An Assessment of Solitary and Arribada Nesting of Olive Ridley Sea Turtles (*Lepidochelys olivacea*) at the Rushikulya Rookery of Orissa, India

BASUDEV TRIPATHY[1,2]

[1]*Department of Environmental Sciences, Andhra University, Visakhapatnam – 530 003, India;*
[2]*Wildlife Institute of India, PO Box 18, Chandrabani, Dehradun – 248 001, Uttraranchal, India.*
Corresponding author E-mail: tripathyb@yahoo.co.uk

Abstract.- The solitary and arribada population of Olive Ridley Sea Turtles at the Rushikulya rookery of Orissa of India was monitored for two nesting seasons (2003–04 and 2004–05). Mass nesting population census of turtles was carried out using standard IUCN/SSC Marine Turtle Specialist Group recommended statistical technique (number of turtles counted: n = 11024). Curved carapace measurements of egg laying females were recorded (67.16±3.65). There was a reduction in the size class of nesting females as compare to the data available on turtle morphometry from Orissa coast in the last decade. The sporadic nesting was documented at the rookery from December to April with a peak in March and with no major intermediate nesting activities in between. The mass nesting census differs greatly as compare to the nesting figures projected by the state wildlife authority. While the state wildlife authority projects a higher figure of nesting turtles, the actual number of turtles that nests during arribada is quite low. Continuous monitoring of the beach for assessment of solitary nesting activities along with accurate methods of mass nesting census is required for proper assessment of the Olive Ridley Sea Turtle population at the Rushikulya rookery of Orissa.

Keywords.- *Lepidochelys olivacea*, solitary, arribada, estimation, technique, India.

Introduction

Nesting of Olive Ridley Sea Turtles (*Lepidochelys olivacea*) takes place either in solitary or in great simultaneous aggregations (mass nesting) where upto 100,000 females come onto the beach to lay their eggs also popularly known as arribada; a Spanish term meaning mass arrival (Pritchard, 1997). Orissa, a state in India along the easten coast, harbours three major arribada sites *viz*. Gahirmatha, Devi and the Rushikulya rookery (Pandav et al., 1994; see Fig. 1). Besides solitary nesting all along the coast of Orissa, more than a hundred thousand turtles are believed to nest annually at Gahirmatha (Dash and Kar, 1990) and tens of thousands nest at other two locations, i.e. Devi and the Rushikulya rookery (Kar, 1982; Pandav et al., 1994). In spite of its biological importance, solitary nesting has never been evaluated adequately in many important nesting rookeries (Castro, 1986). Although some information is available on solitary nesting of *L. olivacea* at Gahirmatha and Devi rookery (Pandav, 2000), there is little or no information on solitary nesting activities at the Rushikulya rookery. Similarly, the mass nesting events at the Rushikulya rookery have not yet been monitored properly; current data are from anecdotal accounts (Pandav et al., 1994) and the imprecise census by the Orissa State Forest Department due to improper statistical techniques (Pandav, 2000; Shanker et al., 2003; http://www.wildlifeorissa.org). The Orissa State Forest Department have reported mass nesting at this rookery every year since 2001, but accurate estimates of the number of nesting turtles in arribadas are not available in the absence of a standard technique for mass nesting census (Patnaik et al., 2001; Shanker et al., 2003). The IUCN/SSC Marine Turtle Specialist Group (MTSG) has recommended for use of strip transect method for estimating the arribada on mass nesting beaches, on the basis of successful experiment by Valverde and Gates (1999).

The Olive Ridley Sea Turtle is an endangered species according to the protection status of IUCN and as per CITES prohibited for trade of any kind and also is included in the schedule I of Indian Wildlife (Protection) Act (1972) and is legally protected. However, over the past decade, more than 100,000 dead turtles have been reported along the Orissa coast due incidental and accidental fishing related casualties in the sea. Whether this mortality has an impact on the population size of *L. olivacea* is yet to be known (Pandav and Choudhury, 2000). In this paper, in light of its importance, the sporadic nesting and mass nesting census of *L. olivacea* at the Rushikulya rookery was evaluated for two season from November to April (2003–04 and 2004–05) using standard techniques recommended by the MTSG to ascertain the actual arribada nesting population of turtles at this rookery and compare this figure with estimates from the Orissa State Forest Department.

