

Figure 1. Confirmed dry season crocodile sites in Cambodia (2001-2004).

in 2002-2004, with no reports or indications that these populations had greatly changed from previous years. There was however a report of one crocodile (approximately 1.2-1.5 m long) being captured and sold from the Areng River in 2004, while another was seen dead on a sand bank after drowning in a net (1.2 m long) also in 2004.

Habitat

Siamese Crocodiles were found in oxbow lakes, rivers (wide slow flowing lowland rivers, narrow slow flowing mountain rivers), streams and marshes. As surveys were undertaken during the dry season, the water levels were at their lowest, and crocodiles were often found in the deepest parts of the remaining water bodies (locally referred to as ‘anlongs’ in rivers). Water was at least 1.2 m deep and slow moving where crocodiles were confirmed. Crocodiles were not found in the shallow water (less than 1.2 m deep) or in the faster flowing sections of rivers or streams.

Basking or haul-out areas were often used, and were all within 10 m of the water. Generally the area was flat with a gentle slope to the water. The substrate on which crocodiles were found to bask differed depending on the surrounding riverside habitat but included sandy and grassy banks and large flat rocks. In swampy areas crocodiles basked on the higher areas which were usually covered in various grasses. The worn paths between oxbow lakes and the river were observed on numerous occasions, and these forested tracks often contained mud smeared on fallen trees, and dung. Some tracks were more than 200 m long and were often used in the dry season when water levels were low, as crocodiles moved between the lake and river.

Riparian habitat disturbance did not seem to affect the distribution of crocodiles along a river system, unless it was associated with current human presence. Areas adjacent to previously disturbed forest, such as an abandoned village or agricultural swidden, still contained crocodiles but this may be because these areas represented relatively small disturbances in large areas of the intact riparian vegetation. Crocodiles were generally not found in rivers adjacent to villages or areas active with human disturbance.

Diet

291 dung samples were collected and assessed for undigested prey items. These samples came from numerous rivers, lakes and marshes, and include samples from a wide range of crocodile sizes, from small to large animals.

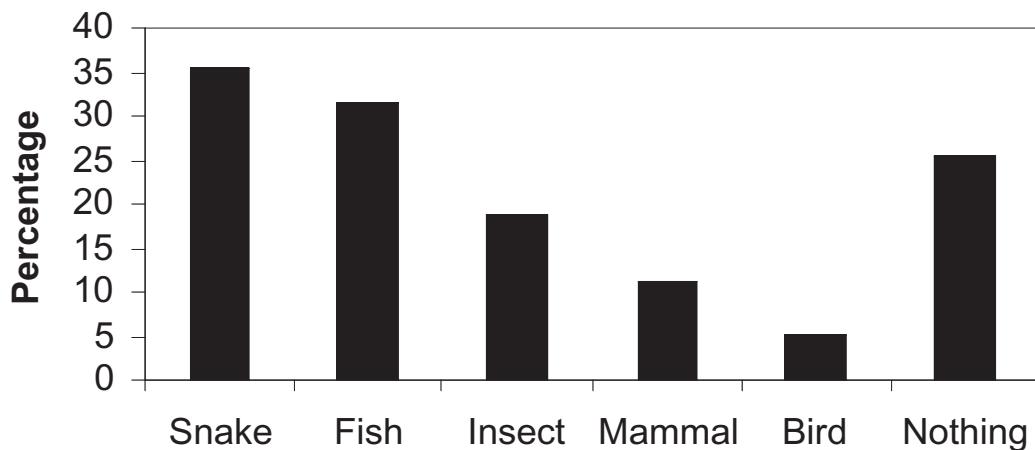


Figure 2. Percentage number of dung found with undigested prey items found in Siamese Crocodile dung (n= 291, all age classes). Note that dung often had more than one prey item represented.

Figure 2 represents the results of these pooled data and shows that Siamese Crocodiles seem to be generalist feeders, preying on a wide variety of prey items.

Further analysis is required to determine differences in diet between adults and juveniles or populations in different parts of their range. A large proportion of the dung did not contain any undigested prey items at all, but these samples were usually small sized, and hence from small animals. These crocodiles have possibly been feeding on tadpoles or frogs that were digested completely, leaving no trace of the prey. The larger dung from some areas provided numerous fish scales, while other areas showed few fish scales but many snakes scales and mammal hair. This indicates that the dominant prey taken varies in different rivers and probably different times of the year.

Nesting

Four active nests were found in 2004 and are the first wild Siamese Crocodile nests documented in Cambodia. These nests will be described in detail elsewhere but are summarized in Table 2. Nesting occurred at the start of the wet season, with all clutches being laid in April. Hatchlings are expected to emerge in June, but this is dependent on climatic conditions and so may change slightly from year to year. Nests were typical vegetation mounds and 3 were found at oxbow lakes while one was in swamp habitat. Three of the nests were well shaded for most of the day except for the Nest #4 (Table 2) which was mostly exposed on a floating vegetation mat. Clutch sizes ranged from 16 to 25 (Table 2), which is considerably less than the 50 eggs recorded for *C. siamensis* in captivity (Youngprapakorn *et al.* 1971).

Table 2. Nest characteristics for wild Siamese Crocodile nests, 2004. CS= clutch size, Flt. Mat = floating grass mat, Area: R=river, S=swamp.

Nest	CS	No. Banded	Lay Date	Area	Substrate	Habitat
1	16	16	Early April '04	Areng R.	Bank	Oxbow lake
2	16	12	Early April '04	Areng R.	Bank	Oxbow lake
3	25	21	Late April '04	Veal Veng S.	Bank	Swamp
4	21	14	Mid April '04	Sre Amble R.	Flt. Mat	Oxbow lake

Three of the four nests were found in the same area as old nests, from either 2002 or 2003, indicating that females show some site fidelity. The nest found from a new area on an oxbow lake, had hatchlings in that lake in 2003 indicating nesting had taken place at that oxbow the previous year.

Nesting information gathered during interviews and from old nest sites corroborated data from active nest sites. A report of a clutch of 27 eggs taken in April 2001 from the Srepok River in Mondulkiri Province, and two clutches of 12 and 15 eggs taken in 1983 and 1984 from a lake in Ratanakiri Province indicate that wild Siamese Crocodiles produce lower clutch sizes than captive animals.

Nests were located at oxbow lakes and swamps (Table 2), but were also reported from the banks of the Srepok (Mondulkiri Province), Pursat and Koi Rivers (Pursat Province). River nest sites were usually within several metres of a deep water section ('anlong') of the river and under tree cover.

Interviews

Interviews provided useful information on numerous topics, but location data was often found to be out of date. Often the interviewees would inform us of rivers or lakes where crocodiles could be found, but on further investigation this information was found to be no longer true. Often we would learn that poachers had been to the area in the last 10 years or so and had taken most (or all) of the crocodiles from the area. Such reports highlighted the need to follow up on verbal reports with fieldwork, because relying on reports alone could lead to the assumption that crocodiles are abundant in the wild, and this is clearly not the case. Interviews have however revealed that the past distribution and abundance of crocodiles has been greatly reduced. Some areas which had "many" crocodiles now have very few, while the crocodiles in other areas have completely vanished.

Interview data did provide us with numerous reports of crocodiles that had been captured alive for sale to crocodile farms. From 2001-2004, we have recorded at least 61 crocodiles being caught and sold alive for the farming trade. In 85% of these cases, the crocodiles were very young individuals. Many were accidentally caught by fishermen who, rather than letting them go, sold them to traders or farmers. This figure is probably only a fraction of the real number taken, however. The wholesale collection of wild Siamese Crocodiles to stock crocodile farms could ultimately wipe out the remaining wild populations in Cambodia.

Discussion

Status

The Siamese crocodile populations in Cambodia have been severely depleted and threatening processes continue to affect the remaining scattered groups. Four years of dry season surveys in 6 Cambodian provinces have revealed that Siamese crocodiles are rare and difficult to find. Isolated groups are scattered throughout the country, but seem to be concentrated in the Cardamom Mountains in the southwest. The majority of the 23 confirmed sites contain only a handful of animals and only Veal Veng Marsh and the Areng River seem to hold significant numbers of crocodiles, with both sites confirmed as nesting areas. Both sites are now the focus of community-based conservation strategies aimed to enhance protection and strengthen local enforcement of these crocodile sites (see Daltry *et al.* this volume).

Although at least 162 crocodiles of all sizes have been confirmed from field surveys, this figure should be viewed as a very conservative estimate. The actual total population in Cambodia is probably considerably larger than this, but unlikely to comprise more than 200 adults. Even though only part of the country has been surveyed so far, the likelihood of finding other significant populations remains low. Most of the areas targeted for surveys so far were selected based on other reports and local knowledge.

Areas around the Tonle Sap Great Lake have been reported to contain wild Siamese Crocodiles (Thuok, pers. comm.), but given the large human population and associated development, the chances of finding substantial crocodile populations seem low. There have however been reports of hatchlings being collected from small lakes around the Tonle Sap over a number of years and so such reports need to be followed up.

Ecological Parameters

The baseline data gathered on various ecological parameters over the last 4 years has increased our knowledge of the Siamese Crocodile. Siamese Crocodiles seem to be a generalist species that can be found in freshwater rivers, lakes, streams and marshes. They are known to overland between lakes and rivers and can be found in wide meandering lowland rivers, or steep-sided mountain rivers up to 600 m above sea level. They can be found in rocky, sandy or muddy rivers and seem to feed on a variety of prey, including invertebrates, birds, mammals, reptiles and fish. Nesting occurs at the start of the wet season, where nests can be made on the banks of rivers, lakes or marshes, or on mats of floating vegetation. Nests seem to be found near dry season crocodile sites but contain low clutch sizes, which may result in slow population recovery times if restricting threats are removed.

Although our understanding of the Siamese Crocodiles has increased considerably since 2001, further in-depth studies are still required. Crocodiles are reported to move considerable distances up- and downstream during the

height of the wet season but these movement patterns are very poorly understood. Gaining a greater understanding of the ecology of this species is essential if local and national management and conservation strategies are to be effective.

Threats to the Crocodiles of Cambodia

Siamese crocodile populations have been severely depleted over the past century and many of these threatening processes continue today. The Siamese Crocodiles of Cambodia represent the last stronghold of this critically endangered species but continue to face problems that threaten their existence and hamper their recovery.

Collection of wild crocodiles

The single most important factor threatening the species at the moment is the continued collection of live crocodiles from the wild. The CCCP has documented 61 crocodiles of all size classes being taken alive for sale in the last 4 years, while hundreds of crocodiles (mostly hatchlings) have been taken from lakes and streams around the Tonle Sap Great Lake in the past 20 years. These wild-caught crocodiles are then sold and usually make their way from the wild into one of the 900 or so small village-based “farms,” and are then traded through middlemen or other farms, probably ending up in the larger CITES-registered farms. From here they can then be traded internationally with relative ease. There is also a thriving illegal cross-border trade to Thailand and Vietnam.

As all crocodiles are protected by law in Cambodia and listed by CITES, this is clearly illegal and opens whole suite of measures that need to be addressed. Farm monitoring needs to be stepped up, education and awareness programs initiated and stricter policing measures enacted. The core problem of Cambodia’s lack of compliance with CITES, amongst others, needs to be solved before there can be any chance of a population recovery of Siamese Crocodiles in the Cambodia.

Habitat Destruction

The alteration, destruction and disturbance of wetland habitats continue as the human population strives to provide enough rice and agricultural produce for its increasing demands. Even though Cambodia’s population is still small by Asian standards, the destruction of land titles during the Pol Pot Period and unfair land distribution after the war means that many poor farmers are moving into wilderness areas while good farmland lies unused. Floodplains and wetlands continue to be converted to lowland rice growing areas, while the clearing of land for slash and burn agriculture is common in forested habitats. Not only does such alteration disturb the crocodiles with the associated human disturbance, but it also has the potential to destroy nesting habitat, cause soil erosion along river banks, increase pollutants in waterways through chemical and fertiliser run-off, and decrease the prey-base on which crocodiles depend.

Cambodia does need to increase its agricultural output to sustain its rapidly growing population and to provide economic stability, but the ad-hoc and uncontrolled wholesale destruction of the forests and waterways is not the answer. Protected areas should be exactly that - protected - and not be exposed to the destructive nature of the various agricultural practices. The permanent alteration of habitat, especially along waterways, whether in protected areas or not, should be regulated to stop the destruction and degradation of riparian vegetation right to the water’s edge. To achieve positive long term benefits for the crocodiles, the environment and the people of Cambodia, a more sustainable approach to land distribution and conversion is required.

Fishing Practices

Unsustainable fishing practices are also used frequently in Cambodia, which can have detrimental affects on crocodiles and their habitat. The use of explosives, poisons and electro-fishing equipment continues to pose a serious threat to the existence of crocodiles in some regions. Crocodiles have reportedly been killed as a result of explosive fishing (Daltry *et al.* 2003).

With 75% of Cambodia’s protein coming from the fisheries sector, numerous waterways are heavily netted. This means that crocodiles frequently encounter nets, traps or set hooks, and are often caught. Drowning in nets, although not frequently reported, does occur, with the smaller animals being more susceptible. Some fishermen complain that large crocodiles destroy their fishing nets by tearing holes in them, and this can lead to killing out of retribution. Drowning in nets continues to pose a threat to the recovery of Siamese Crocodile populations, especially in areas where breeding occurs.

Killing of Crocodiles

Killing out of fear, retribution or for meat and skins, although not common, does occur. In 2004, a “large” crocodile was reportedly shot and killed after it killed a family dog in the Areng River. Reports of crocodiles being shot and skinned have been received over the past few years, with the skins of these animals usually being sold across the border to Vietnamese buyers. There have also been reports of crocodiles being killed for food although this does not seem to be a common practice.

Next steps

In respect to Siamese Crocodile conservation in Cambodia, the main priority for fieldwork is to gain a better and more complete understanding of the status and ecology of the species. Although the CCCP surveys have covered numerous river systems, especially in the Cardamom Mountains, many of the status surveys carried out to date were very rapid should be viewed as preliminary appraisals. Even areas such as Veal Veng Marsh and the Areng River, which have been visited on numerous occasions over a number of years, are still poorly understood with respect to crocodile numbers and population dynamics. More intensive surveys, perhaps using mark-recapture methods or camera-trapping, need to be conducted at these and other significant crocodile sites to gain a better understanding of crocodiles’ numbers and population biology.

Baseline surveys also need to be extended to new areas and provinces, to follow up any and all verbal reports to identify remaining populations. This will be essential to provide a more comprehensive understanding of the status of the Siamese Crocodile in Cambodia to inform the development of an appropriate national conservation strategy. As each significant ‘new’ colony is found, the CCCP will notify local authorities, communities and conservation agencies, and advise and assist them to safeguard the crocodiles and their habitat.

Although useful baseline data have been collected on various ecological parameters over the past 4 years, there is now a real need to carry out more in-depth research on the behavioural ecology of Siamese Crocodiles in the wild. In particular, the movement patterns of crocodiles within, and between sites, will be crucial to the development of relevant strategies: It is essential to know which of the known colonies are connected and which are genetically isolated. To gain a better understanding of the mobility of these populations, we intend to conduct a telemetry study during 2005.

Further studies also need to be conducted to answer and elucidate questions of seasonal and size-related movement patterns, habitat preferences and partitioning, reproductive and feeding strategies, and the use of burrows. The better our understanding of the needs and habits of the Siamese Crocodile, the more likely it is that Cambodia’s conservation strategy will be appropriate and ultimately successful.

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Conservation of the Critically Endangered Siamese Crocodile in Lao PDR

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Abstract

In February and September 2003 we visited sites in Attapeu and Savannakhet Provinces in southern Lao PDR to collate information on the status of wild crocodiles and develop plans for a national conservation effort to be coordinated through LARReC. Based on recent reports and signs we found at the Bung Khe site in Attapeu, a small population of crocodiles remains in the remote headwaters of the Xe Kong River system. However we were surprised to find that there appears to be a larger breeding group of crocodiles in the lower Xe Champhon River system and associated wetlands. A very small group also remains in the Xiabouli district in northwestern Savannakhet, close to the Mekong River, where evidence of a nest from 2002 was found. In most areas in this region of Lao PDR crocodiles are considered to be sacred animals and a community-based program that focuses on management of wetlands will likely be the most productive approach to crocodile conservation.

Background

The Siamese Crocodile (*Crocodylus siamensis*) is one of four species of crocodilians considered to be Critically Endangered by the IUCN Crocodile Specialist Group. Siamese Crocodiles were at one time widespread in lowland wetlands in southeastern Asia, but have suffered from the widespread loss of its wetland habitats, as well as intensive persecution for its skin in the 20th century. The war-ravished region of Indochina was off-limits to biological surveys until recently, and while some wild groups remain in parts of Cambodia, surveys have shown that the species has all but disappeared from Vietnam and Thailand. Siamese Crocodiles were also known historically from Java (where they are now presumed to be extirpated), and may still remain in unknown numbers in some of the backwaters of Kalimantan (Borneo). The status of crocodiles in Lao PDR, however, remains unclear.

The Siamese Crocodile is the only crocodilian known from Laos. It is listed by the IUCN as Critically Endangered, and is protected in Laos under Management Category 1. Historically, Siamese Crocodiles are thought to have been widely distributed in low elevation wetlands in Lao PDR. Much of Laos is mountainous, and suitable crocodile habitat (lakes, ponds swamps, marshes) is mainly restricted to the lowland areas along the Mekong in southern and central Laos, but there is little information on this species and its current and past distribution are poorly understood. Historical accounts indicate that crocodiles were seen in the Mekong River in Laos, particularly during the annual dry season. During the 1860s French Mekong expedition crocodiles were reported from the vicinity of Bassac (Champasak), Laos (Garnier 1996). In the 1880s, victims of cholera epidemics were disposed of by placing their bodies in the Mekong where they were consumed by crocodiles, which were said to be quite common in parts of the river (Neis 1997). Bassenne (1912) mentions that a favorite pastime of passengers on some boats ascending the Mekong was to shoot at crocodiles lying on sandbars near the town of Pakxan, just east of Vientiane. Smith (1931) stated that this species extends northward along the Mekong to about latitude 16°N, with one specimen known from Kemarat (Khemmarat), along the Mekong (which forms the border between Laos and Thailand).

In the 1950s and 1960s crocodiles were reported to be common in permanent water bodies along the Nam Lepou River, which forms the Cambodian-Lao border west of the Mekong. Salter (1993) mentioned several areas where crocodiles were historically reported in northern Laos including two areas near the capital of Vientiane; the Nam Ngum River wetlands and the Phou Khao Khouay protected area (Nam Xan, Nam Leuk, Nam Gnang, Nam Mang). Another site even further north (ca 19° N) along the Mekong (Nam Pouï protected area) was also reported by Salter (1993) to have had crocodiles as recently as the 1950s. A single individual was reported killed at the mouth of the Nam Ma (nearly 21° N) in 1990 but this was considered to be extralimital by Salter (1993).

Present Status of Crocodiles in Lao PDR

No systematic surveys for crocodiles have been carried out in Lao PDR. The status of crocodiles in Laos has been reviewed recently by Stuart (1999) and Stuart and Platt (2001), but information is based largely on anecdotal reports from interviews with local residents.

Some photographic evidence has recently documented the continued presence of Siamese crocodiles in the Phou Khao Khouay National Biodiversity Conservation Area (NBCA). Based on visual records and sign (fresh feces, tracks), a breeding group of unknown size is believed to remain in the Bung Khe wetland system in northeastern Attapeu Province. This site has been visited on previous occasions by LARReC staff, and personnel from the Xe Pian NBCA (see below) and may represent one of the best remaining areas for crocodile conservation in the country. Crocodiles have also been documented from at least two sites in Savannakhet province (Baird 2001; Matheus 2001).

Objectives

1. To evaluate the status of crocodile populations within the Champhone, Xonbuly, Xaibouly Districts in Savannakhet Province and Sanamxai District Attapeu Province.
2. To provide broad recommendations for future conservation and management initiatives in the area.

Field Visits

In 2001, WCS began to work jointly with LARReC (Living Aquatic Resource Research Center) and the National University to initiate a conservation program for the Critically Endangered Siamese Crocodile. In February 2003 an initial visit was made to sites in Attapeu and Savannakhet Provinces in southern Lao PDR. Over a 12-day period we visited three sites and compiled information on reports of crocodiles.

In a subsequent survey in September 2003, the survey team conducted interviews in 8 villages, and daytime surveys in grasslands and bamboo and deciduous forest near wetlands. It was not possible to do nighttime surveys because the water levels were extremely high as a result of the early monsoon season rains.

Bung Khe wetlands, Attapeu Province

Location. Sanamxai District, in the Xe Pian River drainage along the southwestern slopes of the Bolovens Plateau. Two ponds were visited, Nong Khe (N 14° 42' 08.5" E 106° 28' 09.4") and Nong Ke (N 14° 42' 36.6" E 106° 27' 53.5"), just 2-3 km to the N and NE of Pindong village (N 14° 41' 36.2" E 106° 27' 29.6") situated along the old road that extends W from Sanamxai village.

Habitat. Bung Khe means crocodile marsh in the Lao language. Within this seasonally flooded area there are a number of permanent water bodies or ponds referred to as "nongs" in Lao. These ponds are dry season remnants of an extensive floodplain situated to the west of the Xe Pian River. This area is composed of a total of seven wetlands over an area of approximately 700 ha: Pa Tookhong wetland, Pa Tookhong wetland, Duak wetland, Phou Lon wetland, Dindeng wetland, Khea wetland and Thom Niam wetland nearby Pindong village. Many of the wetlands we visited were along a water course that is formed by a Pliocene-Pleistocene lava flow blocking surface water drainage to the south, creating a drainage system that feeds SE into the Xe Pian River. The plain is dominated by dry evergreen, dipterocarp and bamboo forest, and the ponds are shallow wetlands covered almost entirely by thick mats of floating vegetation (*Eichhornia*, *Salvinia*, *Nymphaea*, and *Imperata cylindrica* sedges, Araecea, ferns) with very little open water habitat. The smaller pond (Nong Khe) was estimated to be approximately 20 ha in size and the larger one (Nong Ke) 200-250 ha. We were told that there were other small nongs to the north and that crocodiles had been reported from these as well. Bung Khe wetlands resulted from natural pond which has 700 ha of good crocodile habitat.

Human Use. There are four nearby villages that regularly use the Bung Khe wetlands (Ban Pindong, Ban Hinlat, Ban Samongneua, Ban Samongtay), and the total human population in the area has been estimated at 3000 (Phiapalath *et al.* 2001). Fishing appears to be an important economic activity, particularly in the dry season, primarily for catfish and snakeheads. During our nocturnal survey fishermen were seen at both ponds we visited. Fishermen were reported to use hook and line and also basket traps. The edges of the ponds are also used extensively by water buffalo from nearby villages. In the late 1990s, a Vietnamese company surveyed the site to determine the economic feasibility of

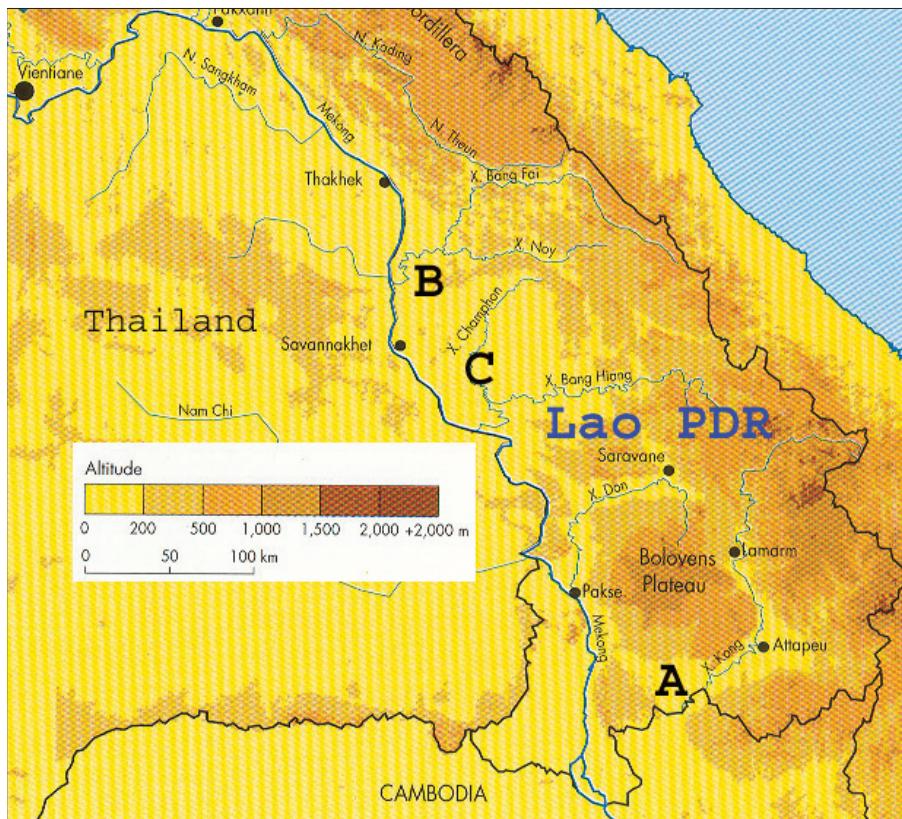


Figure 1. A map of central and southern Laos indicating the locations of the three sites visited during this survey: A- Bung Khe, Attapeu Province, B- Ponds in Xiabouli District, Savannakhet Province, C- lower Xe Champhon region.

extracting peat to be used as a bio-fertilizer. This company cut a road to Nong Ke through the forest, but abandoned the venture due to the unsatisfactory quality of the peat in the region.

The villages around Bung Khe are largely a mixture of ethnic minorities and the use of the wetlands has been guided to a large extent by traditional systems. The ponds themselves are considered to be sacred, and fishermen can only use traditional fishing techniques, and fish are only to be used for local consumption, not for sale.

Crocodile Status. This site has recently been considered as one of the last and best remaining populations of the Siamese Crocodile in Laos (Stuart 1999; Stuart and Platt 2001). Initial reports of crocodile in Bung Khe came from the Forestry Department in Attapeu Province. These reports sparked a visit to the area by WCS personnel in 1997 (D. Davenport, R. Tizard and V. Phommauangs) who found abundant crocodile sign and heard a crocodile vocalization. LARReC personnel have made previous visits as well, and in 1998 one of us (C. Photitay) got a brief glimpse of a crocodile in Nong Ke. Local residents report the crocodile population in the past numbered thousands of individuals, but there appears to be little basis for this estimate.

