Surfacing and diving behaviour of free-ranging Ganges river dolphin, Platanista gangetica gangetica

Article *in* Current Science · January 2010

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Surfacing and diving behaviour of free-ranging Ganges river dolphin, *Platanista gangetica gangetica*

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Swimming and breathing are the two most important behaviours of cetaceans. Due to the turbid waters of the Ganges, underwater activities of the Ganga river dolphin, *Platanista gangetica gangetica* in wild conditions are difficult to observe. Short surfacing time is also a big constraint while studying its behaviour. To observe surfacing behaviour of the species in its natural habitat, individual and groups of dolphins were studied using focal-animal and *ad libitum* sampling protocols at the confluence of the Ganga and Gandak rivers near Patna. The study recorded six types of surfacing patterns, which were dependent on age-class and offshore distance of the individual. Mean dive-time was 120 s, however, the highest dive-time was 465 s. Diurnal movement in the dolphins was also observed. This is the first report on surfacing behaviour of the Ganges river dolphin in natural habitat. We could discuss majority of the diurnal surfacing patterns, while some of them are undiscussed due to limited literature on this aspect. Studies in future should be focused on underwater activities as well as physiological determinants of surfacing behaviour of the species.

Keywords: Behaviour, Ganges river dolphin, River Ganga, surfacing.

SWIMMING and breathing are the two most fundamental behaviours of cetaceans. Swimming is the only mode of locomotion and is a primary component of their time and energy budgets. While swimming, they forage, socialize, copulate and undergo parturition[1]. Swimming is usually studied in patterns, as well as speeds for finding out the functions of different swimming patterns and the capability or intensity of cetacean movement and breathing represents the respiration rate – breathing frequency per unit time[2]. Cetaceans breathe while surfacing and dive to perform underwater activities. Diving behaviour of cetaceans is described mainly as the pattern of surfacing (i.e. dive durations without information on dive depths[3–5]) and to describe surface behaviour with information on depths as well as duration of dives[6,7].

Cetaceans spend a vast majority of their time beneath the water surface, where they are invisible to observers, and the lack of ranging information in three dimension has limited a comprehensive study of their ecology[8]. Knowledge of the underwater behaviour of cetaceans, such as dive-depth, duration and swim-speed is needed to develop countermeasures for avoiding or decreasing by-catch in fishing gears[9] and collisions with commercial ships[10], since the probability of such accidents occurring depends greatly on the underwater body motion of the animal[11].

The four genera of world's river dolphins (*Inia*, *Pontoporia*, *Lipotes and Platanista*) are among the least known and most endangered of all cetaceans[12]. Very few studies have been conducted on swimming and diving behaviour of freshwater cetaceans. A few observations have been made on swimming and diving behaviour of Indus river dolphin *Platanista gangetica minor* in captivity[13,14]. Yang *et al.*[2] studied swimming and breathing behaviour of captive Yangtze river dolphin *L. vexillifer* and specifically mentioned variation in swimming speed and breathing frequency. Very limited information[13,15,16] is available on diving and surfacing behaviour of river dolphins in wild.

The Ganges river dolphin distributed in the Ganga, Brahmaputra, Meghna and Sangu-Karnaphuli river systems of India, Bangladesh and Nepal is facing population threats due to incidental and directed killings as well as habitat degradation due to siltation, pollution and water development projects[17]. The species is categorized as 'endangered' by the IUCN[18]. The Ganges river dolphins are usually solitary but they are also occasionally observed in groups of 2–3 individuals[19] often inhabiting places below the sandbars and tributary junctions[20] and the areas where eddy counter-current system is developed due to convergence of stream with mainstream flow[21]. High level water turbidity limits observation of underwater activities and dolphins can be viewed only when they surface, that too, only for very short durations. Thus, short surfacing time and high turbidity are the limiting factors in observing the behaviour of Ganges river dolphin in the wild. Moreover, surfacing may or may not

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reflect underwater activities like foraging, rest, travel, social interactions, etc.

We report here results of our study on surfacing and diving features of the Ganges river dolphin – *P. gangetica gangetica* in its natural habitat.