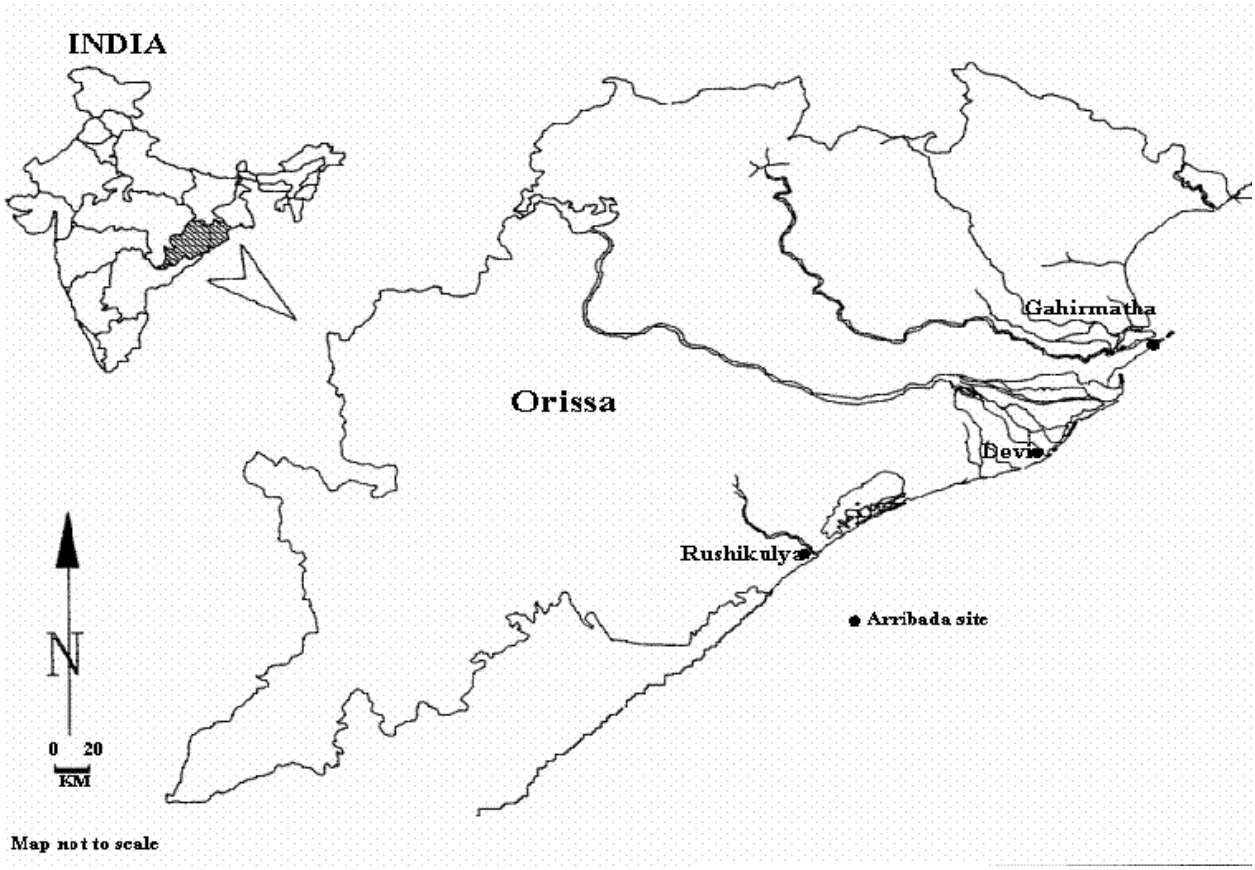

Figure 1. Map of Orissa coast in India with three arribada sites.

