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Evaluation of the problems of captive/natural population of crocodiles in Neyyar Wildlife Sanctuary and suggestions for their management with special emphasis on reduction of human - animal conflict

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(FINAL REPORT OF THE RESEARCH PROJECT KFRI/349/00)

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ABSTRACT OF THE PROJECT PROPOSAL

1. Project No. : KFRI/349/00

2. Title of Project : Evaluation of the problems of captive/ natural population of crocodiles in Neyyar Wildlife Sanctuary and suggestions for their management with special emphasis on reduction of human- animal conflict

3. Objectives:

1. To assess the population status of crocodiles in Neyyar Wildlife Sanctuary and in captivity.
2. To assess whether the population of crocodiles in sanctuary and in captivity has exceeded the carrying capacity of the system.
3. To study and characterise the circumstances under which crocodiles attack human beings.
4. To study the prey-predator relationship in the sanctuary with reference to crocodiles
5. To study the possibilities of introducing the animal to other less problematic areas.
6. To develop awareness among local people for reducing conflict with crocodiles and to produce a booklet on strategies to be followed by local community.
7. To suggest suitable management strategies to mitigate human-crocodile conflict.
8. To suggest suitable management strategies for management of captive crocodiles.

4. Expected outcome

Extend and magnitude of the human-crocodile conflict will be known. People's participation for maintaining the crocodiles in the Neyyar Wildlife sanctuary will be obtained. Potential areas suitable for releasing the captive crocodile population will be available after the study. A booklet describing the strategies to be adopted by local community to reduce the human-crocodile conflict will be available for distribution among public. By practicing the new management strategy, the conflict between crocodiles and humans can be reduced. Better upkeep of captive population of crocodiles will be possible by applying the newly suggested management strategies.

5. Date of commencement : April 2000

5. Scheduled date of completion : March 2002

6. Funding agency : Kerala Forestry Project (World Bank)
Kerala Forest and Wildlife Department

7. Project Team
Principal Investigator : E. A. Jayson
Associate Investigator : P. Padmanabhan
Research Fellow : C. Sivaperuman

8. Study area : Neyyar Wildlife Sanctuary

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ABSTRACT

Human-crocodile conflict in Neyyar Wildlife Sanctuary, Kerala was studied from May 2000 to December 2001, mainly based on observational methods. During May 2001, 21 to 25 crocodiles were estimated in the Neyyar Reservoir. But only 10 to 16 crocodiles were estimated to be present in the Reservoir towards the end of December 2001. This is because, 9 crocodiles were removed from the Reservoir during the period. Availability of mammals was estimated using direct and indirect methods. Food in the form of fishes is sufficient whereas food in the form of large mammals is inadequate.

Human-crocodile conflicts were studied by interviewing the victims, visiting the sites of attack and also by structured questionnaire survey. Twenty-nine crocodile attacks on humans had occurred before the study was initiated and six attacks happened during the period of study. Two people died during the period of study due to the crocodile attacks. In addition to humans, incidents of attacks on livestock were also recorded. The incidents of attacks were recorded from Kappukad to Kumbichal, a stretch of 26 km. However, maximum people were hurt near the dam site and at Pantha. All the attacks were following the known pattern of hunting behaviour reported in crocodiles. It is evident that as the crocodiles were growing from the initial small size when introduced in 1983, the number of attacks has also increased, which shows that the size of the crocodiles is a major factor in the human-crocodile conflict.

Dependence of the local people on the reservoir was studied through sample survey. It was estimated that 2808 houses exist in a 26 km long and 400 m wide belt from Kappukad to Kumbichal. Local people utilise the reservoir for collecting drinking water, bathing, washing clothes, washing cattle, fishing and retting of coconut leaves. Apart from these, three ferry services are operated by Panchayath to cross the reservoir and for reaching the private holdings. Forty-one percent of them depend on the reservoir for drinking water. A majority of the local people depend on the reservoir for their daily needs.

Questionnaire survey conducted among the local population on the banks of the reservoir showed that, among the 150 families contacted, only 35 (23%) were willing to shift from the area to avoid crocodile attacks. Education status of the most of the people was below matriculation. Removing the crocodiles from the reservoir was considered as the appropriate solution by majority of them (61%). Eleven per cent of the families wanted all the crocodiles to be killed and removed. Nobody supported the idea of conserving the crocodiles in the Neyyar Reservoir in the present circumstances.

Four other reservoirs in the State were evaluated for relocating the crocodiles from the Neyyar Reservoir. None of the reservoirs was found suitable for

the purpose. Infrastructure facilities are lacking in the captive breeding centre at Neyyar. A new pen may be constructed at Neyyar for keeping the problem-crocodiles caught from the Reservoir. A brochure on human-crocodile conflicts in Neyyar was prepared for distribution.

It is recommended to catch all the crocodiles above the size of 3 m from the reservoir to solve the human-crocodile conflict. Proper training on chemical immobilization of crocodiles may be given to the veterinary staff for efficient handling of large crocodiles without causing physical injury. Yearly census of crocodiles during the month of May is suggested to monitor the crocodile population in the reservoir, which will assist in the proper management of crocodiles in future. Public awareness programme may be initiated to educate the people on the precautionary measures.

1. Introduction

The crocodilians in the world have benefited from protection and strict control measures. As a result, crocodilian population has increased and its range has expanded back into historically occupied areas. This has also brought about increase in the number of large crocodiles. This has led to increasing conflicts between crocodilians and people, and their livestock. In tropical wetland areas, crocodilians are a major predator. The crocodiles are the only living remnants of the ruling reptiles which evolved in the Mesozoic era. Crocodiles are amongst the most voracious predators on earth, with hunting skills honed through 200 million years of evolution. They are living fossils, superbly designed for the environment in which they live. Birds are the crocodile's nearest living relatives: snakes and lizards have a completely different ancestry. Having evolved into what can best be described as 'almost perfect hunting machines', adult crocodiles have virtually no enemies except man.

In the Indian subcontinent, three species of crocodiles occur, namely Gharial (*Gavialis gangeticus*), which belongs to the family Gavialidae, Saltwater crocodile (*Crocodylus porosus*) and Mugger crocodile (*Crocodylus palustris*) belonging to the family Crocodylidae. Mugger is distributed in most parts of India except Jammu and Kashmir and some northern Indian States.

Crocodiles were released into the Neyyar Wildlife Sanctuary as a part of Crocodile conservation project launched in the State of Kerala with the joint effort of the Government of India, U. N. D. P. and F. A. O. of the United Nations. Two captive-breeding centres were established in Kerala, one at Neyyar and another at Peruvannamuzhi during 1977 (Pillai, 1999). The purpose of the breeding centres was to breed the species in captivity and to release them into protected areas. From 1985 onwards, the crocodiles in Neyyar Wildlife Sanctuary have started attacking local inhabitants along the bank of the Reservoir and many of them were injured in the

process. Further introduction of crocodiles in the reservoir was stopped after the initial release of 29 crocodiles in 1983. This led to increase in the captive population of crocodiles. This is causing severe management problems and the animals have no proper place for movement in the pens.

The attack by crocodiles on humans who depend on the reservoir for daily needs is on the increase. Similarly, the increasing population of crocodiles in the captivity was also of concern. A proper management strategy to reduce the human-crocodiles conflict was very much needed. Hence, a project entitled "Evaluation of the problems of captive/natural population of crocodiles in Neyyar Wildlife Sanctuary and suggestions for their management with special emphasis on reduction of human-animal conflict" was initiated at the instance of the Forest Department under the Kerala Forestry Project (WB) with the following objectives:

Objectives

1. To assess the population status of crocodiles in Neyyar Wildlife Sanctuary and in captivity.
2. To assess whether the population of crocodiles in sanctuary and in captivity has exceeded the carrying capacity of the system.
3. To study and characterise the circumstances under which crocodiles attack human beings.
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8. To suggest suitable management strategies for management of captive crocodiles.

1.1. Study area

The Neyyar Dam was built in the Neyyar River in the early 1940s for the purpose of irrigation for the States of Tamil Nadu and Kerala. The expanse of the Reservoir is 8.45 km^2. The Neyyar Wildlife Sanctuary, declared in 1958, is situated in the Thiruvanathapuram District in Kerala State. The extent of the Sanctuary is 128 km^2 and lies between 8^0 17' and 8^0 53' North latitudes and between 76^0 40' and 77^0 17' East longitudes (Fig. 1). The area was formerly a part of Trivandrum Forest Division. The sanctuary is situated in the Western Ghats on the southern tip of Kerala. The entire area lies within the catchment area of Neyyar River, which originates from the slopes of Agasthiar Peak at an elevation of 1868 m. The entire area is rugged with undulating terrain. Nearest town is Thiruvanathapuram. Many rivers, streams and their tributaries are available in the Sanctuary. Neyyar, Mullayar, Kallar, Valliyar are the major feeder rivers of Neyyar Reservoir. The Neyyar Reservoir is the major source of irrigation and water supply to the agricultural fields in Neyyattinkara and Nedumangad Taluks and Vilavangode Taluk of Tamil Nadu.

Thirty-six Mugger (*Crocodylus palustris*) crocodiles were introduced into the Reservoir during 1983. Before the introduction, crocodiles were recorded in the wild. Human-crocodile conflicts came to notice from 1985 onwards and hence further release of crocodiles from the captive breeding centre to the reservoir was stopped. Humans and domestic animals like dog, cat, goat, poultry and cattle were attacked in such incidents. Local people utilise the Reservoir from Kappukad to Kumbichal, about 26 km in length, on the southern and western side of the Reservoir for their daily needs. The tribal community in the Puravimalai settlement is also

surrounded by the Reservoir. People utilise the reservoir for drinking water, bathing, washing cattle, swimming and various other purposes.

The major vegetation types in the sanctuary are moist deciduous, west coast tropical evergreen, southern hill top tropical evergreen, west coast semi evergreen and southern moist mixed deciduous forests. Typical trees in the evergreen forest are *Palaquium ellipticum, Calophyllum tomentosum, Hopea parviflora and Cullenia excelsa*. *Xylia xylocarpa, Grewia tiliaefolia, Lagerstroemia lanceolata and Schleichera oleosa* are the typical trees in the moist deciduous forest. All the mammals found in the Peninsular India are reported from the sanctuary. Major animals recorded from the sanctuary are Asian elephant, Sambar, Barking deer, Wild boar, Indian Porcupine, Malabar giant squirrel, Tiger and Lion-tailed macaque.

Climate

Climate is tropical with heavy rainfall and high temperature. Both south-west and north-east monsoons are active in the area. But maximum precipitation is obtained from the north-east monsoon during the month of September (Fig. 2). Temperature varies from 16^{0} C to 35^{0} C. Water level in the reservoir varies during different months. Except for the months of March to June, the water level was above 80 m. Lowest level of water was found during the month of May (Fig. 3). The level of water during the months of March to June was low because water is released for irrigation during that period (Plate 1).

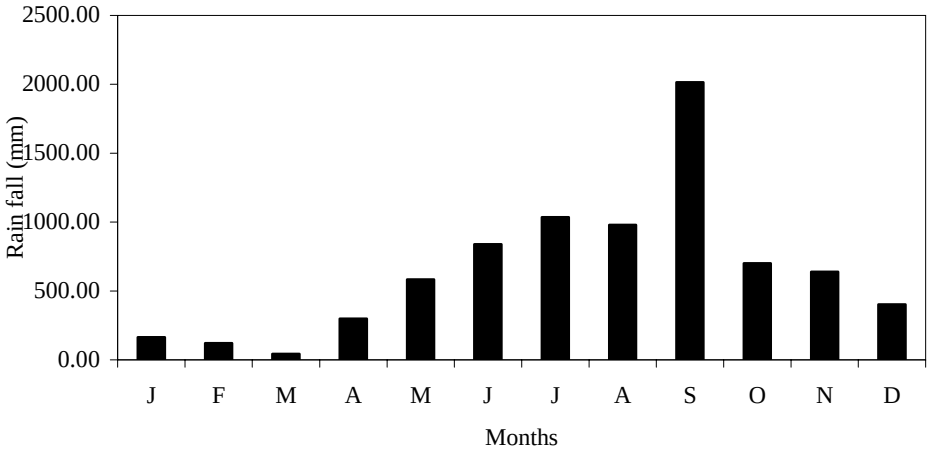

Fig. 2. Pattern of rainfall in Neyyar Wildlife Sanctuary (1994 to 2001)*

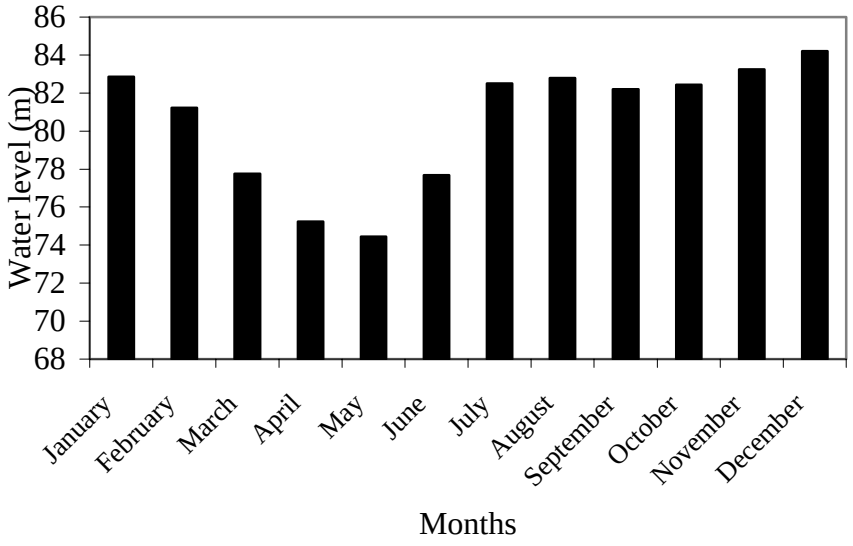

Fig. 3. Level of water in the Neyyar Reservoir during different months (1992 to 2001)*

* Source: Irrigation Dept.

1.2. Biology of Crocodiles

Crocodilians (crocodiles, alligators, caimans, and gharials) are prominent and widespread occupants of tropical and subtropical aquatic habitats. The group is of great antiquity with hundreds of fossil forms and three major radiations. Table 1 shows the taxonomy of the 23 species. Crocodilians are implicated in positive effects in their environments as “keystone species” that maintain ecosystem structure and function by their activities. These include selective predation on fish species, recycling nutrients, and maintenance of wet refugia in droughts.

Table 1. List of the species of crocodilians

Order Crocodylia

Family Alligatoridae

Alligator mississippiensis (American alligator)
Alligator sinensis (Chinese alligator)
Caiman crocodilus (Caiman) includes *C. crocodilus crocodilus, C. c. fuscus, C. c. apaporiensis, C. c. chiapasius*
Caiman latirostris (Broad-snouted caiman)
Caiman yacare (yacaré)
Melanosuchus niger (Black caiman)
Paleosuchus palpebrosus (Dwarf caiman)
Paleosuchus trigonatus (Smooth-fronted caiman)

Family Crocodylidae

Subfamily Crocodylinae
Crocodylus acutus (American crocodile)
Crocodylus cataphractus (Slender-snouted crocodile)
Crocodylus intermedius (Orinoco crocodile)
Crocodylus johnsoni (Australian freshwater crocodile)

Crocodylus mindorensis (Philippine crocodile)

Crocodylus moreletii (Morelet's crocodile)

Crocodylus niloticus (Nile crocodile)

Crocodylus novaeguineae (New Guinea Crocodile)

Crocodylus palustris (Mugger)

Crocodylus porosus (Saltwater crocodile)

Crocodylus rhombifer (Cuban crocodile)

Crocodylus siamensis (Siamese crocodile)

Osteolaemus tetraspis (Dwarf crocodile)

Subfamily Tomistominae

Tomistoma schlegelii (Tomistoma)

Family Gavialidae

Gavialis gangeticus (Gharial)

Crocodilians have some unique aspects of natural history that create special challenges for their conservation. They are the largest predators in their habitats and can threaten humans and their livestock. Many species are exploited for their valuable skin which supports an international trade worth over US$500 million annually. They are also heavily affected by habitat loss and the pollution of aquatic habitats.

