CROCODILES

Proceedings of the 12th Working Meeting of the Crocodile Specialist Group

of the Species Survival Commission of IUCN - The World Conservation Union

convened at

Pattaya, Thailand, 2 - 6 May 1994

(Unedited and Unreviewed)

Volume 1

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Cover. *Tomistoma Schlegelii*, one of a captive group held at Samutprakan crocodile farm, Thailand. This species remains one of the most urgent priorities for conservation action.

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* Paper not presented at the meeting.

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FOREWORD

The two volumes of this PROCEEDINGS are a record of the presentations and discussions that occurred at the 12th Working Meeting of the Crocodile Specialist Group (CSG) in Pattaya, Thailand, 2 - 6 May 1994. These volumes represent the latest in a series which has been published since 1971 by the CSG, reporting on the CSG Working Meetings. To facilitate the rapid dissemination of these materials the manuscripts are unreviewed and unedited. The papers are published just the way they were submitted and for this reason, they appear in a variety of formats and typefaces. Some retain original page numbering but the volume page numbers appear centered at the bottom of each page. A number of papers that were submitted for presentation and publication, but were not presented at the meeting, are also published here. This includes *Harvesting Wild Crocodilians: Guidelines for Developing a Sustainable Use Program*, prepared by Dennis David for CSG, published in Volume 1. Dr. James Perran Ross was the managing editor. These PROCEEDINGS were produced and distributed with a grant from Mr. M. Temsiriphong, Sriracha, Thailand.

Copies of the PROCEEDINGS can be obtained from the the Crocodile Specialist Group or from the IUCN Publication Unit. Copies of individual papers and *Harvesting Wild Crocodilians: Guidelines for Developing a Sustainable Use Program*, should be requested from the authors directly.

The opinions expressed herein are those of the individual authors and are not necessarily the opinions of CSG, IUCN - The World Conservation Union, or its Species Survival Commission.

SUMMARY OF THE MEETING

The 12th Working Meeting of the Crocodile Specialist Group was hosted by the Crocodile Management Association of Thailand (CMAT), the Royal Forest Department, the Department of Fisheries, Kasetsart University and the Thai Association for Trade in Reptiles and Amphibians (TATRA). Between 2 and 6 May 1994, 96 members of the CSG from outside Thailand, as well as an additional 100 participants from within Thailand, gathered at the Royal Cliff Beach Hotel in Pattaya for the meeting.

The meeting was most ably organized by Dr. Parntep Ratanakorn, assisted by Kriengkrai (Ken) Chaimongkoltrakul, and Mr. Leslie George and his staff. Dr. Amara Thongpan acted as Moderator throughout the meeting. Uthen Youngprapakorn provided extensive assistance to participants on behalf of Mr. Utai Youngprapakorn and Charoon Youngprapakorn. Numerous assistants and volunteers from the host organizations contributed to the smooth running of the meeting. These PROCEEDINGS were produced with financial aid from Mr. M. Temsiriphong.

The assistance of the above named individuals and organizations, the participants, and all the many people who contributed to the success of the meeting, is gratefully acknowleged here.

The meeting was honored by an opening address from H.E. Mr. Sawadi Suebsaiprom, Deputy Minister of the Agriculture and Cooperatives Ministry. Forty two papers were presented in sessions covering Conservation in S.E. Asia, Taxonomy and Systematics, The Status of Priority Species for Conservation, Captive Breeding and Conservation, Stress in Farmed Crocodilians, Monitoring populations, and General papers. Particularly interesting reports were received from the S.E. Asian region indicating both the high diversity of crocodile populations in this region and the precarious nature of their status. The very great interest in sustainable use of crocodile resources in the region as a conservation mechanism was presented. Of special interest was the new information revealed about the distribution of wild populations of Siamese crocodile in Thailand and Cambodia and Tomistoma in Indonesia. Conservation of these species is a priority of the CSG.

The Meeting also provided a forum for discussion of the relative conservation merits of different forms of crocodile use. It is evident from the papers presented and subsequent discussion that each of the different methods of crocodilian use (cropping-hunting, ranching, captive breeding-farming) can have conservation value and the key element in sustainable use programs is ensuring that the link to the conservation of wild populations is established and maintained.

Field trips to several crocodile farms were arranged by the hosts and there was the intense discussion and exchange of ideas between sessions for which CSG Working Meetings are known. The CSG Steering Committee met for two days before the Working Meeting and the CSG-CITES Review Committee for Thailand Crocodile Management met immediately following. The CSG would like to express again our grateful thanks to all the many people who made the meeting such a success, and particularly to our Thai hosts who made us so welcome.

IUCN - The World Conservation Union

Founded in 1948, The World Conservation Union brings together States, government agencies and a diverse range of non-governmental organizations in a unique world partnership: over 800 member organizations in all, spread across some 125 countries.

As a Union, IUCN seeks to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. A central Secretariat coordinates the IUCN program and serves the Union membership, representing their views on the world stage and providing them with the strategies, services, scientific knowledge and technical support they need to achieve their goals. Through its six Commissions, IUCN draws together over 6,000 expert volunteers in specialist groups, project teams and action groups, focusing in particular on species and biodiversity conservation and the management of habitats and natural resources. The Union has helped many countries to prepare National Conservation Strategies, and demonstrates the application of its knowledge through the field projects it supervises. Operations are increasingly decentralized and are carried forward by an expanding network of regional and country offices, located principally in developing countries.

The World Conservation Union builds on the strengths of its members, networks and partners to enhance their capacity and to support global alliances to safeguard natural resources at local, regional and global levels.

CROCODILE SPECIALIST GROUP

The Crocodile Specialist Group (CSG) is a worldwide network of biologists, wildlife managers, government officials, independent researchers, non-governmental organization representatives, farmers, traders, tanners, manufacturers and private companies actively involved in the conservation of crocodilians (Crocodiles, Alligators, Caimans and Gharials). The Group operates under the auspices of the Species Survival Commission of IUCN. The CSG provides a network of experts to assess conservation priorities, develop plans for research and conservation, conduct surveys, estimate populations, provide technical information and training, and to draft conservation programs and policy. CSG also assists monitoring international trade and identifying products. The CSG works closely with CITES to promote sustainable use and international trade that benefits the conservation of crocodilians. The Group is headed by its chairman, Professor Harry Messel, and maintains offices in Gainesville, FL USA. Working Meetings of the CSG are held every two years.

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SPEECH
BY
H.E. MR. SAWADI SUEBSAIPROM
Deputy Minister of Agriculture and Cooperatives Ministry
at the Opening Ceremony of the
12TH WORKING MEETING CROCODILE SPECIALIST GROUP
2-6 May 1994
Pattaya, THAILAND
****

Professor Harry Messel
Members of Crocodile Specialist Group
Distinguished Delegates
Ladies and Gentlemen :

On behalf of the Royal Thai Government and Thai people as the host country of the 12th Working Meeting Crocodile Specialist Group, I would like to take this opportunity to welcome you all to Thailand and hope that you have received a warm welcome from the organizer of the Meeting. I firmly believe that this gathering will provide a useful forum for the delegations to discuss with one another to share knowledge and to exchange ideas about the conservation and utilization of crocodile.

Ladies and Gentlemen :

Most Thai people familiar with crocodile for a long period of time due to the abundant distribution of crocodile in the wild in Thailand previously. The distribution of crocodile in Thailand diverses from freshwater to estuarine. With that, there are many stories about crocodile in various Thai folk literatures. The famous crocodile from Thai folk literature is Chalawan which is wellknown to all Thai people. Recently, however, the number of crocodile in the wild in Thailand has been decreasing. Some species almost become extinct, for example, Tomistoma schlegelii. This is due to the fact that crocodile has been seriously threatening from human activities. The most serious threat is the hunt for crocodile skin and crocodile meat. The other factors are the degradation of environment; the damaging of crocodile habitat, spawning ground and
nursery ground; the loss of food supply form the wild; etc.,.

In Thailand, previously the private sector was actively play an important role for the conservation and utilization of crocodile with some supports from the government. Currently, the Thai government has taken serious measures to conserve crocodile. This can be proved from the attempting to amend the Wildlife Law and the new Wildlife Reservation and Protection Act, B.E. 2535 has come into the force in 1992. According to this Act, all species listed in the List of Protected Species shall be prohibited from hunting, trading, possessing, breeding, exporting, importing, etc.,. There are three indigenous species of crocodile listed in the List of Protected Species. Those species include Crocodylus porosus, Crocodylus siamensis and Tomistoma schlegelii. However, if any species in the List of Protected Species can be bred in captivity for commercial purposes such species will be listed as Species for Breeding Purposes which will be permitted for breeding, possessing, and trading under some conditions setforth by the Ministerial Notification of this Act. In addition, Thailand has strictly complied with the CITES regulations for controlling crocodile utilization as well. By doing so, the Crocodile Specialist Group (CSG) has given a very useful and constructive advises for us.

Apart from amending the Wildlife Legistation, there is also a change in governmental agency responsible for crocodile matters. The authority of competent official for crocodile matters has been transferred from the Royal Forest Department to the Department of Fisheries. From now on, the Department of Fisheries is empowered to control all crocodile farms, regulate crocodile registration system, issue CITES Export Permit for crocodile and their products, enforce the law and regulation concerning crocodile matters. However, for scientific research and study of crocodile the researchers of Royal Forest Department, Department of Fisheries and other academic institutions can do research and study for the purposes of crocodile conservation and utilization.

For the management of crocodile conservation, the Ministry of Agriculture and Cooperatives has given the policies for the Department of Fisheries to conduct the research on Biology of pure bred Thai crocodile both freshwater species and estuarine species for artificial breeding purposes. In addition, there will be many conservation programs for Thai indigenous crocodile species to implement such as releasing pure bred of Thai crocodiles back to their original habitat, rehabilitation of crocodiles habitat,etc.,. The same programs are applied to Tomistoma schlegelii as well. For the crocodile farmers and other people interested in crocodile farming, there will be the programs providing information about crocodile farming, technique of breeding, nutrition, diseases, etc. in order to improve the quality of crocodile for sustainable utilization and conservation purposes.

The 12th Working Meeting Crocodile Specialist Group has been organized in collaboration with both private sector and government sector. The organizing committee of this meeting are Kasetsart University, Department of Fisheries, Royal Forest Department, Crocodile Management Association of Thailand (CMAT) and Thai Association on Trading of Reptiles and Amphibians (TATRA).

Distinguished Delegates, Ladies and Gentlemen, permit me to hope that in spite of your tight schedule, you will have some time to relax and enjoy your stay in Pattaya, Thailand.

With that, I am pleased to declare open the 12th Working Meeting Crocodile Specialist Group. I wish you have a very fruitful and constructive meeting.

Thank you very much.

COUNTRY REPORT

ON

CROCODILE CONSERVATION IN CAMBODIA

Thuok, N., MRDM ; Tana, T.S., MSc Fisheries management

(This paper is prepared for presenting in the 12th working meeting on Crocodile conservation held in Pattaya, Thailand from 2 to 6 May, 1994)

1. Introduction

Cambodia is one of the home range of two crocodilian species, the fresh water or Siamense crocodile (C. siamensis) and the salt water or estuarine crocodile (C.porosus). Both endemic species remained in the rivers, lakes, streams, wetland, swamp and estuarine areas. The former one is still presenting in the wild and in captivity while the latter is reportedly existed some in estuarine areas where no human settlement is taken place. One less populated coastal province (Koh Kong) is considered to have a peaceful habitat of this remaining species population. Beside this 4 heads of them ageing 4-5 years were brought from the Mekong Delta in Vietnam and are now bred in captivity in a country largest crocodile farm in Siem Reap province.

Conservation and management of crocodile is subject of the Department of Fisheries since it is an aquatic animal and it became more and more concern since this animal was domesticated in the farm by the people in around the French colonial period.

Even crocodile is a dangerous animal for most of Cambodian people, the recent crocodile trade value was led this wild animal population dwindled year after year due to over hunting for export . This was caused many concern to the concept of wild life conservation of the authority which was later promulgated a regulation as a part of the fisheries law for the purpose of wild crocodile conservation and crocodile farming management.

2. Background

The fresh water or Siamese crocodile (C. siamensis) and the salt water crocodile (C.porosus) are the two endemic species to Cambodia. They were very abundant in the past in every water bodies. The ancient Khmer artists carved them on the Angkor Wat and Angkor Thom temples (constructed in 11-12th Century) as a legacy.

As the human settlement being developed, they compete with crocodiles for usable space and resources, as well as hunting them for foods and hides. When human convert forest into farms, marshes into rice fields, mangroves swamps into aquaculture projects and rivers into human settlement, they displaced the animals from their habitats, driving them to the periphery of their range, where they may, ultimately, never breed successfully (Angel and Maria 1989). As a result of the direct and indirect assaults on habitats from exploitation. colonisation, settlement, exploration and habitat conservation, crocodiles are steadily loosing ground and some species may be heading for extinction. Reportedly, the wild crocodile population is mainly existing in the hinter land and unaccessible swampy areas.

Concept of Crocodile conservation

Because of the decline of crocodile species as mentioned above, crocodile was becoming an endangered species. To protect this wild animal from extinction, the ban for hunting was promulgated along with the fishery law in around 1945 during the French colonial, then later the ban was still legalized during the king Sihanouk and Soramarith rule.

The enforcement of the above ban was ineffectively done during the civil war period from 1970 to 1975 then it seemed to be abolished during the khker rouge rule from 1975 to 1979. The latter situation was continued until there was a promulgation of the new fishery law in 1987.

Very recent, concerning to the environment degradation and wild life depletion, the decree of creation and designition of protected areas was issued by the King and came into effect in late of 1993 (see Figure 1).

How ever, through information collected from many local key persons during recent mailing survey conducted throughout the country, number existing wild crocodile habitats were detected that number of them are located out of the precinct of the protected areas created and designated by the the above decree. So the effort of crocodile conservation is assumed that it requires to tackling of those where location is isolated from the defined areas.

3- Present Status of Crocodile Conservation

a-Distribution and Population

Even human activity hampers the population growth of the wild crocodile, the presence of these species is reportedly found in many remote areas of about 14 provinces of Cambodia (see Figure 2).

Table 1 is indicated the location of existing wild crocodile habitats and its populations.

Table 1. Distribution of wild crocodile in Cambodia.

No.	Provinces	Estimated No.(head)	Habitats
1	Stung Treng	3-4000	Sekong and Sesan region
2	Battambang	1500-2000	Flooded forest in lot No.1-2-3-4
3	Siem Reap	1000-1500	Flooded forest in lot No.1-2-3-4-6-7 & Srey Snam
4	Kg Chhnang	200-300	Flooded forest in lot No.1-2-3
5	Kg Thom	150-200	Region of the Seine stream
6	Kg Speu	150-200	Triangle region of three provinces Pursat, Kg Speu & Koh Kong
7	Pursat	200-300	
8	Kg Cham	80-100	Fishing lot No.2
9	Kampot	50-100	Anlong Vil, Prek Krieng & Stung Kach
10	Koh Kong	300-500	Mondol Sayma district, Kbal chay
11	Svay Rieng	10-20	Kg Trach river
12	Kandal	10-20	Prek Phnouv
13	Kratie	80-100	Chhlong
14	Preach Vihea	2-3000	Swamp area near Tbeng Meanchey district

b- Enforcement of Crocodile Conservation

Article No. 18 of the fishery law issued in 1987 is mentioning that "It is strictly forbidden the catching, selling and transportation of fingerlings, fish eggs, crocodiles, Giant catfish....; and All the above activities can be taken place on the contingency that special permission is available", but the ban enforcement, even it was thoroughly done through control system, is still facing to many difficulties since the location of wild crocodile habitat are mainly in the remote and unaccessible areas. On the other hand, widespread of unsecurity in many part of the country especially remote areas is subject of having gap in the law enforcement. While the decree of creation and designation of protected areas, even the

demarcated areas are not covering all the existing wild crocodile habitat, but at least it can be an additional form of the legal aspect to enhance the enforcement of the wild crocodile conservation in Cambodia.

c- Present status of Crocodile farming

After the free market economy of the country was settled down in around 1988, the privatization of the production sector was promoted in incredible speed, inwhich all scales of crocodile farming began to boom in the private sector. In 1989 and 1990, the market demand increased very high which was led the crocodile business to a very lucrative business that just one single baby crocodile of one month old priced up to about US$ 200-300. Because of it feasibility and profitability, farming of crocodile was became very popular in many different communities especially the communities surounding the Great Lake area. So about 172 private and government farms including one country largest government farm were recorded in 1993. Table 2 below is shown the distribution of crocodile farm and its cultured population in the overall of Cambodia.

Table 2. Distribution of Crocodile farms and number of breeding stocks in Cambodia 1994

			No. of Crocodiles (heads)			
No.	Provinces	No.of farms	Female	Male	Sub-adults	Total
1	P.Penh, Private farms	6	50	20	40	110
2	Siem Reap, gvt & pvt farms	76	354	164	1,445	1,963
3	B.Bang, gvt & pvt farms	71	307	230	496	1,033
4	Kg Chhnang, gvt & pvt farms	5	75	30	10	115
5	Pursat, pvt farms	5	15	8	20	43
6	Kg Thom, gvt & pvt farms	4	20	11	20	51
7	B.Meanchey, pvt farms	3	20	10	30	60
8	Kandal, pvt farms	1	2	1	12	15
9	Kg Som, gvt farms	1	0	0	7	7
10	Total	172	843	474	2,080	3,397

4- Domestication of Crocodiles

History :

Cambodia. is known to have started crocodile farming since 1945 when the country was colonized by France. Farmers especially fishermen in the surrounds of the Great Lake Tonle Sap began domesticating by catching them from the wild and raise them in their backyard since they learned that crocodile are economically viable and important for skin export.

In 1975, when the Lon Nol Government was collapsed, the Pol Pot government came to power. They then collected all crocodiles from private farms together and put them in to

two farms. One farm in Siem Reap province is the largest farm with around 100 heads of breeding stocks. Another is located in Kampong Chhnang province with around 70 broodstocks.

In 1979 , after the country had been liberated from the genocidal regime of Khmer Rouge, these farm were turned back to be real crocodile farms again . In addition to this , 3 more farms were also created in 3 provinces Battambang , Kampong Thom and Kampong Som.

As crocodiles have been considered as a valuable resource for export , many farms especially fishermen who were aware that this business was economically viable and important ,recommenced the raising of crocodiles by catching them from the wild and raised them as backyard animals since the beginning of the 1980`s.

Farming System in Cambodia.

Ratanakorn (1992) classified the crocodile farming in Cambodia into 3 classes , according to number of crocodile kept , the area and management .

Class 1: small scale ,small number of crocodiles , 2- 20 head kept in earthen or concrete ponds or wooden cage. This class is the majority and may be called"family farming "because of the small size and small number of crocodile . There were around 142 small scale farms in Cambodia which scattered on the river banks or near and even in the lake .Cambodian villagers living on the river bank used to keep 1-2 pairs of breeders in an area at the back of their houses . The natural fishes from the rive and lake is a good source of natural food supply .They used their family labour to catch fishes or purchased them at low price. Some fishermen who live on floating house or boats preferred to keep crocodiles in wooden cages that could float around their houses or boats .They brought their breeders to the river bank only during the eggs -laying season when water has receded.

Class 2: Medium scale 20 -70 head, kept in collective concrete ponds .These farms were generally on the bank of river or stream. The farms were constructed by concrete pond and concrete or wooden fence .Crocodiles were put together in social pond with 1:2 to 1:3 male - female ratio. Nesting materials of sod brought from the natural habitat were provided for breeding purposes- there were 25 farms of this class.

Class 3 : large scale Farms which were big in area and number of crocodile were usually more than 100 head . The breeding stocks were kept in concrete ponds and nesting material and pens were provided with sod and rotted vegetation brought from the natural habitat. They used to hatch crocodile eggs in artificial nest imitating the natural condition .Eggs were collected early the day after laying and re-burying in artificial nest. There were only 5 farms of this class.

All crocodile farms in Cambodia produced and sold hatchling to other farmers who want to growout or fattening and also to the Cambodian Fishery Import Export Company or to

brokers for export .The number of hatchings produced in 1993 was 10,322 head. Siem Reap province was the highest producer of baby crocodiles and Battambang and Kampong Chhnang were the second and the third most productive, respectively (Table3) .

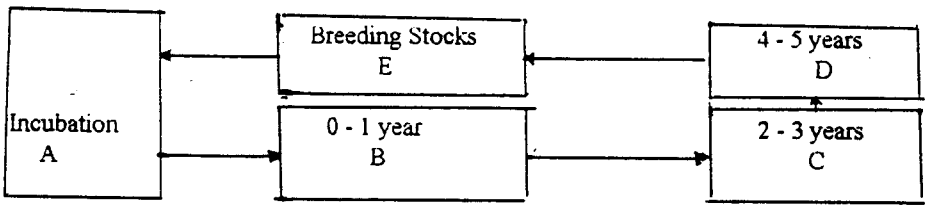
Table3 .Number of hatchling produced in 1993 and the expected number for 1994

		Number of hatchling (heads)	
No.	**Provinces**	**1993**	**Expected 1994**
1	Phnom Penh	450	830
2	Siem Reap	3,850	5,664
3	Battambang	3,350	4,912
4	Kg Chhnang	1,700	1,900
5	B.Meanchey	350	410
6	Kg Thom	310	380
7	Pursat	300	384
8	Kandal	12	36
9	**Total**	**10,322**	**14,506**

Farm Management:

Crocodile farming in Cambodia was a close cycle farming which produced hatching, nursing and breeding stocks. All crocodiles were put in social ponds which were in very restricted spaces and poor sanitation . Some farmers had no drainage at all.
Since 1989 an effort has been made to develop the Siem Reap Provincial Crocodile Farm into a modern one. This modernisation consisted of building new pens , new rearing pens , pens for juvenile and an upgrading for the hatchery . However, the farm could not be developed so much due to limitted budget allocations provided by the provincial authorities. Nevertheless, some primary data on crocodile weight, size, eggs number and incubation techniques have been able to be collected since then.

The structure of farm management could be presented as follows:



After hatching, offspring were brought to rear in nursing pens B where they remain for one year . The mortality was 5 - 10 % (7.5% in 1990) during this period.
During the second and third year, the young breeding stocks, remaining from sale, was reared in the juvenile pens, pen C, where the mortality was very low and generally nil.
The 4 - 5 year old sub adults were kept in pen D, until they were mature and were further

transferred to the pen E, to become breeding stocks.

Breeding technology

The breeding stock were kept in social ponds for breeding . The male, female ratio was 1 to 3 while some farmers kept one pair of animals separately in concrete or wooden ponds . The water depth of each ponds varied from o.5 to 1.5 m. The animals began courting from early january to late March or April . The female crocodiles began laying their first clutch from the end of the fourth week of February or early March until the end of May or June .

Production

In a study collected from the Siem Reap provincial crocodile farms , from 1989 to 1993, an average of 77.33% to 85 .35% of females laid eggs every year with an average mean clutch of around 30 eggs (table 4). The hatching percentage varied from 60 : 00 to 76.30 . The average number of hatchlings produced per female varied from 18.10 to 23.01 (table5)

Table 4. Average mean clutch of Siamese crocodile bred in Captivity in Siem Reap provincial farm.

Year	Total No.of female	Total females laids	% Female laid/Total	No.of eggs	Average mean clutch (eggs)
1989	123	105	85.36	3,203	30.50
1990	129	106	82.17	3,209	30.37
1991	133	107	80.45	3,243	30.37
1992	134	111	82.83	3,416	30.30
1993	150	116	77.33	3,401	29.31

Table 5. Number of hatchlings , hatching percentages and Average number of hatchlings per female Siamese crocodile , recorded from 1999- 1993 in Siem Reap provincial farm .