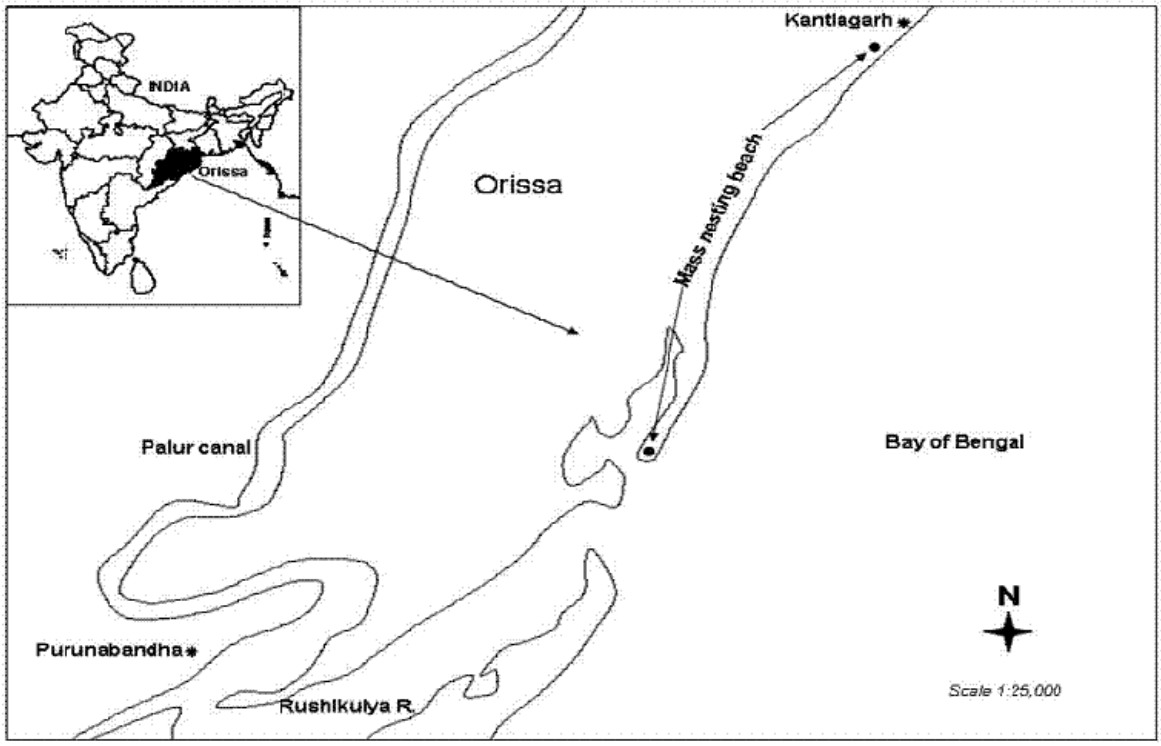

Figure 2. Map of Rushikulya sea turtle rookery, Orissa.

Table 1. Sporadic and intermediate nesting of *L. olivacea* at the Rushikulya rookery of the Orissa coast.

Month	2003–04		2004–05	
	No. of sporadic nesting (No. of nights)	No. of intermediate nesting (No. of nights)	No. of sporadic nesting (No. of nights)	No. of intermediate nesting (No. of nights)
November	5 (5)	0	0	0
December	6 (5)	0	2 (2)	0
January	17 (8)	0	12 (3)	0
February	30 (22)	0	31 (6)	119 (6)
March	166 (21)	258 (9)	170 (29)	0
April	86 (14)	0	23 (10)	0

Being a migratory species *L. olivacea* are known to arrive in the Orissa coast during late October and remain in the coastal waters until May and thereafter migrate back to the southern Bay of Bengal and Indian Ocean area. There are no turtle activities after April/May until October in Orissa. Therefore, the field work was concentrated at Rushikulya between November and May. The mass nesting beach at the Rushikulya rookery is located on the sand spit along the northern end of the Rushikulya River mouth. Rushikulya is situated 320 km south of Gahirmatha mass nesting beach (Lat. 19° 22′ N and Lon. 85° 02′ E). Turtle nesting at Rushikulya takes place along a stretch of ~5 km immediately north of the Rushikulya River mouth from the village Purunabandha (1 km north of the Rushikulya River mouth) to Kantiagada village (Fig. 2).