Form and senses

There is a wide diversity of size, habitat, food preference, reproductive behaviour and many other aspects of biology among the 23 species of crocodilian. However, all species have the following basic similarities. All crocodilians are very effective aquatic predators. Young ones often eat aquatic insects, small fish and crustaceans and as they grow larger they tend to eat vertebrates, including fish, turtles, birds and mammals. Crocodiles attempt to maintain their body temperature within narrow limits by basking in the sun or seeking shade. They are metabolically efficient and have fast reflexes and effective locomotor ability on land, where they

walk on erect legs, and in the water, where they swim rapidly driven by their powerful tails. Crocodilians have complex behaviour including social interactions, dominance hierarchies, vocalization, coordinated feeding and well developed maternal behaviour.

Crocodiles breathe by moving their internal organs backwards to allow expansion of the lungs and forwards to compress the lungs. Air enters the body through the nostrils, situated at the end of the snout. The air passes through the jaw into the throat where it enters the trachea and passes into the lungs. Air can also enter the throat through the mouth. At the back of the mouth are two flaps (top and bottom), which seal the throat when the mouth is closed. These flaps can be closed to seal the throat when the crocodile holds prey under water to drown it. They also allow the crocodile to breathe when in water and only the tip of the snout is above the surface. The nostrils can be closed when the crocodile is under water. Crocodiles also appear to breathe by circulating air in the throat and lungs by “panting”, while keeping the mouth flaps closed. Another view is that the “panting” is for the olfactory purposes.

Crocodiles have extremely good vision. While submerged, crocodiles can see both under and above the water. Crocodiles have upper and lower eyelids that are closed to protect the eyes and when sleeping. They also have a third eyelid (nictitating membrane), which is transparent. This eyelid moves from the front to the back of the eye, and is used under water to protect the eye surface. The eyes can be withdrawn into the head for protection when seizing prey or fighting. Since the nictitating membrane is not very transparent, vision is comparatively good above water.

Crocodiles have extremely sensitive hearing. The ears are situated behind the eyes, and can be closed when the crocodile is submerged. Crocodiles have an extremely good sense of smell. They have two nostrils situated on top of the tip of the snout. The air is passed through the upper jaw into the throat and it passes an olfactory chamber where scent is detected. Crocodiles can taste and can distinguish

between different types of food. Despite its appearance, the skin is sensitive to touch. The tail is an extremely sensitive area (Blake, 2002).

Breeding

During the breeding season, males set up territories and the females approach males for mating. After elaborate courtship, copulation takes place in the water. Mating starts some 40 days before laying, and continues up to the time of laying. Females deposit 10 to 60 hard-shelled eggs into a nest, which is a hole dug into the ground. Most females remain near the nest during incubation and protect it from predators. Upon hatching, vocalizations made by the hatchlings induce the female to assist the hatchlings to emerge, and in some cases to carry the tiny babies to the water in her mouth. Hatchlings remain together near the mother for several months, deriving protection from her. As they grow and become more widely dispersed and independent, a large number of the offspring perish some eaten by other crocodilians (Ross, 2000).

The survivors reach maturity after a period of 5–15 years depending on the species. Females grow more slowly and reach maturity at a smaller size than males. The males continue to grow and usually surpass females in size. Crocodilians live for long period in the wild and there are records of individuals living for decades. Adults of several species emit loud vocalizations during the breeding season. These biological characteristics give the potential of great resiliency to some crocodilian populations, enabling them to recover from population depletion and sustain relatively high harvest rates.

Important features of three species of crocodiles found in India are given in Table 2.

Table 2. Important features of three species of crocodiles found in India

Important features	Gharial	Mugger	Saltwater crocodile
Popular name	Gharial	Indian Mugger	Estuarine crocodile
Zoological name	*Gavialis gangeticus*	*Crocodylus palustris*	*Crocodylus porosus*
Distribution	India, Nepal, Pakistan	India, Bangladesh, Nepal and Iran	India to South China, Indonesia, Philippines, Papua New Guinea, N. Australia
Habitat	Perennial and deep rivers	River, marsh, swamp, lake, and large pond, any fresh water habitat.	Estuarine rivers and creeks where mangroves are present. Seldom in upstream rivers but often in open seas.
Size: Hatchling (Maximum)	34-37 cm 6.6 m	25-27 cm 4.0 m	30-35 cm 7.5 m
Nesting season	March/April	February/April	May-June
Nest sites	Highly sloppy sand- banks	Sand-banks, mud-banks	Open areas amid mangroves
No. of eggs	10-97	8-45	10-75
Incubation period	75-80	55-75	75-80
Age at sexual maturity	Male 15 + years Female 10-12 years	Male 5-6 years Female 5 years	Male 10+ years Female 8 years
Life span	100 years	70 years	100+ years
Breeding life	50 years	50 years	Not known
Temperament	Timid	Aggressive/ Dangerous	Aggressive

Source: Singh, 1999

1.3. Ecology of the species*: Crocodylus palustris* Lesson

Common names: Mugger, muggar, marsh crocodile

Range: Bangladesh, Iran, India, Nepal, Pakistan and Sri Lanka (Fig. 4).

Fig. 4. Distribution range of Mugger

Conservation overview

CITES: Appendix I

CSG Action Plan: Availability of Survey Data – Poor

Need for Wild Population Recovery – High

Potential for Sustainable Management – Moderate

1996 IUCN Red List: VU Vulnerable – Criteria: A.1.a. decline of 20% in 3 generations in extent of occurrence. C.2.a. Wild population less than 2,500 adults and habitat fragmented and declining.

Principal threats: Habitat destruction.

The Mugger is a medium-sized crocodile (maximum length 4–5m), and has the broadest snout of any living member of the genus *Crocodylus*. Muggers are principally restricted to the Indian subcontinent where they may be found in a number of freshwater habitat types including rivers, lakes and marshes. In India and Sri Lanka, Mugger crocodiles have adapted well to reservoirs, irrigation canals and man-made ponds, and in some areas may even be found in coastal saltwater lagoons.

In some areas of northern India and Nepal, Mugger populations are sympatric with gharial, but the two species tend to be segregated by habitat (Fig. 5). Where found together with gharial, Muggers tend to bask in midstream on rocks or muddy banks. This species, like a number of other crocodilians, is known to dig burrows.

Mugger crocodiles are a hole nesting species. As with other hole nesters, egg laying takes place during the annual dry season. Females become sexually mature at a length of approximately 1.8–2m, and lay 25–30 eggs (Whitaker and Whitaker, 1989). Nests are located in a wide variety of habitats, and females have even been known to nest at the opening of, or inside, the burrow. In captivity, some Mugger crocodiles are known to lay two clutches in a single year (Whitaker and Whitaker, 1984), but this has not been observed in the wild. Incubation is relatively short, typically lasting 55–75 days.

1.4. Conservation and status

While illegal skin trade was a major problem in the past (1950s–1960s), the current threats to the Mugger crocodile are principally habitat destruction, drowning in fishnets, egg predation by people, and the use of crocodile parts for medicinal purposes. Adequate survey data exist only for India and Sri Lanka, and indicate that populations, while generally small and isolated, are widespread. Sri Lanka has the largest remaining wild populations (approx. 2,000 individuals), but they are concentrated in only two National Parks, Wilpattu and Yala (Whitaker and Whitaker, 1979).

In India, Muggers are reported from over 50 locations and the wild population is tentatively estimated at 3000 to 5000. In Pakistan, the Mugger is reported to be extinct in the Punjab province due to alteration of habitat. Small populations are reported in Sind along the Nara Canal, in Khairpur Sanghar and Nawab districts and Haleji Lake. These are said to be vulnerable and diminishing. The Mugger remains widely distributed in Baluchistan with confirmed locations on

the Nari, Hab, Titiani, Hingol and Dasht rivers and Nahang and Kach Kuar. In all cases, the populations are of unknown but small size.

A survey in Nepal indicated that the Mugger is now restricted to isolated populations, primarily in protected habitats. Alienation of habitat by river disruption and damming, and mortality in fisheries are the major problems. A recent investigation in Bangladesh reports the Mugger to be extinct in the wild and only six wild derived specimens are kept in captivity. In Iran, Muggers are known from the drainages of the Sarbaz and Kajou rivers. Preliminary counts of the main habitat in 1992 revealed at least 118 individuals. The last record of Muggers in Myanmar was 1867–68 and that the species is probably extinct there (Ross, 2000).

Management of Mugger crocodiles is based principally on the legal protection of wild populations and captive breeding for restocking. In India, a large-scale captive rearing programme was initiated in 1975. Eggs were collected from the wild and captive adult breeding stock of young ones produced. The resulting juveniles were used to restock natural population in 28 National Parks, Wildlife Reserves and Crocodile Sanctuaries throughout the country. A total of 1,193 individuals were released between 1978 and 1992. Unfortunately, there is little additional habitat where more Muggers could be introduced. Currently, there are over 12,000 Muggers in captivity.

In Kerala, Muggers are kept in captivity at Neyyar (66 individuals) and Peruvannamuzhi (6 individuals) by the Kerala Forest Department apart from the Zoos at Thiruvanathapuram and Thrissur. Natural populations of crocodile are seen at Parambikulam Wildlife Sanctuary, islands in Waynaad Wildlife Sanctuary apart from Neyyar Wildlife Sanctuary.

1.5. Human- crocodile conflict

According to Ross (1998), only the larger and fiercer species are involved in human attacks. The Nile crocodile *Crocodylus niloticus* and the saltwater crocodile *C. porosus* are considered most dangerous. American alligator (*Alligator mississipiensis*), American crocodile (*C. acutus*), Morelet's crocodile (*C. moreletii*), Black caiman (*Melanosuchus niger*) and Mugger (*C. palustris*) have been reported for attacks leading to human deaths. **Human fatalities are usually the result of attack by larger crocodilians of 3 m or greater length (Ross, 1998).** However, attacks by smaller individuals are also widely reported. Non-fatal interactions can be serious to local people, particularly predation on pets and livestock. Perran Ross, Executive Officer, Crocodile Specialist Group (CSG), U. S. A. reports, "***It is human death that really raises local people's anger and provokes extreme responses. Crocodilian attacks are human tragedies, particularly when the result is the death of a child, as is often the case. Attacks are a serious conservation issue. The usual response of people to an attack is to kill the most obvious large crocodilian present. Studies by CSG members confirm that a proportion of large adults can be removed from a crocodilian population without causing population decline. The sustainable level of removal varies with species and situation but falls between 5% and about 15% of adults and so regulated control measures are compatible with the conservation goal of maintaining crocodilian populations. There is no biological or conservation reason why a proportion of adult crocodilians should not be removed as long as this is done with appropriate control and monitoring. Our concern is that fear and hatred of crocodilians can lead to calls for complete extirpation of local crocodilian populations. By either direct, and often illegal action, or by generating political pressure, conservation goals for crocodilians can be compromised if human-crocodilian conflicts are not resolved. People's intolerance for a large predator that eats their children and their valuable livestock will override protective legislation or conservation concerns".***

1.6. Review of Literature

Early literature on crocodile in India mainly dealt on the biology of the species and documentation of folklore (D' Abreu, 1915; Dharam, 1947; McCann, 1935). Antoon De Vos (1982) prepared a manual on Crocodile conservation and management in India which paved the basis for crocodile conservation in India.

Many workers studied the biology of Mugger crocodile in the recent past (Krishnamurthy and Bhaskaran, 1976; Acharjyo and Mohapatra, 1977; Kar and Bustard, 1979; Krishnamurthy, 1980). Whitaker (1976, 1976a, 1977, 1978, 1978a, 1979, 1981, 1982 and 1984), Whitaker and Whitaker (1977), and Whitaker and Daniel (1978,1990) studied the Mugger crocodiles of India extensively. However, only few studies were conducted on the crocodiles of Kerala. Rosamma (1993) conducted an ecological study on the crocodiles of Neyyar Reservoir, wherein, it was estimated that 50 crocodiles were present in the Neyyar Reservoir. Similarly, Pillai (1999) also reported on the crocodiles of Kerala. A preliminary survey of crocodiles was carried out in Kabini River also (CSG, 1995). Arumugam and Andrews (1993) studied the crocodiles of Sathanur Reservoir in Tamil Nadu. Banerge (1985) studied the nest-guarding behaviour of estuarine crocodiles. Similarly, Biswas (1970) carried out a survey of Gharial in Koshi River.

Mugger was considered as a rare species in many earlier works like Chaudhury and Bustard (1981). The status of Indian crocodiles was described by Whitaker and Daniel (1990). Similarly, movement patterns of captive-reared Mugger crocodiles, when they were released into wild were studied by Singh (1984 a). Sagar and Sigh (1993) described the captive breeding and rehabilitation of Mugger crocodile in Similipal Tiger Reserve. A detailed bibliography on the crocodiles of India was also compiled by Singh and Rath (1999) recently.

Attacks of crocodiles on people were reported from many countries. Recent reports include those from Tanzania, where several hundred humans were attacked

every year by crocodiles (Anon., 2000), increased human fatalities in Malawi (CSG, 2000), Madagascar (Behra, 1996), South Africa (CSG, 1999 c) and Zambia (CSG, 1998). Fatal attacks by crocodiles in Costa Rica (Jimenez, 1998) and Jamaica (CSG, 1999 a), attacks in the tourist resort of Cancun, Mexico (Lazcano, 1996), and Sri Lanka (CSG, 2000 a) were also reported. The Nile crocodile (*Crocodylus niloticus)* and the saltwater crocodile (*C. porosus)* are considered the most dangerous. But recent attacks, some leading to human deaths, are reported for American alligator (*Alligator mississippiensis*; Conover and Dubow, 1997), American crocodiles (*C. acutus;* Jimenez, 1998), Morelet's crocodile (*C. moreletii*; Lazcano, 1996) and Black Caiman (*Melanosuchus niger;* CSG, 1997). Ross *et al*. (2000) has discussed about the problems of success in crocodile conservation.

Crocodile attacks on humans were reported from India also. Attack by nest guarding Mugger crocodiles was reported earlier (Anon., 1982). Kumar *et al*. (1999) recorded Mugger crocodile attacks from Gujarat. Even timid species like Gharial has been reported attacking humans (Bustard and Singh, 1981). Salt water crocodile was also reported to attack humans and livestock to guard the nests (Bustard and Kar, 1981 and 1981a). They also reported on the crocodile predation on man (Bustard and Kar, 1982).

After the reintroduction programme of crocodiles in the wild initiated by Government of India, many reports have appeared based on the programme. Acharjyo (1978) reported on the return of Muggers into wild. Similarly, many authors reported on the aspects like conservation (Bustard, 1975; Chaudhury and Bustard, 1975; Beechura and Singh, 1979), sexing of crocodiles in captivity (Kar and Bustard, 1979), growth of captive crocodiles (Krishnamurthy and Bhaskaran, 1979; Krishnamurthy, 1980; Bustard and Chaudhury, 1980; 1981, food requirement and movement (Singh, 1984; Singh, 1984a; Rao and Chaudhury, 1992) and other issues (Sagar and Singh, 1993; Kumar *et al.* 1999; Pillai, 1999).

Several researchers reported on the captive management, farming details and disease aspects of crocodiles. Buenviaje *et al.* (1994) described the disease-husbandry problems of crocodiles in Australia. Gallagher (1993) projected farming or ranching of alligators as an industry. Similarly, Webb and Manolis (1993) have stressed the need for conserving Australian crocodiles through commercial incentives. Brazaitis (1983) has projected crocodiles as a resource base for tropical countries of the world and De Waard (1978) showed the economic potential of Muggar farming in India. Blake (1992) standardised the basic method for collection and incubation of crocodile eggs; he also gave details of capture, care, accommodation and transportation of Nile crocodiles (Blake, 2002). The ecological and economical status of the Nile Crocodiles was discussed by Marais and Smith (1992). Pinchin (1994) considered the value of sustainable yield utilisation of Nile crocodiles. The problems of managing too many crocodiles at Madras crocodile bank were unravelled by Sebastian (1992).