During our interviews, residents of Ban Pindong reported having seen juvenile crocodiles, suggesting that successful reproduction is taking place. However, residents had no idea of how crocodiles made nests.

During our visit we found fresh crocodile feces at a basking site in Nong Khe (from an adult-sized crocodile), and saw crocodile trails in the floating vegetation on Nong Ke. However, during our nocturnal survey (1.0 km of shoreline total at these two sites) we saw no crocodiles. Local residents report that the early rainy season (June) is the best time to see crocodiles, particularly in Nong Ke. They also indicated that crocodile would leave the ponds and enter the Xe Pian river at times during the wet season. In a nearby temple in September we found a crocodile that was reportedly given to the monks by local people. The monks did not know where the crocodile had been caught.

Our overall conclusions were that the Bung Khe wetlands contain a small number of crocodiles but that much more survey work is needed. The crocodiles in this area may be part of a diffuse population that exists in the Xe Pian, the Xe Kampho, and the lower Xe Kong River system in southernmost Laos. The adjacent Xe Kong system in Cambodia is also an area from where crocodiles have been reported.

Conservation Issues: Crocodiles were reportedly captured and sold in Attapeu prior to 1993 (Phiapalath *et al.* 2001), presumably for sale to farms in Cambodia and Thailand. However, we found no indication that commercial trade exists today.

The Bung Khe wetlands appear to offer suitable habitat for the Siamese Crocodile, however human use of the area presents a number of conflicts. The presence of fishermen in the ponds is a potential source of disturbance, and the use of basket traps could lead to crocodile mortality by drowning. The quality of the habitat is also degraded by the presence of water buffalo, which move in large groups along the edge of the ponds trampling vegetation and destroying the shoreline habitats preferred by crocodiles.

The Bung Khe region is situated very close to the boundary of the Xe Pian NBCA, a 240,000 ha protected area, one third of which is in Attapeu Province and which includes parts of the Xe Kampho, Xe Kong and Xe Pian lowlands. Attapeu Province has also declared a number of provincial protected areas (PPA), including the Nam Kong PPA (205,000 ha) in the southern third of the province (linking with the Virachay National Park in Cambodia). Another Attapeu PPA is the Xe Kampho floodplain linking the Xe Pian NBCA with the Bolovens escarpment. This latter area may potentially include the Bung Khe area.

Aside from Siamese Crocodiles, the Bung Khe region is also reported to harbor other wildlife species including leopards, leopard cats, jungle cats, otters, pangolins, gibbons, gaur, sambar deer, wooly-necked storks, green peafowl, Bengal and water monitors, king cobras and several species of turtles (Phiapalath *et al.* 2001; Davenport *et al.* 1997).

Conservation Recommendations

1. More survey work is needed to quantify the area of wetlands habitat and the presence/status of Siamese Crocodiles in the Bung Khe wetlands.
2. Surveys should be conducted as part of a larger effort in the lower Xe Kong, Xe Kampho and Xe Pian River systems in southern Laos.
3. Surveys should include the active participation of local communities. This activity also promotes local understanding about conservation and builds local capacity for future project implementation.
4. Initiate discussions with the four villages that share resource-use rights for the Bung Khe area concerning potential and views towards community-based management of this area.
5. Seek funding for community-based protection of the wetlands and the crocodile population
6. Consider the potential for linking management of the Bung Ke site with the adjacent Xe Pian NBCA.

Ban Beung Boua Thong and Ban Nao Neua Lakes, Savannakhet Province

Location. Three ponds along the south shore of the Xe Bangfai River adjacent to the villages of Ban Beung Boua Thong and Ban Nao Neua, Xaibouli district in northwestern most Savannakhet province. Two ponds were visited: Nong Boua (N 16° 59' 06.6" E 104° 53' 14.6") and Beung Saiyan (N 16° 59' 56.8" E 104° 52' 17.2")

Habitat. Nong Boua is a small pond (ca. 500 m x 100 m) located immediately adjacent to the Ban Nao Neua village. At the time we visited water level was low, exposing a open sandy fringe around much of the lake. The northern edge of the lake is an evergreen forest. Although the lake was reported to have floating vegetation (mostly *Eichhornia*) in the past, recent bio-controls have resulted in the water body being completely free of any type of floating plants. Beung Saiyan was a much larger (ca 800 m x 5000 m) marshy area filled with extensive rooted aquatic vegetation. During the annual wet season the size of the lake grows as it floods out into areas used for agriculture during the dry season. We did not visit the third lake (Beung Boua Thong), but this lake is reported to be similar to Nong Boua but somewhat larger in size (Baird 2001).

Human Use. Two of the three nongs are considered to be sacred by the local communities and no fishing is allowed. The third nong, Beung Saiyan is used by eight different communities for fishing, including the use of gill nets. The seasonally exposed fringes of the marsh are also used for rice paddy and other agriculture.

Crocodile Reports and Status. Crocodiles were reported from this site by Baird (2001) and their presence here is well known throughout the province. Villagers are unsure of the number of number of crocodiles, but regularly see one adult (?) in Nong Boua that is very tame and frequently fed. Villagers also made reports of a larger animal (?) that moves between ponds, and smaller animals seen on occasion in Beung Saiyan.

During our visit we saw the Nong Boua crocodile (ca. 2.8-2.9 m total length) and were able to approach it closely and

take photographs. This animal is extremely tame and very used to people, and will occasionally take dogs and pigs that walk around the edge of the pond. This animal is presumably a female as it is the one that has been reported nesting by residents of the nearby village. The reproductive status of this group of crocodiles, however, remains unclear. Baird (2001) reported that the female would nest annually at one location near Beung Boua Thong, but that villagers reported the eggs never hatched. The female has apparently changed locations as she nested in the forest ca. 200 m from Nong Boua in June 2001. Villagers reported that during the previous year the crocodile had been found in the forest and was thought to be ill, so they tried to construct a shelter to cover her but gave up when she became aggressive. They assumed that she nested here but had no clear idea what the nest actually was. We visited the nest location and found the remains of a nest mound, now composed primarily of dried mud, along with the remains of eggshells and 3 decomposed eggs. The female crocodile was reported to have spent at least one month out of the water near the nest. While it is clear that nesting is taking place the fate of the nests is unknown and requires follow-up.

Conservation Issues. While the residents of the two villages consider the crocodiles and the two smaller ponds to be sacred, these areas do not support adequate habitat for even a small group of crocodiles. However, the third pond, Beung Saiyan, is much larger and could potentially support a small population of crocodiles. However, community resource use in this pond is fairly intense, including fishing and seasonal agriculture.

Recommendations

1. Conduct a more detailed survey of wetlands and crocodiles along the lower Xe BangFai and associated wetlands
2. Initiate a dialog with villages that use the Beung Saiyan wetland and evaluate the potential for community consensus to develop a management plan for this pond that would favor the survival of crocodile- perhaps linked to ecotourism.
3. Evaluate factors affecting crocodile nesting success in Nong Boua.

Xe Champhon Wetlands, Savannakhet Province

Location. In February and September 2003 we visited a limited area including a series of oxbow lakes along the western edge of the Xe Champhon River to the southeast of the village of Laonat (N 16° 22' 31.3" E 105° 10' 52.3"). In September we also surveyed wetlands near the villages of Taleo and Donedeng, to the east of Laonat and on the opposite side of the Xe Champhon River.

Habitat. We saw three oxbow lakes that were surrounded primarily by bamboo forest and a riparian fringe of *Mimosa* sp. The overall area contains approximately 300 ha of natural wetlands and another 500 ha of habitat flooded by the construction of small dams. The lakes were a mixture of open water and heavily vegetated areas with an abundance of water hyacinth (*Eichhornia* sp.). Along the western bank of the Xe Champhon River an irrigation project had dammed three smaller streams (Houy Mark My, Houy Kadane, and Houy Nong Ing), creating rice paddies and a series of marshy reservoirs and flooding and killing areas of deciduous forest. These reservoirs and inundated forest also appear to provide good crocodile habitat. The area we visited comprises just a small part of what (according to topographic maps) consists of a series of oxbows and other wetlands in the lower Xe Champhon, Nong Louang, Xe Xangxoy region. There are approximately 300 ha of wetlands around the Taleo and Donedeng villages formed by damming a small stream.

Human Use. The village of Laonat is mostly dedicated to agriculture, but the lakes are fished by this and other villages, particularly during the annual dry season. Fishing is done by hook and line, with baskets, and with gill nets.

Crocodile Reports and Status. Crocodiles were reported in this area by Salter (1993), who considered the lower Xe Champhon-Nong Louang wetlands to be one of three sites in Laos where viable populations of crocodiles may still remain. Salter (1993) reported that breeding was occurring in the oxbow lakes along the Xe Champhon and this appears to still be the case. There have been recent anecdotal reports of crocodiles being seen in the Nong Louang, a large permanent water lake located upstream of the confluence of the Xe Champhon and Xe Bangiang rivers. Also, a recent sighting (1998) of a juvenile crocodile in a pond near the village of Ban Nathom (Atsaphone district) is significant (Matheus 2001). This site is much further upstream in the Xe Champhon system, approximately 55 km NE of the Laonat site. The fact that it was a juvenile suggests that reproduction is still taking place in the area. Also, Matheus reports that the ethnic Phuthai from Ban Nathom considers the pond and the surrounding area sacred.

In September we conducted a brief visit to the Done Yanong wetlands, situated near the confluence of the Xe Champhon and the Xe Bangiang. This is a natural wetland of approximately 500 ha with three major ponds: Kout Kuang Yai,

Kout Kuang noy and Kout Kok. This area is about 500 ha with good crocodile habitat nearby paddy fields of the village. The ponds have some *Eichhornia*, *Salvinia*, *Nymphaea lotus* and *Imperata cylindrica*. We did our surveys by boat and walking. In this area we could not see any crocodile because of the flooding but local people estimate there are >20 crocodiles in the region.

In the small area we visited in February there were indications of that there had been at least two nests in 2002. One nest was reportedly collected by residents of Laonat and brought back to the village to incubate (Nong Kout Phinoy N 16° 20' 51.8" E 105° 13' 17.7"). Another nest in an adjacent pond (Nong Kout Mark Pheo N 16° 21' 16.1" E 105° 13' 02.3") was found by a rice farmer in the area but left untouched. In November, the farmer reported seeing a group of ca. 30 hatchlings at night in a rice paddy bordering a vegetation-choked stream, with a vocalizing adult nearby. In September we were shown a hatchling crocodile that had drown after being caught in a fishing trap. The descriptions of nests (here on floating mats of vegetation), nest timing (during the wet season), and the behavior of juvenile and adult crocodiles adds veracity to the reports of the local residents we interviewed. A small number of crocodiles were reported to be in the Taleo and Donedeng wetlands and villagers reported having seen hatchlings in the recent past.

Taken together, these reports suggest that a small reproductive population of Siamese crocodiles is found along the Xe Champhon River system.

Conservation Issues. The reason why the Laonat villagers would collect and incubate eggs is unclear. Some people indicated that this was done for the novelty of the experience. However, past commercial trading for live crocodiles and skins is known from this area (Salter 1993) and there still may be a market for live animals to be sold to Thailand or Cambodian crocodile farmers.

The Xe Champhon- Nong Louang wetland system may comprise the best remaining area of Siamese Crocodile habitat in Laos. The area is currently unprotected and is subject to increasing pressure from agriculture and fishing. Due to the area's proximity to the city of Savannakhet (1 h by car), this region could potentially develop alternative uses for these wetlands based on ecotourism.

Recommendations.

1. A high priority should be given to surveys of wetlands habitat, crocodiles, and land-use patterns in the Xe Champhon-Nong Louang region.
2. A workshop should be organized in Savannakhet to bring together a range of stakeholders, including government officials, leaders of villages from the Xe Champhon region, and ecotour operators, to discuss the potential for nature-viewing trips to this area and how this could be used to generate economic incentives to protect crocodiles/wetlands.
3. Initiate meetings in the principal villages in the region to discuss resource-use issues in these wetland habitats and their management.
4. Consider declaring this a new provincial or national protected area.

Discussion

As a principally marsh and lake dwelling species, natural habitat for this crocodile may never have been extensive in Laos. The principal habitats of Siamese crocodiles in lowland areas were probably oxbow lakes and other wetlands associated with the lower courses of Mekong tributaries, particularly in the central and southern provinces. Furthermore, it is these lowland marsh and pond habitats that are usually among the first to be affected by agriculture. Today, there appear to be relatively few areas of this habitat that do not receive intensive human use in the form of fishing, agriculture, harvesting reeds for mats, or as water buffalo resting sites. Another area of potential habitat is relatively slow moving sections of rivers and streams, and their associated wetlands, in low hills (to about 500 m elevation). It is these areas where the last remnants of Siamese crocodile populations appear to be surviving in Thailand, and where some of the best remaining groups are found in Cambodia.

Based on previous reports and the results of these preliminary visits, it is apparent that small groups of Siamese Crocodiles remain in at least three locations in Laos. Crocodiles may still be found in other areas in Laos, and further surveys in hill regions (eg Phou Khao Khoay NBCA, Xe Bang Nouan NBCA, Dong Phou Viang NBCA and the middle-upper reaches of the Xe Kaman) are clearly warranted.

However, the two most promising areas for Siamese Crocodile work in Lao PDR are:

1. Bung Khe wetland system in northeastern Attapeu province. A remnant population of Siamese Crocodiles is found in this area and potentially others in the nearby Xe Pian National Biodiversity Conservation Area.
2. The Xe Champhon and Xe Bangiang River systems in southern Savannakhet Province. Crocodiles are scattered throughout a series of natural and artificial wetlands along the Xe Champhon and upstream sections of the adjacent Xe Bangiang.

At these lowland sites most local communities appear to have a relatively benign attitude towards the crocodiles, or even consider them to be revered animals. This will provide a firm basis for developing community-based conservation programs, using crocodiles as a flagship species to protect these valuable wetlands. Linking this in with the growing tourism industry in Lao PDR, and the great interest in ecotourism, could provide a mechanism for local communities to benefit from the protection of wetlands and wetland fauna. For these sites, the approach first outlined in a WCS-Lao project proposal (B. Stuart and S. Platt) offers an excellent strategy based on a four-step process:

1. Gather baseline biological and socioeconomic information from the wetlands where Siamese Crocodile populations are known to still exist.
2. Use the results of the baseline biological surveys to identify the wetland that has the greatest likelihood of supporting a viable population of crocodiles. Designate this as a *pilot wetland* for management of Siamese Crocodile. Use the results of the biological and socioeconomic surveys to design a crocodile management plan for the *pilot wetland*.
3. Implement the crocodile management plan for the *pilot wetland*. Implement a biological and socioeconomic monitoring system that is designed to measure if and how the management plan is working to conserve Siamese Crocodile and meet the expectations of village and district managers.
4. Summarize results from the biological and socioeconomic monitoring. Report on lessons learned and use results to revise the management plan for the next phase.

The first step will require two components, a biological survey of the wetland habitats to estimate the status of the remaining crocodiles, and a socioeconomic survey of the communities that use those wetlands.

Recommendations

Overall recommendations are to:

1. Carry out more detailed surveys of wetlands, crocodile status, and land use/socioeconomic characteristics of communities around the three target wetland sites.
2. Use this information to plan a pilot wetlands conservation project with the Siamese Crocodile as the focal species.
3. Promote a public awareness campaign to build local understanding about the conservation significance of the crocodile and make a link between local livelihood as well as the wetland in the region.
4. It is highly recommended to develop and conduct long-term participatory monitoring of the crocodile. In addition to determining the population trends to help identify existing or potential management problems and possible solutions. This activity also promotes local understanding about conservation and builds local capacity for future project implementation.
5. Investigate the potential for using managed ecotourism as an alternative source of income, linked to wetlands and crocodile conservation, for local communities around the two areas in Savannakhet.

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Overview and Conservation Priorities for the Philippine Crocodile

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Introduction

The Philippine Crocodile (*Crocodylus mindorensis*), or “Buwaya”, is a relatively small freshwater species averaging 1.5-2.0 m in total length, with adult males reportedly reaching 3.0 m (Brazaitis, 1973; Ross, 1998). It is one of only two species of crocodiles naturally occurring in the Philippines, the other being the much larger Estuarine or Saltwater Crocodile, *C. porosus*, which can also be found in many other parts of south and southeast Asia.

Very little is known of the ecology of *C. mindorensis* and information on its reproduction, growth and behaviour is still based largely on captive animals.

Conservation Status

Previously distributed through many parts of the Philippines, it is now thought to only exist in the wild as small remnant populations and scattered individuals in central and eastern Mindanao, and northeast and northwest Luzon (Ortega 1998; Pontillas 2000; van Weerd and General 2003; G. Rebong, pers. comm.). Anecdotal reports of crocodiles still to be found on Busuanga Island, Lake Naujan on Mindoro, and in southwest Negros Occidental have yet to be substantiated or their numbers clarified. The general consensus in 1997 was that no more than 100 adults remained in the wild (Ortega 1998). Whilst the real number may be higher than that, in view of known breeding groups in northern Luzon, there is no question that the species remains severely threatened.

Indeed, the Philippine Crocodile is now recognised by the IUCN/SSC Crocodile Specialist Group (CSG) as among the most threatened species of crocodiles in the world and is listed by the IUCN as Critically Endangered (IUCN 2002). It is legally protected in the Philippines and is listed on Appendix I of the Convention on International Trade in Endangered Species (CITES).

Initiating a Conservation Program

1. Local Management Initiatives

The Philippine Government wildlife agency responsible for the country’s wildlife is the Department of Environment and Natural Resources (DENR), particularly its Protected Areas and Wildlife Bureau (DENR-PAWB). However, like all Philippine Government agencies, the DENR-PAWB is desperately short of resources, especially appropriately trained staff and reliable funding. An additional issue facing all wildlife conservation in the Philippines is a worrying lack of knowledge and understanding of the country’s wildlife, even to the level of the national wildlife agency, due in large part to the lack of appropriate texts for students in school and university. The latter problem is slowly being addressed, but we still very much have a situation where successful development and delivery of conservation programs in the Philippines relies very heavily on DENR-PAWB staff working closely with overseas partners who have the necessary background, commitment and expertise.

The first substantive concerns about the status of *C. mindorensis* were tabled in 1983 following a distribution-wide survey in 1982, which estimated the wild population at 500-1000 mature individuals (Ross and Alcala 1983). This led to the Philippine Government implementing measures to address the plight of both species of crocodiles in the Philippines. As a consequence, a joint venture between the Japanese and Philippine Governments to create the Crocodile Farming Institute (CFI) was established at Puerto Princesa City on Palawan Island in 1987.

A much smaller captive breeding effort had been initiated in 1980 at Silliman University in Dumaguete City, Negros Oriental, but this relied solely on overseas funding. Occasional breeding has continued at the Silliman facility and 10 crocodiles are currently held there (Alcala *et al.* 1987; D. de Leon, pers. comm.).

The CFI was renamed as the Palawan Wildlife Rescue and Conservation Centre (PWRCC) in 2000. The joint venture ceased in 1994 and the PWRCC is now managed solely by the DENR. However, overall management responsibility for the facility was transferred to the National Resources and Development Corporation (NRDC), another arm of the DENR, in April 2002, but with the Protected Areas and Wildlife Bureau (PAWB) retaining responsibility for the *C. mindorensis*. This dual management has not helped the overall management of the captive population and Government funding shortages remain an ongoing issue.

Prior to the transfer to the NRDC, in 1999 the Director of the then CFI and 10 other CFI/PWRCC managers resigned, citing ongoing administrative problems with the DENR-PAWB head offices in Manila. Regrettably, not all these vacancies have been filled, making it impossible for the Centre to fulfill all components of its mandate, including raising community awareness. An additional strain on the Centre's operations is uncertainty about the genetic integrity of some of the captive animals, arising from the mtDNA study initiated 1996.

Despite these pressures, breeding has been successful and the PWRCC maintained over 1169 *C. mindorensis* as at 1 March 2003 (G. Rebong, pers. comm.). The Centre's facilities, whilst currently lacking the necessary operational support, still have the potential to contribute significantly to the conservation of *C. mindorensis* (Ortega 1998).

The species is maintained at a number of other captive facilities in the Philippines. This includes Manila Zoo, which has displayed and bred *C. mindorensis* for many years. Approximately 160 animals are also maintained in a range of private zoos and collections that are registered with the DENR-PAWB, but inadequate resources do not allow for collation and use of appropriate records, such as sex and age. Indeed, this is an issue across most captive facilities in the Philippines.

2. Interest from Overseas Zoos

Interest in *C. mindorensis* from overseas zoos stems from 1988, when Gladys Porter Zoo in the USA imported an adult female from Silliman University to pair with a male already at the Zoo. An additional male was also received and GPZ's involvement with the species is covered by a Memorandum of Agreement (MOA) with the DENR. A total of 68 offspring have been produced and most subsequently distributed to other institutions:

- Eight were repatriated to the Philippines in two groups.
- 47 were sent to other US zoos, the most recent transfer being 33 to five zoos under Breeding Loan Agreements between GPZ and the receiving zoos, under the auspices of the MOA between the DENR and GPZ.

The aim of the GPZ project, supported by the American Zoo Association's Crocodilian Advisory Group (AZA-CAG), is to establish a stable, viable captive population in North American zoos and private collections, which, in turn, allows for the generation of funds to assist *in situ* conservation of the species in the Philippines (C. Adams, pers. comm.).

Melbourne Zoo, in Australia, signed a MOA for *C. mindorensis* with the DENR and Silliman University in 1993. This provided the framework for the Zoo to fund upgrading of the Silliman facility and transfer of a pair of sub-adult *C. mindorensis* to Melbourne later that year. The original MOA expired in 1996 and new Agreement was finally signed in 2001, between the Zoo and DENR. Six young crocodiles, captive-bred at the PWRCC, were transferred to Melbourne in late 2002, but three unfortunately succumbed to stress-induced trauma within one month of arrival. Melbourne Zoo has a strong commitment to the conservation of this species and has been providing a range of *in situ* support since 1994.

There is also interest in conservation of this species from a number of European zoos, most particularly from the Danish Crocodile Zoo at Eskilstrup in southern Denmark. This is supported by the DENR-PAWB, but signing of a MOA, which would allow for transfer of crocodiles, has been stalled by administrative delays. This is frustrating, as the DCZ has committed to provide *in situ* funds once crocodiles arrive and are on exhibit.

Developing a Coordinated Program

1. The First Recovery Plan

A key participant in the establishment of the PWRCC was the Crocodile Specialist Group, whose first global

Crocodile Action Plan recommended establishment of a “national crocodile management program” as the highest priority for the Philippine Crocodile (Messel *et al.* 1992). The CSG also noted that the best chance for the species’ survival was captive breeding, a recommendation which was repeated in the second edition of the Plan, produced in 1998 (Ross 1998).

With the support of Melbourne Zoo, the PAWB and the CFI/PWRCC were represented at the 1998 meeting of the CSG in Singapore. This led to agreement on development of a National Recovery Plan for the Philippine Crocodile, which was published in 2000 (Banks 2000). Two chapters in the Plan are of particular importance:

“Issues & Challenges”, which underpins the basis for the necessary conservation actions:

- Habitat loss: *C. mindorensis* is restricted to freshwater lakes, swamps and rivers, which have suffered greatly from pollution, over-fishing, siltation, conversion to other uses, clearing of riparian vegetation, and the introduction of exotic fish species. Further, those freshwater habitats which are covered by the protected area system receive little if any protection (PAWB/DENR and Wetlands International 1992).
- Negative community attitudes: all crocodiles in the Philippines have a poor image within the general populace and are viewed negatively at almost all levels of society. Locally known as “buwaya”, they are believed by rural people to be bearers of bad tidings and in league with the ‘dark forces of nature’. They are thus often referred to as “asuwang”, or witches (Ortega 1998). The perceived aggressive nature of crocodiles do not endear them to the human population, and reported cases of problem crocodiles, most likely *C. porosus*, attacking people have reinforced the supernatural beliefs of rural people.
- Crocodiles are also the most maligned and ridiculed animals in the Philippines. In the Filipino culture, crocodiles are often compared to corrupt Government officials, greedy businessmen, tax collectors and selfish athletes.
- National policies: although there are several laws that provide for the protection of Philippine wildlife and their habitats, only one piece of national legislation specifically includes crocodiles as protected animals. The new Wildlife and Conservation Act updates many of the existing laws, but its impact on *C. mindorensis* conservation is unclear.
- Captive management: in most respects, captive management of *C. mindorensis* does not differ greatly from that of most species in the genus. However, the seasonal incompatibility that manifests itself in most groupings and pairings, including among juveniles, presents difficulties for intensive captive management.
- Ecology: the ecology of *C. mindorensis* remains poorly understood.

Conservation Objectives, each with a number of Performance Criteria and defined Actions. The primary conservation goal is to re-establish viable wild populations of *C. mindorensis* and ensure its long-term survival throughout its historic range. Recognising the implications of this objective, protection and survival within sections of its historic range may be the reality over the short-term. The objectives cover:

- Establish protected wild populations.
- Promote and encourage positive community attitudes to, and understanding of crocodiles in the Philippines.
- Co-ordinate captive management.
- Determine the species’ ecology.
- Define the extent of remaining wild populations.
- Resolve systematic relationships.
- Integrate the conservation of *C. mindorensis* with conservation of freshwater wetlands in the Philippines.
- Ensure that all relevant Government policies support conservation of the species.

2. Delivering the Plan

Overseeing implementation of the Plan is the primary responsibility of the Philippine Crocodile National Recovery Team, which was created by a Special Order of the DENR on 3 March 2000 and has eight members drawn from the DENR/PAWB, Melbourne and Gladys Porter Zoos, Silliman University and representatives of the legislative regions in which the species occurs. The Team is supported by a four person secretariat drawn from the PAWB.