Methodology

Study area

The study was conducted during 2000–02 at the confluence of Ganga and Gandak rivers (85°11′12″E and 25°37′22″N) near Patna. The Ganga flows from west to east while the Gandak joins it from north. The confluence of the rivers often shifted within 1 km on the east–west axis during the study period. The River Gandak is characterized by fast current and shallow water near its mouth. When the River Gandak discharges into the Ganga at the site almost at right angle, it has little impact on the littoral zone of the Ganga in the left side (west) up to about 25 m from the bank. But, beyond 25 m and up to about 50 m from the bank, the impact of flow of Gandak gets intensified resulting in formation of vortices, eddy counter-current and intense mixing. Up to the next 100 m, the impact of confluence gradually reduces due to voluminous flow of the Ganga, leaving very little impact of confluence. Beyond this up to the right bank, the impact of confluence was nil. In low-water period, i.e. November through March, the Gandak river fans out into multiple channels creating sandbars at its mouth. Strong eddy counter-current is formed at the confluence where depth varies from 3 to 6 m. River width at the study site varied from 300 to 400 m.

Sampling methods

The dolphin behaviour was studied fortnightly during October 2000 and March 2002 except for July to September which are the flooding months. The observations were made during the daylight hours (8.00 am–4 pm) from shore, sandbars or a secured boat near the confluence in order to maintain proximity with dolphins. Three researchers were involved in recording surfacing type, dive-time and anthropogenic activities in the dolphin habitat on a pre-designed data-sheet. Dive-time, the interval between two consecutive surfacing, was recorded using stopwatch. Dolphin observation was categorized on the basis of time of the day as well as off-shore distance. Daytime was categorized as morning (8.00–11.30 am), noon (11.30 am–1.30 pm) and afternoon (1.30–4.00 pm). The off-shore distance was classified into 4 groups: up to 25 m (bank), 25–50 m (strong influence of confluence), 50–150 m (weak impact of confluence) and over 150 m (main channel of the Ganga). As the observations were always made near the confluence, the off-shore distances were expressed in terms of impact-zone of confluence. Specimens were identified as neonates, juveniles, subadults and adults, according to their size and colour pattern without using any optical device.

Individual as well as group-follow protocol[22] were employed in this study. Dolphins present within 100 m radius were considered as a group. Group-follow was adopted when the individuals were not identifiable. 'Individual' in the study refers either to a dolphin identified in a group on the basis of age-class and external features like body colour/mark, deformity, etc. during observation or a solitary individual. Surfacing behaviour was recorded only in case of individual-follow. Sometimes, both the protocols were followed simultaneously and different team members recorded the individual as well as group behaviours. 'Focal animal sampling' was done whenever the individuals were identified and followed continuously[23] and observations on dive-time, surfacing pattern, off-shore distance, migration/travel, if any, were recorded on the data-sheet. Surfacing types were recorded on the basis of body portion exposed outside water. 'Out of sight' situation was considered when the dolphins were out of sight or not identified anymore. *Ad libitum* sampling[23] was also employed in individual as well as group-follows and observations of interest were recorded as field notes.

Descriptive statistics was used to collate, summarize and analyse the results. The method, also termed as exploratory data analysis, was followed due to complex results and the lack of clear hypotheses. MS-Excel and SPSS (10.0) computer programs were used to analyse the data.

Results and discussion

Surfacing types

The study was conducted for 192 h and 19 h were spent on recording surfacing behaviour of 37 individuals (Table 1). Apart from individual dolphins, 22 dolphin groups were also observed. Mean dolphin group-size was 7.4 individuals (range: 4–15; SD: 2.6). We recorded six surfacing patterns and encoded them for convenience in data analysis (Table 2). Frequency of the surfacing types showed the highest frequency of 'Q' surfacing, while leaping was least frequent (Figure 1). Pilleri[15] noticed only three surfacing behaviours: (i) blow hole appears barely above the surface of water; (ii) melon and upper snout emerge with row of teeth approximately parallel to the water and (iii) whole head comes out of the water with snout held up at a slant, in this species in Brahmaputra river. Herald *et al.*[24] and Pilleri *et al.*[13] have reported side swimming in the Ganges as well as Indus river dolphin. Such swimming was occasionally observed in the present

Table 1. Time spent in observing individually identified dolphins in different age-class

Age-class	No. of individuals	No. of surfacing	Total time observed (min)
Adult	21	296	650
Sub-adult	12	201	397
Juvenile	3	49	70
Neonate	1	16	15

Table 2. Categories and codes of dolphin surfacing types

Surfacing type	Code
Only head rises	P
Head and dorsal fin rise	Q
Rostrum, head and dorsal fin rise	R
Rostrum and head rise	S
Rostrum, head, dorsal fin and fluke rise	T
Leaping	L

