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## INTRODUCTION

In accordance with a request from the Government of India for assistance in the development of a crocodile farming industry, the Food and Agriculture Organization of the United Nations (FAO) under the United Nations Development Programme (UNDP) appointed Dr. H.R. Bustard as Consultant (Crocodile Farming) for four months, to be divided into two visits, between May 1974 and March 1975.

The terms of reference for the consultancy were: 'The consultant will assist the Government of India with the establishment of crocodile farm in the New Delhi Zoo, where all facilities for this enterprise could be made available in order to raise crocodiles for harvesting of their skins. If successful, similar farms should be developed in other parts of India.'

However, on arrival the consultant was informed that the problem was of greater magnitude, involving conservation of India's three crocodylian species as well as development of an industry. Government of India requested that the terms of reference be extended and that the consultant:

- (1) investigate and report on the possibility and prospects of farming crocodiles in captivity initially for purposes of conservation in view of the depleted stocks in the wild, and subsequently for commercial purposes.
- (2) undertake tours in the States of Uttar Pradesh, West Bengal, Orissa, Bihar, Tamil Nadu, Andhra Pradesh, Karnataka and Rajasthan in order to provide this information and to define suitable areas where this work could be undertaken.
- (3) indicate how best such captive breeding can be carried out in these different areas from the viewpoint of conservation and economic return.
- (4) devote particular attention to the gharial (Gavialis gangeticus) considered by Government of India and I.U.C.N. experts to be critically endangered.

As a result of the extended terms of reference the initial visit, planned to last six weeks, was extended to twelve weeks. The second mission will provide a detailed assessment of a few selected sites. The initial visit permitted tours to all the States specified in the extended terms of reference. However, in view of the large distances involved and the limited time available these visits must be considered preliminary at this stage. Since time available varied greatly between States, as did distances between prospective sites within any one State, coverage has been unequal.

The opportunity of extremely wide travel afforded the expert within India has provided an excellent overall informational background into the causes of depletion and steps are suggested to conserve the remaining crocodiles in order to build up sufficient stocks of each species for conservation and industrial purposes.

Economic projections must be considered extremely tentative at this stage as the rate at which economic goals can be attained depends not only on the holding capacity of the habitat, and such biological factors as growth rate and reproductive potential, but also on the size of the populations available for management. Accurate censuses have not yet been attempted. These will be included in the second phase of the mission. However, as described in Chapters II and III of the report, it appears that following the implementation of sound management, combined with marketing strategy, a foreign exchange earning industry can be created.

General information has been gathered into the main body of the report. Information relevant mainly to specific States and detailed data on ecological relationships between crocodiles and fisheries has been included in Appendices I-XI.

FAO is indebted to many people who collaborated with the expert during his assignment and who offered helpful advice and assistance. In particular, thanks are due to the Inspector General of Forests, Mr. K.L. Lahiri, the Deputy Secretary (Wild Life), Mr. Ranjit Singh and the IFS officers in the States.

## I. OUTLINE REVIEW OF THE STATUS OF INDIAN CROCODILES\*

### Introduction.

There are three species of crocodilian in India:

- 1) The saltwater or estuarine crocodile (Crocodylus porosus) which grows to more than 7 metres, and is mainly restricted to coastal mangrove areas.
- 2) The freshwater, swamp crocodile, or mugger (Crocodylus palustris) hereafter referred to as the 'mugger'. The mugger, average adult size of which is 3½ meters, inhabits rivers, pools, ponds, village tanks, lakes, swamps and reservoirs.
- 3) The gharial (Gavialis gangeticus), the sole living member of the family Gavialidae. This unique long snouted fish-eating crocodilian is a riverine species of the north Indian Himalayan-fed river systems. The gharial attains a large size - more than 8 metres, and individuals of 6 to 7 metres were formerly common.

Crocodile resources have shown catastrophic decline worldwide in the postwar period largely as a result of sophisticated hunting methods combined with the insatiable demand for hides by the luxury leather market. Control of shooting was generally lax, if it existed at all, and in many parts of the world whole populations disappeared before adequate controls could be implemented.

India has been no exception. Crocodile populations have been extremely hard hit.

Crocodile hunting is now legally banned in India. The Wild Life (Protection) Act, 1972 lists both species of crocodile and the gharial under Schedule I which affords total protection at all times. Similarly Export I Instruction No.46/73 forbids the export of crocodiles and gharial, their hides or products therefrom.

### Status

As a result of their differing geographical distribution and habitat preferences the status of the three species is considered separately.

a) Saltwater crocodile (C. porosus). No reliable scientific information exists on the current status of the saltwater crocodile in India, which formerly occurred abundantly in suitable coastal habitat from Cochin (10° s.) in West India round the peninsula and up the East coast to what is now Bangladesh. Early writers frequently commented on its abundance. The herpetologist Gunther (1863) wrote, 'This is a very common species along all the rivers of the East Indian continent and Archipelago'. More recently Deraniyagala (1939) noted, 'it flourishes along the shores of the Bay of Bengal'. Within the memory of reliable living witnesses this species was still very numerous in most suitable habitat.

It seems certain that, although numbers are now greatly reduced, sporadic individuals still occur throughout much of the former habitat. Certainly the species still exists in Bengali Sunderbans and in the mangrove areas of Orissa (Bhitar Kanika - Chandbali coast). Wild life personnel within the Forest Departments of the States of Andhra Pradesh (continuous with Orissa) and the adjoining State of Tamil Nadu felt certain that the species still occur coastally in their States.

\*Based on preliminary investigations by the expert in the States of Uttar Pradesh, West Bengal, Orissa, Bihar, Tamil Nadu, Andhra Pradesh, Karnataka and Rajasthan during the period 11 May to 31 July 1974

The two remaining strongholds of the saltwater crocodile in India are Bengali Sunderbans and Bhitara Kanika - Chandbali coast in Orissa. In both areas of species has been severely hunted but evidence of recent hunting in the Bhitara Kanika area is scant. Adverse weather conditions (extremely rough seas) prevented thorough investigation of the Bengali Sunderbans. However, enough of the area was seen (approximately 100m.(160 km.) of waterways) to confirm that it provides first class habitat in which saltwater crocodile populations could be managed (Appendix 3). In Bhitara Kanika discussions with local people, examination of the habitat, and a brief nocturnal survey, confirmed the presence of an ideal environment, where the species was formerly common, and that the species appears to be holding its own, perhaps even recovering following cessation of hunting activity (Appendix 4).

The habitat of the saltwater crocodile has been little affected upto the present time. No land/water alienation has occurred of any magnitude. The only important feature to guard against is felling of mangrove timber immediately adjacent to the saline creek habitat of this species. In both main areas referred to above fishing operations are traditional and pose no problems for build-up of large saltwater crocodile populations. Nor would the return to such population levels be in any way antagonistic to the local people. Were they to participate fully, as is suggested should be the approach followed in any development policy (Recommendation 5), they would give the project their wholehearted support.

b) Gharial (Gavialis gangeticus). The gharial, formerly an abundant species\* faces a critical situation in which its survival is in jeopardy. Its habitat has been alienated much more radically than that of the other two species. Habitat has disappeared as a result of 'training' rivers between embankments to prevent flooding (Biswas, 1970b), 'tidiness' in planning (in which 'unsightly' natural features such as large sandbanks, essential for gharial nesting, are replaced by concrete embankments), and loss of former riverine habitat by dam construction for irrigation or hydro-electric schemes. These, combined with fishery management of the resulting habitat, and the lethal effect of set nylon nets now used in fishing, and poaching activity, have all weighed heavily against the survival of this species. Habitat for gharial, free from alternative detrimental usage, no longer exists.

The gharial has shown remarkable adaptation to the loss of its nesting sandbanks in the main river courses, flooded as a result of increased water levels resulting from dam construction, and has successfully adapted to nesting in nullas (side creeks). Its extirpation from the remaining habitat has come about as a result of set netting, now standard fishing procedure.

Remaining populations are extremely small and the rate of loss means that extinction is certain within the very near future. The population on the Mahanadi River in Satkosia Gorge is down to 5 (two males and three females). The eggs are under constant threat from the Matia, a nomadic tribe employed by the PWD in earthwork construction, who relish crocodile eggs and are skilled in nest detection (Appendix 4).

In Rajasthan the species still occurs in the Chambal River but the rate of loss once again means that it will very soon become extinct there. The best comparatively safe habitat is the 12 m. (19 km) stretch of the Chambal between Rana Pratap Sagar Dam and Jawahar Lal Sagar Dam (Kota Dam not the barrage). According to a Forest Ranger with a lifetime's experience of the area and a keen interest in gharial, the mature gharial population consists of about 10-15 individuals. The expert was advised that the gharial were not threatened by poaching or fishery activities. However, as a result of a brief survey it was found that no less than 7 large gharial had been killed

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\*For instance James Inglis (1890) in his book 'Adventure in Tiger Land' wrote, 'Going down the river KOSI (north Bihar) particularly you come across hundreds sometimes lying on one bank, Col. K.K.Singh told the expert that on a boat journey from Kota to Pali down the Chambal River (Rajasthan) - a distance of about 100 miles (160 km.) - he shot 100 crocodiles of which 50-60 were gharial.

during a fishery contract lasting 4-5 days in the previous month. All had been skinned. Since this is half the estimated population the future for the remainder is hopeless unless the area is gazetted as a Sanctuary, fishing activity is stopped and active patrolling instigated. The area is not well suited to fishing being extremely rocky. It is, however, ideally suited to gharial (See Chapters II and II and Appendix IX) but unless the area is transferred to the Forest Department before the next annual fishing contract is let the species may well be wiped out in the Chambal.

The Gharial is probably extinct in West Bengal. It was not possible to survey the last remaining Bihari population which occur in the NW near the border with Uttar Pradesh. In U.P. the species is barely surviving even in the world famous Corbett National Park. Here habitat destruction, resulting from the construction of the Kalgah Dam has destroyed virtually all remaining suitable habitat and the remnants of the population (numbering about four individuals) have had to move upstream to small, poor habitat, water holes never previously occupied by gharial where they are in competition with mugger. Furthermore, dynamiting for fish within the National Park has affected two of the few occupied water holes in the last twelve months. Significantly, the Parks Officer, Negi, and Forest Guard Howard, both good wild life observers, have never seen juveniles though they have both been stationed at Corbett for 13 years and are competent naturalists.

A preliminary survey of the gharial has also been conducted during 1974 by Whitaker et al. (unpublished). Their views concur with those of the expert, namely that the gharial is on the verge of extinction.\*.

c) Mugger (C. palustris). The status of the mugger is much more complicated due to its extensive distribution throughout the Indian subcontinent and its adaptability to village and irrigation tanks in addition to rivers, swamps and lakes. However, the species, formerly very abundant, is now greatly depleted in numbers and must be considered rare in most, if not all, of its former range. This is noticeably so in the following States visited: Uttar Pradesh, West Bengal, and Bihar. Biswas (1970 noted in 1968 following a survey tour to N. Bihar, Mirzapur District, U.P. and Balaghat District, M.P. that the mugger 'has become a rare animal in these places if not on the verge of extinction.' In South India (Tamil Nadu, Karnataka and Andhra Pradesh), populations, though hard hit, could show a rapid response to management combined with effective protection. This is probably also the case in Rajasthan and Gujarat.

The habitat situation facing the mugger is intermediate between that of the saltwater crocodile and the gharial. Much of its habitat has been.

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\*Whitaker et al. wrote, 'Killing for its skin is the most important reason for the rapid decline in numbers, and at present fishermen with nets are a very serious threat. The skin of a 12' animal may bring in Rs. 800 - which represents at least half a year's Indian wages. The increase in river activity by way of fishing, transport and agriculture has limited Gavialis habitat to a very few remaining wild areas. Major alteration of rivers by earthquakes, dams, canal diversions, artificial embankments and increased siltation through erosion are other reasons for the decline... Gharial are shot at, netted and prevented from basking all but the most remote places and today there are very few spots free from commercial fishing and the other river activities. The gharial is a river animal... It's association with river gorges makes it a casualty in almost any dam project in North India... In many places fishermen now use nets which stretch right across rivers and some of them specialise in gharial catching. The various State Fisheries Depts. consider Gavialis, marsh crocodiles and others as enemies of fish and often we were told that they advocate the elimination of these animals: Under 'Status' they write, 'the gharial is on the brink of extinction'. Under 'Conservation' they advocated translocation of threatened gharial to protected areas and 'the establishment of captive or semi-captive breeding stock of Gavialis, preferably near original riverine habitat, collection of eggs, rearing of young.'

affected by dam construction - which in itself would tend to favour mugger were it not for the adverse effects of fishery management (setting of nylon gill nets). This is a key factor as virtually all such areas are under fisheries. However, the mugger's adaptability to a wide range of habitats including small ponds and tanks and its ability to move long distances overland tends to reduce its vulnerability.

The mugger, like the gharial and indeed most forms of wild life, has suffered dramatically from the high rate of population growth in India in recent decades which has placed an additional burden on all natural resources, none more so than habitats.

#### Reasons for decline.

Major disappearance of all three species has resulted from large-scale hunting for their skins. With the disappearance of all large populations and total legal protection afforded to the remnants this phase is past. The problem now centres around poaching and destruction of the remaining crocodile resource by fishery activities either direct or indirect. Incidence of poaching is highly variable from locality to locality. Although severe in some places, in others, including many investigated by the expert, poaching is either insignificant or totally absent. Crocodile losses from fishery activities, however, are extremely widespread and areas free from this are the exception.

Several modern writers refer to deliberate killing of crocodiles. For instance Biswas (1970a) wrote, referring to Sirsi Reservoir, Mirzapur District (U.P.), 'In 1967 a contractor was engaged by the Fishery Department at Sirsi to kill the crocodiles of the reservoir due to the reason of si fishing difficulties. 'The expert came across many such instances during the course of this investigation.

Modern fishing methods have been most damaging and in many areas are a threat to the survival of the gharial as well as a cause of depletion of the remaining muggers. Until recently villagers fished using traditional methods such as throw (cast) nets, scoops and lines with baited hooks. All of these are completely innocuous to crocodiles (provided large baited hooks are not set).

The Fishery Departments have recently been active in promoting the use of nylon gill nets. These large nets, equipped with floats and sinkers, hang down in the water across whole stretches of rivers, backwaters and reservoirs. They are lethal to crocodiles which become entangled in the nets and quickly drown as a result of their struggles. The nets are generally set in the evening and taken up the next morning. Should the villagers notice that a crocodile is caught in the net they will club it to death to save the net as the latter represents a substantial investment. This is not a deliberate act of poaching, although illegal. In many parts of India the villager may not even bother to skin the carcass, as, the price he receives for the hide may not even recoup his effort. However, extensive destruction of crocodiles in this manner negates in practice the legal protection afforded them by the 1972 Wild Life (Protection) Act.

Since the remaining crocodiles are being destroyed as a result of fishery activities it becomes important in order to conserve crocodile to examine the fishery activity at village, State and National level and to see how far it can be deviated in with crocodile management. Furthermore, the possible returns to the villagers, State Governments and Government of India if some of the areas in question were utilised primarily for crocodile management, should be considered. The protein production from fishery activities is important in many areas. However, a good fishery is in no way incompatible with large crocodile populations (Chapter II and Appendix XI).

The future

In the past little thought was given to crocodile protection. This situation is now changing as a result of the Wild Life (Protection) Act, 1972 which singles out the two species of crocodile and the gharial for total protection under schedule I. Responsibility for wild life matters is vested in the Forest Departments in the States. The Forest Departments in all States visited professed a keen interest in wild life, including crocodile conservation. They showed a desire to implement crocodile management schemes with assistance from the Union Government and they assured the expert that they could contain poaching where this was a problem. However, almost without exception, they expressed concern about the apparently conflicting approach of their own Fisheries Departments (Chapter II).

