale, NSW. Australia.

Miller, J. D. 1985 Embryology of marine turtles. Biology of reptilia Vol. 14 (Carl Gans edited). Academy Press.

Mohanty-Hejmadi, P. 1970. Transfer of maternal serum proteins into the eggs of *Rana pipiens* and their role in development Ph. D. Thesis. Univ. of Michigan, U.S.A.

Mohanty-Hejmadi, P. 1983. SOS from sea-turtle from Orissa. Marine Turtle Newsletter. Canada. No. 25 : 2.

Mohnty-Hejmadi, P. 1983. Conservation of the olive ridley sea-turtle *Lepidochelys olivacea* Seminar on "Environment and Natural Resources Management", Bhubaneswar (June 4-5, 1983.)

Mohanty-Hejmadi, P. 1987. Unique second Arribada at Gahirmatha. Marine Turtle Newsletter. 40 : 7-8.

Mohanty-Hejmadi, P. and M. Behera. 1984. Effect of nesting time on developmental rhythm of the Olive Ridley sea-turtie *Lepidochelys olivacea*. Proc. Sixth All India Congress of Zoology. Gwalior. Abstr. 216.

Mohanty-Hejmadi, P. and M. Behera. 1985. Temperature-dependent sex-differentiation in the olive ridley sea-turtle (*Lepidochelys olivacea*). Proc. 72nd session of the Indian Science Congress. Abstr. 68.

Mohanty-Hejmadi, P. and M. Behera. 1986. Effect of incubation temperature on the morphometry of *Lepidochelys olivacea* hatchlings. Proc. 73rd session of the Indian Science Congress. Abstr. 286.

Mohanty-Hejmadi, P., M. T. Dimond and J. Kanungo. 1984, Biochemical constituents of serum of young female hatchlings of olive ridley *Lepidochelys olivacea*: Marine turtle Newsletter, Canada. 27 : 4-5.

MOHANTY-HEJMADI, P., M. BEHERA and M. T. DIMOND. 1985. Temperature dependent sex-differentiation in the olive ridley *Lepidochelys olivacea* and its implications for conservation. Proc. Symposium on Endangered Marine Animals and Marine Parks. The Marine Biological Association of India, Post Box 1023, Cochin, India : 260-263.

MOHANTY-HEJMADI, P. and M. T. DIMOND. 1986. Temperature dependent sex-determination in the olive ridley turtle. Progress in Developmental Biology, Part A, pp. 159-162. Alan R. Liss, Inc. (Presented in the 10th International Congress of Developmental Biologists at Los Angeles, U. S. A., 1985).

MOHANTY-HEJMADI, P., M. BEHERA and S. K. DUTTA. 1989. Commensals on the olive ridley sea turtle, Marine Turtle Newsletter 45 : 11-13.

MROSOVSKY, N. 1982. Sex ratio bias in hatchling sea turtles from artificially incubated eggs. Biol. Conserv. 23 : 309-314.

MROSOVSKY, N. 1983. Conserving sea turtles. British Herpetological Society, Zoological Society of London, London NW1 4RY.

MROSOVSKY, N. and C. L. YNTEMA. 1980. Temp. dependence of sexual differentiation in sea turtles : Implication for conservation practices. Biol. Conservation 18, 271-280.

OGUMA, K 1937. Studies on sauropsid chromosomes III. The chromosome, of soft-shelled turtle, *Amyda Japanies* as additional proof of female heterogamety in the reptilia. J, Genet. 34 : 247-264.

PANDA, S. and P. MOHANTY-HEJMADI. 1985. Development of skeleton in *Lepidochelys olivacea*. Proc. 72nd session of the Indian Science Congress. Abstr. 67.

SILAS, E. G. (Editor) 1984. Proceedings of the workshop on sea turtle conservation. CMFRI Publication 18, Cochin.

SILAS, E. G., M. RAJAGOPALAN, S. S. DAN and BASTIN FERNANDO. 1985. On the large and mini arribadas of the olive ridely *Lepidochelys olivacea* at Gahiramatha, Orissa during the 1985 session. CMFRI information service 64 : 1-16.

SILAS E. G., M. RAJAGOPALAN, A. BASTIAN FFRNANDO and S. S. DAN. 1983. Marine turtle conservation and management : A survey of the situation in Orissa 1981/82 and 1982/83. CMFRI technical and extension series No. 50.

Sea turtle hunts throughout the world. 1982. Center for environment education. Washington D. C. U.S.A.

TAKAGI, N. and M. SASAKI. 1974. A phylogenetic study of bird karyotypes. Chromosoma, 46 : 91-120.

WHITAKER, R. and C. S. KAR.1984. Arribada : The arrival of the turtles. Sanctuary, Asia , Vol. IV, No. 2 pp. 140-149.

YNTEMA, C, L, 1968, A series of stages in the Embryonic development of *Chelydra serpentina.* Journal of Morph, 125. (2) ,219-230.

YNTEMA, C, L, 1976, Effect of incubation temperature on sexual differentiation in the turtle *Chelydra serpentina.* J, Morph, 150, 453-462,

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