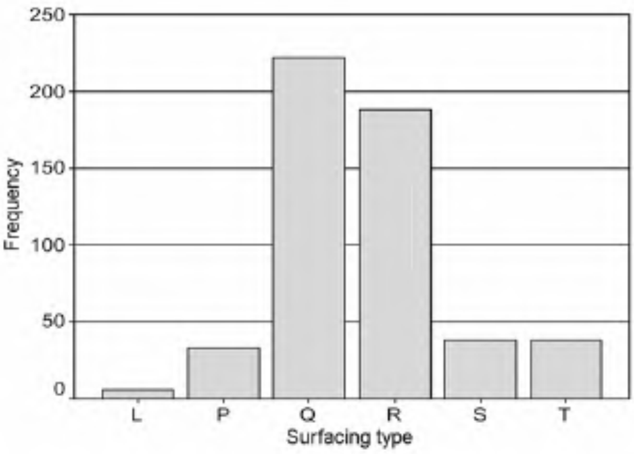

Figure 1. Frequency of different surfacing types.

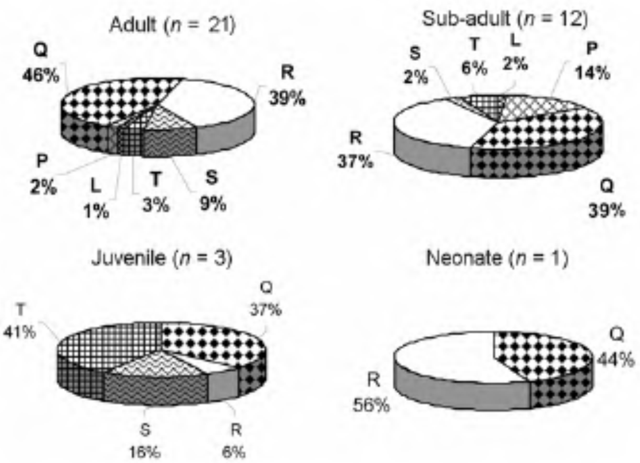

Figure 2. Surfacing types in different age-classes of dolphins.

study. Fishermen in the study area also reported this behaviour. Leaping is supposed to be associated with play and greeting in *Tursiops aduncus*[25] and also with mating and feeding behaviour in *T. truncatus*[26]. Distribution of surfacing types among the studied individuals was unequal ($\chi^2 = 0.0488$, $df = 5$, $P < 0.001$). Eighty five and 75% surfacing in the adult and sub-adult dolphins respectively comprised 'Q' and 'R' types. In juvenile dolphins, 'T' and 'Q' surfacing types were dominant while neonate showed only 'Q' and 'R' surfacing types (Figure 2). Exposure of head and dorsal fin (Q type) and rostrum, head and dorsal fin (R type) might be associated with breathing and other routine activities of dolphins. Pilleri[14] described the quiescent surfacing in Indus river dolphin while breathing – the dolphin approached the surface in a graceful curved manner and just before reaching it turned over on to their front, and head appeared above the water. He also observed that vigorous surfacing – demonstrating flick of the body and powerful stroke of the fluke, is needed to make sharp turns, breathing, rolling over or dodging either during play or chasing fish in the river dolphin in captivity. This mode of surfacing was also demonstrated when pursued by other dolphins. Vigorous surfacing exposing most of the body portion observed in the Ganges river dolphin in the present study might be a reflection of such underwater activities. Wakid and Braulik[16] observed exposure of blowhole, rostrum and dorsal fin in 44.2%, blowhole and rostrum in 38.4%, only blowhole in 17.4% of all the surfacing of Ganges river dolphin in Brahmaputra river. They observed leaping in only 0.3% of all the surfacing.