For systematic coverage, the entire stretch of nesting beach was divided into 100 m segments and was marked with wooden poles. To monitor nesting activities, patrolling was done by foot every night between 1700 and 0700 hr from November to April of 2004 and 2005 (1st November to 30th April for both years). Sea turtles are known to nest along the Rushikulya rookery towards the end of December (Basudev Tripathy, personal observation) and therefore the chance of missing out of some crawls during the nesting season was minimal. Turtle crawls onto the beach were classified into nesting and non-nesting types based on crawl mark pattern and sign of nest (Schroeder and Murphy, 1999). There is no standard classification of solitary nesting or arribada nesting based on the number of nests per night. However, keeping the beach length of the study area (~5 km) in mind, the author classified night with less than 20 nesters (~4 nests/km) as solitary nesting, nesting densities of 20 to 99 turtles (<20 nests/km) were considered intermediate nesting, while those with >100 (>100/km) or above turtles as arribada nesting. A modified strip transect method was used to estimate the mass nesting at the Rushikulya rookery (Valverde and Gates, 1999). This method was effective in arriving at an estimate of the number of nesting females, with a mean, variance and confidence intervals that provide rigorous statistical support for the results. A 20 m strip transect was laid at every 100 m segment of the nesting beach. Only egg-laying females (turtles in oviposition) within the strip were counted on hourly intervals starting with the first individual ascending the beach in the evening until morning when there were no nesting activities.

Table 2. Sea turtle (*L. olivacea*) mass nesting census at the Rushikulya rookery.

Parameters	Year	
	2004	2005
No. of days sampled	4	2
Total area of nesting (m^2)	150,000	200,000
Duration of arribada (in minutes)	780	780
Total number of egg laying turtles	1,144	3,908
Width of transect (m)	20	20
Number of sampling period (one hour sampling)	13	13
Total length of transect (m^2) (100 x 100 x No. of transect)	1,500	2,000
Average duration of oviposition (in minutes)	14.5	13.5
Estimated number of turtles nested during arribada	23,461	86,688
Estimated variance of the total number of egg laying females	1,138.571	4,599.4

The formula below was used for computation of the mass nesting data (see Valvarde and Gates, 1999):

$$\text{Estimate of nesting} = \frac{A \times H \times N}{W \times t \times L \times h}$$

Where:

A	=	Total available nesting area (in m^2)
H	=	Duration of arribada (in minutes)
N	=	Total of number of egg laying turtles
W	=	Width of the transect (in m)
t	=	Number of sampling period (in days)
L	=	Total of length of all transects (in m)
h	=	Average time spent by turtles for egg laying (in minutes)

Size of female *L. olivacea* was determined by the measurement of curved carapace length (CCL) at the time of egg lying. Each turtle was measured down the midline from the nuchal notch to the posterior carapace

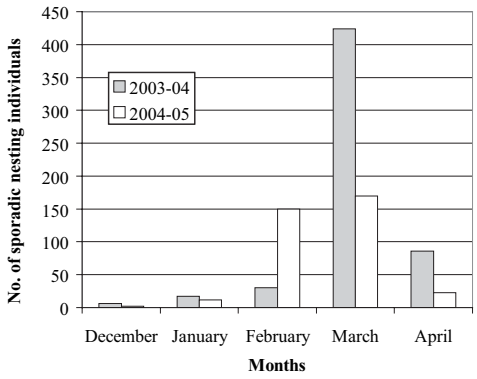

Figure 3. Monthly turtle nesting at Rushikulya for *L. olivacea* (2003–04 and 2004–05).

tip using a flexible measuring tape. Values were rounded to the nearest 0.5 cm.

Of the 568 nests observed during the 2003–04 nesting season between December 2003 and April 2004, 45.2% of the nesters were intermediate nesters, with rest being sporadic nesters (Table 1). Similarly, during the 2004–05 nesting season, intermediate nesting was calculated to be 33.3% (Table 1). There was a distinct pattern of solitary nesting observed at Rushikulya rookery, with a peak in activity during March for both the season (Fig. 3).

A total of 15 and 20 transects with 20 m width and 100 m length were established for counting turtles in arribadas during 2004 and 2005 respectively (Table 2). During 2005, the topography of the beach changed drastically and mass nesting was extended from the estuarine mouth and 2 km northward, and therefore, five more transects were laid. Although arribada took place twice during 2004 (February 9–10 and March 10–13), the February arribada could not monitored due to logistic constraint and hence the census was done only for the March 2004 arribada. During four days of peak nesting in March, a total of 23,461 turtles were estimated to have nested in arribada. However, the 2005 arribada was larger and was estimated to be 86,688 nesting individuals in two nights when censuses were carried out (Table 3).

