PREDATION ON NATURAL NESTS OF THE SALT-WATER CROCODILE (*CROCODYLUS POROSUS* SCHNEIDER) ON NORTH ANDAMAN ISLAND WITH NOTES ON THE CROCODILE POPULATION[1]

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(*With five plates and two text-figures*)

During June/July 1978 a quantitative study of saltwater crocodile nests and nest predation was carried out in North Andaman. Predation was found to be extremely higher, twentyeight of thirty nests (93.4%) were destroyed by predators and a further nest was completely flooded, giving a 3.3% hatching success. Human predation accountd for almost all nest predation (84.6%). Nests occurred predominantly in the creeping cane/evergreen vegetation zones. Data are presented on the ecology of nesting and compared with data from elsewhere in the species' wide geographical range.

Active nest hunting by settlers, together with killing of adult crocodiles—often the nest-guarding female—combined with data on the remaining adult population gives cause for great concern for the future of this population of an endangered species.

INTRODUCTION

Precise scientific data on saltwater crocodile nests has been lacking until recently (Neill 1971) although the natural history has been known in outline for a long time Deraniyagala (1939). The recent paper by Webb *et al.* (1977) is an important contribution. However, it deals with a typically Northern Australian situation which is very different from the Indian situation. In Northern Australia flooding is a major nest hazard, but predation, both human (by aborigines) and by wild life, is invariably extremely low.

During the latter part of the 1978 egg laying season approximately four weeks (22nd June to 16th July) were spent in the crocodile habitat of North Andaman observing nests. Data were collected on a total of thirty nests in which eggs had been laid, as a result of personal observation, or readily checkable information, collected on nests from reliable sources. This paper gives an account of nest predation together with information on the crocodile population of North Andaman.

North Andaman (Fig. 2), with a total area of 1376 sq km is one of the five main islands which form the Andaman group. The Andaman Islands (10° 13′—13° 30′N and 92° 15′—93° 10′E) lie in the Bay of Bengal. The northernmost major island of the Andaman group, North Andaman, lies at a distance of 896 km south-east of the mouth of the Hoogly (Ganges) and at a distance of 192 km south of Cape Negaris in Burma. The main mass of North Andaman is roughly hexagonal in outline with a maximum length of 77 km from North to South and maximum width of 29 km from East to West. North Andaman Island

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is separated from Middle Andaman by a narrow sea water creek known as Austin strait.

The study area, together with the rest of the Andaman-Nicobar Group, comprises one of the three last remaining saltwater crocodile habitats in India—the other two being Sundarbans in West Bengal and Bhitar Kanika at the Brahmini-Baitarni delta in Orissa.

Study area

The coastline of the study area is highly indented and at many places penetrates deeply into the island landmass to form island bays and deep creeks. Most of the rivers and streams empty into these creeks.

In the South of North Andaman, Kalara, Balmi, and Parangara creeks, in the East, Kalpang River and its tributaries, and in the West the streams that empty into the Casurina and Hudson Bay, were the major areas where extensive field work was carried out (Fig. 2). These creeks and streams form the major saltwater habitat in North Andaman.

All these creeks are fringed by belts of mangrove swamps (Plate I) which are regularly inundated during the high tide. Over the years, forests on both banks of the Kalpang River have been cleared and settlements are growing. This river was formerly a good habitat for saltwater crocodiles.

The creeks along the East coast of North Andaman are deep, those along the West coast shallow, about nine and three metres respectively, at mean tide level, the latter creeks (Plate I) with pebble beds. There are two tides every twentyfour hours inundating the banks of the streams. The tide fluctuation in the creeks is above 2 mts.

In the undulating terrain and thick tropical forests of North Andaman communication depends entirely on the open sea and inland creeks. This results in a certain amount of disturbance. Other than transport, fishing, crabbing and cutting of cane, bamboo and mangrove trees along the creeks, also creates some disturbance.

Climate:

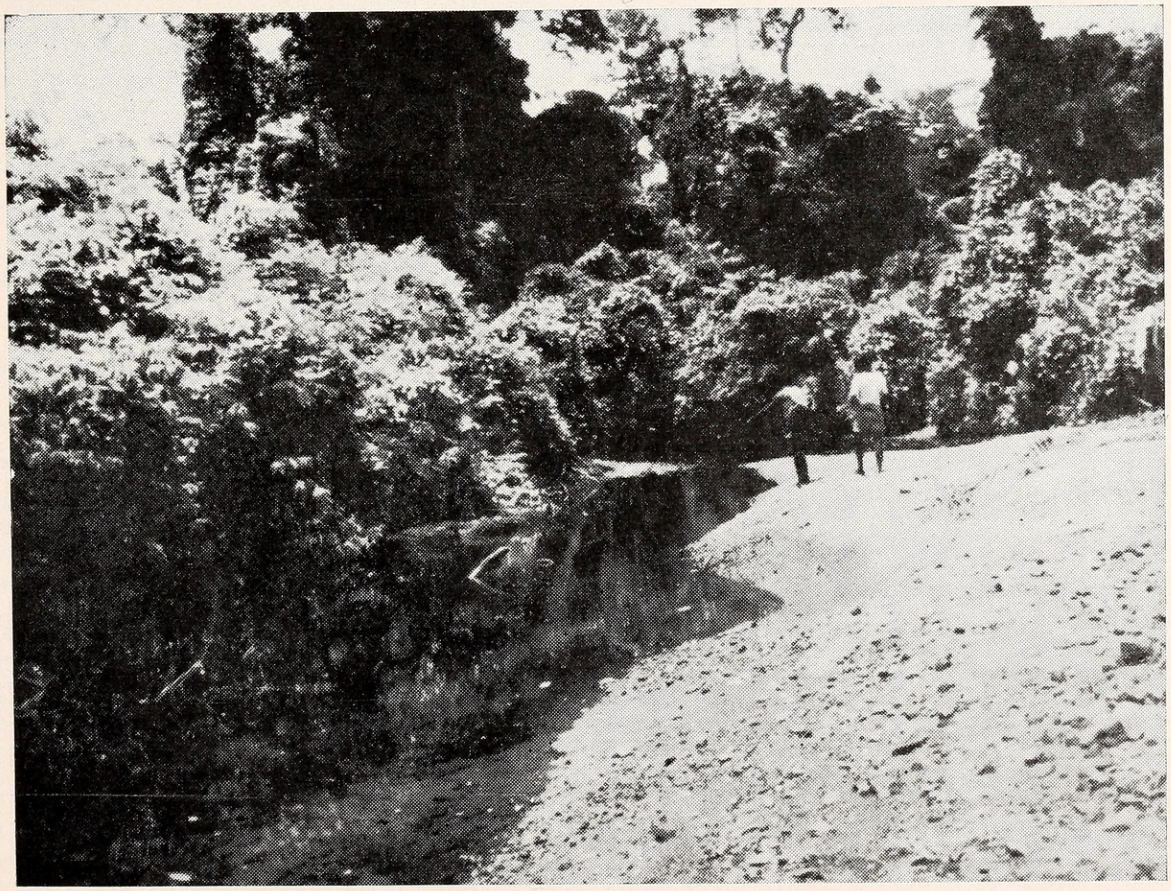
The study area lies south of the Tropic of Cancer between 12°50′ to 13°13′N and experiences a tropical climate, warm and moist throughout the year except for a cool period during December and January. The location subjects it to the South-West monsoon from the beginning of May to the middle of October and the North-East monsoon from the middle of October to mid-December.