Undoubtedly the most encouraging facet of the mission was this ever present interest in wild life conservation problems. Not unexpectedly knowledge concerning crocodiles was extremely scant and expertise in the conservation-management field as it applies to crocodiles was absent, but the interest and desire to succeed were there. The Indian Forest Service with its efficient nationwide administrative and field network in all States is uniquely placed to tackle the problems.

To summarise: Crocodiles and the gharial no longer represent a croppable economic resource in India, and, furthermore, their very existence is threatened, imminently in the case of gharial probably in the short-term for the saltwater crocodile, and over the next decade or two in the case of the mugger. This, together with absence of recent reliable information on their status prior to the present mission, forms the basis of the problem.

Possible approaches to the problem are set out in Chapters II and III.

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## II. POTENTIAL FOR CROCODILE FARMING\*

The immediate aim is conservation of all three species of Indian crocodilians. Extensive crocodile farming using natural areas as well as battery-type farms would appear to be a sound way to bring this about. Only management will restore the crocodiles quickly and it appears probable that without management the gharial will become extinct. The schemes, at least initially, would be Government or preponderantly Government operated, and commercial operations would not commence on any species until the resource had been built up. The population parameters of crocodiles, including fecundity and long reproductive lifespan, are such that under effective control combined with sound management practices crocodiles could rapidly become a resource again. The economic return would commence after about five years and could be built up to full **sustainable** production levels over a period of 15-20 years. Detailed conservation advice is found in the Appendices.

There is good potential for crocodile farming in India provided the necessary technology can be built up. The requirements are discussed in the present Chapter and listed in summary form in Chapter III. Crocodile farming falls into two categories (a) 'battery' farming, and (b) free-range management. The two methods are outlined briefly below.

Battery farming. In this approach crocodiles are kept densely **crowded**. All food requirements have to be supplied and the highest standards of hygiene are essential. Pool hygiene entails daily cleaning out of all hatchling and immature pools. Usually the crocodiles are held in concrete pools but earthen pools may be used at a somewhat lower stocking rate provided they can be allowed to dry and sterilize in the dry season. This requires extra pools.

Free-range management. In this method the crocodiles of an area, which could be a lake or reservoir or a section of river or tidal creek, are managed in situ. Crocodiles are fecund animals (30-60 eggs/clutch) but have many egg and hatching predators. If this predation is eliminated production of sizeable crocodiles increases greatly (up to as much as 50 to 90 times natural increase, depending on the species). Hence it is advisable to bring all eggs into a central hatchery area as soon as laid and to raise the **young** in captivity until they are large enough (about 30 inches (75 cms) to be safe from predation. The time required is about 18-24 months depending on the species. The immatures are then seeded **out into suitable** habitat to grow to the best culling size.

Advantages of the methods. Many of the advantages of range management are obvious. All the breeding stock, with large space and feed requirements, and the animals being grown to become future breeding stock or to the best culling size, are free-ranged. They are self-sufficient, stocking rates being adjusted to a range of environmental parameters including food supply. Housing costs are eliminated. Most important, the extremely complicated technology of running a large fully-integrated crocodile farm is circumvented since the only captives are the very small crocodiles for which housing and feed requirements are minimal. However, the technology of egg/hatchling raising is highly skilled.

There are also several less apparent advantages to free-range management. These include:

- 1) Conservation. If crocodile farming is to proceed solely with penned animals the economic justification for setting aside sizeable natural areas for crocodiles is lost. Furthermore, since economic management is not possible without a sizeable resource, free-range management is one of the best ways to ensure survival of many species of crocodilians in the wild.

\*A crocodile farm (I.U.C.N., 1974) is, 'an establishment whose products are ultimately obtained from eggs laid on the farm'. This contrasts with a 'rearing station' which is, 'an establishment which collects eggs/and or hatchlings and raises them for a period of time after which they are slaughtered.'

2) Economic benefit to villagers - village employment schemes. A key aspect of free-range management is that it allows operations 'at all levels' and thereby creates ideal conditions for a 'cottage industry'. The sum of a number of such village enterprises can be substantial in national terms and the gainful employment to large numbers of village people is significant.

3) Opportunities progressively to learn technology of battery farming.

A battery-type farm such as the one at Samut Prakan (near Bangkok) Thailand, which holds some 16,000 crocodiles at present, requires an extremely high level of technical skills not yet available in India. (It is noteworthy that this farm has so far not been replicated anywhere in the world). This expertise needs to be built up over a period of several years. The ideal way in which to do this is to develop free-ranging with associated small hatcheries. This will provide an opportunity to gain expertise in the required skills for subsequent large-scale battery farming.

There are also advantages in battery farming. These relate mostly to the high degree of stock control. Moreover, crocodiles grow faster under battery conditions as a result of better feeding up to approximately twice as fast as the normal wild growth rate. However, the added costs of housing and food may negate this, making free-range management equally if not more desirable, depending on the conditions.

#### PROTEIN COSTS AND SUPPLY:

In many parts of India there is a cheap source of food in the form of old buffaloes which can be purchased on the hoof for Rs. 50-75 (\$ US 7-10) each. This works out at about 12-20 paise/kg. The range noted was from \$ US 0.026 to 0.075/kg. Buffaloes are available so cheaply because most people do not eat buffalo meat. The price for a goat is about twice the figure quoted above for a buffalo. Buying fish to feed crocodiles would not normally be an economic proposition in India, although it certainly is in Thailand where the enormous battery farm referred to above is able to buy trash fish for 2 baht (\$ US 0.10 ¢)/kg. It should be noted, however, that the price quoted above for Indian buffalo is only one quarter to three quarters of this Thai fish price.

#### FUTURE DEVELOPMENTS:

Looking to the future it is clear that selective breeding will greatly improve the industry. Quite apart from high quality it should be able at least to double the growth rate by selecting future breeding stock from the top ten per cent of the growth curve.

Species to use. All three species should be subjected to management with a view to ultimate commercial utilisation. The expert recommends inclusion of the endangered gharial as (in his opinion) not to do so would be to ensure its extinction. The best way to restore the gharial to its former abundance in selected areas is by management involving the local people. A financial incentive in view of competing interests will be essential (Appendices IV and IX).

Village people and crocodiles. It is important to put on record the attitude of the local people towards crocodiles. Throughout the tours of the States the expert questioned villagers on their attitudes towards crocodiles. Indian villagers do not fear crocodiles nor do they kill for the sake of killing. Both crocodiles and local people co-exist with minimal conflict. The villagers do not attack the crocodiles and the crocodiles very rarely disturb the villagers. (It is well known that man is not within the preferred prey range of crocodiles and that the occasional attacks, except for the aberrant crocodile which becomes a 'man-eater', are the result of mis-predation).

Crocodile may, however, take domestic stock though even incidence of this is generally much exaggerated and the villager takes a philosophical attitude towards such occasional losses.

The above refers to a situation in which the local people have no financial involvement in crocodiles. Were they to be given the opportunity to participate in a crocodile industry the poaching problem would largely disappear as it is impossible to poach without the knowledge of the local people who would certainly protect 'their' crocodiles.

#### Crocodiles and fisheries.

No discussion of free-range management of crocodiles would be complete with consideration of this topic. There need be little conflict between fisheries and crocodiles. Past and present conflict has been largely the result of a misunderstanding of the role of crocodiles in a fishery. For this reason a resume of Dr. H.B.Cott's African findings on crocodiles and fisheries is given in Appendix XI. This important study indicates that in Africa crocodiles are not detrimental but beneficial to a fishery. Hence there would appear to be considerable scope in India for multiple management in at least some areas having good potential for both crocodiles and fisheries. Multiple management, by raising two crops from the one area of water, substantially increases the financial return.

The main threat to crocodiles in a fishery under contemporary Indian conditions is from set gill nets. Hence it would also seem advisable to investigate the practical possibilities of crocodile management in several areas good for crocodile but relatively unimportant for commercial fishing operations. The results of management in these areas could be used as the basis for future decision-making (Appendices IV, VII and IX). This is similar to the conservation approach recommended by Biswas (1970 a) for the mugger. Biswas recommended:

1. Each State should be requested to reserve a natural or an artificial reservoir as a crocodile sanctuary where Crocodile Fishery or Farming may be taken up in future.
2. In reservoirs where Crocodiles form hindrance to the Fishery and create difficulties for fishing such crocodiles should be caught and transferred to these special reservoirs meant for them in each state.
3. There should be a total ban on killing of crocodiles and all departments of administration including the Fisheries must be asked to enforce the law strictly.'

Under present fisheries procedures this may have to be the approach initially adopted, as multiple management techniques may be difficult to implement effectively since Fisheries do not operate their own areas but auction the right to take fish, usually annually. This method is unsatisfactory as by reducing control over the fishery it prevents the development of sophisticated long-term biological management. Furthermore, it provides a poor financial return to the State. Not inland fishery revenue at State level was small in most States visited by the expert.

The early development nature of fisheries was in part responsible but high operating costs combined with low financial return were major factors. The financial return can be improved quite dramatically by the imposition of a royalty on all fish caught. Although this approach does not in itself result in improved management it involves much closer supervision as departmental officers must be on hand to inspect the catch.

Since crocodiles are not in conflict with fish production, in a crocodile management scheme villagers can continue to take their fish requirements as before. The only stipulation is that fishing methods should be traditional, not by set netting. However, this may often be in

interests of the fishery and the villagers (see Appendix IV):

In such areas villagers would still require fishing licences. Licences would be issued by the authority managing crocodiles. Hence it is not a matter of opting for crocodiles or fish production. Opting for crocodiles does not prevent the protein production of the fishery, only the manner in which it is harvested.

#### Preliminary economic assessment.

The demand for crocodile hides is certain to continue to grow. To date the demand has been such as to bring many of the world's twentytwo species of crocodilian to the verge of extinction. Crocodile hides are the luxury end of the leather market, a market in which India has become increasingly, and most successfully, involved. Leather prices have risen steeply during the last decade as a result of a marked shortage of supply. Crocodile hides, like those of other reptiles (sea turtles, python, monitor lizards etc) are sought after for their special desirable characteristics such as softness and suppleness as well as attractive appearance. It is due to a lack of wild hide supply that interest in crocodile farming is now developing rapidly in many areas. Any country setting up a managed crocodile industry today would be in the forefront of such developments.

Crocodilians inhabit the tropics and sub-tropics. Crocodile farming is, therefore, an industry of which tropical countries have a natural monopoly. It would not be economic to heat the extensive areas of enclosures needed for farming in Europe. Likewise virtually all of North America is climatically unsuitable. The climate of much of India, however, is ideal. The best crocodile growth rates, and hence better economic return, will be obtained in parts of the country where the winter is less pronounced, as a marked cold season results in a cessation of growth for these months. Hence the most favourable areas for crocodile farming are South India and coastal areas, particularly of the Bay of Bengal where the valuable saltwater crocodile occurs.

North India, however, is the habitat of the currently endangered gharial, a crocodilian accustomed to cold winters and low water temperatures (it inhabits rivers, seasonally snow-fed, flowing from the Himalayas) and preliminary indications are that the gharial has an excellent growth rate in North India.

Crocodile hides are sold on the international market measured in inches across the belly between the armpits (a 'belly' is the favoured cut for all but very small hides). The price, which undergoes relatively small sporadic movements in the course of its strong upward momentum, varies from species to species. At present the price for saltwater crocodile skins is approximately Rs.39 (₹ 62.10 = \$ US 5.00) per inch of belly skin width. This means that a smallish-average skin of 13" belly (most hides should be considerably larger) is worth about Rs.500.

The above calculation, based on the end of the range, is intentionally conservative. A medium figure (16") would give a unit value of Rs.600. It should be noted that these prices are for raw (untanned) skins. The value for skins of freshwater crocodiles and gharial is likely to be slightly less.

The world's first battery-type crocodile farm was established in 1950 near Bangkok, Thailand. Saltwater crocodile skins produced in this farm

\*The detrimental effects which can result from extensive nylon gill net usage in restricted fisheries are becoming recognised. In the valuable European Atlantic salmon fishery, 'The harmful nylon monofilament net is already banned in Ireland, and British river authorities have recommended banning it, too. It may seem paradoxical that the rod angler should be in the forefront for conservation; but at least many fish get past him and up the river to spawn.' (London Daily Telegraph, 26/8/74).

reach a value of \$ US 75 (approximately Rs.560) each, within three years of hatching from the egg. Indications of the Thai farm's profitability for the past two and a half decades have been given by Yangrapakorn, the founder and owner of the Bangkok crocodile farm.\*

The expert last visited the farm in August 1974. The total number of crocodiles is now over 15,000 and no less than 3,000 are being grown for future breeding stock which will result in an annual egg production in the future around 120,000 eggs. The current investment value of the farm is US \$ 5 million. When the present development phase is completed it would be possible to produce about 100,000 skins per annum. These at 1970 prices of US \$ 75 each would gross US \$ 7.5 million (= Rs.4.1 crore/annum). The above figures demonstrate the return from a well managed, battery-type crocodile farm.

It is not possible until this report has been considered by the Government of India to state, even approximately, the net annual return to India from a crocodile skin industry since this depends on political decisions as to the rate and scale of development.

In the past three years leather has been India's most rapidly expanding export. In 1970 exports of leather amounted to Rs. 70 crore (£ 37.5 million). In 1973 they amounted to no less than Rs. 160 crore. But even the 1970 figure was considerably up on the figures for the previous decade. In 1967 the figure was Rs. 53 crore and in 1964 Rs. 27 crore.

Tanning technology, now developed in India, and the subject for considerable ongoing technical research is an invaluable asset to any development of the crocodile leather industry as it will enable foreign exchange earnings to be raised substantially from the outset. India has drastically reduced the export of completely undressed hides and skins (currently worth Rs. 60 lakh/annum compared to Rs. 16 crore/annum in 1966) by local tanning and is now developing leather processing industries using the low Indian labour costs and the skill of India workers. Not only does this greatly improve employment opportunities within the industry, but as Government of India appreciates in pushing ahead with the development, it substantially increases unit value and thereby brings about the maximum foreign exchange earnings. Quality control has also been excellent.

The expertise already developed in marketing a wide range of leathers will be an important asset for the development of any crocodile hide industry. Normally an embryonic industry would have to export raw hides until local technology had been built up, thus greatly depressing earnings. India will be able to export processed hides from the start.

Incidentally much the largest market for Indian leather is in Europe. The EEC countries accounted for more than half of leather exports and the EFTA countries accounted for a further quarter, in 1972-73. With Britain's accession to the EEC, the Community is now the predominant buyer. Japan and the United States make much smaller purchases.

Clearly some indication of probable earnings is required. This is possible provided the assumptions made are clearly stated. Based on a programmed development over two decades, with first export earnings commencing after about five years (at the start of the 6th fiveyear plan, if the project

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\*Yangrapakorn (1971) wrote, 'I started the Samut Prakan Crocodile Farm in 1950 with an investment of US \$ 500. After 21 years, (and the sale of many skins), I have an investment around US \$ 1.5 million. I started with 20 wild-caught crocodiles; today the farm has over 11,000 individuals. In 1960, 150 crocodiles were hatched at the Farm; last year about 3,500 were hatched. The skin of a three year old porosus is sold for US \$ 75 before processing; siemensis skins (the Thai mugger) are sold about 10% less'.

is initiated speedily), the annual production value of raw hides could ultimately be of the order of Rs. 20-30 crore/annum. This calculation is based on the following assumptions:

- i) A unit raw skin value of Rs. 500.
- ii) A Government of India sponsored crocodile farming project along the lines recommended in Chapter III with inputs to ensure extensive training in crocodile management technology within the country.
- iii) That as a result of (ii) above the following production figures are achieved.