There are several detailed studies on crocodile conservation plans in different countries. Crocodile Specialist Group of IUCN (1992) has published a detailed action plan for crocodile conservation. Godshalk (1994) reported on the feasibility of conservation and sustainable yield plan for Yacare Caiman in Bolivia. Jelden and Messel (1992) reported on the crocodile conservation and management in Thailand. Messel *et al*. (1992) dealt on the crocodile conservation problems in Indonesia; similarly Messel and King (1992) discussed the conservation and sustainable use of Caimans in Paraguay and Republic of Vanuatu; Philippines (Messel *et al*., 1992); Cuba (Ottenwalder and Ross, 1992); Honduras (Ross, 1992); China (Webb and Vernon, 1992 and Thorbjarnarson *et al*., 2000).

Many authors also studied other species of crocodiles extensively. Nesting ecology of caimans was studied by Allsteadt (1994). Thorbjarnarson and Hernandez (1983) reported on the reproductive ecology of the Orinoco crocodiles. Census of African crocodiles was reported by Marais (1992).

2. Methods

Approaches to investigation

Assessment of the number of crocodiles in the Neyyar Reservoir was the important objective of the study. Even though an earlier study had documented about 50 crocodiles in the Reservoir in the early 1990's (Rosamma, 1993), the general belief and the reports in the newspapers mentioned about thousands of crocodiles in the Reservoir. Considering the above facts and the human-crocodile conflict incidences, assessment of exact number of crocodiles in the Reservoir was needed as prerequisite for any management suggestions. One reason attributed for the human-crocodile conflict in the area was lack of food. So in order to clarify this point the food availability in the sanctuary was assessed. Household density on the banks of the Reservoir was estimated to assess the pressure on the reservoir by local people. Apart from this, opinion of people on crocodile and its conservation was also assessed.

Different areas of the Reservoir were visited using boats, rowing boats, country crafts, and the banks by two wheeler and jeep. The study period was from May 2000 to March 2002. Detailed methodology is given below for each objective.

2.1. Population assessment

Population counts of crocodiles were made by direct sighting and by indirect evidences. Walking along the banks of the reservoir and from boats daytime counts were made. Night counts were made using searchlights from a rowing boat. Animals above 1.6 m in size were categorised as adults and those between 1.2 m and 1.6 m as sub adults. In the night count, the light reflecting from the eyes of the crocodile helped to detect the animal. This is a standard technique used in crocodile census (Arumugam and Andrews, 1993). In each month, all the areas of the Reservoir were visited and direct and indirect sighting of crocodiles recorded. Indirect evidences were the presence of footprints, body and tail imprints on the

bank of the reservoir. A total count census was done in March 2001 with the help of the officials of Kerala Forest Department and volunteers from the Non-Governmental Organisations. In this census, both night count and daytime count of crocodiles in the reservoir were made.

2.2. Assessment of food availability

2.2.1. Fishes

In order to assess the fish availability in the reservoir, a sample survey was undertaken. Using gill nets, fish samples were collected from different stations on different days. Most of the stations were closer to the area where human-crocodile conflicts had been reported. Since there is no regular fishing, activities in the reservoir, random catches were made in order to get an estimate of possible catch during a year.

Two gill nets of varying mesh sizes were used for the sampling. One net was capable of catching Mackerel size fishes and another one fishes of Sardine size. The large mesh sized net was of 100 m length whereas short mesh sized net was 150 m. Gill nets were spread across the reservoir at 6 PM and fishes were collected at 6 AM. Cast nets were not employed because this method was not prevalent in the area. Sampling of fishes was carried out from the following places, namely Aruvipuram, Safari Park area, Mullayar, Kombai, Kottamanpuram, Boat landing, and Valliyar. Fishes were collected from May 2001 to December 2001. Number of *Catla catla* and *Labio rohita* fingerlings released into the Reservoir was collected from the Department of Fisheries, Thiruvananthapuram. Amount of fish caught in a day by the unauthorised catchers was also estimated by assessing the quantity of fish transported in a day by illegal catchers from the reservoir. The final analysis of fish abundance was done with the assistance of Dr. T. R. Sankaran, Head of the Department of Statistics, Fisheries College, Panangad, of Kerala Agricultural University.

2.2.2. Mammals

Availability of wild mammals in the forest was assessed using indirect methods by identifying scats, pellets and spoor. Fifteen transects of 100 m length were searched for indirect evidence of smaller mammals in each month. Transects were made at different localities of the sanctuary distributed all around the reservoir, namely Kombai, Kappukad, Boat landing, Puravimalai, Mayam, Pantha, Aruvipuram, Kottamanpuram, Meenmutti and Kanchimoodu. During the fieldwork whenever an animal was sighted, it was identified and details like species and number were recorded.

Dietary habits of the muggar were also studied during this period. Diet was studied by examining the Crocodile scats collected from the reservoir. Nine scats were collected during the period. Scats were soaked in water for 48 hours and separated using sieves and then the parts identified.

2.3. Human-crocodile conflicts

Information on human-crocodile conflicts in the Neyyar Wildlife Sanctuary was quantified by interviewing the victims and by visiting the sites where the attacks had occurred. Fifteen human-crocodile encounters that were serious and which had occurred before the study were assessed in detail after visiting the victims. In addition to this, a questionnaire survey was also carried out. The structured questionnaire survey (Appendix 1) with 34 questions was conducted among the 150 families around the reservoir to study their dependence on the Reservoir and incidences of human-crocodile conflict. Circumstances under which crocodiles attacked people were also documented. Following areas were covered for the survey, namely Anamugam, Chembur, Kanchimoodu, Kappukad, Karikuzhi, Karumankulam, Kumbichal, Mali deep, Mayam, Mlavatti, Parathi, Puravimalai, Puttukallu, Sangumkonam and South Pantha. All the applications filed in the Office

of the Assistant Wildlife Warden at Neyyar were scrutinised for collecting details and the victims were interviewed.

2.4. Response of local community

2.4.1.Population pressure on the Reservoir

Apart from this, local people's dependence on the reservoir for drinking water, bathing, washing clothes, etc. was assessed from 0600 hours to 2000 hours in each month by direct observation. Walking through the banks of the reservoir during different times and counting the number of people engaged in different activities was the method adopted for this. Apart from this, an assessment of number of houses near the Reservoir by people in the selected portions was carried out. Ten stretches of 1 km each were selected systematically along the bank and the number of houses in each stretch was assessed. This was done within a distance of 400 m from the reservoir.

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2.5. Potential sites for relocating crocodiles

Selected reservoirs in the State were evaluated for relocating the crocodiles from Neyyar Reservoir. Area of the reservoir, presence of human settlements near or on the banks of the reservoir, temperature of the area, altitude, social acceptance for introducing the crocodiles and the presence of natural crocodiles in the area were the parameters considered for evaluating the suitability of the reservoirs. Parambikulam Wildlife Sanctuary, Peruvannamuzhi Reservoir, Chimmony Reservoir and Kakki Reservoir were visited for evaluating the reservoirs.

2.6. Management of captive crocodiles

Current management practices of captive population have been documented. Observations on activity pattern and behaviour of crocodiles in captivity were also studied. Hourly activity pattern of 55 captive crocodiles was recorded for this and

data were collected for 144 hours. Captive Breeding Centre at Peruvannamuzhi and Crocodile Bank at Chennai were visited for studying the captive breeding facilities.

3. Results and Discussion

3.1. Population assessment of crocodiles

Surveying in rowing boats and walking through the banks were the most successful methods. The team spotted crocodiles easily when they basked on the banks of the reservoir. Crocodiles were also spotted when they were swimming in the lake. By the repeated sighting of a crocodile in a given area, it was possible to assign a territory to the identified individuals. In this way, the number of crocodiles in the reservoir could be estimated, apart from the complete census carried out in March 2001. The best months for censusing the crocodiles in Neyyar Reservoir are April and May when the water level is the lowest and banks are exposed to the maximum. By selecting these months, the basking crocodiles can be detected easily.

3.1.1. Direct observations

An adult crocodile with 10 young ones was recorded in the month of May 2000. Most of the crocodiles sighted in the reservoir were adults of more than 3 m in length. Only few instances of sub adult crocodiles were recorded. Eggs of crocodiles were found in the sanctuary during the breeding seasons of 2000 and 2001 (Plate 2). However, during 2002, no eggs were recorded from the area. Even though hatching and young ones were recorded in May 2000, no hatching and young ones were recorded in 2001 and 2002. Based on the sighting of crocodiles, the number of crocodiles in the sanctuary was estimated as 25 to 35 animals during January 2001.

The results indicated that sighting of crocodiles was low in general. There was no significant difference in sighting of crocodiles between wet (June – December) and dry season (January – May). ($t = 0.80$; $P = 0.45$; $df = 8$). This was mainly because the number of crocodiles was low in the Neyyar Reservoir. This was proved with a single visit to Parambikulam Wildlife Sanctuary, where six crocodiles were sighted within one and half hours of boat survey. Only eight nestlings and one

sub-adult crocodile were recorded from the Neyyar Reservoir. Detailed sighting records of crocodiles in each month are given in Table 3.

3.1.2. Indirect evidences

Nine faecal samples of crocodiles were collected from the bank of the reservoir (Plate 2). This provided indirect evidence of crocodiles in certain areas and helped in the estimation of crocodile population in the reservoir.

Main avian predator of young crocodiles at Neyyar Reservoir was identified as Crested Serpent Eagle and Little Cormorant.

Table 3. Direct sighting of crocodiles in the Neyyar Reservoir during the months of May 2000 to December 2001.

Month	Date	Area	Time	No. of crocodiles	Size
May 2000	08.05.00	Boat landing	08.30	1	Large
	09.05.00	Kombai	07.30	1	Large
	09.05.00	Aruvipuram	08.20	1	Large
	09.05.00	Kottamanpuram	08.30	8	Hatchlings
	10.05.00	Kombai	11.00	2	Large
June 2000	No sighting (Reservoir full)				
July 2000	No sighting (Reservoir full)				
August 2000	No sighting (Reservoir full)				
September 2000	No sighting				
October 2000	26.10.00	Kanchimoodu	10.00	1	Large
	27.10.00	Puravimalai	09.00	1	Large
November 2000	14.11.00	Boat landing	08.00	1	Large
	15.11.00	Puravimalai	09.30	1	Large
December 2000	19.12.00	Mayam	08.30	2	Large
	19.12.00	Boat landing	09.00	1	Large
January 2001	05.01.01	Boat landing	08.00	2	Large
February 2001	14.02.01	Mayam	10.00	1	Large
March 2001	21.03.01 to 23.03.01	Whole area	**Census**	14	Large
May 2001	18.05.01	Safari Park	11.00	1	Large
	18.05.01	Karumankulam	12.00	1	Large
	16.06.01	Mayam	10.30	1	Large
	17.05.01	Puravimalai	11.00	1	Large
June 2001	25.06.01	Kottamanpuram	12.00	1	Large
	25.06.01	Puravimalai	12.50	1	Large
	26.06.01	Puravimalai	08.00	1	Large
	26.06.01	Narakkavu	15.00	1	Large
July 2001	24.07.01	Aruvipuram	14.00	1	Large
August 2001	10.08.01	Safari Park	1500	1	Large
	13.08.01	Puravimalai	1030	1	Large

	14.08.01 15.08.01 16.08.01 20.08.01	Mayam Anamugam Puttukallu Kumbichal Kadavu	1600 1100 1000 0700	1 1 1 1	Sub-adult Large Large Large
September 2001	20.09.01 20.09.01 23.09.09 24.09.01	Pantha Kottamanpuram Boat landing Kombai	1000 0900 0930 1030	1 1 1 1	Sub–adult Large Large Large
October 2001	09.10.01 18.10.01	Ulattimoodu (Mayam) Pantha	1030 1100	1 1	Sub–adult Sub-Adult
November 2001	No sighting (Reservoir full)				
December 2001	15.12.01	Pantha	10.30	1	Sub-adult
December 2001	18.12.01	Pantha	10.30	1	Sub- adult

Details of identified crocodiles are given in Tables 4 and 5.

Table 4. Number of crocodiles estimated near the human settlement areas in the Neyyar Reservoir (May 2001)

Sl. No.	**Area**	**No. of crocodiles**
1.	Chembur	1 (Caught and died, 02.04.01)
2	Chembur	1 (Caught, 25.05.01)
3	Pantha	1 (Killed, 16.08.01)
4	Parathi	1 (Caught, 09.09.01
5.	Kombai	1 (Caught, 01.10.01)
6.	Mayam	1 (Caught and died, 02.10.01)
7	Lion Safari Park	1
8	Kappukad	1
9	Puravimalai	1
10.	Mayam	1
11.	Anamugam	1

Table 5. Number of crocodiles estimated near the interior forest areas in the Neyyar Reservoir (May 2001)

Sl. No.	Area	No. of crocodiles
1.	Kottamanpuram	1 (Caught, 25.09.00)
2	Kottamanpuram	1 (Caught and died, 03.10.01)
3	Pazhinipara	1 (Caught, 01.10.01)
4	Aruvipuram	3
5	Kombai	1
6	Mullayar	1
7	Meenmutti	2

In the wild population of crocodiles, natural mortality is very high and many juvenile crocodiles were entangled in the fishing nets and drowned in the reservoir. Apart from these, local people destroyed crocodile eggs whenever they located them in the sanctuary. Due to these reasons, recruitment to the population of crocodiles is low or almost nil at Neyyar.

After the two casualties in January 2001 and August 2001, nine large crocodiles were caught from the reservoir (Plate 3); four died due to various reasons. All these crocodiles except one were more than 3 m in length. Taking this into consideration it is estimated that only 10 to 16 crocodiles were left in the wild, when we consider the lower limits of the population estimated in the reservoir. Some crocodiles may have been poached when the two human causalities occurred during the period of study.

3.1.3. Census

Complete census of crocodiles in the reservoir was conducted from 18th to 20th March 2001 with the help of Kerala Forest Department and NGOs. In this census, 12 crocodiles were found in areas of the reservoir adjoining the human habitations and two animals in the interior areas. It is recommended to census the crocodile population in the Neyyar Reservoir in each year when the level of water is lowest, usually in the month of May. Continuous monitoring of crocodile population is necessary to avoid conflicts with humans.

3.2. Food availability

All crocodilians are carnivorous. Juvenile crocodiles diet consists mainly of insects and other small creatures. As they grow, they start taking fish, reptiles, birds, and small mammals. While the adults are fish eaters, they are also opportunists and will consume large mammals. Larger crocodiles may attack, drag in, and drown any animal that is within their capacity to kill. The recorded stomach contents of the mugger include leopard, wild dog, hyena, chital, sambar, Nilgai fawn, four horned antelope, barking deer, monkeys, domestic dog, goats, pig, duck and a variety of wild birds (Daniel, 1983).

They prefer fresh food, but with large carcasses, they wait until decomposition starts. Crocodiles are unable to chew their food due to the absence of a lateral motility of the jaw. Small prey is crushed and swallowed completely. Larger prey is first drowned and then broken up into swallowable chunks. The crocodile breaks up a carcass by seizing a limb or part of the body and spinning on a horizontal axis. If the chunk is still too large, it is further broken up by flicking it violently from side to side. Crocodiles break down all food in the stomach, and no solids are passed into the intestines. Accumulated hair is regurgitated in the form of a hairball. Crocodiles swallow stones that keep the food separated and provide a greater food surface for the digestive juices to work on, which speeds up the rate of digestion (Blake, 2002).

Many variables are known to affect crocodiles feeding among these, important are temperature, activity, season (breeding and nesting), size of crocodile and density of population. Crocodiles are extremely variable in the food intake being capable of ingesting a significant portion of body mass when large prey is in abundance, but also being capable of going for several months without feeding at all. Young active crocodilians maintained at high temperature (32-35^{o} C) can consume 10 to 20% of their body weight in food (wet weight) per week. However, the minimum maintenance ration for an inactive, adult (non-growing), non-breeding crocodile is much less, possibly, as little as 1% of body weight per week (Ross,

2001, Personal communication). According to this estimate, a crocodiles with 3.5 m in length having approximately 200 kg of weight will need 100 - 200 kg of food per year.