Year	No.Females laid eggs	Number of eggs	Number of hatchlings	Hatching%	Hatchlings/ Female
1989	105	3,203	1,922	60.00	18.30
1990	106	3,209	2,440	76.00	23.01
1991	107	3,243	2,247	69.28	21.00
1992	111	3,416	2,183	63.90	19.66
1993	116	3,401	2,100	61.74	18.10

Incubation of Eggs

Eggs were incubated by Semi- artificial incubation, imitating their natural condition. Usually , in the early morning ,after eggs were laid ,the female crocodile were transferred to another pen and eggs were collected carefully, without changing their initial position from the nest, to incubate in the artificial hatchery. Eggs of one female were placed into 2 - 3 piles, in the same position in which they were laid, in a hole dug about 25 - 30 cm wide, 30 deep. Before piling, a handful of dried leaves and grass was placed at the bottom of the hole, and before covering, dried leaves and grass mixed with soil were added, and a small 15 - 20 cm high compact mount was made. Each artificial nest was located about 0.5 m from each other.

The artificial hatchery was about 0.5 m higher than the soil level and filled with sod and rotted vegetation brought from the crocodile habitat near the Great Lake. It was fenced with barbed wire to a height of 1.6 m. A 0.5 m wide and 0.3 m deep canal was dug around the hatchery to retain water during dry season.

The hatchery was left to open sunlight from morning to noon when it was too hot, coconut tree leaves were brought in, to shade the nest and lessen the heat. It was also exposed to the rainfall during the whole incubation period. During the dry season (especially in April) if there was no rain , water was sprinkled over the nest and around the hatchery, filling up the surrounding canal. The sprinkling of water was intended to add moisture to the rotted vegetation, to help in the decomposition of these materials. Temperature was monitored every day (every two hours in Siem Reap Provincial Farm) by permanently inserting a ground thermometer at the egg-layer. The temperature varied between 28,5 C° during the first month of incubation (March) to 33 C° in April and May.

Hatching

At the time of hatching, 68-75 day of incubation, sound from the hatchlings could be heard when one approached the nest. At that time, eggs were excavated and offspring could come out, by using their egg teeth to slice the shell membrane and then puncture the hard shell from the inside. If the offspring could not puncture the shell and come out by themselves, they were helped manually. After hatching, if the umbilical cord was not yet broken, it was cut with a pair of clean scissors.

Nursing

After hatching, offspring were brought to the nursing pen, washed and placed in separate wooden cages, about 15-20 head in each 30 x 60 Cm compartment. If there were any abnormalities, e.g. the yolk was not completely absorbed, it was reasonable to keep them separate from the others and to expose them to adequate sunlight at about 31 C, which helped them to absorb the remaining yolk. During the first year, especially the first 2 months, young baby crocodiles of about 28 Cm were, very difficult to look after. They suffered stress or shock when exposed to loud noise or sharp light, or changes of food or variation of temperature and would not eat for many days which led to stunting on some cases. During the cool weather from December to February, they were unwilling to take any food because of lowered body temperature. Therefore, farmers used to keep their

offspring in a warm environment by heating them with charcoal fire stoves or electric lamps, where available.

Feeding

Hatchlings fed with small whole fish (sometimes live) mixed with shrimps, grew very fast. The fishes were caught from the stream, and fed to crocodiles right after catching. Farmers used to feed hatchlings with small whole fish mixed with shrimps in the first few months. They increased the size of fish gradually, as the animals grew up. During the second and third year they kept providing fishes daily, as much as the animals could eat. By practising this feeding technique they have recorded a considerably fast growth rate. The animals could grow from 28 to 120 Cm during the 1st year, and reached 140-150 Cm by the end of the second year. At the end of the third year, the animals measured 160 to 180 Cm. Some specimens recorded 2m or more.

In the state farms, the growth rate was lower, the animals reached 1,5 m in 4 yeas. This low growth rate may be because of large number of crocodile and restricted areas.

Mortality

Depending on market demand, hatchlings were sold within 1-6 months of hatching. Farmers used to sell all hatchlings and keep only a small number for breeding purposes. Therefore, the mortality was low ranging from 0-7.5% during the first year. Some farmers kept 50-100 head of hatchlings for fattening without any mortality. Among 200 heads kept in the Siem Reap state farm, 15 heads died during the 1st year, corresponding to 7.5% mortality.

Diseases

Diseases were frequent in crocodiles, from hatching to 1 year of age, and especially during the cold months, from November to February. From the second year onwards, crocodiles were rarely found sick, if food was available. The following diseases were usually frequent on the Siem Reap provincial farm :

(1)- **Pox Virus** : the animals had grayish-white circular skin lesions scattered over the body surface and particularly on the jaw, eyelids and ear drums.

(2)- **Runt** : from a few weeks to a few months after hatching some individuals remain small and weak and could not grow, even though they received identical treatment to the others.

(3)- **Limbs paralysis** : the disease appeared to effect to hatchlings during the cold weather months. The animals could not move its four limbs and died some times later.

(4)- **Gout** : This disease occurred generally in the small and medium scale private farms which was caused by over feeding.

Disease had been very rare for all small and medium scale farms, due to their small scale which made management and cleaning very easy.

5- Marketing of Crocodile

The hatchlings produced every year were sold to the Kampuchea Fishery Import Export Company (KAMFIMEX. Co), the state fishery products import export enterprise, for export. or to farmer and fishermen. for raising as broodstocks, or for further sale when market price were good. Depending on market demand, hatchlings aged from one to six months were sold at the farm gate price, which was very cheap. For private farmers, they used to raise their hatchlings until they were big enough. They were only sold when the price had peaked. They generally sold them to brokers who would smuggle the animals to Thailand. These brokers offered higher prices.

The largest market was Thailand. Therefore, the value of crocodiles was dependant on the demand for crocodiles in Thailand. Each hatchling could be sold from US$ 40-60 except in 1989 + 1990 during which the market peaked very high (between $ 200 and 300). The export of baby crocodiles was channelled through two routes: through Kampong Som to Trat and Poipet to Arunvaprathet.

6- Constraints in culture and Conservation

Cambodia has been in war for more than 2 decades. Information on crocodiles farming, management and conservation around the world is lacking. The crocodile farming is still considered illegal from the international point of view.

Political constraints: the country has been torn by the civil war and until now the political situation is still unstable. The K.R guerrillas are still disturbing in some areas. Thus, the conservation of crocodile can not be undertaken.

Technological constraints: any international cooperation with the international community except a short training course in Cuba of 2 gvt staff. National park and reserves had just created. No technical staff available to use in this field.

Economical constraints: because of war the country had not enough money allocated for the conservation of this species. Furthermore, most people are poor and they use to do gathering, fishing and also hunting for wild life as well as crocodile if it is profitable even these are restricted or banned by the natonal law.

Social and culturaral constraints:

Crocodiles have been and still are considered to be one of the most dangerous animals to human beings and domestic stocks, comparable to lions, tigers etc. and people tend to kill them whenever they meet them, either to use as food or simply out of fear.

Legal constraints:

Long run civil war and its adoption for national politique in the past led the country failed to link with external cooperations. Furthermore, the previous regime had no management policy. In addition, when the country was liberated from the Khmer Rouge regime, no conservation law was settled down until 1987. And even the law was enacted, the enforcement of the law was roughly done due to unsecurity in many parts of the country. More over, Cambodia had not been acceeded to join any international crocodile organisations as well as CITES, so neither information nor assistance had been taken place for developing the crocodile conservation in the country.

7- Priorities for dealing with crocodile conservation problems

- To promote conservation activities by the direct agreement and participation of local people by providing them economic incentives for crocodile conservation.

- To join CITES and other international crocodile conservation in order to request legal commercialisation of the resource and to participate in any international activities related to world crocodile farming, management and conservation.

- To cooperate with developed farms in neighbouring country such as Thailand to seek its technical assistance in the transference of modern technology.

- To conduct a wild crocodile population survey in order to assess the detail stocks and the expected outcomes related to the conservation in the future. This might need financial assistance from international organisation.

- To promote crocodile extension programmes

- To monitor the farming system for sustainable development.

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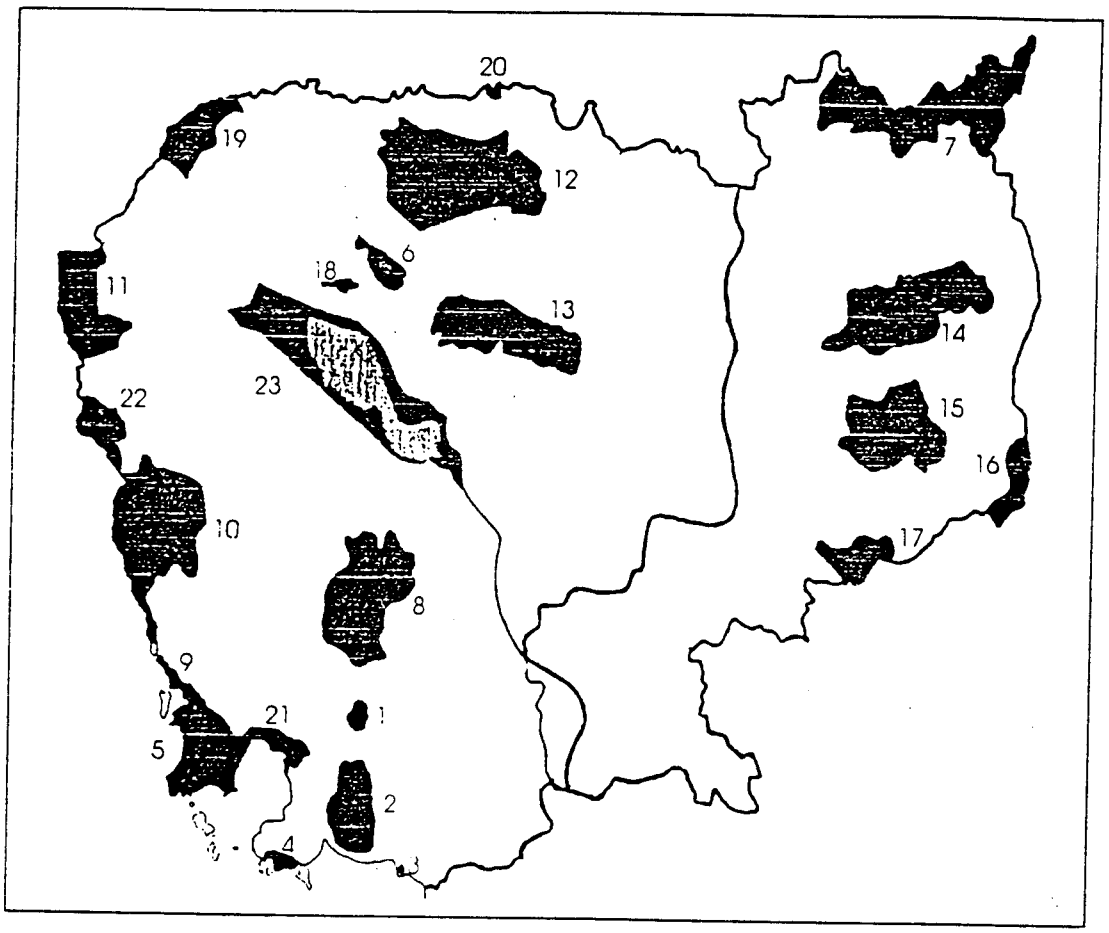
AREAS DESIGNATED AS PROTECTED AREAS



NATIONAL PARKS
1. Kirirom
2. Phnom Bokor
3. Kep
4. Ream
5. Botum - Sakor
6. Phnom Kulen
7. Virachey

WILDLIFE SANCTUARIES
8. Aural
9. Peam Krasop
10. Phnom Samkos
11. Roniem Daun Sam
12. Kulen - Promtep
13. Beng Per
14. Lomphat
15. Phnom Prich
16. Phnom Nam Lyr
17. Snoul

PROTECTED LANDSCAPES
18. Angkor
19. Banteay Chmar
20. Preah Vihear

MULTIPLE-USE AREAS
21. Dong Peng
22. Samlaut
23. Tonle Sap

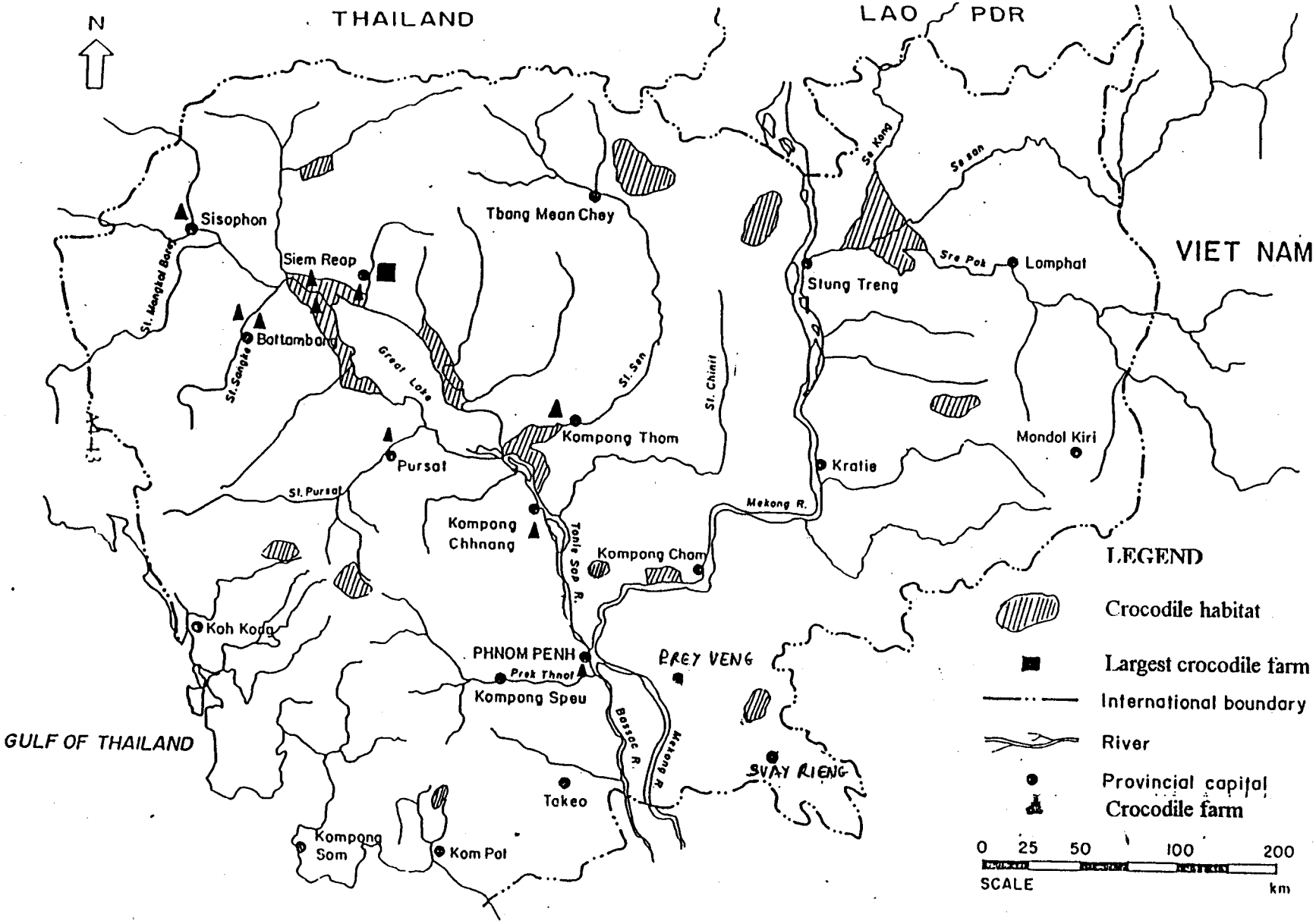


Fig. 2. Map of Cambodia indicating the distribution of wild crocodile and crocodile farms

Sivannavong Sawathvong, Wildlife Inventory & Research, National Office for Nature Conservation.

THE STATUS OF CROCODILE OF THE LAO P.D.R.

GENERAL INFORMATION

The Lao P.D.R is a land-locked counrty in SouthEast Asia bordered by China to the North, Vietnam to the East, Cambodia to the South, Thailand to the West and the Union of Mynmar to the North West. The total land area is 236800 square kilometres.

The Lao P.D.R is a mountainous country, only 20% represents the lowlands. The Mekong river and its tributaries flow from north to south through the country.

The population is small and comprises of 68 ethenic groups with different cultural backgrounds, sparsely dispersed through out the country. The population in 1990 was estimate to be 4.2 millions. About 1.7 million live in upland area and 2.5 million on the lowlands formed by plains of the Mekong river.

The level of culture, education and public health of the Lao people is not well developed yet. The communication and transport networks still remain inadequate. Economic production is still at the subsistance level, output is at low level. Gross Domestic Product is only US$220 per capita.

A national reconnaissance survey indicates that the total forest cover was about 49% in 1982 and 47% in1989 . About 70000 Ha of forest have been lost each year during 1982-1989. The main causes of deforestation are shifting cultivation, forest encroachment, forest fire, inapproppriate forest management, inadequate law enforcement, inadequate public care for the forest and an increased demand for timber and fuelwood.

Lao P.D.R issituated in the Indochinese of the Indo-Malayan Realm. Laos contains parts of four Biogeographic Units: Annam; consisting of the Anamite Range and extanding across Vietnam to the south china sea; and tropical lowlands, tropical montane and sub tropical transition zone subunits of central Indochina shared with Cambodia, Thailand, Burma, Vietnam and China. The Anamite range and the Mekong river are the main natural barriers in the area, forming the limits of the range of a numbeeer of species and subspecies.

THREATS TO THE SURVIVAL OF CROCODILES

There problably is some trade in Siamese Crocodile skins, and of hatchling destined for thai crocodile farms. However; it is now being considered by other parties in combination with a tourist development near Vientiane . A crocodile ranching operation that would collect hatchlings from the wild and raise them for skins and meat has also been proposed by N.A.F PtyLtd, Canbera; Australia and has been approved by government but has not yet been established because of funding problem. The proposal for a crocodile ranch is of particular concern as it was based on an incomplete feasibility study in which there was no

attempt to determine current level of crocodile population in project area. Although it includes provisions for returning crocodiles to the wild to maintain breeding stock.

EXISTING LAW \PROVISIONS

At present Wildlife Management and Conservation in Lao P.D.R are governed by the following executive decrees and instructions for their implementation:

1./ Decree of the Council of ministers No 185/CCM in relation to the Prohibition of Wildlife Trade(21 October 1986).
This decree specifically prohibits all kinds of wildlife trade(trade in live or dead specimens,in trophies,or in articles produced from wild animals).

2./ Decree of the Coucil of Ministers No 118/PCM, on the Management and Protection of Wildlife and on Hunting (5 October 1989).
This decree prohibits hunting using military weapons,grenades,poison or other equipment of a" mass-destruction"character.It is also prohibited tohunt protected or endangered species (not specify),pregnant or nursinganimals.Import or Export of wildlife (living or dead) or parts thereof requires specified forms of documentation.Protected species may be cayght or killed in defence of human life but ownership of such animals reverts to the state.

3./ Instructions on the Execution of Council of Minister's Decree No 118/PCM dated 5 Otober 1989 on the Management and Protection of Wildlife and on hunting.
These instructions require the registration of all firearms used for hunting,and prohibit the use of firearms modified from war weapons.They prohibit hunting,catching,killing,damaging, transporting,selling,exchanging or having in possession without authorization alive or dead animals or parts such as horns,hides,bones,ivory,gall-bladders,skins,scales etc. They also specify that import or export of wildlife should comply with international principles regarding certificates of origin,certificates of health,and import-export licences;These can be issued by the National Office for Nature Conservation (Protected Areas snd Wildlife Division) not by any local administrative committees. They also define management categories for wildlife species ,as follows:

Prohibited Category_ (1) : valuable and nearly extinct species . Hunting is banned in all seasons except with the approval from the Council of Ministers. Individual animals may be killed in defence of human life or property but become the property of the State.

Controlled Category (2): rare species, which may be threatened with extinction if hunting is not controlled.Hunting is permitted only during the off (non-breeding) season,and only for food and not for sale or exchange.The breedingseason is taken to coincide with the Buddhist Lent or fasting period,from the beginning of August to the end of October.

General Category : species that are not included in Catergories 1 or 2.

Provinces may increase the level of protection for individual species (eg., by placing general Catergory species in the Controlled Catergory,or Controlled Catergory species in the Prohibited Catergory) but can not decrease the level of protection withoutauthorization from the Ministry ofAgriculture and Forestry.

4./ Hunting Ban during the Buddhist Lent (30 July 1993).
This notice, sent to all ministries, provinces,municipality, special zones and districts in the country,reiterates the need to enforce the provisions of Decree No118 and the subsequent instructions for its implementation, and specifically to :

- stop the hunting, capture or export of all wild animals cited in the lists of prohibited and controlled species.
- prohibit the selling,service in restaurants,and consumption of wild meat.
- prohibit the transport of live or dead wildlife including trophies.

5./ Penalties.
Penalties for violation of these decrees and instructions are outlined in the Penal Code of the Lao PDR (23 October 1989).

CURRENT STATUS OF CROCODILE

Crocodiles still occur in a number of the tributary drainages of the Mekong primarily inhabiting perennial rivers, oxbow lakes and freshwater lakes and ponds,but also swamps ,marshes,seasonally flooded grassland,permanent reservoirs and (transiting through) rain fed paddies.They apparently are absent from NorthEastern Laos and the Anamites.

Population level are problably very low through out the range of this specie in Laos,and it has recently disappeared from a number of areas.

Virtually all remaining populations are threatened by hunting and habitat destruction. Although most villagers reported that they do not purposely persue crocodiles;they are occasionally captured accidentally in fishing nets and there is some eggs collecting and purposeful hunting of adults for skins. Wildlife traders from thailand currently are the major byer of both live animals and skins. There also is an active trade in live animals and skins of this specie from Cambodia through Southern Laos in to Thailand.