The surfacing types were significantly dependent on age-class of the dolphins ($\chi^2 = 0.0146$, $df = 15$, $P < 0.001$). Most of the adults (43%) and sub-adults (50%) were observed displaying two surfacing types while 67% juveniles exhibited three surfacing types. Only one neonate dolphin observed showed two types of surfacing, while a maximum of five types of surfacing were shown by an adult. Number of surfacing types displayed by individuals in one bout was independent of age-class ($\chi^2 = 6.040$, $df = 9$, $P = 0.736$). Dolphins displayed surfacing pattern according to off-shore distance ($\chi^2 = 99.343$, $df = 15$, $P < 0.001$) as well as day hours ($\chi^2 = 65.000$, $df = 10$, $P < 0.001$). Between 25 and 50 m from shore, 'Q' surfacing type dominated in adult and sub-adults. Within this distance, juveniles exposed rostrum, head and dorsal fin (R type) and rostrum, head, dorsal fin and fluke (T type) the most. Surfacing of sub-adult dolphins was very quiescent exposing only head, while juveniles exposed head and dorsal fin the most (Figure 3). The dolphins exposed most of the body part while surfacing in the impact zone of confluence, while in the main channel the surfacing was quiescent. In the impact zone of confluence, where eddy counter-current system is formed, aggregation and vigorous surfacing of dolphins may be the manifestation of feeding activities and the adaptive strategy by the dolphins to minimize foraging costs (maximize the difference between energy inputs and energy output during food search and capture). Surfacing within the still water pool of the counter-current system requires little energy. Surfacing within the eddy-bends is adjacent to high velocity currents where dolphins can take advantage of passing fish. Hearns[27] stated that greatest potential net energy gain is obtained by maintaining positions in minimal current adjacent to swift flows in case of salmonid fish.

In adult dolphins, 'Q' surfacing type was dominant throughout the day, while in sub-adults, 'R' type was dominant in the morning and afternoon hours while 'Q' surfacing type dominated in the afternoon. The juvenile dolphins were observed only during morning and afternoon hours during which 'Q' and 'T' surfacing types were dominant respectively (Figure 4). In bottlenose dolphins (*T. truncatus*), morning and afternoon have been observed as feeding hours[28,29]. The surfacing type dominant during these hours in Ganges river dolphin may also be associated with feeding activities.

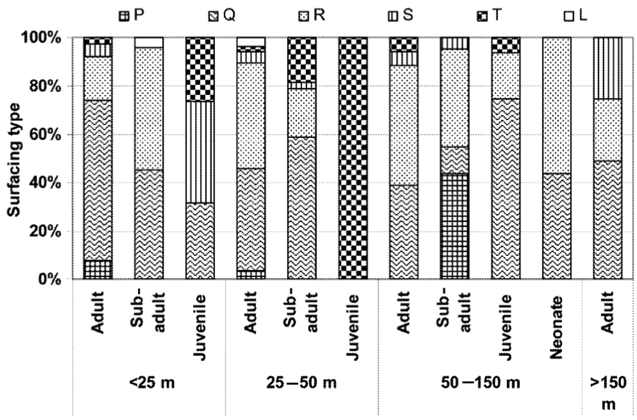

Figure 3. Surfacing type of dolphins in different age-class vis-á-vis offshore distance.

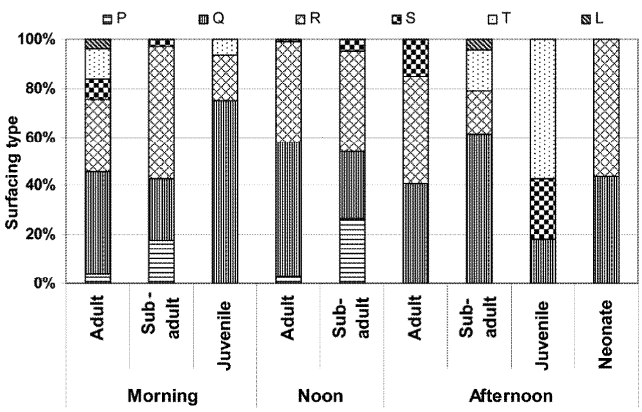

Figure 4. Diurnal variation in surfacing types in the dolphins of different age-class.

Dive-time

Dive-time in the dolphins ranged from 10 to 465 s. Maximum frequency of dive-time was between 80 and 115 s (Figure 5). Dive-times of adult (mean: 129 s; range: 10–465 s; SD: 87) and sub-adult (mean: 120 s; range: 10–385 s; SD: 66) dolphins were almost similar and more than juvenile and neonate individuals. Juvenile dolphins (mean: 92 s; range: 20–267 s; SD: 58) remained underwater more than the neonate (mean: 59 s; range: 25–115 s; SD: 26). Pilleri[15] reported the modal diving time of 180 s, averaging 30–60 s in the Ganges river dolphins, which is much lesser than the dive-time recorded in the study. Wakid and Braulik[16] recorded average dive-time of 107 s (SD: 46.8) in Ganges river dolphin in Brahmaputra river. A mean dive interval of 62.6 s was found to be related to a predominance of foraging behaviour in a bottlenose dolphin in wild[30]. Marino *et al.*[31] found the body mass and brain size of cetaceans positively correlated with dive duration. The dive limits in cetaceans are dictated by the rate of oxygen utilization. Large bodies are able to store more oxygen through large muscle mass and also utilize oxygen more slowly because of lower mass-specific metabolic rate[32]. Noren and Williams[33] observed that body mass and myoglobin content accounted for much of the variation in cetacean diving performance and large muscle mass as the main correlate of long dives. These observations explain the inter age-class difference in dive-time of Ganges river dolphin in the present study.