Arguably the greatest value of the Recovery Plan lies in its actual existence as a DENR-endorsed document that can be used to emphasise and reinforce the urgent need for co-ordinated action to conserve *C. mindorensis*. Achieving desired conservation outcomes for any wildlife in the Philippines is a daunting task - the Philippine economy is in decline, corruption remains widespread, information sharing is not routine, government bureaucracy

is cumbersome, the general populace is desperately poor, the birthrate is climbing, and understanding of Philippine wildlife is very low. Law and order has been an issue for the past two decades and its linkage with terrorism adds yet another dimension to a very gloomy outlook for wildlife conservation in the Philippines. Indeed, organisations like Conservation International and BirdLife International rate the Philippines as one of the highest priority areas in the world for urgent conservation action (Heaney and Regalado 1998).

Despite these problems, all of which are interwoven, successes are being gained and it is documents such as the Recovery Plan, and its associated Recovery Team, that can be used to draw the Government's attention to relevant issues and assist it to move forward.

3. Updating the Plan

A number of significant developments have occurred since the first edition of the Recovery Plan was published. Most particularly, these include:

- Confirmation of *C. mindorensis* breeding in the Northern Sierra Madre area of northeast Luzon Island and the very promising level of community support.
- The genetic study being undertaken by Frederick Pontillas to assess the level of relatedness between the various island populations.
- The resourcing issues facing the PWRCC.
- The growth in overseas interest for supporting *in situ* conservation.

These developments require that the first edition of the Plan be reviewed to reflect the changes and a new suite of actions to be pursued. These are outlined further on in this paper.

***In situ* Initiatives**

The only *in situ* program for *C. mindorensis* is located in the Northern Sierra Madre Range in far northeast Luzon Island. This commenced in 2000 following confirmation of the species' presence in 1999. Since then, a number of surveys has been carried out, initially by the PLAN-Philippines/Northern Sierra Madre Natural Park-Conservation Project (NSMNP-CP). Some of these were conducted as a joint effort between the NSMNP-CP and the PWRCC, whilst others also involved Louisiana State University. Other more detailed studies have been undertaken by Dutch MSc students through the NSMNP-CP and the Cagayan Valley Program on Environment and Development (CVPED) (Pontillas 2000; van Weerd 2000; Oppenheimer 2002; Oudejans 2002; Rodriguez *et al.* 2000; van Weerd *et al.* 2003).

These links led to a short-term conservation plan with the Local Government Unit of San Mariano and the DENR/Protected Area Superintendent Unit (PASU) of the NSMNP (van Weerd 2002). This consisted of:

- Crocodile research and surveys.
- Awareness raising activities, including a poster developed through a Whitely Foundation Rufford Small Grant to Melbourne Zoo.
- Livelihood support.
- Local legislation and institutional arrangements.

Of particular significance is the enacting of four municipal resolutions by the Local Government Unit of San Mariano to:

1. Protect and conserve *C. mindorensis* in San Mariano, making it illegal to catch, possess, sell or hunt crocodiles in San Mariano.
2. Declare the Philippine Crocodile as a flagship species of the municipality.
3. Enable the establishment of a crocodile rescue centre/holding pen in San Mariano for crocodiles retrieved from captivity.
4. Declare a portion of the Disulap River as a Philippine Crocodile Sanctuary, including the area where a *C. mindorensis* nest was found in 2000.

All these developments were presented and explored further at the "Philippine Crocodile (*Crocodylus mindorensis*) Conservation Workshop" from 16-19 May 2002 at Isabela State University in Cabagan (Anon 2002) and summarised

at the following Regional Conference on Environment and Development (Van Weerd and General 2003).

The CROC Project, funded by the BP Conservation Program in 2003 and building on an earlier initiative of the same name, plans to continue with the community-based approach in San Mariano and in other municipalities with remaining wild crocodile populations.

Priority Actions

The draft Second Edition of the Philippine Crocodile Recovery Plan has been endorsed by the Recovery Team and only requires finalisation of the Forward from the DENR Secretary before it goes to print. This follows the same format as the first edition, but reflects the important developments that have occurred in the intervening three years. The revised conservation actions include:

1. Reassess the distribution and wild status of *C. mindorensis*:
 - The species is confirmed, including breeding, from parts of north-east Luzon, but the full extent of remaining populations needs to be defined.
 - Specimens are now known from Abra Province in far north-west Luzon Island, but we have very little knowledge of their distribution in this area.
 - Recent eye-shine reports from Lake Naujan on Mindoro Island need to be explored.
 - Mindanao Island was a stronghold for the species, but current political unrest in parts of this island makes further surveys very risky.
 - South-west Negros Island needs surveying to confirm if the species is still present.
 - Survey other areas as reliable reports are received, eg a survey of Jomalig Island suggests that the species is not present there.
 - Monitor protected wild populations.
2. Establish a list of possible release sites in the Philippines and develop conservation management plans for priority locations:
 - Complete surveys of potential locations, on both public and private land.
 - Build on the *C. mindorensis* Reintroduction Protocol endorsed in 2003.
3. Promote and encourage positive community attitudes towards crocodiles in the Philippines:
 - Some good examples exist of projects where concerted community efforts have turned around negative community attitudes towards crocodiles, eg in northern Palawan and the Northern Sierra Madre. These need to be expanded and replicated as broadly as possible.
4. Co-ordinate the captive management of *C. mindorensis*:
 - A national registry of all captive crocodile in the Philippines is urgently needed, together with all associated specimen details.
 - Build co-ordinated regional captive programs, as part of a global program.
 - Improve the operational efficiency of the PWRCC, including reliable administrative support and evaluation of all aspects of the Centre's operations.
 - Disperse numbers of captive *C. mindorensis* at the PWRCC to other institutions to reduce the overall risk of disease and other catastrophic events, and increase community involvement with the species.
 - Conduct a detailed analysis of PWRCC records for *C. mindorensis* - Melbourne Zoo has recently funded an ISIS Sponsorship for the PWRCC, which includes provision of data recording software.
5. Determine *C. mindorensis* ecology:
 - Very little is known about the species' ecology, so projects to address this are needed urgently. Some work is underway in the Northern Sierra Madre, but more is needed.
6. Clarify the population genetics of *C. mindorensis*:
 - The mtDNA study commenced by Frederick Pontillas through Louisiana State University is being generously continued through the good offices of the Henry Doorly Zoo in Omaha, USA.
 - Reassess current management of captive *C. mindorensis* in light of the outcomes of this important work.
7. Build partnerships to support *C. mindorensis* conservation:
 - Promote and facilitate breeding loan extensions, both locally and internationally. There is growing interest

- in the species, both within the Philippines and overseas; fostering these will generate much-needed *in situ* support.
 - Provide training in crocodile management and surveys within the Philippines. Very few Filipinos have these skills and there is an urgent need to expand this resource.
8. Establish reliable funding sources to support *C. mindorensis* conservation:
- In light of the shortage of Government funding from within the Philippines, it is likely that overseas support will be increasingly important. All efforts should be expanded to achieve this.
9. Ensure that all relevant Philippine Government policies support conservation of *C. mindorensis*:
- There are many pressures on the implementation of wildlife conservation policies in the Philippines, so it is important to use all available means to support government conservation efforts (eg through the Philippine Crocodile Recovery Team).

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The Status of *Tomistoma schlegelii* (Mueller) in Malaysia

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Abstract

Tomistoma schlegelii has been known from both Peninsular Malaysia and Sarawak since the end of the 19th Century. Investigation of old localities indicates that the species may still be present, though its ability to reproduce in substantially modified habitats may be questioned. New locality records in Malaysia include at least one from a large lake in Terengganu State on the east coast of Peninsular Malaysia, and a possible new record from western Sabah. More than 70 Tomistoma are currently held captive in Malaysia, but have reproduced at only two facilities. The most serious threat to the survival of the species in Malaysia is the draining and conversion of peat and pandan swamps to agriculture on a large scale.

Introduction

In the late 1890s, well before any significant hunting or development activities in Sarawak, William Hornaday commented that he could not obtain a fresh specimen of Tomistoma as this species was “much more rare than the other one” (*C. porosus*). This view has not changed over the last 100 years, though the rarity of the species is now attributed to habitat loss and opportunistic killing.

Sebastian (1993) attempted to compile records of Tomistoma from all parts of Malaysia, which at that time expanded the number of localities known, but viewed the species as endangered. Simpson (1998) spent six weeks looking for Tomistoma in the Tasek Bera region of the Peninsular Malaysian State of Pahang, but despite widespread reports of its continued existence, encountered none. Stuebing *et al.* (1998) reported several new locality records for Malaysia, from Sarawak, including a nesting female in August of 1994, disturbed by an Iban farmer in the Sg Runjing (tributary of the Batang Luper), several Tomistoma seen near the site of a 1996 crocodile attack in the Sg Tisak, and a Tomistoma observed by a local field researcher in the mid-1990s in the Sg Kakus, a tributary of the Tatau River near Bintulu.

This pattern of discovery of small numbers of Tomistoma either in areas where it was formerly reported, or unsurveyed (but appropriate) habitats, has continued. Following the 2002 Crocodile Specialist Group Meeting in Gainesville (Florida, USA), several of us have made efforts to check up on areas of Malaysia where Tomistoma was historically recorded, to review on any recent references to it in several new field guides recently published from the region, look for existing live collections in various facilities around Malaysia (and determine the origin of their holdings), and to interview anyone potentially with knowledge of the species. As a result, some new and interesting information has come to light, and while the picture of Tomistoma’s conservation status in Malaysia is not particularly rosy, there is reason to be hopeful concerning its continued survival.

Recent Records

A list of the most recent known localities for Tomistoma in Malaysia is given in Table 1. Almost all records obtained by the end of 2003 were either from the Perak, Pahang and Sadong (Western Sarawak) River systems.

RBS visited the Malaysian State of Perak in September, 2003, and personally investigated one of the oldest Malaysian records from the species, a locality called “Pulau Tiga” on the Perak River about 10 km upstream of the Sg Kinta (Sg = River in the Malay language). The original settlement, according to local people there, was a Chinese trading outpost disappeared in the early 1900s. Locals, however, were confident that the specimen had come from the area, and specifically mentioned the Sg Kinta (a blackwater river that now runs through largeswaths of oil palm planted in the 1970s) where the crocodile still could be found. Discussions with the Director of the Taiping Zoo (Dr. Kevin Lazarus), where four live Tomistoma are held, revealed that two specimens had been captured in southern Perak in

2003. An interview with Mr. Jasmi Abdul, State Director of the National Parks and Wildlife Office confirmed this story, and dated photos of the animals were produced as proof. There was also confirmation of the “complaints” by villagers along the Sg Kinta of the presence of Tomistoma.

Following this, on a visit to Field Museum of Natural History, RBS referred to a guide to Southeast Asia Reptiles (Chan-ard *et al.* 1999), in which a photograph of a small, juvenile Tomistoma is printed, along with a locality of “Kenyir Lake” (an extensive man-made lake formed above a hydro-electric dam, now a protected area) in the northeastern Peninsular Malaysian state of Terengganu. A follow up by SAMS confirmed that at least one live Tomistoma currently held in the Wildlife and National Parks’ Malacca Zoo (west coast of P. Malaysia) originated from this same area of Terengganu.

All recent records (and we assume all previous ones) are derived from areas containing extensive peat swamps, or less commonly, freshwater pandan (*Pandanus* sp.) swamps. These include more vague reports from the Sg Bernam (Selangor) and the lower Sg Baram (Sarawak). Recent discoveries of the species in patches of inland peat swamps, such as those associated with the Kakus River (in the Bintulu District of Sarawak) indicate that Tomistoma may be rather widespread, though restricted to “pockets” of swamp. In March 2004, local people reported that Tomistoma inhabited an area of peat/pandan swamp in the upper Binyo River, a tributary of the Kemenia River in Bintulu District.

Prior to 2002, there were no confirmed reports of Tomistoma from Sabah (Whitaker 1984), but Stuebing *et al.* (2002) reported a firsthand sighting of two Tomistoma that had been seen on the south bank of the Klias River in April 2002, about 100 m downstream from Kampung Kota Klias. The upper Klias originates in the only extant peat swamp on the West Coast of Sabah, the now much-degraded Binsuluk Forest Reserve. In April 2003, a tourist reported that he had seen a Tomistoma in an oxbow lake off the Kinabatangan River, above the town of Sukau, in eastern Sabah. Unfortunately, the observer could not be contacted afterwards. Although this record seems dubious as it seems too far from the core of Tomistoma’s distribution within northern Borneo, in 2003 RBS was told (by Mr. Rifai of the Tarakan KSDA) of a sighting in the Sg Sebuku (3° 50' N, 117° 10' E) at the Malaysian border with East Kalimantan.

Malaysian Tomistoma in Captivity

The current number of captive Tomistoma held at various facilities around Malaysia is approximately 77 animals, details of which are given in Table 2. In Peninsular Malaysia, the largest number is at Malacca Zoo. As far as is known, there are no breeding facilities in Peninsular Malaysia. The length of captivity is not known with precision for any of the facilities except in Kuching. The Sarawak Forest Department’s Matang Wildlife Centre has a single female who was discovered on a nest near Engkelili (Runjing River) in 1994. The Tomistoma in captivity for the longest period are undoubtedly those in the Jong Farm in Kuching, several of which were obtained in the 1970s.

Breeding of captive Tomistoma in Malaysia is known from only the National Zoo in Kuala Lumpur (first four hatchlings in 2003), and the Jong Crocodile Farm outside of Kuching, Sarawak. Success at the National Zoo is new, and at the Jong Farm has been limited. A total of 19 hatchlings were produced from 1996-2001, but in 2002 and 2003, although several nests were constructed, no fertile eggs were laid. So far it appears that even though the ecological conditions for successful breeding may have been achieved in several facilities, problems remain with the breeding animals themselves, in finding compatible pairs both in age and behavior.

Threats

Much of the peat swamp in western Peninsular Malaysia was converted to oil palm in the 1970s and 1980s, leaving only patches of the habitat in northern Selangor State and Southern Perak. The central State of Pahang, where Simpson’s 1998 field sites were located, has also continued to drain and develop large areas of its peat swamps, including the last substantially intact piece inland from the east coast town of Pekan. Coastal and interior swamps in Sarawak are facing rapid development for agriculture (oil palm, exotic tree plantations), and about half of the area southwest of Bintulu towards the Mukah and Oya Rivers, has already been converted. *Crocodylus porosus* seems to have survived conversion of forests to oil palm estates in Sabah (Stuebing 2002), but it is unknown whether Tomistoma will be as resilient. To answer this question surveys of such coastal peat swamps, including those converted circa ten years ago, are needed.

Stuebing (2002), working in Sabah on the management on *Crocodylus porosus*, found the latter is now rarely hunted by local people, as there were no local buyers for the skins. As Tomistoma skins are of less value commercially than

Table 1. Records of *Tomistoma schlegelii* in Malaysia 1997-2004. * Records since 1998; ** Wildlife and National Parks Office (PERHILITAN).

Locality	State	Age Class	Date Source, Year
Sg Jengka	Pahang	Subadult, 1995	Simpson <i>et al.</i> (1998)
Sg Lepar	Pahang	"All sizes frequently seen"	Simpson <i>et al.</i> (1998)
Sg Luit	Pahang	Occurs	Simpson <i>et al.</i> (1998)
Sg Pahang	Pahang	"All sizes frequently seen"	Simpson <i>et al.</i> (1998)
Sg Rasau	Pahang	"all sizes frequently seen"	Simpson <i>et al.</i> (1998)
Sg Rompin	Pahang	Reported	Simpson <i>et al.</i> (1998)
Tasek Bera, Sg Bera	Pahang	"3-4 sightings/year"	Simpson <i>et al.</i> (1998); Dr. Kevin Lazarus, Taiping Zoo, September 2003
Tasek Cini	Pahang	Juv., 1997	Simpson <i>et al.</i> (1998); Dr. Kevin Lazarus, Taiping Zoo, September 2003
Sg Kinta *	Perak	"Common", 2003	Villagers reported to Perak Wildlife Office (Ipoh), June 2003
Sg Merah (trib. of Sg Perak)	Perak	Reported, 2003	En. Ahmad Darubi, Kg Pulau Tiga, 2003
Sg Sungkai* (trib. of Sg Perak)	Perak	2.6 m male, June 2003	En. Jasmi Abdul, Perak Wildlife Office (Ipoh), September 2003
Sg Dusun *	Selangor	Occurs	Dr. Kevin Lazarus, Taiping Zoo, Sep. 2003
Sg Erung* (trib. of Sg Bernam)	Selangor	Subadult, January 2003	En. Jasmi Abdul, Perak Wildlife Office ** (Ipoh), September 2003
Kuala Berang*	Terengganu	In Malacca Zoo	SAMS
Sg Terengganu, Lake Kenyir*	Terengganu	Juvenile captured, 1998?	Chan-Ard <i>et al.</i> (1999)
Sg Kinabatangan *	Sabah	Reported by tourist, 2003	En. Zainal Abidin, ex-WWF & KOCP, Sukau, 2003
Sg Klias*	Sabah	Pair sighted, April 2002	Stuebing (2002)
Loagan Bunut ?	Sarawak	Reported	Sebastian (1993)
Sg Baram	Sarawak	Occurs (2002)	Simpson, pers. comm. 2002.
Sg Dor	Sarawak	Old record	Stuebing <i>et al.</i> (1998) (from 1917 record)
Sg Ensengai	Sarawak	Observed	Cox and Gombek (1985)
Sg Kelauh	Sarawak	Occurs	Cox and Gombek (1985)
Sg Kerang	Sarawak	Occurs	Stuebing <i>et al.</i> (1998)
Sg Kroh	Sarawak	Nesting	E. Lading, pers. comm. 1997
Sg Mayeng *	Sarawak	Numerous	Dr. C.K. Lim, pers. obs. 2003
(trib. of Sg Tatau, Bintulu Dist.)			
Sg Mukah	Sarawak	Old record	Unconfirmed (1917)
Sg Penyilam* (trib. of Sg Kemena, Bintulu Dist.)	Sarawak	Occurs	Report by local residents
Sg Runjing	Sarawak	Nesting	Stuebing <i>et al.</i> (1998)
Sg Sadong	Sarawak	Occurs	J. Jong, pers. comm. 1998
Sg Seterap	Sarawak	Reported	Stuebing <i>et al.</i> (1998)
Sg Simunjan	Sarawak	Reported	Stuebing <i>et al.</i> (1998)
Sg Tisak	Sarawak	Possible attack on human?	Stuebing <i>et al.</i> (1998)

those of *C. porosus*, it is unlikely that hunting has been a serious threat in Malaysia, apart from opportunistic killing, especially given the secretive nature of the species. It appears that Tomistoma is also not regarded as food by many people, as we (RBS and EL) have never heard of anyone consuming the species as food in Malaysia.

Although Bezuijen *et al.* (2002) linked the heavy logging of habitats in Sumatra to a decline in Tomistoma abundance over a period of about ten years, fewer sightings may necessarily furnish sufficient proof of a precipitous decline in a population. Other, perhaps less favored explanations, would include the animals becoming more secretive, or temporarily withdrawing from disturbed area. Death of Tomistoma in suboptimal habitats or through conflicts with *C. porosus* is a clear possibility as well, but difficult to substantiate. Upon seeing the destruction caused by non-selective logging, and being unable to find Tomistoma in that area, it is reasonable to assume that the animals are gone, but it may not be completely accurate to state that they are dead. A long-lived species such as Tomistoma does have the ability to return to an area to breed, even after many years. The purpose in making such a statement here is

Table 2. *Tomistoma schlegelii* currently held in captivity in Malaysia. Source/year: 1= S. Anuar Mohd. Sah 2004; 2 = Dr Kevin Lazarus (Zoo Director), 2003; 3 = farm owner; 4 = J. Jong 2004. * Simpson (pers. comm., 2003) stated that these animals had come from the Baram River, but the owner reported to Mr. C.H. Tan of Miri that the Tomistoma were all imported from Indonesian Borneo (probably West Kalimantan).

Facility	Location	No. animals	Origin	Source, year
Langkawi Crocodile Farm	Pulau Langkawi, Kedah	10	Singapore	1
Taiping Zoo	Taiping, Perak	4	Pahang (1 reportedly from Bera R., Temerloh)	2
Malacca Zoo	Malacca	1M, 6F	Tanjung Karang, Kuala Berang (Terengganu), Perak, Selangor?	1
Taman Buaya	Malacca	1M, 1F	unknown	1
National Zoo	Kuala Lumpur	1M, 3F, 4 juv. (hatched)	unknown	1
Miri Crocodile Farm	Miri, Sarawak	9	Kalimantan*	3
Jong Crocodile Farm	Kuching, Sarawak	Approx. 37	Upper Sadong (tributaries), W. Sarawak	4
Total		77 (approx.)		

not to detract from the seriousness of the situation, but to encourage conservation efforts even in areas which may seem (temporarily) "lost" to development.

In the opinion of the current authors, the most serious threat to the species in Malaysia is the draining of peatlands and pandan swamps, and their conversion to agriculture. Intensive fishing of swamps with *selambau* nets, which block entire channels and could conceivably drown many animals in the process, is also a possible source of mortality. Nevertheless, local Iban people in the Sg Binyo dismissed this idea, and said they almost never caught any crocodiles. Interestingly, some of these swamps are now being adopted (at least in Sarawak) as breeding refuges for the much prized "ikan tapa" (*Wallago* sp.). Conservation of these important fish spawning areas will augment current efforts to conserve Tomistoma, as long as there is an effort to promote public awareness for conservation of all components of the ecosystem.

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Management of the Siamese Crocodile in Thailand

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We present the management of the *in-situ* conservation and domestic as well as international trade of the Siamese Crocodile in Thailand. Like most crocodile range countries, Thailand has similar problem affecting long-term survival of wild populations, including poaching, human encroachment, loss of habitat and loss common crocodile prey. After a two-year feasibility study, the re-introduction of the Siamese Crocodile is set to release the first set of crocodiles from the temporary pond in this August. In 2003, 1191 CITES Export Permits were issued, 868 of which were issued specifically for tourist and the rest 323 permits were for live specimens, meat, salted skins, tanned skins, and leather goods. The number of export permits is increasing due to the constant growth of the market, the expansion of captive breeding farms, and the better quality of product that meet several standards such as ISO9001, GMP, and HACCP. As the number of captive operators increase, the competition for the market is unavoidable which could result in smuggling. We believe that there is a scope for greater political commitment by Thailand and its neighbours to implement the Convention and to play a full role in combating illicit trade in crocodile.

Re-introduction has become an important technique in crocodile management especially in the critically endangered species. As the public becomes increasingly interested in crocodiles, their management may become more contentious. Nevertheless, the value of these charismatic animals is high. Although crocodiles will have to be controlled and regulated in some situations, wherever possible they should be nurtured. The greatest challenges to crocodile conservation are to control the human population and to preserve as many extensive natural areas as possible. At CMAT general assembly (Bangkok, March 2004), the Standing Committee agreed that the first release is to be held on August 12, 2004 in order to celebrate Queen Sirikit's 72nd birthday. We have prepared the pure-bred Siamese Crocodiles tested with the microsatellite technique by Kasetsart University, Bangkok. Twenty park rangers have been trained to handle crocodiles, and capable of monitoring the released population. The crocodile ecology classes have been set up in the local village to teach children how to safely live near crocodile habitats. With Government funding, survey trail, access road, and temporary compound have been built. The existing trails are being cleared for faster access to most of the survey point and will also be used by tourists as a trail. The great concern is the size of suitable habitat, which deems to accommodate no more than 100 crocodiles at present. The plan is to release 20 crocodiles a year. Therefore, the population may slowly increase in near future. In addition, Huoy Samong Dam is projected to complete within 5 years. This hopefully will create a large and suitable habitat for Siamese Crocodiles.

The market-driven conservation is the tool for the sustainable use of crocodilian because of three reasons. First, the first-graded skin is usually achieved by implementation of the intensive feeding program of juvenile crocodile in a specially designed pond. The demand for such skin quality is overwhelmed, which contrast to the demand for wild skins. In another word, the skin industry only demand for flawless skins. Second, the intensive feeding program must be done through the contracted farming system, which usually requires a large number of farmers involved in such program. Even though many large-scale crocodile farms are capable of raising tens of thousand of juvenile crocodiles, the result is much different. Finally, the greater number of crocodile farmers, the stronger the farmer organization. The organization, like CMAT, will eventually support conservation program, at least within the country. The conservation program for the crocodile in such country must follow CSG guideline or the national master plan for crocodile conservation. The crocodile farming industry within Thailand involves many people whose stocks are totally captive-bred. Such individuals have had little direct impact on the depletion of wild crocodiles. The depletion of wild stocks that resulted from the past exploitation was finally legal under WARPA (Wild Animal Reservation and Protection Act B.E. 2535) that allowed the farmers to register the farm with the government. Thus, the 17 current CITES-registered operators cannot necessarily be held responsible for the present situation in the wild. Nevertheless, through CMAT, the conservation program for the Siamese Crocodile in Thailand is finally happening. CMAT was established in 1991, and has undertaken to assist with surveys for existing populations and exploring the potential areas for re-introducing captive-bred *C. siamensis* into the wild. The reality of ever-decreasing wild populations, ever-increasing captive breeding populations, and continuing demand for crocodile skin continue to encourage CMAT responsibility to complete the cycle of sustainable conservation. Unlike members of some crocodile association, CMAT members well understand the role of CMAT in conservation. CMAT, thus, is able to collect fees from farmers according to the number of crocodile traded and slaughtered.

Regarding to the Article VII paragraph 4, 5 of the Convention, specimens and by-product derived from Appendix I species reared in CITES registered operations can be traded as Appendix-II species. Consequently, the Siamese Crocodile, Appendix-I species, from CITES registered farms in Thailand can be export; there are 17 registered farms in Thailand. CITES is implemented in Thailand by the Wild Animals Reservation and Protection Act (WARPA) and the Plant Act (both enacted in 1992). Ministerial Regulations have been issued to supplement this primary legislation; for example to make provision for the issue of permits and certificates to regulate trade in specimens of CITES-listed species and to incorporate into the legislation the Appendices of the Convention. However, the most recent amendments to the appendices covered by WARPA are those adopted at the 8th meeting of the Conference of the Parties. New legislation is being drafted to better address CITES-related trade and it is hoped to enact this before the 13th meeting of the Conference of the Parties in Bangkok, Thailand. WARPA also regulates Thailand's domestic utilization of wildlife and determines which native species are protected and the level of protection. The Siamese Crocodile has been listed as a protected species that can be traded , which means hunting, possessing, breeding, and trading of the specimens is regulated under such law.