For the above mentioned reasons, approaching the human-crocodile conflict from the perspective of availability of food for crocodiles is unlikely to be productive. Crocodiles of a sufficiently large size will probably attempt to prey on people in vulnerable locations independent of other food sources or lack thereof. It may be generally true that extremely well-fed crocodiles with an abundance of natural prey might be less likely to prey on people, but this is not a certain rule. The relative size of prey, prey behaviour and particularly the apparent vulnerability of prey all may involve in a crocodile's 'decision' to prosecute an attack (Ross, 2000). Considering above facts, an assessment of food availability in the Neyyar Reservoir was carried out. Estimation of fish availability and abundance of mammals was carried as described in methods.

3.2.1. Fish

The major item of food of crocodiles is fish. As described earlier, the Neyyar Reservoir is of 8.45 km^2 area. It is a protected area and no regular fishing is allowed. Hence, there is no information available on the fishery potential of this reservoir. However, the Department of Fisheries, Kerala has been stocking fish seedlings here, mainly the major carps under an Indo-German project. The last time the stocking done was in 1995-1996 and 1996-1997. During 1995-1996, 16,38,050 fingerlings and in 1996-1997, 5,39,542 fingerlings were introduced, as per the information gathered from the Department. Twelve species of fishes were collected from the reservoir. Most of the larger fishes collected were in the range of 1- 2 kg. Crocodiles are known to prefer scale less variety of fishes (Choudhury, B.C. Pers. Comm.). Among the fishes caught, *Wallago attu* is a scale less variety, which is found only rarely in the samples. Species of fishes abundantly found in the samples like *Catla catla* and *Oreochronis mossambicus* are with many scales. Length and weight of

fishes collected from the reservoir are given in Table 6 and locations from where the fishes were sampled are given in the Figure 6. Species of fish collected from the reservoir are listed below.

1. *Labio rohita*
2. *Catla catla*
3. *Cirrhina mrigala*
4. *Channa striatus*
5. *Wallago attu*
6. *Oreochronis mossambicus*
7. *Etroplus suratensis*
8. *Barbus* sp.
9. *Puntius thomassi*
10. *Puntius filamentus*
11. *Puntius sarana*
12. *Cyprinus carpio*

Table 6. Length and weight of fishes collected from the Neyyar Reservoir

Date	Area		Name of the species	Length (cm)	Weight (g)
23 May 2001	Safari Park	1.	*Oreochronis mossambicus*	15	150
		2.	*Oreochronis mossambicus*	15	150
		3.	*Oreochronis mossambicus*	10	100
		1.	Paval (local name)	10	100
		2.	Paval "	12	100
		3	Paval "	15	100
		4.	Paval "	12	150
		5.	Paval "	10	100
		6.	Paval "	18	200
		7.	Paval "	14	150
		8.	Paval "	15	150
		9.	Paval "	15	150
		10.	Paval "	10	100
		11.	Paval "	12	100
		1.	*Wallago attu*	20	300
		2.	*Wallago attu*	15	150
		3.	*Wallago attu*	10	150

Date	Area		Name of the species	Length (cm)	Weight (g)
20 July 2001	Aruvipuram	1.	*Catla catla*	45.5	1000
		2.	*Catla catla*	50.5	1500
		3.	*Catla catla*	50.2	1500
		4.	*Catla catla*	45.0	1000
		5.	*Catla catla*	47.0	1000
		6.	*Catla catla*	47.0	1000
		7.	*Catla catla*	32.0	750
		8.	*Catla catla*	35.0	750

Date	Area	Sl. No.	Name of the species	Length (cm)	Weight (g)
11August 2001	Mullayar	1	*Oreochronis mossambicus*	15	250
		2	*Oreochronis mossambicus*	18	250
		3	*Oreochronis mossambicus*	12	200
		1	Paval	10	100
		1	*Puntius filamentus*	12	150
		2	*Puntius filamentus*	15	150
		3	*Puntius filamentus*	10	100
		4	*Puntius filamentus*	12	100
		5	*Puntius filamentus*	15	150
		6	*Puntius filamentus*	13	100
		7	*Puntius filamentus*	15	100
		8	*Puntius filamentus*	14	100
		1	*Wallago attu*	18	100
		2	*Wallago attu*	15	100
		3	*Wallago attu*	10	100
13 August 2001	Kombai	No catch			
20 August 2001	Kottamanpuram	No catch			
21August 2001	Safari Park	No catch			

Date	Area	Sl. No.	Name of the species	Length (cm)	Weight (g)
19 Sept. 2001	Kottamanpuram	1	*Catla catla*	45	1500
		2	*Catla catla*	30	1000
		1	*Catla catla*	35	1000
		2	*Catla catla*	30	1000
		3	*Catla catla*	40	1500

21 Sept. 2001	Kombai	4	*Catla catla*	45	1500
		1	*Oreochronis mossambicus*	10	200
		2	*Oreochronis mossambicus*	20	250
		3	*Oreochronis mossambicus*	15	200
		4	*Oreochronis mossambicus*	15	200
		5	*Oreochronis mossambicus*	10	200
23 Sept. 2001	Boat landing	No catch			
24 Sept. 2001	Aruvipuram	No catch			

Date	**Area**	**Sl. No.**	**Name of the Species**	**Length (cm)**	**Weight (g)**
19 Oct. 2001	Mullayar, Valliyar and Neyyar	1	*Oreochronis mossambicus*	10	100
		2	*Oreochronis mossambicus*	15	200
		3	*Oreochronis mossambicus*	20	100
		4	*Oreochronis mossambicus*	15	150
		5	*Oreochronis mossambicus*	10	100
		6	*Oreochronis mossambicus*	15	150
		7	*Oreochronis mossambicus*	10	100
		8	*Oreochronis mossambicus*	12	150
		9	*Oreochronis mossambicus*	18	200
		10	*Oreochronis mossambicus*	15	200
		1.	*Catla catla*	45	1500
		2.	*Catla catla*	32	1250
20 Oct. 2001	Boat landing	1	*Catla catla*	32	1000
		2	*Catla catla*	45	1500
		3	*Catla catla*	40	1250
		4	*Catla catla*	30	1000
21 Oct. 2001	Aruvipuram	No catch			
22 Oct. 2001	Kottamanpuram	No catch			

Date	Area	Sl. No	Name of the Species	Length (cm)	Weight (g)
16 Nov. 2001	Kottamanpuram	1	*Oreochronis mossambicus*	12	100
		2	*Oreochronis mossambicus*	12	100
		3	*Oreochronis mossambicus*	10	100
		4	*Oreochronis mossambicus*	15	150
		5	*Catla catla*	45	1500
		6	*Catla catla*	40	1200
17 Nov. 2001	Kombai	1	*Catla catla*	45	1500
		2	*Catla catla*	40	1000
		3	*Catla catla*	42	1200
		4	*Catla catla*	50	1700
18 Nov. 2001	Mullayar, Valliyar	1	*Oreochronis mossambicus*	10	100
		2	*Oreochronis mossambicus*	12	100
		3	*Oreochronis mossambicus*	12	120
		4	*Oreochronis mossambicus*	15	150
		5	*Oreochronis mossambicus*	10	100
		6	*Oreochronis mossambicus*	15	150
		7	*Oreochronis mossambicus*	10	100
		8	*Oreochronis mossambicus*	15	150
		9	*Oreochronis mossambicus*	15	100
		10	*Oreochronis mossambicus*	12	100
		11	*Oreochronis mossambicus*	12	120
		12	*Oreochronis mossambicus*	12	100

		13	*Oreochronis mossambicus*	15	150
		15	*Catla catla*	45	1500
		16	*Catla catla*	40	1000
		17	*Catla catla*	42	1000
		18	*Catla catla*	35	750
		19	Paval	10	100
		20	*Puntius filamentus*	12	120
		21	*Puntius filamentus*	15	150
19 Nov. 2001	Safari Park	1	*Cyprinus carpio*	45	1500
		2	*Oreochronis mossambicus*	10	100
		3	*Oreochronis mossambicus*	12	120

Summary of fishes sampled is given in Table 7.

Table 7. Summary of fish sampling from the Neyyar Reservoir

Sl. No.	Station	No. of days sampled	Total fish caught (gm)	Daily average (gm)	Estimated annual catch (kg)
1	Safari park	3	4,120	1,373	501
2	Aruvipuram	3	8,500	2,833	1034
3	Mullayar	3	12,410	4,137	1510
4	Kombai	4	16,000	4,000	1460
5	Kottamanpuram	4	5,650	1,413	516
6	Boat landing	3	4,750	1,583	578
7	Puravimalai	2	950	475	173
8	Karumankulam	1	0	0	0
Total		**23**	**52,380**	**2,277**	**5,772**

As per the sample survey, an estimated catch of 5,772 kg of fish can be obtained from the reservoir. In addition to this, on enquiry, it is understood that almost every day the local people and tribals catch fish from the reservoir for their own consumption or for local sale. This being unauthorised, details were not available. However, from the information obtained through oral enquiry, these people catch between 1 to 12 kg per day. Based on the data gathered from the locals,

an estimated average catch of 4 kg is caught per day, making a total of 1460 kg per year. This information is gathered on the same days on which the sample surveys were made. Hence, it may be added to the total catch and a grand total arrived at as 7232 kg of fish per year. Evidently, the potential will be several times than this.

3.2.2. Mammals

As the crocodiles are known to feed on mammals, an attempt was made to assess the abundance of mammals on the banks of the reservoir. Sambar and Bonnet Macaque were observed on many occasions from the area. Details are given in Table 8.

Table. 8. Mammals recorded from the banks of the Reservoir

Date	Species	Location	Time
09 May 00	Bonnet Macaque	Aruvipuram	08.20
08 Aug. 00	Bonnet Macaque	Aruvipuram	09.00
15 Nov. 00	Bonnet Macaque	Puravimalai	09.30
05 Jan. 01	Bonnet Macaque	Karumankulam	09.40
15 Feb. 01	Sambar	Puravimalai	10.00
16 Mar. 01	Sambar	Karumankulam	09.30
09 May 01	Bonnet Macaque	Kombai	11.45
15 Jul. 01	Bonnet Macaque	Kappukad	11.00
25 Jul. 01	Bonnet Macaque	Kappukad	11.30
20 Aug. 01	Sambar	Kottamanpuram	08.45
22 Sept. 01	Sambar	Mayam	11.00
17 Oct. 01	Sambar	Kappukad	11.45
24 Oct. 01	Sambar	Kombai	10.15
05 Nov. 01	Bonnet Macaque	Meenmutti	14.00
55 Nov. 01	Sambar	Meenmutti	15.00
15 Dec. 01	Bonnet Macaque	Kanchimoodu	09.20
22 Dec. 01	Sambar	Kombai	10.15

On 14.11.2001, an incident of crocodile attacking a Sambar was observed near the boat landing area. In another incident a crocodile attempted to catch a Bonnet Macaque, when the macaques were feeding on a tree, the branches of which were touching the water. The macaques made loud alarm calls, when they spotted the crocodile and climbed to the top, from where they continued the alarm calls. Indirect evidences on the presence of Sambar, Wild Boar and Bonnet Macaque were also obtained from the line transects. The presence of herbivores was extremely low for any meaningful density analysis (Table 9).

Table 9. Indirect evidences of mammals detected in the line transect sampling on the banks of Neyyar Reservoir

Date	Name of places	Name of the species	Number of indirect evidences	Remarks
19 Sept. 00	Kombai	--	--	--
26 Oct. 00	Kappukad	--	--	--
26 Oct. 00	Boat landing	--	--	--
15 Nov. 00	Puravimalai	--	--	--
16 Nov. 00	Kappukad	--	--	--
19 Dec. 00	Puravimalai	--	--	--
19 Dec. 00	Mayam	--	--	--
06 Jan. 01	Pantha	Sambar	Two	--
07 Jan. 01	Aruvipuram	--	--	--
14 Feb. 01	Kottamanpuram	Sambar	One	--
15 Feb. 01	Kombai	--	--	--
18 Mar. 01	Kappukad	--	--	--
15 May 01	Aruvipuram	Sambar	Two	--
16 May 01	Kottamanpuram	Bonnet Macaque	One	Direct sighting
17 May 01	Kombai	--	--	--
25 Jun. 01	Kottamanpuram	Sambar	One	--
25 Jun. 01	Pantha	Sambar	One	--
13 Jul. 01	Pantha	Sambar	Two	--
15 Jul. 01	Kappukad	Sambar	One	--
15 Jul. 01	Kappukad	Bonnet Macaque	Two	Direct sighting
11 Aug. 01	Kombai	Gaur	Three	Direct sighting
17 Sep. 01	Puravimalai	--	--	--
19 Sep. 01	Kottamanpuram	--	--	--
20 Sep. 01	Pantha	--	--	--
22 Sep. 01	Mayam	--	--	--
21 Oct. 01	Aruvipuram	--	--	--
22 Oct. 01	Kombai	--	--	--
17 Nov. 01	Meenmutti	Wild boar	one	--
18 Nov. 01	Puravimalai	--	--	--
13 Dec. 01	Kappukad	Sambar	Two	--
13 Dec. 01	Kappukad	Wild Boar	One	--
14 Dec. 01	Kombai	Wild Boar	One	--
15 Dec. 01	Kanchimoodu	Sambar	One	--
21 Dec. 01	Kappukad	Wild Boar	Two	--

----- = No evidence

Line transect direct counting was not attempted as the sightings were very few. Crocodile scat analysis revealed the presence of fish scales and Sambar hairs in two samples. No other food materials could be identified from the scats.

Density of herbivores was low in the Neyyar Wildlife Sanctuary. Many reasons can be attributed for this phenomenon. History of the area showed that 111 ha of the Sanctuary was planted with *Eucalyptus* hybrid in 1964 and 1965 (Vighnarajan, 1990). The planting operations and subsequent felling might have reduced the density of herbivores. Presently the remnants of eucalypt plantations are seen in many places. Apart from this, the Kani tribals living in the Sanctuary are a known hunter-gatherer community. They are known to hunt many smaller animals. In the adjacent Peppara Wildlife Sanctuary also, the density of herbivores was low (Jayson, 1998). Low density of larger mammals may have an effect on the crocodile behaviour in the Neyyar Reservoir.

Other than wild animals, crocodiles in the Neyyar Reservoir were feeding on livestock and domestic animals also. They have been recorded as feeding on domestic dog, small cow, goats, buffalo calves, domestic fowls, ducks, and cats. Preferred item is domestic dog.

3.2.2. Birds

Apart from fishes and mammals, crocodiles can feed on other animal groups like birds. Crocodiles are known to feed on both land birds and aquatic birds. Only few species of aquatic birds were recorded from the Neyyar Reservoir. Migratory ducks were absent in the Reservoir. Little Cormorant (*Phalacrocorax niger*) was the most abundant bird observed in the reservoir. Ten to twenty birds were seen in a flock. No feeding of Little Cormorant by crocodile was recorded in this study. Apart from Little cormorant, Darter (*Anhinga rufa*) and Little Egret (*Egretta garzetta*) were also seen rarely. Twenty-seven taxa of land birds were also seen on the banks of the reservoir.

An adult wild crocodile with 3.5 m length having 200 kg weight may need 100 to 200 kg of food per year comprising all animals based on the assumption that the animal may feed 1-2 % body weight per week (Ross, 200). From the analysis, it can be concluded that food in the form of fishes is sufficient, whereas food in the form of wild large mammals is inadequate.