The distribution of Siamese Crocodile as reported during village interviews 1988-1993 are as follows:

1. **Nam Ma** *:A 1.5m long individual reportedly was shot at the mouth of the Nam Ma in 1990,and its skin sold.(previous occurrence problably extralimital).*
2. **Nam Poui PA:** *Formerly occured in the Nam Poui and Nam Gnam drainages but dis appeared,atleast from the upper reaches,about 20-30 years ago;occasional individuals may still occur in the adjacent lower Nam Gnam and main Mekong.(probably extirpated).*

3.Nam Gnum Reservoir : *Small crocodiles have occasionally been caught in fishing nets in the reservoir,and whenever captured are sold.Villagers at the northern edge of Phou Khao Khouy PA reported that crocodiles occur in the Nam Xan,which drains into the Nam Ngum reservoir.(Probably on the verge of extirpation).*

4.Phou Khao Khouy PA :*Crocodiles are reported from the area's peripheral drainage the Nam Xan and its main drainages the Nam Leuk,the NamGnang and the Nam Mang and its tributary the Nam Pa.(Endangered,probably on the verge of extirpation).*

5. Nong Ngom Wetland : *A population of 100 or more crocodiles reportedly occupied this area,a small freshwater lake at the northern edge of the Vientiane plain,up until about 30 yaers ago.According to some villagers crocodiles are still occasionally seen in inaccessible,heavily vegetated parts of the wetland.(On the verge of extirpation if not already gone).*

6.Khammouane Limestone PA :*Currently report only from location,a small wetland at the western edge of the area,near Nam Hinboun.*

7.Phou Xang He PA : *Reported from the upper Xe Champhon during the rainy season,the Xe Kang and the Xe Xangxoy;previously occurred in the Xe Noi and the Xe Thamouak but now have disappeared from these rivers.*

8. Xe Banghiang : *Reported by villagers to be common in the Xe Banghiang River and its tributary the Houei Namkhan.They are reportedly seen baskingevery year and sometime are caught in fishing nets.*

9. Xe Champhon Wetland : *Crocodiles occur throughout the southern part of this wetland complex,with Kout Xelat and Kout Chiak,and perhaps other small oxbow lakes and ponds along the xe Champhon,having resident breeding populations.Calling and presumably matinf takes place during May,the early part of the rainy season.Part of the area has been declared a protected area by villagers but eggs,hatchlings and adults all are at leat occasionally harvested and sold to itinerant thai traders or in the market in Savannaket.(Major threats include invasion by the aquatic weed Mimosa,flooding of breeding habitat if currently planned irrigation projects go ahead,and illegal harvest of eggs,hatchlings and adults).*

10. Nong Luang Wetland Group : *Crocodiles occur in several wetlands in this area,with Kout Bakkok and Kout Koang,two small oxbow lakes south of the Xe Xangxoy,probably providing the best habitat .Crocodiles also occur in Nong Luang,where they are occasionally seen moving overland through rice paddies and are sometime accidentally caught in fishinf nets.In addition to incidental caprye in fishingnets there is evidence that crocodiles in this are have been and probably still are hunted for their skins.(Available information suggests that crocodiles were much more common in this area prior to the mid-1980,although a small population and some excellent habitat still remains).*

11.Xe Bang Nouane PA : *Crocodiles are reported to occur virtually all along the Xe BangNuane,which rises at the eastern end of the protected area.(Widely distributed along the river but probably uncommon).*

12.Phou Xieng Thong PA: *Crocodiles reportedly occur in deep pools in one or more of the stream draining this low plateau.(A small and spatially limited population possibility remains).*

13. Houei Khamouane: *Villagers in the area reported that there is a population of crocodiles in the Houei Khamuoane,its tributaries the Houei Khala and others,and possibly associated seasonally flooded wetlands.*

14.Nam Lepou: *Villagers in the area reported crocodiles in the Nam Lepou,which flows into yhe Mekong and forms the border between Laos and Cambodia.*

15.Seephandon Wetlands: *Two villages at the southeastern edge of this wetland(a widening of the Mekong river with numerous islands,channels and rapids) reported that crocodiles are often seen in the river channels in this area.*

16.Dong Hua Sao PA: *Crocodiles apparently stil occur in a number of streams and ponds in the lowland section of th PA.*

17.Xe Khampho: *Crocodiles are frequently seen in the middle section of the Xe Khampho,which flows from the southeastern corner of the Dong Hua Sao PA across a flat plain to the northeastern of the XePiane PA.*

18. Xe Piane PA: *Crocodiles reportd from Bung Gnai-Kiatngong ,a large ,swampy wetland complex at the northen edge of the area.*

19.Nathongsomlong/Nong Houei Soymong Wetlands: *Local residents reported that crocodiles occur in the small lakes and ponds of this wetland complex year-round,basking on rocks in the wet season and staying in the heavy grass cover during the dry season.*

20.Mid and Upper Xekong Drainage: *Crocodiles appear to be widely distributed in the Xekong river and its left bank tributaries arising in the anamites and along theLao-Cambodia border.Villagers report frequent sightings and consider crocodiles to be common in some areas.*

CONSERVATION MEASURES

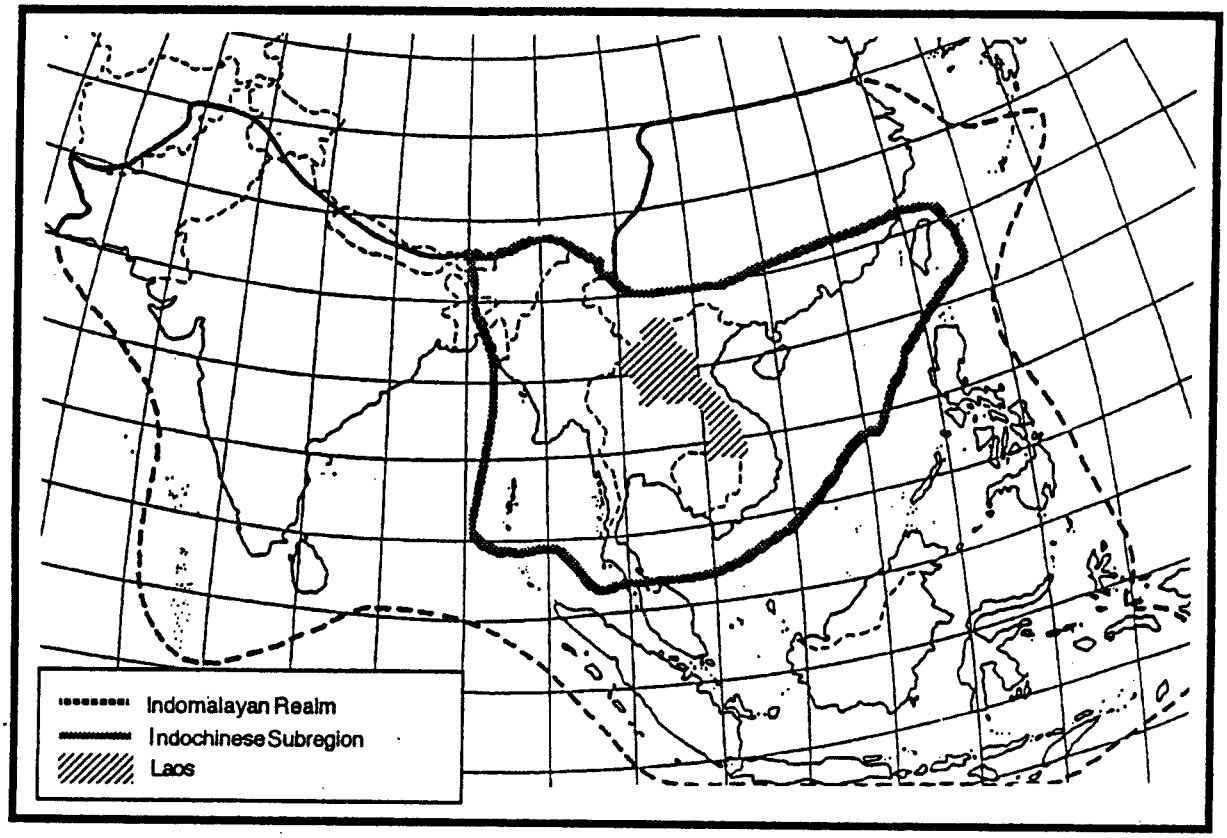
The historic range of Siamese crocodile encompassesThailand,Indonesia,Malaysia, Cambodia,Vietnam and Laos, It is currently known from only few locations within this range.It is listed in the SSC Crocodile Action Plan as extremely endangered and is considered to have the highest priority specie for conservation action and the specie for which the least and poorest quality population survey data are available.So in Lao PDR , i would like to suggest that :

1.The status survey is the highest conservation priority for this specie.

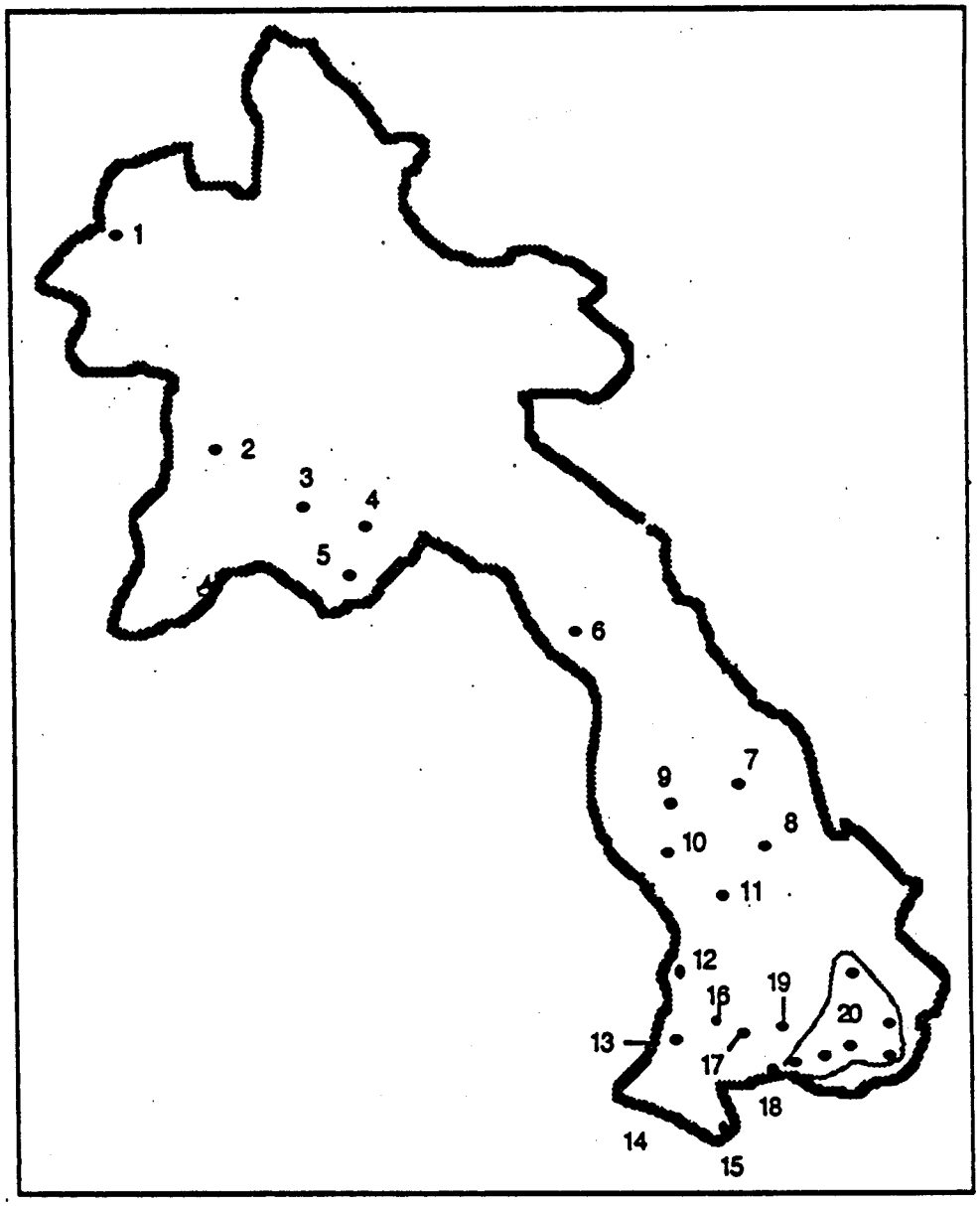
2.Establishment of wetlands protected areas.

3. Accession to CITES to help control illegal trade..

4. Develop of an educatinal program regarding values of crocodile conservation aimed at local people to ensure their input and participation in crocodile management.



Biogeographic units.



Distribution of **Siamese crocodiles**, as reported during village interviews 1988-93, and from other sources.

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THE STATUS OF CROCODILIANS IN MYANMAR

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Myanma Fisheries Enterprise
2 - 5 - 1994.

Mr president, CSG members, distinguished guests and participants-

First of all, please allow me to express my sincere thanks and appreciation to Dr. Parntep Ratanakorn, Secretariat General of the 12th CSG Working meeting for inviting me to this gathering in order to present a paper on " The Status of Crocodilians in Myanmar"

Introduction

Myanmar is the largest country in mainland Southeast Asia with a total land area of 676,577 sq.km. It has a coastline of 2,832 km.

Myanmar could be taken as a forest clad mountaineous country. Three parallel "Chains of mountains ranges run from north to south, the Western Yoma or Rakhine Yoma,the Bago Yoma and the Shan plataue.They begin from the eastern extremity of the Himalayan mountain range. These mountain chains divide the country into three river systems, the Ayeyarwaddy, is the Sittaung and the Thanlwin, of which the Ayeyarwaddy is the most important river whole length is about 2,170 km. As it enters the sea, the Ayeyarwaddy forms a vast delta area of 240 km x 210 km.

As it is mainly in the Tropical region, Myanmar has a tropical climate with three seasons:- the rainy season from mid May to mid October and the cool season from mid February to mid May. Annual rain fall vary from 500 cm in the coastal regions to 75 cm and less in the central Dry Zone. Mean temperature ranges from 32° C in the coastal and delta areas and 21° C in the northern low lands.

Myanmar's population is estimated at 40.03 million in 1989-90,an increase of 1.88 % over the previous year. The area under cultivation is 8.0 million hectares, Forest covers about 57 % of the total land area.

The Crocodilians in Myanmar

Crocodiles are quite familiar to Myanmar people for ages. They are found in the old paintings, drawings, carvings of the ancient pagodas and monestaries of Myanmar. In the great legendaries of Myanmar crocodiles play a great role as the main character.

Myanmar kings usually dug up moats around his palace and reared crocodiles to fend off enemies.

Myanmar Species

According to the past records, it seems that there were four species of crocodiles in Myanmar. But at present only *Crocodylus porosus* species remain.

i. *Crocodylus porosus* is found in tidal Ayeyarwaddy waters at delta regions of Bogale Township.

ii. *Crocodylus palustris* were found in fresh water ponds. At present the existence of this species in not known yet.

iii. *Crocodylus siamensis* is also not known for the present. But Peacock in his book known as the " Game book of Burma " stated that both *G. gangeticus* and *C. palustris* (or possibly *Crocodylus siamensis* rarely occur in the Ayeyawaddy river.

iv. *Gavialis gangeticus* were found existed in the past but there is no evidence whether existing now.

Present wild population

There is no surveys made as to the existence of *C. palustris*, *C. siamensis* and *G. gangeticus* in Myanmar.

In 1980 Mr. Caughley made his survey at Bogale township in the delta area. I was one of the members of that Survey Group.Only 16 crocokiles were seen and according to his survey it was found that the isolated population, i.e. the largest remaining population is about 4,000. There is a decline in population on account of illegal hunting, destroying of nests and habitat destrucrtions.

No specific legal protection is enforced for crocodilians. But protection by the general way is normally made for illegal catching, hunting and farming. During the year 1993 the farm made a purchase of 177 hatchlings from the Ayeyawaddy delta area at the rate of ks 2000/- each.

According to the information received from Kowthoung and Sittway, crocodiles are still existing there. But it is not possible to estimate their population. At the border area, illegal businesses are carried out. In the year 1992 a Navy Boat while on duty recovered 12 crocodiles (2 of them breeder size), from an abandoned ship, which were later handed over to there crocodile farm.

The Forest department is planning to nurture a crocodile Sanctuary on Meinma Hla Kyun Island (in the Ayeyawaddy Delta) and the area is declared as a reserve forest. The Department of Fisheries has also declared this area as a reserved fishery area.

Legislation

The present government enacted three Laws in respect to the conservation of natural resources including crocodilians. They are: Myanma Marine Fisheries Law 1990, Freshwater fisheries Law 1991 and Forest Law 1992. The laws protect crocodilians. No one can hunt or catch or farm without Licence. When any one is found guilty of violation any of the prohibitions shall be liable to be punished with fine which may be extended to Kyats 300,000 or with imprisonment which may be extended to 10 year or both.
Crocodile farming is being conducted by the government only. There is no private farm in Myanmar.

Conservation & Farming

The present Government is well acquainted with the economic value of the crocodilians and that is why some Laws were made for conservation and farming. There were three main objects for crocodile farming:-

1. For conservation and research.
2. For sustainable use.
3. To develop the farm as a Tourist centre.

Tharketa Crocodile Farm.

This farm was established in the year 1979 by the Myanma Fisheries Enterprise, under the Ministry of Livestock Breeding and Fisheries.

At the beginning, wild crocodiles were bought and reared at the farm. Since 1982 egg laying had been started in the farm. In the year 1992 26 nests and 1076 eggs was obtained.

At present there are nearly 830 crocodiles of all sizes reared at the farm. Big crocodiles are being fed with fish and hatchlings are fed with small prawns. Rearing ponds are made of concretes. The Breeder pond is of 450 ft x 350 ft in size. There are altogether 46 male and 69 famale breeders. Eggs are incubated by man-made nest and rearing is being done under natural environment. The mortality rate is still high in hatchlings.

From 1983 to 1989 a total number of 1830 live crocodiles were exported to Thailand and Singapore by the farm, at on F.O.B price of US$ 1,62,689.

Discussion

There is a National Commission for Environmental Affairs to preserve the natural resources of Myanmar. The Government is very keen in conservation and interested in sustainable use of crocodiles. There is a possibility to develop a sanctuary in Ayeyawaddy delta area and to develop the farm as a Tourist Centre. For this, new information techniques are needed to develop our current crocodile research and farming.

STATUS AND CONSERVATION OF CROCODILES IN VIETNAM

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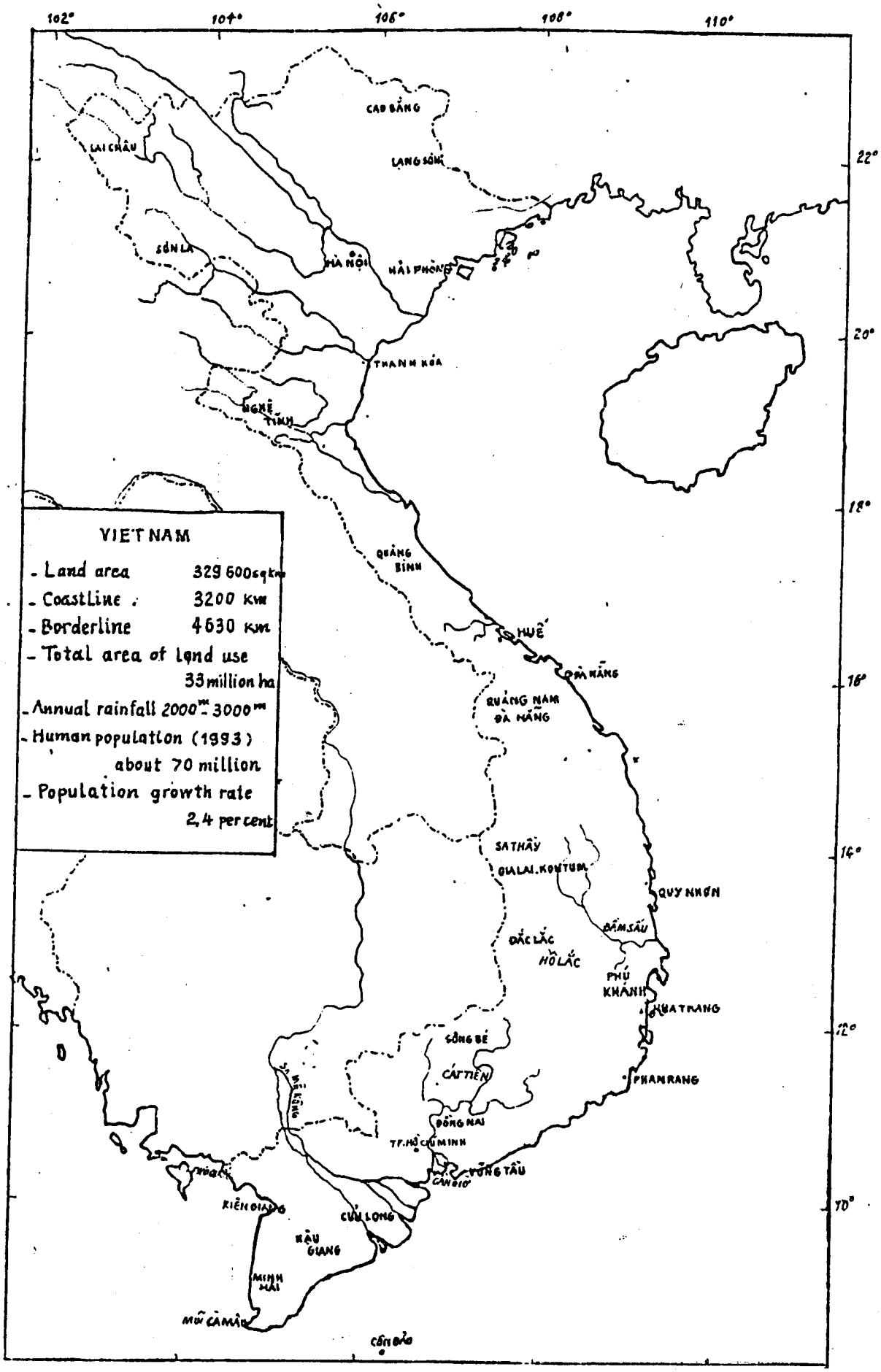
I. NATURAL AND SOCIAL CONDITIONS OF VIETNAM

Vietnam situates along the southeast margin of the Indochinese Peninsula. It stretches from latitude 8°N to 24°N. Total coastline is about 3 200km and total land area is 329 600km². The main mountain range - Truong Son range - forms the natural boundary with China, Lao and Cambodia. The mainland borderline is 4 630km (1 430km with China, 2 067km with Lao and 1 100km with Cambodia).

The country is S-shaped, broader in the Northern and Southern parts, where it is swelled by the Red river and Mekong Delta and very narrow in the middle, where in the Binh Tri Thien province it is only 50km wide at the narrowest point. So, the country has its length much longer than its width. A broad, shallow continental shelf follows the shape of the land, wide in the North and South and narrow in the middle.

Three-quarter of the country consists of mountains and hills. The highest peak - Fanshipan - reaches 3 144m in Northwestern Vietnam, where they form an extension of great Himalayan range. The land suitable for agriculture reclamation covers about 100 000km². It is situated mostly in the large fertile plain of Nambo and Bacbo, which include the Mekong and Red river deltas, respectively. Total area of all current patterns of land use is 33 million ha. Of it 6.9 million ha for agriculture, 11.8 million ha for forestry, 1.4 million ha for towns and other special use and 12.9 million ha of very poor or unproductive land.

Vietnam shows a variety in climate condition on account of it wide range in latitude and altitude. Although, the entire country lies in the intertropical zone, climate varies from humid tropical condition in the southern lowland to bracing temperate condition in the northern hills. Mean annual sea level temperatures correspondingly decline from 27°C in the South to 21°C in the extreme North. The mean annual rainfall is 2 000mm, but this increases in the narrow central mountainous region to 3 000mm, sufficiently heavy to support tropical rain forests. There are three monsoon seasons, namely the northeast winter monsoon, and the southeast and western summer monsoons. Destructive typhoons sometimes develop over the East sea during hot weather.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CỬU LONG
HẬU GIANG
MINH HẢI
MŨI CÀ MAU
CÔN ĐẢO
VIET NAM
- Land area 329 600sq km
- Coastline : 3200 km
- Borderline 4630 km
- Total area of land use 33 million ha
- Annual rainfall 2000mm - 3000mm
- Human population (1993) about 70 million
- Population growth rate 2,4 per cent

The river network of Vietnam is mazy and varied. The North alone has 1 083 rivers and water ways of all sizes. In Nambo, there is a big river every 10km along the road, and a river estuary every 20km along coast.

The very rich lake, swamp system in conjunction with 3 200km of coastline and islands provides Vietnam with large wetland area as favourite habitats for water fauna, including crocodiles.

Vietnam is the most densely populated country in Southeast Asia with about 70 million residents in 1993 and a mean annual growth rate of 2.4 per cent. This gives a mean density of about 200 persons per square kilometer, the highest density for any agricultural country in the world.

The high population growth rate, together with severe destruction during the recent war has brought great negative affects to the habitats of wildlife, including crocodile: forest loss for agriculture land use and new villages, towns, forest logging and fires etc...