The target date for the full production levels is the year 1995 in each case:

- iv) That extensive management in Sunderbans, West Bengal, by both free ranging and village penning produces 100,000 skins/year.
- v) That similar activities in Orissa (Bhitar Kanika - Chandbali coast). produce 20,000 skins/annum.
- vi) That ten medium-sized battery-type crocodile farms are each producing 20,000 skins/annum.- making a total of 200,000 hides/annum
- vii) That other managed areas spread around the Indian States are producing a combined total of 200,000 hides a year.

This gives a total annual production of 500,000 hides, the raw skin value of which, at present prices, is Rs. 26 crore. While this is undoubtedly a large operation, requiring a well-co-ordinated processing and marketing network (which already exists in India for other leathers) it is well within the biological potential of the areas visited by the expert. Furthermore, there are suitable areas in a number of other States not visited by the expert. No allowance for these has been made in the above calculation.

The net foreign exchange earnings will depend on how successful India is at manufacturing finished products within the country. Major developments of this nature could raise the foreign exchange earnings from the above skins severalfold - to a conservatively-estimated Rs. 60 crore/annum.

It must be stressed that these figures are tentative, and that they exclude estimates of costs. A detailed economic feasibility study will be needed to determine the potential profitability of the farming enterprises.

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### III. CONCLUSIONS AND RECOMMENDATIONS.

The expert has located many areas of ideal habitat, populations urgently in need of managed conservation - which can form the basis of a sustainable foreign exchange earning industry, and has noted a keen interest in the Indian Forest Service to embark on wildlife management.

Crocodile farming is solely viable in tropical areas. The environment of much of India is ideal. Accordingly the expert recommends:

1. Pilot Farm.

That a pilot crocodile farming project be set up to train Indian personnel in all aspects of crocodile management, and to multiply crocodiles of all three Indian species, initially for conservation purposes, and subsequently for economic enterprises.

2. Location.

That the location of the pilot farming project be Orissa and West Bengal in view of extremely favourable husbandry conditions in these localities and the presence of all three Indian species (Appendices III and IV).

3. Conservation in the States.

That simultaneously the best conservation advice be made available to the States in the field so that immediate remedial action can be taken to conserve the remaining crocodile resources. Otherwise there will be no resource available for subsequent management when personnel have been trained at the Orissa-West Bengal farming projects.

4. The form recommended for the pilot project is as follows:

a) Orissa. A central co-ordinated battery-type farm utilising all three species, located in Bhubaneswar (but not at Nandankanan) and three outstations, one for field management of each species. The latter to be located as follows: saltwater crocodile - Bhitarkanika-Chandbali coast; gharial - Satkosia Gorge (Tikerpara); freshwater crocodile - possibly Similipal (Appendix IV).

b) West Bengal. A battery-intensive farm for both saltwater and freshwater crocodiles in the Salt Lakes close to metropolitan Calcutta and a free-range management scheme in Sunderbans for the saltwater crocodile.

5. Role of village people. That in free-range management schemes and their derivatives the villagers be fully incorporated into the project. Failure to do this, and thereby return a sizeable proportion of revenue earned from the crocodile resource in any area for the development of that area, will jeopardise the scheme. This approach, basic to wildlife management, is frequently overlooked. Poaching is not possible without the knowledge and active participation of the local people.

6. Gharial.

The best hope for the threatened gharial lies in active management. This will require substantial investment in personnel, habitat areas and funds. This would only appear to be possible if it is clearly stated that the gharial conservation's ultimate aim is economic management to benefit the local communities.

7. Management agency.

The managing agency should establish close liaison with Fisheries in order to (a) prevent loss of the remaining crocodile resource in

areas managed by Fisheries, and (b) try to establish multiple water use schemes (concurrent crocodile and fish management) in suitable areas.

8. Ecological role of crocodiles in a fishery. A thorough, academically-based study is needed in India on the ecological role of crocodile-fish relationships. This would flow naturally from the pilot project if initiated. The first species investigated should be the mugger. The findings from such studies should be disseminated as widely as possible.

9. Personnel.

The successor failure of the schemes will depend on the personnel selected. Key personnel should be young and be offered a permanent career in crocodile management. They should implement management, procedures, although, of course, conservation work will continue to be dependent on the Forest Department administrative machinery.

10. Training.

It is recommended that all training of personnel take place in India, working on Indian species under Indian conditions. Training outside the country is considered to have relatively little value in view of its doubtful relevance to Indian conditions.

Personnel will require to be trained at all levels. To maximise the success of the operation India should produce its own experts in crocodile population ecology. As a result of decisions, based on extensive on-going research, a truly Indian approach to crocodile farming can be developed which will not be dependent on outside inputs. At present no such people exist in India and very few anywhere. Induction of personnel with sound academically-based qualifications should start at the beginning of the scheme (several such research workers are budgeted for from the initiation of the Orissa pilot farming schemes in the State Plan).

11. Return of expert.

The expert is due to return to India early in November 1974 as originally planned. However, the balance of one month available for the consultancy is insufficient to undertake the task now required of the expert under the extended terms of reference. It is believed that Government of India has sought an extension of the second phase of the mission.

12. Future inputs.

In the initial phase of the establishment of the pilot farming schemes, specialised inputs will be required in crocodile management and population ecology, economics and marketing. An expert on crocodile management/population ecology will be required full-time for the first five years of the project. It is essential that the crocodile expert have practical management experience, extensive practical experience of working with people at village level as well as having sound academic qualifications so that he can gain close collaboration for the project from Indian Universities. The expert may also be required to co-supervise, or be an external supervisor for students working on crocodile population ecology. The establishment of a crocodile project would appear to be the only way in which the required skills can be built up rapidly concurrently with the development of the pilot farming projects.

13. Public relations.

If crocodile farming is to be developed it is important that the Government make its policy clear through good public relations. The following points should be stressed.

- a) that the industry is not utilising wild unmanaged crocodile and is, therefore, no drain on the species.
- b) that on the contrary, the industry, under strict Governmental control at all levels, is responsible for conserving the species and by the high economic return ensuring that large areas of ideal habitat are kept under crocodiles instead of being alienated.
- c) that by supplying the hide markets in this way the industry is taking the pressure off wild stocks elsewhere. (In order to justify this the farming must be developed on a large enough scale to make international impact).
- d) It is possible to demonstrate that crocodiles, a valuable renewable resource found only in tropical countries, by sound management can provide foreign exchange earnings and much needed employment at village levels. The demonstration of this is a basic requirement of the project.

14. Timing.

If crocodile farming be developed in India it is essential that it commence with the minimum delay. Each month's delay reduces the resource and thereby extends the time before the venture will become economically self-supporting.

15. Zoos.

- a) Farming. Crocodile farming operations are not generally suited for Ecological Gardens. They are specialist activities to be carried out by trained personnel working preferably in conjunction with Sanctuaries or other areas of natural habitat, or as separate entites (battery farms).
- b) Gharial breeding. Zoos holding groups of gharial should be encouraged to make every effort to breed this endangered crocodilian. Zoos should not collect further wild stock except in exceptional circumstances.

16. Aims.

The aims are twofold:

- a) to ensure the conservation of India's three species of crocodilian as a result of extensive management in natural habitat areas
- b) as a result of (a) to build up an export industry with maximum foreign exchange earnings. The latter will best be achieved by following the policy being implemented in the Indian leather industry with major success - processing the hides as far as possible within the country prior to export.

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The possibility of crocodile farming in Delhi Zoo was carefully assessed in line with the original terms of reference, but following the extended terms of reference transmitted to the expert on his arrival in India. In order to do this the Zoo was visited several times, between 13-16 May 1974.

The Zoo has three mugger. No breeding occurred in former years as the male was sexually immature. One female laid infertile eggs two years ago. Mating was observed on 19 and 22nd February 1974, but no eggs were noted. The enclosure in which the mugger are kept is good, providing natural cover.

Possible crocodile farming at Delhi Zoo should be considered in relation to the role of zoos, and their success in ventures of this kind and then the specific choice of Delhi should be considered. This approach is used below.

- 1) Zoos are required to show the public a representative selection of animal life in a circumscribed area. Hence it is difficult for a zoo to devote a large part of its resources, including space, manpower and finance, to a single species. Extensive management, including breeding, of any one species negates the zoo's general role so it is not surprising that zoos, with few exceptions, have not had a good breeding record.
- 2) Where successful breeding has occurred it has usually been on a small scale, by no stretch of the imagination comparable to a 'farm'. Exceptions have occurred where the breeding generated sufficient interest, and a very senior zoo official was involved (usually the Zoo's Superintendent).
- 3) Crocodile breeding is a specialised task. By 'breeding' the expert means the combination of egg laying, successful incubation and a high level of success in rearing the hatchling crocodiles. Lack of specialist skills makes crocodile breeding outside the scope of most world zoos. Furthermore, in Europe and North America because of the unsuitable climate, crocodiles must be kept in heated reptile houses often quite unsuited for breeding.
- 4) It may be useful to examine the limited success achieved by zoos in breeding crocodiles in light of the above 'guidelines'. Zoos have usually achieved little success in reptile breeding. Considering crocodiles specifically, only two zoos have regularly bred crocodiles over a period of many years and been most successful in hatchling husbandry. Both are in India - Jaipur and Ahmedabad. In both cases the success is the result of the continual care over very many years by one man, combined with that man's interest in crocodiles. The men are Mr. R.N. Yadav at Jaipur and Mr. Reuben David at Ahmedabad. Significantly both men are Superintendents of their respective zoos.
- 5) Climate, as well as highly motivated interest within the zoo, is a crucial consideration for farming crocodiles. If the winters are cold, growth ceases, and since financial return is dependent on growing the crocodiles to a commercial size as quickly as possible so that the resources (pools, labour, food) can be used to grow other crocodiles, the return will be aired.
- 6) If the possibility of farming crocodiles at Delhi Zoo were envisaged as an example of how to achieve this (as would seem to be the case from the original terms of reference) then the expert could not recommend that the plan be implemented at Delhi. Any demonstration site should be selected further south, and preferably coastally, where the disadvantages of Delhi's continental climate are absent. Crocodiles kept under battery-farm conditions are much more vulnerable to cold nights than free-ranged crocodiles, which are able to utilise warmer micro-environments as well as

benefiting from the large mass of water which does not cool off as rapidly at night as do small pools. Hence crocodiles may not thrive in captivity even in areas where they occur in nature but are near their geographical (climatic) limits.

7) If, however, it is proposed to build even a modest crocodile farm within Delhi Zoo the following points should be considered.

i) Success will depend on the presence of a highly motivated individual either senior within the zoo hierarchy or assured of the Director's support. The latter would be difficult to guarantee in Delhi as the Director changes every two years.

ii) The enterprise should start in a very modest way, and the climatic disadvantages be appreciated from the outset. Best growth rates cannot be expected so that results will not in any way reflect what would occur in a more favourable environment.

8) It should be noted that Delhi Zoo has been somewhat unsuccessful in rearing young mugger and even gharial (the latter are well used to cold winter conditions). Small gharial received by the zoo have all died ash have young mugger obtained from Ahmedabad and Jaipur Zoos. It is not clear whether this was due to unsuitable climate or inadequate husbandry or both. The continental climate of cold winters and hot summers causes problems especially with very small crocodiles. Delhi Zoo has not attempted rearing saltwater crocodiles. These have the best commercial skin but are the species most likely to be adversely affected by Delhi winters.

9) It has been suggested that Delhi Zoo should perhaps breed the endangered gharial. This seems an optimistic role as this is certainly the most difficult Indian crocodile to breed. To date no one appears to have succeeded. The zoo has no gharial and the rearing of one or more pairs to breeding size (a long term task) would undoubtedly result in further deaths of juveniles. The species is now so rare that Government of India should discourage zoos from obtaining further wild stock. There should be no legitimate drains on the remaining wild individuals.

10) It is recommended, however, that Government of India take steps to encourage those zoos with breeding size gharial groups to make every effort to achieve captive breeding. This would necessitate funds to equip them with enclosures in which breeding could take place. Suitable gharial groups occur in the following Zoos: Nandankanan, Mysore, Ahmedabad, Baroda (H.U. Baroda's collection) and a pair are being reared at Jaipur.

11) The best approach is to carry out captive breeding in conjunction with a Sanctuary (see Recommendation 15) into which the juvenile crocodiles can be released at 30 inches long. The rearing station should be located at, or as conveniently near, the Sanctuary, as possible. Hence the involvement of a zoo is unnecessary except in the case of zoos which have demonstrated outstanding success (Jaipur, Ahmedabad) or are clearly such excellent zoos on a world basis (Hyderabad) that they must succeed at any task on which they embark.

APPENDIX II

UTTAR PRADESH

The State of Uttar Pradesh was visited from 17th to 28th May 1974. The areas which the expert was requested to report on were Corbett National Park (for gharial), Dudwa Sanctuary (mugger) and the Mohan River along the Indian border with Nepal (gharial). Findings were as follows:

1) Corbett National Park. Both the gharial and the mugger occur in Corbett National Park. However, the gharial is now exceptionally rare and only two individuals were seen during the expert's stay, one on several occasions. According to the Whitaker investigation (see letter from Charles A. Ross dated June 4, 1974 addressed to the IUCN Crocodile Specialist Group) only four gharial now occur in the Park.

The rate of loss of gharial from Corbett has been catastrophic. As a consequence of human interference there is now only one-third to one-quarter the number that existed five years ago. The building of the Kalagarh Dam has resulted in large-scale disturbance of the best former gharial areas (at Boxar) and the remaining gharial now occupy pools further upstream where they are in competition with mugger, and where significantly, there were formerly no gharial. The best gharial pools, now devoid of gharial, are currently being flooded as a result of the dam which will be managed for fisheries (see Chapter I, Reasons for Decline, for effects of this). As well as this habitat loss periodic dynamiting for fish in deep pools inhabited by the gharial results in accidental deaths.

There have been no indications of gharial breeding in the past thirteen years according to the Parks (Officer (Negi) and Forest Guard R.M.Howard - both competent naturalists. Both report having seen mugger hatchlings in former years.

The low number of gharial, combined with their uncertain habitat future as a result of the flooding now in progress, which will require two good monsoons to achieve its optimum level, and human disturbance factors, makes the expert dubious of gharial management in Corbett. Hence the expert does not recommend implementation of the gharial farm in Corbett National Park proposed by the State Government. The effort would be much better spent looking elsewhere in the State for a viable population which can receive complete protection combined with management. It was for this reason that the Mohan was investigated.

2) Mohan River. Time available without any specific leads in the Mohan did not permit the location of specific gharial populations but it was possible to confirm the presence of gharial in Baharaich Division of the State following reports from Forestry who detailed a staff member to check the two year old reports.

In a Memo addressed to the Wild Life Warden, Khuri Region, and dated 25th May 1974 the Bahraich Forest Officer gave the following information:

1. Crocodiles (this refers specifically to gharial) are available in GIRWA River near KATARNIAGHAT in Behraich Division.

2. Crocodiles (again gharial) are found in Bahraich Division West (NISHANGARA) Range KATARNIAGHAT at the following places:

- (1) GIRWA River near KATIYAYA - about four in number
- (2) " " " " five "
- (3) " " " KHAIRA GAURHI two "

He further advised it would not be possible to see gharial at this time because the Ghangra River was already rising steadily, as a result of melting snow in the hills. IT IS RECOMMENDED that this area be carefully surveyed during winter when water levels are low and gharial spend the day basking on sandbanks.

The appointment of a zoologist to carry out a detailed ecological survey of all present and former gharial habitat in the State is recommended. It is envisaged that this would take between two and three years. The survey would cover any areas of suitable habitat located where gharial still occur in numbers and where their continued conservation is practicable, so that the Uttar Pradesh Forest Department could consider implementation of schemes at these localities.