In adult and sub-adult dolphins, mean dive-time was highest before 'S' and 'L' surfacing types respectively while juveniles and the neonate dolphins showed highest dive-time prior to displaying 'Q' and 'R' surfacing types respectively (Figure 6). Dive-time of dolphins in different

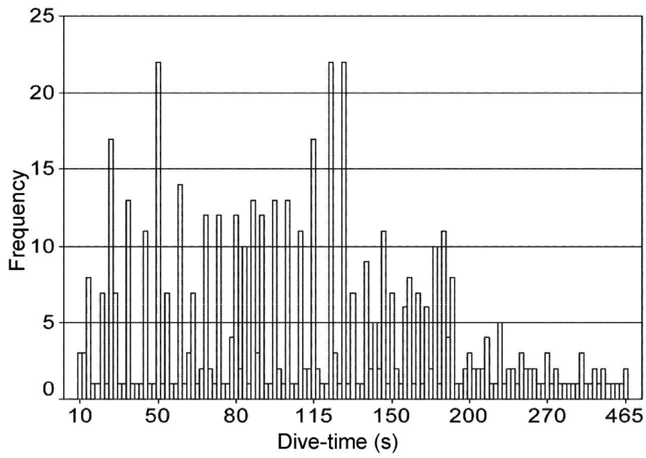

Figure 5. Frequency of observations of dive-time in dolphins.

Table 3. Dive-time of individually identified dolphins during different day hours

		Age-class			
Day (h)	Dive-time (s)	Adult	Sub-adult	Juvenile	Neonate
Morning	Range	20–336	10–385	23–267	–
	Mean ± SD	124 ± 59	101 ± 65	142 ± 70	
Noon	Range	10–465	30–275	–	–
	Mean ± SD	100 ± 82	128 ± 58		
Afternoon	Range	15–465	30–355	20–120	25–115
	Mean ± SD	149 ± 94	132 ± 69	67 ± 31	59 ± 26

–, Not observed.

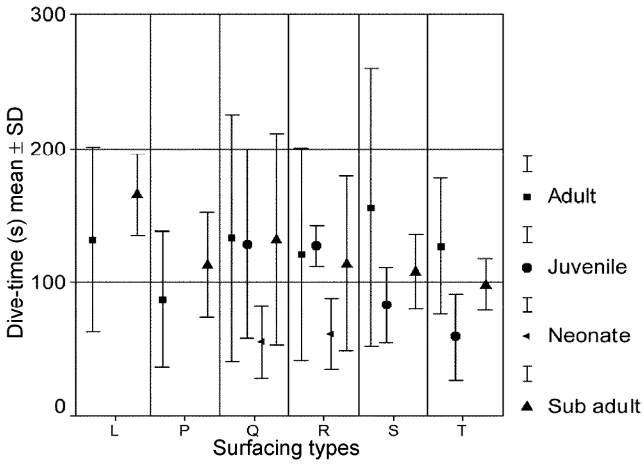

Figure 6. Dive-time of dolphins in different types of surfacing.

age-classes differed significantly ($F = 2.891$, d$f = 36$, $P = 0.043$). During different day hours, dive-time of adult dolphins followed a trend of afternoon > morning > noon, while in sub-adults the trend was afternoon > noon > morning. The juvenile dolphins could be observed only during morning and afternoon and dive-time was highest during morning hours (Table 3). However, mean dive-time of dolphins in different age-class did not differ significantly with day-hours (adult: $F = 0.623$, d$f = 17$, $P = 0.440$; sub-adult: $F = 1.596$, d$f = 13$, $P = 0.246$; juvenile: $F = 93.831$, d$f = 2$, $P = 0.065$). Surfacing of adult dolphins was usually vigorous (L and T surfacing) after their long dive of over 3 min. This was observed on 12 occasions. Lopez *et al.*[30] observed that the length of dive was related to the behavioural events prior to dive in free-ranging bottlenose dolphins.