North Andaman receives less rainfall than Middle and South Andaman. The average annual rainfall recorded at Mayabundar, the northern most part of Middle Andaman is 216 cm. Because most of the landmass of North Andaman lies on the lee side of Saddle Peak (737 mts) it receives less of the South-West monsoon.

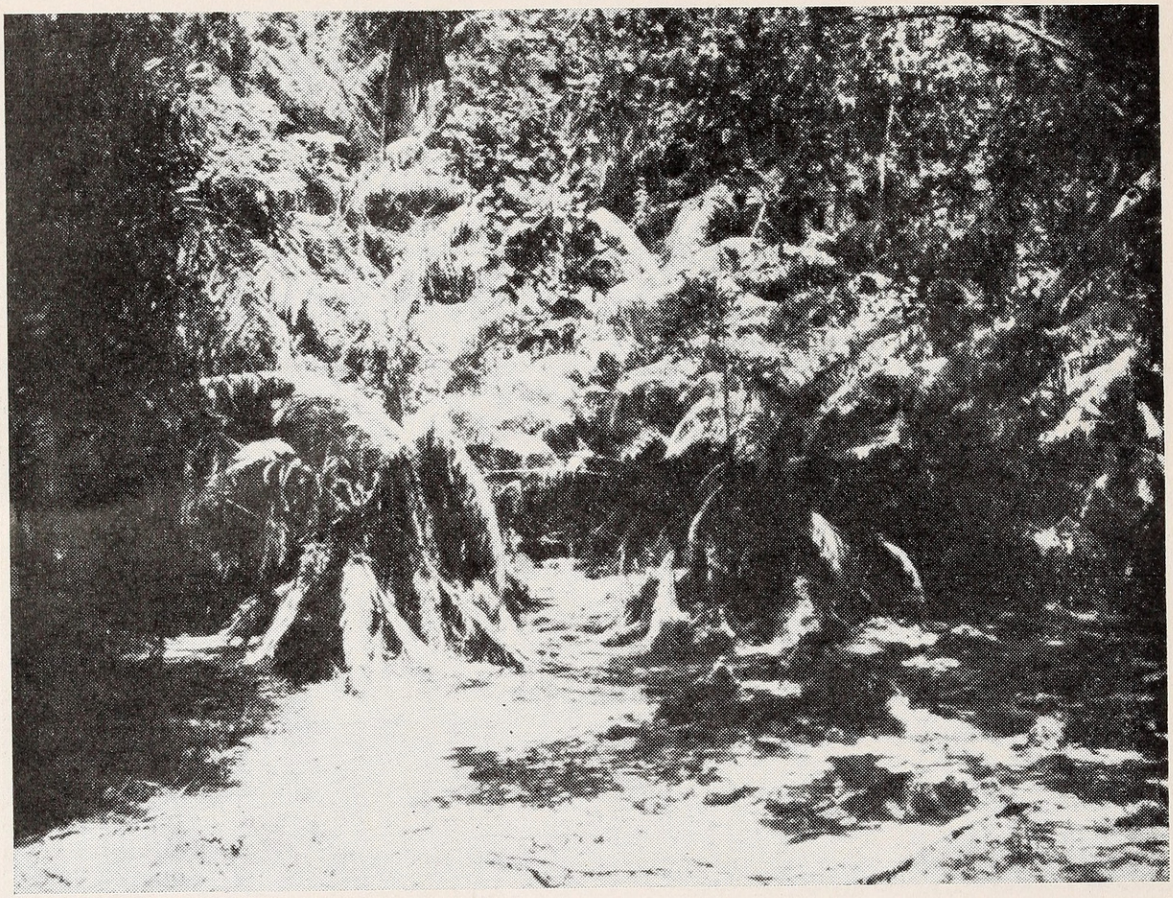
The mean maximum/minimum temperatures for North Andaman are 27.7°C/24.3°C respectively and humidity is relatively high at 80% (Lal 1976).