3) Dudwa Sanctuary. Dudwa Sanctuary is an outstanding place which one hopes will shortly be gazetted a National Park. Its status and fauna are largely the work of one man - Arjan Singh. The Sanctuary consists of 87 sq. mi. (212 sq. Km.) of which approximately one-third is open country and two-thirds forest. The dividing line between the grasslands and the forest is the approximate flow of the NEORA-SHELI, a smallish river. The Sanctuary area as presently gazetted contains 6 mi. of the NEORA which is joined by the SOHELI and thereafter called the SOHELI of which 10 mi. are completely inside the Sanctuary. The proposed National Park would contain 12-13 mi. of the NEORA (since the proposed Park boundary will extend further up river) together with 15 mi. of the SOHELI much of which will, however, demarcate the proposed Park boundary on its southern side. North-west of Dudwa the NEORA runs about 1 mi. inside the border, south-east of Dudwa (as the SOHELI) it is the border.

Within the present Sanctuary the NEORA has five good crocodile holes - deep even when examined in May (extreme dry season), with good nesting sandbanks and plenty of fish, harvesting of which is not allowed within the Sanctuary. The 10 mi. of the SOHELI within the Sanctuary has several suitable holes four of which were investigated by the expert, and at two crocodile tracks were present.

The extreme vulnerability of the crocodiles was demonstrated at one of these by the presence of fishing sticks (used to anchor nets) around the sandbank where the mugger hauls out to bask. It is essential that such illegal fishing be prevented if crocodiles are to survive.

The National Park, on presently proposed boundaries, will leave only 2 mi. of the SOHELI inside the Park and 7-8 Mi., which is at present inside the Sanctuary, will become the boundary. The river cannot receive effective protection as the boundary. The proposed National Park would contain an additional 4-5 mi. of the NEORA but this is a relatively fast-flowing section with few holes suitable for crocodiles. There is one important pool in this stretch which the expert examined which does not now contain crocodiles, almost certainly as a result of intensive fishing. This pool is outside the Sanctuary (but within the proposed National Park area) so fishing rights are still auctioned and this pool provides most of the fish from this section of the river.

Ideally the National Park boundaries should be drawn at least 1 mi. south of the river. The expert believes that this may be untenable due to human pressures for cattle grazing, that extraction, fuel extraction plus requirements for roofing timber. It is most important, however, that the present Sanctuary border be maintained in PHERSAIA block (where it is approximately 1 mi. south of the river) as this stretch provides good crocodile habitat. There will be 12-13 mi. of the NEORA River inside the proposed National Park boundaries almost 6 mi. of which contains crocodile habitat. In addition 2 mi. of the SOHELI provides good habitat, making a total of nearly 8 mi. The addition of the 3 mi. in Pheraia block would increase the crocodile habitat within the proposed National Park by approximately two-fifths (40%). The expert understands that there is no human pressure against PHERSAIA block and, therefore, recommends its inclusion in the proposed National Park.

The above discussion on crocodile habitat in Dudwa Sanctuary and in the proposed National Park is included because the expert was asked by Government of India to comment on a proposed mugger farming scheme at Dudwa proposed by the State Government. The feasibility of this depends on the available habitat, which at best is restricted. If the above recommendations are implemented and sound protection is guaranteed then the expert would recommend a small mugger conservation farming scheme at Dudwa. The scheme would not be much larger than that proposed for Palamau National Park in Bihar (Appendix 5) and costs should be proportionate.

According to Arjan Singh, who has lived at Dudwa since 1959, when the Sanctuary was created in 1968 there was only one mugger left. By 1972/3 there were five sizeable mugger. In 1974 he has seen only four mugger. The above figures refer to the Sanctuary only. The expert is aware of others outside, some of which, on the basis of the present holes occupied, will be included in the proposed National Park. In the earlier years Mr. Singh saw many young mugger. At this time fishing was permitted (it was stopped in 1971/2). Last year he saw only a single young mugger which from his description was then one year old as came from a 1972 nesting.

If a mugger scheme is implemented at Dudwa costs will be extremely modest. The following plan of operations may provide a guide:

- a) Complete effective protection should be provided by Forest Department personnel.
- b) IT IS RECOMMENDED that some sizeable mugger be brought in from unsafe areas outside following implementation of sound protective practices in Dudwa Sanctuary. Translocation should take place during the dry season and crocodiles should be liberated singly into unoccupied pools.
- c) Eggs would be collected and young reared (Chapter II). This would be an activity with considerable tourist potential as would the large unhunted crocodiles. The tourist potential of Dudwa, so far largely overlooked, would appear to be considerable, if judiciously developed.

In the foreseeable future, under the overall control of a responsible person domiciled in the area, the 'farm' could be operated by two people - (1) a fisherman and (2) a keeper. At Dudwa small whole fish would be the preferred food for juvenile crocodiles. The expert is informed that these would be easy to obtain from the river. Permission to take these would presumably be granted for a Government crocodile conservation project (commercial fishing is now forbidden within the Sanctuary). The fisherman, on present local wages, would receive about Rs. 4/day. The total recurrent costs for the farm, excluding protection staff for the Sanctuary, would approximate Rs. 3000/annum.

The plan would be in two stages:

STAGE I. The implementation of a conservation/replenishment programme which would aim to build up a breeding population of approximately 4 adult mugger (1 male and 3 females) per water hole. If one works on a figured of a dozen suitable holes this gives a holding capacity of 48 adult mugger of which 36 would be breeding females. This should give an annual production of about 1250 eggs.

STAGE II. When the adult population has achieved this optimum level the future progeny can be used for re-introductions to other Sanctuary areas or used for commercial farming. If one assumes 15% egg loss and only 80% successful rearing in the early stages when egg production may be around the 1000 egg/annum mark one can expect a gross annual revenue of Rs. 3-4 lakh. Alternatively some of the progeny could be kept for future breeding stock in order to build up in captivity a breeding herd or series of breeding herds as has happened at Bangkok.

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4) Lucknow Zoo. The expert does not recommend the implementation of a crocodile/gharial breeding project in Lucknow Zoo. This decision is reached purely on the basis that Zoos, other than in the most exceptional circumstances, are not suitable for this work (Appendix 1).

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APPENDIX III.

WEST BENGAL

Investigations were carried out in the State of West Bengal from 3rd to 7th June 1974. Two areas were examined - the Salt Kakes adjacent to metropolitan Calcutta and the Sunderbans, an area of tidal, coastal, mangrove creeks in the Gangetic delta.

Salt Lakes. A suitable site for crocodile farming was visited in sector 4/5 of the northern Salt Lake City East of metropolitan Calcutta. This area is partly reclaimed, partly low-lying. Adjoining it are vast stretches of water used for fish culture. This section, like other water-logged areas in the northern Salt Lake region was approached by surface routes.

Some areas are under land acquisition proceedings by the State Government. IT IS RECOMMENDED that the crocodile project site be located in this region. At first the site was approached from the S.E. extremity of the City, thereafter it was inspected through the N.E. entry - across the new township (a Government of West Bengal rehabilitation scheme) developing there. This area of Government-owned land was approached from the N.E. and the 'NALBAN' fishery occupying approximately 60 acres was seen. Other fishery areas were contiguous.

The heart of the Salt Lake area was subsequently approached by boat from Krishanpur Hat which is located near the main throughfare from the airport to the City. The Krishanpur canal was traversed for 8 mi. (13 km.) through low-lying terrain thus obtaining a panoramic view of the numerous shallow fisheries.

This area has considerable crocodile farming potential as the water levels can be precisely regulated by taking water in/letting water out from/to the canal at will. In 'PATRABAD' the expert observed all necessary requirements - only minor modifications are necessary - for full-scale crocodile farming. The situation is ideal and a farming complex could be created cheaply.

Furthermore, the expert understands that the State Government has proposed the establishment of a Bird Sanctuary in this area. A crocodile farm adjacent to this could not fail to be an important tourist attraction (like the Bangkok farm) being so close to both metropolitan Calcutta and the airport.

It is envisaged that the farm, of the battery-type, would utilise buffalo meat, as the demand for fish in Calcutta is insatiable and fish, therefore, costly. Even if fish were produced in the ponds, it would be poor business practice to transfer it to the crocodiles at other than its local saleable value. Indications are that buffalo meat can be obtained at comparable prices to Uttar Pradesh (Chapter 2). The supply should now be investigated.

Sunderbans. The area was examined on two consecutive days. Rough seas and the lack of a large boat prevented penetration deep into Sunderbans therefore further investigation is required. Travel was undertaken on M.L. Banalakshmi from Namkhana to Kakramari Char in Muriganga River, on the first day, then back to Namkhana and travel to Prentice Island. The island was partly encircled then a return was made to Namkhana. The following day deep southern areas of Sunderbans were investigated. The route taken was as follows: Namkhana to Lothian and Prentice Islands, then across Habila Creek to touch Patharpratima and then West down through Curzon Creek and through Chaltabani Khal and Jagabal River. The vessel then went up to Dhanchi, along Rose Creek to the wide Thakuran River and returned to Namkhana. In all, some 100 mi. (160 km.) of waterways were examined.

IT IS RECOMMENDED that a conservation/commercial crocodile farm be set up in the Salt Lakes area initially using both saltwater and mugger crocodiles. When experience has been gained an attempt at gharial farming may be made.

IT IS FURTHER RECOMMENDED that a free-range management scheme or schemes be set up in Sunderbans Reserve Forest areas and peoples' Co-operatives or village enterprises in other areas of Sunderbans. The two can be closely interwoven to maximise production.

REVENUES On the basis of the preliminary investigation it is considered that the sustainable annual revenue from management of entire Bengali Sunderbans could be of the order of Rs. 4-10 crore/annum (US \$ 5.3 - 13.3 million) at to-day's prices. No estimate of the speed with which this rate of production can be attained can be made until systematic surveys have been carried out.

In the Salt Lakes area the return achieved depends on the acreage utilised. The Bangkok farm, discussed in Chapter II, could be replicated many times in a small corner of the Salt Lakes.

PROCEDURE. IT IS RECOMMENDED that the Government of West Bengal in conjunction with Government of India elaborate a project to cover the first five years of the setting up and development of the two crocodile farming scheme proposed above. This should be devetailed into the scheme which has been prepared by the Government of Orissa (Appendix 4). It should then be possible for the project to develop with minimum delay. In view of the unique potential of both areas it is to be hoped that the Bengal State scheme will receive the fullest consideration from Government of India.

In order to provide a detailed economic development schedule a thorough survey of Bengali Sunderbans should be undertaken prior to any large-scale investment. The government of West Bengal has requested that the expert return for approximately twelve days during the winter (preferably commencing in the second week of January 1975) to undertake this task.

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The State of Orissa was visited from 8th to 15th June 1974. The expert visited Nandankanan Biological Park located between Bhubaneswar and Cuttack, the coastal mangrove habitat of the saltwater crocodile at Bhitarkanika, and Batkosia Gorge on the Mahanadi River (gharial). Findings were as follows:

1) Nandankanan Biological Park. Nandankanan has three gharial about 8-9 feet in length. They are reported to be two females and one male, a view in agreement with the well developed gharial at the snout extremity of one and its undeveloped condition on the other two. However this may not be an infallible indication of sex and the cloaces should be probed to confirm this.

In view of the rarity of this crocodilian, and its natural occurrence in this region of Orissa, every effort should be made to breed from this group. The present enclosure is unsuitable. Furthermore, the three gharial are confined with two breeding size crocodiles said to be mugger.

The gharial should be housed separately from the crocodiles and given a mound of sand in which to nest.

Nandankanan feeds its gharial entirely on live fish, a commendable practice. Breeding should be feasible, and to encourage this a large pool was designed during the expert's visit. Several features of this pool may be of interest to other States:

- i) Wild animals must be secure in captivity if they are to breed
- ii) Crocodiles like to bask but will not do so if frightened.
- iii) Most zoo enclosures consist of a small concrete pool, often square or rectangular with little surrounding soil. The enclosure is fenced with iron bars covered with chicken wire.

Hence the public, who will get a poor view through the 'protective' screening, can approach the crocodiles from all sides.

It is noteworthy that in the only two zoos where regular breeding takes place (Jaipur and Ahmedabad) this is not the case.

- iv) Approach should be limited. Jaipur provides the ideal situation in which the crocodiles can be viewed only from the front. The public have an uninterrupted view from the front at Jaipur but on the other three sides a high concrete wall prevents anyone looking in. At the front of the enclosure is a narrow strip of soil, then a large pool and at the rear a large land area. It is here that the crocodile bask and close to the rear wall the nest is dug each year.
- v) Gharial like clear, running water. Whereas saltwater or mugger crocodiles can feel secure by submerging a foot or so below the surface of muddy water, gharial need deeper water. In nature they select deep pools.
- vi) If a pool is being constructed for gharial breeding these factors should be borne in mind. Not only should the pool be deep but facilities for at least some water circulation should be provided and an attempt made to keep the water clear.

Likelihood of breeding will be increased in a larger enclosure and a Zoo intending to breed from a gharial group should aim to build an enclosure about 100 feet square with a sloping water area extending the full breadth and going down to at least twenty feet at the deep end.

- vii) Most of the land area should be on the far side and the public should only have viewing access from the front.

viii) The enclosure should be sited so that the basking sandbanks at the rear receive good sunshine and shade trees should be provided in one corner.

IT IS RECOMMENDED that the new gharial pool being constructed in Orissa be located not at Nandankanan but within the central crocodile pilot research farming complex which it is hoped can be located in Bhubaneswar. Adequate supervision is not available at Nandankanan and although it is easy to keep a few crocodiles, regular breeding and rearing of the young is a highly specialised task requiring motivated staff and facilities.

2) NARAJ Village. Naraj, 10 mi. (16 km.) W. of Cuttack (population 250,000) on the Mahanadi River was visited. About ten years ago a barrage was constructed for water diversion. Gharial nesting used to occur directly below the Naraj rest house and in front of the village but this no longer occurs. The nesting bank below the rest house was destroyed by the construction of a stone retaining wall. Gharial still occur in the area but are mostly small. Young individuals have been captured at Naraj and sent to Nandankanan, the last as recently as two years ago.

3) Saltwater crocodiles of Bhitarkanika. The expert travelled by boat from Chandbali along the river Dhamara to its confluence with the Baitarani river at Muhan. The boat entered the man-made Paramanadapur Khala and skirted the eastern side of Bhitari Kanika island to reach the Bhitari Kanika river and hence to Dangmal. The area is prime saltwater crocodile habitat in which the species was formerly abundant. The resource suffered greatly from harpooning, carried out with a light at night, mostly by Mohammedans from Cuttack side, after the end of the Raja's reign. During the reign of the Raja the only exploitation was trophy shooting. However, the harpooning occurred over a decade ago and it seems that the crocodiles may be increasing again. Certainly management combined with effective protection could readily restore them.

Dangmal creek, approximately half a mile (0.8 km.) E. of the Forest Rest House was surveyed after dark. It was discovered that two crocodiles live just inside the mouth of the creek. Neither were seen but their presence, not mentioned by the local people, was detected from fresh spoor on mudbanks on both banks. Both had basked that morning and one again in the late afternoon after the high tide. At both sites spoor going back several days was located indicating that the mudbanks were favoured basking sites. Spoor examination indicated a size of between 11 and 12 feet and about 8 feet respectively for the two crocodiles. About one mile up river a small saltwater crocodile from the 1973 breeding season was seen and closely approached several times. This indicated that breeding occurred last year (the 1974 eggs were only being laid). Probably the two large individuals at the creek mouth were the parents.