Today, live specimens and most products derived from Siamese Crocodiles are being exported. 1191 CITES Export Permits were issued in 2003, 868 of which were CITES Export Permit: for tourist. The number is increasing due to constant growth of the market, expansion of captive breeding farms and number of crocodiles, better quality of product, and sanitary standard that meets the GMP, ISO, and HACCP standard. Sriracha Crocodile Farm, for example, uses 100 tons of chicken per month to feed to over 50,000 head of all sized crocodiles. However, stocks in such farm are about 10% of all crocodiles in Thailand. A rough estimate for nation-wide need for crocodile feed is approximately 40,000 tons per year. We can supply chicken to our crocodiles because Thailand is a major country producing and exporting chicken to USA, EU and Japan. This remarkable success in hatching and raising techniques for *ex-situ* conservation of sustainable resources can guarantee genetic stocks for the *in-situ* conservation.

The channel of illegal trade through the border between Thailand and Cambodia, etc., that heavily hinder conservation programs in Indo-Chinese region is currently a major concern. Small numbers of unregistered farms in Thailand continue selling live hatchlings to Cambodia without official documents. We understand that it is possible because of lack of CITES authorities at the point of import/export as well as high price and demand. Usually, CMAT charges members to run the organization activities. Thus, CMAT is losing revenue through illicit trade over the border! The Chinese Government is also losing import tax from smuggling of crocodiles through southern border. To solve the problem, both the import and export countries should come up with a solution. The border inspection must be carried out and maintain the high level of custom check to preclude the smuggling of specimens without the CITES permit.

Drought Results in Small Mugger Population of Iran

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Abstract

Gandou Protected Area, which extends in about 3800 sq. km is the main distributional area of Mugger population in Iran. Small but scattered population with about 200-300 crocodiles, occupies vast fresh water habitats like natural and artificial ponds, reservoir and rivers. The last years prolonged drought has brought very harsh situation for the crocodiles in the area so that the natural features of the area as well as the crocodiles have completely changed. Lack of water, which in turn causes lack of food, shelter and habitat, has increased the mortality rate of the weak, thin and small crocodiles. The main part of the population is suffering from existing situation. Moreover the main part of the crocodiles have aggregated to remaining available water bodies. This situation itself could result some ecological problems in the future. Unfortunately, there is not any specific management plan for the population now although as a cultural and legal point of view there are many possibilities for any conservational activities.

Introduction

Southeastern part of Iran, near Pakistan border, is the only distributional area of Mugger crocodiles in Iran, which is considered as the western limit of its global range too. The small but scattered population with about 200-300 crocodiles, inhabit in limited rivers and related water bodies as well as artificial constructed ponds close to villages.

Considering the climatic situation of the area in southeastern part of Iran, most of the existing developments like forming of small and big villages are along the main rivers in the area and it means that crocodiles are in close contact with local people. However, the important subject is that the people never disturb, harm or hunt the crocodiles and even respect them as a creature living in water. The local name for the crocodiles is "Gandou" and everyone knows them by this name. Main part of the area due to its importance as crocodile habitat designated as "protected area" with an area of 3800 sq. km with the name of "Gandou" protected area. More over some parts of the area (75,000 hectares) has designated as 19th wetland of international importance of the country. The area comprises of riverine and estuarine wetlands of lower Sarbaz River, including permanent fresh water pools and marshes.

Small population of Mugger crocodile in Iran has been severely affected by prolonged drought during the past years and crocodiles have been faced with very harsh situation. Natural feature of the habitats has completely changed so that lack of raining has drastically reduced water levels in the main rivers of the area. Many ponds along these rivers dried up completely, and the remaining ponds have little water. In this situation, the main problem is that the aquatic food resources have depleted and are not easily available. Therefore, most of the crocodiles are too thin, meager and weak to seek for food or move to other ponds, which unfortunately are very far from each other. With the scarcity of food and water, many crocodiles appear notably thin and dehydrated, so that there are record of 3 kg for about 1 m long mugger. In this relation, the attack of crocodiles to the villager's livestock has increased in some places, which caused some other problems in the area. Lack of food has increased mortality of the crocodiles so that even there is a record of five dead crocodiles in one small pond in the southeastern part of Bahukalat River and another one found dead in his burrow. In this situation, reproductive activities are likely to be affected by the lack of food and water which in turn influences the egg quality and survival rate of the hatchlings too.

Lack of water makes crocodiles to seek for and inhabit in any existing water body. Some of these resources do not seem to be the suitable habitats, like drainage or agricultural wells, which sometimes it is impossible for the crocodiles to leave them without the help of the man. In this regard, three crocodiles were inhabited in a small well and were removed by the help of local people and DOE guards. Although walking in long distances is one of the most important and main behaviours of Mugger crocodile, considering the far distances between the existing ponds caused by drought, as well as weakness of crocodiles movement between these water bodies seems impossible and useless attempt. Although the population is small, it is very scattered too. Considering the lack of DOE staff and existing facilities, it is difficult to cover and monitor the whole area. However, the main part of the population lives along Sarbaz, Kaju, Bahukalat and Shirin kor Rivers. There was not any record for the latest river, but as there are some permanent ponds feed by under ground water, some of the crocodiles affected by drought have introduced to these

ponds. In some ponds, the results are satisfactory, although there is not any recent report. Nowadays, the most important, reliable and largest water source in the area is Pishin Dam reservoir. DOE staff when being informed move all the crocodiles that have lost their habitats or are not in suitable situation to this water body. Therefore, the main part of the population is aggregated in this small lake and subsequently has negative ecological effects on the population, creating unnaturally competitive situation amongst the crocs as well as providing difficulties to monitor them. Another problem in the area that aggravates the drought is using of existing ponds water for agricultural purposes. There are usually some diesel pumps near each pond that transfer the water to the existing agricultural fields. Considering that the most people are poor and the agricultural activities are the only possible livelihood, it is impossible to prevent them from water exploitation. More over in the most parts of the area the water of the ponds is the only available water resource for the people's daily usage like, drinking, washing and bath as well as for livestock. At this time, there is not any specific management and research program on the crocodile population although unfortunately, there have not been regular activities before too and that is why there are too many japes in our information in both biological and population aspects. Results from recent conducted studies, in which 15 Mugger crocodiles were captured and measured during the past two years reveal the poor nutritional status of crocodiles due to the drought (Table 1).

Table 1. Length and weight of Mugger crocodiles caught in southeastern Iran.

No.	Total length (cm)	Tail length (cm)	Weight (kg)
1	250	120	45
2	230	116	45
3	192	95	26
4	190	97	23
5	184	96	23
6	181	92	19
7	181	90	17
8	176	90	14
9	172	85	19
10	155	69	15
11	150	74	9
12	141	75	10
13	127	63	5
14	115	56	5
15	110	46	3

Due to vast size of the area and lack of equipments, the mortality rate of the muggers during the drought has not been determined. On a positive note, a few ponds in southeastern Iran have enough amount of water and are home to the healthy, well-fed crocodiles. Located in front of Pishin Dam and near to the town of Rask, these ponds are fed the whole year by underground water sources.

It is possible too that mugger crocodile habitat exist in other parts of southeastern Iran that have not yet been studied: the area that borders Pakistan, especially Nahang River and its associated ponds. There are some unconfirmed reports on the movement of crocodiles, between Iran and Pakistan in this area. However, the area is generally unknown due to security concerns. An investigation of this area in cooperation with Pakistani experts would be worthwhile.

High Potential for Conservation

Apart from the drought, which is a natural problem, there are many different factors create high potential for the conservation of Mugger crocodile in Iran. Each of these factors, on their own turn, could be very important and very positive:

1. Crocodiles are legally listed as "Protected wild life species"
2. There are cultural and religious bans that prevents people from any harm to crocodiles
3. There is no consumptive use of meat and eggs
4. There is no harvest for leather
5. There is no use for traditional medicines

Each of these factors are very difficult to achieve in other parts of the world in which, most of the existing programs are proposed to initiate such a situation.

Recommendations:

1. Regional Interaction, coordination and cooperation
2. Conducting more research and survey works especially on population status and biology to provide any needed information
3. Providing needed funding for proposed research and conservation activities (GEF, CSG)
4. Providing needed scientific and technical supports
5. Establishment of conservation and management programs
6. Planning for the establishment of rearing or breeding center
7. Providing the needed fund for establishment of rehabilitation center
8. Conducting of Regional or sub-regional workshops and training programs
9. More coordination and cooperation of CSG and Regional coordinator of CSG and initiating close contact with Madras Crocodile Bank

Discussion

Considering the aims addressed at the Action Plan, as the main reference, as well as classification of the *Crocodylus palustris* according to the available data in the class of *very poor* and need for conservation in the class of *high* (IUCN/SSC, CSG 1992), it seems that conducting and executing of base line studies on the biology and population status of Mugger in Iran for providing the needed information, and planning for starting of conservation activities is necessary. In this regard, any financial and technical support of the related organizations or NGOs will help us lot to start these activities and considering the fact that there is not any harvest on crocodiles in Iran, the results of the activities would be satisfactory indeed. Regarding with the drought and related problems, establishment of a rehabilitation center for recovering crocodiles that have severely suffered from the lack of food and habitat is an urgent need. This in turn will prevent from transferring of the crocodiles to the Pishin Dam reservoir causing population aggregation and other related problems.

Identification of the permanent water bodies in the area which are fed by underground resources could be another choice for the management of crocodiles affected by drought.

Acknowledgments

I would like to extend my great thanks to the Organizing Committee of the 17th Working Meeting of the CSG for the travel grant which enabled me to attend in the meeting. I am also grateful to Charlie Manolis, Tom Dacey and Dr. Mahnaz Mazaheri (Research Advisor of DOE) and Mr. Hosseini (Director General of Marine Environment Bureau of DOE), for their kind help.

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Photo 1. Dehydrated and malnourished *C. palustris* in southeastern Iran.



Photo 2. One dead mugger in one of the dried out ponds along Shirin-kor River.



Photo 3. Most of the main ponds along the rivers have dried out.

The Conservation of Siamese Crocodile in Cambodia

Heng Sovannara

Summary

Over four years that Cambodian's crocodile scientist cooperated with Department of Fisheries and other NGOs in Cambodia. Specially Wildlife Conservation Society to do survey around some areas that have presented. Estimated around 200 adult crocodiles occurred in Cambodia (FFI survey) as in the Cardamom Mountain; adding more have been survey by Department of fisheries and WCS founding 4 places in Sre Ambel Kohkong Province (bordering Thailand); around Tonle Sap Great Lakes and Ratanakiri Province (border Laos) that crocodiles are remaining every years and also some places not survey yet. But still report about crocodiles from the villagers, However did survey for this year we found on nest about 21 eggs and conservation keeping for incubated.

Related management by Department of Fisheries with conservation we have a big national crocodile farmers meeting supported by DOF; WCS and Crocodile association on the extent the regulation of CITES with trade and pushing all farms be com official farms provided permit from Department of Fisheries and some from Provincial fisheries. There are 6 farms have registered with CITES for exporting crocodile.

Threat of wild population has some disturbed from human activities moving to living near crocodile habitat and used illegal activities like electro-fishing, poison, and some poacher try to catch and collected eggs for consumption and selling to middle man close to the town and then middleman sent to outside countries. Fisheries Department working strictly with on problem follow by law.

Distribution

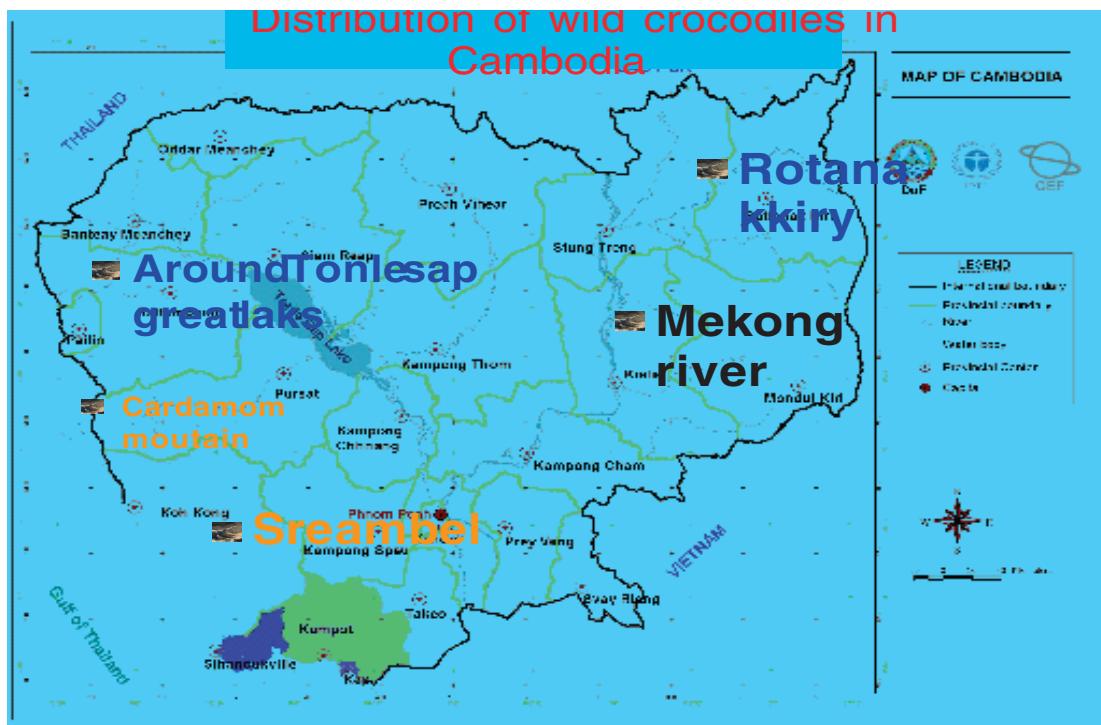
There are many places are remaining wild crocodile population in Cambodia, some place have been survey and some not yet. But we will be continuing to survey complete all. on this we will be talk about Sre ambel that did survey all ready accompany with B.baska project supported by WCS and DOF. Sre Ambel is the part of Koh Kong Province near bordering Cambodia and Thailand; small town and most of the people are living in rural areas making fishing, logging and t. There are around 7 villages closely crocodiles habitat; this the villagers who usually reported and saw of wild crocodiles. Based on all imformation related wild crocodiles from all around areas; We used the day survey methods to surveyed all the places founding 4 location crocodiles remaining Prek Kombot found one nest 21 eggs in this year also keeping for incubated in nature nesting guarding by conservation teams and other three places Prek Keantok found on crocodile about 3 m length, Prekpokatim and Tropangpeng founding crocodiles track; Estimation the population of wild crocodiles round more than 10 adults crocodiles living this areas on the wet season spread all areas and some areas survey at Cardamom mountain by FFI, around Tonle Sap Great lakes and Ratanakiri Province border Laos country.

Threat

On the past before B.baska project started the conservation at Sre Ambel there are a lot of illegal activities (former Khmer Rouge) as boom fishing electro-fishing specially shooting and collected crocodile eggs every years for consumption and selling to mild man at Sre Ambel town and then continuing to Thailand or Phnom Penh. The people are very poor; low education and habit operation activities of fishing disturbed to the wildlife. It's other problem from the people not permanently only short time living try to collected wild life from this areas. some wild crocodile have accidental by net and hook and automatic death.

Conservation

Department of Fisheries and Wildlife Conservation Society are supporting to do conserved wild crocodile population and did survey all the places to finding out key stone areas to protected and also on the March 2004 supporting to organized national crocodile farms meeting at Siem Reap Province attending from crocodile farmers and crocodile farmer Association, the objectives of the meeting are management and conservation. During that time Mr. Nao Thuok, director of Department of Fisheries in Cambodia toke of time to announces and clearly explain to all farmers about situation and status of crocodile around the woudl and especially concerning with wild protection, suggestion to farmers should be have license from DOF or province department fisheries and follow by CITES regulation and



stop to collected from the wild coming to help saving together keeping on the natural. adding more works related with management and conservation on be has DOF have been opened the small meeting all province that crocodile farms presented to push all the farms to register and provide the log book and receipt book. The purposing to get all the information from the farm of all action operating the farms as when's start the farm? Where's breeding stock came from? and etc. The crocodile farmer association is importance role to do crocodiles conservation program cooperated with farmers, Authorities, and NGOs setup action plans and submit to DOF and practical. Crocodile association will be providing crocodile for releasing if Government need.

Action plans

- Training on crocodile conservation
- National workshop on the CITES regulation and implementation
- Appropriate measures for protection and conservation of habitats known to have crocodiles present
- Enhance law enforcement
- Promote community participation
- Crocodile farm monitoring
- Release program in suitable habitats

Conclusions

- Cambodia can be considered as the last stronghold for Siamese Crocodile in this region. Around 200 wild population still inhabit the remote habitats in many places of the country. But there is a threat to these populations if appropriate management measures are not urgently undertaken. Law enforcement, capacity building and awareness raising are extremely crucial for the survival and recovery of this keystone species.
- The Fisheries Department is cooperating with all stakeholders involved especially local authorities, communities and NGOs to safeguard this remnant species to recover and exist for generations to come.

Acknowledgements

We would like to thank all of you who supported to protecting Siamese Crocodile in Cambodia: Mr. Nao Thuok (Director of Fisheries in Cambodia), Dr. John Thorbiarnason (Wildlife Conservation Society USA), Mr. Joe Walston (Director Country Program WCS in Cambodia), Crocodile Farmer Association, and all of staff in Cambodia to do related crocodile conservation.

Status and Conservation of the Siamese Crocodile

Crocodylus siamensis in Kalimantan (Indonesian Borneo)

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Abstract

Field surveys in 1995 and 1996 concluded that a relictual, highly disjunct population of *Crocodylus siamensis* inhabits the Mahakam River of East Kalimantan province, Indonesia (Ross *et al.* 1998). On the basis of roughly estimated suitable habitat, observations of captive juveniles and anecdotal evidence, probably less than several hundred individuals persisted at that time. No subsequent study has been undertaken. Impact on the population and habitat from the prolonged 1997-1998 drought and human pressure is unknown. Comparative mitochondrial DNA analyses indicate that *C. siamensis* in the Mahakam has been isolated from mainland SE Asian *siamensis* since the late Pleistocene (ie $\geq 10,000$ ybp) (Gratten 2004). This clearly endangered (and declining?) remnant of the Kalimantan lineage needs urgent formulation and implementation of an integrated conservation program.

Introduction

The Siamese crocodile *Crocodylus siamensis* was historically and widely distributed in freshwater habitats of SE Asia, occurring from Thailand, Laos, Vietnam and Cambodia (Groombridge 1987), to Sumatra, Bangka, Java (Ross 1986), Borneo (Cox *et al.* 1993; Ross *et al.* 1998), and possibly the Celebes (Ross 1986) (Fig. 1). The species apparently persists in very small numbers in Thailand (Ratanakorn 1994), Laos (Stuart and Platt 2000; Thorbjarnarson 2003) and Vietnam (Cuc 1994). A larger, apparently viable breeding population occurs in Cambodia (Thuk 1998).



Figure 1. SE Asia, Kalimantan and the Mahakam River system of East Kalimantan Province.

Outside mainland SE Asia, the only reported extant *C. siamensis* population is from the lower Mahakam River system (Fig. 1) in the Indonesian province of East Kalimantan (Ross *et al.* 1998). Due to its drastically reduced abundance, the Siamese Crocodile is listed by IUCN (2001) as Critically Endangered. The Kalimantan population

remains very poorly known. Pressing need exists for biological and socio-ecological studies, and resultant integrated conservation action if viable wild populations are to be maintained or re-established.

Methods

C. siamensis in Kalimantan was assessed in 1995-1996 mainly by semi-structured interviews of former crocodile hunters and skin traders, other knowledgeable residents in the vicinity of crocodile habitat, and crocodile ranchers/farmers. Open-ended questions were emphasized to obtain unbiased responses. In 1996 a laminated sheet of unnamed *Crocodylus* photographs showing neck and body squamation was used to assist species identification by village informants citing local names (Ross *et al.* 1998). Direct observations and photographs were made of captive individuals in village holding facilities and farm stock.

Standard night counts of crocodiles were conducted at Danau Tanah Liat, a lake in the middle Mahakam where *C. siamensis* purportedly resided. The littoral zone was scanned for crocodile eyeshine using a bright beam of light from the bow of a paddled *perahu* (dugout). Data on survey routes, duration, water levels, weather and habitat were recorded.

Results

East Kalimantan: The first record of *C. siamensis* in Kalimantan was reported by Frazier and Maturbongs (1990). A 2.3 m caged individual purportedly caught in 1983 at Danau Sohuwi, was inspected and photographed at Muara Ancalong in the central Mahakam on 5 and 6 September 1990. The authors subsequently found 35 *C. siamensis* ranging from yearlings to adults at P.T. Makmur Abadi Permai crocodile farm outside Samarinda on 10 September 1990. These and four juveniles examined at C.V. Surya Raya crocodile farm in February 1991 (pers. obs.) near Teritip (N of Balikpapan) were said to originate from lakes in the central Mahakam (W. Mawengkang, pers. comm.; T. Sugiarto, pers. comm., respectively).

Field surveys of palustrine crocodiles in 1995 and 1996, undertaken as part of a collaborative project by *Pusat Penelitian dan Pengembangan Biologi* (Center for Biological Research and Development) of *Lembaga Ilmu Pengetahuan di Indonesia* (LIPI) (Indonesian Institute of Sciences) and the Smithsonian Institution (SI) focused on crocodilian systematics, but produced substantial data on the occurrence of *C. siamensis* in Kalimantan, particularly East Kalimantan Province.

Nine juveniles were inspected from village holding facilities in the central Mahakam in 1995, and deduced to be offspring from at least two, possibly three or more breeding crocodiles (Ross *et al.* 1998). The smallest juvenile (59.5 cm total length), measured at Sungai Bongan (Ross *et al.* 1996), indicated that *C. siamensis* had bred in the Mahakam as recently as 1994.

By September 1996, the number of captive *C. siamensis* at C.V. Surya Raya had increased to 37 (Ross *et al.* 1998). The 33 additional individuals were received as small juveniles from the wild, acquired as incidental take from fish nets and traps in the central Mahakam, mostly from the Danau Mesangat area (T. Sugiarto, owner, pers. comm.). All stock were juveniles or sub-adults (pers. obs.). The number at P.T. Makmur Abadi Permai was unknown and estimated in 1995 at 35 adults and large juveniles. Some individuals showed signs of hybridization with *C. porosus*, which accounted for most stock in the farm's common breeding pens (Ross *et al.* 1996).

By September 2003, 24 mostly adult *C. siamensis* were isolated in a common breeding pond at C.V. Surya Raya (pers. obs.), but have only produced infertile eggs (T. Sugiarto, pers. comm.). The decline in number since 1996 is attributed solely to mortality. No additional individuals were said to have been acquired from the wild.

Information on *C. siamensis* habitat was obtained during the LIPI-SI surveys from crocodile hunters and fishermen, who referred to the species as *buaya badas hitam* (black *badas* crocodile) (Frazier and Maturbongs 1990) or *buaya kodok* (frog crocodile) (Ross *et al.* 1998). Informants stated that the species prefers small, mostly perennial lakes as foraging habitat and associated marshes of floating vegetation for nesting. The nesting period was recounted as approximately August through October. Wetland habitat is evidently semi-partitioned with the Malayan false gavial *Tomistoma schlegelii*, which was observed in and alleged to favor open tributaries, and found to nest in permanent swamp atop floating vegetation (Ross *et al.* 1998).

In 1997-1998 the central Mahakam experienced a severe ENSO (El Niño-Southern Oscillation) event. The semi-

nomadic D. Mesangat fishing community emigrated upriver when lakes and channels became too dry to catch fish. As of April 2004 most of the people have not returned (T. Sugiarto, pers. comm.) The effects of this prolonged drought on *C. siamensis* in the Mahakam remain unstudied.

In the central Mahakam habitat protection is extended to crocodiles in the Muara Kaman Strict Nature Reserve (62,500 ha). *Tomistoma schlegelii* was confirmed to nest in the reserve in 1996; local villagers asserted that *C. siamensis* also nested there (Ross *et al.* 1998). Throughout the Mahakam lakes region open bodies of water were found to be heavily utilized for fishing (Kurniati 1997; Ross *et al.* 1998).

South Kalimantan: LIPI-SI field surveys were not conducted in South Kalimantan province because areas of suitable crocodile habitat had been converted or were assessed from local information and map study as too heavily degraded to support palustrine crocodiles. However, c.15 mostly adult *C. siamensis* were observed at P. T. Alas Watu Utama crocodile farm near Banjarbaru in 1995 and 1996 (Ross *et al.* 1998). The crocodiles were purportedly received in the 1980s as small juveniles from traders in Central Kalimantan. A pair reportedly nested in January 1996 but failed to produce hatchlings (Kasan, farm caretaker, pers. comm.). None of the *C. siamensis* showed signs of hybridization with numerous *C. porosus* kept in the same common breeding pond (pers. obs). Isolation of *C. siamensis* to prevent hybridization and encourage breeding success was recommended to farm management.

Central Kalimantan: Surveys in the Barito river system in 1996 found only anecdotal evidence of *C. siamensis*. Descriptions of *buaya kodok* at upriver villages were consistent with dorsal characteristics of the species and correctly pointed out on the *Crocodylus* sheet. At Kampung Buyui on the Sungai Ayu tributary residents said *buaya kodok* inhabited lakes and rivers, but was last seen c. 1991 (Ross *et al.* 1998).

West Kalimanta: *Buaya kodok* was reported by a Kubu village hunter to occur in freshwater lakes of southern river systems in the Ketapang area, and was last caught in 1982 at Sungai Pinggan in the Gunung Palung area (Ross *et al.* 1998). No evidence, even anecdotal, was found that *C. siamensis* inhabited Sungai Kapuas, the main river system of West Kalimantan Province.

Discussion

C. siamensis in Kalimantan is an intriguing artifact of the broad historical distribution of this species from the SE Asian mainland to islands of the Greater Sundas. Radiation was apparently accomplished during Pleistocene glacial periods when the region was united by dry seabeds and major paleoriver systems of the exposed Sunda Shelf (Ross 1986). These freshwater connections were intermittently disrupted by marine incursions during interglacial periods, and no direct freshwater linkage is thought to have existed between the SE Asian mainland and Borneo (Gratten 2004). Eastern Borneo was further isolated from the Sunda Shelf by the Meratus mountain range.