3.3. Human-crocodile conflicts

Crocodiles have varied hunting techniques, ranging from simple, savage rushes to complex entrapment behaviours. They use their powerful tails to knock larger prey into the water where the crocodile has the advantage. One of the most common hunting techniques is surprise attack. A crocodile waits for its prey to come down the water's edge for a drink, and then it slowly swims to the shore and lies in wait, with just its eyes above the water, a few feet from the animal. Then it suddenly lunges out of the water and latches onto the animal's head with its powerful jaws. If it can get a firm grip with its teeth, the crocodile pulls the animal into deeper water, where it drowns its prey. Crocodiles have no way to anchor their prey once it is dead, so to get a mouthful of meat, they bite the animal and roll over and over on their long axis until they twist off a chunk of meat. Then they bring their heads above water, flip their food into the air and grab it again, each time getting it further and further down the gullet. They usually need to rest for a few minutes before taking another bite. If the skin of the prey animal is too tough for the crocodile to penetrate, it stores the dead animal in an underwater hollow until it rots enough for the crocodile to bite into it.

3.3.1. Past attacks on humans

Crocodile attacks were reported from 1985 onwards from the Sanctuary (Table 10). Before initiating the study, 30 incidents were recorded from the Sanctuary. Among these, more than 15 were serious attacks on humans. Ten men and five women were attacked in these incidents. A woman was attacked twice causing severe injury to body and hand. She had lost one of her hands. In another incident, a woman lost her forearm. Similarly, many victims survived crocodile attacks and live with serious deformation to the body parts. All other victims were severely mauled and hospitalised varying from one to six months. Most of the

attacks were on legs and the attacks happened when the victims were in knee-deep water for bathing or for washing clothes. Two peaks of attacks were noticed. One

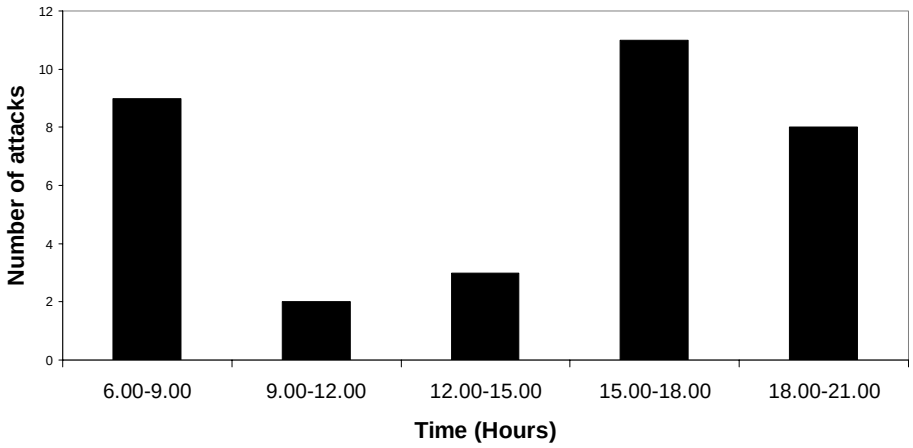

Fig. 7 Number of crocodile attacks recorded in different time periods

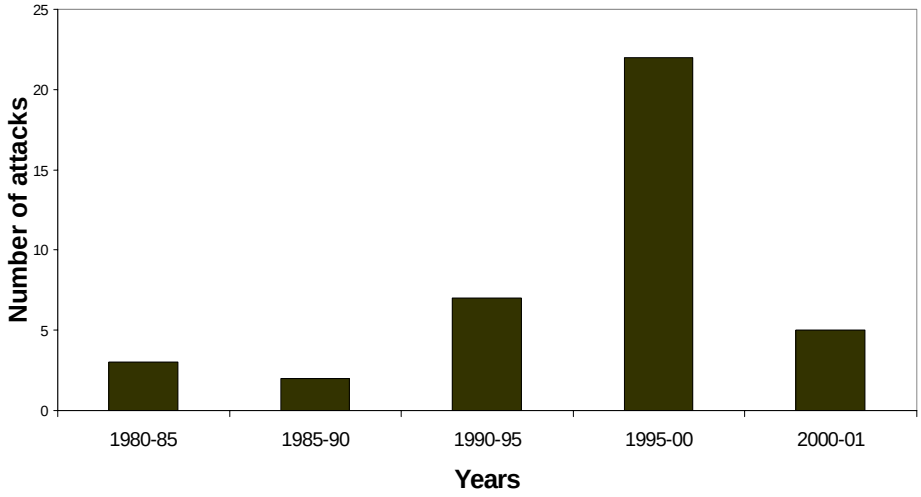

Fig. 8 Number of crocodile attacks in different years

peak was in the morning hours and another one in the evening hours (Fig. 7). Age of the victims ranged from 8 to 60 years. Many of the victims were alone when the attack happened (Plate 4). Chronology of attacks revealed that highest number of attacks occurred during the years 1995 to 2000 (Fig. 8).

Table 10. Crocodile attacks on humans recorded from the Neyyar Reservoir before and after initiating the study

	Date of attack	**Name of person**	**Age**	**Time of attack**	**Compen-sation**	**Amount Received (Rs.)**	**Activity**
Before the study	1985	Rajaki Anitha Kumari Maniyan	45 25 20	9 am	Yes	2100	Walking on the banks
	1987 1992	Krishnamma	50	7 pm 5 pm	Given job		Collecting water (hand lost)
	1990	Mohammed Haneefa	----	5.30 pm			Bathing
	1991	Sasi D.	48	6 pm	No	0	Bathing
	1992	Nabeesa Beevi	52	6 pm			Collecting water
	1994	Ashuma Beevi	42	-----	No	0	Bathing
	1994	Vanaja		-----			Bathing
	1995	Shamila	20	11 am	No	0	Bathing
	1995	Surendran	33	7 am	Yes	1000	Bathing
	1996	Babu K.	46	7.30 pm			Bathing
	1996	Thankappan	37	6.30 pm	No	0	Bathing
	1996	Omana	50	6 pm	No	0	Bathing
	1996	Molly	28	7 am	Yes	1000	Collecting water
	1996	Leela	40	3 pm	No	0	Bathing
	1997	Asharaff	35	5.30 pm	No	0	Bathing
	1998	Antony E.A.	24	8.30 pm	Yes	1000	Bathing
	1998	Shamsudheen	--	6 pm	--	--	Bathing
	1998	Sukumaran	48	6.30 pm	--	--	Washing face
	1998	Kamalam	-----	----	--	--	Washing clothes
	Feb. 1998	Augustine	43	11.30 am	--	--	Bathing cow
	27 Oct. 98	Vijayan S.	38	7 pm	--	--	Bathing
	28 Nov. .98	Suresh J.	25	7 pm	--	--	Bathing

	14. Dec. 98	Achamma Thomas	48	7 pm	--	--	Bathing
	19. Dec. 98	Varghese V.	8	3 pm	--	--	Playing near water
	1999	Ramachandran	53	6 pm	--	--	Bathing
	1999	Jobin	9	3.30 pm	Yes	2100	Bathing
	1999	Augustine K A.	34	----	Yes	1000	Bathing
	21 Aug. 99	Krishnan Asari	50	6 pm	--	--	Bathing
	23 Dec. 99	Thomas Baby	52	2 pm	--	--	Bathing cows
	2000	Bhavani	45	6 pm	No	0	Bathing
During the study	Oct. 2000	Rosamma	60	8 am	Yes	Hospital expenses	Washing (Lost hand)
	2 Jan. 2001	Rajamma	57	6.30 am	Yes	50,000	**Washing (Killed)**
	07 May 2001	Chinnamma	40	9 am	No	0	Bathing, Lost basket
	16 May 2001	Surendran	42	8.30 am	Yes	Hospital expenses	Bathing
	16 Aug. 2001	James	56	6 am	Yes	50,000	**Washing face (Killed)**
	29 Sep. 2001	Ajesh	20	8.30 pm	No	0	Bathing

-- = No data

Apart from humans, crocodiles attacked dog, goat and cattle also. According to local people many incidents of attack on livestock happened after the release of the crocodiles into the reservoir, some of which were not reported to the officials. Some of the incidents occurred in the past which were revealed during the questionnaire survey are listed in Table 11.

Table 11. Crocodile attacks on livestock recorded from the Neyyar Reservoir

Year	Animal attacked	Owner
1990	Dog killed (1)	Joseph A.P.
1995	Cow (1)	Sharafudeen K.P.
1995	Bull (1)	Ibrahim Pillai
1995	Dog killed (1)	Poulose
1997	Hen	Chandran D.
1997	Hen (6) Duck (4)	George Kutty M.P.
1998	Hen (2) Duck (1)	Radhakrishnan
----	Goats (2)	Joseph M.M.

Detailed case studies of crocodile attacks happened before the study are given in Table 12.

Table 12. Details of crocodile attacks (Case studies).

I.

Smt. P. Krishnamma
Marakunnam
Neyyar Dam P.O.

Date of incidence	- 1987, 1992
Time	- 7.00 pm; 5.00 pm
Location	- Marakunnam
Activity of victim	- Walking through the banks
Body part attacked	- Hand and Leg
How escaped	- By struggling (alone)

Age	- 50 years
Whether hospitalised	- Yes (two times, six months)
After effect	- Lost one hand
Current problem	- Handicapped due to the loss of hand
Remarks	- Attacked the legs first and when the victim fell down one hand was cut and taken away.

II

Smt. Nabeesa Beevi
Roadarikathu Veedu
Neyyar Dam PO

Date of incidence	- 1992
Time	- 6.00 pm
Location	- Neyyar Dam
Activity of victim	- Collecting drinking water
Body part attacked	- Legs
How escaped	- By struggling (alone)
Age	- 52 years
Whether hospitalised	- No
After effect	- Nil
Current problem	- Nil
Remarks	- Nil

III

Shri. K. Babu
Marakunnam
Cherpana
Marakunnam, Neyyar Dam PO

Date of incidence	- 1996, Summer
Time	- 7.30 pm
Location	- Marakunnam, Small earthen dam

Activity of victim	- Bathing
Body part attacked	- Below the knee
How escaped	- By struggling (alone)
Age	- 46 years
Whether hospitalised	- No
After effect	- Now very careful
Current problem	- Nil
Remarks	- Large size crocodile attacked

IV

Shri. Agustin Agustin
Kottakkal
Neyyar Dam PO

Date of incidence	- February 1998
Time	- 11.30 am
Location	- Neyyar Dam
Activity of victim	- Bathing cow
Body part attacked	- Below the knee
How escaped	- By struggling (alone)
Age	- 43 years
Whether hospitalised	- No
After effect	- Now very careful
Current problem	- Nil
Remarks	- Attacked twice, a single crocodile was seen in the area for a long time.

V

Shri. S. Vijayan
Koliakodu Roadarikathu Veedu
Neyyar Dam PO

Date of incidence	- 27.10.1998

Time	- 7.00 pm
Location	- Marakunnam
Activity of victim	- Bathing

VI

Shri J. Suresh
Thachankodu Vadakkunthara Veedu
Near Open Prison
Neyyar Dam PO

Date of incidence	- 28.11.1998
Time	- 7.00 pm
Location	- Deer Park area
Activity of victim	- Bathing
Body part attacked	- Above the knee
How escaped	- By struggling (alone)
Age	- 25 years
Whether hospitalised	- Yes (Three weeks)
After effect	- Very careful
Current problem	- Nil
Remarks	- Nil

VII

Smt. Achamma Thomas
Irurikkal House
Mayam PO

Date of incidence	- 14.12.1998
Time	- 7.00 pm
Location	- Mayam
Activity of victim	- Bathing (husband waiting on the banks)
Body part attacked	- Below the knee

How escaped	- By struggle
Age	- 48 years
Whether hospitalised	- Yes (One week)
After effect	- Highly afraid
Current problem	- Nil
Remarks	- Dogs were caught in the nearby places

VIII

Shri Varghese, V
Vayalippadath House
Mayam PO

Date of incidence	- 19.12.1998
Time	- 3.00 pm
Location	- Mayam
Activity of victim	- Playing near the water with mother
Body part attacked	- Above the knee
How escaped	- By struggle
Age	- 8 years
Whether hospitalised	- No
After effect	- Very careful
Current problem	- Nil
Remarks	- Nil

IX

Shri Sukumaran
Shobavilas
Marakkunnathu
Neyyar Dam PO

Date of incidence	- 1998
Time	- 6.30 pm
Location	- Marakunnam

Activity of victim	- Washing face
Body part attacked	- Shoulder
How escaped	- By struggling (alone)
Age	- 48 years
Whether hospitalised	- Yes (Five days)
After effect	- Nil
Current problem	- Nil
Remarks	- Nil

X

Shri. Krishnan Asari
Thekkumkara puthan Veedu
Marakunnam
Neyyar Dam PO

Date of incidence	- 21.08.1999
Time	- 6.00 am
Location	- Marakunnam
Activity of victim	- Bathing
Body part attacked	- Above the knee
How escaped	- By struggling (alone)
Age	- 50 years
Whether hospitalised	- Yes (two weeks)
After effect	- Now very careful
Current problem	- Scars on the leg
Remarks	- Nil

XI

Shri. Thomas Baby
Parakkal House
Karumankulam
Mayam

Date of incidence	- 23.12.1999
Time	- 2.00 pm
Location	- Mayam
Activity of victim	- Bathing cows
Body part attacked	- Below the knee
How escaped	- By struggling (alone)
Age	- 52 years
Whether hospitalised	- Yes (7-8 days)
After effect	- Now very careful
Current problem	- No deformity
Remarks	- Finds doing the daily works difficult

XII

Shri Ramachandran
Marakunnam
Cherpana
Marakunnam, Neyyar Dam PO

Date of incidence	- Summer month, 1999
Time	- 6.15 am
Location	- Marakunnam
Activity of victim	- Bathing
Body part attacked	- Above the knee
How escaped	- By struggling (alone)
Age	- 53 years
Whether hospitalised	- Nil
After effect	- Now very careful
Current problem	- Nil
Remarks	- Large crocodile attacked

3.3.2. Incidents of attacks on humans during the study

During the period of study, six crocodile attacks happened and two people died (Fig. 9). In the earlier incidents which happened before the study was initiated, no human casualty was reported.

First incident

In a gruesome incident that occurred in October 2000 near Kanchimoodu, an adult large crocodile attacked a women (Smt. Rosamma) and her right hand was torn off from the elbow onwards. She was attacked in the morning at 7.00 hours, when she was washing vessels in the reservoir. Local people helped her to escape from the crocodile after hearing her cries. The area was visited and the circumstances of attack were studied. The attack occurred near her house and the crocodile was trying to catch a child near the victim. When the victim came for the rescue of the child she was attacked and the animal caught hold of her hand. In the struggle, she lost one hand and was hospitalised. She has been following the pattern of cleaning the cooking vessels in the morning hours in the reservoir every day. Waste food thrown into the reservoir might have attracted the crocodile to the locality apart from the regular pattern of movement followed by the victim.

Second incident

One month after the first incident, in the same locality, a large crocodile killed a women aged 57 years (Smt. Rajamma) in January 2001. This was the first death caused due to a crocodile attack. The woman was washing her clothes alone on the banks of the reservoir in the morning. The crocodile approached the victim stealthily and caught hold of her from behind. She was pulled towards the middle of the reservoir and drowned. When the crocodile surfaced with the body of the victim, people gathered around the reservoir and the crocodile submerged into the water again. This continued for about 5 hours and police was called. They fired with the

service revolver and when the animal was injured on the dorsal side of the mouth, it released the body of the victim. The crocodile escaped into the reservoir. The crocodile with injury was recorded several times after this incident. In this incident, the woman was alone and she was following a regular pattern of activity *i.e.* going for washing the clothes every day on a particular time.

Third incident

On 7 May 2001 at 09.00 hours, a large crocodile near Mayam tried to attack a woman named Chinnamma (40 years) of Arakkal Veedu, and in the process, the crocodile destroyed her bamboo basket. The woman was not harmed. She was cleaning vessels in the reservoir and was alone.

Fourth incident

On 16 May 2001, a large crocodile attacked a person named Shri P.T. Surendran (42 years) from Mayam at 0830 hours. The attack occurred when he was washing clothes on the banks of the reservoir. Initially the crocodile caught hold of his left hand. When he shouted and tried to save himself from the crocodile, local people rushed to the spot and he was saved. He was hospitalised for 3 weeks and a big scar is seen on the left hand. According to him, the animal came stealthily. He used to follow a regular pattern of activity, by taking bath in the same area everyday alone.