Nesting females in arribadas at the Rushikulya rookery had an average CCL of 67.163.65 cm (n = 515; min: 60.8, max: 73.61), a value slightly greater than that of the solitary nesters at 66.024.34 cm (n = 335; Mann-Whitney = 505, $p = 0.0004$). No significant differences in CCL existed for arribada of February and March 2004 (Kruskal-Wallis $\chi^2 = 6.9$, $p = 0.2412$) and also between 2004 and 2005 season (Kruskal-Wallis, $\chi^2 = 5.80$, $p = 0.1225$).

Solitary nesting emergence of *L. olivacea* is known to occur almost every month along rest the Orissa coast (Dash and Kar, 1990). However, solitary nesting is found in greater numbers during January to May, indicating that this is the main nesting season for this species (Pandav and Choudhury, 2000). Although year round sporadic nesting is not known from the Rushikulya rookery, this study confirms sporadic nesting of olive ridley turtles at the rookery between December and April, with a peak in March and is identical to other sea turtle rookeries along the Orissa coast. Temperature, weather condition, physiography of nesting beaches and the adjacent sea, conditions of tide, temperature and surface current circulation all play an important role in determining female nest selection (Pandav and Choudhury, 2000). However, this study could not incorporate the above variables at the Rushikulya rookery due to logistic constraints. Unlike Gahirmatha and Devi (Basudev Tripathy, personal observation) where sporadic nesting is almost continuous for the entire season (>10 turtles/night), at Rushikulya rookery, sporadic nesting is irregular, with nesting intensity increasing before the commencement of the arribada. During the other nights, there is either no nesting or low sporadic nesting (<5 turtles/night). However, it is likely that the females emerging on nights with intermediate levels of nesting are responding to arribada cues (cue such as southerly strong wind, cloudy weather and strong wave action in the sea) and are truly arribada nesters. What actually comprises solitary or arribada nesting must also be evaluated in light of the total population for a given beach (Dash and Kar, 1990). During the present study, there was no major intermediate nesting events observed at the Rushikulya rookery except for nine nights in 2004 February and six nights during 2005 March, when nesting per night was over 100. However, it is likely that these turtles were early arribada nesters, since the arribada commenced in the rookery few days later.

At the Rushikulya rookery, although arribadas were reported for many years, precise mass-nesting censuses have not been carried out. The Orissa Forest Department report estimates the number of turtles during the arribada every year, but the methods used are unpublished and unavailable (estimated by Orissa State Forest Department; Table 4). Furthermore, it is not clear that methods are standardized, unbiased and therefore comparable. The State Forest Department staff counts all female turtles that remain on the beach during arribada. However, during arribada emergence, many turtles do not deposit their eggs (~30–40%) and hence are not part of true nesting population. While estimating nesting arribada population, this factor greatly affects the population size estimation and leads to bias. In the past 25 years, a variety of approaches and methods have been used to estimate female populations at arribada beaches

Table 3. Estimates of arribada (nesting number) for the 2004 and 2005 nesting season.

Date	Number of nesting turtle ($\bar{x}$)	Lower confidence interval	Upper confidence interval (95%)	Standard error
2004				
10th March 2004	4,262	3,534.1	4,990.03	364.36
11th March 2004	12,434	11,270.86	13,598.1	507.45
12th March 2004	4,362	4,227.1	4,297.1	273.25
13th March 2004	2,503	2,204.03	2,802.86	149.8
Total (4 nights)	23,561	21,236.09	25,688.09	
2005				
14th March 2005	44,466	42,017.33	46,915.99	7,379.48
15th March 2005	42,222	40,444.45	44,001.99	6,129.67
Total (2 nights)	86,688	82,461.78	90,917.98	

of Orissa (reviewed by Shanker et al., 2003). The present study estimated very low nesting populations during arribadas (using the standard technique as suggested by the IUCN/MTSG (Valvarde and Gates, 1999) compared to the figures projected by the Orissa state forest department (Tables 3 and 4). While projection of a large nesting figure attracts attention, particularly to the national and international media and conservation communities at large, it may results in the downgrading of this species in the Indian Wildlife (Protection) Act and IUCN's Red List.