Comparative studies of mitochondrial DNA (mtDNA) between Kalimantan *C. siamensis* (sampled from C. V. Surya Raya stock) and the fragmented SE Asian population clearly shows the phylogenetic distinctiveness of the East Kalimantan population (Gratten 2004). On the basis of estimated mtDNA control region substitution rates, *C. siamensis* in East Kalimantan has been isolated from mainland SE Asian *siamensis* since the late Pleistocene (ie $\geq 10,000$ ybp) (Gratten 2004).

The current status and distribution of *C. siamensis* in Kalimantan is poorly understood. The last remaining ‘stronghold’ of the species appears to be the lakes region of central Mahakam, in particular the Danau Mesangat area, and possibly other small lakes and associated marshland in the vicinity.

Although the wild population was deduced to breed as recently as 1994, records of wild capture since 1995 are lacking. This may be the result of area crocodile farmers ceasing take of additional individuals once *C. siamensis* was identified and understood to be unlicensable for trade (T. Sugiarto, pers. comm.), and concomitant halting of juvenile capture by local fishermen. Alternatively, the population may have declined further, due in particular to the severe 1997-1998 ENSO event, and individuals were no longer netted or trapped.

Genetic studies of the Mahakam population show population bottleneck signatures, presumably indicating recent severe declines in range and size (Gratten 2004). On the basis of roughly estimated suitable habitat using basic topographic maps, observed captive juveniles and considerable anecdotal evidence, probably less than several hundred individuals persisted in 1996 (Ross *et al.* 1998).

It remains unclear if *C. siamensis* survives in the wild in Kalimantan outside the central Mahakam. Anecdotal evidence suggests an extant population was distributed in palustrine environments of Central and West Kalimantan Provinces as recently as 10-15 years ago (Ross *et al.* 1998). Individuals from this population may be harbored at P.T. Alas Watu Utama in Banjarbaru, underscoring the critical need to isolate and maintain them. The stock number is adequate (*c.* 15) for genetic studies in microsatellite diversity that may resolve their Bornean ancestry. East Kalimantan is isolated from Central, South and West Kalimantan by the Meratus mountains. This barrier may have promoted formation of a genetically distinct evolutionary unit. If so, the Banjarbaru stock comprises invaluable extant material.

Similarly, individuals isolated and maintained at C.V. Surya Raya form a reservoir of pure breeding stock that is of inestimable value. Improved techniques being implemented at present should achieve captive breeding success, and formation of a breeding nucleus that can be reared to produce additional breeding stock or juveniles to restock suitable habitat in East Kalimantan where *C. siamensis* is severely depleted or extirpated.

The remnant *C. siamensis* population in Kalimantan clearly meets the criteria for IUCN's Critically Endangered listing, and warrants highest priority for conservation action. Additional surveys are needed throughout Kalimantan to assess population status, suitable habitat, the socio-ecological and socio-economic roles of local communities, and to ultimately design a conservation strategy.

Population surveys should be as systematic as possible, but where habitat or funding mechanisms are not amenable to standard night counts or other direct count methods, a community-based effort can provide valuable feedback to gauge trends in resource use. Moreover, the involvement of local communities at every stage of the conservation initiative and delivery of tangible economic benefits to them can serve as the crucial link in achieving management objectives.

Local people can perform an important role by regularly monitoring the crocodile resource. The knowledge, skills and efforts of local communities may also prove crucial in gauging the status quo and insight into the most appropriate design and implementation mechanism for a conservation initiative.

Towards the success of a long-term conservation program, an additional incentive exists in sustainable commercial use of *C. siamensis*. This crocodilian has a "classic" hide whose fine, intricate bellyskin rivals *C. porosus* in value. Strategies such as egg harvests can effectively link economic returns from protection of critical population cohorts to the welfare of local communities (Cox and Solmu 2002). Tapping the commercial potential of *C. siamensis* in Kalimantan, although a distant option, could add a substantial conservation incentive and contribute to rural development, at least on a local scale.

Palustrine crocodile habitat in the central Mahakam ranges from seriously degraded (eg overfished, infested with water hyacinth *Eichhornia crassipes*) to marginally disturbed, and was considered important for formal protection (Kurniati 1997). The relatively compact and accessible lake system is logically favorable for a community-based conservation initiative. A suitable rural development effort there would need to create incentives for fishing communities to achieve their basic development aspirations and simultaneously support conservation measures. This may merit a comprehensive regional development effort, probably emphasizing sustainable fisheries and ecotourism in the mid-term.

Crocodile ranchers and farmers in Kalimantan need the active support and encouragement by government of Indonesia and international organizations. These strategically located entrepreneurs and their wetland dependant local communities likely hold the keys to recovery and enduring conservation of *C. siamensis* in Kalimantan.

Acknowledgements

Tarto Sugiarto is warmly thanked for information regarding C.V. Surya Raya farm stock and wild *C. siamensis* in East Kalimantan, and his interest to participate in conservation activities. Messrs. Welly Mawengkang (P.T. Makmur Abadi Permai), Dharma Surya, Moelyono and Kasan (P.T. Sapto Argo Unggul/P.T. Alas Watu Utama) and T. Sugiarto are remembered and thanked for granting access to farm stock. Jacob Gratten kindly shared the results of his recent studies in *C. siamensis* population genetics and along with Phil Hall contributed helpful comments in the writing of this paper. Many local residents throughout Kalimantan provided valuable information of crocodile distribution and status, and much appreciated hospitality. LIPI and the Directorate General of Forest Protection and Nature Conservation (PHPA), Ministry of Forestry, facilitated the bureaucratic requirements of conducting the LIPI-SI project, and made available outstanding field counterparts.

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Conservation and Management of the Two Species of Sri Lankan Crocodiles (*Crocodylus porosus* and *Crocodylus palustris*)

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Abstract

Sri Lanka has two of the 23 species of crocodile extant in the world today. The Mugger or Marsh crocodile (*Crocodylus palustris* Lesson 1831) and the Saltwater or Estuarine crocodile (*Crocodylus porosus* Schneider 1801). Sri Lanka is one of the few countries, which has done little with regard to researching the biology and ecology of its crocodiles. No management or conservation plans have been formulated either.

In earlier times both species were found in abundance in their respective habitats (Deraniyagala 1953). Though the status of the mugger seems to be secure in the sense that there probably are a few thousand spread throughout various water bodies, the status of the saltwater crocodile (*C. porosus*) is doubtful. This may be for a number of reasons, not the least being that no formal long-term study has been made on either species in Sri Lanka. It is known that crocodiles have been extirpated from a number of their habitats in the island.

This paper discusses the historical and present status of the two species in Sri Lanka. It looks at human-crocodile interventions and the environmental status of both species. The paper also poses a few questions and options for their future conservation and management in Sri Lanka. It also stresses the need for a firm and comprehensive policy on crocodiles to be adopted by the Government of Sri Lanka.

There is an opportunity to get a more innovative management systems in place in respect of both species, especially with regard to research, education etc., which in many other countries have gone hand-in-hand with improved conservation and habitat protection. Though there are sensitivities in Sri Lanka regarding the use of crocodiles for commercial purposes, it is necessary to at least discuss this aspect especially in the light of a number of success stories elsewhere.

Introduction

Crocodiles are carnivorous reptiles and are generally at the top of the predators in their ecosystem. They feed on fish and keep all species under control not allowing the larger and invasive species to dominate the ecosystem. They also feed on the weak and sick fish and help to keep the fish populations and water clean and uncontaminated by their scavenging. The presence of crocodiles is an indication of a clean aquatic environment.

Literature shows that, in earlier times, both species of crocodiles were widely distributed in suitable habitats throughout much of the country. The habitats of *C. porosus* include coastal mangroves, marshes, swamps and some inland water bodies. *C. palustris* is found widely in the different inland water bodies like tanks (man-made reservoirs), streams, rivers and other suitable water bodies. Even though earlier the two species shared habitats in many locations, they now coexist in only a few places. *C. porosus* is the largest living reptile and its hide is the most sought after crocodile skin in the commercial world.

Deraniyagala considered the Sri Lankan crocodiles to be different to the Indian forms. He therefore named the Sri Lankan Marsh crocodile *Crocodylus palustris kimbula* (Deraniyagala 1936) and the Estuarine crocodile *Crocodylus porosus minikanna* (Deraniyagala 1955). However, Wermuth (1960) and Whitaker and Whitaker (1982) have shown, from a larger series of specimens, that the criteria used by Deraniyagala, does not support his contention of the islands two forms to be separate subspecies.

Sri Lanka Profile

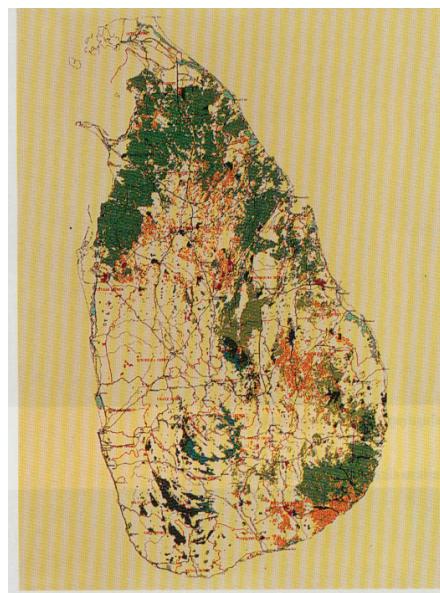
Sri Lanka is located between latitudes 5°55'- 9°51'N and longitudes 79°41'- 81°54' with a land area of 64,742 km² or 6,463,000 hectares. Earlier Sri Lanka was a part of the Indian mainland and during the Miocene period it was

separated for the first time. However during the Pleistocene due to four drops of the level of the sea up to 100 m, there had been successive land connections and severances.

The island is divided into three climatic zones according to rainfall distribution. They are the dry zone (rainfall less than 1,900 mm per year), the wet zone (rainfall 2500-5000 mm per year). The dry and wet zones constitute 65% and 23% respectively of the island's total land area. The intermediate zone, consisting of 12% of the land and a rainfall between 1900-2500 mm per year, lies between the dry and wet zones.

Sri Lanka posses three hectares of inland lentic waters for every square kilometre of land. This is one of the highest densities of inland lakes, tanks, ponds, man made canals and other still waters in the world (Baldwin 1991). There are about 12,000 man made lakes, known as "tanks", located mainly in the dry zone of Sri Lanka.

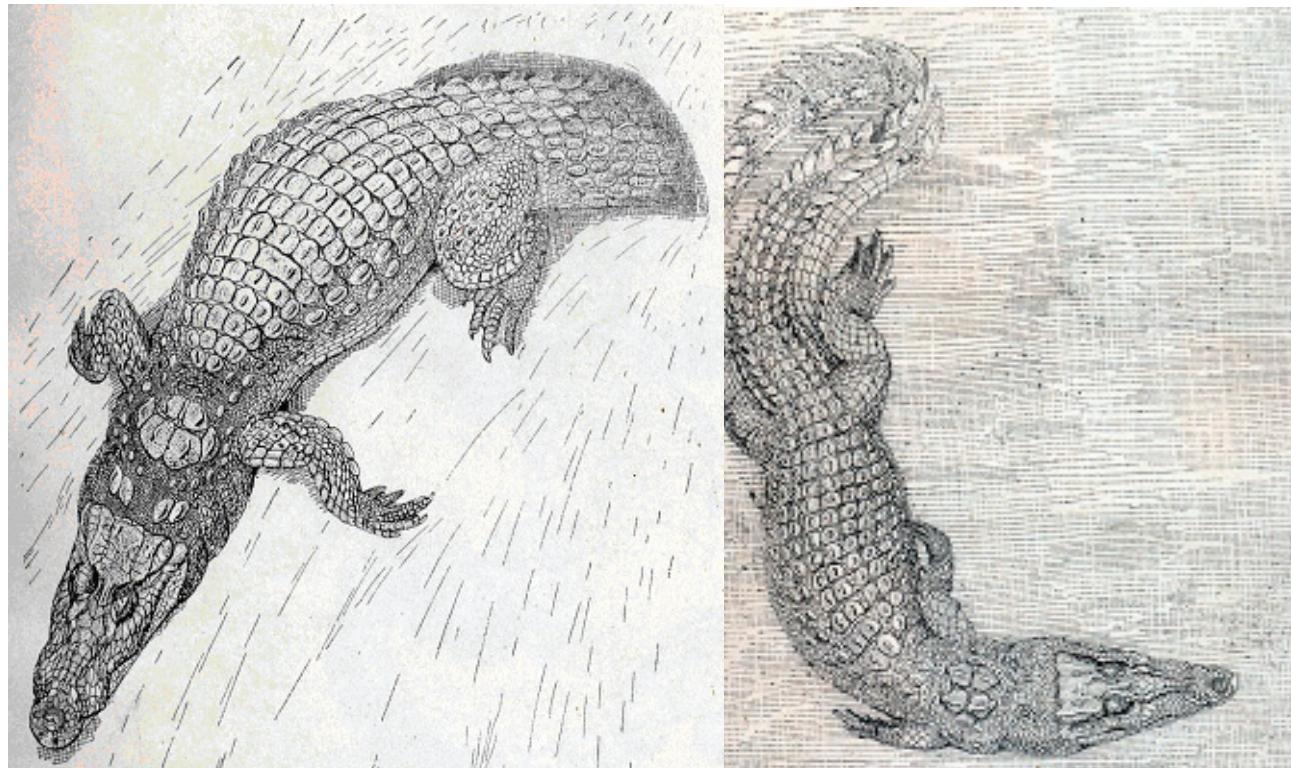
Identification and General Morphology



The two species are easily distinguished by their pattern of dorsal osteoderms. The osteoderms of *C. palustris* are rectangular and aligned to form transverse rows. The snout of *C. palustris* is relatively short, wide and has four post occipital scutes. *C. porosus* has ellipsoid osteoderms, which are separated from one another by epidermis. It has an elongate snout. The post occipital area is covered with small, granular scales, no big scutes.

The adult *C. palustris* is dorsally a dark olive green shading into brown, with black or dark brown bars and spots. Ventrally, white with faint traces of dark gray transverse bands interrupted mesially. None of the black markings extend beyond two rows of scales and are relatively constant in size throughout life (Deraniyagala 1953).

C. porosus is dorsally a brassy yellow spotted and blotched with black in four or five irregular transverse rows, ventrally pale yellow with dark spots under hind limbs and subcaudals. After the animal is three metres long the dorsal colour is almost uniform black, the head and jaws yellow, and densely speckled with black (Deraniyagala 1953).



Ecology of the Two Species

Different individuals of *C. palustris* vary in their temperament. Animals from one locality might be ferocious man-eaters, while others from the neighbouring swamps or reservoirs will permit people to bathe or fish in their abodes with impunity (Deraniyagala 1953). Regarding *C. porosus* Deraniyagala (1953) says ‘This form is usually a man-eater and even today claims many human victims annually.

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Crocodiles spend most of the time in the water but are not comfortable in waters that are deeper than about 10 metres. During drought, crocodiles that have been molested by man quit a swamp directly the water reaches a certain level that seemingly is still ample for their safety. Other individuals in jungle swamps remote from villages continue in them so long as any moisture remains (Deraniyagala 1953).

Young crocodiles emit croaks whilst adults croak and also emit a bellowing grunt, which can be heard for a great distance.

In the 1970s fisherman netted many crocodiles to make ‘jerky’ (dried meat) or to get rid of them because they were considered a nuisance (Rom Whitaker, pers. comm.) The destruction of the mangrove and marsh habitats of *C. porosus* has resulted in the depletion of its numbers. This destruction is due mainly to increasing urbanization.

Reproductive Behaviour

Some of the breeding habits of the two species differ. *C. palustris* buries its eggs in soft sandy soil and decaying leaf matter mainly on riverbanks and tanks (lakes). *C. porosus* builds a mound-like nest often using the flag plant (*Lagenthera toxicaria*), but any reeds, pandanus, palms, thick grass, etc., will also do. The vegetation with which the nest is built decomposes as time goes on and generates heat necessary for incubation.

The females of both species are sexually mature and start to breed from about 6 to 8 years (*C. palustris*) and 10 to 12 years (*C. porosus*) of age. The males mature when they are older. *C. palustris* usually breeds once a year but at the Madras Crocodile bank, they have bred twice a year (Rom Whitaker, pers. comm.). *C. porosus* breeds only once a year. It is likely that the two monsoons that occur annually in the island have a bearing on the breeding regimes of the two species.

Most females remain near their nest during incubation and protect it from predators. On hatching vocalizations made by the hatchlings induce the female to assist the hatchlings to emerge. In some cases the mother carries the tiny babies to the water in her mouth. The sex of the hatchlings is determined by temperature. More males are born during

Table 1. Details of the reproductive behaviour of the two species.

Species	Nest type	Eggs /clutch	Breeding season	Nesting
<i>C. porosus</i>	A mound-like nest of vegetation. Also a hole dug into the ground	40 to over 60 An average of 50 eggs Hatching takes 80-100 days	Wet season	Female stays near nest and defends it Opens eggs for hatchlings to come out
<i>C. palustris</i>	Buries its eggs in soft sandy soil and decaying leaf matter Communal nesting	20 to 35 per clutch Hatching takes 50-65 days	Dry season	Female stays near nest and defends it. Opens eggs for hatchlings to come out

periods of high temperatures. The hatchlings remain together near the mother for several months, deriving a certain amount of protection from her. As they grow and become more widely dispersed and independent, the majority of the offspring perish due to predation by monitor lizards, wild pigs, feral dogs, etc. - some are even eaten by other larger crocodiles.

The survivors reach maturity between 6-12 years depending on the species. Females grow more slowly and reach maturity when much smaller than males, who continue growing and usually exceed females in size. Records show that crocodiles are long lived in the wild. Adults of both species emit loud vocalizations during the breeding season. Both species have a complex courtship display prior to mating.

The biological characteristics of crocodiles give them a resilience to recover from population depletion if the adverse conditions that caused the depletion improve. However, unregulated killing of adults can lead to rapid population reductions, particularly if combined with habitat loss.

Range and Distribution

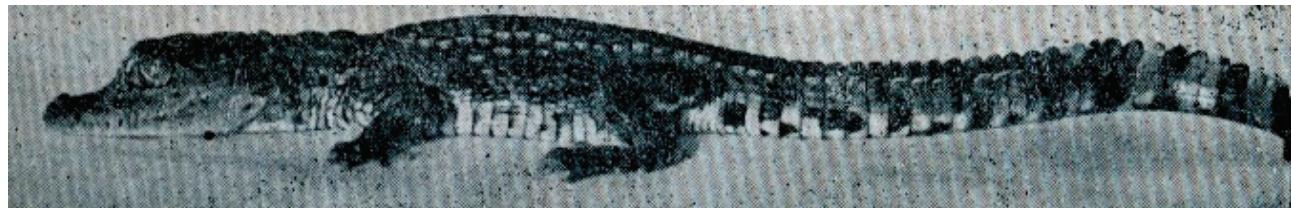
With reference to the distribution of *C. palustris* Deraniyagala (1953) states 'this sub species ranges from the saline coastal lagoons up to the swamps in the intermediate peneplain and also inhabits some of the islands to the northwest and north of Ceylon which it has reached either by crossing the sea during heavy rainy weather or by being isolated when these islands separated off from the mainland. It prefers sedentary or slow flowing water and is more terrestrial, fossorial and gregarious than its estuarine relative'.

Writing on its distribution Deraniyagala (1953) states '*C. porosus* is generally confined to the coastal region of the first peneplain and sometimes travels far up rivers ascending the Kalu Ganga up to Ratnapura while a large individual was found dead in the Mahaweli river above Alutnuvara, a distance of over 160 kilometres (100 miles) from the sea. It occurs in the estuaries of the larger rivers, appearing to prefer water that is only faintly brackish to that which is more saline. Although numerous individuals dwell in the same lagoon, *C. porosus* is a comparatively solitary species'.

Though there is mention of *C. porosus* occurring in the Yala National Park, these are confined to the mangrove marshland area in Kumana. Although an occasional *C. porosus* may have either swum or been washed down in times of flood into the Yala National Park. However the habitat by and large does not appear to be suitable for their welfare and breeding. In recent times the Department of Wildlife Conservation (DWLC) has released one large man-eating saltwater crocodile from the Nilwala Ganga in Matara, into the Bundala National Park. They have also released another, a man-eater that was brought to the Dehiwela Zoo, in the Yala NP. However recent surveys by Rom Whitaker have not revealed the presence of *C. porosus* in the Yala NP.

C. porosus has a wider distribution in Sri Lanka than *C. palustris*, which is mainly restricted to the lowland dry zone of the island. Neither of these two species has been recorded higher than 150 metres above sea level.

"Salties (*C. porosus*) have a different set of specific habitat requisites compared to the ubiquitous mugger (*C. palustris*) who can make do with a mud hole or a drainage ditch if it has to. The typical habitats of the salty are the rivers and backwaters once lined with mangroves in Sri Lanka's southwestern coast from Negombo down to Galle. There are very few salties left now in Sri Lanka, perhaps the only breeding population is in the Muthurajawela swamp near Negombo with sporadic breeding at places like the Bentota River" (Rom Whitaker, pers comm.).



In earlier times the local communities used to construct special ‘crocodile proof’ enclosures along most of the rivers that drain out into the sea in the southwest coast of the island. These enclosures were used by them to bathe in comparative safety. The fences were constructed with railway sleepers planted in the water with two opposite sides coming well up the bank. However now with the decrease in the Saltwater crocodiles less and less of these enclosures are seen.

This preliminary survey has confirmed the presence of crocodiles in the (Jaffna) peninsula. Both freshwater and saltwater crocodiles are present, and locals refer to them by their vernacular names *Chaanakan* and *Semmooken* respectively (Santiapillai 2004). For a long time it was believed that crocodiles had been extirpated from the Jaffna Peninsula.

The two species of crocodiles in Sri Lanka need to be conserved for different reasons. *C. palustris*, though abundant in the island, has its numbers decreasing in the rest of its range states. On the other hand *C. porosus*, found widely in Papua New Guinea, Australia and other countries, have a small and dwindling population in Sri Lanka.

Present Status

It is pertinent to record here that during the 19th Century crocodiles were found in abundance in most of the lakes and tanks of the northern and southern parts of the island Davy (1821). Tennent (1859) a foremost naturalist on Sri Lanka in the 19th century records “Batticaloa lagoon and all the still waters of this district are remarkable for the numbers and prodigious size of the crocodiles which infest them. Their teeth are sometimes so large that natives mount them with silver lids and use them for boxes to carry chunam. Samuel Baker (1853) records that all lakes in Ceylon swarm with crocodiles of very large size. Ferguson (1877) records that *C palustris* had been common in tanks in the Jaffna Peninsula

Though globally secure as a species, *C. porosus* is in extreme danger of extirpation from Sri Lanka due to the reasons given above and the attitude of the local communities towards this crocodile. The reputation it has as a man-eater being the main reason for this dislike.

Sri Lanka has a large mugger population probably numbering several thousand throughout the island. While the largest number occur in the two national parks, Yala and Wilpattu, muggers can be seen in large tanks, in rice fields, waterways and small and large rivers in the more sparsely populated areas. The mugger is strictly protected in Sri Lanka and a crocodile management and conservation project is being formulated (Whitaker, in prep.). A recent film on the mugger in Sri Lanka reveals unique underwater footage of breeding and parental care by the male. Sri Lanka holds the responsibility for the long-term survival of the mugger (Whitaker *et al.* 2003).

Sri Lanka also has isolated populations of *C. porosus*, mainly on the southwest coast which still has some suitable habitat left. Detailed surveys are required to establish the status and survival potential of this, now rare, species (Whitaker *et al.* 2003).

Threats to Crocodiles

Crocodiles are threatened by many human activities.

- Destruction or alteration of their natural habitat.
- Commercial overexploitation, to a lesser extent, and indiscriminate killing.
- Irresponsible land use practices leads to disturbances in the downstream habitats.
- Soil erosion and other habitat disturbances upstream, lead to the siltation of their habitats. This reduces the carrying capacity of the rivers, muddy the tank bed and banks, and reduce the quality and quantity of water available for fish, on which the crocodiles feed.
- Regular fires in the dry zone forests and riverine grasslands during the dry season can destroy the breeding grounds of crocodiles.
- Dried up water bodies during severe droughts experienced periodically also play an important part in the lives of the crocodiles.
- Destruction and clearing of wetland crocodile habitats can take many forms. The most obvious being drainage and infilling, deforestation, conversion to agricultural use.
- Pollution of aquatic habitats like rivers, streams, etc.

- The removal of the important shelter plant (*Lagenandra toxicaria*) which *C. porosus* uses for nest material along the west coast.
- Killing of crocodiles by fisherman.
- In many areas crocodile meat is dried and sold as items purported to be of medicinal value or as dried shark fish. Dried crocodile meat is a cure for asthma.
- Crocodiles living near human habitations are deliberately misnamed man-eaters or considered a potential threat to humans and their livestock, and are killed.
- Crocodile nests face egg and hatchling predation from land monitors (*Varanus salvator*), stray dogs, crows and egrets. This predation if unchecked could lead to rapid decrease in crocodile populations.
- Unseasonal rains and heavy seasonal rains cause flooding, which affects crocodile nesting. Periodic flooding in the monsoon season, which is the main breeding period of *C. porosus*, washes away and destroys the nests.
- Similarly, unseasonal rains affect the nesting of *C. palustris*. Prolonged droughts too can wipe out young crocodile populations.