Other surfacing behaviours

Apart from the above observations, some special surfacing behaviours of dolphins were observed during 'focal group study'. On one occasion, all the dolphins were observed exposing only fluke and slapping the water surface in shallow area (1–1.5 m depth) near the bank. Geise *et al.*[34] interpreted fluke slapping as feeding behaviour in *Sotalia fluviatilis*. Brown and Norris[35] and Norris[36] have termed fluke-slapping as aggressive behaviour in bottlenose dolphins in the context of establishing or maintaining dominance hierarchies, protecting young or defending food items. Also, bubbles were observed at places where dolphins surfaced within a few seconds as if the dolphins were 'bubbling' inside the water. On some occasions, splashing of water was followed either by vigorous surfacing or even without surfacing of dolphins in shallow water. Side swimming was observed on few occasions. Only on one occasion, a sub-adult dolphin was found surfacing vertically, exposing only the snout. On another occasion, a dolphin was swimming downstream through the mid-channel of the Ganga. On every surfacing two flukes of different sizes, one above the other appeared simultaneously. In the event, surfacing was very quiescent. This activity was observed for 3–4 min before the animal got out of sight. It could be a case of parturition, as in cetaceans the fluke of the baby emerges first[37]. In this case, one fluke could be of the baby while the other could be of mother.

On two occasions, travelling of mother and calf was observed, the calves were ahead of their mothers. This movement pattern was in contrast to the behaviour of *S. fluviatilis* observed by Geise *et al.*[34] who observed that larger dolphins are always ahead of other members of the group. In the present study, the calf surfaced moderately exposing dorsal fin while the mother followed her calf with very quiescent movement exposing only her head.

Ad libitum observation of the dolphin groups reflected that they were more active, demonstrated by vigorous and frequent surfacing, during morning and afternoon hours. Fishing activity during morning and afternoon hours in the habitat might disturb the fishes and thereby increasing the activity of dolphins to feed on them. These periods can be assumed as dolphin's feeding time. During the period of low activity (11 am–3 pm), they moved in the mid and deep channel of the river from shallow areas of the confluence. Less activity of dolphins at noon can be assumed to be the period of least activity. Most likely during this period the animals move to the quiet and deep zones with low current as compared to confluence zone. This might be a mechanism of energy conservation by the dolphins. Geise *et al.*[34] and Wursig and Wursig[38] also observed *S. fluviatilis* and bottlenose dolphins respectively entering the open deep sea during mid-day. Caldwell and Caldwell[39] have reported local movements of bottlenose dolphins and they have hypothesized that this diurnal pattern may be sun-related. In low activity period, dolphin movement was so quiescent that many times it was difficult to ascertain their presence. Occasionally they disappeared for about 1 h and reappeared singly or in a group. They spent more time near the places where the eddy vortices straighten up and run parallel to the main flow. Such diurnal migrations are common in many cetaceans[40]. They also followed the drift nets being operated by the fishermen in the habitat. Feeding was observed during winter on few occasions. The dolphins aggregated near the drift fishing nets in shallow zone most probably to steal or catch entangled/escaped fish from the fishing nets. Geise *et al.*[34] observed *S. fluviatilis* feeding frequently in shallow areas (1–3 m) from 6.00 to 7.00 am. The Ganges river dolphin is a catholic feeder and small fishes and gastropods are their major food[41]. However, during the study big fish weighing about 1 kg was observed being caught, at anterior 1/3 distance of the gape, by dolphins on two occasions. The dolphins were also seen surfacing in circular and semi-circular manner – a feeding behaviour described by Donoghue and Wheeler[37] in dolphins.

Conclusion

The present study describes the surfacing and diving behaviour vis-à-vis several co-variates in the free-ranging Ganges river dolphin in detail for the first time. The species shows great diversity in surfacing pattern depending on several environmental factors. Association of majority of the diurnal surfacing patterns with underwater activities could be discussed, while reasons behind some of them could not be ascertained and discussed. A detailed study on various aspects of surfacing and diving using state-of-the-art techniques needs to be undertaken in future to unravel the underwater activity as well as physiological determinants of surfacing behaviour of *P. gangetica gangetica.*

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ACKNOWLEDGEMENTS. We acknowledge the financial assistance by Wildlife Division, Ministry of Environment and Forests, Government of India. We thank Janet Mann, Departments of Psychology and Biology, Georgetown University, Washington DC, for her suggestions and help during the inception of the study. Assistances of boatmen are duly acknowledged.

Received 16 July 2009; accepted 23 December 2009