Vegetation:

The vegetation along the streams and creeks can be classified into three distinct types; zone 1: tidal mangroves (Plate I), zone 2: standing cane, sometimes associated with bamboo brakes, (Plate II), zone 3: low level evergreen, riverine forests along the banks of the streams (Plate II). All these three vegetational types occur within 300 mts of a high water mark. The stratification from coastal mangroves (foreground) to the evergreen forests (background) is clearly illustrated in Plate III. Settlements have been established on the upper reaches of the streams due to availability of fresh water, and forests have been cleared to provide cultivated land.



Above: Typical mangrove vegetation along the Kalpang River, East coast of North Andaman. *Below*: Typical, shallow, West coast, creek with pebble bed providing excellent habitat for *C. porosus*.



Above: Zone III. Creeping cane, in this case associated with bamboo brakes, inland from the main river. Note the firm ground in this vegetational zone not usually liable to flooding. *Below*: Zone III. Creeping cane/evergreen forest complex at the head of a side creek. It is in this zone that most of the nests occur.

Rhizophora mucronata and *Rhizophora apiculata* are the major plant species bordering the creeks with a height of 10 mts or more. Immediately behind this zone follows *Brugviera parviflora* and *B. gymnorrhiza* with an undergrowth of *Ceriops tagal* (Blasco 1977). This zone is called *Khals* (Bengali) by the East Bengal settlers living in North Andaman.

The transitional zone of the tidal mangroves and the riverine forests forms a belt of cane brakes which is most important in the present context as this is the best nesting habitat for saltwater crocodiles in North Andaman. *Calamus andamanicus* and *Calamus palustris* dominate this belt. Creeping cane, is also present in this region. In the next zone of semi-evergreen and evergreen climaxes, dense clumps of bamboo *Oxylenanthera nigso-ciliata* occurs with scattered trees of *Dipterocarpus incanus. Planchoria andamanica, Pinsonia exelsa* etc. Actually the cane brakes and semi-evergreen climax zone is a continuous zone which has been divided here for convenience.

Materials and methods

Nests were located with the help of boats or by walking along the river and stream banks. Local people also assisted in showing areas where nests had been seen by them in previous years. Wherever the nests were located incidence of egg robbing, flooding and predator damage were noted. Measurements of nest dimension, its position in relation to permanent water, physical surroundings, vegetation in and around the nest, presence of wallows around the nest and presence of nesting female near the nest, were also noted irrespective of the condition of the nest.

Results

The Nest:

The members of the Order Crocodylia lay their eggs in one of two nest types. These are, hole nests and mound nests. In hole nests eggs are laid in a pit dug in dried mud-banks or sand. In mound nesting, rather like Megapode birds, the eggs are laid in the middle of a nest mound prepared with vegetation and mud. Eggs are deposited in a cavity dug in the central area of the elevated nest mound. The saltwater crocodile is a mound nester.

In the study area, the saltwater crocodile nests observed were made of vegetation and mud. The nest mound was circular in appearance with an elevated centre. Since ten, of fifteen nests personally inspected, had already been opened by humans no precise measurements of these nests could be taken. Of the remaining five nests, two opened by wild pigs also had a similar appearance. Only the two Monitor-predated nests, and one flooded nest, from which eggs were collected, were measured. Measurements were also taken of a nest made and abandoned in a wild sugarcane fringe. These three nests averaged about 75 cm in height and 2 mts. in diameter at the base.

The nests were observed to have been made in three types of vegetation zone. These are, tidal cane fringes, creeping cane and evergreen vegetation and cultivated land. In the tidal cane fringes, where four nests were observed (Table III), the nests were made of standing canes; *Calamus* sp. with a higher percentage of mud in the nest construction. The distance of the nearest permanent water varied considerably since the areas were inundated by the high tide. The surface around such nests was

mostly swampy with a certain depth (about 15 cm) of water present all the time. Since the nests were made mostly on the elevated bases of old cane clumps, they were at a higher level to the surrounding ground.

In the next nesting zone, proceeding further inland from creek-bank—the creeping cane and evergreen vegetation zone—ten nests were observed. The ground in this region was solid and dry. The vegetation used in nest making was mostly creeping cane and dry fallen leaves of evergreen trees. These nests had very little mud in them. The nearest permanent water (streambed) was as close as five mts. in some cases. A typical undisturbed nest in this zone is shown in Plate IV. The nest, opened to show the eggs, is shown in Plate IV. The presence of people gives a good idea of the physical size of the nest. In the third nesting zone of cultivated land along the freshwater streams and creeks, only one nest was observed. This nest was made of grass and miscellaneous shrubs without mud.

The nests observed were invariably close to water. Due to the influence of tides, the water mark on the banks also changed, and as such it was not possible to correctly measure the distance of permanent water from the nest. The distance of permanent water from the creeping cane/evergreen vegetation fringes varied at mean tide level from 5-50 mts.

The nests made in tidal can fringes were in shade all the time with the canopy of canes covering the nests. The nests in creeping cane and evergreen vegetation zone were on the forest edge thus exposing the nest to light for some part of the day.

The single nest observed in the cultivated land and the abandoned nest in the wild sugarcane fringes were both totally exposed with no protection from sun, wind and rain.

The presence of wallows near the nests was also recorded. Except for one nest in the cultivated land and one nest in the evergreen forest region, upstream from a creek, wallows were observed in all other nests. From a single wallow to as many as three were seen near the nests. The wallows near the tidal cane fringe nests were not very deep but the wallows in the creeping cane/evergreen forest fringe nests were deep. Wallows in the two habitats measured as follows: (a) tidal cane fringes (four nests observed with nine wallows: mean length, breadth and depth are followed by range in brackets 161.2 (105—185), 74.9 (63—90), 46.8 (35—65), (b) creeping cane/ evergreen forests complex (nine nests observed with seventeen wallows) 176.0 (135—223), 81.6 (58—108), 113.2 (65—155). The difference in depth between the two habitats is significantly different.