Confirmed presence of three saltwater crocodiles in under an hour in the creek nearest the rest house is extremely favourable. It is considered that a full survey embracing night spotting of actual crocodiles and daytime spoor examination and checking of nest sites should show a fairly substantial population. A check can be made on the breeding cohort of the population from an examination of old nests (this species is a mound nester).

IT IS RECOMMENDED that a full survey of this area down to the coast, where much ideal habitat is said to occur, and where a rich tidal fish influx will be capable of supporting a dense crocodile population, be made on the follow-up visit. In the intervening period IT IS RECOMMENDED that the Orissa Forestry Department employ villagers throughout the area Bhitari Kanika-Chandbali coast to search for old nests. These nests should not be disturbed but have their location pin-pointed on a map by Forestry staff. They can then be examined subsequently by the expert.

Not only does the number of nests indicate the number of breeding females but much biological data can be gathered from expert examination of old nests,

including indications on size of the female and level of nest destruction both by predation and flooding. Hence a detailed, cross-checked picture of the population can be assembled.

The Orissa Forestry Department, having located sufficient nests to indicate a good breeding resource - and the expert feels that it should be possible to locate 10-15 nests - can then proceed to management procedures.

The expert talked to the people at Dangmal village who said that the best creeks for crocodiles were Suajori creek and the creek opposite it, together with creeks to the west of Dangmal. The people were unafraid of crocodiles and showed interest in participating in a management programme.

In the Bhitara Kanika - Chandbali coast area sustained management, having the objective building up the breeding stock and then maintaining it at its optimum level, should provide an annual sustained yield of Rs. 1-1.5 crore/annum (= US \$ 1.3 - 1.95 million). The rate of attaining this level depends on the current resource, which has yet to be fully surveyed, and the extraction of several hundred skins annually (mostly surplus males) commencing in about the fifth year. These should produce annual revenue of the order of Rs. 3-4 lakh (\$ US 40 - 53,000). Attainment of the maximum level of Rs. 1-1.5 crore/annum should be possible after about 15-20 years.

4) Satkosia Gorge gharial. The expert travelled Chandbali-Chandikhol-Angul-Tikarpara, the last a village on Satkosia Gorge 36 mi. (58 km.) from Angul and 111 mi. (178 km.) due W. of Cuttack. The gorge, 600-700 feet above sea level, fringed by mixed sal forest with bamboos, the hills rising to 1800 feet above sea level, is 14 mi. (22 km.) long. The best area of gharial habitat extends from Tikerpara village to Barmul village a distance of approximately 10 mi. (16 km.), below which the gorge fans out to a wide river. At about 3 mi. (5 km.) from Tikerpara F.R.H., at Dengapathar, is a rocky area where the gharial are often seen in the water. In the wet season they sometime enter Barmul nulla, dry at other seasons. Two males can be seen there both about 18 feet but readily distinguishable and sometimes a female. Last year a young gharial was killed by village boys.

A total of 5 adult gharial, fortunately consisting of three females and two males, now inhabit the gorge two of which the expert saw close to Tikerpara in a night survey. The very few adults and their eggs are extremely vulnerable because of preferred closely circumscribed basking and nesting areas. There are only four nesting sandbanks in the entire gorge area. The Matia, a tribe employed in earthworks by the P.W.D. like to eat crocodile eggs. Location and robbing of nests is easy.

The only future for the Satkosia gharial - in an area of great scenic beauty providing extensive good gharial habitat - is in rigid protection combines with sound management. Numbers are so low that any poaching activity could prove fatal.

Protection can best be achieved by involving the local people. Tangible benefits must accrue to them in return for rigid protection of the gharial. Poachers rely on village co-operation. The gharial is now so rare that only positive action can save it. The typical preservation approach declare the area a Sanctuary, remove the people, stop forestry activities, remove all grazing animals - is not only unnecessary but will not have the desired effect. The only future for the gharial in Satkosia, as in certain other places, lies in its economic management as part of a multi-land use scheme.

IT IS RECOMMENDED that the gharial be managed in Satkosia in a two phase project (a) to restore its numbers and provide animals for translocation to other completely safe areas both intra-and inter-state if necessary (it is not suggested that they be given way, it is recommended that they be sold for conservation purposes), and (b) when sufficiently numerous as to be no longer endangered, for commercial purposes.

The gharial has a very valuable hide. It was common in Satkosia until comparatively recently but the population was severely reduced about five years ago following the introduction of extensive nylon set netting. Since it has co-existed with the local people it can do so again. But they must have an incentive to protect it in the face of mounting outside pressures. Provided the project is carefully explained to them and the future commercial prospects outlined from the outset the villagers will play a key role in saving the gharial. Local people are always the best conservationists as they have to live in the area. They will realise that they are the ultimate losers in the destruction of local resources. Unfortunately they are usually the victims of circumstances. However, given the correct ground rules, their presence, so often considered a disadvantage, can become a major asset.

The Orissa Forestry Department has taken and implemented an excellent decision. As from April this year it has employed two local villagers full time on a country boat to protect the gharial. A second country boat is now to be added also operated by local people. Already this tangible help (employment) has caused considerable local interest and goodwill.

Effective protection can, of course, only result from close collaboration between the Forestry Department and the local people. The Department is the authority charged with implementation of the Wild Life Act but the village people as the 'eyes and ears' of the Department are invaluable. Direct employment of villagers on protection work will have a marked deterrent effect. If need be a round-the-clock watch could be instigated at each gharial nest while numbers are so low.

However, an alternative approach (see below) may be more effective. Tourism can offer some return to the local people. However it would need to be extremely carefully controlled if it were to achieve the necessary aims of (a) preserving the gharial and (b) providing money to the local people. Tourism could readily spoil the habitat (introduction of power boats for instance) and might fail to provide any return to the villagers. If tourism is encouraged - and the presence even now of 18 foot crocodilians is a sight not equalled in many parts of the world - it should be of an unsophisticated type in which people book in advance with the Forest Deptt. Gharial tourism should be run by the local people. People should not be allowed on the gorge without a village guide. No mechanised transport should be permitted, transport should be only country boats and a fee of around Rs. 30 should be charged for two-hour hire of a country boat and boatmen (the boats are able to accommodate upto four tourists).

Tourism, however, can never supplant ultimate commercial utilisation of gharial. It can only be an extra income-earner. Cropping will provide most of the revenue.

There are three breeding females in the gorge resulting in an annual production of about 120 eggs. IT IS RECOMMENDED that the nests be removed to a safe incubation area adjacent to Tikerpara (Chapter II), and that the young be captive-reared to a size of about thirty inches before release. If about a hundred young are hatched annually and even eighty per cent of these are successfully reared, at the end of a decade the gorge population will be back to its original numerical levels, though, of course, average size will still be smaller as crocodilians take many years to reach large adult size. However, the key point concerns egg production during the second decade when each year the young from one year's eggs, hatched in the preceding decade, are becoming sexually mature. Although during the first decade egg production will remain static, if even sixty surviving young mature annually and half are females, egg production will thereafter increase annually by about 1000 eggs, during each year of the second decade (1120, 2120, 3120 etc.). Clearly there will be no room in the Gorge for these progeny as they grow. It is at this stage that one either allows natural wastage (extremely high egg and hatchling predation) to take its toll, together with territorial fighting and resultant

displacement to less favourable habitat as a result of overcrowding, or introduce culling. The latter is the logical approach. Natural resources should not be wasted. Equally important the sizeable cash crop which annual culling provides is the best incentive for effective protection at village, Departmental, State and Union Government level. It must be remembered that the success of the scheme depends on sustained effective protection. The return from poaching, and, therefore, the incentive to poach, will increase with the gharial population. The costs of the protective staff and necessary works will be substantial (recurrent costs for the initial five year plan are estimated by the State authorities, who have to find the money, at Rs. 2.60 lakh).

Since nylon set netting has resulted in the virtual extinction of the Satkosia gharial population the scheme is only possible if set netting is banned. Forunately, it seems that such a decision would be welcomed by the local people as its extensive use has resulted in gross over-exploitation of the fish resource on which the local villages depend.

Extensive information on the local fishery and gharial was obtained from discussions with villagers. Major points of interest are summarised below.

#### CROCODILES.

- 1) Mugger. A few mugger occur in the gorge but gharial were always far more abundant.
- 2) Gharial numbers. Twenty years ago gharial were basking in front of the F.R.H., upto 8-10 in a group, and boating down river one would come across them in groups of 4-6 either in the water or on sandbanks. A large gharial of upto 21-22 feet with a girth of 5 feet was associated with each group. From its size it was obviously an old bull.
- 3) Nests and young. The local people are confident that they can locate nests. The presence of the female nearby gives away the nest location. They were able to describe the habits and habitat of the young extremely well.
- 4) Attitude to gharial. The people do not fear gharial (or mugger). Fishermen and gharial were often in close proximity during traditional fishing.
- 5) Poaching. Poaching was carried out by shooting and hooking. Hooks, fixed to a chain, were placed on the favoured basking site, and when the gharial came out to bask it was booked. Even the largest individuals could be taken by this method.

#### FISHING.

- 1) Former abundance of fish. Formerly, when gharial were common, fishing was very good.
- 2) Catch. In the old fishing methods people went out in a dinghy and brought back at least 25 kg. of fish.
- 3) Fishing methods and catch. The old methods - line fishing - only caught large fish. Traditional methods also involved the use of throw (cast) nets.
- 4) Effect of traditional fishing on crocodiles. Both methods were completely harmless to crocodiles (line fishing should not be confused with the use of very large, especially baited hooks, often used most effectively to take crocodile).

- 5) New fishing methods. Set netting, introduced about five years ago involves putting out the nylong gill nets in the evening and taking them up the next morning.
- 6) Effect on crocodiles. When first used 4-5 gharial could be taken in a single net. However, this phase was hort-lived as the gharial were all lost either from drowning in the nets or being killed by the villagers to save the net. Most of the gharial were lost in little more than a year. Gharial of eighteen feet were taken in the nylon set nets. For more than three years the local people have seen no recruiting gharial in the six foot size class. Clearly all recruitment has ceased.
- 7) Effect on fish resource. The effect of the nylon set nets was scarcely less damaging to the fishery than it had been to the gharial. The village fishermen soon noticed a drop in the fish catch, at first extremely good with minimum effort following the introduction of set netting. As the catch became steadily poorer the set nets came to be referred to as 'worthless' nets. What had happened was that the fishery resource, as a result of gross over-exploitation - the nylong set nets were too efficient in catching fish - was declining. The rapid decline so worried the villagers that they asked the Fisheries authorities what they should do. They informed the expert that they were told to make the mesh size smaller in order to catch smaller fish. Hence having decimated the breeding stock - on which the fishery depends for replenishment - they started to concentrate on the recruiting fish, taking them before they had a chance to breed. It is scarcely surprising that the resource diminished.
- 8) Present catch. The villagers told the expert that now they barely catch 5 kg. of fish on a good day. The extremely poor catch was indirectly corroborated by the eagerness of local fisherman to undertake gharial protection duties. This is hard work and the pay rather low at Rs.75/- month. The contractor who leases the gorge buys fish from the villagers at Rs. 3/kg. so that the monthly gharial protection wage is equal to 25 kg. of fish. Clearly they cannot be sure of taking this in a month despite formerly taking more than this in one day's dinghy line fishing.

#### SUMMARY

Quite apart from destroying the gharial - the most valuable economic resource in the gorge - the set nets have destroyed the fishery. This has been done at an annual revenue to the State of onloy Rs. 400/- annum or less than the value of a single gharial hide. The worst sufferers are, of course, the villagers.

IT IS RECOMMENDED that set netting be banned in Satkosia Gorge and that the Gorge be declared a gharial management area. In order to bring this about the Gorge should be created a Sanctuary. As such, commercial fishing would no longer be permitted, but the local people should be allowed to continue to take fish for their own use. Limited sale of fish might also be permitted. The authority responsible for the Sanctuary (Forestry) should issue licences which should stipulate that only traditional fishing methods are permitted, that gharial are fully protected, and that set netting is illegal. It is essential that the licence method be continued to have control over the fishing.

A large gharial population in the Gorge will in no way affect the local fishery. The evidence for this statement is to hand - the fishery was excellent according to local fishermen, when gharial were abundant. Following the banning of set netting the fishery can be expected to recover. By the time the gharial are again numerous the fishery should also be good.

The following sequential acts should be taken:

- i) Discussions with villagers to outline the long-term gharial management programme, their involvement, and how it will benefit them.
- ii) The banning of set netting and creation of Satkosia Gorge Sanctuary.
- iii) The creation of a small gharial management team at Satkosia to run the hatchery and nursery pools, co-ordinated with protection work (the responsibility of the Forest Department). Local involvement should be maximised although the unit will need a specially trained post-graduate in charge. This unit, because of its close involvement with the conservation enforcement staff, would be best located within the embryonic Wild Life wing of the Forest Department but will require considerable scientific autonomy as is envisaged for the other two field unit and the central research farming unit at Bhubaneswar. It is anticipated that the proposed developments would also work in closely with the University of Bhubaneswar.

The Satkosia gharial situation has been discussed in detail because Satkosia offers the most favourable habitat seen by the expert in India for the future conservation of this endangered species. It is vitally important that this project be pursued.

The Satkosia gharial scheme is also potentially substantial revenue earning. It is difficult at this very preliminary stage, when the management plan has yet to be prepared, to state the probable annual return on a sustained yield basis. However, it will be many times the recurrent expenditure which in the first 5 years will be Rs. 2.60 lakh. Once the scheme has gathered momentum an annual return of the order of Rs. 15 lakh seems attainable. However, this can be greatly increased by further management and/or by extension of the scheme beyond the gorge.

As outlined in Recommendation 4(a) of Chapter III outstations for management of all three Indian crocodilian species are proposed for Orissa together with a centrally-located battery-type farm working on all three species located in or near Bhubaneswar. Orissa has received detailed comment because it is the State where it is recommended (in conjunction with West Bengal) that a pilot crocodile farming project be initiated; because of the extremely favourable situation for gharial management; and most important, because the State Government has prepared a plan, which has already been adopted for implementation in the State's 5th 5 year plan, including provision of the recurrent costs amounting to Rs. 9.50 lakh. The plan has been submitted to the Union Government with a request for Central Assistance for capital works. In view of the realism of the aims and the significance of this project not only to Orissa but to the development of crocodile farming in India generally, it is recommended that this project be assisted.

The proposed Orissan developments would in due course provide training in India in crocodile management for inter-state personnel as well as operating village level training schemes. There would appear to be considerable potential in Orissa for local participation in crocodile management at a village level, either by individuals, family groups or village Co-operatives. Skilled advisory services will be essential to ensure the success of these. Attention must also be given to the manner in which any Co-operatives are organised if they are to succeed.

5) Sea turtles.

Large sea turtle rookeries occur coastally adjacent to Bhitarkanika, contiguous with the sea coast saltwater crocodile habitat. The expert's advice concerning management of these was sought.

The expert identified the species from a carapace as Lepidochelys olivacea the subject of a large-scale industry in Mexico where extensive management has been practised. By the late 1960's this involved the protection natural nests of over 9 million hatchlings a year. This species has a valuable hide and high quality oil used in cosmetics. \*1 Both could readily be exported. However, it is not possible to take large numbers of adult turtles on a sustained yield basis from a wild population unless the latter is subject to extensive management.\*2

Turtles are even more fecund than crocodiles laying more than 100 eggs in a clutch and producing a clutch every fourteen days during a breeding summer. They do not nest every year but usually after two or three years spent feeding at sea (Bustard, 1972).

At present the Bhitara Kanika turtles are commercially exploited for their eggs. Last year fifteen boatloads of eggs, each boat estimated to hold 1 lakh of eggs (100,000) making a total of 15 lakh (= 1.5 million eggs) were taken for sale in Calcutta. The State Royalty was Rs. 15/- boat. The villagers get nothing except food in season from the resource. Furthermore, there is no control on the present level of egg take which may be over-exploiting the resource.