II. STATUS OF CROCODILES IN VIETNAM

1. Status in the wild

There are 2 species of crocodiles in Vietnam:

- Siamese crocodile or freshwater crocodile (Crocodylus siamensis)
- Saltwater crocodile (Crocodylus porosus)

Both species has distribution range only in South Vietnam

The siamese crocodile is freshwater one. They inhabit big rivers, lakes, swamps in Tay Nguyen plateau and Cuu Long delta, such as Sa Thay river (Kon Tum province) , Ba river (Gia Lai province), Lac lake, Krongpach thuong lake, Easup river, Krongana river (Dac Lac province), Dam Sau Tay Son (Khanh Hoa province), Bau Sau in Nam bai Cat Tien Reserve (Song Be province), Dong Nai river (Dong Nai province) , La Nga river (Lam Dong province) and Cuu Long river.

In the past, freshwater crocodile was relatively abundant in Vietnam. Pham Mong Giao, 1981 informed of 200 crocodiles in 80-hectared Tay Son "Crocodile lake" (Khanh Hoa province). Hunter and local people oftenly caught the crocodiles in Lac lake (Dac Lac province), uper part of La Nga river for sale and for meat, they also collected crocodile eggs in "Crocodile swamp" of Nam Bai Cat Tien Reserve for food. It was informed that the crocodiles were captured in large number in Krongpach lake and Easup river.

Saltwater crocodile (Crocodylus porosus) had inhabited

mangrove swamps, river estuary in Vung Tau, Can Gio, west to Kien Giang Bay, Phu Quoc Island and Con Dao Island. But it was decades of years ago and now they probably extinct in the wild, there are some of them now are keeping in Sai Gon Zoo.

The forest logging and conversion of hundreds hectares of riverain, lakes, swamps into agriculture land have seriously decreased the habitats of wildlife, in general, and crocodiles, in particular. Meanwhile, agressive hunt has also seriously decimated the number of crocodiles in the wild. The crocodiles were captured by different ways, such as shooting by guns, traping, explossive mines. The using mines for capture of crocodiles is very dangerous due to mines can kill not only adult but also young crocodiles and severely destroy their habitats. At the present, according to the hunters and local people not more than 100 crocodiles still survive in the nature.

2. Captive propogation of crocodile

There are several crocodile farm in Vietnam (The Vietnam-Cuba Friendship Crocodile farm, Hanoi Zoo, Saigon Zoo, Centre for Forestry Science Application, etc...) , but mostly for economical purposes and zoo servises, not for conservation, properly.

Before 1960, Hanoi Zoo kept some individuals of crocodile provided by China, which lived for 10 years in the Zoo. In 1979 Sai Gon Zoo have received 7 siamese crocodiles from Siem Rep province of Cambodia (as present), wich have very good status and successfully breeding in captivity.

In October 1985, a group of 100 crocodiles (Crocodylus rhombifer) was imported from Cuba. These crocodiles have been distributed to several provinces for captive breeding: 5 in Hanoi Zoo, 10 in Sai Gon Zoo, others in Da Nang, Nha Trang and Minh Hai. Of them, at present only 26 individuals still survive (Sai Gon Zoo: 4, Vietnam- Cuban Friendship Crocodile Farm: 10 and Centre for Forestry Science Application: 12). Others died or have been sold to private farms. Recently, in 8 March 1994 one crocodile of Hanoi Zoo died due to swallowed a resin tube givenby a visitor. The keeping facilities here, were also not suitable for the crocodiles.

Due to budgetary investment shortage all these governmental farms could not provide the crocodile populations with relevant conditions for their development.

The farm even have to cooperate with private farmers for the animal keeping. SaiGon Zoo, for example,

cooperated with farmer Bui Van Do in An Giang province for breeding of 31 crocodiles. They now are of 3 years old, weight about 12kg each, with costs about $700 each.

Except for the governmental farms there are some private crocodile farm in Vietnam. Mr. Nguyen Thanh Thuan in Thu Duc province (for example) have invested $170 000 to set up his crocodile farm of area 31 000m². The farm is keeping 170 young crocodiles (of about 20kg each). He expects that by 1997 his farm will have 150 breeding fimales and 50 breeding male.

The private farmer understand well the economic value of crocodiles. They are pure bloodline and have high reproductive capacity and now become very rare in the wild.

Some farms (Saigon Zoo, Vietnam- Cuba friendship crocodile farm. . .) have been successful in breeding crocodiles. Saigon Zoo, for example, got the first result of crocodile breeding in captivity in July 1989, and present percentage of hatching sometimes reach to 80-90%. Especially the Zoo has been successful in hybridization of 2 species crocodylus siamensis (female) and crocodylus porosus (male). Their hybrid has given 20 eggs, 17 of which hatched successfully. But, in general, crocodile farming in Vietnam is not developed and the achieved results are very limited. The main reasons are shortage of knowlegde on techniques of husbandary and limitation of fund.

III. CONSERVATION

Inspite of small number of crocodiles remained in the wild the crocodiles in Vietnam are still intensively hunted for meat, eggs and for skin. Morever, illegal crocodile trade also becomes more intensive during recent years. The crocodiles (adult and young) are captured and skins are collected for illegal export to Cambodia, Thailand and other countries. In Vietnam, a crocodile is sold for about $100 - $2000 depending on their status. The crocodile are sold in animal market of big city (Ho Chi Minh City. . .) . Some brokers collect crocodiles captured by local people keep them for short period of time until they meet the customers who willingly pays high price.

The conservation of crocodiles in Vietnam is of government interest. The government has adopted a number of regulations for habitat protection, stop of hunting and animal trade of endangered species, including crocodiles.

Recently, a national workshop on protection and restoration of crocodiles was held in Ho Chi Minh city in 31

March 1994 which pointed out that the number of crocodiles in Ho Chi Minh city alone has increased from several tens to 500 heads for recent 3 years, mainly in private farms. However, the death rate of youngs is still high (25 - 30%) due to deficiency of nutrition and unproper keeping facilities. The workshop called for close cooperation between scientists and farmers for protection and captive breeding of crocodiles in Vietnam.

Both species of crocodile in Vietnam are enlisted in the "Red Data Book of Vietnam" in highest category - " E" , "Endangered" for urgent conservation measures.

A network of 87 national parks and nature reserves has been gazetted by Vietnam's Government in 1986 for nature conservation. Of them there are 3 reserves with crocodile occupation:

- Nam Bai Cat Tien National park (36 000 ha) in Dong Nai province. Coordinates: 11°25 N, 107°26 E. The park has a swampy area, where the crocodiles concentrate in high density, so that it is named "Bau Sau"
- "Crocodile swamp".
- Suoi Trai Nature Reserve (80 ha) in Tay Son district, Khanh Hoa province. Coordinates: 13°20 N, 106°45 E. There is named "Dam Sau" - "Crocodile Lake" - with high density of crocodile in the Reserve.
- Lac Lake (540 ha) in Dac Lac province. Coordinate: 15°25 N, 108°11 E.

Due to many reasons the management of these reserves is not strict enough and crocodiles are still poached occasionally.

IV. CONCLUSION AND PROPOSALS

In Vietnam, both species of crocodile survive in very small number and face with threats of extinction in near future. Several conservation measures have been conducted but not effectively enough. As the result, crocodile habitats are being destroyed and disturbed, hunting pressure is still considerable.

Meanwhile, very little is known about the natural history of the crocodiles and study on crocodiles in Vietnam is very unsufficient.

All these make the conservation of crocodiles in Vietnam a very urgent and difficult problem. In order to ensure survival of the last remained populations of crocodiles in

Vietnam, restor them in future an action plan for conservation of crocodiles in Vietnam should be developed and implemented as soon as possible. The following activities should be included in the action plan:

- To strengthen the effectiveness of extant policy and measures of crocodile conservation, aware people of the government policy and regulations for crocodile conservation and interest of crocodile conservation by radio broadcasting and TV programmes, video, posters etc...
- To conduct fieldsurveys to determine exact status and distribution of crocodiles in the wild to elaborate relevant recommendation for their management and conservation.
- To carry out crocodile farming project for conservation (not for economical) purposes, to ensure their survival, increase their number, and study their biology and ecology.
- To train Vietnamese officers on techniques of crocodile management and breeding.
- The conservation of crocodiles requests large manpower, experience and budget, so that the international cooperation for crocodile conservation in Vietnam is utmost important. We are seeking for international support and collaboration on the crocodile conservation in Vietnam.

PRELIMINARY SURVEYS OF CROCODILES IN THAILAND

by

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INTRODUCTION

The Siamese Freshwater Crocodile (Crocodylus siamensis) was once widespread within the freshwater wetlands of Thailand (Ratanakorn1994). However, its status in terms of both distribution and abundance has declined dramatically over the last 50 years, due to: use of natural habitats for agriculture and aquaculture; hunting for skins; collection of wild stock over many years for sale to crocodile farms [which started in the 1930's (Webb and Jenkins 1991)]; and, the destruction of crocodiles as vermin (Yangprapakorn et al. 1971; Webb and Jenkins 1991; Thorbjarnarson 1992; Ratanakorn 1994).

Saltwater Crocodiles (Crocodylus porosus) also occurred in the coastal areas of the southern peninsula and Gulf of Thailand (Webb and Jenkins 1991). Their status has also declined dramatically, probably for the same reasons as C. siamensis (Yangprapakorn et al. 1971; Webb and Jenkins 1991; Thorbjarnarson 1992). The Malayan False Gharial (Tomistoma schlegelii), now almost certainly extinct in Thailand, was known historically from near the southern border with Malaysia (Yangprapakorn et al. 1971; Webb and Jenkins 1991; Thorbjarnarson 1992; Ratanakorn 1994).

A recent review of the status of crocodiles in Thailand (Ratanakorn 1994) revealed two locations within which remnant populations of C. siamensis may still exist (Pang Sida National Park and Ang Lue Nai Wildlife Sanctuary; Fig. 1). An additional area was identified on the Island of Phuket where C. porosus may still exist.

The primary aim of the present study, undertaken by the Royal Forestry Department (RFD) and the Crocodile Management Association of Thailand (CMAT), with financial asisstance from the Asian Conservation and Sustainable Use Group (ACSUG) and the

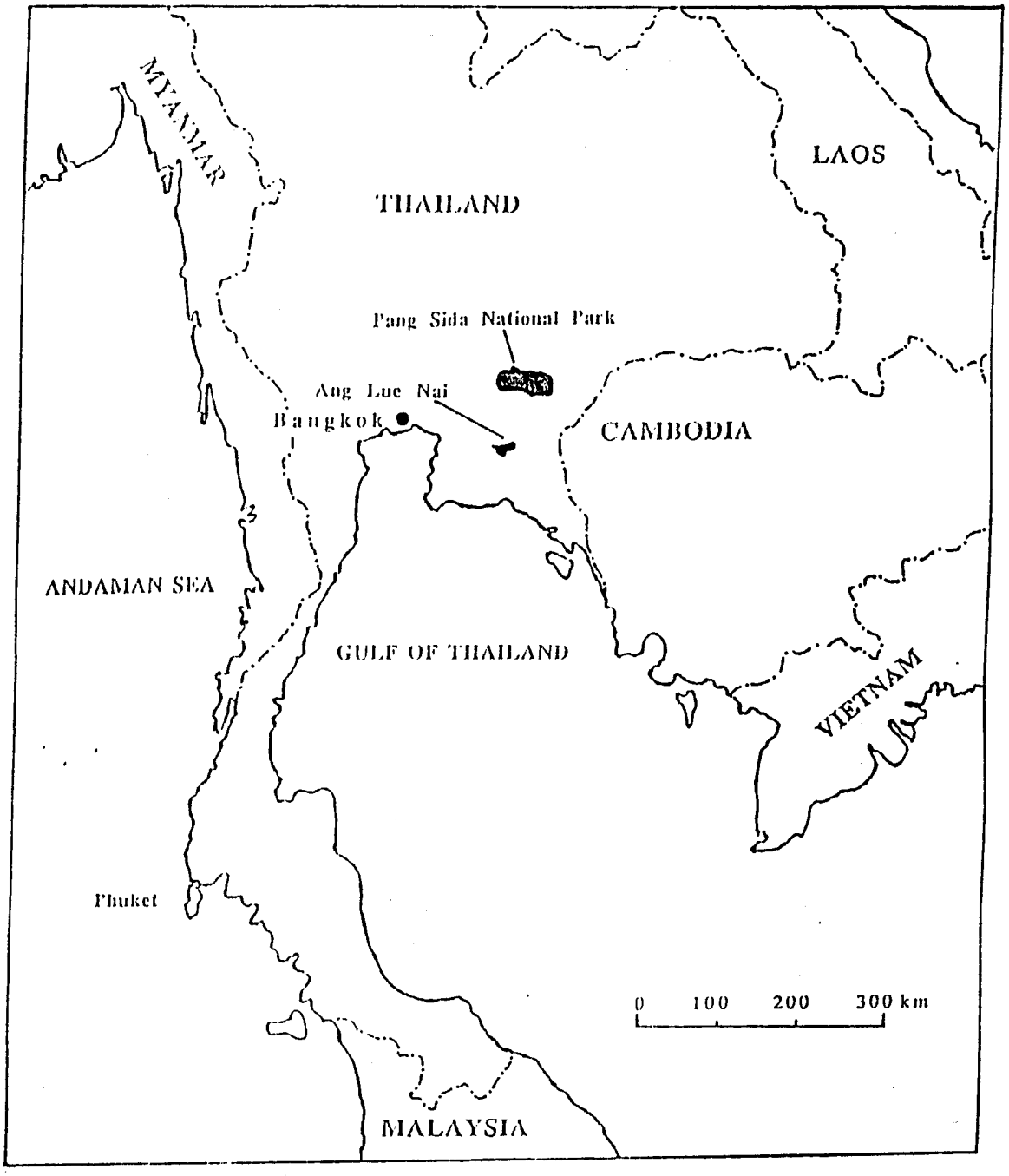

Figure 1. Location of Pang Sida National Park, Ang Lue Nai Wildlife Sanctuary and Phuket Island in Thailand.

German reptile leather associations ("Internationaler Reptillederverband-IRV" and "Reptil-Artenschultz e.V.-RA"), was to confirm the presence of crocodiles in these three areas. Secondary aims were to: establish baseline survey data that could be used for monitoring future status: assess the suitablity of the remaining habitats for the re-establishment of crocodiles; familiarise RFD staff with survey methodology and provide some guidelines for them (Appendix 1).

METHODS

Pang Sida National Park

Location

Pang Sida National Park comprises 845 km^2 of predominantly natural forest in in the Khorat Hills, in Prachinburi Province, eastern Thailand (Fig. 2). The vegetation is dominated by deciduous and evergreen rainforest (Grey et al. 1991), and there are areas of lowland scrub and open grasslands at the foothills, which reflect past logging and clearing for agriculture. Rainfall occurs throughout the year, but there is a distinct "wet" season between May and mid-October, when water levels rise appreciably. The cool dry season usually extends from mid-October to mid-February (Grey et al. 1991).

Houa Nam Yen Creek (Fig. 2) was selected as the survey site because a crocodile was sighted and photographed from a helicopter there in 1992. It is located in the western part of the Park, formed by drainage lines from the hills, and flows out of the western boundary of the Park into surrounding lowland country (Fig. 2). Agricultural use of lowlands on the edge of the Park is intense, with all viable areas under cultivation with tapioca and rice.

The creek is characterised by steep banks, high sinuosity and numerous sections of shallow water and rapids separating deeper more permanent bodies of water. Heavily vegetated banks are dominated by dry deciduous forest and bamboo thickets. Areas which have previously been logged, cleared and burned are now dominated by open vegetation consisting of tall grasses, vine thickets and shrubs (e.g. Calamis spp.).

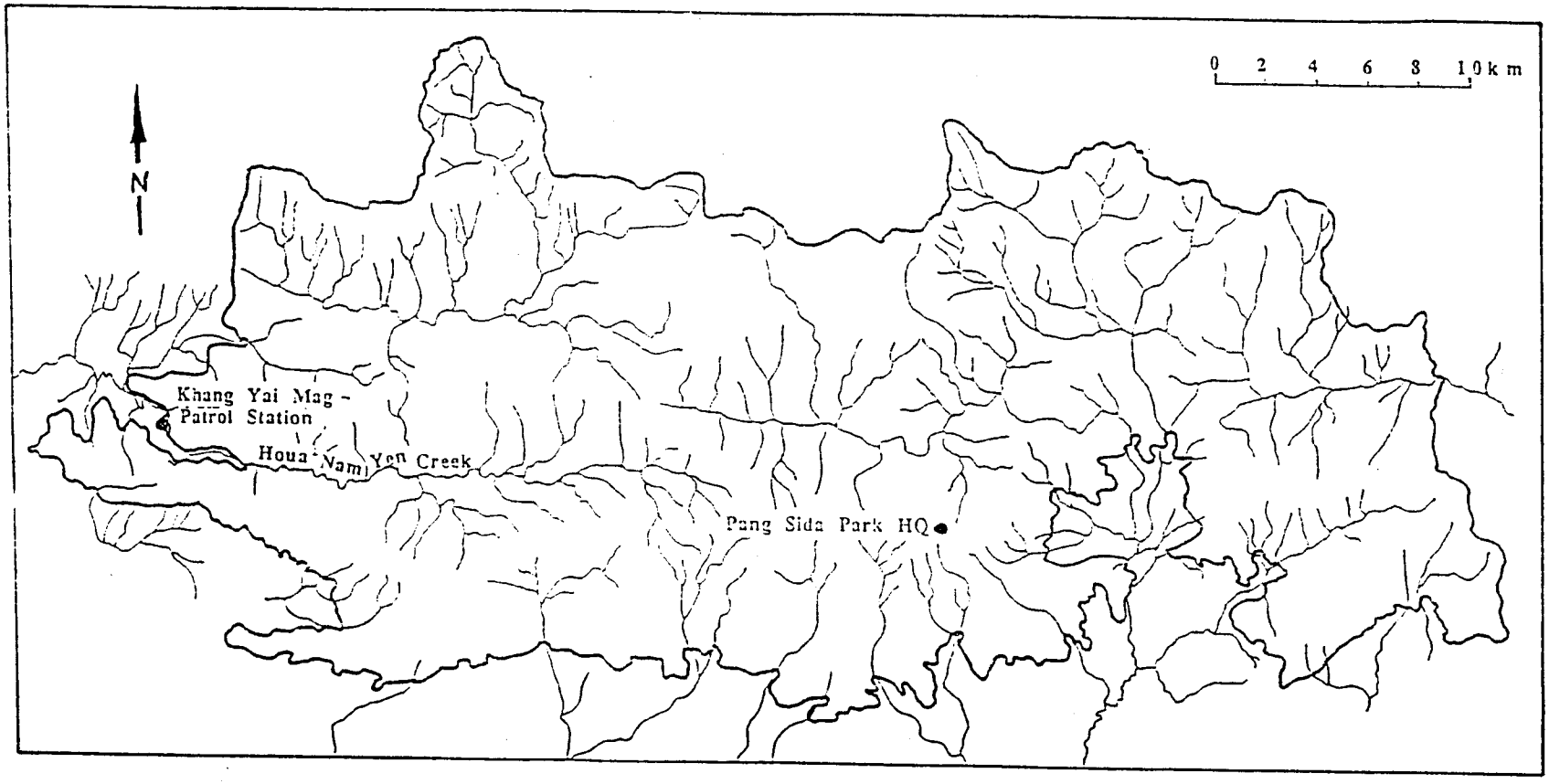

Figure 2. Location of Houa Nam Yen Creek in Pang Sida National Park.

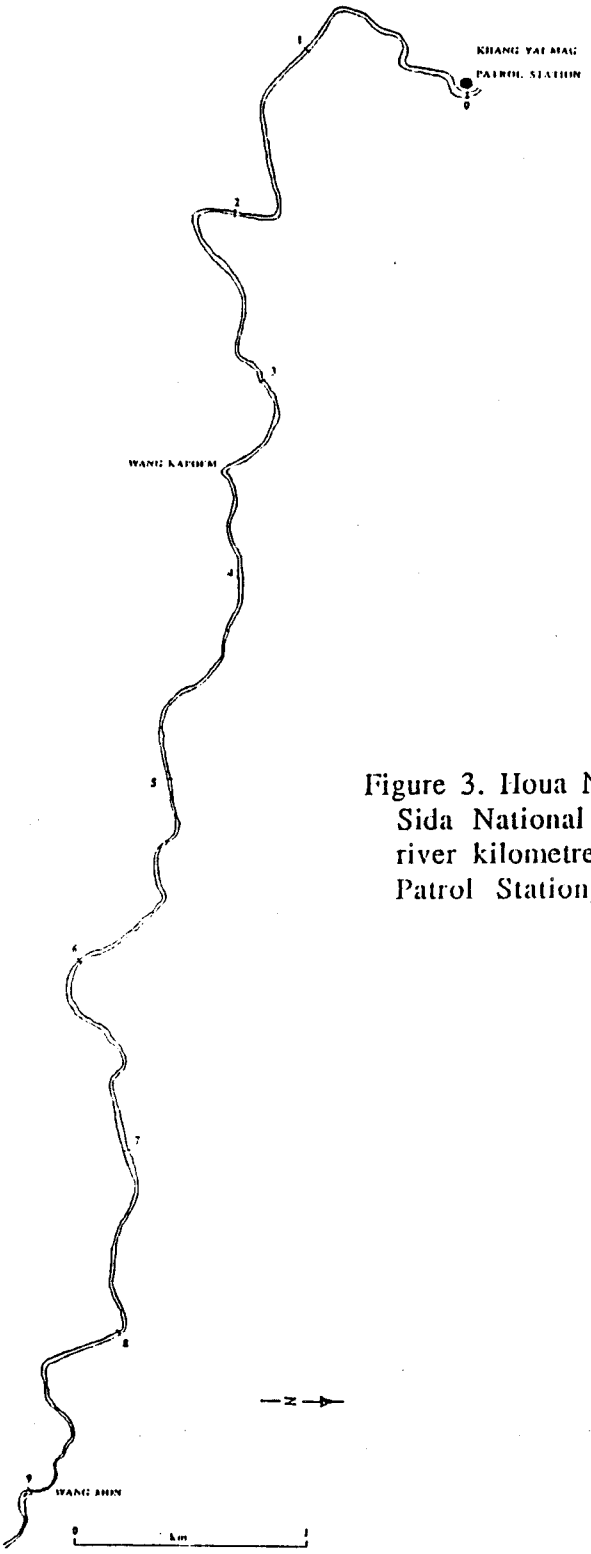

Figure 3. Houa Nam Yen Creek in Pang Sida National Park. Numbers indicate river kilometres (0= Khang Yai Mag Patrol Station).

Survey Transect

The survey transect was defined by the Park boundary near Kang Yai Mag Patrol Station and extended upstream for 9.3 km to rapids at Wang Mon (Fig. 3). A section of rapids (0.8 km) extending downstream from Wang Kapoem was not surveyed for logistic reasons. Upstream of Wang Mon the creek is too narrow and shallow to survey by boat.

During the day, sections of bank were walked and observations on habitat and other information were recorded. Particular attention was paid to any signs that may reveal the presence of crocodiles (e.g. slides, old nest sites, basking sites). The section of the river to be surveyed each night was paddled during the day to familiarise the observer with the creek course and to note habitat type.

Mapping the Water Course

Prior to the surveys being undertaken, a working map of Houa Nam Yen Creek was prepared from aerial photograghs (scale 1: 10,000) as described by Messel et al. (1981). The creek course was traced and a geared-wheel map measurer used to define midstream distances upstream (in units of 0.1 km) from the boundary of the park to Wang Mon (Fig. 3).