Before any attempt was made to inspect the nests closely, the wallows were disturbed with long poles to note the presence of nesting females. Of the fifteen nests observed, nesting females were seen at three of them, one of which had the eggs intact, one had been predated by *Varanus* but the nest shape remained intact (Plate V) and the third nest had been destroyed by humans, and at another nest, also destroyed by humans, an adult was observed in the water of the creek close to the nest. Additionally, tracks, believed to be those of the nesting females, were seen at six of the nests. Though many of them seemed to be fresh, the last visit of the nesting female to the nest could not be ascertained with certainty. Thus nest-guarding was taking place, or could be inferred, at ten of the fifteen nests. It is noteworthy that at the nest from which eggs were collected and the female was present in the adjacent wallow the mother crocodile meekly ran into the water after once being poked with a long pole.

Above: A view of the East coast from the open sea. The fringing mangroves are clearly visible, and behind and towering over them, the darker vegetation of the evergreen forests. Between these are the transitional tidal cane fringes. *Below*: Mangroves, completely felled and cleared, on the West coast, for use as fuel and for house construction.

Above: An undisturbed saltwater crocodile nest (the only one encountered during the study) in creeping cane/evergreen forest, Zone III, on the West coast. *Below*: The same nest opened to expose the eggs. This plate gives a good impression of the size of the nest, here mostly constructed of creeping cane and dry, fallen, leaves of evergreen forest trees.

Nest predation

Of the thirty nests studied only one gave rise to hatchlings (Table 1).

Table 1

Hatching of Natural Nests of Saltwater Crocodile (*Crocodylus porosus*) at North Andaman Island.

Number of nests	Number hatched	Number destroyed by predators	Number flooded
30	1 (3.3)	28 (93.4)	1 (3.3)

(Figures are followed by percentage in brackets).

This results from an high incidence of nest predation, almost entirely by humans (Table 2).

Table 2

Incidence of Nest Predation

Number of nests	Predators			
	Humans	Monitors	Wild Pigs	Undetermined
26	22 (84.6)	2 (7.6)	2 (7.6)	2 (7.6)

(Figures are followed by percentage in brackets).

Wherever, humans have taken the eggs clear evidence of clearing of bushes, canes etc., using sharp cutting instruments and complete destruction of the nest mound was observed. In case of wild pig predation, the nest mound was spoiled (Plate V) and hoof marks were clearly visible on the cleared vegetational area around the nest. The most clearly ascertained predation was that by Monitor lizards (*Varanus*). Fresh tracks as well as the tail marks with a few scattered egg-shells around a perfect nest with neat holes (Plate V) indicated the presence of *Varanus*. A Monitor Lizard was seen close by one of the two nests which had been predated by *Varanus* (Table 2). This nest also had the nesting female crocodile lying in one of the wallows on one side of the nest. The *Varanus* had made a neat hole in the opposite side and eaten all the eggs (on opening the nest no more eggs remained).

Non-human predators may not eat all the eggs. However, when the egg mass is exposed by a predator, the micro-environment of the nest, essential for incubation, is destroyed. Hatching of any of the remaining eggs is, therefore, unlikely. The nests observed with one exception (Table 3) were restricted to two vegetational complexes. No nests were observed in the mangroves at the mouths of the creeks. In these two types of vegetational complexes, namely tidal cane and creeping cane/evergreen forests, more than two-thirds of the total nests occurred (Table 3).

The break-up of nest predation in the nests personally observed in the various habitats is given in Table 4. Humans frequent both of the main nesting habitats, wild pigs are mostly in the creeping cane/evergreen vegetation and monitors favour the tidal cane fringes since they search for small invertebrate and vertebrate prey in the areas subject to inundation.

Table 5 analyses the human predation on eggs in the nesting habitats.

Crocodile population

Data on the naturally occurring crocodile population were recorded during the course of this study. However, no night survey work was carried out for census determination purposes.

A female observed with her brood of young

TABLE 3

NEST LOCATION IN RELATION TO VEGETATION COMPLEX

Number* of nests	Location of nest			
	Mangroves	Tidal Cane Fringes	Creeping Cane and Evergreen Vegetation	Cultivated land along the fresh water streams
15	-	4 (26.6)	10 (66.6)	1 (6.6)

(Figures are followed by percentage in brackets).

* These fifteen nests were all personally inspected.

TABLE 4

PREDATION IN RELATION TO VEGETATION COMPLEX

Vegetation complex	Predator				
	Humans	Monitors	Wild Pigs	Undetermined	Total
Tidal cane fringes	4 (26.6)	2 (13.3)	-	-	6 (40)
Creeping cane and evergreen vegetation	4 (26.6)	-	2 (13.3)	2 (13 3)	8 (53.4)
Cultivation lands along the fresh-water creeks	1 (6.6)	-	-	-	1 (6.6)
Total	9	2	2	2	15

(Figures are followed by percentage in brackets).