IT IS RECOMMENDED that, if the State Government wishes to carry out sustained yield exploitation of this resource, it is first subject to census by a tag-recapture operation. Following this a management plan can be prepared.

In order to provide a detailed economic assessment and to prepare a full management plan, a thorough survey of the Bhitara Kanika area is essential. Other areas to be included in the scheme also require further study. The Government of Orissa has prepared a tentative schedule according to which the expert returns to Orissa on November 23 1974, departs for West Bengal on January 6th 1975, returning Orissa on 17th January. The proposed programme, subject to approval by Government of India, would terminate in Orissa on 17th February 1975.

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\*1. Sea turtles are valuable. Small adult green turtles (Chelonia mydas) of 100 lb weight fetch Rs. 1460 (= £ 80) on the international market, and hawksbill turtles (Eretmochelys imbricata) up to 2-3 times this sum for high quality shell large individuals. Both can be farmed.

\*2. Bustard, H.R. (1972). 'Sea Turtles.' Collins. London

APPENDIX V.

BIHAR.

Investigations in the State of Bihar were restricted to the period 17 - 19th June. This permitted travel from Ranchi to Palamau National Park, assessment of possible localities within the National Park, and return to Ranchi.

Palamau National Park is an outstanding achievement - a National Park in which the animals are completely safe. As such it is an ideal location for the Forest Department to start conservation farming of mugger in a modest way. Within the Park is an ancient dam - Kamaldah - which is ideal for the purpose and formerly held mugger.

IT IS RECOMMENDED that mugger be re-introduced into Kamaldah and that these be used as the nucleus of a small breeding station which would collect the eggs and rear the young for subsequent re-introductions into other suitable water holes both within and without the Park. Thus Kamaldah would be used to support a breeding population of large mugger and produce a supply of eggs initially for conservation purposes and subsequently for commercial farming.

As a result of discussions with the expert Bihar has submitted a request for financial aid to develop this small-scale venture to the Union Government. The project outline and financial request are a model of their kind and provide a blue print for similar grant applications. They indicate the sound management practices which can be expected to flow from modest, but judiciously placed, sums of money, when accompanied by technical advice. IT IS RECOMMENDED that this request be met by the Central Government.

Bihar has requested that the expert be made available again during November 1974 for approximately ten (10) days so that the gharial habitat in the north-west of the State can be examined together with other favourable mugger habitats in the north.

IT IS RECOMMENDED that following this survey the Government of Bihar initiate a gharial management scheme. This action is most important in view of the threatened status of the gharial (Chapter I). Bihar is one of the few States where the species still occurs.

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APPENDIX VI

TAMIL NADU

The State of Tamil Nadu was visited very briefly (24-26th June 1974). The expert visited two distant mugger habitats and held discussions in Madras. The talks with Mr. R. Whitaker of the Madras Snake Park Trust and his associates concerned their report on the gharial (Whitaker et al. 1974) and the creation of a conservation-oriented crocodile farm by the Trust.

The Trust could play an important role in the development of crocodile farming technology (although it, too, will require considerable outside technical assistance).

IT IS RECOMMENDED that the Trust and the Forest Department of Tamil Nadu work in close liaison on matters relating to crocodile conservation.

On 25th June the expert visited Chidambaram Water Works. Chidambaram is located 140 mi. (224 km.) S.W. of Madras. There are 2 water storage tanks both 1650' x 350' x 11.5' deep at full water levels. Mugger, protected by the authorities, live in the tanks of this deeply religious city. Since 1969 they have been under the special care of the Electrical Superintendent Mr. Vijayaraghavan who is interested in and knowledgeable about the crocodiles. There are reported to be 17 or 18 large mugger, the largest about 14 feet. The expert was able to observe several, and noted numerous sings of crocodile activity.

The Municipal authorities have recently banned fishing in the tanks at the request of the Chief Conservator of Forests. (Formerly the tanks were let for fishing for Rs. 210/tank/annum).

The tanks provide ideal habitat for large crocodiles but paucity of cover makes them unsuitable for baby crocodiles. IT IS RECOMMENDED that these tanks be used as a breeding site for mugger but that the eggs laid be removed to a safe adjacent site for incubation. The young crocodiles should be pen-reared (Chapter II) then released for conservation purposes or sold to a commercial (private or Government) crocodile farming enterprise. This activity would be revenue earning. The tanks can support about twenty breeding females. If the eggs are protected and the day old hatchlings sold at about Rs. 60 each, then assuming 30 hatchlings per nest the annual revenue would be Rs. 36,000/- annum. This compares with Rs. 410 from annual fish auction.

There are, however, further considerations. The Public Health Inspector (interviewed by the expert) likes crocodiles in the tanks 'as it keeps people out' and he believes that crocodiles, like fish, help to keep the water pure. However, additional feeding could not take place in the tanks since they are the source of Chidambaram's water supply. Any seasonal additional feeding for the larger crocodiles (as in extreme drought conditions) would be in a small pool adjacent to one of the tanks.

Chidambaram Municipal authorities are keen on developing the tourist potential of their city. The present water supply tanks could offer a sight equalled at few other places in the world. The addition of hatchling crocodile rearing station would greatly add to tourism and thus the interests of the Municipality, the Forest Department, and conservation can develop hand in hand.

There is an occasional loss of adult crocodiles when (rarely) the tanks become very low and some crocodiles walk off in search of standing water (mugger are great wanderers). Some nearby villagers believe crocodile meat is a cure for many sicknesses including bronchitis and leprosy and therefore kill the crocodiles. Accordingly the Municipality and Forest Department seek Central Assistance to build a wall around the tanks and also to construct a pen-rearing complex for baby crocodiles. IT IS RECOMMENDED that the Union Government make this aid available. The situation would permit an annual production of about 600 baby crocodiles/annum at small expense under completely safe conditions.

On 26th June the expert visited Kilikudu, a small village located 12 mi. (19 km.) from Trichy which is 200 mi. (320 km.) S.E. of Madras. This provided the most remarkable experience in the expert's whole mission to India.

In the village pond immediately adjacent to the houses live 7 large mugger of ten to eleven feet and many smaller individuals. They are strictly protected by the villagers because of a small temple beside the pond. Formerly the villagers fished the pond in the dry season. Before doing this they first caught all the large mugger (to prevent them becoming entangled in and damaging the nets) and tied them up to coconut trees as one does with buffalo.

The villagers have no fear of the odiles which frequently sit outside their houses at night time and regularly wander round the paddy fields in search of food at night. There have been no human attacks despite this extremely close contact and no loss of livestock. The villagers told the expert that in 1968 a large mugger took one of their goats in its jaws but they 'smacked it on the head' and it released the goat unharmed.

Kilikudu has also been helped by a remarkably skilful and understanding Forest Department. The villagers have agreed to stop fishing the pond and the Forest Department has stationed a Forester to help them meet any conservation problems. Furthermore, the Forest Department has wisely taken two local villagers into its employ to look after and supply buffalo meat to the mugger in the dry season when the nearby river is dry so they cannot walk there to feed on seasonally abundant fish. This additional feeding would result in a spectacle of great tourist potential if judiciously developed (see Abhera Tank, Appendix 9).

The crocodiles are normally fed at 4 p.m. following the ringing of a bell. In view of the expert's tight time scheduling the feeding demonstration had to be advanced to the quite unnatural time of 9 a.m. (crocodiles are nocturnal). The expert stood by the water hyacinth-covered pool surrounded by the entire school population and a number of Forest Department personnel. No crocodiles were visible. The bell was rung. At first nothing happened then the water hyacinth started to move in various places and several large crocodiles came to be fed. Such a spectacle used to occur in a number of localities in India. This is the only place where, to the expert's knowledge, it still exists. It has great tourist potential. Furthermore, Kilikudu pond can provide an annual source of eggs for conservation/commercial farming enterprises like Chidambaram. While the resource is so low it is vital to maximise all sources of production.

IT IS RECOMMENDED, therefore, that the Government of Tamil Nadu's request for Government of India assistance to develop the Kilikudu project be granted.

The Government of Tamil Nadu has requested that the expert re-visit the State during the second part of his survey to advise on other sites including those for the saltwater crocodile. In view of the threatened scarcity of this species in India, and its extremely valuable hide, this work should be given high priority.

APPENDIX VII.

KARNATAKA

The State of Karnataka was visited from 27th June to 5th July 1974. The following sites were investigated: Bannerghatta National Park, Mysore Zoo, Ranganthitoo Bird Sanctuary, K.R.Sagar Dam, Sethikattia Reservoir, Nagerhole National Park, Settihally Sanctuary, Talakalele Dam, Linganamakki Dam, Sharavathi River and Bhadra Reservoir.

The following areas have potential for crocodile management. They are arranged in descending order of importance since it may be impractical to develop all simultaneously:

SETHIKATTA Reservoir  
TALAKALELE Dam  
BANNERGHATTA National Park  
RANGANTHITTOO Bird Sanctuary  
SHARAVATHI River near KARGUL  
NAGERHOLE National Park  
SETTIHALLY Sanctuary  
BHADRA Reservoir

K.R.Sagar Dam is unsuitable as is Linganamakki Dam. There is no need to involve Mysore Zoo in the project (Appendix 1).

The following notes will help to explain the order of selection.

1) SETHIKATTA Reservoir. This consists of approximately 200 acres of ideal habitat. Agriculture extends right to the water's edge but this is unimportant as the area is full of islets and untouched headlands providing first class nesting sites. The area could be developed as a major Indian crocodile management centre.

The reservoir is under the P.W.D. and is managed by Fisheries. A licence to operate a drag net in conjunction with a coracle costing Rs.90/annum replaces an annual auction. Gross revenue is about Rs. 10,000/annum. IT IS RECOMMENDED that the reservoir be developed to hold 120-140 breeding female mugger together with 50-60 males. Revenue (at Rs. 20/egg) would be Rs. 80,000/annum. It would be advantageous to sell the newly hatched baby crocodiles in preference to eggs. At Rs. 60 each revenue would be Rs. 2.4 lakh/annum on a sustained yield basis. It would be more lucrative for the Government to rear the crocodiles right through to skinning size.

It is considered that about one-half the above stocking level need not be at all incompatible with the present fish yield. Accordingly, if it is decided that the protein production is important, the area should be developed for crocodiles at a lower stocking level. But if the fishing is continued then the method of taking the fish must be compatible with maintaining a crocodile population (Chapter I, Reasons for Decline).

If the area is selected for crocodile management the managing agency should then be responsible for issuing any fishing licences and prescribing how fishing should take place.

2) TALAKALELE Dam. The dam is 3 sq. mi. in extent, has many islands and abundant fish resources. The constant water level, absence of fishing, as it is a restricted area, and absence of villages, extremely low human population and few cattle in the area combine to make it a most advantageous site. Union Government approval would be necessary to run crocodiles in the dam. The only drawback is absence of ideal nesting banks but this could be overcome. The crocodile potential of the area is very large.

3) Major attractions are location close to Bangalore (allowing good supervision) large areas available and numerous holding tanks suitable for growing crocodiles. No less than 39 of these are under construction. The area would have been first choice but for the exceptional promise of the other two areas. Some doubts are felt about crocodile growth rate during winter as even at the time of the expert's visit it was extremely cool. Apparently this was unusual.

It is envisaged that at Bannerghatta some pools could hold breeding stock, others various year classes and yet others given over to intensive fish culture to provide supplementary feed.

4) RANGANTHITTOC Bird Sanctuary. This is a small area, 3 furlongs (5/8 km.) in length, with good protection and at least six large mugger. The area should support a prolific fish population due to nutrient-rich sources (large flocks of birds feed in paddies and nest and defaecate at Ranganthittoo, and large flocks of fruit bats also roost and defecate in the Sanctuary).

A crocodile breeding tank is under construction. Further expenditure should not be incurred on this as it cannot be justified. If completed a water pump will be required which will need fuel and maintenance and food will have to be provided for the crocodiles. The tank design is only suitable for large crocodiles. IT IS RECOMMENDED that crocodiles be allowed to live at freedom in the Sanctuary, eggs be collected annually and the young captive reared for subsequent release at first into the Sanctuary and then elsewhere. The adult population in Ranganthittoo should be built up to 24-30 females and 8-10 males (reared as a batch and released simultaneously). This will then provide an annual egg production of about 1000 eggs. Costs will be two protection staff who will gather eggs as soon as laid as well as protecting the crocodiles.

5) SHARAVATHI River near KARGUL. The site proposed is right beside HEDDALI sand quarrying village and immediately below Linganamakki Dam. It consists of 3-4 furlongs (5/8 - 4/5 km) of river course with islands. The downstream limit is an anicut. The nesting banks are excellent and there are at present 7-8 large mugger.

This site is mentioned because of the local villager situation. People work twelve hours/day diving to the river bottom to collect sand for loading into small canoes. They are not at all worried by the close proximity of large crocodiles.

The fishery resource may need building up. Provided this is done there is habitat for about thirty breeding females ensuring an annual egg production of about 1000 eggs. The village population is about 40-50 people. If 800 hatchlings were sold annually at Rs. 60 each (and it might be possible to subsequently further increase the breeding population) then the local people would have a good income. Such a development could readily be initiated and would ensure complete protection of the crocodiles. It is envisaged as stage I in a two-stage development. Stage II would involve the villagers in raising the young for release at thirty inches. The increased revenue should make this further development extremely attractive to them.

6) NAGERHOLE National Park. This area is included because of the good protective situation and the existence of about six small holes each of which could hold 1 male mugger and 1-3 females (depending on the size of the water hole). Such a development would produce a further 400 eggs/annum at minimum cost, as no additional feeding would be required other than to stock the holes with fish initially.

7) SETTIHALLY Sanctuary and BHADRA Reservoir. These have been given low priority because of protection problems at the former and fishing activities at the latter. Settihally Sanctuary contains a 20 mile stretch of river which forms the Sanctuary boundary so that legally only half of the river's width is Sanctuary. To bring Sottihally into the scheme a strip of the unprotected bank would have to be declared a Sanctuary hence affording protection to the whole river. Given time and the development of some of the high priority schemes it should be possible to incorporate Bhadra at a latter stage.

Further time should be allocated the expert in the State of Karnataka as per request of the State Government, in view of the rich crocodilian resource.

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APPENDIX VIII

ANDHRA PRADESH

A brief visit was made to the State of Andhra Pradesh from 5th to 8th July 1974.

In addition to Hyderabad Zoo the following localities were investigated as potential mugger sites: (1) Godavari River, near Siwaram village, 40 km. (25 mi.) from Mancherial and 250 km. (156 mi.) N.E. of Hyderabad City. (2) Nagarjunasagar Dam, 150 km. (94 mi.) S.E. of Hyderabad City on the River Krishna Sakaligutta. (3) Ethipothala approximately 18 km. (11 mi.) down river from Nagarjunasagar Dam. Findings were as follows:

- 1) Hyderabad Zoo is outstanding ranking among the world's finest. Working in close association with the three areas described below the zoo could initiate valuable crocodile conservation/economic development projects.
- 2) Godavari River near Siwaram village. This site is good. There are few villages and the only approach is through Manthani on the other side of the river, making protection relatively easy. The habitat is gorge with reserve forest, good vegetative cover and crocodile nesting sites on the one side, and extensive sandbanks (not used by crocodiles as there is no cover) and paddy on the other side. According to villagers at Siwaram, whom the expert found well informed concerning crocodiles, there are 7 or 8 mugger of around the twelve foot mark. The village people at Siwaram, like most Indian villagers questioned, do not bother about the crocodiles. They say 'we go our way and the crocodile goes its way'. They have no fear of crocodiles nor do they kill them, though they have sometimes eaten the eggs in the past. They report that no people or livestock have been taken for 'as long as they can remember'.