Spotlight Survey

The mainstream of Houa Nam Yen Creek was spotlight surveyed on 24-26 November 1993, using a small (2.3 m long) fibreglass boat. Access to the creek upstream of the Patrol Station was by foot, with all equipment being carried some 5 km over hills to Wang Kapoem, approximately halfway along the length of the survey transect. The survey team consisted of a spotter and a boat paddler. To the extent possible, the boat was paddled in the middle of the creek and the banks scanned with a 100W spotlight.

Ang Lue Nai Wildlife Sanctuary

Location

Ang Lue Nai Wildlife Sanctuary is located in Chachoengsao Province, south-eastern Thailand (Fig. 4). It comprises 108 km^2 of land, and encompasses hills covered in evergreen and dry deciduous forests, with open grasslands in the lowlands. There are numerous creeks draining the hills within the Sanctuary, and these

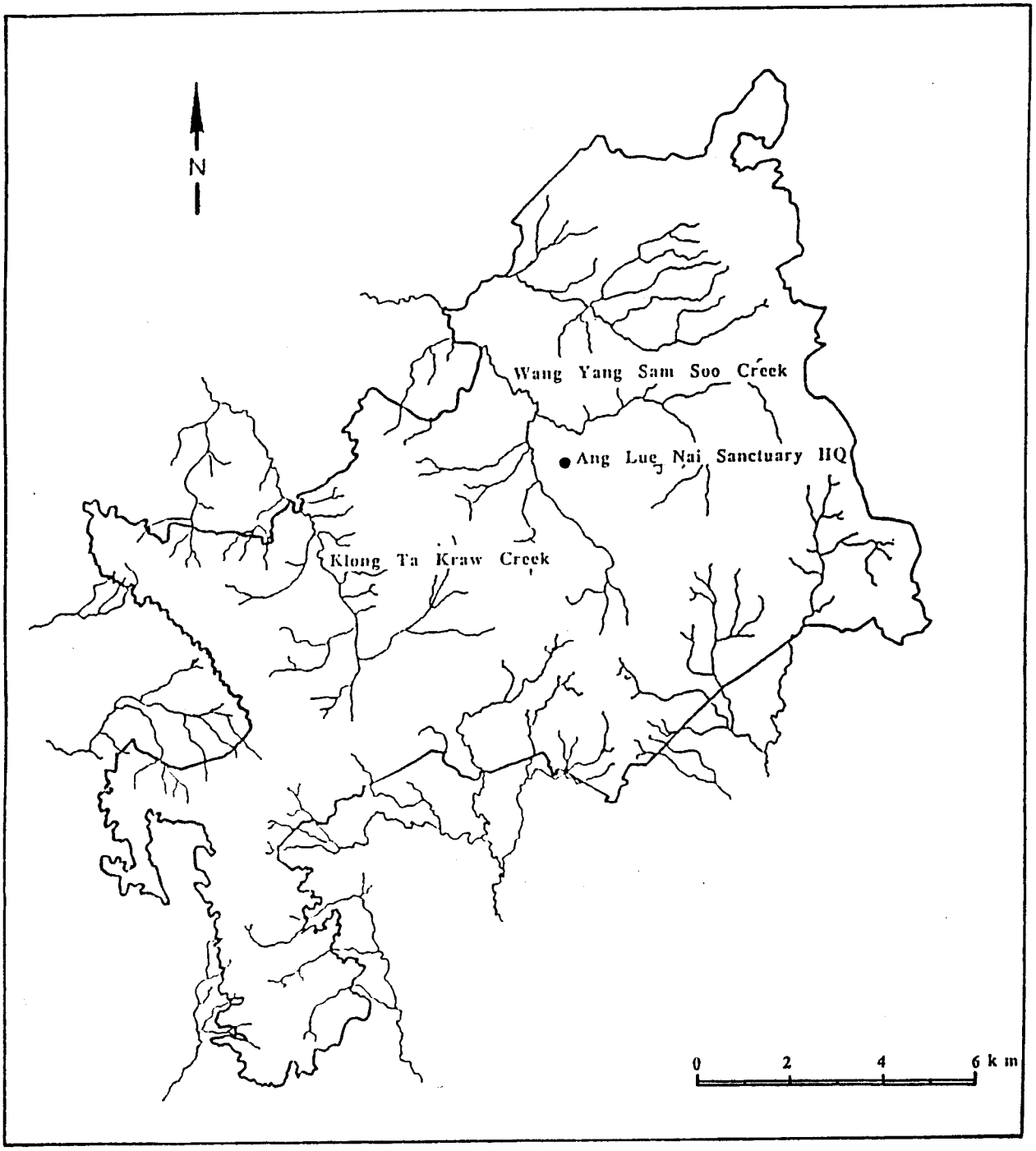

Figure 4. Ang Lue Nai Wildlife Sanctuary.

coalesce to form larger creeks which eventually flow into river systems well outside the Sanctuary. During the dry season, most of these small creeks dry into series of small pools.

Two small creeks were selected for the survey: Klong Ta Kraw Creek, where there has been a recent sighting and photogragh of a 2.5 m C. siamensis, and Wang Yang Sam Soo Creek, where crocodile tracks were recently photograghed by RFD staff. Both creeks are on the western side of the sanctuary (Fig. 4).

Klong Ta Kraw Creek is very narrow (3-5 m wide) and dries to a series of shallow pools less than 1.5 m deep during the peak of the dry season (according to RFD rangers). Banks are covered in secondary growth dry decidious forest with a dense understorey dominated by bamboo and ratan cane palm. These conditions made the use of a boat for the spotlight surveys impractical. After a trail was cut through the understorey, approximately 200 m of the creek was walked during the day to familiarise the observer with conditions and to evaluate the habitat.

On the night of the 28 November 1993, a survey was carried out by walking the bank, and, wherever tracks into the creek had been cut (determined by thickness of vegetation) scanning the water surface with a "Magna-lite" torch. Six observation sites were used, each allowing the spotter to view some 10-20 m of the creek. At each site, there was an initial scan with the light, and then it was switched off. The spotter remained silent for 15-20 minutes before quickly scanning the area again. Three scans were carried out at each site.

Wang Yang Sam Soo Creek is north-east of Klong Ta Kraw Creek (Fig. 4) and flows from hills to the south-east and out onto lowland country. Access to most of the creek is restricted by thick vegetation and the lack of any tracks. During the dry season, water flow in the creek ceases, and it dries to a series of deep waterholes separated by shallow gravel beds. Stream width was approximately 15 m and maximum water depth in the deepest holes about 2 m. Bank vegetation consisted of fringing scrub and tall grasses, the result of past clearing for agriculture.

Only 1 km of the creek was accessible by foot. A spotlight survey was not conducted during this visit. Observations on the availablity of suitable habitat for crocodiles were made and the logistics assessed so that a future spotlight survey could be conducted in an efficient manner.

Phuket Island

Phuket Island is situated off the west coast of the southern peninsula of Thailand, in the Andaman Sea (Fig. 1). The hottest period of the year is from February to May and the coolest from September to December (Grey et al. 1991).

The survey area is located at the northern end of the island, at Ban Mai Khao (Fig. 5), a remnant peat swamp and coastal lagoon complex. Historically, the total area was some 3 km in length, but most of it has been altered through draining and clearing of vegetation. The lagoons and associated swamps lie behind coastal sand dunes (about 100-500 m inland from the sea), and form a chain connected by shallow canals. The swamps are formed in depressions bordering the lagoons and are characterised by a dense understorey of sedges, hanguana, climbing fern and cane grasses (Phragmites spp.). There is an overstorey of low Melaleuca spp. Local villagers have cultivated all suitable areas to the water's edge, and the lagoons are intensively fished. It is estimated that less than 1.5 km of lagoon and swamp remain.

Of the three small remaining swamps, two were walked, for signs of nesting and crocodiles. A small boat was used to spotlight survey those parts of the lagoons and swamp edge that were accessible. The remaining open water was surveyed by walking the bank and scanning with a 6V handtorch. Surveys were conducted on 2-3 December 1993.

RESULTS

Pang Sida National Park

One eyeshine was located at km 5.5 on Houa Nam Yen Creek (Fig. 3). The animal surfaced some 40 m in front of the boat and swam away from the boat before diving. The angle of the animal's head relative to the spotlight beam resulted in a weak eyeshine, and it dived before it could be approached. No positive identification could be made.

No other evidence of crocodiles was found during daytime searches of the banks by boat or walking. Although 8 basking sites were located on the banks, none could be attributed definitively to crocodiles. Otters (Lutra perspicillata or Aonyx cinerea) and water monitors (Varanus salvator) could also be responsible. Tracks and tail grooves at three of these sites matched the track patterns of

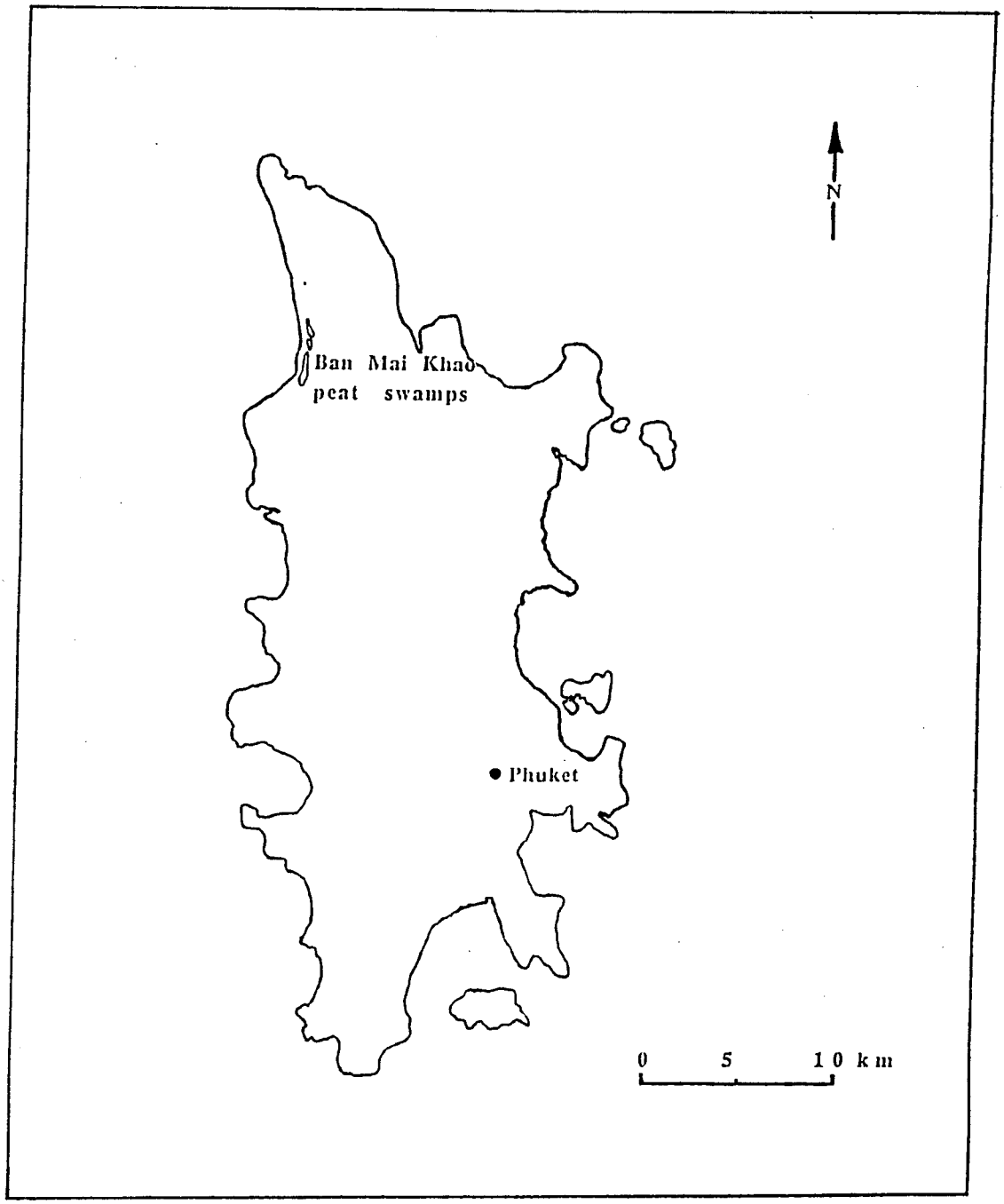

Figure 5. Phuket Island. See Fig. 1 for location in relation to mainland.

V. salvator. Only one slide found at Wang Mon could possibly have been made by a small crocodile. However, even here, the tracks were not distinct, and the possiblity that they were made by a large V. salvator cannot be rejected. In gereral, basking sites are limited due to the steep banks and tall, thick vegetation.

Observations made at night in the clear water suggest that there is a paucity of large fish species and turtles in the creek, which may reflect a generally limited food supply for crocodiles. Potential nesting habitat is limited to some patches of thick grassy bank, although nesting may be possible in leaf litter under bamboo thickets. The overall impression was that Houa Nam Yen Creek provides only marginal crocodile habitat in terms of area, nesting habitat and food availability. Historically, upstream sections of such creeks may never have provided anything but marginal habitat. The recent photogragh of a large crocodile near Wang Mon remains the only definitive record that one crocodile still exists in the river.

Ang Lue Nai Wildlife Sanctuary

Daytime searches of the banks and the torchlight survey of Klong Ta Kraw Creek revealed no evidence of crocodiles. A 2.5 m C. siamensis was photographed there in November 1992, after 3 days observation from a blind. The narrow, highly sinuous nature of the creek, and the thick vegetation which obscures the water's edge, make this system unsuitable for spotlight surveys (Bayliss et al. 1986). Sightable portions of the creek at any point are restricted to 5-6 m in length. Any nesting would be restricted to the floor of the dense forest, and the only basking sites were partially submerged tree trunks. There was no evidence of large fish or other potential prey species in the creek, again suggesting limited food availablity.

Wang Yang Sam Soo Creek was more suitable for spotlight surveying, but logistics did not allow the survey to be carried out. There are limited basking sites and potential nesting sites are restricted to the levy bank where vegetation is predominantly tall grasses (a result of extensive clearing in the past). A photograph of crocodile tracks (by RFD rangers) at the creek indicates that at least one animal is present.

Both Wang Yang Sam Soo and Klong Ta Kraw Creeks appear to be marginal habitat for C. siamensis, and probably never contained significant densities of crocodiles.

Phuket Island

Spotlight surveys of Ban Mai Khao peat swamps by foot (using a hand held torch) and by boat (with a spotlight) did not result in any crocodile sightings. Over the last three years there have been 3 records of C. porosus in these lagoons: a medium sized (2 m) crocodile was caught in a lagoon after it was drained; a small crocodile (possible a hatchling) was caught in a fishing net; and, a small to medium crocodile (1-2 m) was seen crossing a road separating a lagoon from a canal (information from local villagers and fishermen). With the exception of the small crocodile, these records probably reflect animals entering the swamp from the sea (possibly originating from Myanmar or Malaysia).

Up until 20 years ago crocodiles were common in the lagoons, and villagers never entered the water for fear of being attacked. Fishermen regulary saw crocodiles and they remember a buffalo being bitten. However, the intensive use of the area by people and the recent destruction of a large proportion of the remaining habitat make it difficult to avoid the conclusion that the area is now totally unsuitable for C. porosus. They are probably extinct in the area today. The daily use of the area by villagers, the large size of mature Saltwater Crocodiles, and the small area of habitat left (about 0.75 km^2) would make it near impossible for crocodiles to exist there without being sighted.

The coastline of Phuket Island has a number of mangrove-lined creeks, which until recently were relatively undisturbed, and may have provided some remnant refuges for C. porosus. Crocodiles from these creeks may have used the lagoons during the nesting season, and as a source of fresh water. Similar use of freshwater swamps by C. porosus occurs in the Northern Territory of Australia, where animals cross from the sea to the swamps (Messel et al. 1979).

DISCUSSION

The surveys did not provide evidence of a remnant population of C. siamensis in Thailand, although photographs taken recently do indicate that a few C. siamensis still exist in the wild. However, the extremely wary nature of any existing crocodiles and type of habitats they are restricted to (thick fringing vegetation at the water's edge; narrow, sinuous creeks) greatly reduced the chances of them being sighted using conventional spotlight survey techniques (Messel et al. 1981; Webb et al. 1989).

All areas investigated are considered to be marginal habitat for crocodiles. They consisted of narrow creeks that are fast flowing in the wet season, with limited deep water in the dry season, limited nesting sites; and possibly a limited food supply. They may never have supported high densities of crocodiles.

On Phuket Island the remaining peat swamp has no potential for maintaining even a small population of C. porosus. There is intensive use of the area by people who cannot afford to tolerate a large dangerous animal in such close proximity. In addition, the remaining habitat has been extensively degraded and reduced in size. Tidal creeks along the coastline, where mangroves have not been cleared for aquaculture, may still contain some C. porosus. Such areas would be more amenable to spotlight surveys.

Recommendations

1. Resurvey all areas by spotlight during the next cool-dry season (October to February).

2. Fly all areas by helicopter during the next dry season. This may prove to be a more appropriate survey method for wary crocodiles in such habitats.

3. Prepare working maps for Wang Yang Sam Soo Creek, in Ang Lue Nai Wildlife Sanctuary. The length of the creek within the Sanctuary needs to be mapped and ground surveys conducted to determine the feasiblity of using a small boat to spotlight survey the creek. Information on the extent of deep waterholes and the type of habitat along the creek should be collected for assessment.

4. Identify from topographic maps, aerial photos and ideally by helicopter survey, any other creeks which may be suitable for crocodiles in Ang Lue Nai Wildlife Sanctuary. Groundchecks of these areas would indicate whether spotlight surveys can be carried out there.

5. Fly all areas during the nesting season, searching the banks for signs of nests and/or nesting activity.

6. Conduct spotlight surveys of the Phuket Island coastline and tidal creeks.

ACKNOWLEDGEMENTS

We would like to thank all of the Royal Forestry Department staff for assistance in the field. This report represents part of the crocodile research program being undertaken in Thailand by Dr. Parntep Ratanakorn under the auspices of the Asian Conservation and Sustainable Use Group and the Crocodile Management Association of Thailand. Additional technical support was provided by the Royal Forestry Department. The involvment of Brett Ottley and Dr. Grahame Webb was made possible through financial support from the German leather industry associations ("Internationaler Reptillederverband-IRV" and "Reptil-Artenschutz e.V.-RA").

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APPENDIX 1

SURVEY METHODS USED TO MONITOR CROCODILE POPULATIONS

A Report to the Royal Forestry Department and the Crocodile Management Association of Thailand

GENERAL

When designing a monitoring program, it is important that the managment "problem" that requires monitoring is clearly defined. It will influence the type of monitoring program instigated. If the main objectives are to monitor changes in the total population, the survey program will need to be designed to sample discrete units of crocodile habitat across the known range of the species. Monitoring at this level of resolution is concerned primarily with whether the population is increasing, decreasing or stable. It may not be sensitive enough to detect changes within local populations (i.e. within any one survey unit): for example, the population in one unit may be declining, while the total population is increasing.

A separate problem may be to assess changes in one segment of the total population or one area over time- perhaps in one river system. This may require an intensive survey program designed to provide data on basic population parameters such as annual hatchling recruitment and size class distributions within the population (Webb and Smith 1987).

These two levels of monitoring are not necessarily exclusive, but they are quite different and need to be considered independently.

The Royal Forestry Department (RFD) and the Crocodile Management Association of Thailand (CMAT) need to determine what the managment questions are that need to be answered by surveys. It would appear that the first priority at this stage is to locate any remaining crocodile populations in Thailand. The monitoring program needs to be designed to provide presence or absence information in the first instance. This maybe followed by surveys designed to provide information on populations in individual river systems: establishment of more systematic survey programs, within each river, may be warranted. These will provide data on the numbers present, annual recruitment and long-term changes in the populations. Such a program could form the basis of a total population survey program in the future.

The two main techniques used to survey crocodile populations are spotlight surveys and helicopter surveys. Spotlight surveys are best suited to monitoring in areas were the sightability of crocodiles is high. Such areas are characterised by a low sinuosity and a waters edge which is not obscured by vegetation. In areas with thick vegetation along the waters edge and/or a high degree of sinuosity the sightability of crocodiles is reduced and the accurracy of spotlight counts is accordingly reduced (Bayliss et al. 1986). In areas suitable to spotlight surveys, the results will give precise estimates for annual changes in hatchling recruitment and size class distribution within the one population (Bayliss 1987; Webb et al. 1990). Helicopter surveys tend to be less sensitive to subtle changes within a population as this method does not readily detect the hatchling and juvenile size classes. This survey method is best suited to sampling extensive sections of crocodile habitat cheaply and quickly (Bayliss et al. 1986; Webb et al. 1986).

To meet the aims of the present management program in Thailand, both survey techniques can and should be used. The primary aim at this stage is to confirm the presence of crocodiles in the wild. Where the animals are particularly wary after a long history of exploitation, and have learnt to avoid man [which is the case in Thailand (Ratanakorn. 1994)] helicopter surveys are probably more likely to locate animals. However, where it is desirable to monitor changes in any remnant populations, spotlight surveys may be the best to use.

For a survey program to be of use in the long term, it must be designed to be REPEATABLE over time. This is achieved by reducing the sources of variation in the methods used to conduct surveys, so that a standarised procedure can be followed each time a survey is done.

SPOTLIGHT SURVEYS

The basic method for conducting spotlight counts has been described by Messel et al. (1981). The critical elements of that description, as they relate to the method and principles used to design and conduct spotlight surveys, are:

1. The survey transect (the section of mainstream river or creek and any associated sidecreeks to be surveyed) has to be defined by a START POINT and a STOP POINT. Any sidecreeks off the mainstream which are amenable to spotlight survey must also

have definitive stop points. Both banks of the mainstream and any sidecreeks are surveyed. This ensures that the exact same area is surveyed each time, which means that the data collected from year to year is related and can be assessed for changes over time. It is useful to measure the survey distance in units of 0.1 km, as this allows the location of each animal to be recorded reasonably accurately. It allows the distribution of animals within the survey transect, to be mapped over time.

2. Time of year and water level will affect the number of crocodiles seen. It is important to do surveys at the same time of year. For the best results, the cool dry season is the most suitable time to conduct surveys. At this time of year crocodiles tend to be in the water at night because it is warm relative to the cool, night air.

3. Changing the strength of the spotlight or torch used on different surveys may affect the number of crocodiles seen, and thus bias the results. It is important to use the same type of light each time an area is surveyed. The choice of light used will be determined by the nature of the waterway to be surveyed. For small narrow creeks with thick vegetation fringing the waters edge and a high frequency of bends, it is best to use a powerful hand torch as opposed to a 100W spotlight. Under these conditions the area effectively scanned with the light is usually restricted to distances of 50 m or less. The use of a powerful spotlight creates a glare from light reflected off the vegetation. This may result in "eyeshines" going undetected as they tend to be obscured by the reflected light. Furthermore, crocodile eyes, like cat's eyes, close up in bright light. In wider, more open waterways, where the observer can scan 200-300 m ahead of the boat, a 100W spotlight is ideal.

4. When using the spotlight it should be held so that the observer's eye is positioned behind the light so they are looking along the beam of the light. The light is swept in an arc of 180 degrees, so as to cover the waters edge along both banks and the water ahead of the boat. The eyeshines are most easily detected from a distance, especially the eyeshines of hatchlings and those of crocodiles hidden in thick vegetation. The boat should be kept in the middle of the river while seaching for eyeshines. When an eyeshine is picked up in the light the spotter directs the boat driver to approach the eyeshine until close enough to see the crocodile, determine species and make a size estimate. If the animal dives before it can be identified and "sized" it is recorded as an "eyeshine". The boat should then be moved back into the middle of the river.