Conservation and Management

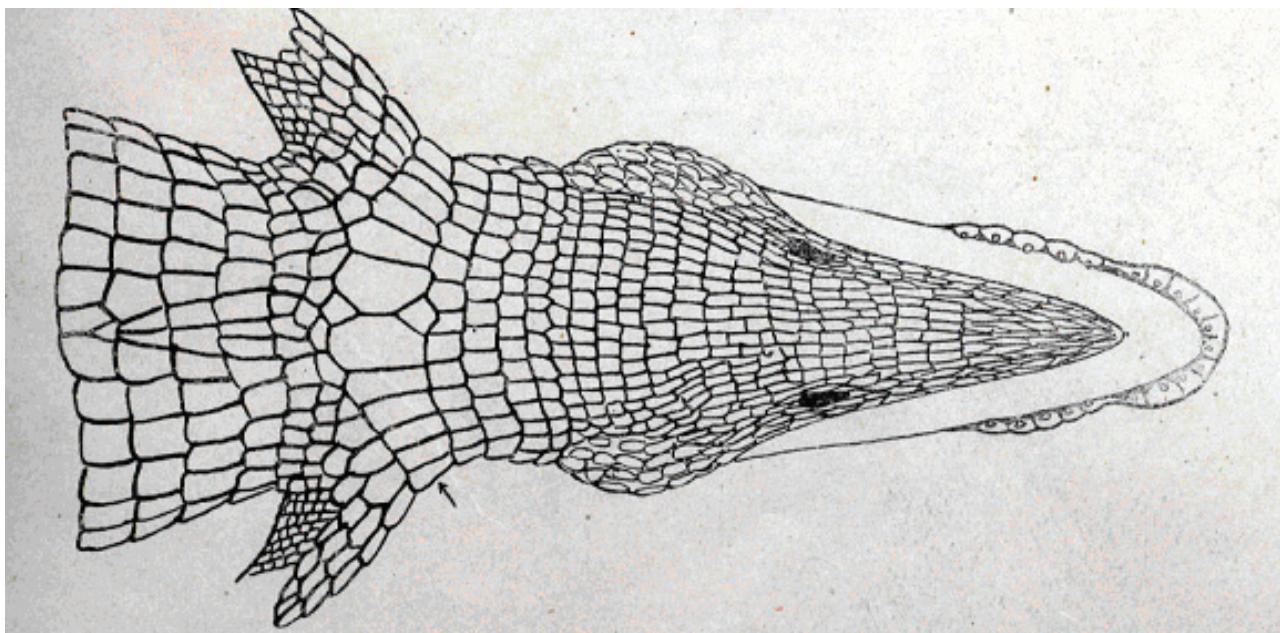
The conservation of crocodiles is therefore dependent upon good management practices, maintenance of habitats in as undisturbed state as possible and successful coexistence between crocodiles and humans.

Successful crocodile management and conservation poses many problems. Many who have to live near crocodiles usually regard them as dangerous and worthy of destruction. In other countries where crocodile conservation programs have succeeded in increasing their numbers, problems of crocodile-human conflict by man-eaters, have often increased. Therefore both species on the island require complete protection through legal means in protected areas and also preservation in captivity. Fishing, which is an important source of income to local communities, is hampered by the presence of crocodiles. However, conservation measures should also consider a more creative approach that provides incentives to people living with crocodiles to offset their real and perceived losses and costs.

The challenge for researchers and managers responsible for crocodiles is to establish programs where their population numbers are maintained at optimum levels through the conservation of resources and habitats. Effective conservation measures will ensure that the population numbers increase.

One component considered critical to the successful management of healthy wild populations is the maintenance of genetic variation. To manage a species with that goal in mind, appropriate genetic markers should be developed that allow insight into the genetic structure of the populations of interest (Davis *et al.* 2001). Since males are known to disperse greater distances than females, studies will show a male-mediated gene flow pattern within a certain population. This information would be very important for long-term conservation planning.





Policy

In Sri Lanka there is no stated policy for the conservation of crocodiles. The DWLC, which is responsible for the management and conservation of crocodiles in the wild, is backed by the Fauna & Flora Ordinance No 2 of 1937. However very little action is taken by the department with respect to crocodile management.

Recognising the important role played by crocodiles in many of the island's ecosystems. The DWLC must immediately formulate and put into practice a policy for the management and conservation of crocodiles. This policy should form the base of a management and conservation action plan. If necessary the existing laws should be amended to give strength to the implementation of the new policy.

Legislation

In early part of the 20th century crocodiles were extensively hunted for their skins. However, with the introduction of the Fauna and Flora Protection Ordinance in 1937 this large scale persecution was greatly reduced. Though crocodiles are completely protected under this ordinance, they are subject to continued killing and exploitation and face extinction. Habitat degradation, unplanned land use practices and an expanding human population, are the major threats to crocodiles in Sri Lanka. The solutions to crocodile conservation, and probably to conservation in general, lie in adapting social, economic and cultural perspectives into an integrated whole for habitat and ecosystem management.

In 1946 crocodiles were placed on Schedule IV of the Fauna & Flora Protection Ordinance, which means they could not be shot without a Special License. This license allowed one crocodile to be taken. The export of crocodile skins is now totally banned. Combined with adequate habitat protection it would seem that these laws, if enforced, would ensure the future of Sri Lanka's crocodiles. The two factors running against that supposition are the sale of dry crocodile meat (without the risk of dealing in the skins) and the possibility of smuggling skins to India. In late 1975 the Indian excise authorities seized 86 crocodile skins at Dindigul with markings on the crate indicating that it had come from Sri Lanka via the ferry to Rameswaram (Whitaker and Whitaker 1979).

Crocodile Conservation

Crocodiles have a unique natural history that creates special challenges for their conservation. They are the largest predators in their habitats and can threaten humans and their livestock. They are also heavily affected by habitat loss and the pollution of their aquatic habitats. The extirpation from the island of either species of crocodile would result in a significant loss of biodiversity and ecosystem stability in their habitats. Actually the presence of crocodiles is good for fisheries since they control fish predators and raises the genetic quality of their prey just like any apex predator. A healthy crocodile population equals a healthy fish population.

Crocodiles are necessary in their habitats, since they directly affect wetland nutrient cycles and the fish population there. For example the Bolgoda Lake, which had *C. porosus* in the past has no crocodiles there now. Invasive species of fish have recently been introduced into this lake and are now destroying the smaller species of fish, like the knifefish (*Chitwala chitwala*) leading to their extirpation. However if there were crocodiles still in the Bolgoda Lake, they would have consumed the larger invasive fish (knifefish grow up to four feet and occur in the Bolgoda and Diyawanna Oya), thus allowing the smaller local fishes to exist. Crocodiles do not consume the smaller species of fish on which the invasive species predate. Crocodiles are a keystone species, which helps keep the biological balance and structure of their habitat in equilibrium.

No comprehensive survey of crocodiles in Sri Lanka has been carried out, except for that done by Whitaker and Whitaker (1977). There is a lack of information on the zoogeography, population dynamics, abundance and the distribution of crocodiles in Sri Lanka

Outline for a Crocodile Conservation Plan

If an effective long-term crocodile management plan is to be formulated in Sri Lanka, the following information must be collected. This can be done through research, surveys and studies.

The objectives of this plan should be; 1. Coordinated management and plan ready for implementation, 2. Security, protection and law enforcement, 3. Biological management, 4. Community involvement, 5. Sustainable funding, 6. Capacity building.

1. Distribution of crocodiles and land-use patterns in their habitat
 - Species status: historical, recent past and present, for both species
 - Distribution maps: known range for each species; using GIS
 - Vegetation maps: habitat types, elevation, etc.
 - Land-use maps: including ownership, concession boundaries etc. particularly as it may effect the long-term conservation of the species.
2. Threats to their survival
 - Declining populations: main causes and stakeholders involved, including rate of population reduction
 - Direct threats: hunting for meat, traditional uses (?), live capture, diseases
 - Indirect threats: traps and snares, disturbances from gem and sand mining, other habitat threats (eg prawn farming)
 - Resource extraction: legal and illegal activities in crocodile habitats in each administrative area. Destruction of tunnel banks especially in the drought prone areas. Also feral buffaloes ruining the waterholes.
3. Current legislation and conservation action relevant to crocodiles
 - National Law: current legislation and enforcement - are they adequate?
 - Traditions: relevant local traditions and beliefs
 - Protected Areas: current and proposed Parks covering crocodile habitats
 - Conservation projects: filed surveys and projects, awareness programmes, etc.
 - International Agreements: current and proposed CITES, Ramsar, etc.

Once the above information has been gathered a comprehensive management plan, consisting of the following segments, can be developed.

1. Action to conserve the two species of crocodiles
 - a. Priorities for action: immediate, medium and long-term proposals
 - b. Implementation: government, NGOs, private individuals
 - c. Action plans: It is necessary for the following actions to be carried out prior to developing an Action Plan for the Management and Conservation of both species of crocodiles in Sri Lanka
- a. Research
 1. Determine the degree of perceived and positive threats to specific populations and to crocodiles in general
 2. Determine how effective present protection measures (if any) are to these threats
 3. Survey the distribution of crocodiles past and present

- b. Protection
 - 1. Strengthen law enforcement relating to the killing, skin trade, etc., in crocodiles
 - 2. Designate new protected areas or alter size or status of existing PAs
 - 3. Create new protected area designations, eg community reserves for grazing cattle, game management areas, etc.
 - 4. Increase anti-poaching efforts in protected areas that include crocodile habitats

- c. Awareness/Education
 - 1. Awareness campaigns to be carried out in schools for children and adults, on the economic and ecological value of crocodiles
 - 2. Include a subject related to crocodiles in schools curriculum

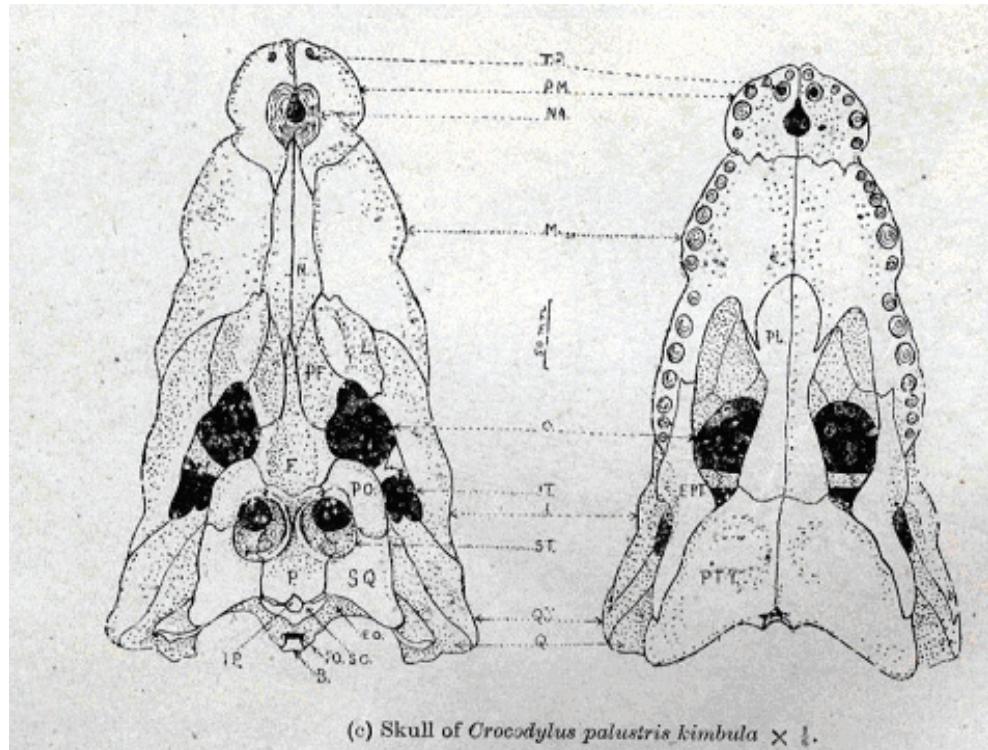
- d. Development
 - 1. Develop and implement plans for the proper management of crocodiles and their habitats
 - 2. Develop and implement plans for alternate livelihoods for people whose presence has adverse impacts on crocodiles and their habitats especially in protected areas
 - 3. Develop plans for ecotourism, research and filming opportunities in respect of crocodiles
 - 4. Develop and implement plans where the local community would benefit from the presence of crocodiles

- e. Budgets

Once the plans for crocodile conservation and management are formulated, the finances required for the implementation of these plans should also be determined. It is also important to identify the sources of funding, to carry out the activities listed in the plan, including the government, funding agencies and NGOs.

Survey

Initially it is necessary that a survey be conducted to ascertain the present status in respect of crocodiles in the wild. This information will help to formulate a pragmatic management and conservation plan. Given below is a list of the objectives of the proposed survey.



Specific Objectives

- Estimate the populations of *C. palustris* and *C. porosus*.
- Provide a national distribution map of both species of crocodile covering all tanks, rivers, lagoons, estuaries, canals and other water sources.
- Identify areas with important or high populations of both species of crocodiles.
- Identify areas of threat to crocodile populations.
- Identify nesting locations of both species of crocodile.
- Ascertain crocodile prey species.
- Ascertain threats faced by all age groups of crocodiles from eggs to adulthood.
- Investigate the status of, and threats to, the natural habitats of crocodiles throughout the island.
- Investigate the instances of ecto- and endo-parasitism when practical.
- Investigate the numbers and circumstances of crocodile attacks on humans and livestock.
- Investigate the number and sizes of crocodiles killed for human consumption.
- Propose conservation management concepts and strategies for the conservation of both species of crocodile in Sri Lanka.
- Obtain a molecular assessment of both species of Sri Lankan and Indian crocodiles.
- Encourage veterinary, wildlife management and herpetological students to participate in crocodile field research whenever possible during the course of the study, including crocodile handling, restraint and general ecology and behaviour.
- Conduct outreach awareness programmes for villagers living in and around known crocodile locations.
- Provide a comprehensive and well-illustrated report of the project's findings within three months of its completion.

Conclusions

Conservation programmes need to start now. The development of a policy for crocodiles is the first step that the Sri Lankan Government has to take. Based on this policy a strategy has to be worked out. A management and conservation plan which should also include a budget and time scale should be developed. Trained and dedicated personnel should implement this plan if it is to help successfully save the crocodile populations in Sri Lanka.

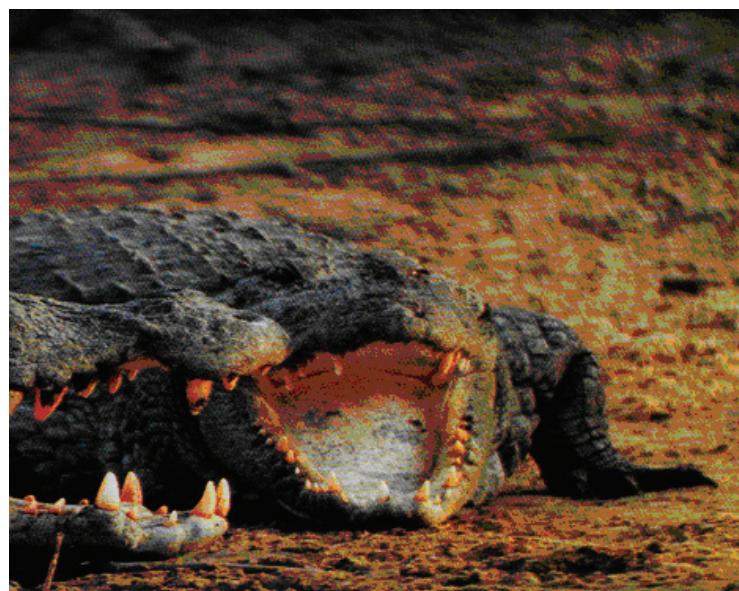
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The Current Distribution and Population Size of the Philippine Crocodile and Estuarine Crocodile in Northeast Luzon, the Philippines

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Abstract

There is hardly any reliable recent information on the distribution and population size of the two crocodile species found in the Philippines: the Estuarine crocodile *Crocodylus porosus* and the endemic Philippine crocodile *Crocodylus mindorensis*. Since the discovery of a remnant population of *C. mindorensis* in NE Luzon in 1999, efforts have been undertaken to systematically survey NE Luzon for additional crocodile localities. Moreover, identified localities have been monitored at least once a year. At present, six localities have been identified with permanent *C. mindorensis* sub-populations and two localities with *C. porosus*. In three localities, successful *C. mindorensis* breeding has been observed. The total known non-hatching population of *C. mindorensis* has increased since 2002 from 15 to 27, mainly because hatchlings observed in 2002 have grown. Hatchling survival rate was relatively high. A large concern however is the lack of observed breeding since 2002. Monitoring data is available for the last 5 years, enabling the presentation of population trends. New *C. mindorensis* sub-populations have been discovered in the Sierra Madre Mountains but surveys in the Cordillera Mountains have not yet resulted in confirmation of surviving populations. Our crocodile research efforts in the area are now shifting from field surveys towards monitoring and more in-depth ecological studies.

Introduction

Status of crocodilians in the Philippines

Two crocodilian species are found in the Philippines: the Estuarine crocodile, *Crocodylus porosus*, and the Philippine crocodile, *Crocodylus mindorensis*. The Estuarine crocodile occurs widely from the Seychelles, Sri Lanka and India to Australia while the Philippine crocodile is endemic to the country (Groombridge 1987). *Crocodylus mindorensis* is listed in the IUCN Red List (Hilton-Taylor 2000) as critically endangered. The IUCN Crocodile Specialist Group considers *C. mindorensis* to be the most severely threatened crocodile species in the world and placed the species on the top of the priority list of crocodiles needing conservation action (Ross 1998). International trade in Philippine crocodiles is banned under CITES Appendix 1 (UNEP-WCMC 2003). Philippine crocodiles are nationally protected since 2001 under Republic Act 9147, commonly known as the Wildlife Act (DENR 2001); however this act is not implemented because the accompanying Implementing Rules and Regulations have not yet been finalised and accepted.

Previous studies and published data

Published survey data on this species are limited. The only extensive nation-wide field surveys targeted specifically at *C. mindorensis* were carried out by Charles A. Ross in 1981 (Ross 1982; Ross and Alcala 1983) and recently by Pontillas *et al.* (Pontillas 2000). The determination of the historical distribution of the Philippine crocodile is largely based on a survey of museum specimens with collection locality data (Ross and Alcala 1983). Anecdotal and regional survey data have been collated by the Crocodile Farm Institute (CFI) of Palawan (Ortega 1998). Ecology, behavior and life history of *C. mindorensis* have not been studied systematically in the wild. The only available data, mainly on breeding factors and behavior in captivity, were gathered at the CFI (Ortega 1998) and at a small captive breeding center at Silliman University on Negros island (Alcala *et al.* 1987).

Distribution

The Philippine crocodile is thought to have occurred widely throughout the archipelago, with the exception of Palawan Island (Ross 1982). Specimens have been collected on the islands of Luzon, Mindoro, Masbate, Samar, Negros,

Mindanao, Jolo and Busuanga (Ross 1982). Ross confirmed the presence of *C. mindorensis* on Negros and Mindanao in 1981 and presumed the presence of extant populations on Mindoro, Samar and Northeast Luzon, although he did not observe crocodiles on Mindoro and was not able to visit Samar and Luzon for security reasons (Ross 1982).

An update presented in 1994 with additional information confirmed the presence of *C. mindorensis* on Busuanga (Ortega *et al.* 1994). Ortega presented a comprehensive report on the Philippine crocodile in 1998, in which he identified Mindoro, Mindanao, Busuanga and Northeast Luzon as regions with extant populations, all based on sightings during the 1990s (Ortega 1998). However, we identified the two captive crocodiles at the provincial museum in Tuguegarao (Ramirez, pers. comm. in Ortega 1998) on which Ortega based his record of the Philippine crocodile on Northeast Luzon as *C. porosus*.

Pontillas (2000; Pontillas 2002 pers. comm.) conducted field surveys in the years 2000, 2001 and 2002 on Luzon, Mindoro, Busuanga and Mindanao, and was able to confirm Philippine crocodile presence on Luzon and Mindanao but did not observe any *C. mindorensis* on Mindoro or Busuanga. A small extant population is thought to be surviving on Negros (Alcala 2001, pers. comm.). Recently, a survey was carried out on the island of Jomalig in the Pollilo Island group off the coast of Luzon to check reported sightings of crocodiles (Reyes 2003). Indirect evidence of crocodile presence was found but the presence of *C. mindorensis* could not be confirmed nor excluded (Reyes 2003).

In summary, the best available recent survey data confirm extant *C. mindorensis* populations on the islands of Luzon, Negros and Mindanao. The species has not recently been observed by field workers on Mindoro and Busuanga. Samar was identified by Ross (1982) as having probable extant populations but was, to our knowledge, never surveyed thoroughly. Clearly, much more extensive survey work is needed on all Philippine islands to gather reliable data on present *C. mindorensis* distribution and population size.

Population size

Ross estimated the remaining wild population at 500 to 1,000 individuals in 1982 (Ross 1982). It is not entirely clear how he arrived at this figure, having observed very few individuals during the surveys in 1981. Presumably, this estimation includes all age classes. Ortega estimated the remaining population in 1998 at “500 animals held in captivity and in the wild” (Ortega 1998). Contradictory, the CFI also reported at that time that it had a total of 1173 *C. mindorensis*, some acquired and some bred in captivity (Ortega 1998). Perhaps the estimate presented by Ortega concerns only non-hatching crocodiles. The latest population estimate used to determine the IUCN Red List status is 100 non-hatchlings and was made by the IUCN/SSC Crocodile Specialist Group (Hilton-Taylor 2000; Ross 1998). It is important to note that none of these estimates are based on counts or extrapolations of field survey data.

Crocodile Surveys in Northeast Luzon

Area description

Northeast Luzon, as used in this publication, is the area encompassing Cagayan Valley, the Northern Sierra Madre Mountains and the eastern part of the Cordillera Mountains. Cagayan River is the largest river of the Philippines. Originating in the highlands of the Sierra Madre in the East, the Cordillera in the West and the Caraballo Mountains in the South it flows north through the broad Cagayan Valley ending in the Babuyan Channel. The Sierra Madre Mountain Range is situated on the eastern side of Cagayan Valley and extends south from the extreme tip of Northeast Luzon to Quezon Province. The highest peaks of the Sierra Madre are about 2000 m. The Cordillera is situated on the western side of Cagayan Valley and covers the entire central part of northern Luzon. The highest peaks here are nearly 3000 m. The Caraballo Mountains in the South form the natural barrier between the Central Luzon plains and the Cagayan Valley.

Tuguegarao City, located centrally in the Cagayan Valley, received an average of 1727 mm of rainfall annually during 1994-1998 (range 1199-2310 mm) and is characterised by a wet season from July till December and a drier season from January till June. Mean temperature ranges from 23.5°C in January till 29.3°C in June (PAGASA 1999).

In 1997, a large portion of the Northern Sierra Madre in Isabela Province was declared a protected area under the National Integrated Protected Area System: the Northern Sierra Madre Natural Park. Crocodile surveys were carried out along the Pacific coast of this park, confirming through interviews the presence of a small population of the Estuarine crocodile (NORDECO and DENR 1997). It was until 1999 unknown that *C. mindorensis* was also present in the park.

Methods

Since 1999, crocodile surveys have been carried out by the Northern Sierra Madre Natural Park-Conservation Project (NSMNP-CP) until October 2002 (van Weerd 2002). Since then researchers have been engaged in crocodile surveys under the framework of the Crocodile Rehabilitation, Observance and Conservation (CROC) project. The Mabuwaya Foundation, registered in 2003, implements the CROC project.

Field surveys started after a local fisherman in San Mariano incidentally caught a Philippine crocodile and turned it over to field staff of the NSMNP-CP who identified it as *C. mindorensis*. After this surprising rediscovery of *C. mindorensis* on Luzon, a protocol was developed for the gathering of secondary data from local fishermen and hunters. Past and recent sightings mentioned during interviews were checked, often by hiring the informant as a guide. Field surveys consisted of searching for crocodiles, tracks, basking areas or faeces at daytime, and spotlight surveys at night. Surveys were carried out on foot by slowly following riverbanks and lake edges with a maximum of four observers. Night surveys were usually carried out from 8 pm (about one hour after sunset) till midnight. In the case of positive sightings of tracks or crocodiles, spotlight surveys were repeatedly carried out during several nights. The maximum number of one count was taken as count result. Crocodile length was estimated and sizes were pooled in the following categories: (1) up to 0.3 m (hatchling); (2) 0.3-1.5 m (juvenile/sub-adult); (3) 1.5 m and longer (adult). Identified crocodile localities were regularly revisited to monitor changes in population size and structure. Each year in May it was tried to survey identified localities for a minimum of three nights. The weather in May, the end of the drier season, is favourable for crocodile surveys as remote areas are better accessible and rivers are low enabling coverage of larger areas. Furthermore we experienced difficulties in observing crocodiles in the wetter months (June-February) because heavy rains at night often diminished visibility and the range of spotlights. The results presented here are mostly from May surveys.

Results

Distribution

Map 1 shows the current (2004) known distribution of the Philippine and Estuarine crocodile in Northeast Luzon, including suspected and recent formerly known distribution sites where crocodiles reportedly went extinct during the last 20 years. We only discuss confirmed sites in this paper. Note that we did not visit western parts of the Cordillera, Philippine crocodile presence was confirmed here by a CFI team in 2001 (Pontillas, pers. comm., 2002).