TABLE 5

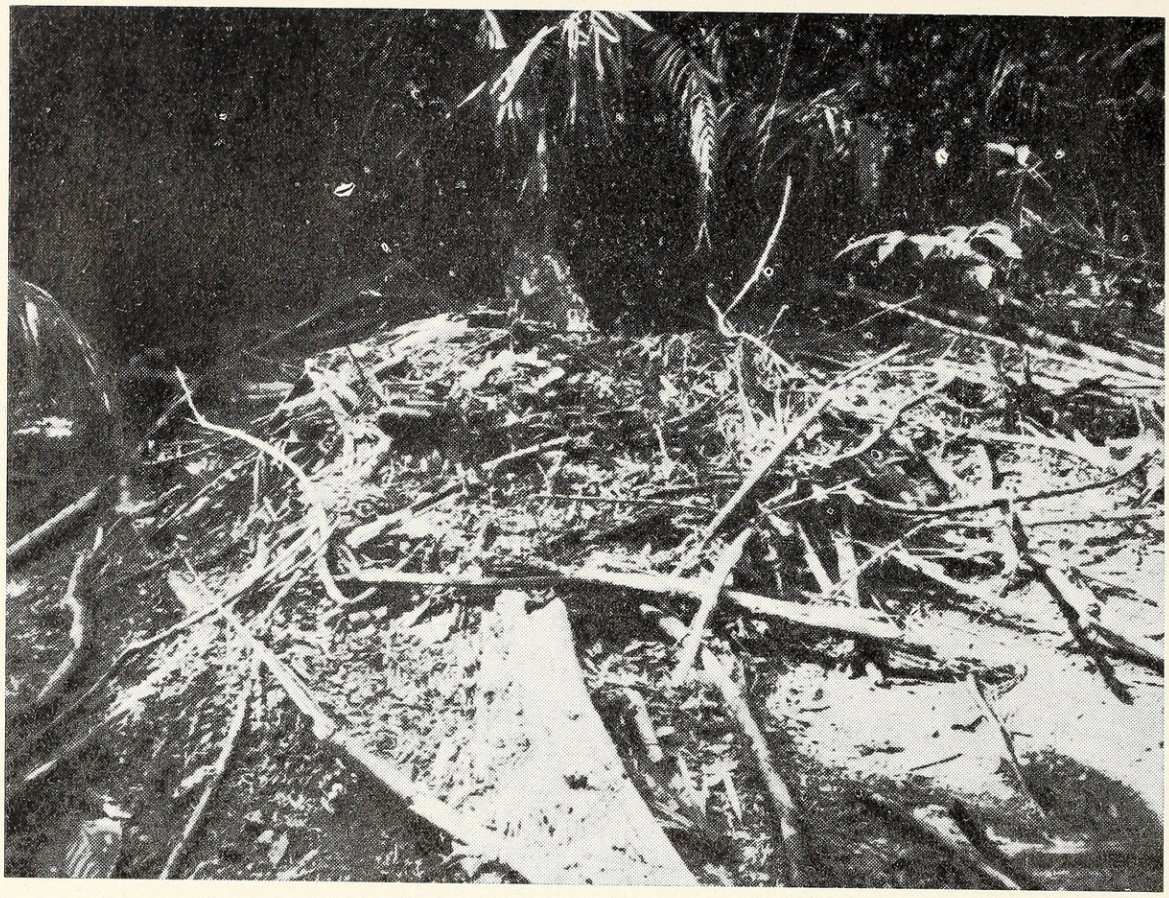
TYPE OF HUMAN HUNTING ACTIVITY

Number of nests taken by humans	Type of human hunting activity	
	Deliberate hunting for eggs	Chance encounters of crocodile nests
22	19 (86.3)	3 (13.7)

(Figures are followed by percentage in brackets).

measured about 2.7 mts. Two nest-guarding females also measured approximately 2 mts. A third nest-guarding female measured approximately 3.5 metres.

Four crocodiles were sighted in the open water. Two measured approximately 3 to 3.75 mts and two were in excess of 4.5 mts, one of which measured about 6 mts. Apart from these eight adults, six juvenile crocodiles measuring not more than 1.2 mts were sighted in the creek emptying into Casurina Bay on



Above: A nest destroyed by wild pig. Note that the nest shape has been completely lost and the debris scattered over a wide area. *Below*: A nest preyed upon by monitor lizard. The nest retains its shape and access to the eggs is gained through a well defined hole. Two wallows can be seen behind the nest on left and right.

the West Coast, and a cluster of approximately twentyfive recent hatchlings was sighted in the company of their mother at a creek on the west coast.

The crocodiles actually sighted are given according to size/age class group in Table 6.

Adult Losses:

During the nest survey information on killing of nesting females was also collected. A total of five nesting females were reported to have been killed during the 1978 nesting season. Of these killings four were reported from the west coast (Casurina and Hudson Bay) where encroachment on forest land along the fresh water streams is very high. Activities such as bamboo and cane cutting, crabbing and fishing are also high. One nesting female was reported to have been killed on the Kalpang river in an area of cultivated land (but outside the cultivation season). All these females were reported to have been of less than three metres in size.

TABLE 6

DIFFERENT SIZE/AGE CLASSES OF SALTWATER CROCODILES SEEN IN NORTH ANDAMAN

Number of crocodiles seen	Adults			Hatchlings	Yearlings/Second years
	Nesting females	Other adults	Total		
39	4	4	8	Approx.25 in one group	6

Further insight into the population structure can also be obtained from an examination of clutch size data, since clutch size in saltwater crocodiles increases with increase in length/age females. Precise data are available for six nests from this study and cross-checked reports of clutch size for further five nests (Table 7 and Figure 1).

TABLE 7

CLUTCH SIZE OF SALTWATER CROCODILE IN NORTH ANDAMAN

Cluth size*		Mean (all nests)
Confirmed	Unconfirmed	
55	39	
60	39	
42		
42	39	46.1
42	69	
67	19	
Mean 51.3	Mean 41.0	

* During 1976 June one nest collected from North Andaman had 51 eggs, and during the latter part of June/July 1976 another nest with 72 eggs was also observed by Whitaker (1978).

DISCUSSION

Whitaker and Whitaker (1978) have stated that North Andaman nests are susceptible to flooding and predation, especially by the water monitor (*Varanus salvator*). These observations are not borne out by the present quantitative study also in North Andaman. While it is true that nests of saltwater crocodiles tend to be susceptible to flooding, the building of two-thirds of the nests in the cane/creeping cane, evergreen forest interphase area reduces this most effectively. Only one nest (3.3%) was lost from this cause (Table 3).