IT IS RECOMMENDED that immediate protection be afforded these crocodiles by employing villagers full time. This will provide most effective protection, as one month's wages is more than they can obtain for a hide. The villagers should work in close liaison with a full time Forest Department staff member seconded to the project to provide the conservation 'authority! Conditions are ideal as such an individual, currently occupied on other duties, but who could be made available to the project, actually lives in Siwaram village. Furthermore, revenue from the sale of eggs (or book cost transfer within the Forest Deptt.) would be sufficient to more than cover the recurrent costs from the first year. Revenue from raising young would cover costs many times.

- 3). Nagarjunasagar. Crocodile potential of this enormous dam is good, but there is currently some crocodile conflict with fisheries which is resulting in depletion of the remaining crocodile resource. The expert found the local Fisheries staff very enthusiastic and research-oriented. Furthermore, the Fisheries staff have problems with catfish control in which mugger could perhaps play a key role. The dam is being stocked with large numbers of small fish fingerlings of fast growing species. It is suspected that catfish destroy large numbers.

The Forest Department is developing a deer park and the area is one of major tourist development. The crocodile potential of this 60 mi. (96 km.) long reservoir is substantial as is the tourist potential both of the large crocodiles and a crocodile rearing farm. In view of the size of the area this activity is not seen as incompatible with fishery operations although it might be necessary to delineate areas of backwater as non-fishing zones to limit crocodile catches in nets. It would appear that a joint Forest Dept. Fisheries Dept. study on the role of mugger in fisheries could be initiated here. The use of set nets must be continued due to the depth of the water. However, if local people are meaningfully (financially) involved in the venture the revenue from the crocodile industry would more than offset any damage to nets.

4) Ekthiopathala. This is a most scenic pool, biologically very suitable for crocodiles, situated immediately below waterfalls approximately 18km. (11 mi.) down river from Nagarjunasagar Dam. At the time of the expert's visit (lowest water levels) the pool was approximately 25 feet deep. There are suitable nesting/basking sandbanks. Other smaller holes occur nearby, down river. Baby crocodiles will not be swept away in the floods because of bio-physical features. The main pool could hold six breeding females with more located down stream. Unfortunately all the crocodiles have been shot. However, they can be replaced with the captive-raised juveniles from Hyderabad Zoo.

The tourist potential of the crocodiles is considerable especially if associated with the falls and a surrounding deer park. It is essential that 'development' of this scientific area be kept to a minimum. It is envisaged that visitors would view crocodiles through binoculars located at the top of the falls. They should not be allowed down to the main pool as three students were recently drowned there.

A few hundred yards along the river, by easy path, are two old temples; two other smaller ones are sited near the rest house above the falls. The area is enhanced by historical interests. The site, currently Reserve Forest, should be made a Sanctuary to stop fishing and other interference such as reed and vine cutting - latter beautify the falls.

One local person could be employed to protect the crocodiles. He could also prevent desecration of the temples. The area, though easily protected, is extremely vulnerable in the absence of a permanent guard. It will be important to keep cattle out of this small section of river. There are many better watering spots slightly downstream. Production of hatchlings (300/annum at Rs. 60 each = Rs. 18,000/annum) from the main and subsidiary pools, quite apart from tourism, will guarantee the economic viability of the scheme.

Captive rearing of young crocodiles from wild-laid eggs for subsequent release is an essential aspect of the conservation part of the schemes. IT IS RECOMMENDED that this be carried out initially at Hyderabad Zoo. Experience gained there can be used to set up regional centres beside field populations of crocodiles. The Zoo's role is seen as an initiation, and subsequently training, centre.

IT IS RECOMMENDED that Central Assistance be made available to enable these small schemes to commence.

In view of the brief time allocated the expert in Andhra Pradesh, a follow-up visit is most important. This visit would extend the scope of the investigations and also examine the status of the saltwater crocodile.

The State of Rajasthan was visited from 13th to 22nd July 1974. The expert visited Jaipur - a successful breeding site (one pair of mugger have bred regularly for a decade in the Jaipur Zoo) - and to carry out local field work, then worked in the Kota district (River Chambal and Abhera tank) and finally in the Udaipur district.

1) Jaipur Zoo. An adult pair of mugger are housed in an enclosure built around 1900 for rhinoceros. The enclosure has strong, high, cemented walls on three sides thus the crocodiles may only be viewed from the front. This security, further reinforced by the land area being at the back of the large enclosure with the pool between it and the public, is considered to be important in the reproductive success. Breeding started in 1965 when the female was about 7 feet long and the male about 8 feet. The female is now about 10 feet and the male 11 feet. Breeding has occurred each year.

Egg laying is only one facet of successful breeding in crocodiles. Incubation and rearing of the resultant young are equally important. Here credit for the outstanding success achieved must go to Mr. R.N. Yadav the zoo Superintendent who is most interested in zoo breeding and has a impressive record of achievement. Incubation success has been first class - an average of 88% over the last 5 years.

Hatchling crocodiles are notoriously difficult to rear without specialist care. Here, too, Jaipur Zoo has achieved outstanding success. At the time of the expert's visit, hatching of the 1974 eggs was expected any day. All last year 24 hatchlings had been kept at the Zoo and after 12½ months 23 of the original 24 were alive and in good health.

Unfortunately lack of space and housing has prevented capitalising on this local expertise and in the past the baby crocodiles have been exchanged with other Zoos at an exchange value of Rs. 100 each. Generally, without expert care, they have failed to survive away from Jaipur.

The following RECOMMENDATIONS are put forward to utilise Jaipur Zoo's expertise to help build up mugger stocks in Rajasthan:

- i) All future hatchlings be retained in the Zoo until they are of a size to be safely released into the wild. This is at about 30 inches (total length). They can then be released into depleted areas in Sanctuaries or retained for captive breeding purposes.
- ii) The three additional three footers (2 females, 1 male) being reared in the Zoo should be used for breeding in due course. They will require a breeding pool of their own as the large pair will not accept them.
- iii) Assistance be sought from the Union Government for the relatively small capital finance required for pen building for this conservation scheme now that an area of land has been selected adjacent to the hatchling crocodile enclosure.
- iv) That every effort in due course be made to breed from the pair of young gharial being reared in the Zoo. It might advisable to increase these to four females and two males providing Central Assistance can be obtained to construct a large breeding pool.

It should be noted that the conservation effects of crocodile breeding at Jaipur Zoo can be substantial over a decade as well as making an important contribution to technical know-how in the State. Crocodilians also have high appeal among Zoo visitors.

2) Ramgarh Dam. This dam, 30 km. (19 mi.) from Jaipur, provides the City's water supply and also good crocodile habitat formerly holding about fifty large mugger (Col. K.Singh). The dam is subject to annual fishery auction. The current yield to the Government (73/4) was Rs. 1,31,000 on a Royalty basis which the expert considers to be a good return, which furthermore has been increasing rapidly. The crocodile resource is greatly depleted. There are reported to be only two or three crocodiles of 15-16 feet laying at least one clutch of eggs annually.

IT IS RECOMMENDED that steps be taken to protect these very large mugger. It is NOT recommended that the area be used for crocodile farming, at least at present. Crocodile farming in the State should be developed in areas less important for fishery.

3) Amber. The lake below the Palace of Amber could house about 10-15 breeding size mugger. These would be of considerable tourist potential. The costs of protection guards would be more than offset by the value of egg/hatchling production (350 eggs = Rs. 7,000/annum at Rs. 20/egg; 300 hatchlings at even Rs. 60 each (Jaipur Zoo get Rs. 100 each) = Rs. 18,000/annum).

4) Rantumber. Unfortunately monsoon conditions made it impossible for the expert to visit Rantumber a series of three joined lakes, within a secure Sanctuary, where there are reported to be about a score of mugger - a most valuable resource for management. It is hoped that the area can be examined during the second phase of the mission.

5) Chambal River (Jawahral Sagar). A 12 mi. (19 km.) stretch of the Chambal bounded up river by Rana Pratap Sagar Dam and downstream by Kota Dam was examined. This area, known as Jawahral Sagar, is of key importance at a National level, in any attempts to conserve the endangered gharial and is the only place in Rajasthan where this work could be carried out.

Both mugger and gharial are now greatly depleted in Jawahral Sagar as a result of persecution. (The Fisheries Department formerly auctioned the right to take gharial). This gharial area should be made a Sanctuary, the fishery auction - death to the remaining gharial (see below) - stopped, and effective patrolling by villagers in boats and Forest Department personnel ashore, exactly as is being implemented in Orissa (Appendix 4) instituted. Management will encourage gharial at the expense of mugger. This is important as the two are in competition, competition which has been intensified as a result of large-scale habitat alteration. Fortunately mugger are not numerous in the area.

The present population of large gharial is estimated by a reliable local forestry official, long interested in the gharial, as 'probably 10-15 animals up to 20 feet. Formerly they are reported to have reached a length of 25-30 feet. Most unfortunately, the gharial and mugger are still being netted.

The local people have no fear of the gharial. Although they know that large mugger occasionally take cattle they do not kill them. There are 10-15 small villages along this stretch of the Chambal. The people live from agriculture, with very little fishing, since they are largely vegetarian. Bhils (tribals) comprise ¼ of the population and they do not eat crocodile or the eggs although non-vegetarian.

Villagers at Jaora and Deopura made the following comments;

Jaora. 'There is one 9 foot gharial and two 12 foot mugger. There were plenty before and no one tried to kill them. They have all been killed by fishery contractors. Used to see plenty gharial at Karabkhal before the dam. Now see none due to water spread. Used to see 50-60 hatchlings at a time. No good sandbanks (for netting) now.'

Deopura. 'See three gharial regularly near the damaged bridge about 1 mi. (1.6 km.) below Rana Pratap Sagar Dam.'

The expert was advised that there was no remaining threat to the gharial in Jawhral Sagar as no commercial fishery existed. A small survey, initiated by the expert, disclosed that Jawahral Sagar was auctioned for fishery and that during a fishing contract the previous month, lasting 4-5 days, 7 large gharial were killed (the population before this was estimated at 10-15 individuals). Three were killed in the Brahamini River and 4 near Basorgarh. These four or five days commercial fishing, which brought a Royalty payment of Rs. 35,000, have jeopardised the future of what appeared to be a small but relatively secure gharial population. If the contract is let again during 1975 then it is likely that the gharial - the last known viable population in Rajasthan - will be wiped out. The situation closely parallels the Orissan experience (Appendix 4). This 12 mi. (19 km.) of the Chambal is rocky and, compared to Rana Pratap Sagar for instance, has poor fishery potential.

The gharial have successfully adapted their habits to the changed conditions following the dam construction and resultant higher water levels which keep the preferred nesting sandbanks in the main river under water at all times. They were used to entering nullas (side creeks) during the worst of the floods. Now they nest in these nullas laying the eggs in dark soil. These locations offer poorer protection from predators than the sandbanks in the main river but fortunately egg predators appear to be scarce, and the female gharial guards the nest site. What is not known, even to the scientific community, is that she also guards the hatchlings for many months. The expert was taken to a 15 foot female gharial in a nulla which had been guarding her young for about three months under surveillance by Forestry Department staff. On arrival the female was in the shallows with hatchlings on her head and body, others swimming around her or lying basking on the bank immediately beside her. A total of 34 young, judged to be 15-16 inches long were counted.

A guarding female will not tolerate the presence of other large gharial. Nor will she tolerate mugger. Since all nesting must now take place in these nullas, and since they are restricted both in number and extent, there is bound to be competition for them when the gharial population increases. It may well be that an upper limit to the size of the breeding population will be set by availability of nesting/nursery site locations. It is for this reason that it is recommended that gharial be encouraged at the expense of mugger.

The gharial observed with her 3-month-old brood is known to have nested in the same nulla in each of the preceding two years. Return to the same or closely adjacent site for nesting is well known in crocodilians.

If the area is to be managed for gharial the way in which the dam (Rana Pratap Sagar) releases water requires investigation so that the degree of flexibility available to the Dam's engineers and the requirements of the Forest Department are fully understood by both parties and the best compromise is achieved. Indeed this subject goes considerably beyond gharial. Sudden opening of the dam gates last year released water at such a rate that people were killed (swept away) at Kota. As far as possible water flow rates should be changed gradually since this has critical importance in soil-erosion, a major problem facing dams and greatly reducing their effective life. The expert walked over areas adjacent to the Chambal where large trees had been uprooted and craters left as a result of last year's pattern of water release. Every effort should be taken to minimise erosion in the interests of the dam itself. One can imagine the effect of such water releases on the wild life including female gharial in their nurseries. It is the rate of increase that is the key factor for the gharial as well as in erosion. Gharial are adapted to annual floods (as are riverside trees). Whereas, before the dam was constructed, a nulla might exceptionally rise 8-10 feet in 3 or 4 hours, and stay up for a day or so (a more average rise would be 3-4 feet) it can now exceptionally rise 20 feet in one hour (if all 17 dam gates are opened simultaneously) and stay up for over a week.

Once gharial are rehabilitated in Jawahral Sagar they should be cropped. It would appear that the sustained annual crop would substantially

outweigh in value return from fisheries. Hence conservation of the species can be carried out concurrent with a net gain, not loss, in State Revenue. A phase one annual return for Jawahral Sagar would be about Rs. 3-7 lakh/annum. IT IS RECOMMENDED that management be organised so as to provide maximum participation and therefore financial return to the local villagers.

6) Abhera Tank. This tank, immediately adjacent to Abhera Palace, formerly the property of H.H.Kota, was famous for its crocodiles which came to the Palace steps daily at feeding times. As recently as 1951 there were 50-60 large mugger in the tank. Now there are none. The right to kill the mugger in the tank was auctioned by State Fisheries.

There is a proposal to restore Abhera tank to its former (crocodilian) glory. The plan has much to commend it in that the area can easily be protected and the spectacle of a number of large mugger, used to taking food virtually from the hand, has considerable tourist potential. In crocodile management Abhera is a small-medium-scale project and as such could not claim the sort of funds which ought to be channelled by both the Union Government and the State into the proposed Chambal (Jawahral Sagar) gharial scheme, partly on account of the gharial's endangered status. However, the scheme is clearly deserving and should receive the best possible support.

It is proposed that Abhera tank be regarded as an egg production centre (as well as holding large mugger in safety, and having tourist outlets). When numbers have been restored to 50-60 adults (of which about 40 should be females) an annual production of about 200 eggs can be expected. These eggs, which should be incubated outside the tank (to reduce predation hazard on eggs and hatchlings), will provide young crocodiles for conservation projects and/or for commercial crocodile farms. The sum of a number of such operations, in which the annual egg production is in effect a by-product of other activities - but should always be husbanded - can be substantial. The financial return should more than cover conservation costs. For instance the annual crop of hatchlings from Abhera at Jaipur values would be considerably in excess of Rs. 1 lakh. Were they to be reared to a commercial size it would be much greater - of the order of Rs. 8 lakh/annum.

7) Jaisamand. This reservoir, built in 1685, has only a 8-12 foot water level variation and good crocodile nesting habitats. Furthermore, it is enormous with a perimeter of about 100 mi. (160 km.). The potential for mugger farming in this reservoir is very great with an annual estimated return well in excess of the total gross fisheries revenue for the whole State. At present the reservoir is let for fisherise on a Royalty basis and the return during 1973/4 was Rs. 1,25,000. Crocodiles are now rare in Jaisamand. IT IS RECOMMENDED that:

- i) crocodile protection be instituted in Jaisamand as recommended for the Chambal (Jawahral Sagar).
- ii) that crocodile numbers be built up by management. It might be necessary to restrict them to suitable side arms to reduce vulnerability from fishery activities at least initially.
- iii) that following implementation of successful management the potential for enlargement of the scheme to most/all of Jaisamand be considered in the light of **experience** gained.