5. A common fault when spotlighting is the tendency for some spotters to hold the light on a eyeshine as they are approaching it, until the crocodile is sighted and sized, and thus fail to continue searching the area for other eyeshines. This will result in some crocodiles not being detected if they dive at the approach of the boat or the boat passes them. The best technique is to give the boat driver the direction of the eyeshine then continue to search the area as the boat approaches it.

6. The observer should be the same for all surveys. If spotters are changed then the new spotter should be checked against the original one, to ensure that they are equivalent. Some observers just seem unable to detect crocodile eyeshines in the distance.

HELICOPTER SURVEYS

The methods used for helicopter counting of crocodiles has been described by Bayliss et al. (1986). The same principles apply to setting up the survey transect as for spotlight surveys. In areas that are spotlight surveyed the same transect should be flown. When conducting a survey the helicopter is flown at a height of 100 feet, a speed of 60 knots and is positioned out from the bank toward the middle of the river. Usually only one bank is flown and the best time of year is the cool dry season, when crocodiles bask and are more easily seen. Each crocodile sighted is identified to species, placed in a size category, and its location along the survey transect recorded. If the crocodile cannot be identified to species it is recorded as "unknown".

AIMS

The current survey program has three main aims. The first is to determine if crocodiles are present. The second is to determine how many are present and where they are. The third is to set up a long-term monitoring program so that accurate data on numbers and size classes can be collected. This information will give estimates of the population growth and changes in the size structure of the population over time.

RECOMMENDATIONS

General

1. Accurate work maps of the creeks to be surveyed need to be prepared.

2. The survey team needs to be trained to identify crocodile eyeshines from those of spiders, frogs and mammals.

3. Drawings of the crocodile hind foot print should be made from the photogragh taken in Ang Lue Nai Sanctuary. This drawing can then be distributed to ranger staff, to aid them in distinguishing crocodile tracks from those of Varanus salvator and otters.

4. Post-hatching time is a good time to spotlight survey all areas, as the hatchlings will be close to the nest site and still in clutch groups. Location of these hatchlings will give some indication of the nesting effort and indicates the presence of adult crocodiles, which may have been too wary to be sighted during surveys.

5. A short workshop on crocodile survey techniques would be useful.

Pang Sida National Park

1. It would be worthwhile surveying Houa Nam Yen Creek again this dry season.

2. Any sections of the creek where tracks and belly slides are found, should be closely monitored. These may be regularly used basking sites, which can be observed from hides built near these sites. Baits could be hung near the sites to encourage the crocodiles to show themselves.

3. Helicopter surveys of this creek will probably be more likely to find crocodiles than the spotlight surveys. The crocodiles are extremely wary and have learned to avoid man, boats and spotlights. However, they have not been subject to interference by helicopter.

4. Over the nesting season the creek banks should be searched for nests, both by boat and by helicopter. Female crocodiles visit the

nest sites regularly and create well defined paths through the vegetation to the nest. Careful searches of the bank from a boat, may locate these paths. Nest mounds can often be seen from the air if the helicopter is flown slowly along the bank.

Ang Lue Nai Wildlife Sanctuary

1. Maps of the creeks to be surveyed need to be drawn. The maps need to be of a scale that will show the creek in detail (1: 10 000 would be suitable).

2. An assessment of other creeks in the sanctuary which may be suitable for crocodiles needs to be made. Factors such as the presence of deep water, especially during the dry season, bank vegetation, availability of basking sites and food supply can be used to form an assessment of the potential of each creek for crocodiles.

3. If possible Wang Yang Sam Soo Creek should be spotlight surveyed this dry season.

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CLASSIC IDENTIFICATION OF SOUTHEAST ASIAN CROCODILES

TAXONOMY AND SYSTEMATIC PROBLEMS OF CROCODILES IN S.E. ASIA.

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A REVIEW OF THE HISTORY OF SOUTHEAST ASIAN CROCODILE TAXONOMY WILL BE PRESENTED INCLUDING THE CLASSIC CHARACTERS HISTORICALLY USED TO IDENTIFY SPECIES SPECIFIC POPULATIONS. DIAGNOSTIC CHARACTERS FOR IDENTIFICATION OF POPULATIONS WILL BE PRESENTED. EXAMPLES OF INDIVIDUALS WHICH DO NOT FIT CURRENT CHARACTERIZATIONS OF RECOGNIZED POPULATIONS WILL BE DISCUSSED.

Karyotypes of 5 species of crocodile kept in Samutprakan Crocodile Farm and Zoo

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*Sumitra Wattanodorn**
*Panya Youngprapakorn*****

Abstract

Five species of crocodile bred in Samutprakan Crocodile Farm and Zoo were used in this study. They were 8 Siamese freshwater *(C. siamensis)*. 7 saltwater *(C. porosus)*. 12 crossbreds produced by these two species, 3 Cuban *(C. rhombifer)*. 2 New Guinea *(C. novaeguineae)* and 4 Nile crocodiles *(C. niloticus)*. Lymphocyte cultures from heparinized blood were performed using Amphibian medium and incubated at 29 °c for 3 days. Well spread metaphase cells were examined under light microscope and photographed. The results from karyotype analysis were show in the following table.

Keyword : chromosome karyotype crocodile

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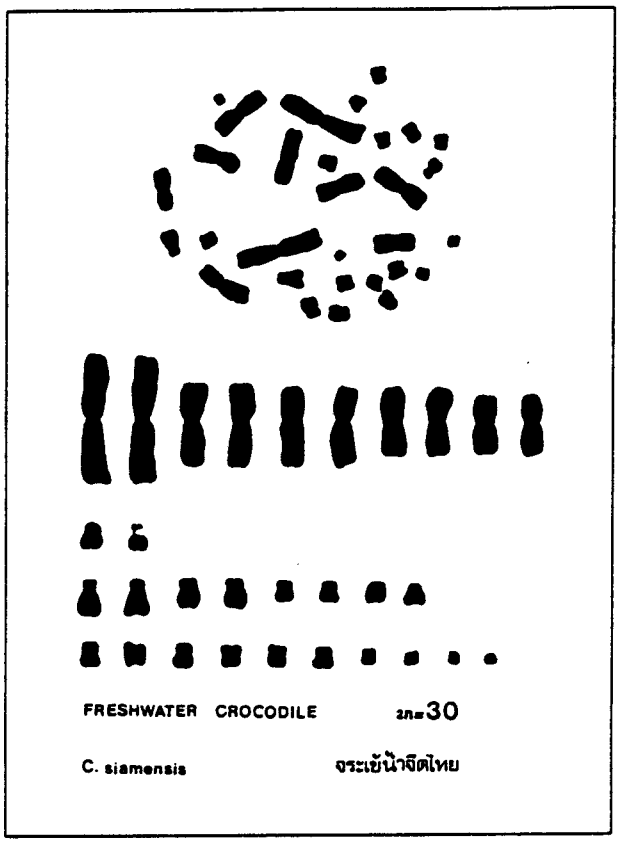
Karyotype analysis of five species of crocodile

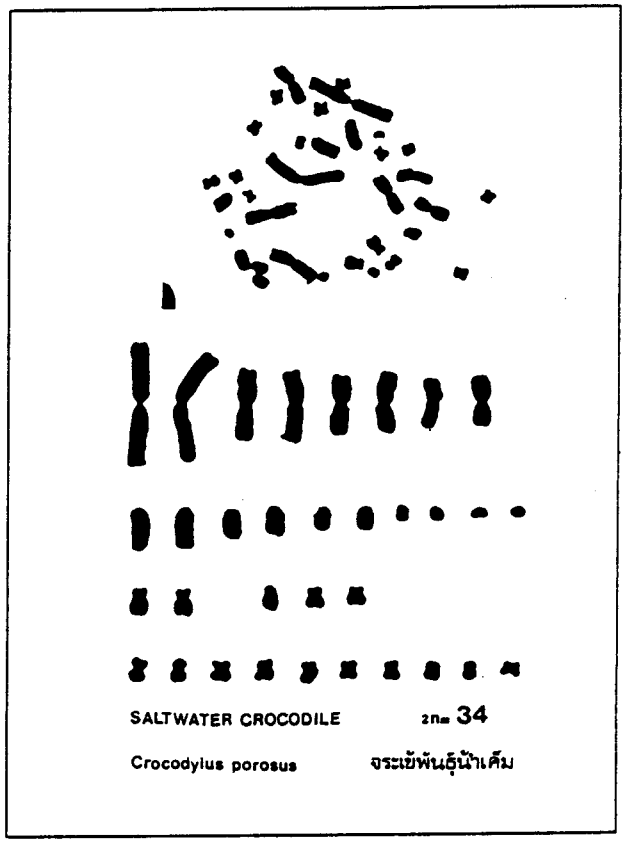
Species of crocodile	Number studied	2n =* (NF)**	Meta-large	Acro	Submeta small	Meta-small
1. Siamese freshwater croc. (*Crocodylus siamensis*)	8	30 (58)	10	2	8	10
2. Saltwater croc. (*Crocodylus porosus*)	7	34 (58)	8	10	6	10
3. Crossbred F1 (*C. siamensis* x *C.porosus*)	8	32 (58)	9	6	7	10
4. Crossbred F1-freshwater (F1 x *C. siamensis*)	1	31 (58)	9	4	8	10
5. Crossbred F1-saltwater (F1 x *C. porosus*)	2	33 (58)	9	8	6	10
6. Crossbred F2-*Inter se* (F1 x F1)	1	32 (58)	10	6	6	10
7. Cuban crocodile (*C. rhombifer*)	3	30 (58)	10	2	8	10
8. New Guinea crocodile (*C. novaeguineae*)	2	32 (58)	8	6	6	12
9. Nile crocodile (*C. niloticus*)	4	32 (58)	8	6	6	12

2n* = Diploid number NF** = Fundamental number
Meta- = metacentric Acro- = Acrocentric Submeta = Submetacentric



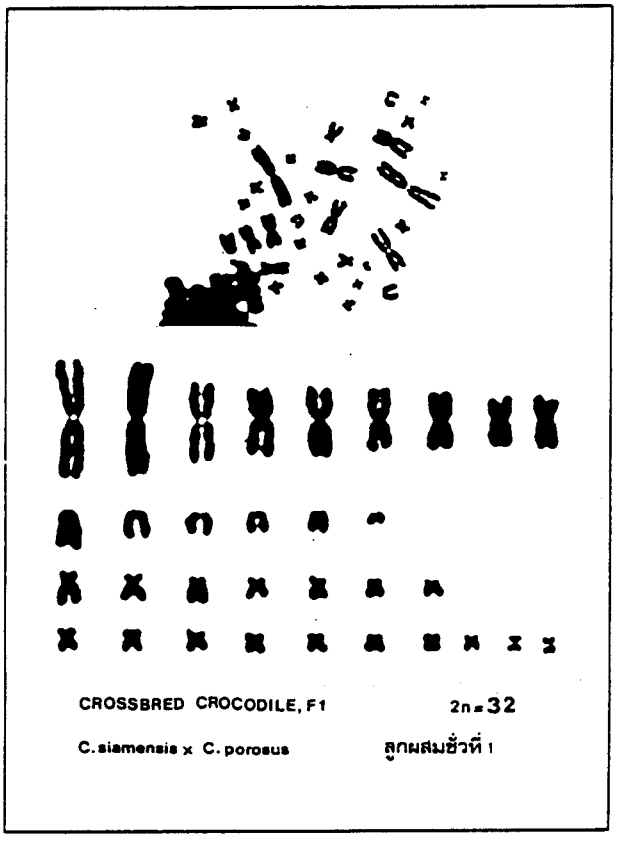
FRESHWATER CROCODILE 2n=30

C. siamensis จระเข้น้ำจืดไทย



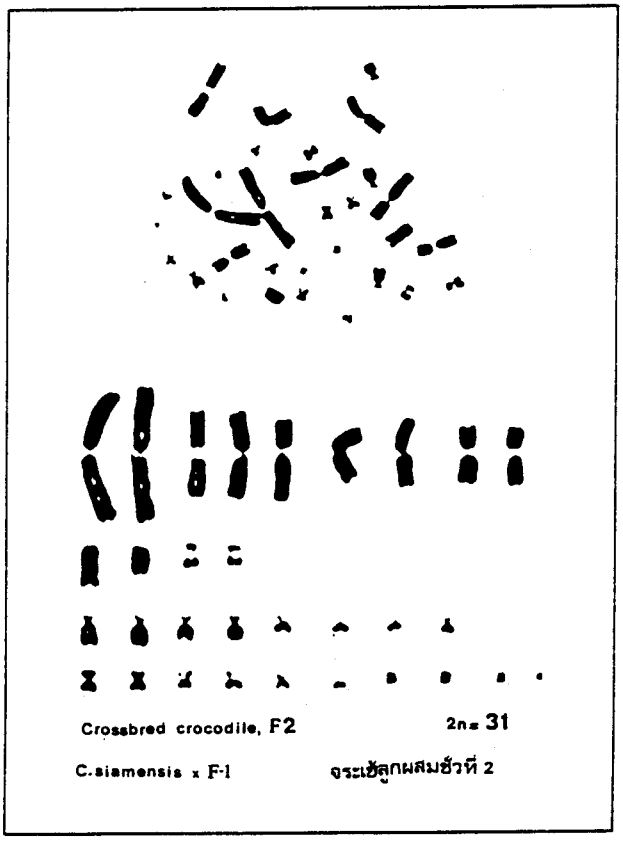
SALTWATER CROCODILE 2n= 34

Crocodylus porosus จระเข้พันธุ์น้ำเค็ม



CROSSBRED CROCODILE, F1 2n=32

C.siamensis x C. porosus ลูกผสมชั่วที่ 1



Crossbred crocodile, F2 2n= 31

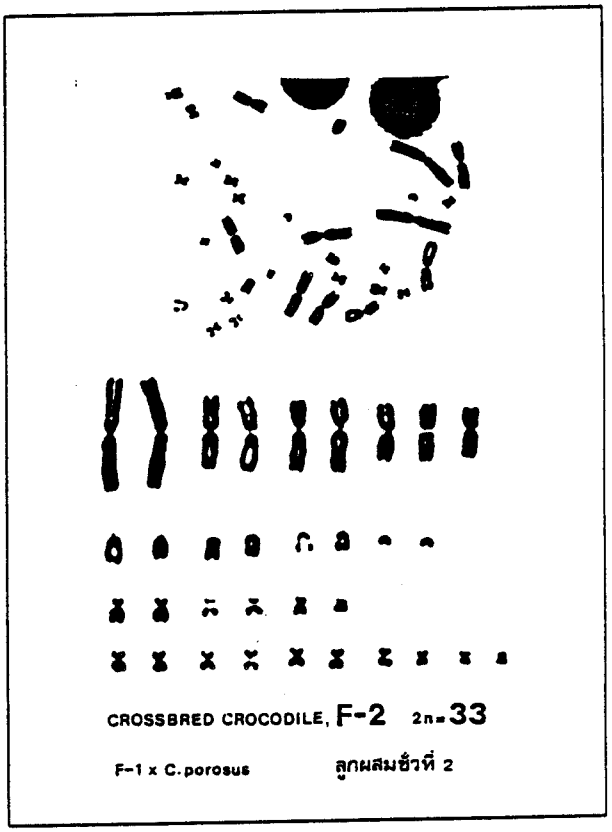
C.siamensis x F-1 จระเข้ลูกผสมชั่วที่ 2

CROSSBRED CROCODILE, F-2 2n= 32

C. siamensis x C. porosus จระเข้ลูกผสมชั่วที่ 2

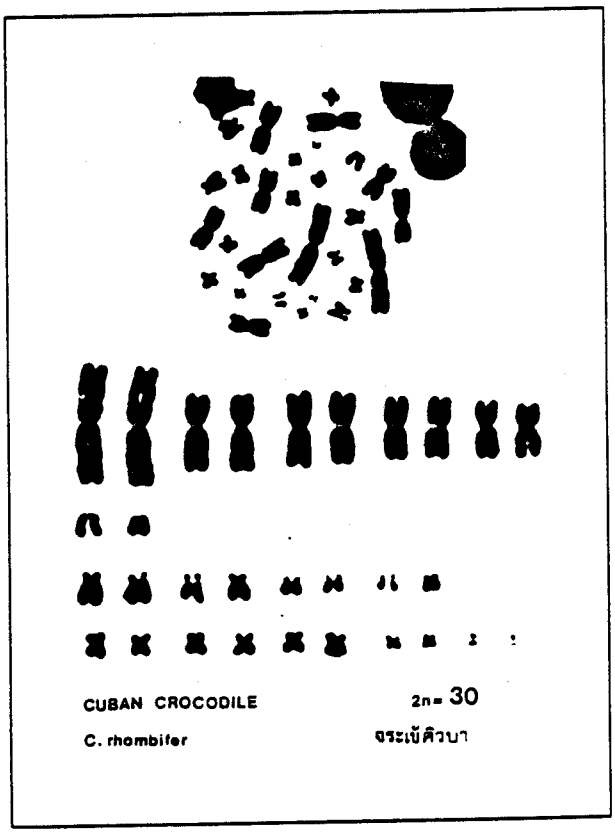
F-1 x F-1

รูปที่ 6 ลาริโอไทป์ของจระเข้ลูกผสมชั่วที่ 2(F1 x F1) 2n=32



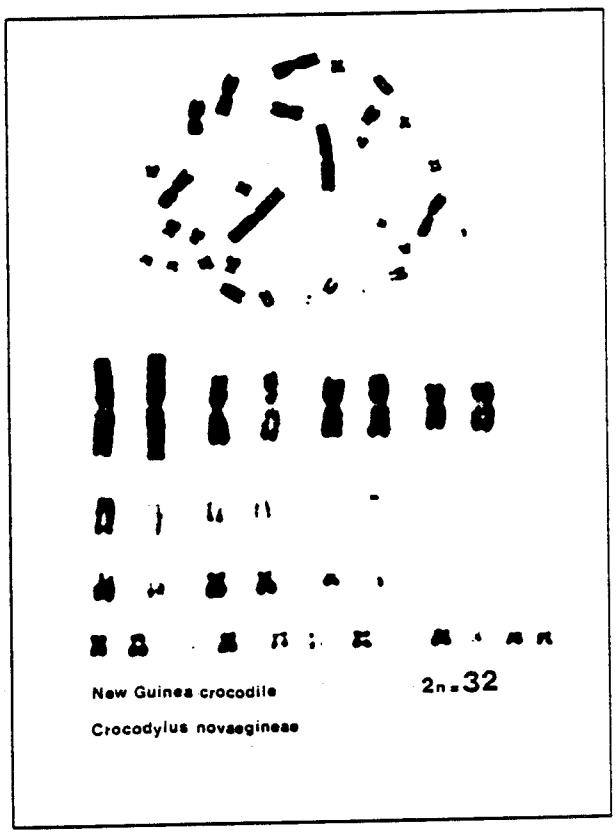
CROSSBRED CROCODILE, F-2 2n=33

F-1 x C. porosus ลูกผสมชั่วที่ 2



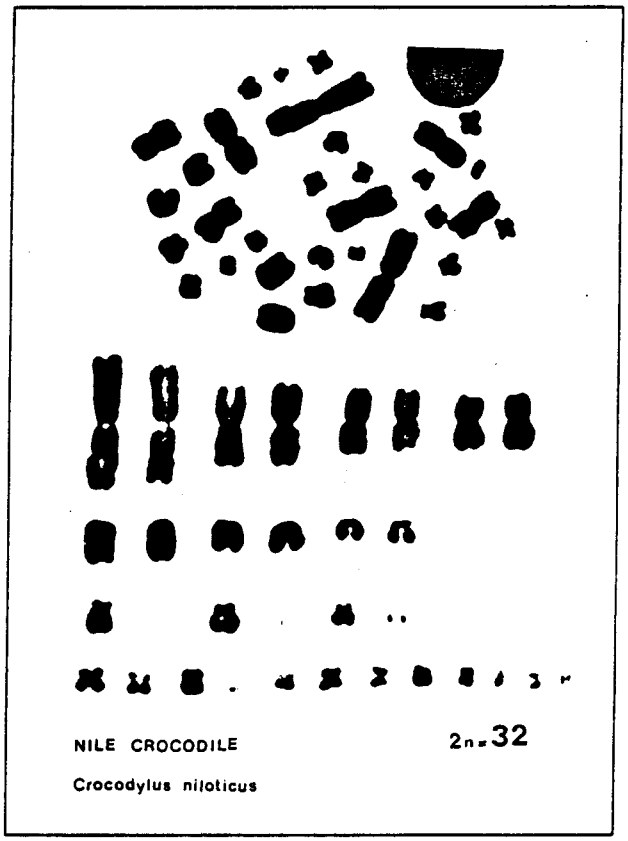
CUBAN CROCODILE 2n= 30

C. rhombifer จระเข้คิวบา



New Guinea crocodile 2n=32

Crocodylus novaeginease



NILE CROCODILE 2n=32

Crocodylus niloticus

Differential Morphology of Crocodilian Leucocytes

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Abstract

Blood smear from 50 crocodiles of three breeds (Crocodilus siamensis, C. porosus and crossbreds) are examined after Wright-Giemsa stainning.Three types of granulocytes are distinguished: heterophil, eosinophil and basophil. In addition, 2 types of agranulocytes are characterized: lymphocyte and monocyte. Heterophil with the size of 8-10 um has spiculate pink granules with oval eccentric light blue nucleus. With the mixing of round, rod and tear drop-shaped acidophilic granules, the eosinophil is 8-9 um., its pale blue nucleus is also at the periphery. Basophil is the largest(9-12 um) among the granulocytes. Granules are of various sizes and stained purple. Nucleus is rounded and surrounded by pale blue cytoplasm. Granules of the heterophils and basophils are dissolved in methanol. Moreover, it is possible that the basophilic granules are also dissolved in water. Lymphocyte's diameter is 7-9 um with eccentric or centrally located round nucleus. Its fine basophilic granules are evenly distributed in the cytoplasm. Monocyte (8-10 um) is few, mostly with kidney-shaped, eccentric nucleus and vacuolated blue cytoplasm. Crocodile has nucleated thrombocyte which is very much like lymphocyte but of smaller size (6 um). The small thin rim cytoplasm surrrounds the rounded nucleus. In addition, the unknown cell is also reported and discussed. It is possible that the unknown cell is another white cell type, "the azurophil".

Introduction

Addition information concerning the morphological and physiological characteristics of crocodilian blood are needed to make a successful differential diagnosis and disease monitoring. Examination of a stained blood film is integral and very helpful in routine hematological examination. Apart from differences in the form and size of the nucleus and cytoplasm, staining characteristics of the cell constituents are essential in classsification of the white blood cells . Confusion and contradictory interpretations on nomenclature of the reptilian blood cells have been an interesting controversy for a long time (5,6,7). Moreover, different staining techniques, type of anticoagulants and whether or not are used all have various effects on blood cell morphological interpretations(4).

The present study is to provide informations on morphological differences (size, shape, nuclear-cytoplasmic ratio and cytoplasmic granules) of the crocodilian leucocytes. In addition, details and results of fixative used in blood smear preparation are also discussed.

Material and methods

Blood samples are collected from blood sinus located behind the base of the skull of 50 crocodiles of 3 types (Crocodilus siamensis, C. porosus and hybrid type). Heparin coated venoject tubes are of tremendous convenience in blood collection. Blood samples are centrifuged at 2,500 rpm for 20 mins. to obtain the buffy coats. One drop of buffy coat is smeared on the slide and 4 slides are prepared from each sample. Two slides of each sample are fixed in methanol for 1 mins. The fixed and nonfixed buffy coat smears are stained with Wright-Giemsa (Clinical diagnostic Ltd.part. , Thailand).