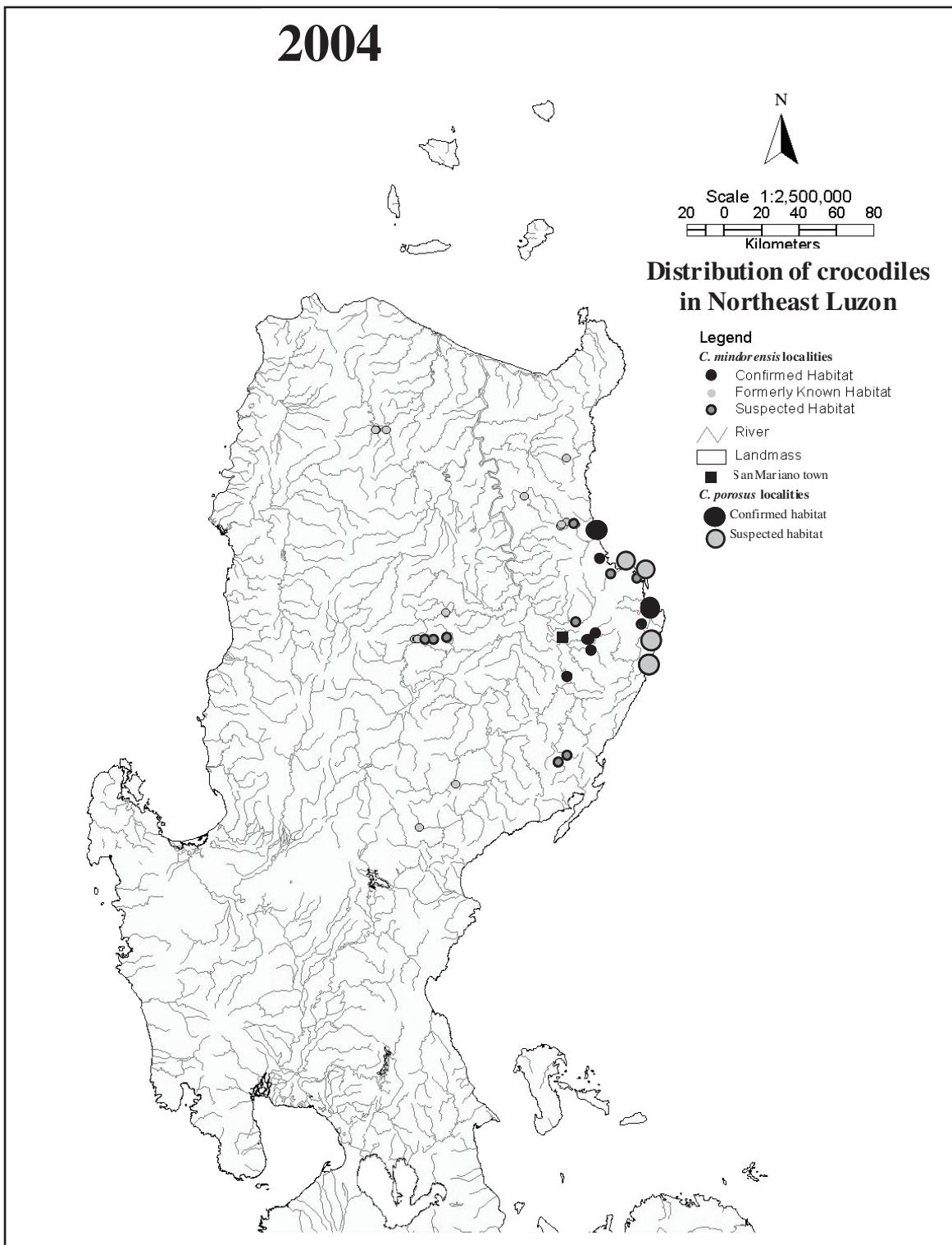
Philippine crocodile: population size and structure

Table 1 shows the currently identified localities where the Philippine crocodile is found. A total of 27 individuals have been sighted in six distinct localities of which 6 are adults and 21 are juvenile/sub-adults. At another site: Dikabulan Lake in the municipality of Palanan near the Pacific Ocean, tracks were found but it is not known whether they belong to *C. mindorensis* or *porosus*. Disulap River (N 16°57'27"; E 122°09'40"), Dunoy Lake (N 16°59'51"; E 122°09'34"), Dungsog Lake (N 17°01'02"; E 122°11'31") and Dinang Creek (N 16°47'31"; E 122°02'31") are all found in the municipality of San Mariano. Dicatian Lake (N 17°20'26"; E 122°16'28") is found in the municipality of Civilacan at the Eastern side of the Sierra Madre Mountains. Dibukarot Creek is found in the municipality of Palanan, also at the Eastern side. Dunoy Lake, Dungsog Lake, Dicatian Lake and Dibukarot Creek are all situated within the Northern Sierra Madre Natural Park.

Table 1. Current distribution and population size of *Crocodylus mindorensis*.

No.	Location Confirmed Sites	Year	Month	Adults	Juv./Sub-adults	Hatchlings	Total
1	Disulap River	2004	May	1	2		3
2	Dunoy Lake	2004	May	1	7		8
3	Dungsog Lake	2004	May	1	1		2
4	Dinang Creek	2004	February	1	9		10
5	Dicatian Lake	2004	April	1	2		3
6	Dibukarot Creek	2004	April	1			1
Total				6	21	0	27

2004



Map 1. Current distribution of Philippine and Estuarine crocodiles in Northeast Luzon.

Monitoring data

The following three localities in San Mariano have been monitored since their identification in 1999 and 2000: Disulap River, Dunoy Lake and Dinang Creek. In all three, successful breeding events were recorded. The conservation program in San Mariano focuses on these three key sites.

- Disulap River

Systematic surveys started in 1999 when 2 hatchlings, 2 juveniles and 1 adult were observed. Breeding must have taken place in early 1999 or late 1998 as hatchlings were still very small in March 1999. Breeding was

observed in 2000, the nest with broken eggshells and eight very small hatchlings nearby in the river were found in August 2000. In 2001 only one hatchling remained, suggesting a hatchling survival rate of 12.5%. No breeding has been observed since 2000 although 2 adults were present in 2003. In May 2004 two sub-adults and one adult were present. The number of non-hatchling crocodiles was three in 1999 and in 2004. We do not know where adults and sub-adult crocodiles move to when not observed, or whether we simply miss them during some surveys.

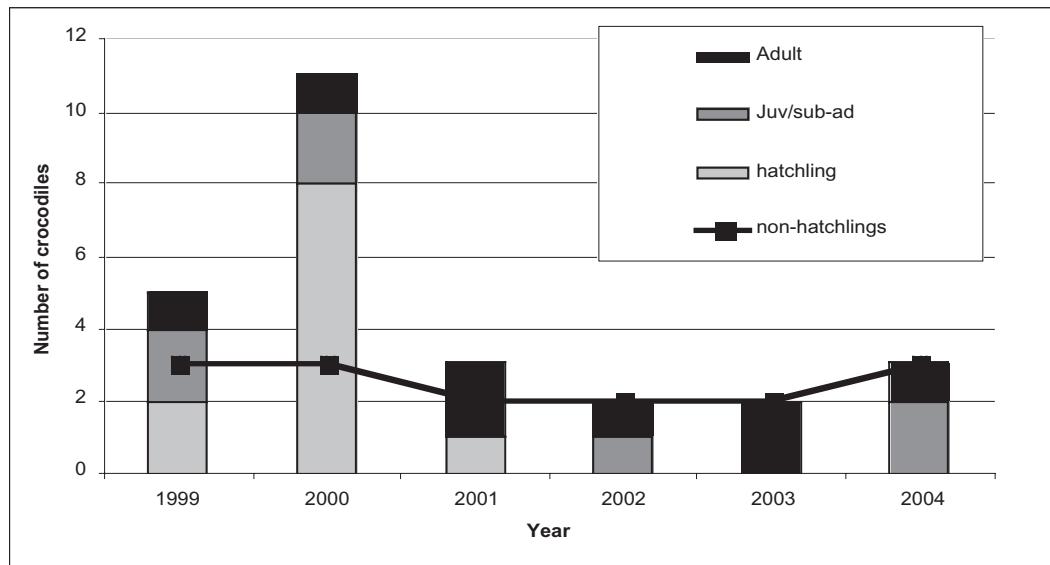


Figure 1. Annual monitoring results in Disulap River. The black line shows the total number of non-hatchlings over the years.

- Dunoy Lake

Surveys started in 1999 but no crocodiles were observed then. In 2000, the presence of an adult was confirmed followed by the observation of two adults in 2001. Breeding occurred early 2002, 12 hatchlings were observed in March that year. Nine juveniles were found in 2003, suggesting a hatchling survival rate of 75%. In 2004 seven juveniles remained suggesting a juvenile survival rate of 78% from 2003-2004. Although the juveniles always seem to remain in the lake, the adults are not always present. We assume that adult crocodiles sometimes move to nearby Catallangan River (ca. 200 m from the lake). The number of observed non-hatchling crocodiles increased from one in 2000 to eight in 2004.

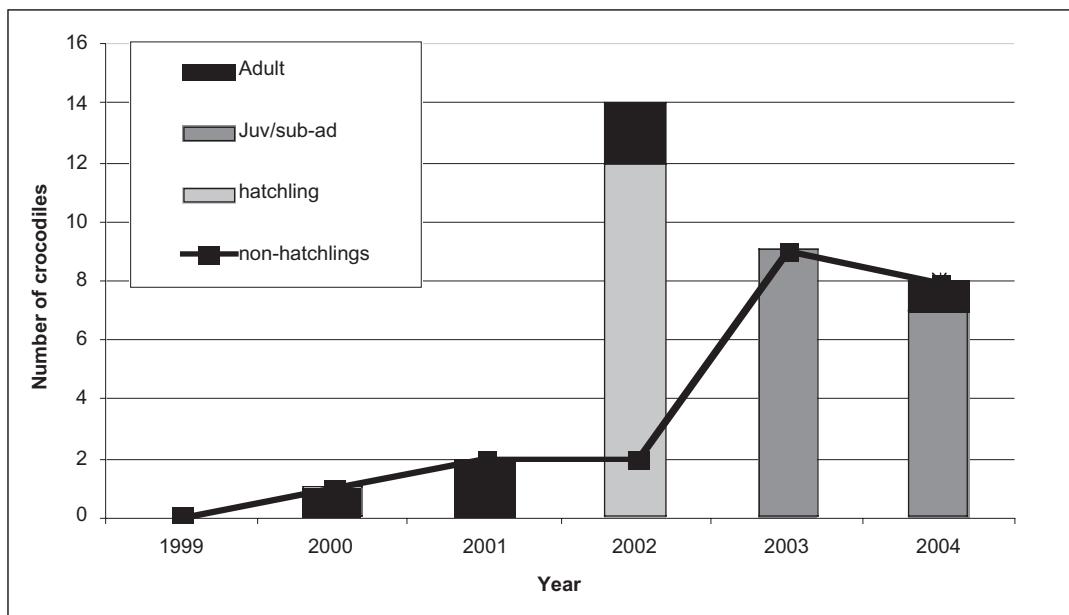


Figure 2. Annual monitoring results in Dunoy Lake.

- Dinang Creek

Dinang Creek was identified in 2000 as an important Philippine crocodile site. At the end of that year, four hatchlings and eight juveniles were observed. The hatchlings observed in early 2001 are from the same nest as in 2000. Breeding must have occurred in the latter half of 2000. In 2002, new hatchlings were found indicating a second successful breeding event. That year we also observed two adults. In 2003, 17 juveniles were observed. Assuming all juveniles observed in 2002 survived in 2003, hatchling survival rate over 2002-2003 was 79%. A strong typhoon hit San Mariano in July 2003 causing massive flashfloods, especially in denuded areas such as along Dinang Creek. In February 2004 only 10 crocodiles were found in the creek. Because of national election related violence in the area we were not able to survey the creek in May 2004. If really only 10 crocodiles survived, typhoon caused mortality could have been as high as 53%. The number of non-hatchling crocodiles increased from seven in 2000 to 19 in 2003, possibly decreasing to 10 in 2004.

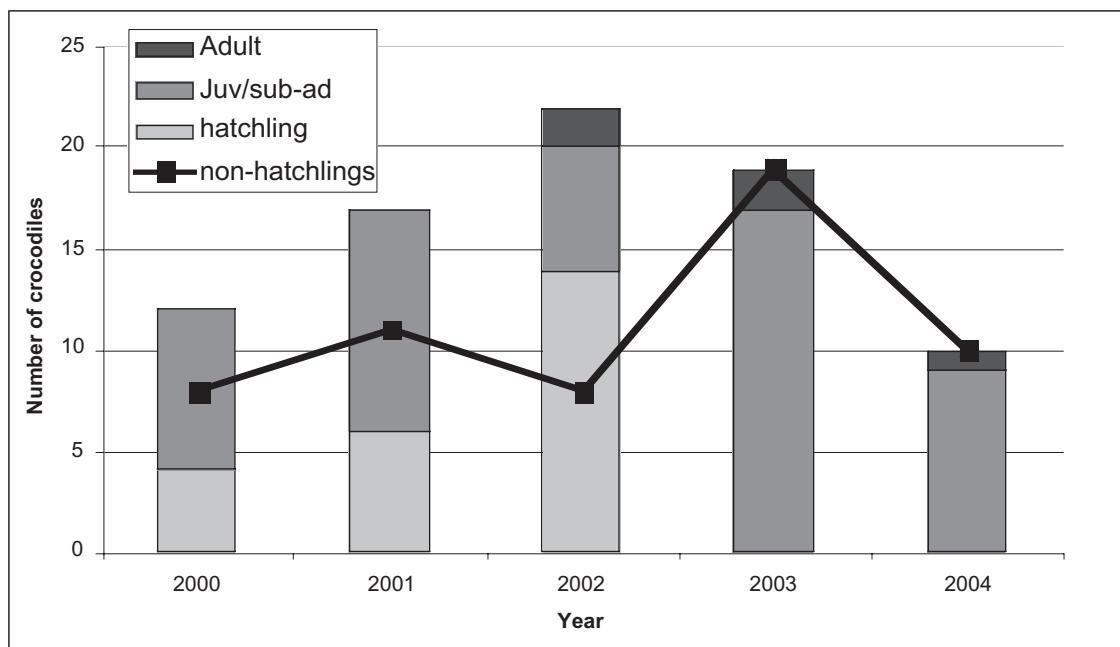


Figure 3. Annual monitoring results in Dinang Creek.

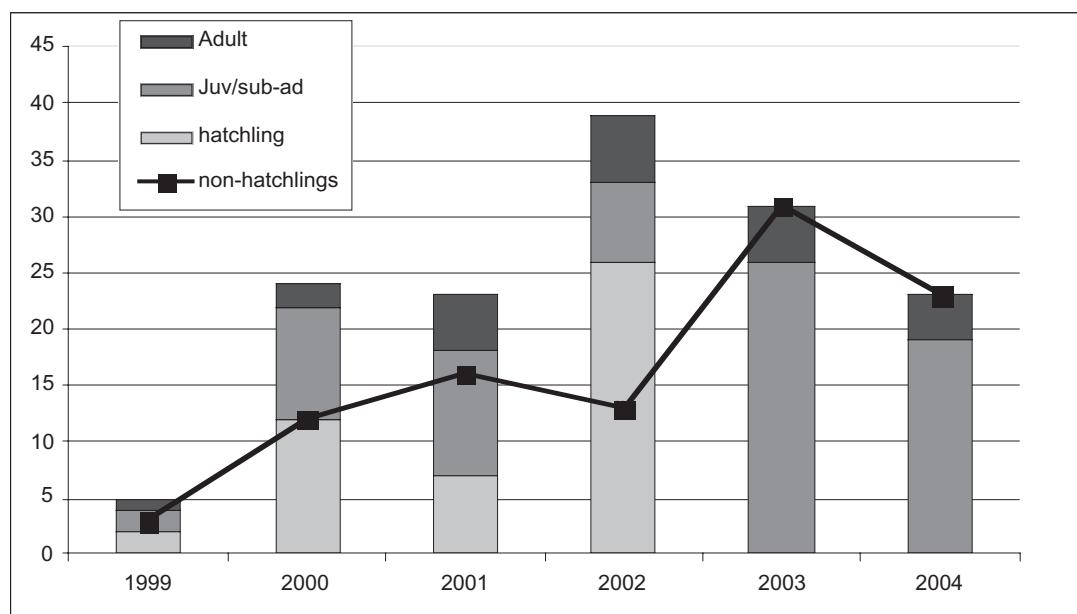


Figure 4. Combined annual monitoring results in Disulap River, Dunoy Lake, Dinang Creek and Dungsog Lake.

All monitoring sites combined

Figure 4 shows the results of four San Mariano monitoring sites combined, the three sites mentioned above + Dungsog Lake, a small lake without any observed breeding. The number of non-hatchling crocodiles increased from 12 in 2000, the first year when all these sites were surveyed, to 23 in 2004. The highest number observed, in 2003 was 31. No successful breeding has been observed in 2003, possibly caused by the July typhoon. Breeding could still occur in 2004. Please note that the results presented here only refer to permanent monitoring sites in San Mariano. Sites in other municipalities are not included, nor are observations of free-roaming crocodiles.

Estuarine crocodile: population size and structure

During a survey along the Pacific coast of the Northern Sierra Madre Natural Park in March 2004, an attempt was made to survey Estuarine crocodile in addition to *C. mindorensis*. Interviews among fishermen and other local inhabitants identified six suspected sites (see Map 1). In two sites, the Blos River Estuary in Reina Mercedes (municipality Maconacon) and the Mangrove area of Culasi (municipality Palanan), Estuarine crocodile presence could be confirmed and documented (Table 2). Both individuals were an estimated 3.5-4 m long.

Table 2. Distribution and population size of Estuarine crocodile *Crocodylus porosus* in Northeast Luzon.

No.	Location Confirmed Sites	Year	Month	Adults	Juv./Sub-adults	Hatchlings	Total
1	Reina Mercedes	2004	March	1			1
2	Culasi	2004	March	1			1
	Total			2	0	0	2

Crocodiles in captivity in Northeast Luzon

A survey was made of possible captive crocodiles in the area. Two *C. porosus* were found in two different privately owned collections, they were brought to Luzon from Dumaguete City (Negros Island) when still small. Two additional *C. porosus* are kept in a mini-zoo near Tuguegarao City (Cagayan Province), the origin of these animals is not clear.

One *C. mindorensis* was found in a privately owned collection in Santiago City (Isabela Province). The owner declined to reveal the source but it is likely that this animal is of regional wild origin. Two *C. mindorensis* are kept in the San Mariano municipal crocodile rescue centre, these crocodiles were retrieved from fishermen who caught them in Disulap River and the Pinacanuan de Ilagan River, both San Mariano, respectively.

Discussion

A total number of 27 Philippine crocodiles is now known from six different sites in Northeast Luzon. Twenty-three crocodiles are found in the municipality of San Mariano, four in two sites along the Pacific Ocean coast. In addition, three *C. mindorensis* are kept in captivity in the region. The number of non-hatchling crocodiles has increased since 2000 from 12 to 27, partly because of the discovery of new sites but mainly because of successful reproduction during the years 1999-2002. No breeding was observed in 2003, probably caused by a typhoon which struck the area in July of that year. The monitoring scheme which is in place in San Mariano provides valuable data to assess the threats to the extremely small population and to assess the success of conservation measures.

In 2004, two Estuarine crocodiles were observed along the Pacific coast of the Northern Sierra Madre. In addition, four *C. porosus* are known to be held in captivity in the region. Although not globally endangered, the Estuarine crocodile is possibly even more threatened in the Philippines than the Philippine crocodile.

Many questions remain about the ecology of the Philippine crocodile. Movement patterns are unknown. Diet is unknown. Reproductive behavior has never been studied in the wild. We aim to study the most important Philippine crocodile life-history parameters in the coming years.

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Crocodile Conservation in Sarawak

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Abstract

Estuarine crocodile (*Crocodylus porosus*) and false gharial (*Tomistoma schlegelii*) are the two known crocodilian species found in Sarawak. The former are found to dominate most of Sarawak main rivers whilst the latter usually confine themselves to upper reaches of rivers in peat swamp forests. After undergone its black era in early and mid-1990s, where hunting was reported to be rampant, the populations of estuarine crocodiles in Sarawak are now found to be recovering quite fast in a number of rivers, with a density ranging from 3.0 individual/km in Sadong River to 8.0 individual/km in Bako River near Kuching. Whilst the ecological status of estuarine crocodiles is quite well understood the ecological status of false gharials are somehow limited. Old record on the existence of the species in Ensengei, Kroh, Runjing, Dor, Kelauh, Maying and Loagan Bunut have not been updated since late 1980s. The enforcement of the Wildlife Protection Ordinance, 1990 and the implementation of the Master Plan for Wildlife in Sarawak have contributed to the drastic increase in the crocodile population, particularly *Crocodylus porosus*. Both species are placed under Appendix II of the protected species list of the Ordinance. Those found to be in possession of the species without valid license from the Forest Department shall be guilty of an offence which carries a penalty of imprisonment for one year and a fine of RM 10,000. Keeping the individual species requires a licence fee of RM10/head/year, while a license fee for a crocodile farm is RM100/year. Unfortunately the increase in number of crocodiles in the wild leads to marked increase in human-crocodile conflicts. A total of 42 attacks have occurred since the last twenty-five years. Culling of potentially dangerous crocodiles in the wild does not seem to solve the conflict. While culling is allowable under the Wildlife Protection Ordinance *in situ* conservation of these species should go on. As such the Sarawak Forestry Corporation Pty Ltd. is now making an effort to extend its awareness program to villagers along crocodile-infested rivers and at the same time putting up 'crocodile warning signs' within the areas. To enhance conservation of crocodiles in the wild at least two areas been earmarked as Crocodile Reserves and eventually would be developed as hot spots for crocodile watching activities.

Introduction

Out of about 23 species of crocodilians found worldwide, only two species are found in Sarawak. These are the estuarine crocodile (*Crocodylus porosus*) that dominates most of Sarawak's main rivers from the estuaries to the furthest tidal point, and a relatively smaller type, the false gharial (*Tomistoma schlegelii*). The latter are usually found in upper reaches of some rivers in peat swamp habitat. The two species can be easily distinguished from their external appearance. The snouts of estuarine crocodiles are normally shorter and somewhat blunt, whilst those of the false gharials are elongated and usually slimmer. Crocodiles are amongst the largest living reptiles and have changed little since the time of the dinosaurs, more than 150 million years ago. Both species represent an advanced group of reptiles from that period and they have certain features which are not found in other reptiles today. For example, the heart has four chambers and, like a mammal's heart, can pump blood to and from the lungs without mixing (Gans 1976). The by-pass arrangement in crocodile enables them to be amphibious (ie being able to stay under water for a period of time as well as on land). In terms of global distribution, *C. porosus* is reported to be widely distributed from southern India, through the Gulf of Bengal and down to Peninsular Malaysia, Borneo, Indonesia, Papua New Guinea and to northern Australia (Bayliss *et al.* 1986).

Local Distribution and Abundance

Recent spotlight surveys in a number of rivers throughout Sarawak have shown relatively high density of estuarine crocodiles as compared to that in early 1980s. This is a good indication that the species is recovering well after its population was badly depleted during the colonial era. Surveys in early eighties indicated that relative density of estuarine crocodiles in most rivers in Sarawak were less than one crocodile per km. (Cox and Gombek 1985). As compared to the previous result the recent study along a number of rivers near Kuching, the State Capital of Sarawak, have given a range of relative density of 0.5 to almost 7 individual per km of the rivers surveyed (Fig. 2). Other surveys conducted in mid and late 1990s along rivers in central and northern part of Sarawak like the Sungai Lingga and Sungai Lumar, Sungai Sebelak, Sungai Sadong, Sungai Bakong, Sungai Niah and Sungai Sibuti have shown an

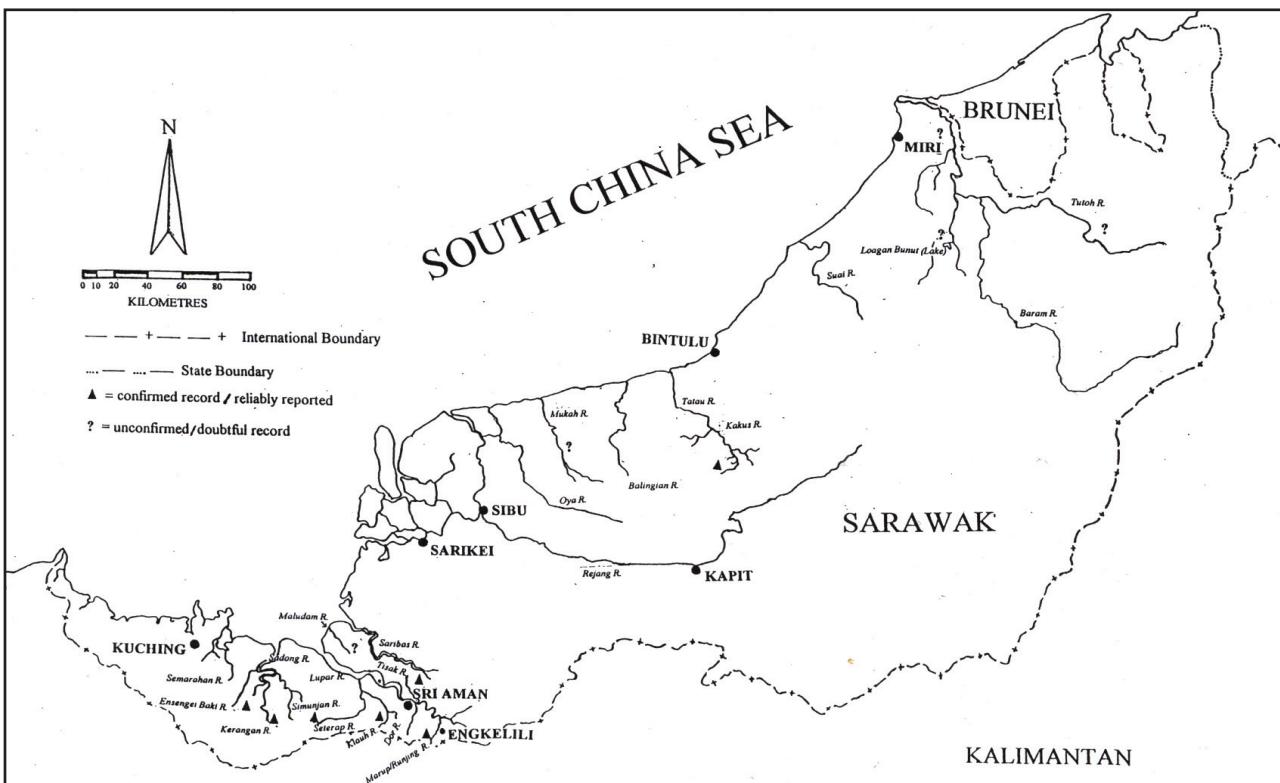


Figure 1. Some of Sarawak's main rivers where crocodile (*Crocodylus porosus*) surveys have been conducted.