Flooding was the major cause of the nest loss in Webb *et al.*'s (1977) study in which

twentyfour of thirty nests under study were flooded. However, data have to be collected over a number of years. In the Northern Australian environment due to marked variations in the severity of floods Bustard (unpublished data) arrived at an annual, average, nest loss, due to flooding, of about 50% for the West coast of the Cape York peninsula in North Queensland, Australia, in the vicinity of Edward River. In the present Andaman study of the fifteen nests personally inspected only one was flooded. However, the eggs were taken by people from most nests before they had a chance to be flooded. Incidence of flooding might, therefore, have been much higher in the absence of this very high level of human predation. However, even making allowance for this we do not anticipate a level anywhere

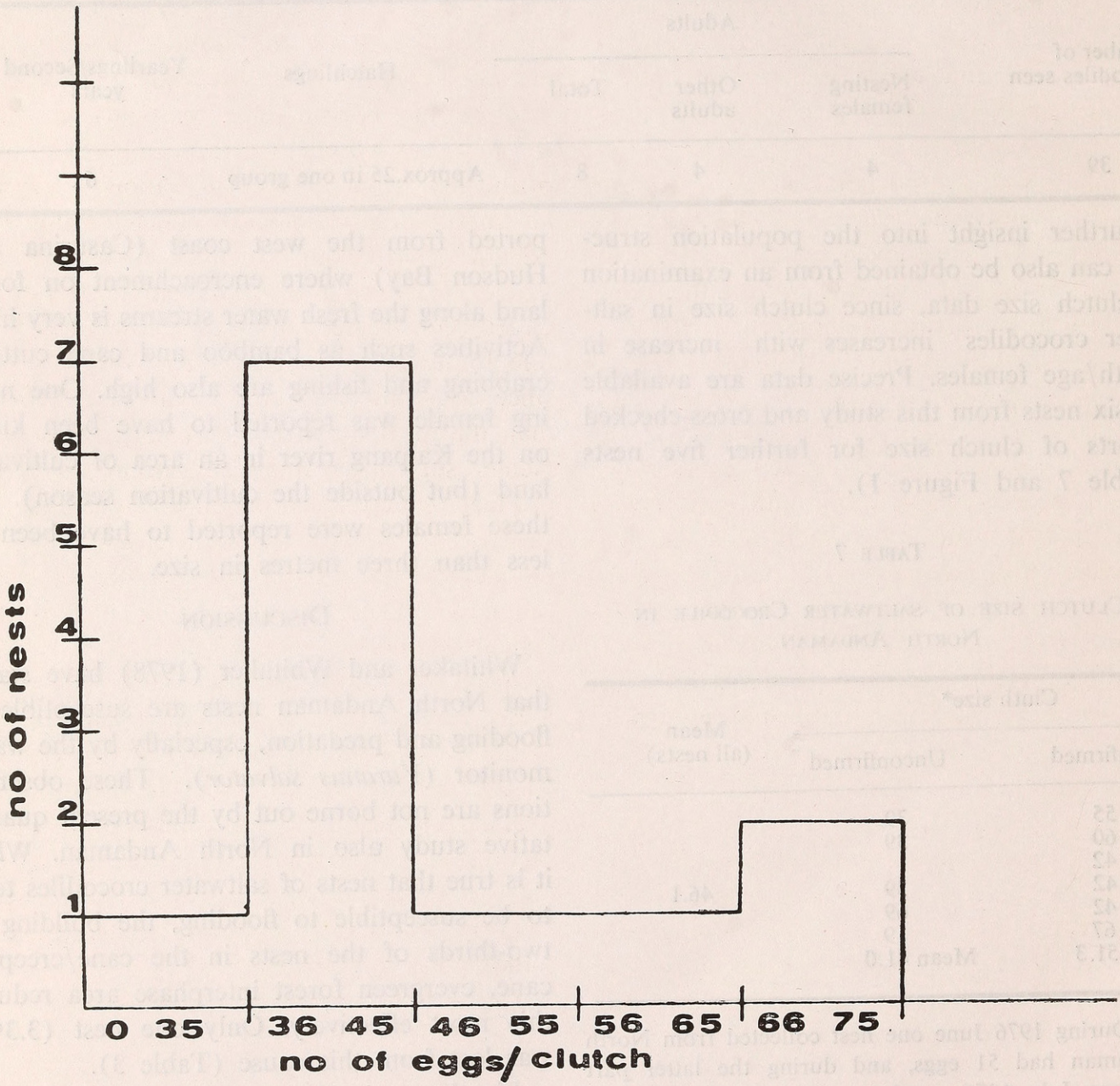


Fig. 1. Clutch size variation. Note 36—45 eggs is the most common range of clutch size.

approaching the Australian figures quoted by Webb *et al.* (80% of nests lost through flooding).

Webb *et al.* also record absence of nests from the tidal mangrove forests. There would appear to be good reason for this due to the high probability that nests laid in this environment would be flooded. Webb *et al.* give the mean distance of fifty nests from the water as 7.8 metres but agree with our observation that this distance is difficult to measure and somewhat arbitrary due to tidal fluctuations.

The mean dimensions of the three nests examined in the present study are considerably larger than those given by Neill (1971) for the Philippines, several parts of Indonesia and Papua (height 25-30 inches, diameter 4-5 feet), and the mean figure given by Webb *et al.* although our figures are well within the range observed by the latter authors.