Observations

Examination of the buffy coat smears with Wright-Giemsa stained under the light microscope reveals the following leucocytes:

Granulocytes

1. Heterophils are abundant (Fig 1) .The slightly oval cell of 8-10 um has oval eccentric light blue nucleus with spiculate pink granules densely packed in the cytoplasm. As expected examination of the ruptured heterophil exhibits acidophilic needle-liked granules. The nuclear-cytoplasmic ratio(N:C) is 1:2-2.5.
2. Eosinophils is round, 8-9 um in size (Fig.2) .The nucleus is round or oval and located at the cell periphery. Dark acidophilic, rod and round granules are closely packed in the cytoplasm. However, some of the eosinophilic granules are sparse in the nuclear area. Studies of the disrupted eosinophils reveal a few tear drop-shaped granules mixing with the numerous round and rod shaped granules. The N:C ratio of the eosinophil is 1:2.5-2.8.
3. Basophils (Fig.3) are not as numerous as heterophils and eosinophils. The cell is the largest (9-12 um) among granulocytes with N :C ratio of 12:1 . Granules are mostly round of various sizes and stained dark purple. The nucleus is round and situated in the middle of the cell.

Agranulocyte

1. Lymphocytes are small (7-9 um), round cells with round eccentric or centrally located nuclei(Fig.4). In some instant, very fine basophilic granules are observed in the cytoplasm. The N:C ratio is 5:1.
2. Monocytes (Fig.5) are large (8-10 um) round cells with N:C ratio of 1-2.5:1. The kidney-shaped or oval nuclei are eccentric with vacuolated (ground-glass) blue cytoplasm on one side. Some monocyte has prominent halo areas imprint in the cytoplasm.

Thrombocytes

The thrombocytes (Fig. 6) are nucleated and very similar to lymphocytes but are smaller (6 um). The round nucleus has a thin rim cytoplasm all around. Thrombocytes always appear as clusters or clumps.

Unknown leucocytes

Few unknown leucocytes (Fig.7) are observed in the buffy-coat smears. The cell is round, about the size of lymphocyte (8 um) with various sizes of basophilic granules dispersing in the cytoplasm. It is possible that this unknown leucocyte is azurophil.

Additional reports from the present study are on solubility of the leucocyte granules. Buffy-coat smears that are fixed with methanol display disintegration of basophilic granules (Fig. 7) and granules of the heterophil (Fig. 7 and 8). Whereas, eosinophils remain intact (Fig. 8).

Discussion

Three types of granulocyte are distinguished in the blood of brids and reptiles and these cells probably have the same functions similar to those of mammals. The difference is that cells of brids and reptiles which are generally assumed to be homologous with mammalian neutrophils have cytoplasm containing a large number of strongly eosinophilic spiculate granules.Therefore, the term "neutrophil" is not appropriate and these cells are named as heterophils (6,9).

Heterophils and eosinophils of the crocodile have round or oval eccentric nucleus. Spiculate eosinophilic granules in the heterophils give rise to problems in distinguishing between these cells and true eosinophils. Especially when the granules are densely packed and no single granule can be examined. To add more confusion, ruptured eosinophils always contain a few tear drop-liked granules which sometimes appear very much like the spiculate granules in the heterophils.

Neutrophils/heterophils are the most numerous granulocytes found in normal mammals, birds and reptiles.Their primary function is bacterial killing through phagocytosis, ingestion and lysis (2,6). Some investigator (5) has reported the presence of alkaline phosphatase and peroxidase in reptilian neutrophils while the others(1,3,8) found that both positive and negative alkaline phosphatase and peroxidase reactions in the heterophils. Further investigation on histochemistry of the crocodilian hetrophils would answer this ambigity.

The unknown leucocytes of 8 um diameter display similar characteristics as basophils but are smaller. Two possible interpretations may apply: 1) The questionable cells are degranulated basophils. This is based on the report that in adequate fixation would results in degranulation of the heterophils and basophils(6). 2) These cells are another white cell type, "the azurophil". An outstandingfeature of azurophils is the metachromatic reaction of their cytoplasmic constituent with Romanowsky stains. Little is known about azurophils and they have been considered as allied to the granulocyte or monocyte series.This is due to their roles in the inflammatory response(6).

In addition to degranulation of the heterophils and basophils causes by inadequate fixation(6). Granules of the heterophils and basophils are dissolved when using an alcoholic fixative (methanol).In contrast, the eosinophils remain intact. In addition, degranulation of heterophil is not observed in the nonfixed buffy coat smears.

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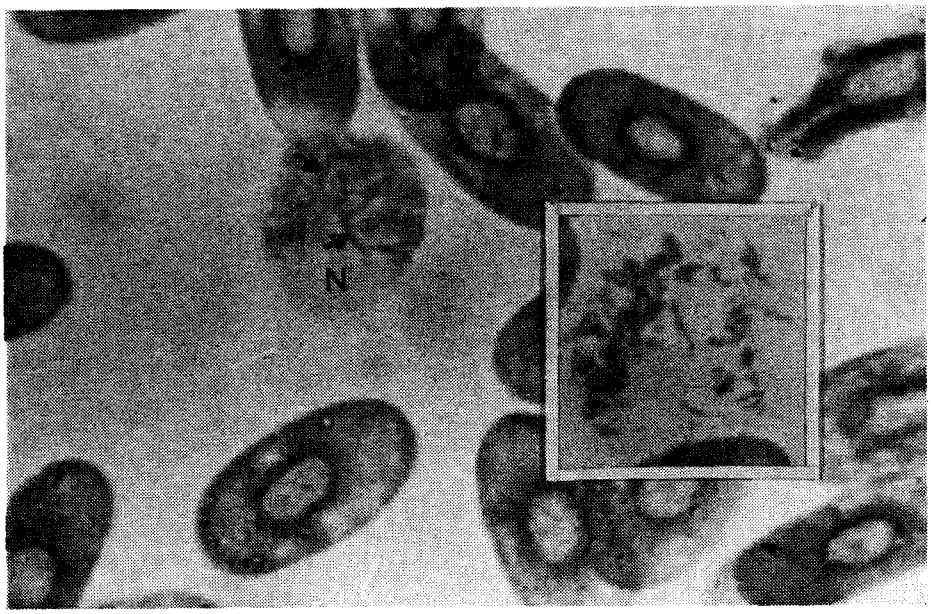

Fig.1 An intact heterophil(8-10 um) with spiculate pink granules (arrows). Inset is a smashed heterophil, the pointed, needle-liked granules are scattered around. (N = nucleus). (Wright-Giemsa x3,600)

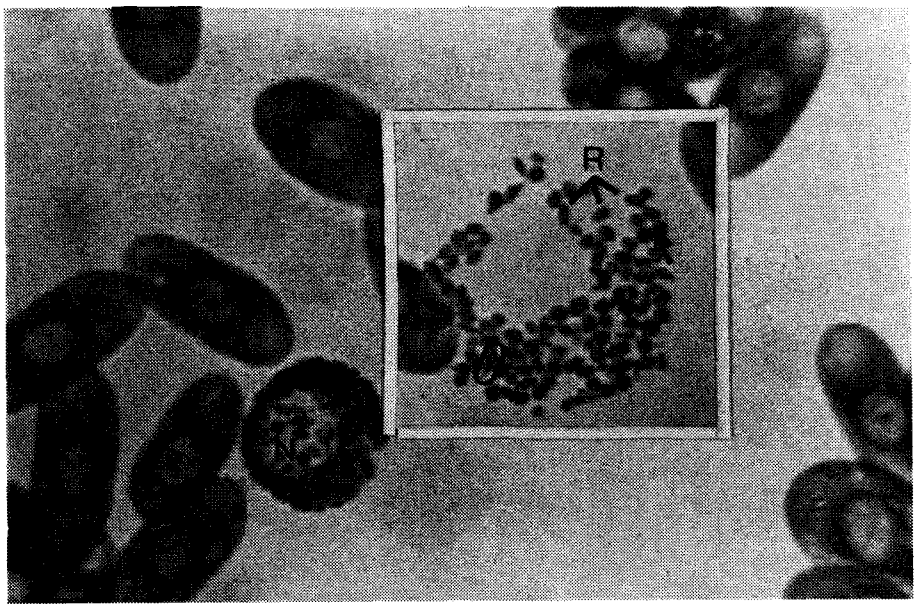

Fig.2 Eosinophil has 8-9 um diameter with eccentric nucleus(N). Round, rod and fusiform granules are found in the cytoplasm. Inset is the disrupted eosinophil with round (arrow), rod(R) and tear drop-liked (oval) granules. (Wright-Giemsa x3,600)

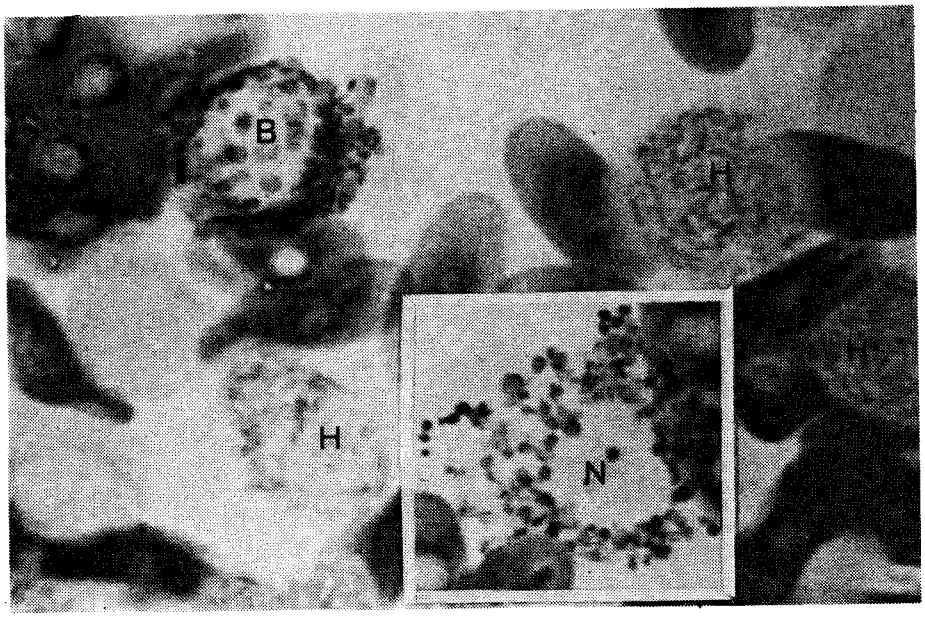

Fig.3 Basophil (B,9-12 um) with round, big basophilic granules are scattered in the cytoplasm. Three heterophils(H) are also observed. The disrupted basophil in the inset displays various sizes and basophilic intensity of the granules. (N= nucleus) (Wright-Giemsa x3,600)

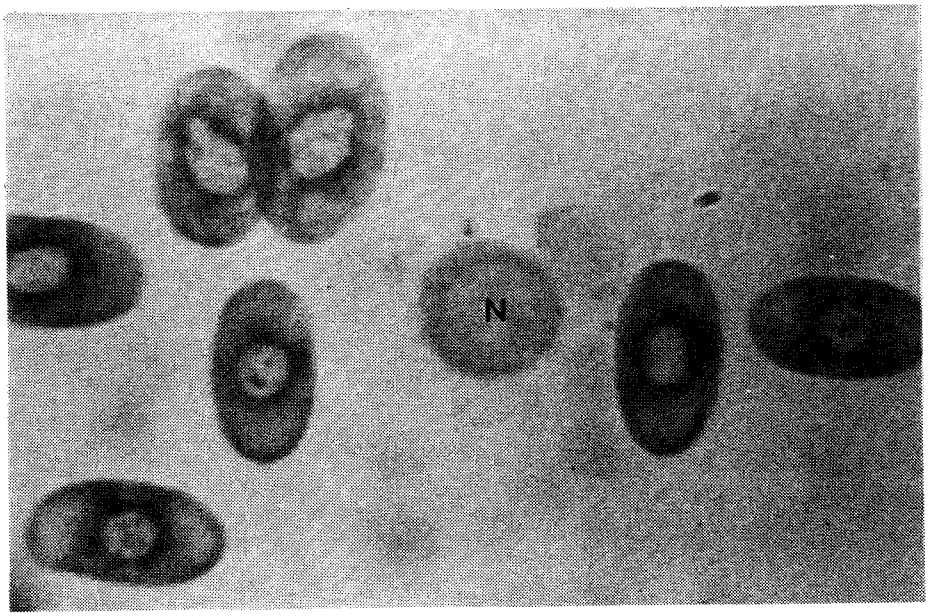

Fig.4 Lymphocyte (7-9 um) is one of the agranulocytes. This lymphocyte has eccentric, round nucleus(N) surrounded by a small amount of basophilic cytoplasm. (Wright-Giemsa x3,600)

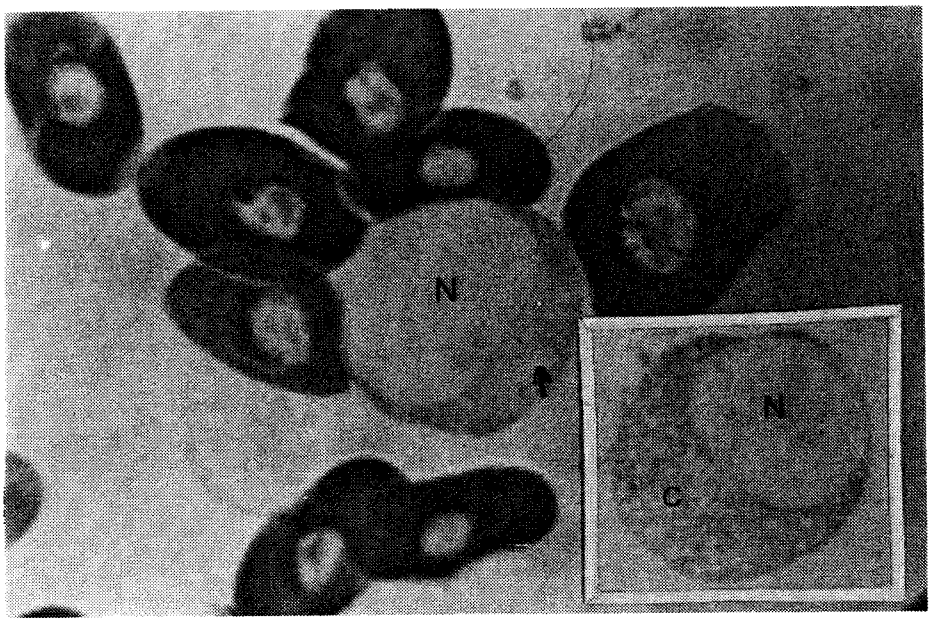

Fig.5 The monocyte (8-10 um) has eccentric nucleus(N). A large amount of pale blue cytoplasm surrounds on one side of the nucleus and halo area(arrow) is also observed. Monocyte in the inset has a prominent foamy cytoplasm(C). (Wright-Giemsa x3,600)

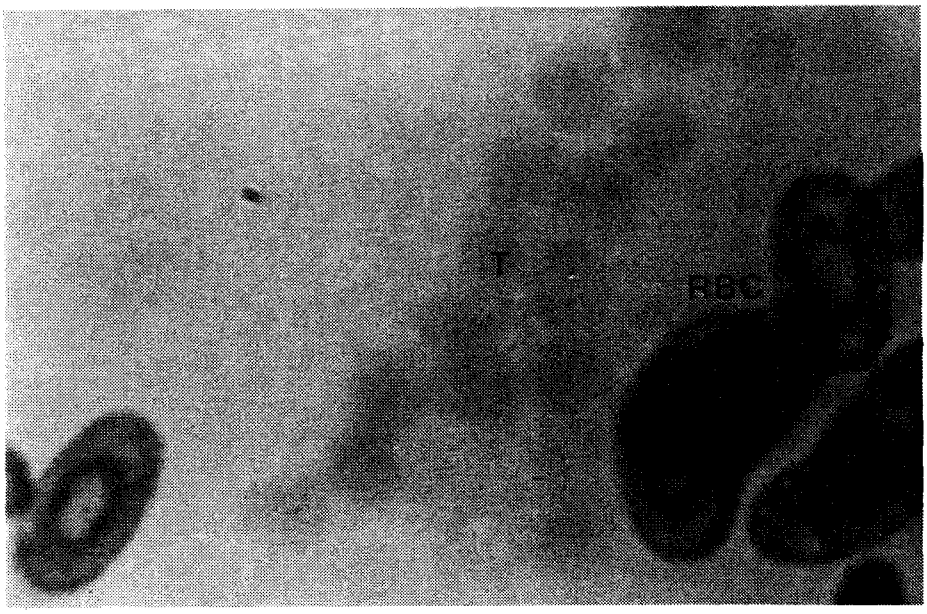

Fig 6 Clump of thrombocytes(T) is displayed along with the nucleated red blood cells (RBC) on the lower right corner. (Wright-Giemsa x3,600)

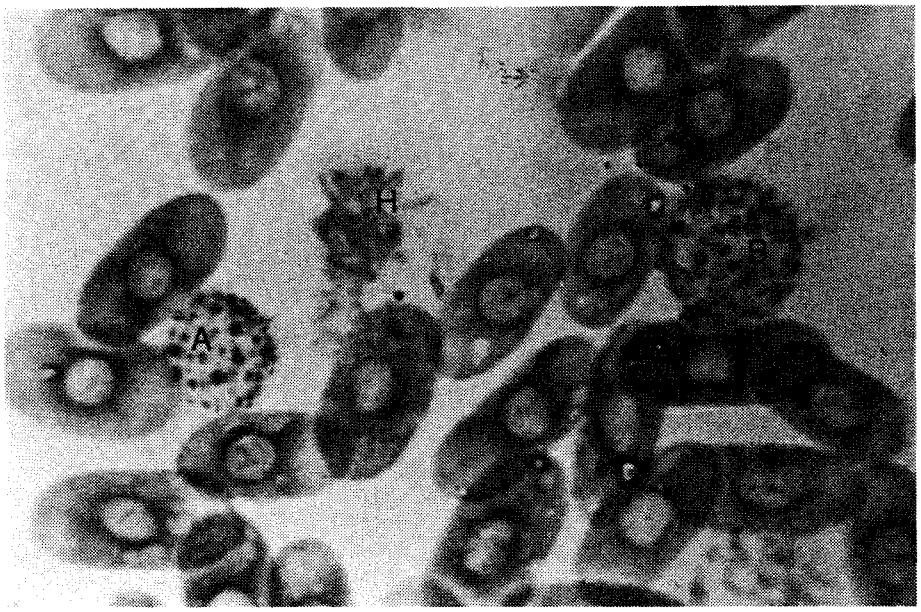

Fig. 7 An unknown leucocyte which could possibly be an azurophil (A) is on the far left. The granulated cell is round with 8 um diameter. The basophilic granules are of various sizes and dispersed in the cytoplasm. Ruptured heterophil (H) is in the middle. (B=basophil)(Wright-Giemsa x 3,600)

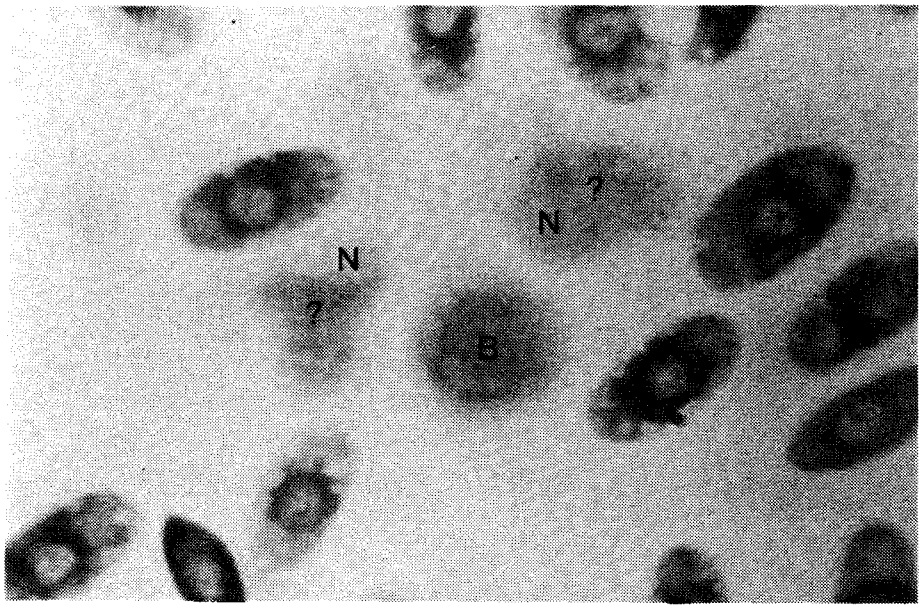

Fig. 8 Blurred basophilic cytoplasm of the basophil (B) is observed after the granules are dissolved away. The upper two cells (?) have eccentric nuclei (N) and fainted remnant of spiculate granules. Disintegrated heterophils are suspected.(Methanol fixed, Wright-Giemsa x3,600)

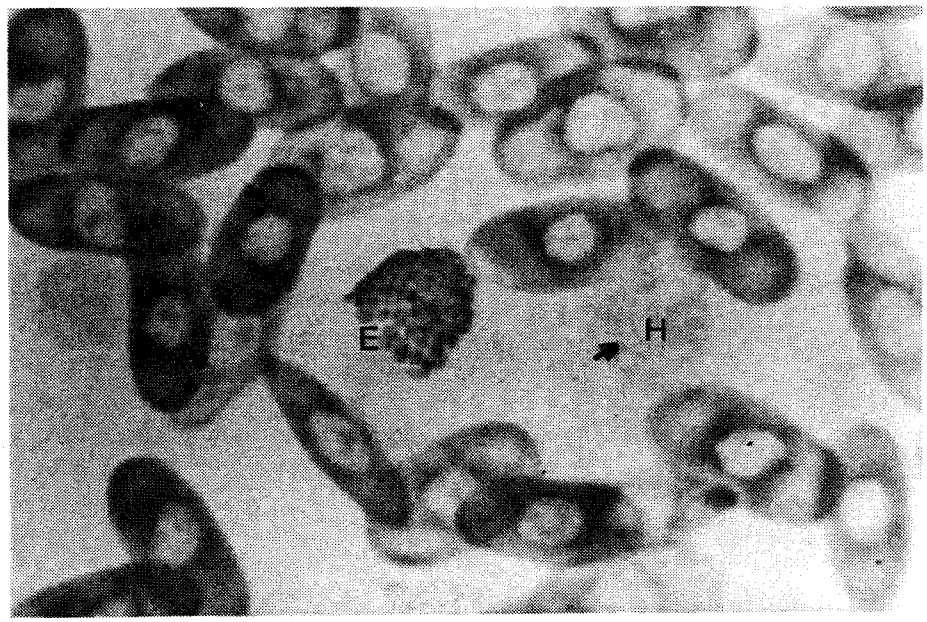

Fig.9 Some spiculate granules (arrow) remain distinct giving an impression that granules of the heterophil (H) are dissolving. Interestingly, eosinophil(E) appears intact and normal with densely packed round granules. (Methanol fixed, Wright-Giemsa x3,600)

Allozyme Variation in the Nile Crocodile *Crocodylus niloticus* from Southern Africa

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INTRODUCTION

The Nile crocodile in South Africa is under severe pressure due to increased human activity and habitat destruction (Blake and Jacobsen, 1992). This could possibly explain the fact that almost 6000 (75%) of the estimated 8000 animals in the wild are at present found in National Parks. Although the remaining animals are protected by local conservation legislation (Marais and Smith, 1991), their numbers are rapidly decreasing.