In recent years (at least between 1996 and 2000), a small but significant decrease in curved carapace length (CCL) of female Olive Ridley Sea Turtles has been documented (Pandav et al., 1994; Kalb, 1999). Similarly, the average CCL of females at Gahirmatha from 1978 to 1985 were larger than those measured during 1996–2000 (Dash and Kar, 1990; Pandav and Choudhury, 2000). The present study found that arribada nesters are significantly larger than the solitary nesters, with a mean CCL being 1.14 cm greater, but was within the range. The decrease in size class (as compare to 1996–2000) was not detected during the current study, but this could be due to a small sample size, the lack of sufficient data, and a less accurate measuring technique (measuring tape for CCL *Vs* metallic calipers for SCL).

In conclusion, it is apparent that the solitary and arribada nesters are not different, but from the same population stock. The genetic study on Olive Ridley Sea Turtles from Orissa also supports this view (Shanker et al., 2004). Also, sporadic nests contribute equally to the population recruitment as that of arribada nesters being hatching success is higher for the later (Castro, 1986, also see Tripathy et al., 2003). Olive Ridleys along the Orissa coast are known to exhibit fidelity to their breeding as well as nesting ground (Dash and Kar 1990, Pandav et al., 2000). Nesting females are known to exhibit movement between rookeries in Orissa both within and between seasons (Tripathy and Pandav, in press; Pandav and Choudhury 2000). Migration and inter-rookery movement by females during the breeding and nesting season along Orissa coast has also been documented (Pandav and Choudhury, 2006). Hence, knowl-

Table 4. Estimates of arribada at the Rushikulya rookery by the Orissa Forest Department and other researchers (1994-2005).

Year	Nesting estimate	Date of arribada	Reference
1994–1995	2,000,000	14–16 March 1995	Pandav et al., (1994)
1995–1996	?	06–08 March 1996	- do -??
1996–1997	?	31 January–3 February 1997	B. Pandav (Personal Observation)
1997–1998	?	20–23 March 1998	—
1998–1999	—	No arribada	—
1999–2000	—	No arribada	—
2000–2001	1,59,000	26 February–4 March 2001	—
2001–2002	—	No arribada	—
2002–2003	2,08,000	09–14 March 2003	Orissa State Forest Department
2003–2004	2,01,000	10–15 March 2004	—
2004–2005	?	15–18 February 2005	—

edge of the location and temporal use of nesting grounds of Olive Ridley Sea Turtles in Orissa is important in view of the habitat loss and large-scale mortality of turtles in the offshore waters. Therefore, along with protection of arribada nesters, it is necessary to monitor the beach and safeguard the sporadic nesters and their habitat as well.

Prior to this study, there were no proper estimates of the number of turtles that nest during arribada at the Rushikulya rookery. Our estimates show that the number of turtles could be much less than what is projected by various governmental agencies. Thus, declaration of a mass nesting population in broad terms (e.g. hundreds of thousands) without a proper assessment may result in the reduction of protection required for *L. olivacea* in their breeding ground, which is already meager. Hence, standard and accurate techniques for mass nesting census are urgently required for additional years for monitoring the status and nesting trends of *L. olivacea* at the in Rushikulya rookery of Orissa. As evidence from the last decade of sea turtle mortality data from Orissa (Pandav and Choudhury, 2000), reduction of the size class of individuals participating in arribadas (Shanker et al., 2004; Tripathy, 2005), and elimination of the older females from the breeding stock over a period of time. However, to confirm this, extensive and accurate measurements of the nesting females and clutch sizes need to be performed to determine if there is a difference/reduction in size of *L. olivacea* over the years at rookeries in Orissa, and thereby a declining of the Olive Ridley Sea Turtle population of the Indian Ocean area and or the rest of the world.

Acknowledgments

This study was part of the author's doctoral work and he is thankful to Dr. P. S. Raja Sekhar and the Head of the Department of Environmental Sciences, Andhra University, Visakhapatnam for approving the work and support as well as the Orissa Forest Department for permission to conduct field work. The author is thankful to field assistants and volunteers of Purunabandha village, Ganjam for their help in data collection during arribadas.

Literature Cited

Castro, J. C. 1986. Contribución de las tortugas loras solitarias, *Lepidochelys olivacea*, en el mantenimiento de esta especie. Tesis de Licenciatura. Universidad de Costa Rica.

Dash, M. C. and C. S. Kar. 1990. The Turtle Paradise: Gahirmatha. Interprint, New Delhi. 295 pp.

Kalb, H. J. 1999. Behavior and physiology of solitary and arribada olive ridley sea turtle (*Lepidochelys olivacea*) during the internesting period. Ph.D. Dissertation, Texas A & M University, USA. 200 pp.