Surprisingly, Neill (1971) dismisses the presence of nest wallows thus:

> "According to the Ceylonese legend, the female estuarine crocodile scoops out two basins near her nest, waits until these basins are full of water, and then with her tail splashes this water over the nest. It is easy to see how the legend of the two basins could have developed: the female uproots and scrapes up vegetation from a small area in which her nest will be located, and in so doing might easily leave depressions in which rainwater or seepage could accumulate."

With the exception of two nests, one to three wallows were always present in the present study. Bustard has also noted the invariable presence of wallows elsewhere in India and in Australia. Webb *et al.* also noted the presence of one to four wallows and raised the interesting question that these could be of two origins. While some might have been created by sweeping up mud and debris for nest construction as suggested by Neill, some, they state, appeared to have been excavated specifically for the crocodile to lie in. They noted, and this is the important point, that the nest-guarding crocodile occupies both types of wallow, an observation with which we concur. We confirm that the saltwater crocodile regularly lies in wallows close to the nest, both in the wild and in captivity (Bustard and Maharana in preparation).

The function of the wallow deserves discussion. We consider that they may play a role in thermoregulation—particularly where the nest is exposed to direct sunlight for part of the day. We also feel that wallows may have an important psychological effect for this very aquatic crocodilian. In this connection we would stress the role of the larger wallows—clearly constructed specifically for the crocodile to lie in as suggested by Webb *et al.*—since they are frequently many times larger than the total volume of nest material, so that Neill's suggestion that they occur as a by-product of nest construction is untenable (see Figure 2 of Webb *et al.* for a clear illustration of this). In these latter wallows, the crocodile can lie completely unseen, giving it a psychological advantage, and certainly a feeling of security. Further substantiation of this hypothesis comes from the fact that the wallows in the creeping cane/evergreen forest zone are deeper and longer compared to those in the tidal cane fringes. This increased depth is necessary in this drier zone to ensure a good supply of water. Incidentally, Deraniyagala (1939) also refers to the presence of nest wallows in Sri Lanka.

The mean clutch size observed by Webb *et al.* (1977) was fifty eggs (range 40 to 62). Neill (1971) gives a range of twentyfive to seventytwo. Our own observations for North

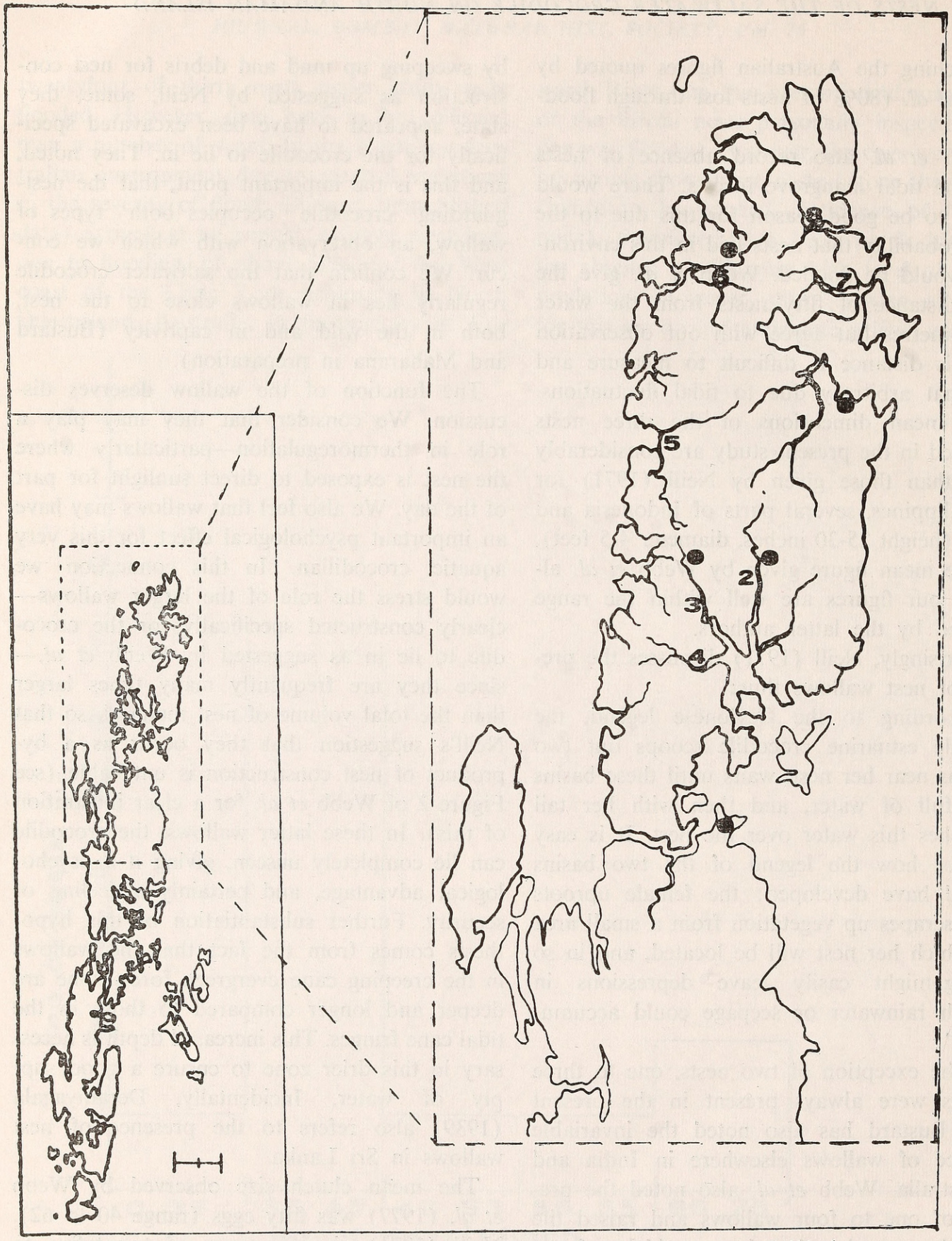


Fig. 2. Map of the Andamans showing details of North Andaman. Solid dots represent centres of field activity. Scale on small map represents 16 km. Large map not to scale. Numbers refer to rivers and creeks as detailed below:
1. Kalpang river, 2. Kalara Creek, 3. Parangara Creek, 4. Balmi Creek, 5. Creeks emptying into Casurina Bay, 6. Creeks South-West of Shyamnagar, 7. Creeks near Gandhinagar, 8. Creek emptying into Caddle Bay.