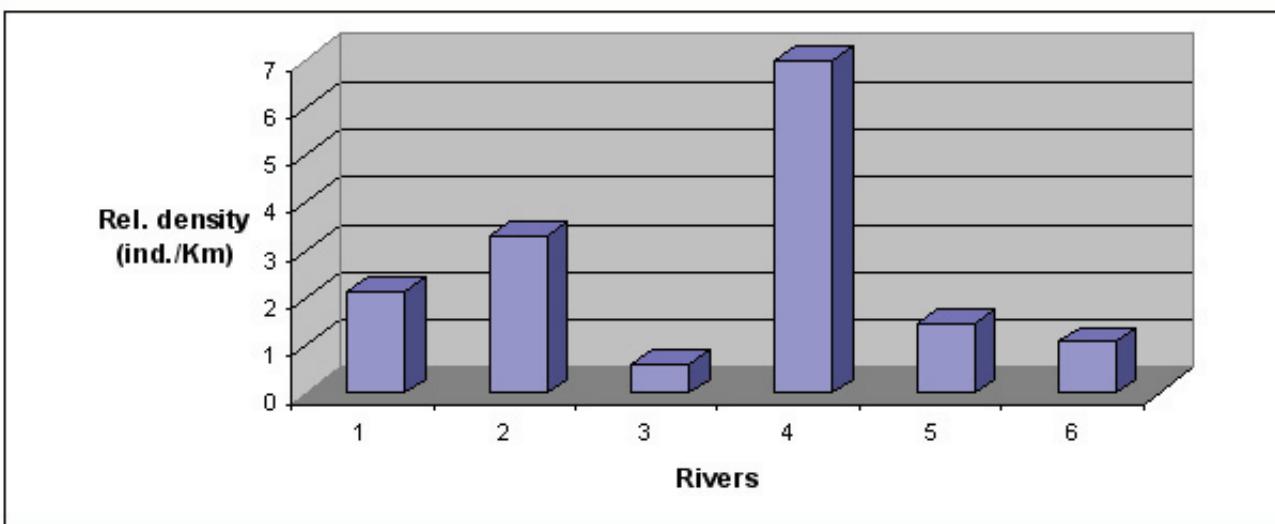


Figure 2. Relative density of *Crocodylus porosus* in some rivers in Sarawak. 1= Sg. Santubong* (8.46 km); 2= Sg. Santubong* (8.46 km); 3= Batang Salak and Btg Samariang (10 km); 4= Sg. Bako (7 km); 5= Sg. Serai-Dedap-Bako (9.65 km); 6= Sg. Buntal and Sg. Selesong (6.93 km). * same river surveyed at different time and different tidal condition.

average density of around 2 crocodiles per km. The result was probably an early indication of the population recovery throughout the State.

While the population of estuarine crocodiles is known to be increasing well in their natural habitat the population status of false gharials, reported to be endemic to Borneo, is somehow not quite well known. Previous reports have indicated that the species was distributed along upper reaches of Sungai Ensengei (tributary of Batang Sadong), Sungai Kroh and Sungai Runjing, Engkelili (tributaries of Batang Lutar). Old record has indicated that the species have also been found in Sungai Dor (upper Sungai Kelauh), Sungai Maying (upper Tubau) and also Loagan Bunut in Tinjar. Extensive surveys and research are now required to assess the species current population and ecological status of the species throughout Sarawak. Most of the available data and information on the species were collected from local people. Difficulties in sighting the species in the wild, since they are more secretive in nature, and the problem to have access to its most likely habitats are the two main constraints to research on the species in Sarawak.

Conservation Status

Hunting pressure on crocodiles in Sarawak has been intense during times of the white Rajah rule in the last eighty to hundred years. Local people were offered bounties for each crocodile killed and egg collected. In some cases local extermination was a deliberate policy because crocodiles were classified as vermin (Bolton 1989), a danger to people and domestic stock. Quite apart from deliberate hunting, crocodiles have come increasingly into conflict with man because of their need for undisturbed nesting and foraging habitats. At the same time expanding human populations have made particularly heavy demands upon the same watershed habitats. As a result, wild crocodile populations throughout the state were found to be drastically declining in the eighties (Cox and Gombek 1985).

In Sarawak, under the present Wildlife Protection Ordinance 1998, *Crocodylus porosus* and *Tomistoma schlegelii* are both placed under Appendix II of the protected species list. It means any person who is in possession, captures, sells, exports and imports these species, and their parts thereof without valid license shall be guilty of an offence which carries a penalty of imprisonment for one year and a fine of RM 10,000.

Keeping of these species would require a valid license (License to possess) from the State's Department of Forestry. The fee for the "License to Possess" is RM 10.00 per head per year, if the number is less than ten heads. However it is considered as having a "Wild Animal Farm" if and when the animals are more than ten heads, and the license fee for having such a farm is RM 100 per farm per year. Currently there are two registered commercial crocodile farms throughout Sarawak where each one of the farms are housing about 3000 individual crocodiles, mainly *C. porosus*. Killing or even harassing crocodiles is strictly prohibited amongst some indigenous people in Sarawak, especially among the Ibans and the Malays. It is not simply because they are afraid of being arrested by relevant authorities for breaking the law (Wildlife Protection Ordinance, 1998) but it is more of a taboo to them. Some older generation of those people still believed that the species would take revenge some day if they are disturbed. Apart from the taboo, the restrictions by Wildlife Protection Ordinance, 1998 and the Wildlife Protection Rules on sales and keeping of the animals have also greatly contributed to the recovery of their populations in the natural habitats.

Despite the fact that there are not much direct threats to the population of *C. porosus* in the wild the conversion of peat swamp forests into agricultural lands is likely to be one of the greatest threats to *T. schlegelii* in the wild. A 9-foot female *T. schlegelii* was translocated to Semengoh Wildlife Rehabilitation Centre from a plot for paddy farm in Engkelili just before the burning season in 1995. Prior to this a 10-foot female was also surrendered to the Forest Department after it got entangled in a fish net at Sungai Ensengei, Sadong. Both animals are now being kept at the Matang Wildlife Centre near Kuching.

Human-Crocodile Conflict

Records have shown that there has been marked increase in crocodile attacks throughout Sarawak since 1980. A total of 42 attacks on human have been officially reported to the Forest Department over the last 25 years (Fig. 3). The latest victim was a 15-year old boy, attacked while casting a fish net at Layar River in Central Sarawak in March 2004. The body of the boy has never been found despite intensive effort to search for it along the river. A year prior to this incident another fisherman was also killed by the man-eater at Bako River (Fig. 4b). His body was found entangled in between nipah fronds two days later. A 10-year old boy was also fatally attacked by a crocodile in the Niah River in January 2001 while taking a dip. His body was badly mutilated by the animal (Fig. 4a).

Though found more abundantly in the Sarawak Mangrove, Sungai Santubung and Sungai Bako, as compared to elsewhere in Sarawak, about 80% of the crocodile attacks on mankind occurred along Batang Lupar and its tributaries. Preference by the predators to establish their breeding territories along the river and greater human activities in the area could possibly explain the higher incidence of attacks. The profile of the Batang Lupar River bank which is gently sloping down towards its river bed is probably an excellent breeding ground for the breeding population of its crocodiles (Stuebing 1985). At the same time human activities along the river, such as in agriculture and fishing have also increased. Clearing of forests along the river usually destroys refuges for other animals like primates and otters that usually are source of food for the reptiles. As these food animals become scarce the predators may be easily tempted to take on humans. Breeding animals would also be motivated to attack anything that intrudes into their territories. Unfortunately, these intruders are sometimes humans who also use rivers for bathing and transportation, and also as a source of food and water supply to river bank dwellers.

No. of crocodile attacks in Sarawak since 1980

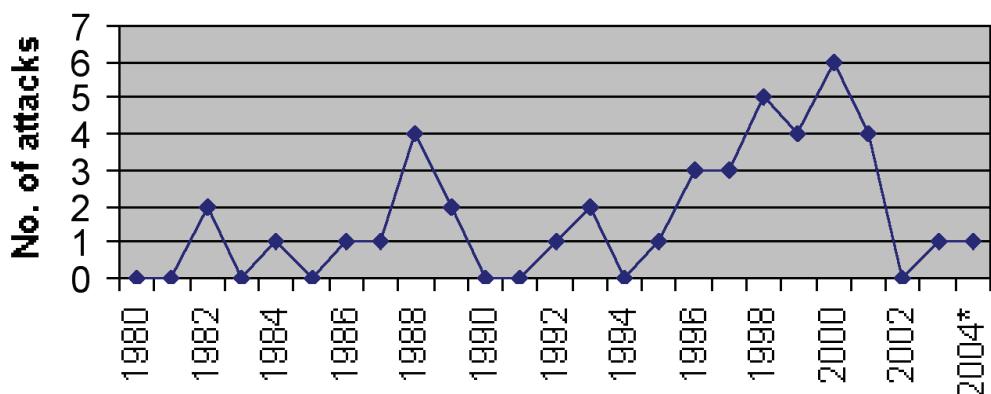


Figure 3. Numbers of crocodile attacks on humans in Sarawak since 1980. * = Number of attacks until May 2004.



Figure 4a. Limbs of a 10-year-old boy found in the stomach of a 17.5 foot crocodile killed at Niah River, January 2001.



Figure 4b. A body of a fisherman found entangled in between nipah fronds in Bako River, May 2003.

Management of Crocodiles in the State

Section 42 of the Wildlife Protection Ordinance 1998 (amendment 2003) provides right for general public to defend themselves, their properties and other people against any aggression by the animal. However every animal killed or captured must be reported to the nearest Forest Department as soon as possible.

Upon request, the Forest Department issues permit to cull nuisance crocodiles that are known to be dangerous to humans being or their properties such as livestock. The Department has also conducted a number of culling operations in some crocodile-infested rivers where fatal attacks have taken place. One of the sites where culling operation was conducted recently is Bako River where six individual crocodiles were killed.

Apart from issuing permits for culling and translocation of dangerous crocodiles, the Department is also making move to gazette several crocodile-infested areas as Crocodile Reserves. At the moment at least two areas in the State have been earmarked for this purpose. The first one is the Sarawak Mangrove area near Kuching, which currently is still a Forest Reserve. The other is the Ulu Klauh area, a tributary of Sungai Lingga in Sri Aman Division. It has been suggested that any dangerous crocodiles outside the Reserves could be destroyed. Once the Reserves have been put in place and officially gazetted the areas could possibly become hot spots for crocodile sighting activities. In other words they could possibly help in promoting tourism in Sarawak.

General Perceptions Toward Crocodile Conservation

Following marked increase of crocodile attacks throughout the State in recent years there seems to be an increasing number of conflicting views from the general public on how the Department is handling the crocodile conservation statewide. An editorial of one of the local newspapers published recently even suggested that the crocodiles, particularly *Crocodylus porosus* should be downgraded from their present protected list into a non-protected status as their populations are now greatly increased. In some rivers their populations are probably well exceeding their respective carrying capacities. Others are of the opinion that the Department concerned should be fully responsible for every crocodile attack on man and their properties and compensation or some kind of insurance should be granted to the victim.

On the contrary another ‘school of thought’ feels that crocodile attack is a natural process in the ecosystem and that humans living along rivers should change their lifestyle, for instance, be extra careful when going into rivers, fencing-up their jetties and bathing places, etc. The most likely questions raised by this opinion group are ‘what is crocodile attacks as compared to road accidents? And ‘why are the use of cars not banned?’ Some members of this group even view that crocodile attack on man is an act of God. This group of ‘environmental fundamentalists’ who have adopted an almost religious view of their chosen field are not likely to compromise on the ongoing culling process of crocodiles in some Sarawak rivers. To some ‘killing’ is a highly sensitive issue probably because they relate to the killing of nuisance crocodiles to the killing of people. In this circumstances, the crocodile species, especially *Crocodylus porosus* are not the ones that are endangered but instead local people staying along the rivers are the ones who are most likely to be endangered by the animal. Webb (1997) has stated that the conservation prospects for wildlife are not great if it has a high positive value to distant people in or from distant lands, but a low or negative value to the people who own it or live with it and have a power to keep or destroy it. Conservation, animal rights and animal welfare are three totally different issues that should not be seen as all being part of the same entity (Webb 1997). The issues of animal rights and animal welfare need to be separated and treated as legitimate problems of their own, and have little to do with conservation. In the case of crocodiles that are potentially dangerous to human and yet cannot be killed since they are protected by law there are some concerns that rights given to animals may turn out to be rights taken away from people. Thus it shows that the real problem with animal rights is not the assigning of human values to a few animals like crocodiles, but rather the justification that it may provide for treating people like animals (Cockburn 1996).

Conclusions

Whilst the issue of whether the crocodile culling and translocation should go on to a level that the animal is no longer a threat to riverbank dwellers is debatable, the conservation of this last relics of the extinct dinosaur must be continued. It might not be in a way that the reptile must be left alone in their natural habitat (rivers), but alternatively the conservation of this potentially man-eating species would best be done in legal commercialized farms. Sustainable commercialization of legally captive-bred crocodiles would at least generate revenue for the State and subsequently help to improve its economy. In this respect there is a prime need for the existing Wildlife Master Plan for Sarawak to be thoroughly reviewed to allow and encourage *ex-situ* conservation of crocodiles. The conservation of *Crocodylus porosus* should not only be for the interest of the few fundamental conservationists, but it should also of interest to the majority of local people as well. One should not be too worry of the possible extinction of the crocodiles. The species can reproduce successfully if given the right conditions while in captivity. According to Chai (pers. com.), survival rate of crocodiles in farm is much higher than that in the natural habitat. Similarly, the animal’s population in their wild habitats normally have various means of compensating for losses in numbers due to mortality or harvest (Webb 1978). Bolton (1989) has also stated that when crocodile numbers in the wild have been reduced, for instance by hunting, the survival rate of young ones would improve. In other words, survival depends partly on the numbers or on the density of crocodiles, and the losses are greater at the higher densities.

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I would like to thank the General Manager of the Protected Area and Biodiversity Conservation Unit for allowing me to attend this very important meeting on crocodiles. I also would like to thank Mr. Rob Stuebing for his time giving me some information on crocodiles. With this opportunity I also would like extend my thank to Mr. Paschal Dagang, Mr. Ganya Liap, Mr. Henson and Mr. Uning for their untiring effort to assist me conducting the surveys all these while.

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Recent Reversals in the Population Trends in the Population of Gharial in the National Chambal Sanctuary in North India; Implications and a Suggested Strategy for the Conservation of One of the World's Most Endangered Crocodilians

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Introduction

The gharial *Gavialis gangeticus* was critically endangered in 1975 with a world population numbering less than 300 individuals (Behler 1975). This resulted in conservation action through a Government of India/FAO-UNDP Crocodile Conservation Project comprising of a head-start program with captive reared animals and the creation of the National Chambal Sanctuary, which encompasses 425 km of the Chambal River flowing along the borders of the three north Indian states of Rajasthan, Madhya Pradesh and Uttar Pradesh. These steps enabled the gharial to recover from its critically endangered condition. The Gharial population of the Chambal that had numbered 150-175 before the initiation of the project was monitored regularly and showed steady growth reaching a figure of 1289 individuals in 1998, Sharma (1999). Because of the positive trend of the gharial population in the Chambal River, it was accepted in many quarters that the status of gharial had 'stabilized' and the species did not require proactive conservation efforts for its survival.

Recent Reductions of Gharial Population in the Chambal River; its Nature and Extent

After 1998, the Chambal was surveyed in 2003 following a gap of four years and then again in 2004. These surveys were conducted in the months of February/March, when conditions are favorable for gharial enumeration, using methods identical to those of earlier workers. Year wise summarized results of these surveys, along with the results of surveys conducted by previous workers are given in the following table.

The population decreases were first noticed during a survey of dolphins conducted by the first author in 2001 when intense clandestine fishing operations were observed in a particular section of the river. However, in that year the survey did not extend over the entire length of the National Chambal Sanctuary and the population decreases could not be comprehensively assessed.

There is no plausible cause for the observed decrease of gharial population other than mortality due to accidents in nets of fish poachers that operate in the sanctuary. Many fishing nets were confiscated and destroyed by burning in the course of the surveys. The smallest age class of gharials showed maximum decrease in the latest surveys. This is possibly because this age class also routinely disperses downstream beyond sanctuary limits and is also the one most susceptible to mortality from accidents in nets of the mesh size most commonly used in fishing. That the mortality rate due to fishing nets can be extremely high was revealed in 2003, when 8 gharials were found dead during a survey lasting only 15 days. The observed decrease of 30-40% in the populations of adult and sub-adult gharials, in the five years between 1998 and 2003, works out to 6-8% annual reduction.

The Current Management Status of the Sanctuary

Three different management systems and hierarchies are in force in the three states in which the sanctuary lies, encompassing areas of a total of twelve administrative districts.

Rajasthan

The sanctuary in Rajasthan has no separate machinery or staff for administration of the sanctuary. This is the responsibility of the District Forest officers of five districts viz. Kota, Bundi, Sawai Madhopore, Kaila Devi and Dholpur. There are apparently no special budget allocations for the administration, nor any field-staff deployed exclusively for protection or maintenance of the sanctuary and neither is there any management plan.

Table 1. Population of Gharial in the Chambal River differentiated into 3 size classes. (To facilitate comparison of populations between years, crude population densities per river km are shown, since river stretches surveyed in different years were not identical). SA+J = sub-adults and juveniles; H+Y = hatchlings and yearlings. References: 1= Singh (1978); 2= Singh (1985); 3= Rao (1988); 4= Hussain and Choudhury (1991); 5= R.K. Sharma (unpublished information).

Year	Section of River Surveyed	Length of River Surveyed (km)	Details of Enumerated Gharials							Ref.
			Total Adults	Adult Density (gh/km)	Total SA+J	SA-J Density (gh/km)	Total H+Y	H+Y Density (gh/km)	Total Population	
Pre-1979	Sections near major breeding sites	~250	30	0.120	43	-	34	-	107	1
1983-84	Rahuka Gaon to Pachnada**	315	37	0.117	369	1.171	45	0.143	451	1.432
1984-85	Pali*** to Pachnada	425	49	0.115	491	1.155	65	0.153	605	1.424
1985-86	Pali to Gyanpura/Jagtauli	385	66	0.171	391	1.016	170	0.442	627	1.629
1988	Pali to Pachnada	425	114	0.268	536	1.261	170	0.400	820	1.929
1990	Pali to Pachnada	425	113	0.266	727	1.711	142	0.334	982	2.311
1993	Pali to Pachnada	425	186	0.438	305	0.718	407	0.958	898	2.113
1994	Pali to Bhare	415	202	0.487	418	1.007	488	1.176	1108 (*1026)	2.670
1995-96	Pali to Bhare	415	212	0.511	445	1.072	557	1.342	1214 (*1042)	2.925
1996-97	Pali to Bhare	415	226	0.545	459	1.106	554	1.335	1241 (*1078)	2.993
1997-98	Pali to Bhare	415	0	0.000	0	0.000		0.000	1289 (*1121)	3.106
2003	Pali to Chakarnagar	395	150	0.380	265	0.671	99	0.251	514	1.301
2004	Pali to Chakarnagar	395	158	0.400	276	0.699	118	0.299	552	1.397

*** Pali is the upstream-most point of National Chambal Sanctuary

** Pachnada is the downstream-most point of National Chambal Sanctuary

* Total population corrected for the river section from Palito to Chakarnagar

Madhya Pradesh

The sanctuary is under the financial and administrative control of the Divisional Forest Officer, Morena Forest Division, while the executive officer is the Sanctuary Superintendent, National Chambal Sanctuary, who is an officer

of the rank of Assistant Conservator of Forests. The Sanctuary Superintendent is assisted by three Forest Rangers, one Research Ranger and sanctioned staff strength of about 28 subordinate field staff. The effective strength of executive subordinate cadre field staff, as computed in the draft management plan, works out to single personnel for guarding 40 km of river. The sanctuary being situated in non-forest areas of civil districts necessitates the involvement of the staff with the revenue and civil authorities of 3 very large districts Sheopur, Morena and Bhind of Madhya Pradesh.

The sanctuary has experienced a financial crunch for the past several years with very little available resources for so-called plan expenditure through which budget allocations are made for development works of the sanctuary. Even the 'non-plan' budget allocated has fallen short of the requirements for meeting expenditure on salary which has had to be supplemented with budget appropriations from financial heads that are not earmarked for the sanctuary. As a result, there has been hardly any available budget for meeting the maintenance expenditures of the sanctuary including fuel, lubricant and expenditures for regular and effective patrolling of the sanctuary that is estimated at Rs 5 lakhs (~\$12,000) per annum. It will however be noticed that between 2003 and 2004 there has not been any decrease to the gharial population and in fact there is a slight improvement in the gharial populations of all age classes. This, in all probability, is because of the action taken by the MP authorities to intensify patrolling of the sanctuary with additional budget being made available for this. This step was taken in view of the abrupt and alarming decrease in the sanctuary gharial population noticed in 2003. Also river patrolling for all echelons of field staff for stipulated periods was made mandatory by the higher authorities of the Forest Department.

A management plan has been drafted for the MP sector by the MP Forest Department. The draft management plan is well focused on the problems of conservation of aquatic biodiversity in the sanctuary and contains some innovative approaches to long term solutions to some of the problems faced by the sanctuary. However, whether the Government of MP will have political support to carry out the far reaching reforms required for implementation of the draft management plan, even if the plan is formally approved, cannot be said with any certainty at this stage. The estimated cost of implementation of this plan over a ten year period from 2003 to 2013 is Rs 777 lakhs (or \$US1.8 million) so the total cost of implementation of similar plans in all the three states comprising the sanctuary would be about \$US5-6 million.

Uttar Pradesh

The sanctuary is under the control of the Divisional Forest Officer, National Chambal Sanctuary. Because of some changes in the administrative structure of the Forest Department, the controlling officer and field staff have been burdened with the protection of certain forest areas lying within the sanctuary boundaries whereas formerly the management and protection of gharial and river biodiversity was their exclusive responsibility and concern.

Nature and Intensity of the Various Threats being faced by the Sanctuary

Agriculture

Agriculture is the most serious of long-term threats because it damages habitat and alienates wildlife off it. When the river recedes in summer growths of riverine succession of *Tamarix* on the exposed islands, which now become accessible, are hacked down to reclaim the areas for agriculture and gharial, mugger and turtle nesting sites may also be destroyed in the process. Shrinkage of stream due to reduced discharge of the river (see water abstraction below) increasingly exposes sandy riverbanks that are utilized for cultivation of cucurbit crops such as gourds and melons. As a result, increasing human activity on the river banks alienate gharial of all size classes from basking habitats and lead to permanent emigration of animals from these areas, as has occurred in the Yamuna and many other north Indian rivers, where ever riparian cucurbit cultivation is practiced. Although not quantified, it can safely be said that agricultural activity on riverbanks has steadily increased over the years.

Water Abstraction

Water abstraction for agriculture thorough a lift irrigation scheme in Uttar Pradesh within the last decade would definitely have impacted stream flow in downstream sections of the river. A second, major lift irrigation scheme has been approved, which is meant to supply the nearby town of Dholpur in Rajasthan with drinking water. During the recent surveys increasing numbers of small diesel pump sets were noticed being used for local agricultural irrigation. Certain midstream rocks, formerly submerged, that seem to have become exposed to heights of up to 2 m during the surveys in 2003 and 2004. There are unconfirmed reports about the planned construction of a hydroelectric dam

Rahughat. If this dam is eventually constructed, the hydrological regime of the river may be radically transformed with serious implications for gharial habitat. Apart from causing stream shrinkage, water abstraction also exposes more sand banks for potential, large-scale cucurbit horticulture with adverse impact on gharial because of reason already discussed. Unsustainable water abstraction is likely to severely and adversely impact gharial habitat to the extent that Chambal River may eventually be rendered uninhabitable for gharial.

Fishing

During the survey, fishing on commercial scale was observed in most of the stretches. Fishermen were seen using nylon gill nets and other advanced fishing gear. Fishing activity was recorded from 60-75% of the Chambal River flowing within the sanctuary. Interrogation of fishermen in the upper stretches revealed that they worked for fish contractors who resided in Rajasthan where planned sanctuary management is yet to come into force because of this state's non-participation in the National Chambal Sanctuary Project. Illegal fishing is rampant and occurs on a scale, which apart from directly causing mortality of gharial in net accidents is likely to affect the food availability for gharial and reduce the carrying capacity of the river for piscivorous aquatic vertebrates like gharial, mugger, dolphin and otters. The most serious implication of fishing arises from the fact that the fishing regime has changed from the pre sanctuary notification period to that in the current time. Previously, fishing was carried out by different contractors who acquired fishing rights auctioned by the district authorities. The contractors used the services of fishermen from outside the sanctuary areas who were forced to discontinue fishing activity and leave when the contract fishing system was scrapped. Today the local residents of the area are gradually discovering the economic benefits of fishing and once this becomes incorporated into the local economy, as is happening at present, curbing and regulating fishing will become more and more difficult if not impossible. The lawlessness of the area is well documented and fishing in certain stretches has come under the control of criminal elements making control of fishing an uphill task requiring large investments on enforcement. Fishing pressures have also become acute at the upstream and downstream most extremities of the sanctuary.

Sand Mining

During the survey in 2004, sand mining on the Madhya Pradesh side of the river, was recorded only on 5 sites. However, large-scale sand mining was recorded in all the 11 survey zones on the Rajasthan side. Intensive mining of building stone from the riverbed was also recorded in Zone 1 (Rameshwar-Khirkiree) at Solghata near Adavasipura. Over the years, the financial implications of sand mining at Rajghat, the only mining site that is actually auctioned by the government owned Mining Corporation, have magnified manifold. Today this site generates an annual revenue of Rs 23 crores (\$5.35 million) for the state. Due to reduced river discharge most of the upper stretches of the river have shrunk to a very narrow and shallow stream, easily fordable on foot and tractors, enabling activities like sand and stone mining from the bank as well as the riverbed. These are reaching a level when they are bound to become serious threats for the biodiversity of the sanctuary. Not only is human presence at the mining sites leading to the exclusion of wildlife from these areas, but mining activity is also probably altering the geomorphology and adversely affecting wildlife habitats in unknown ways. Apart from the Rajghat site mentioned earlier, sand mining occurs clandestinely at several points along the river on a scale which is drastically and irreparably altering several important nesting and basking sites for gharial like Banwara, Ajbapura, Pureni, Barenda, Gyanpura. Sand mining in Chambal sanctuary has reached an industrial scale and feeds the building construction business of several big cities of the region including the country's capital, Delhi. While directives of India's Apex Court go against any exploitation, whatsoever, of the natural resources of any PA, the ground reality is that the economic value of Chambal building sand is too large for its exploitation to be prevented by simple legal protection. The industry is labor intensive and a major income generator in the local economy as well, so the illegal syndicate which controls this unorganized industry, will go to great lengths to prevent any impediment to it, for which it has not only its own financial base but also local socio-political support.

Firewood Collection

Harvesting of fuel wood and denudation of tree cover from bordering ravenous areas leads to catchment erosion and increased stream turbidity as well as silt deposition with a resultant shrinkage of stream.

A Strategy for the Conservation of Gharial

The gharial, because of its great and unique scientific value, requires conservation action guaranteeing its indefinite survival. The lessons learnt from the successes and more importantly the failures of the first conservation action to