Fifth incident

On 16 August 2001, a large crocodile killed another man named Shri James (56), while he was washing his face. He was unaware of the crocodiles in the reservoir and went to the reservoir alone in the morning. He hailed from another village and came to his daughter's house for participating in a family celebration. Waste of the non-vegetarian food was recorded near the reservoir after the incident.

This food might have attracted the animal to the area. On the same day, the police killed the crocodile. The body of the victim surfaced only on the next day. Compensation of Rs. 50,000 was given to his relatives by the authorities.

Sixth incident

This was a minor attack on Shri Ajesh, aged 20 years. He escaped with minor injury on knee and was not hospitalised.

On 26 May 2001, the local people using fishing nets caught one large-sized crocodile. It was brought to the Crocodile Breeding Centre and kept there. Attempt to capture other problematic crocodiles continued. On 25 September 2001, Eco-Development Committee (EDC) caught another crocodile in the net. This was brought to the Captive Breeding Centre. (Details are given in Tables 4 and 5)

Most of the assaults on humans occurred near the banks when the victims were washing clothes or taking bath, alone. No specific time was observed in the pattern of attacks. The incidents of attacks were recorded from Kappukad to Kumbichal within a stretch of 26 km. However, maximum people were hurt near the dam site and Pantha. In some cases, there is a relationship with the dumping of waste food in the lake. Moreover, in all the cases, the people were following a regular pattern of activity. This might have helped the crocodiles to locate the humans for attack and wait for their arrival. All the attacks have followed the known pattern of hunting behaviour reported in crocodiles (Daniel, 1983). As seen from the case studies, large crocodiles above 3 m length were involved in all the major and fatal attacks on humans.

3.3.3. Possible reasons for attacks

One of the possible reasons for attack on people may be to defend the territory of individual crocodiles. During the months of October, November and

December, the males will be courting the females and all the intruders into the territory including the humans will be attacked. Again, in the months of February, March, April and May, the females will be laying eggs and will be defending the nests. During this time, anybody seen near the nest site will be attacked. From June to September the females will be protecting the nestlings and chances of attack are more by females during this time. Presence of livestock and other domestic animals on the banks was attracting the crocodiles to the inhabited areas. In addition to this dumping of waste food materials on the banks of the reservoir is an added attraction for the crocodiles. It is evident from the Figure 8 that as the crocodiles were growing from the initial small size, the number of attacks has also increased, which shows that the size of the crocodiles also contributed to the human-crocodile conflict.

3.4. Response of local community

3.4.1. Population pressure

A major factor contributing to the human-crocodile conflict in the Neyyar Wildlife Sanctuary is the population near the reservoir. Local people are utilising the reservoir in a stretch of 26 km starting from Kappukad to Kumbichal (Fig. 7). Presence of people in the reservoir was observed from 0500 hours to 2300 hours. But the majority of the families (83%) were using the reservoir from 0500 hours to 1600 hours. During the study period about 35 people utilising a stretch of 3 km of the reservoir in the morning hours alone (0600 to 0700 hours) was observed.

People utilise the reservoir for various daily needs like washing, bathing, collecting water, washing cattle and retting of coconut leaves (Fig. 9). Apart from these, people cross the reservoir for collecting grass used as fodder, and for gathering firewood. As many of the private holdings are surrounded by water of the reservoir, people cross the reservoir using country crafts. Two Panchayaths are operating ferry services across the reservoir.

Number of households in the sampled areas is given in Table 13, which shows high density of houses near the reservoir. Main source of drinking water is the reservoir.

Table 13. Number of households near the vicinity of Neyyar Reservoir

Sl. No.	Locality Stretch of 1 km	Distance from the Reservoir (m)				Total no. of houses
		100	200	300	400	
1.	Kappukad	nil	Nil	6	6	12
2.	Mlavatti	nil	Nil	2	13	15
3.	Neyyar Dam	109	12	7	2	130
4.	Marakunnam	132	30	nil	12	174

5.	South Pantha	73	23	6	6	108
6.	Mayam	77	20	12	30	139
7.	Parathi	48	22	2	4	76
8.	Kumbichal	70	45	40	14	169
9.	Near Dam	35	40	52	72	199
10.	Puravi Malai	24	2	8	23	57
	Total	**568**	**194**	**135**	**182**	**1079**

Mean number of houses in one km stretch was 108. Maximum number of houses was seen near the dam site followed by Kumbichal, Marakunnam. If we extrapolate this into 26 km, 2808 houses exist on the banks of the reservoir within a 400 m width from the reservoir. Thus the high human population density on the banks of the reservoir, contribute to the human-crocodile conflicts. It is not practical to relocate the houses from the banks of the reservoir. Except for a few houses on the *Puramboke* area, all the houses were having genuine land records.

3.4.2. Socio- economic status

Out of the 150 families surveyed, there were 358 were males and 334 females. Among these families, only 35 families were ready to move out from the area in order to escape from the attacks of crocodiles. Educational status of these families showed that most of them were below matric (453); others included matric (160), higher secondary (57), and degree (23). Most of the houses have asbestos roofing (53) followed by reed roof (30), tiles (56) and other types of roof were only 12 in number and most of the houses were situated near the reservoir.

Occupation wise, the families were depending on daily wage labour for their livelihood (133), followed by farming (13). One is a Block Panchayath member and another one employed as a Government servant and another one is employed in a co-operative society. Among the surveyed houses, 130 houses were within a 100 m distance from the reservoir. The survey covered houses up to 800 m from the

reservoir (Fig. 11). Distribution of income is given in Figure 12. Sixty-three percent of families have an income below Rs.1000 per year. Details of people attacked by the crocodiles, obtained from the questionnaire survey, are included in Table 14.

3.4.3. Attitude towards conservation of crocodiles in the Neyyar Reservoir

In the opinion of the local people, shifting of crocodiles from Neyyar Reservoir is the most suitable solution to the problem (61%). Thirty-three families have no idea and 17 families (11%) favoured killing the crocodiles. Nobody supported the idea of conserving the crocodiles in the Neyyar Reservoir in the present circumstances. Other methods like constructing fences was suggested by seven; supplying drinking water through pipes was preferred by only one family, and shifting of families was suggested by one family. Sources of drinking water to the families were also ascertained from the survey. Sixty-one families (41%) depend on the reservoir, while 87 families on wells, 2 families on streams and one family on pond. All the families raise livestock and following are the details. Cattle are owned by 28, cat 38, dog 75, and goat by 17 families and hen by 75 families.

The analysis revealed that local population heavily depends on the reservoir for its daily needs (Plate 5). Most of the families depend on daily wage labour for their livelihood. In the opinion of local people removing the crocodiles from the reservoir, either by catching them or by killing them is the only one way to solve the problem.

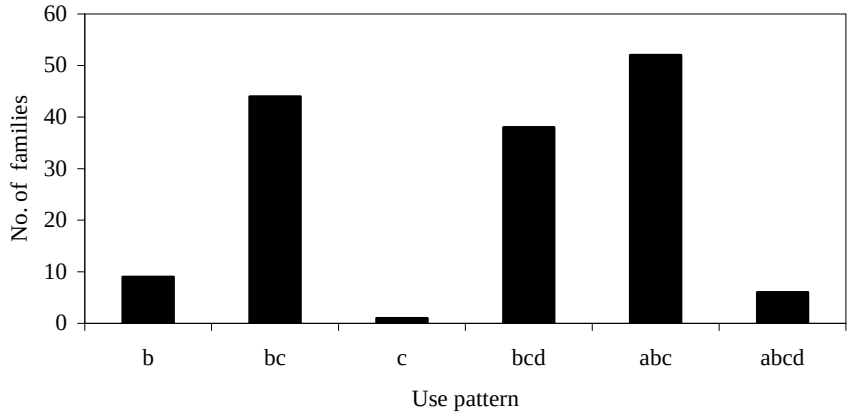

Fig. 10 Dependence of local people on Neyyar Reservoir

a = Drinking water, b = Bathing & washing clothes,

c = Washing of household materials, d = Bathing of cattle

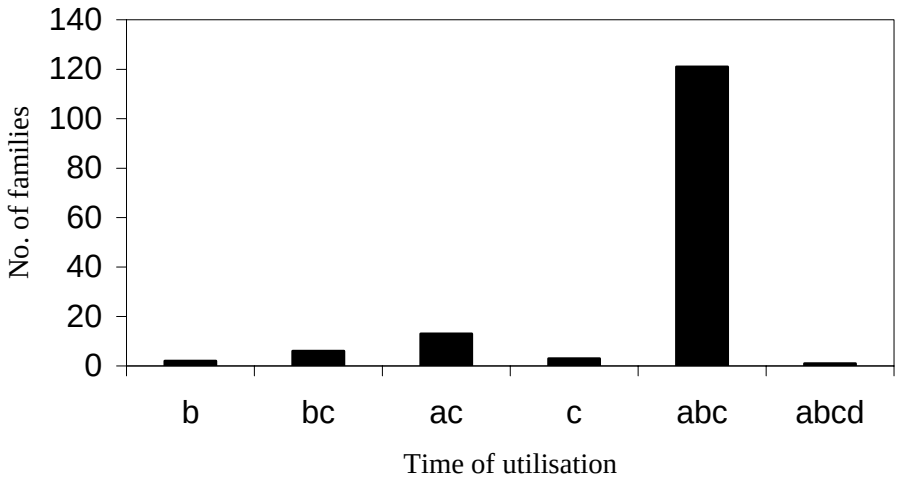

Fig. 11 Daily utilisation pattern of the Neyyar Reservoir

a. 0500 to 1000 hrs, b. 1000 hrs to 1300 hrs,
c. 1300 to 1600 hrs, d. 1600 hrs to 1830 hrs

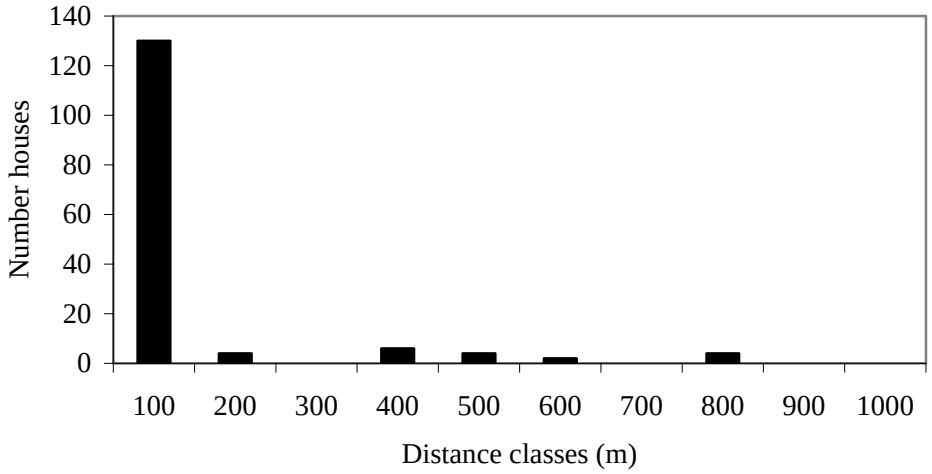

Fig. 12 Distance of houses from the Neyyar Reservoir which was surveyed through the questionnaire

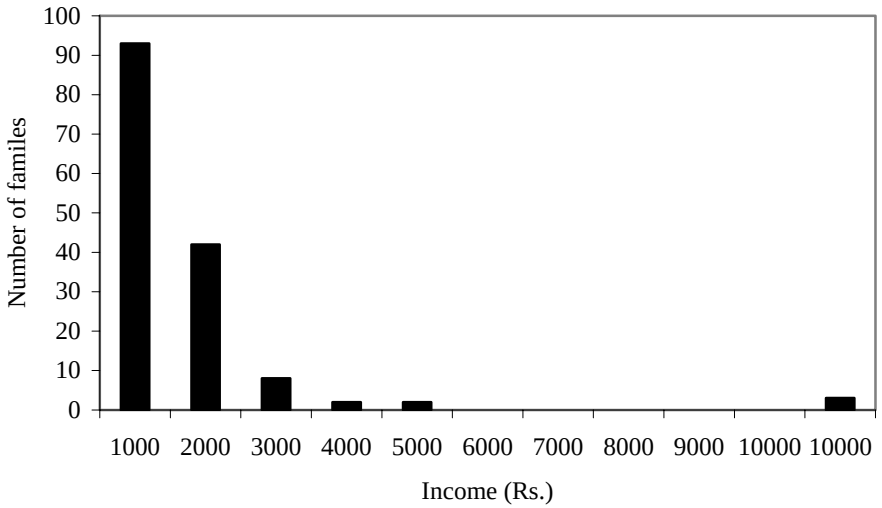

Fig. 13 Monthly income of familes covered in the questionnaire survey

3.5. Potential sites for relocating crocodiles

One solution suggested to solve the human-crocodile conflict was to relocate crocodiles from the Neyyar Reservoir to other reservoirs in the State. This method was suggested to solve the congestion in the captive population of crocodiles also. In this context, other potential reservoirs in the State were evaluated to relocate the crocodile from the Neyyar Reservoir. Reservoirs evaluated for this purpose were, Parambikulam Reservoir in Palghat District, Chimmony Reservoir in Thrissur District, Peruvannamuzhi Reservoir in Kozhikode District and Kakki Reservoir in Pathanamthitta District.

3.5.1. Evaluation of reservoirs

Crocodiles are usually found up to 600 m above msl. Due to this biological restriction, only low-lying reservoirs in Kerala can be considered for relocating crocodiles. Three reservoirs in the Parambikulam Wildlife Sanctuary can be considered for relocating crocodiles from Neyyar. But Parambikulam Wildlife Sanctuary already has wild crocodiles. There are no human settlements on the banks of the reservoir, as in Neyyar, except for a few tribal settlements. Habitat and climate is suitable for crocodiles here. But as already a thriving and good population of crocodiles exist at Parambikulam, shifting crocodiles to Parambikulam does not gain any conservation purpose. In addition to this, already a court case is pending against the transfer of crocodiles from Neyyar to Parambikulam.

Chimmony Wildlife Sanctuary is another potential site for relocation where no human habitations were found near the reservoir. Tribals who were staying in the forest areas near the reservoir have already been shifted to far away places. But one negative point is that this area never had the crocodile population earlier. Social acceptance for living with crocodiles is also not in favour of relocation of crocodiles from Neyyar.

Peruvannamuzhi Reservoir is not appropriate for relocating crocodiles because people are staying close to the banks and the reservoir is being used for transportation using boats. Apart from these, fishing is legalised in the reservoir, so that, the availability of food to crocodiles will be a problem. As the existing pens at Peruvannamuzhi can accommodate more crocodiles, at least 10 captive crocodiles from Neyyar can be shifted to Peruvannamuzhi. Construction of new crocodile pens at Peruvannamuzhi can also be considered for shifting excess crocodiles from Neyyar.

Kakki Reservoir is not suitable for crocodiles as it is located above 600 m above msl and the waters of the reservoir have connections to Pamba River through Kochu Pamba, which is utilised by Sabarimala devotees. If, by chance, any animal escapes to the Pamba River, more human-crocodile conflicts will happen. Social acceptance for introducing crocodiles is also negative; apart from these there is no history of crocodile population in the reservoir earlier. Parameters considered for assessing the suitability of reservoirs for relocating crocodiles are given in Table 14.