Andaman give a mean, based on confirmed nest data, of fiftyone eggs (range 42 to 67), remarkably similar to the data of Webb *et al.*

Nest materials in the present study were fresh leaves of standing canes eight to nine feet tall, fresh leaves of the much taller creeping cane, and dead evergreen tree leaves. This agrees with Smith (1931). Neill (1971) found tall green grass or herbaceous aquatic plants most commonly used in the Philippines, Indonesia and Papua. Kopstein (1929) noted that in Java the nests were constructed of man height grass and small branches. It would appear that the saltwater crocodile uses the available material. For instance, in North Andaman there is no herbaceous aquatic vegetation, and the single nest found in cultivated land was made of grass and miscellaneous shrubs.

In the present study no emaciated crocodiles were seen as reported by Deraniyagala. We believe that the nest-guarding female leaves the nest periodically for unknown periods of time. This fits in with frequent observations of tracks leading from the nests to the water and absence of female crocodiles from the wallows near the nest, a view which agrees with the data of Webb *et al.* (1977) but conflicts with the data of Deraniyagala (1939). Incidentally, the latter's observation that two nest-guarding individuals which he shot had empty stomaches is not convincing data that they do not feed during the incubation period as very many stomachs of crocodiles shot during the course of normal activities were found to be completely empty of food (Cott 1961).

Neill (1971) states that the female saltwater crocodile will guard the nest against man. We have no personal experience of this in Andamans, although occasional instances are known to us from elsewhere. We consider the trait unusual, nowadays, since such nest-guarding females are usually killed.

Human predation was found to be eleven times more serious than that of either the water monitor lizard or wild pigs (Table 2). These latter predators could have been expected to take a larger proportion of eggs in the absence of a such a high level of human predation. Human predators, as a result of deliberate hunting for eggs, get to the nest shortly after the eggs have been laid, before other predators chance upon the nest. The intensity of human predation on saltwater crocodile nests is in part a result of the belief in the medicinal properties of the eggs (believed to be a reliable cure for rheumatism and bronchitis) combined with the fact that the nesting season takes place with the onset of the South-West monsoon at a time when the villagers are going to the forest to collect cane and bamboo to fence in their fields against wild pig (*Sus andamanicus*) and cheetal (*Axis axis*). Cultivation has not yet started, and encouraged by the believed medicinal values of the eggs, they have ample time to search out the nests.

The very high level of predation, despite nest-guarding by the female, requires elaboration. Firstly, taking the case of the two main non-human predators, the female crocodile, if present at the nest, will not hesitate to attack. However, during an incubation period extending over about two months, it is not possible for the female to remain alert at all times. Even when the female is present at one of the wallows it may be possible for a predator to approach the nest undetected from the other side. An instance of this was observed when visiting a nest, the eggs of which had been eaten by the water monitor. The female crocodile was present in one of the wallows at the time of the visit and it

could be seen that the nest had been opened from the opposite side through a neat hole (Plate V) and the entire clutch consumed. As mentioned in Results the mother crocodile does not remain at the nest throughout the entire incubation period. Should the predator arrive at the nest during one of the absences of the female predation is, of course, simple. The nest guarding behaviour of the female crocodile is an aspect of the nesting biology which deserves quantitative study in the field.

Turning to human predation, there has been active selection against females which will guard the nest in the face of a human intruder. Since, such females are easily killed they do not survive to pass on this trait to their offspring (it should be noted that crocodile hunters elsewhere in the world, who may not be interested in the eggs, often shoot nest-guarding female due to the ease with which they can (could) be shot. Nowadays it is unusual, therefore, for a female to attack humans at the nest and it would seem that the present predation pattern on adults, as well as eggs, would favour poor mothers who desert the nest at the first sight of a human intruder! To this should be added the fact that hunting pressure has reduced the average age, and, therefore, average size of nest guarding females. Not only are present-day, nest-guarding females, smaller and therefore, less able physically to protect the nest against predators but they are new or relatively new nesters and, therefore, inexperienced.

The small size of most of the observed females reinforces the concern for the future of this population, since it indicates that they have only recently recruited to the breeding population, and that hunting pressure on nesting females is severe.

Exact information about the female breeding population size can be gathered from precise knowledge of the number of nests. In the present study thirty nests in which eggs have been laid were located, and an additional nest was located which had been constructed by a female which did not lay eggs in it. This phenomenon is discussed by Webb *et al.* This female might have laid subsequently elsewhere. The nest survey was carried out exhaustively. It is unlikely that nests were missed except, perhaps, in the most remote areas. If it is assumed that a further five to six nests were laid and missed, this gives a breeding population of thirtysix females for North Andaman, considered to be the best remaining area in the Andamans for the saltwater crocodile. Assuming the expected sex ratio of about 2.5 females per male the breeding male population would be approximately 15. Due to a probably higher incidence of killing nesting females the male population may be somewhat higher.

There is a need to strengthen the Wild Life Wing of the Andamans Forest Department so that it can offer more effective protection in the field to such an endangered—and fully protected—member of the Indian fauna. A Union Territory such as Andaman and Nicobars should set an example to other States. The problem of the conservation of the saltwater crocodile—on an all India basis—is taken up in a later paper.

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