Kar, C. S. 1982. Discovery of second mass nesting ground for Pacific ridley sea turtles in Orissa, India. Marine Turtle Newsletter 23:3.

Orissa State Forest Department, Government of Orissa. http://www.wildlifeorissa.org.in.

Pandav, B. and B. C. Choudhury.2000. Conservation and management of olive ridley sea turtle (*Lepidochelys olivacea*) in Orissa. Project Final Report, Wildlife Institute of India. 77 pp.

Pandav, B. 2000. Conservation and management of olive ridley sea turtle (*Lepidochelys olivacea*) along the Orissa coast. Unpublished PhD thesis, Utkal University, Orissa, India. 148 pp.

Pandav, B. and B.C. Choudhury. 2006. Migration and movement of Olive Ridley Turtles along the east coast of India. Pp. 365–379. In: Marine Turtles of the Indian Subcontinent. B.C. Choudhury and K. Shanker (eds.). Universities Press, Hyderabad, AP, India, 415 pp.

Pandav, B., K. Banugopan, D.Sutaria, and B.C.Choudhury. 2000. Fidelity of male Olive Ridley Turtles to a breeding ground. Marine Turtle Newsletter 87: 9–10.

Pandav, B., B. C. Choudhury and C. S. Kar. 1994. A status survey of olive ridley sea turtle (*Lepidochelys olivacea*) and their nesting beaches along the Orissa coast, India. Wildlife Institute of India, Dehradun, India. 48 pp.

Pattanaik, S. K., C. S. Kar and S. K. Kar. 2001. A quarter century of sea turtle conservation in Orissa. Publication of wildlife wing of forest department, Government of Orissa publication, Bhubaneswar 34 pp.

Pritchard, P. C. H. 1997. Evolution, phylogeny and current status. Pp. 1–28. *In*: P.L. Lutz and J. A. Musick (Eds.). The Biology of Sea Turtles. Boca Raton, Florida, CRC Press, 432 pp.

Schroeder, B. A. and S. Murphy 1999. Population surveys (ground and aerial) on nesting beaches. *In:*

Research and management techniques for the conservation of sea turtles. K. L. Eckert, K. A. Bjorndal, F. A. Abreu-Grobois and M. Donnelly (eds). IUCN Marine Turtle Specialist Group Publication # 4, CGC, Blanchard, Pennsylvania, USA. 235 pp.

Shanker, K., B. Pandav and B. C. Choudhury. 2003. An assessment of the olive ridley turtle (*Lepidochelys olivacea*) nesting population in Orissa, India. Biological Conservation 115, 149–160.

Shanker, K., R. K. Aggarwal, J. Rama Devi, B. C. Choudhury, and L. Singh. 2004. Phylogeography of olive ridley turtles (*Lepidochelys olivacea*) on the east coast of India: implications for conservation theory. Molecular Ecology 13:1899–1909.

Tripathy, B. 2002. Is Gahirmatha the world's largest sea turtle rookery?. Current Science 83 (11): 1299.

Tripathy, B. 2005. A study on the ecology and conservation of Olive Ridley Sea Turtle (*Lepidochelys olivacea*) at the Rushikulya rookery of Orissa coast, India. Unpublished PhD Thesis. Andhra University, Visakhapatnam, India. 168 pp.

Tripathy, B. and B. Pandav. In Press. Beach fidelity and inter-nesting movement of olive ridleys (*Lepidochelys olivacea*) at Rushikulya, India. Herpetological Conservation and Biology.

Tripathy, B., B. Pandav and R. C. Panigrahy. 2003. Hatching success and orientation of *Lepidochelys olivacea* (Eschscholtz, 1829) at Rushikulya rookery, Orissa, India. Hamadryad 27(2):185–192.

Valvarde, R. A. and C. E. Gates. 1999. Population surveys on mass nesting beaches. Pp. 56–60. In: K.L. Eckert, K. A. Bjorndal, F. A. Abrell-Grobois and M. Donnelly (Editors), Research and management technique for conservation of sea turtles. IUCN Marine Turtle Specialist Group Publication # 4, CGC, Blanchard, Pennsylvania, USA. 235 pp.

Submitted*: 19 October 2006*
Accepted*: 23 September 2007*