Table 14. Characteristics of Reservoirs considered for relocating Crocodiles from Neyyar Reservoir

Name of the Reservoir	Presence of settlements	Temper a-ture ^{0} C	Social acceptance	Presence of natural crocodiles
Parambikulam Thunakkadavu Peruvarippallm	Few	20-25	No	Yes
Peruvannamuzhi	Extensive	24-36	No	No
Chimmony	Nil	24-36	No	No
Kakki	Nil	19-25	No	No

According to Richard Ferguson, Vice Chairman (Africa), IUCN Crocodile Specialist Group, the Zimbabwe programme with *C. niloticus* was the only major reintroduction programme carried out in Africa. It ran for 5 years between 1991 and

1995. It is assessed as largely unnecessary and could have been implemented more successfully on a smaller scale in better selected areas. The animals were reintroduced from farms at around 1.2 m length into areas with existing crocodile populations. The existing populations varied in density from very low to quite high. The conclusions from the Zimbabwe reintroduction programme are reported as:

1. It was largely unnecessary *i.e.* animals were being added to systems with a large existing population and effective recruitment.
2. The animals were behaviourally naive and suffered considerable predation from resident adult crocodiles.
3. Many of the areas used for the release also support intensive gill-net fishery and many of the released and a smaller proportion of native crocodiles became entangled in nets and/or were drowned/clubbed to death by fishermen.

It is reported that in Africa also there have been a small number of incidents in which released animals have subsequently been shot for interfering with livestock and human use of the water bodies. It is assessed that the majority of the animals released in Zimbabwe during this programme will not yet have reached a size that is a real threat to humans. Human-crocodile conflict is on the increase in Africa and it is unlikely that large reintroduction programmes will ever be necessary or acceptable (Ferguson, 2002 Pers comm.).

Based on the above facts, it is not advisable to introduce crocodiles from Neyyar to other reservoir in the State. The large crocodiles caught from Neyyar if relocated to other areas may create problems in the new areas also.

A brochure on human-crocodile conflicts in Neyyar was prepared for distribution to the local people (Appendix 2).

3.6. Management of captive crocodiles

3.6.1. Crocodile Breeding Centre

Crocodile Breeding Centre at Neyyar was established in the year 1977 within an area of about 0.3 ha. Initially 15 crocodiles were there in the Centre. Twelve were brought from Madras Crocodile Bank and three locally. Twenty-six pens are now in operation (Plate 6). Twenty-nine crocodiles reared in the Centre were released in the reservoir during 1983. In March 2000, 66 crocodiles were kept in the farm and of these, 43 were adults above 10 years and 11 below 10 years. Three individuals were below 3 years of age. Number of crocodiles housed in each cage in each month is available in the records kept at the Range Office. This will be changing frequently with the arrival, shifting and death of crocodiles.

Feeding is done everyday except Monday. Food is usually provided in the morning hours at 1030 hours. The practice of providing food every day may need a revision, because the reptiles usually take food only occasionally. The suggested practice is to provide food once in a week during evening hours and the uneaten food removed the next morning. Otherwise, the crocodiles may indulge in fighting for getting the food. There is no scarcity for water in the centre. The current ration schedule followed at the Centre for captive crocodiles are given below.

1. Small sized (below 3 years)	: Beef 100 gm	(To be given on alternate days)
	Fish 100 gm	
2. Medium sized (3-10 years)	: Beef 200 gm	"
	Fish 150 gm	
3. Large sized (above 10 years)	: Beef 300 gm	"
	Fish 300 gm	

3.6.2. Infrastructure

The infrastructure of the Captive Breeding Centre is inadequate to maintain 66 crocodiles. Due to congestion in the cages, fighting between individuals has been reported. Inadequate number of cages was another problem. Death of crocodiles in captivity was mainly due to fight in the cage and subsequent injury and shock. All the existing cages in the Centre should be maintained and put to effective use. Leakage of water from the ponds may be rectified. Ten captive crocodiles may be shifted to the existing Peruvannamuzhi Captive Breeding Centre to reduce the congestion of crocodiles in pens at Neyyar. Care and maintenance of Mugger crocodiles as explained in detail by Antoon De Vos (1982), may be followed meticulously for the efficient management of the Centre.

Problem-crocodiles captured are usually held in captivity. A new spacious pen (similar to the one at Peruvannamuzhi) may be constructed at Neyyar. Some of the pertinent points, which should be followed while constructing the new pen, are given below. Each pond should be surrounded by a land area somewhat larger than the water area. The land area around the pool should be at least 4 m wide and there should be adequate basking facilities. Shade should be plentiful in the pools. The ponds should be in concrete and irregular in shape. The breeding enclosure should have a large centrally located pond with a surface area of at least 50 $m^{2.}$ The water-to-land ratio should be 40 to 60%.

3.5.3. Activity pattern

Major activities of the captive crocodiles can be divided into four. They are resting inside water, resting on the banks, moving in the cage and mating. Activity pattern of crocodiles is summarised and presented in Figure 13. From 0600 to 0700 hours, 70 percent of the crocodiles were taking rest inside water and by 0800 hours

when weather becomes hot, they come out of water and bask on the banks. At 1200 hours with temperature rising again, 65 percent of the crocodiles go inside the water. Again, at 1600 hours, only 40 percent of the crocodiles were seen in the water. Movement was only limited in the cages and maximum was recorded during the

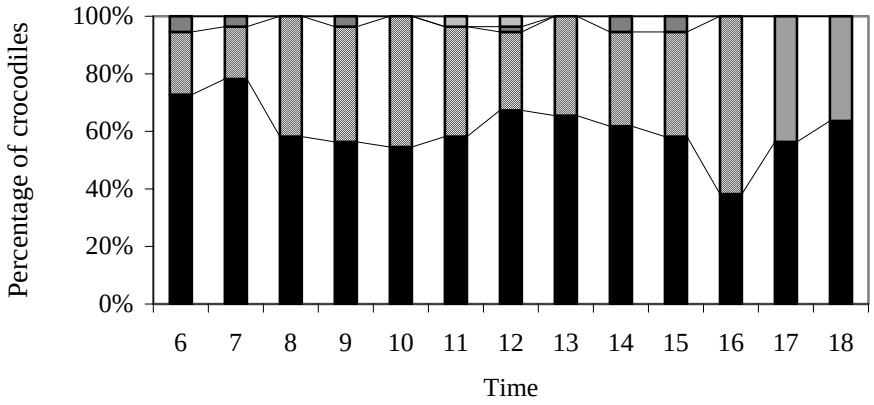

Fig. 14 Activity pattern of captive crocodiles

early hours. Two incidents of mating were observed in the cages, during the noon hours in the water. No detailed studies on behaviour in captivity were carried out, since this aspect was already studied in detail by Rosamma (1993). She had reported that the activity pattern of crocodiles is highly influenced by the variation in the temperature.

3.6.4. Capture of crocodiles

The methods for capturing crocodiles are given in detail by Blake (2002). Haagner and Reynolds (1992) have also given particulars of chemical capturing of crocodiles in Africa. Similarly, a method for restraint and transport of crocodiles was reported by Jones and Hayes-Odum (1994). It is reported that free-living crocodiles always take shelter in water when threatened. Chemical darting of wild crocodiles for capture is therefore not an option. They must be trapped first and then immobilised. Once in captivity small crocodiles can be physically restrained

whereas large crocodiles need drug immobilisation for avoiding injury to animals. Drug can be administered with a dart pole syringe or where possible by hand. As the veterinarians in the Forest Department do not have experience in drug immobilisation of crocodiles, it is recommended that training on capture of crocodiles using drugs may be given to at least two of them.

The Forest Department can utilise the expertise of the officers trained at the former Crocodile Breeding and Management Centre at Hyderabad for capturing the crocodiles. Madras Crocodile Bank, Mamallapuram, Tamil Nadu has sufficient experience in capturing and transferring crocodiles (Whitaker and Andrews, 1989). Their expertise can also be requested for capturing the crocodiles from the reservoir. If needed, skilled people to catch crocodiles from the reservoir may be brought from outside the country also.

4. Conclusions

Crocodiles are threatened by many human activities. Foremost and the most significant among these is the destruction or alteration of wild habitat. In the past, commercial over-exploitation and indiscriminate killing have resulted in many species suffering drastic decline in numbers and reduction in distribution, but no species has become extinct because of direct human exploitation. However, over exploitation combined with severe habitat loss has brought several species to the brink of extinction.

Crocodilians of all species depend wetland habitats. Different species have varying preferences and requirements and crocodilians have adapted to most available tropical and subtropical wetland types (marshes, mangroves, rivers, lakes, lagoons, etc.). Because crocodiles are quite large animals and as they grow from hatchling to adult, they require habitat that is both large and diverse. Rural people are often intolerant of large and potentially dangerous crocodiles and deliberate destruction of both nests and adults has been widely reported from the Andamans, China, Bangladesh, Madagascar and Neyyar. Conservation of crocodilian population is therefore highly dependent upon providing incentives to maintain crocodiles and their habitats in a relatively undisturbed state, and a willingness to accept management practices that allow crocodiles and humans to co-exist.

One cannot relate the human attacks to scarcity of food in the case of crocodiles. Crocodiles of a sufficiently large size usually attempt to prey on larger animals including humans in vulnerable locations independent of other food sources or lack thereof. It might be generally true that extremely well fed crocodiles with an abundance of natural prey might be less likely to prey on people, but this is not a certain rule. The relative size of prey, prey behaviour and particularly the apparent vulnerability of prey, all may be involved in a crocodile’s 'decision' to prosecute an attack. People, particularly of smaller stature (women and children), at the water’s edge or in the water, distracted by other activities (washing, fishing), following

predictable daily patterns of movement and becoming complacent about crocodiles are likely to be attacked sooner or later. Crocodiles are careful, opportunistic and patient (Ross, Personal Communication).

The best solution is to change people's behaviour so that they are unlikely to encounter crocodiles in the crocodile's habitat. The provision of enclosures within which people can access the water's edge in safety to wash, collect water etc. is a simple and feasible solution. This is not feasible at Neyyar due to the long distance of 26 km and undulating water table and the steepness of banks. It is also possible to manipulate the size distribution of the crocodiles, removing some of the larger and more dangerous individuals to other locations (Ross, 1998). Walsh and Whitehead (1993) also suggested capturing problematic crocodiles for relocation as a management strategy in Australia. Another strategy to manage the crocodile populations is to treat them as a resource (Brazaitis, 1983) and utilise it.

Due to social commitments, it is practically not possible to relocate people from the fringes of the Neyyar Reservoir to other areas. Except for a few recent encroachers on the bank of the reservoir, majority of the people have been staying there even before the crocodiles were released into the reservoir. From our studies, it is clear that even if the local population is provided with drinking water they will continue to utilise the reservoir for bathing, fishing and washing of cattle. During summer, people from far away places also depend on the reservoir for drinking water and bathing. Taking bath in the reservoir has become an age-old practice, which the local people are not ready to give up. This happens all along the length of 26 km of the reservoir where people reside.

As the local inhabitants dump waste food materials, including meat, in the reservoir, there is an added attraction for crocodiles to be near human habitations than the interior forests. As the herbivore population is low in density, crocodiles are always attracted towards the populated areas from where easy prey like dog, cow, goat and poultry and discarded waste food are easily available.

5. Management strategies

Based on the study, the following management strategies haven been suggested to mitigate the problems connected with human-crocodile conflict in the Neyyar Wildlife Sanctuary and also with regard to the crocodiles in captivity.

5.1. Wild crocodiles

1. Census of crocodiles

Assessment of population of crocodiles in the reservoir is a prerequisite for any management decision. It is recommended to census the crocodile population in the Neyyar Reservoir every year when the level of water is the lowest, usually in the month of May. Continuous monitoring of crocodile population is necessary to avoid conflicts with humans.

2. Removal of the large crocodiles from Neyyar Reservoir

The case studies at Neyyar revealed that large crocodiles above 3 m length are involved in all the fatal attacks on humans. It is also evident that initially, when the crocodiles were introduced in 1983, their size was small and the number of attacks was minimal or nil. However, as they grew older and size increased, the number of attacks also increased. All the crocodiles more than 3 m in length, seen near the inhabited areas, are potential attackers on humans. It is recommended to capture the crocodiles of length 3 m and above from the Neyyar Reservoir (10 to 16 crocodiles) and maintain them in captivity. NGO's specialising on crocodiles, for example, Madras Crocodiles Bank, Mamallapuram, Tamil Nadu have sufficient experience in capturing and

transferring crocodiles. Their expertise can be sought for capturing crocodiles from the reservoir and also for getting the Forest Department staff trained in capturing crocodiles.

Problem-crocodiles captured are usually held in captivity. A new pen may be constructed at Neyyar for maintaining the captured crocodiles following the principles outlined in Chapter 3.6.

3. Training on chemical immobilisation

Chemical darting of wild crocodiles for capture is not an option because free-living crocodiles always take shelter in water when threatened. They must be trapped first and then immobilised. Large crocodiles need drug immobilisation for avoiding injury to animals. The veterinarians in the Forest Department should be trained in drug immobilisation of crocodiles.

4. Public awareness

Effective public awareness programme may be initiated to explain both the nature of attack and precautions to be taken by the public. Following precautions need to be highlighted.

i. Avoid entering water at dusk, dawn or night.

ii. Avoid going into the reservoir alone.

iii. Don't leave children alone near the reservoir.

iv. Avoid grazing of livestock near the water.

v. Take extra caution during the breeding period of crocodiles starting from December to May.

vi. Fight back if attacked.

5.2. Crocodiles in captivity

1. Facilities in the Captive Breeding Centre at Neyyar

The present infrastructure of the Captive Breeding Centre is inadequate to maintain 66 crocodiles. All the unused cages in the Centre should be repaired and put to effective use. Water leakage from the existing ponds should be stopped.

2. Shifting of excess crocodiles from captivity

Due to inadequate space in the cages, fighting among the existing captive crocodiles has been reported. Death of crocodiles in captivity was mainly due to the fights and subsequent injury and shock. Ten captive crocodiles may be shifted to the existing Peruvannamuzhi Captive Breeding Centre to reduce the congestion of crocodiles in the pens at Neyyar.

6. Acknowledgements

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7. References

Acharjyo, L.N. 1978. Return of the captive Marsh Crocodile (*Crocodilus palustris*) into the wild. *Indian Forester* 104: 385.

Acharjyo, L.N. and S. Mohapatra 1977. Growth rate of Mugger (*Crocodilus palustris*). *Hamadryad* 2: 9.

Allsteadt, J. 1994. Nesting ecology of *Caiman crocodilus* in Cano Negro, Costa Rica. *J. Herpetol.* 28(1):12-19.

Anonymous, 1982. Attack by nest guarding female Mugger (*C. palustris*) *Hamadryad* 7 (2): 3

Antoon De Vos, 1982. *A Manual on Crocodile Conservation and Management in India*. FAO Project IND/82/003. Dehra Dun, Uttar Pradesh. P 69.

Arumugam, A. and H. Andrews 1993. Status of the Mugger crocodile (*C. palustris*) in the Sathanur Reservoir, Tamil Nadu, Report C-1/93, *Centre for Herpetology*, Madras Crocodile Bank, Tamil Nadu.

Banerge, R. 1985. Nest guarding by Estuarine Crocodile – A behaviour study in the Sunderban. *J. Bombay nat. Hist. Soc.* 82: 214 – 215.

Bechura, B.K. and L.A.K. Singh 1979. Conservation of Crocodiles in India. *Indian Forester* 83 – 92.

Behra, O. 1996. Reports of crocodile attacks on people in Madagascar. *Crocodile Specialist Group Newsletter* 15(3):3-4.

Biswas, S. 1970. A preliminary survey of Gharial in the Koshi River. *Indian Forester* 96: 705 – 710.

Blake, D. K. 1992. A basic method for the collection and incubation of crocodilian eggs. *J. Herpetol.* Assoc. Afr. No. 40. p. 97-99.

Blake, D. K. 2002.The Nile crocodile *Crocodylus niloticus:* capture, care, accommodation, and transportation, *In: The capture and Care Manual Ed.* Andrew A. McKenzie On line version.

Brazaitis, P. 1983. *Crocodiles as a Resource for the Tropics*. National Academy of Sciences, Washington, D.C.

Buenviaje, G. N.; P. W. Ladds; L. Melville and S. C. Manolis 1994. Disease-husbandry associations in farmed crocodiles in Queensland and the Northern Territory. *Aust. Vet. J.* 71(6):165-173.

Bustard, H.R. 1975. Crocodile conservation in India. *Tiger Paper* 2: 17.