8) Udaisagar. This reservoir is unsuitable for crocodile management due to excessive changes in water level (it feeds a zinc smelter) combined with extensive local human and cattle populations and close cultivation right down to the water's edge making nesting difficult.

9) Raisamand. This large reservoir, built in 1676, is not physically suitable for crocodile management.

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10) Baghdara. This small tank in the Reserve Forest affords complete protection. IT IS RECOMMENDED that it be stocked with fish and then with 15-20 thirty inch crocodiles when these are available for distribution. In view of its small size about 10 acres with a depth of 15-20 feet in the wet, and 8-10 feet and about 5 acres in the dry season, it could not be expected to hold more than 10-15 breeding crocodiles. However, the egg production of 10 females kept with 2-3 males (350 eggs/annum) should not be overlooked. The tank has suitable nesting areas but currently has no crocodiles.

11) There are a number of other reservoirs in the Udaipur district but none of those, namely Pichhola (Swa-roo-sagar), Fatehsagar or Bagiola) are suitable for various reasons.

12) Crocodiles are reported to occur in old abandoned and flooded mine workings at Betumbi. This should be checked.

13) There is a tank at Uniara (District Tonk) extending over 3½ sq. miles containing more than 30 mugger, half of them in excess of 8 feet. They have been protected by Mr. Digvai Singh and his brother but following a Court decision concerning ownership of the tank and its contents this may no longer be possible. The Forest Department should initiate speedy action to see that this important group of mugger are not destroyed.

CO-OPERATION WITH STATE FISHERIES. The expert met Dr. M.M.Doshi, Director of Animal Husbandry and his Deputy Director (Fisheries). The latter confirmed that he would be very happy to co-operate with the Forest Department as his Branch is trying to reduce fish poaching which apparently is very serious. Close liaison between the two Departments should be built up in the interests of both. This will benefit crocodile conservation and hopefully enable management to proceed in at least some areas.

#### CONCLUSIONS AND RECOMMENDATIONS.

There are substantial prospects for crocodile farming industries in Rajasthan. The State has an extensive system of dams and reservoirs, some extending back several hundred years. The State return from Fisheries, despite the large areas under fishery management, is not large (net Rs. 1 lakh/annum). Quoted returns for specific reservoirs are most misleading as they are always quoted gross. Although gross revenue was Rs. 30 lakh for 1973/4 expenditure was Rs. 29 lakh. The people of Rajasthan are predominantly vegetarian so that it is the financial return, not fish production, which is important to the State. The combined revenue from mugger/gharial management may tentatively be estimated, after a period of about 15 years of successful control to be of the order of Rs. 1 Crore/annum.

IT IS RECOMMENDED that the following be considered as State priorities, listed in descending order of importance:

1. Gharial project Chambal River (Jawhral Sagar)
2. Jaipur Zoo conservation replenishment scheme
3. Abhera tank (it will depend on Jaipur for young mugger)
4. Jaisamand (pilot scheme should start as soon as possible).

The expert has been requested to return to Rajasthan on the next mission for about fifteen days. During this visit he should carry out detailed assessments of Jawhral Sagar, Rana Pratap Sagar and Jaisamand as well as any other areas which the State Government may request.

.../...

APPENDIX X.

GUJARAT

A survey of Gujarat State did not come within the terms of reference of the expert. Gujarat was visited from 26th-29th July 1974 in order to learn about crocodile breeding schemes at Ahmedabad Zoo and H.H.Baroda's private Zoo at Baroda. Ahmedabad Zoo is one of the two world crocodile breeding centres in Zoological Gardens where regular mugger breeding has long been a feature.

Crocodile breeding at Ahmedabad Zoo is the result of Mr. Reuben David the Zoo Superintendent's long term interest in crocodiles. Mr. David initiated and developed this superb zoo which has received universal praise. The expert saw about 100 mugger, more than three quarters of which have been bred in the Zoo. To date all breeding has been of muggers but plans exist to extend this to other species, several of which are already in the Zoo. These include a valuable group of 4 gharial of 8-10 feet of which two are definitely known to be females and one a male, and a pair of young Tomistoma schlegelii a most threatened species.

Quite clearly any captive breeding of crocodiles in Gujarat should build on this accumulated knowledge. There is a hard nucleus of husbandry experience within the zoo, but especially with Reuben David.

While the expert was in Baroda he had discussions with the Chief Conservator of Forests and several of the senior Forestry Dept., staff. AJWA lake was discussed and visited as a possible area for crocodile management techniques. The lake, which occupies 5 sq. mi. when full, is said to hold about 15-20 sizeable mugger. It certainly has the potential to house at least forty breeding females, and hence provide a revenue of at least Rs. 75,000/annum from the sale of hatchlings at Rs. 60 each. Much more lucrative would be the development of captive rearing.

The Forest Department has requested that Government of India send the expert to Gir Forest where there are 15-20 mugger with which the Dept., would like to establish a conservation/management scheme in that protected environment.

.../...

APPENDIX - XI

FEEDING HABITS OF THE AFRICAN CROCODILE

The ecological role of crocodiles in fisheries is little appreciated. Too often it has been summarised by the words 'crocodiles eat fish' and fisheries interests have then set out to destroy crocodiles without further investigation. Cott (1961)\* published a monograph on the 'ecology and economic status' of the widespread African species, Crocodylus niloticus roughly equivalent to the Indian mugger. He undertook the investigation at the request of the (then) Government of Northern Rhodesia 'to assess the probable effect which extermination or drastic reduction of crocodiles may have in the economy of inland waters and in particular on commercial fisheries.'

Unfortunately, this key monograph, important both to fisheries and for conservation and/or crocodile management, is little known in Asia. For this reason some of the more important findings are given below.

1) Crocodiles do not seem to eat large quantities of fish.

Cott wrote, "wholly extravagant views as to the quantity of fish eaten have been held in the past ... Remains of some 393 fish were recovered from 265 of the 851 crocodiles examined. In 701 stomachs containing food of any kind, the percentage occurrence of fish-prey is 37.8; and the number of fish per stomach only 0.56."

2) Crocodiles are not voracious feeders.

The following data from Cott is quoted because of its importance in crocodile farming projects. Food is a costly item and the modest food requirements of crocodiles compared to birds or mammals needs to be stressed. Cott wrote, "It is commonly stated, or assumed, that crocodiles are voracious feeders, daily consuming enormous quantities of fish and other prey. Such notions are quite unsupported by evidence. Indeed, stomach examinations have shown that a large meal is a rarity.

"Of 591 stomachs (from all length groups) only fifty-six (9.5 percent) were near repletion; eightythree (14.1 per cent) were empty; and more than half of the total were either empty or contained indigestible fragments only...

"Crocodiles are usually credited with extraordinary powers of digestion, and to this has been attributed the frequency of empty stomachs. This is contrary to evidence. For example, the stomach of a specimen killed in captivity at Jinja still contained partly digested remains of a small crocodile it had eaten a week previously (Cott, 1954z). Thus the relative scarcity of food recovered appears to indicate infrequent feeding rather than rapid digestion.

"More than half of the specimens had probably not taken a large meal for at least a week, although they were shot in waters where fish and other prey abounded. In short, it seems clear that the Nile Crocodile leads an idle life, expending little energy in an environment ideal for a large poikilotherm, and troubles to take only the little food it needs. The field observations suggest that adults take, in bulk, not more than fifty full meals in a year.

\*Cott, H.B. 1961. Scientific Results of an Inquiry into the Ecology and Economic Status of the Nile Crocodile (Crocodylus niloticus) in Uganda and Northern Rhodesia. Trans. zool. Soc. London 29:211-358.

"These conclusions find support from what is known of the food requirements in captivity. For example, Dr. H.G. Vevers tells me (25.5.54) that two crocodiles in the Society's Gardens, each measuring about 2.3 metres consumed the following rations over an observation period of thirty-six days. The average daily intake is thus shown to be only about 365 and 280 grams respectively. These crocodiles were not weighed; but specimens of the same length are known, from field measurements, to weigh about 45 kg. These two animals would therefore take, respectively, about 124 and 160 days to consume their own weight of food.

"Such slight requirements appear the more striking when compared with the food eaten by waterfowl in nature. For example, stomach examinations of Pelecanus onocrotalus in Uganda have shown that a pelican takes at least 6 lbs. (or 2.8 kg.) of fish daily, and may carry prey amounting to one third of its body weight.

3) Crocodiles feed mostly on coarse fish (themselves predators of economically valuable fish)

Cott wrote;

"Crocodiles and fish prey

"In most of the localities with which this investigation is concerned, comparatively worthless or second-class fish (compared with the commercially desirable Tilapia, Serranochromis and Sargochromis) predominate among prey eaten ... Out of 119 fishes identified from stomachs in the Kafue and Zambesi Rivers, sixty-one were siluroids (Clarias and Synodontis); Jackson (27.1.58) informs me that this is certainly a higher proportion than occurs in the natural population. In Mweru Wa Ntipa crocodiles were found to be feeding almost entirely upon Clarias.

"Several of the above-mentioned genera ... are themselves at some stage predatory on fish, fry or fish-eggs. Thus it appears that the destruction of crocodiles would be unlikely to benefit fishery interests, and might well be harmful.

"The wisdom of killing crocodiles in Hunyani Poort Dam, near Salisbury, has been questioned by L.H. Stewart, Secretary of the Natural Resources Board of Southern Rhodesia (Anon, 1952); and it was suggested that crocodiles should be maintained to limit the numbers of unwanted cannibal fish, such as barbel (Heterobranchus). Dugley Hey (ibid.) Director of Land Fisheries in the Union of South Africa, reported that where crocodiles had been reduced in the Belgian Congo, barbel rapidly multiplied.

"Again referring to the marked recent decline of crocodiles around Mwanza, Mr. Lucas informs me (9.9.55) that the number of Protopeterus appears to have increased, and that this is having an adverse effect upon the Tilapia fishery - as shown by the increase in the number of Tilapia mutilated in gill nets. R.S.A. Beauchamp (24.9.55) confirms that Protopterus mutilate fish in the nets.

"Others (Lutra maculicollis) are also causing an increasing amount of damage to netted Tilapia (E.A.F.R.O. Report, 1954-55) in Lake Victoria; and the destruction of crocodiles in Lake Mweru has also been followed by similar damage. The crocodile is known to prey upon the other ...

"The importance of the crocodile in relation to the Tilapia fishery is clearly seen in the conditions at present obtaining Mweru Wa Ntipa, where the reptiles are very plentiful and strictly protected. In the lake they tend to be monophagous, feeding extensively upon Clarias mossambicus, but apparently not upon Tilapia, and in so far as the crocodile keeps Clarias in check there can be little doubt that it is beneficial. If, owing

to a change in policy, unrestricted hunting were to be permitted, crocodiles would speedily be exterminated, and the consequences might well be disastrous to the fishery."

4) Small crocodiles eat many invertebrate predators of fish fry and fingerlings.

Under the heading 'Young crocodiles and invertebrate predators' Cott wrote, "On the evidence available, it is also reasonable to suppose that young crocodiles play a useful role in the fresh-water economy. During the early years of life crocodiles prey extensively upon giant waterbugs (Belostomatidae), adults and nymphs of dragonflies (Gomphidae, Libellulidae), voracious water beetles (Dytiscidae, Hydrophilidae), freshwater crabs (Potamonautes) and upon aquatic spiders (Dolomedes). All these invertebrates feed, either as larvae or adults, upon fish fry ... The Belostomatidae are formidable enemies; and here again the beneficial role of crocodiles may be presumed, especially in Uganda, where genera such as Hydrocyrius and Limnogeton are destroyed wholesale. The omnivorous crabs, which form an important part of the crocodile's diet in the Kafue and Upper Zambesi Rivers, also take their toll of fish; Mr. A.D. Fraser informed me that in parts of Southern Rhodesia where where crocodiles have been shot out of existence, crabs (Potamonautes) appear to have increased and are reported to be feeding the nests of Tilapia. Fryer (1959) states that in Nyas land Potamonautes "will readily feed on fishes entangled in gill nets - to which it sometimes causes considerable damage".

5) Larger crocodiles eat fish-eating birds which may cause considerable damage to a fish resource

Following detailed investigations on this topic for the white-breasted and Pigmy Cormorants (Phalacrocrax lucidus and P. africanus) and the African Darter (Anhinga rufa), the results of which are tabulated in his report, Cott concluded, "Bearing in mind the fact that crocodiles feed mainly upon fish only during part of their life-cycle and that even then many other foods are also taken, we are left with the surprising conclusion that the overall average daily fish-consumption of an individual crocodile is less in bulk than that of a White-breasted Cormorant (which consumes at least one kilogram of fish per day). Estimated in terms of occurrence, fish were found in only about one third of the crocodiles which contained food of any kind; the birds are almost exclusively fish eaters. The mean number of fish per stomach is ten times greater in P. lucidus and A. rufa than in the crocodile. In the light of these observations, it must be remembered that cormorants and darters themselves constitute the main avian prey of the crocodile in most waters where the reptile's habits have been studied."

6) Ecological status

Cott summarised his findings on the Ecological Status of the crocodile as follows, "On the ecological side, the conclusion may be reached that crocodiles are not detrimental to fishery interests, except in so far as, in certain localities, they damage gear. On the other hand, there is evidence that their presencer is directly or indirectly beneficial to the industry.

"In general relatively few fish are eaten except in the middle years of life (see. p. 294); and, in various localities, a large proportion of the fish prey are either of secondary value or are predatory species (see p. 320). Juvenile crocodiles, representing the most numerous and voracious age group, account for many enemies of fish, fry and eggs (see. p. 321). Adults take their toll of others, cormorants and darters."

7) Crocodile attacks on man

Cott concludes the ecological section with comments on attacks on man:

"Finally the specious argument that the Nile Crocodile merits persecution because it endangers human life will impress no one who is familiar with the species in the field today. Its depredations have often been grossly exaggerated, as by Hubbard (1927) and Siggins (1931). In all areas known come in Uganda, Northern Rhodesia and Zululand, human fatalities appear, from enquiries made to be rare. This conclusion is fully supported by the observations of Land (in Schmidt, 1919) from the Belgian Congo."

8) Economic value

Under the heading 'Commercial Status' D r. Cott made two comments which are equally valid for India today. He wrote, "There are two grounds for regarding the crocodile as a commercial asset. Firstly it is a producer of high quality leather. But hitherto intensive hunting has been carried out irrationally, on a mining rather than a cropping basis. Already in many parts of Africa the hunters and their agents are showing concern at the reduced yield. Under rational management, the reptiles could provide a sustained yield of skins to the trade. But if the industry is to be saved, it will be necessary to check the present uneconomic slaughter."

"The species has a subsidiary, but by no means negligible value, as a tourist attraction."

There is need for data of a similarly detailed nature on the ecological interrelationships of the three Indian species of crocodilians. However, this is a medium term aim. Effort should be concentrated first on the mugger because, due to its widespread distribution, frequently it comes into conflict with fisheries. It seems probable that parallels with the African situation described above will be found in India. For instance others are now abundant in Corbett National Park following a marked reduction in mugger-gharial numbers. Others are very destructive to a fishery killing three times as many fish as they eat and consuming considerably more fish than a crocodile. In Karnataka a fisheries research officer discussed the need for biological control of catfish in Nagarjunasagar Dam with the expert. The catfish are eating fish fingerlings liberated into the reservoir by fisheries. Mugger could perhaps control the numbers of catfish. There would seem to be considerable scope for a close liason between the authority developing crocodile management and fisheries in each state.