Bustard H.R. and B.C. Chaudhury 1980. Parental care in the Salt water crocodiles (*Crocodiles porosus*) and management implications. *J. Bombay nat. Hist. Soc.* 77: 64 – 69.

Bustard, H.R. and B.C. Chaudhury 1981. Marking crocodiles for release back into the wild for subsequent identification. *Indian Forester* 102: 447 – 485.

Bustard, H.R. and S.K. Kar 1981. Defence of the nest against man by the salt-water crocodiles (*Crocodilus porosus*). *J. Bombay nat. Hist. Soc.* 77: 514 – 515.

Bustard, H.R. and S. K. Kar 1981. Attack on domestic livestock by the saltwater crocodile (*C. porosus*) in Orissa, India. *Brit. J. Herpetol* 6 1981.p.

Bustard, H.R. and S. K. Kar 1981. Crocodile predation on man *Brit. J. Herpetol* 6 : 222-223.

Bustard, H.R. and L.A.K. Singh 1981. Gharial attacks on man. *J. Bombay nat. Hist. Soc.* 78 (3): 610-611.

Chaudhury, B.C. and H.R. Bustard 1975. Restocking Mugger crocodile *Crocodylus palustris* (Lesson) in Andhra Pradesh: Evaluation of a pilot release. *J. Bombay nat. Hist. Soc.* 79: 275-289.

Conover M. R. and T. J. Dubow 1997. Alligator attacks on humans in the United States. *Herp. Review* 28(3):120-124.

Crocodile Specialist Group 1992. Crocodile conservation action. A special publication of the crocodile specialist group of the Species Survival Commission of the IUCN - The World Conservation Union. IUCN (Int. Union Conserv. Nat. Nat. Resour.) Gland, Switzerland 128p.

CSG. 1995. Preliminary survey of *Crocodylus palustris* in the Kabini River. *Crocodile Specialist Group Newsletter* 14 (1): 6.

CSG. 1997. Black caiman attack. *Crocodile Specialist Group Newsletter* 16(3):11-12.

CSG. 1998. Zambia to kill man-eating crocodiles. *Crocodile Specialist Group Newsletter* 17(1): 8.

CSG. 1999a. Woman (70) killed by crocodile in Jamaica. *Crocodile Specialist Group Newsletter* 18(4): 12.

CSG. 1999b. Killer crocodile caught by villagers (Malaysia). *Crocodile Specialist Group Newsletter* 18(2): 6.

CSG. 1999c. New water scheme to protect people from crocs (South Africa). *Crocodile Specialist Group Newsletter* 18(1): 3-4.

CSG. 2000. Crocodile magic kills Malawians. *Crocodile Specialist Group Newsletter* 19(1): 3-4.

CSG. 2000 a. Crocodile killers use dogs as bait (Sri Lanka). *Crocodile Specialist Group Newsletter* 19(1): 10-11.

Daniel, J.C. 1983. The Book of Indian Reptiles. Bombay Natural History Society. pp11.

D' Abreu, E.A. 1915. Note on the Mugger (*Crocodilus palustris*) contents of their stomach's, folklore, etc. *J. Bombay nat. Hist. Soc.* 23: 780.

De Waard, J.M. 1978. Economic potential of Indian Mugger crocodile farming (*Crocodilus palustris*). FAO, FO:IND/74/046, May 1978, PP 24.

Dharam, A K. 1947. Mating and the parental instinct of the Marsh crocodiles (*Crocodilus palustris*). *J. Bombay nat. Hist. Soc.* 47: 175.

Gallagher, G. J. 1993. The farmed/ranched alligator production industry. *Aquacult. Mag.* 19(6): 93-94.

Godshalk, R. E. 1994. Feasibility of a conservation and sustainable yield plan for the Yacare caiman, *Caiman crocodilus yacare*, in Bolivia. M.S. thesis, University of Florida, U.S.A.

Haagner, G. V. and D. S. Reynolds 1992. Preliminary observations on the use of zoletil for the immobilisation of captive Nile crocodiles, *Crocodylus niloticus* (lauranti). *J. Herpetol. Assoc. Afr.* No. 41. p. 25-27.

Jelden, D. and H. Messel 1992. Summary Report of the Crocodile Specialist Group Review Committee on Crocodile Management in Thailand. In: *Crocodile Conservation Action.* A Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - The World Conservation Union. Gland, Switzerland. p. 71-77.

Jimenez, Y. L. 1998. Crocodile attacks cause conservation crisis. La Nacion, San Jose Costa Rica, translated and reprinted CSG newsletter 17(3): 8-9.

Jones, D. and L. Hayes-Odum 1994. A method for the restraint and transport of crocodilians. *Herpetol. Rev*. 25(1): 14-15.

Kar, S.K. and H.R. Bustard 1979. Sexing of crocodiles in captivity. *Indian Forester* 106: 545 – 546.

Krishnamurthy, V.S. 1980. Some observations on the growth of captive crocodiles. *J. Bombay nat. Hist. Soc.* 77: 516 – 521.

Krishnamurthy, V.S. and R. Bhaskaran 1976. Growth studies on two species of crocodiles in captivity. *J. Bombay nat. Hist. Soc.* 73: 532 – 533.

Kumar, V. V., R. Vayas and B. C. Chaudhury 1999. Status of Mugger in Gujarat State (India). *Crocodile Specialist Group Newsletter* 18(2): 7-8.

Lazcano B. M. A. 1996. Crocodile attacks in Cancun (Mexico). *Crocodile Specialist Group Newsletter* 15(4): 18-19.

Marais, J. and G. A. Smith. 1992. Ecological and economical status of the Nile crocodile *Crocodylus niloticus* in South Africa. *J. Herpetol. Assoc. Afr*. No. 40. p. 102-103.

Marais, J. 1992. South Africa-Zambia crocodile census. *Afr. Herp News* No. 18. p. 13-14.

McCann, C. 1935. The Mugger (*Crocodilus palustris*) feeding on large water beetles (*Cybister* sp.). *J. Bombay nat. Hist. Soc.3*8: 409.

Messel, H.; D. Jelden and G. Hemley 1992. Summary Report of the Crocodile Specialist Group Review Committee on Crocodile Management in Indonesia. In: *Crocodile Conservation Action*. A Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - The World Conservation Union. Gland, Switzerland. p. 55-70.

Messel, H. and F. W. King 1992. Conservation and sustainable use of *Caiman yacare* in Paraguay. In: *Crocodile Conservation Action*. A Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - The World Conservation Union. Gland, Switzerland. p. 78-97.

Messel, H. and F. W. King 1992. Survey and plan for recovery of the crocodile population of the Republic of Vanuatu, southwestern Pacific Ocean and a project for the sustainable use of wildlife resources based at Port Patteson on Vanua Lava, Banks Islands, in the Banks-Torres conservation region. A report to the Government of the Republic of Vanuatu, Port Vila, Vanuatu. In: *Crocodile Conservation Action*. A

Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - The World Conservation Union. Gland, Switzerland. p. 102-128.

Messel, H.; F. W King; Grahame J. W. Webb and Charles A. Ross 1992. Summary report on the workshop on the prospects and future strategy of crocodile conservation of the two species (*Crocodylus mindorensis*, *Crocodylus porosus*) occurring in the Philippines. In: *Crocodile Conservation Action*. A Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - The World Conservation Union. Gland, Switzerland. p. 98-101.

Ottenwalder, J. A. and J. P. Ross 1992. CITES Mission to Cuba, June 9-June 16, 1991, Report of the Technical Advisors, Part 2, Crocodilians. In: Crocodile Conservation Action. A. Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - The Conservation Union. Gland, Switzerland. p. 28-40.

Pillai, K.G.M. 1999. Crocodile conservation in Kerala. *Envis* 2 (1): 58-61.

Pinchin, A. 1994. Conserving the Nile crocodile in Zimbabwe - the value of sustainable yield utilisation. *Int. Zoo News* 41(2): 19-24.

Rao, R. J. and B. C. Chaudhury 1992. Sympatric distribution of gharial *Gavialis gangeticus* and Mugger (*Crocodylus palustris)* in India. *J. Bombay Nat. Hist. Soc*. 89(3): 312-315.

Rosamma, K.M. 1993. Studies on crocodile species of Kerala. Ph.D. Dissertation. University of Kerala, India.

Ross, J. P. (Ed.) 1998. Crocodiles. *Status Survey and Conservation Action Plan*, 2nd edition. IUCN/SSC Crocodile Specialist Group. IUCN, Gland, Switzerland and Cambridge UK.

Ross, J. P. 2000. Status Survey and Conservation Action Plan, Crocodiles. Second Edition **(**Editor)**,** *IUCN/SSC Crocodile Specialist Group*

Ross, J. P. 1992. Crocodilian management in Honduras - report of a fact finding mission to Honduras, 20-25 September 1992. *In: Crocodile Conservation Action*. A Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN-The World Conservation Union. Gland, Switzerland. p. 41-53.

Ross, J. P., M. S. Cherkiss & F. J. Mazzotti 2000. Problems of success: Conservation consequences of crocodilian-human conflict. Pp. 442-445 In Crocodiles, *Proceedings of the 15th Working Meeting of the Crocodile Specialist Group, IUCN-The World Conservation Union, Gland Switzerland and Cambridge UK*.

Sagar, S. R. and L. A. K. Singh 1993. Captive breeding and rehabilitation of Mugger crocodile (*Crocodylus palustris*) in Similipal Tiger Reserve, Orissa, India. *Indian For*. 119(10): 807-815.

Sebastian, A. C. 1992. One too many Muggers at croc bank. *Asian Wetland News* 5(1): 8.

Singh, L.A.K. 1984. Observations on food requirement and food conservation in the Mugger (*Crocodilus palustris*) reared in captivity. *J. Bombay nat. Hist. Soc.* 80: 418 – 423.

Singh, L.A.K. 1984a. Observations on the movement of two captive- reared Mugger crocodiles, *Crocodylus palustris* Lesson when returned to the wild. *J. Bombay nat. Hist. Soc.* 80: 86-90.

Singh, L.A. K. and D.P. Rath 1999. *Envis* 2 (1): 118-153.

Singh, L.A.K. 1999. A profile of Indian crocodiles *Envis 2* (1): 1-5.

Solmu, G. 1996. Another attack in PNG. *Crocodile Specialist Group Newsletter*. 15 (1): 8.

Thorbjarnarson, J. B. and G. Hernandez 1993. Reproductive ecology of the Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. I. Nesting ecology and egg and clutch relationships. *J. Herpetol*. 27(4): 363-370.

Thorbjarnarson, J. B. and G. Hernandez 1993 a. Reproductive ecology of the Orinoco crocodile (*Crocodylus intermedius*) in Venezuela. II. Reproductive and social behavior. *J. Herpetol.* 27(4): 371-379.

Vighnarajan, G. 1990 Neyyar Wildlife Sanctuary, Management Plan 1990-91 to 1999-2000. Kerala Forest Department, Thiruvanathapuram. 12-13.

Vijaya, J. 1981. Crocodile nesting at Sathanur. *Hamadryad* 6: 2 3-4.

Walsh, B. and P. J. Whitehead 1993. Problem crocodiles, *Crocodylus porosus*, at Nhulunbuy, Northern Territory: An assessment of relocation as a management strategy. *Wildl. Res*. 20(1): 127-135.

Webb, G. J. W. and B. Vernon 1992. Crocodilian management in the People's Republic of China - A review with recommendations. In: *Crocodile Conservation Action*. A Special Publication of the Crocodile Specialist Group of the Species Survival Commission of the IUCN - The World Conservation Union. Gland, Switzerland. p. 1-27.

Webb, G. J. W. and S. C. Manolis 1993. Conserving Australia's crocodiles through commercial incentives. In: *Herpetology in Australia: A Diverse Discipline*. Daniel Lunney and Danielle Ayers, (Editors). p. 250-256.

Whitaker R. 1976. Nests collected in Tamil Nadu. *Hamadryad* 1:2 p 6.

Whitaker, R. 1976a. A note on crocodilian sex determination. *J. Bombay nat. Hist. Soc.* 73: 531 – 532.

Whitaker, R. and Z. Whitaker 1977. Collection and hatching of Marsh Crocodile (*Crocodilus palustris)* eggs. *J. Bombay nat. Hist. Soc.* 73: 403 – 407.

Whitaker, R. 1977. Notes on captive breeding in Mugger. *J. Bombay nat. Hist. Soc*, 75: 228-231.

Whitaker, R. 1978. Growth rate of *Crocodilus palustris J. Bombay nat. Hist. Soc*. 75: 231 – 232.

Whitaker, R. 1978. Note on the status of the Gir Crocodiles. *J. Bombay nat. Hist. Soc.* 75: 224 – 227.

Whitaker, R. and J.C. Daniel 1978. The status of Asian crocodiles. *Tiger Paper* 5(4): 6.

Whitaker, R. 1979. Future of crocodiles in Tamil Nadu. *Indian Forester* 105 (8): 14-15.

Whitaker, R. 1982. Crocodile conservation in India. *The Zimbabwe Science News* 16(9): 210-213.

Whitaker, R. and J.C. Daniel 1990. The status of Indian crocodiles. *J. Bombay Nat. Hist. Soc*. 75:8.

Whitaker, R. 1981. Optimum growth rates of captive Mugger *Crocodilus palustris* at Madras crocodile Bank. *Indian Forester* 102 – 103.

Whitaker, R. 1984. Reproduction biology of the Mugger *Crocodilus palustris*. *J. Bombay nat. Hist. Soc*. 81: 297 – 316.

8. Appendices

Appendices 1

QUESTIONNAIRE SURVEY ON CONSERVATION OF CROCODILES

(PROJECT: KFRI\349\2000)

Schedule No.:

Date :

Time :

A: IDENTIFICATION DETATILS

1. Name of the area :

2. Distance of the house from Reservoir :

B. PROFILE OF THE RESPONDENT

3. Name of the respondent/house holder :

4. No. of members in the house

a. Male b. Female c. Children

5. Occupation

6. Educational status

Sl. No.	Below metric /metric /H.Sc.	Degree and above

7. Approximate annual income of the family:

C. DEPENDENCE ON RESERVOIR

8. Source of drinking water :

9. Status of Live stock

1. Cattle
2. Goat
3. Dog
4. Cat
5. Other (specify)

10. If your have a Cattle/Goat, How do you feed animals?

a. Stall feeding b. Grazing C. both D. Others

11. If stall fed, from where do you get the fodder?

a. From own land b. Forest c. Both d. Others

12. If grazed, where does it go for grazing?

a. Near the Reservoir b. Near by forest area C. both D. others.

13. Did ever Crocodile or any other wild animals attack your domestic animals?

14. Dependence on Neyyar Reservoir:

a. Drinking water
b. Bathing & washing clothes
c. Washing of household materials
d. Bathing of cattle
e. Others (specify)

15. Time of utilisation of lake:

a. 0500 hrs to 1000 hrs
b. 1000 hrs to 1300 hrs
c. 1300 hrs to 1600 hrs
d. 1600 hrs to 1830 hrs

16. Whether own water source available : Yes/No

D. Conflict with Crocodile

16. Any incidence of attack by crocodiles

a. Human beings b. Domestic animals C. Others

E. Details of attack

17. Time Date Area Mode of attack

a. Name
b. Age
c. Male/Female

18. Damage caused by the attack

19. Any compensation obtained : Yes/No

If yes, amount :

20 approximate age of Crocodile : Small/Middle/Huge

21. Reason for attack :

22. Awareness about crocodile attack : Well/Normal/Nil

23. Awareness about habits of Crocodiles : Well/Normal/Nil

24. Do you go for fishing :

25. Mode of fishing :

26. Have you seen any crocodile in the wild :

27. How do you avoid crocodiles now? :

28. If provided alternate land are you ready to move out :

29. Are you thinking of moving out from here due to this problem :

30. Do you prefer construction of well as a source of drinking water :

31. Do you know that crocodile is an endangered animal :

32. How can this problem be solved :

F. Housing and infrastructure

33. Roof type : Reed hut/Tiled/Asbestos/ Others

34. Types of wall : Mud/Brick/Reed/Bamboo/Others