Crocodiles are also commercially bred on several farms located throughout the country, mainly in the provinces of the Transvaal, Natal and the Cape. The total number of crocodiles involved here are unknown, but is estimated to be in the thousands. Most farmers obtained their breeding stocks from other countries such as Zimbabwe, Botswana, Namibia and also Zambia, mainly because it is illegal to utilize animals from local wild populations. However, the lack of suitable broodstock and hatchlings have lately become a major problem for the crocodile industry (Smith and Marais, 1990) and most farmers now rely on captive-bred breeding stock.

Conservation authorities are understandably concerned that the present inadequate control and coordination between crocodile farmers and various authorities may lead to interbreeding and a loss of genetic variation in local Nile crocodile populations. Although the re-introduction of crocodiles into the wild is not taking place at present (Smith and Marais, 1990a), restocking of river systems did occur in the Transvaal during the 1970's. Reasons for, and possible implications of such mass releases were discussed by Loveridge (1980).

Little is known about the genetic structure (amount, distribution and pattern of allelic variation) of natural as well as domesticated populations of the Nile crocodile in South Africa. This information is of vital importance for the formulation and implementation of coordinated management strategies (Adams *et al.*, 1980).

The purposes of this study were therefor (i) to determine the genetic variation within and between natural and captive breeding populations and (ii) to compare these results with those obtained for other crocodile populations as well as for closely related crocodilian species. This information will undoubtedly contribute to our knowledge of existing genetic resources and phylogenetic relationships within the order Crocodilia.

MATERIAL AND METHODS

Nile crocodiles were sampled from a captive-bred population from Rustenburg, Transvaal (originating from Zimbabwe) and a natural population from St. Lucia Crocodile Centre (originating from the St. Lucia Estuary: 27°51'S; 28°25'S; 32°27'E).

During a routine slaughtering operation at the Rustenburg farm, tissue samples (blood, eye-fluid fat-organ, heart, kidney, liver, muscle and testis) were obtained from 100 two to three year old individuals. The samples were stored in liquid nitrogen (-196°C) and transported to the laboratory.

At the St. Lucia Crocodile Centre blood samples were obtained from 50 young adults. Samples were immediately centrifuged to separate the cellular fraction from the serum. Muscle samples were also collected from 20 individuals by performing biopsies. Crocodiles are not slaughtered at St. Lucia and it was therefor not possible to obtain any other tissues from this population. Samples were kept frozen (-20°C) until used.

Tissue samples were prepared and analyzed in the laboratory by horizontal starch-gel electrophoresis using standard electrophoretic procedures. Histochemical methods of Harris and Hopkinson (1976) were used in staining for protein activity. Interpretation of gel banding patterns was done as described by Grant (1989), and genetic nomenclature as described by Shaklee *et al.* (1990) was used. Statistical analysis of allozyme variation was executed using a biochemical systematics computer program (Swofford and Selander, 1989).

RESULTS AND DISCUSSION

A total of 51 protein coding loci were detected with 23 in all specimens and an additional 28 in those individuals from which heart, liver and kidney tissue were used. The larger number of presumed loci surveyed should provide a more accurate estimate of heterozygosity compared to studies in which fewer loci were studied (Van der Bank *et al.*, 1992).

The mean number of alleles per locus was 1,12 ($\pm$0,06) for the Rustenburg population and 1,22 ($\pm$0,05) for the St. Lucia population. Similar allelic frequencies were found in related crocodilian species.

Allozyme variation was detected at only five of the 51 protein coding loci (9,8 %). The percentage polymorphic loci were 7,84 % for the Rustenburg population and 17,39 % for the St. Lucia population. Chi-square (X^2) values for polymorphic loci showed significant ($P > 0,05$) deviations of alleles from expected Hardy-Weinberg proportions at three loci (MPI-1, PGD-1, PROT-1) in the Rustenburg population and at two loci (MPI-1, PGD-1) in the St. Lucia population. These deviations from the Hardy-Weinberg proportions could be the result of a sampling error, or it might reflect non-random mating during breeding and/or the consequence of using limited brooding stock which might lead to interbreeding. Genetic frequencies at one locus (MPI-2) in the Rustenburg population closely approximated Hardy-Weinberg expectations and at two loci (GPI-1, MPI-2) in the St. Lucia population. Heterozygotes at the GPI-1 and PGD-1 loci were triple-banded, as expected for dimeric enzymes, and they were double-banded for the monomeric enzymes PROT-1, MPI-1 and MPI-2.

The mean heterozygosities per locus were 0,035 and 0,042 for the Rustenburg and St. Lucia crocodile population, respectively. Heterozygosity usually ranges from 0,05 to 0,18 with proportions of polymorphic loci between 0,20 and 0,86 in most animal populations (Gartside *et al.* 1976). Particularly low heterozygosity values have also been obtained in other reptile populations (e.g. Gartside *et al.* 1976; Menzies *et al.*, 1979; Adams *et al.* 1980; Lawson *et al.*, 1989).

Low genetic variability could be attributed to various factors, such as genetic drift where population size is small (as found at St. Lucia). Fixation of loci would be inevitable where neither migration nor mutation takes place. Certain breeding practises at some farms could reduce variability which might lead to interbreeding.

Gartside *et al.* (1976) indicated that fixation of genes could be the result of long periods of environmental stability. Selection for homozygosity might have taken place and the high level of homozygosity could be advantageous if it is an approach to optimal adaptation. Due to the protected status of the Nile crocodile, it is unlikely that a reduction in numbers will take place. However, habitat destruction might cause a decrease in numbers.

CONCLUSIONS

This preliminary study of two Nile crocodile populations indicated general low genetic variability, yet revealed distinct differences between the populations. These differences imply that uncontrolled release into the wild should be avoided. The random mixing of broodstock from different populations is therefore also not advisable.

One major goal of the crocodile industry should be to find a compromise between the short-term need to achieve high-performance consistency, and the long-term need to conserve genetic variability.

To conserve the Nile crocodile, it will have to be managed as a resource and the routine implementation of genetic management programs on crocodile farms could play a major role.

(NOTE: A list of all loci assayed is available from the senior author on request).

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STATUS AND CONSERVATION OF GHARIAL IN NEPAL

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STATUS AND CONSERVATION OF GHARIAL IN NEPAL

Abstract

A field study of the gharial, Gavialis gangeticus, was conducted in the Royal Chitwan National Park and Royal Bardia National Park during 1993 to determine the status of gharial in the Narayani, Kali, Karnali, and Babai river systems of Nepal. Systematic survey conducted in December and May revealed that a minimum of 58 wild gharials and about 70 released gharials survived in the Narayani, Kali, Babai, and Karnali rivers. the sex ratio of wild gharials 1 male to 10 females, was at a critical stage. The low number of males were tributed to the heavy poaching of males in the past. The population may be sustained by releasing captive-reared gharials

Introduction

The gharial, a large crocodilian with a long,slender snout, is the only surviving member of a once well represented family, Gavialidae. The adult male gharial develops a large, cartilaginous protuberance on the end of ist snout, and in fact, the name gharial originated from the resemblance of the protuberance to a ghara or earthenware pot common in India and Nepal (Smith 1931). Mystical beliefs have been attributed to the ghara in Nepal. Local tribesmen (specially the Tharu) believed that a ghara placed under a pillow of expectant women relieved and speeded labor (Mishra and Maskey 1981). They also believed that when the ghara is made into incense and burned in their fields, crops are freed of insects and other pests.

Gharial eggs were believed to have medicinal value in parts of India and Nepal. In Nepal, the local Tharu people believed that gharial eggs had aphrodisiacal and medicinal value. For example, the dry powder of the egg is considered to be effective as a cough medicine (Maskey 1989). Because the eggs do not taste good, they were mixed with flour and prepared as bread (Bika Ram and Nathu Ram, pers. comm.). Eggs were sold for Rs. 30-40 (US $0.60-0.80) on both sides of the Nepali-Indian border.

Until the early 1960s, gharials were found in all the major river systems of Nepal, including the Mahakali, Karnali, Babai, and Rapti rivers in western Nepal, the Kali Gandaki and Narayani Rivers in central Nepal and the Koshi river in eastern Nepal (Fig. 1) By the late 1970s, there had been a drastic depletion in their abundance and distribution; in fact, the wild gharial had become extinct in the Mahakali and Rapti rivers in western Nepal and Koshi River in eastern Nepal. The gharial population in Nepal would probably be on the verge of extinction were it not for the present gharial conservation program.

Many factors contributed to the decline of the gharial population: habitat loss and disturbances, lack of strict enforcement of existing laws, entrapment in nylon gill nets

introduced for fishing construction of reservoirs and dams in suitable habitat, and poaching of eggs by the local people for medicine and food. Collectively, these factors have resulted in the gharial becoming one of the rarest and most endangered crocodilians in Nepal. A high priority was given to this species by the IUCN/SSC Crocodile specialist Group during its working meetings in different countries. Gharials in Nepal are fully protected under the National Parks and Wildlife Conservation Act 1973, and are listed as "endangered species" in the IUCN Red Data Book(1975).

Study Area

The study was conducted in the Karnali and Babai rivers of Royal Bardia National park and the Narayani and Kali rivers of the central Nepal. The Narayani Nepal's third largest river, flows through a relatively low gradient and is fed principally by two major rivers, the kali and Trisuli, which originate in the Himalayan region. The Narayani River has a maximum width of a kilometer and consists of many channels and islands. It swells to a maximum level during the monsoon of June-Septemder, and carries a high sediment load. During the dry season (December-March) the river recedes to the center of the flood plain, and is fed by snow-melt water from the Himalayas. the river is flanked by open sand banks, rocks, and stands of phragmites (Phragmites Karka) and other grasses.

The Mugu Karnali River, originating in the Ladakh Himal, joins the Humla Karnali which originates in China (Tibet), giving rise to the Karnali River (Fig. 2). The Karnali, which flows for 507 km., is characterized by many gorges. One of the area that provided habited for gharials was the Chisapani Gorge, which lies in the Royal Bardia National Park in western Nepal.This habitat was severely degraded by the construction of a bridge over the Karnali River at the Chisapani gorge.

Mathods

Surveys of gharial were conducted in the Karnali and Babai rivers of Royal Bardia National Park and the Narayani and Kali river of the Royal Chitwan National Park. Surveys were conducted from dugout canoes with the help of the members of the local ethnic culture, the Bote. The main livelihood of the Bote is derived from fishing in the rivers, and consequently, they are very familiar with the habits and natural history of the gharial. During the study period, the entire lenghth of the Narayani, Kanali, and Babai rivers within the park area, and Kali River outside the park was surveyed and the estimated size, sex, and location of sighted animals were recorded. The number of gharials in the Koshi River was recorded on the basis of the Warden report.

Results

Approximately minimum of 58 wild and about 70 released gharials were extant in Nepal in 1993. The largest single population of wold gharial, consisting of minimum 39 adults, was found on the Narayani and Kali rivers. The smllest number of minimum five wild gharials were recorded from Karnali River (Tabe1 1). Similarly among the released

ghariais, 22 were recorded from the Narayani and Kali rivers, 36 from the Babai River, 10 from the Karnali River and two in the Koshi River (Table 2).

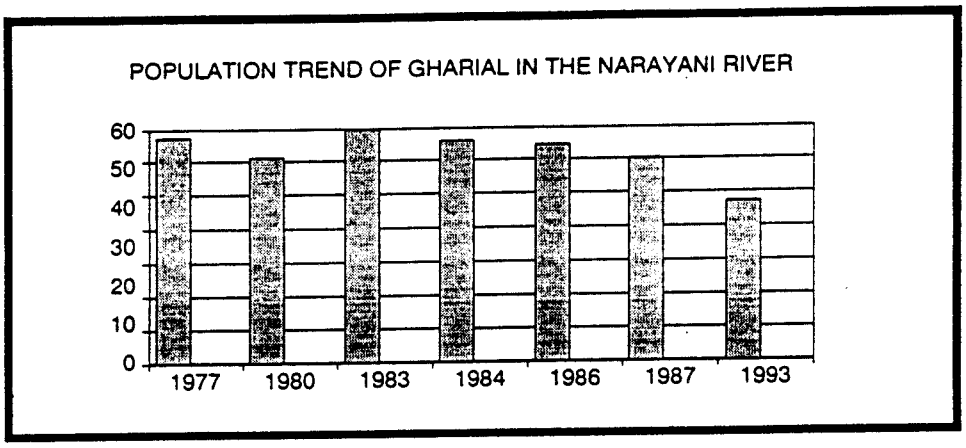
TABLE 1: Present status of Wild Gharial in Nepal

RIVER	MINIMUM NUMBER OF WILD GHARIAL SIGHTED
Babai	12
Kali	9
Karnali	5
Koshi	0
Mahakali	0
Narayani	30
Rapti (west)	2
TOTAL	58

TABLE 2: Number of relesed gharials and their survival to 1993

RIVER	NO.OF GHARLAL RELEASED	NO.OF GHARIAL SIGHTED	SURVIVAL PERCENTAGE
Narayani	273	20	7%
Koshi	84	2	2%
Babai	50	38	76%
Karnali	20	10	50%
Rapti (Chitwan)	5	3	60%
TOTAL	432	75	17%

In chitwan Shrma (1977) reported a population of 58 wild gharials in the Kali and Narayani rivers. Minimum popoulation estimates of 53, 60, 57, 56, and 51 wild gharials were calculated from 1980, 1983, 1984, 1986, and 1987 surveys, respectively, in the Narayani and Kali rivers.



Hundreds of gharials were observed on the lower Narayani River prior to the construtions of the dam on the river near the indo-Nepalese border in 1964 (pers. comm. with local people). In the early 1950s, about 235 gharials occured along the river between Narayanghat and Tribeni (Juthe Ram pers. comm.). These gharial had been extirpated by poachers and dam construction (Jung Prasad pers. comm.)

Many gharials and muggars were observed on the upper and lower Karnali River prior to the survey of Karnali dam site in 1970s (Pers. comm. Krishna Man), but at present the population of gharial in the Karnali River is highly uncertain. The local people living near Kuinae reported that earlier in 1960s, they observed as many as 20 gharials in one spot of the kachali area (Shrestha 1990). Shrestha (1990) also reported 9 muggars, 11 gharials in the various spot of Karnali River, whereas 10 gharials were detected in both 1978 and 1979 (Bhim Gurung, pers. comm.). In 1987 Krishna Man (Former Senior Warden, Royal Bardia National Park) reported the occurence of seven adult and two juvenile gharials in the Karnali River, seven in Babai River, and three (or less) in the Rapti River of western Nepal. During the field survey in the Karnali River, only 5 adult gharials all females were observed in the upper Karnali River (Chisapani Gorge area), whereas not one gharial was observed in the lower Karnali area Among the released gharials, the survival rate in the Babai River is 10 times more than in the Narayani River (7% survival in 1993) and about twice more than in the Karnali River (50% survival in 1992). The main reason of high survival rate in the Babai River is because of less disturbance by the people and less fishing activities, whereas these activities are high in the Karnali and Narayani River.

During the monsoon season, wild gharials enter tributares to avoid the increase force of waterflow in the Narayani River A maximum of five wild gharials were counted in the Rapti River of Royal Chitwan National park Three of the five young gharials that escaped from captivity into the Rapti River in 1986 were observed regularly near Dudhaura in Rapti River.

The visually observed sex ratio of the gharial in the Narayani, Karnali and Babai rivers strongly favors females, represent a problem. The highest sex ratio of the gharial 1 male to 6 females was recorded in 1984, 1 male to 9 females in 1987 and 1 male to 10 females in 1993. The low numbers of males can be attributed directly to (a) heavy poaching of the male in the past for the "ghara" and, (b) temperature effects on incubation/hatching in the hatchery, because earlier superstitious beliefs about the ghara have diminished, modern poaching may not be selective. In the future the number of male gharial might be increased by releasing more captive reared males, however, that strategy does not lessen the severity of the current situation.

Conservation Strategy

The surviival of the gharial in Nepal is threatened primirily by continuous haditat destruction that is related to increasing human pressure on the environment due to extensive agriculture, firewood collection cattle grazing, grass cutting, and heavy traffic in the river course. Since the gharial population has continued to decline, conservation measures are necessary to protect the surviving population. Fewer than 1% of all ghrials hatched in nature reach a length of 2m, a length at which they are generally secure from nature predation (Singh 1978) One breeding female may lay from 14 to 62 eggs in a clutch (Maskey 1989), but the eggs generally fall vicitm to predators, to poachers, and particularly to flooding. To protect this animal from extinction, His Majesty's Government of Nepal strongly supported by the Frankfurt Zoological Society, launched its Gharial Conservation Project in Royal Chitwan National park in March 1978. The objectives of the Chitwan rehabilitation project are to protect natural nest sites, to carefully collect and incubate will eggs, and to rear hatchlings to a length of 2m for restocking the major river systems in Nepal. A similar project was initiated at Royal Bardia National Park Headquarter, but later it was abandoned because of heavy flooding in the rearing facilities

The gharial conservation Project released the first lot of 50 3-year old animals in to the Narayani River on March 2, 1981; subsequent releases were made in the Narayani River in 1982, 1983, 1984, 1987 and 1989, in the Kali river in 1983, in the Koshi River in 1983 and 1986, in Rapti River in 1985 (escaped from the enclosure), in the Babai River in 1990, and 1991, and in the Karnali River in 1992.

Since 1981, the Gharial Conservation Project adopted several strategies. It included updating the status of wild and released gharials in Nepal, identifying suitable habitat for reintroduction and protection, collection of wild eggs from the Kali, and Narayani rivers. The strategy also includes incubation, and reaing at Kasara, reintroduction of captive-reared stock, and long term monitoring of the effectiveness of the reintrodution.

The Nepal Gharial Conservation project has successfully produced over two

thousand gharials and reintroduced 432 into the Narayani, Kali, Koshi, Karnali and Babai rivers. Until now, budgets and extreme logistical difficulties have prevented the development of an expanded program of this project.

Recently a crocodile Project was initiated in Nepal under the auspices of the local IUCN office in collaboration with the Department of National parks and Wildlife Conservation. The main objectives of the project are:

- Creation of gharial and muggar sancturies outside the protected areas
- Continue of control hatching of wild eggs of both species
- Continue of restocking of both species in different river systems
- Initiation of a country wide surver of both gharial and muggar
- Creation of data base to centralize crocodile information

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STATUS AND CONSERVATION OF THE GHARIAL IN INDIA

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ABSTRACT

The Government of India has taken up a long-term conservation programme for three species of Indian crocodiles. Due to hunting and habitat destruction, the gharial population was reduced significantly. Its range is limited to few rivers in North India. Massive fishing activities in the rivers where gharial occur have caused mortalities of gharial. To save the species along with other crocodiles, the Govt. of India in collaboration with FAO/UNDP has developed a National conservation management plan for the gharial and its habitat. Under this plan gharial habitats have been declared as protected areas. There are 7 existing gharial sanctuaries in 5 States with a total area of about 2986 sq. Km. In addition to these special sanctuaries about 520 sq. Km. of protected area in Uttar Pradesh is also available for gharial protection. To give more protection to the gharial habitat some of the protected areas, especially the National Chambal Sanctuary has been proposed for National Park status. At present 3 gharial rehabilitation centers are under operation where 'grow and release' programs are being taken up. Three capitve breeding centers have been established where gharial is successfully breeding. Monitoring of gharial populations in different protected areas revealed that the gharial population has been recovered, particularly in the National Chambal Sanctuary where more than 64 gharials are breeding in the wild. The total population is estimated to be more than 1500 animals in the wild. Although the speceis is recovered it is not suitable for commercial exploitation as the Government laws are against wildlife exploitation in the Country.

INTRODUCTION

The gharial, *Gavialis gangeticus*, one of the three crocodilian species in India suffered from a long period of habitat degradation and to certain extent exploitation for skins (FAO, 1974). Gharial population dwindled down in many of its distributional ranges. However, due to conservation programmes taken up since 1975, population in different areas has been recovered (Singh, *et al.*, 1984; Rao, 1990). This paper deals with the historical background, conservation aspects and current status of gharial in India.

DISTRIBUTION

The gharial orginally occured in the river systems of India, Pakistan, Bangladesh, Nepal, Burma and Bhutan (Smith, 1931), According to Steel (1989) occurence of an extinct fossil species in Sumatra that is allegedly referable to Gavialis indicates that the genus probably had a much more extensive range in South-eastern Asia in geologic times than is the case today. The gharial inhabits major northern river systems particularly Ganges, Indus, Brahmaputra and also Mahanadi (FAO, 1974). It occur in Madhya Pradesh, Rajasthan, Uttar Pradesh, Bihar and Orissa. Its occurrence in the Godavari in the South India (Andhra Pradesh) was reported by Bustard and Choudhury (1982).

HISTORICAL BACKGROUND

Old records indicate that the gharial abounded in all the great rivers of Northern India (Shortt, 1921, I.A.K. 1921, Rao, 1933). According to Adam (1867), ten to twenty gharial may be frequently seen together in different rivers. Hornaday (1885) reported seeing 22 gharial in two hours on the Yamuna river.

The gharial has been illegally hunted throughout its range for hides, meat, and medicine. This "harvet", the loss of habitat from alteration and human settlement, and the use of nylon set nets for fishing may have been significant in regulating some local populations. By the end of 1960's the gharial dwindled to a trace of its former abundance (Biswas, 1970, Whitaker *et al.*, 1974). According to Whitaker and Basu (1982), during mid 1970's the largest known wild concentration was 34 animals including adult and juveniles in 5-6 km, of river at

Katerniaghat, U.P., 50 adults and 100 smaller animals in 600 Km. of the Chambal river and 14 adults in Rapti-Narayani River in Chitawan National Park, Nepal. They reported that an estimated 100 wild gharial survived in India in 1975, which was half of the estimated world populaition.

CONSERVATION STATUS

Gavialis gangeticus, is listed on Appendix I of CITES. Under the National legislation, the species is protected through Wildlife (Protection) Act, 1972. The gharial is considered as endangered in IUCN Red Data Book.

CONSERVATION MANAGEMENT

A Nation-wide crocodile conservation project was initiated in the Country by the Govt. of India during 1975 in technical collaboration with FAO/UNDP (FAO, 1974). Under this crocodile project many corcodile habitats were identified and protected by declaring thirteen of them as crocodile sanctuaries where captive reared crocodiles are released since 1977. Wild gharial eggs are being collected for artificial hatching in different rehabilitation centres. The important captive rearing centres for gharial in India are shown in table 1.

Table No. 1. Gharial captive rearing centres in India.

Sl. No.	Centre	State
1.	Kukrail Crocodile Rehabilitation Centre, Lucknow	Uttar Pradesh
2.	Katerniaghat Centre	Uttar pradesh
3.	Deori Gharial Rearing Centre, Morena	Madhya Pradesh
4.	Gharial Research and Conservation Unit, Tikerpada	Orissa
5.	Nehru Zoological Park, Hyderabad	Andhra Pradesh
6.	Madras Crocodile Bank, Madras	Tamil Nadu.

The captive reared gharial from these centres are released in many protected rivers in North India and Mahanadi in the east and also released in

Pakisthan (Fig. 1). The number of gharial released in different rivers in India are shown in table 2. So far a total of 3342 captive reared gharial have been released in these rivers.

Table No. 2.Year wise gharial releases in Indian rivers.
(Source : M.P. and U.P. Forest Departments)

Year	River	State	No. of Gharials
1979-93	Chambal	M.P./Raj./U.P.	1718
1985-93	Son	M.P./U.P.	106
1986	Rapti	U.P.	10
1979-94	Girwa	U.P.	172
1986-92	Ghaghra	U.P.	45
1982-94	Ramganga	U.P.	257
1986-92	Sharada	U.P.	105
1985-93	Ken	M.P.	35
1977-89	Mahanadi	Orissa	609
1990-93	Betwa	U.P.	55
1990-91	Dudhwa	U.P.	5
1990-93	Ganga	U.P.	225

The protected areas where gharial receives active protection are given in table 3 (Fig. 2).

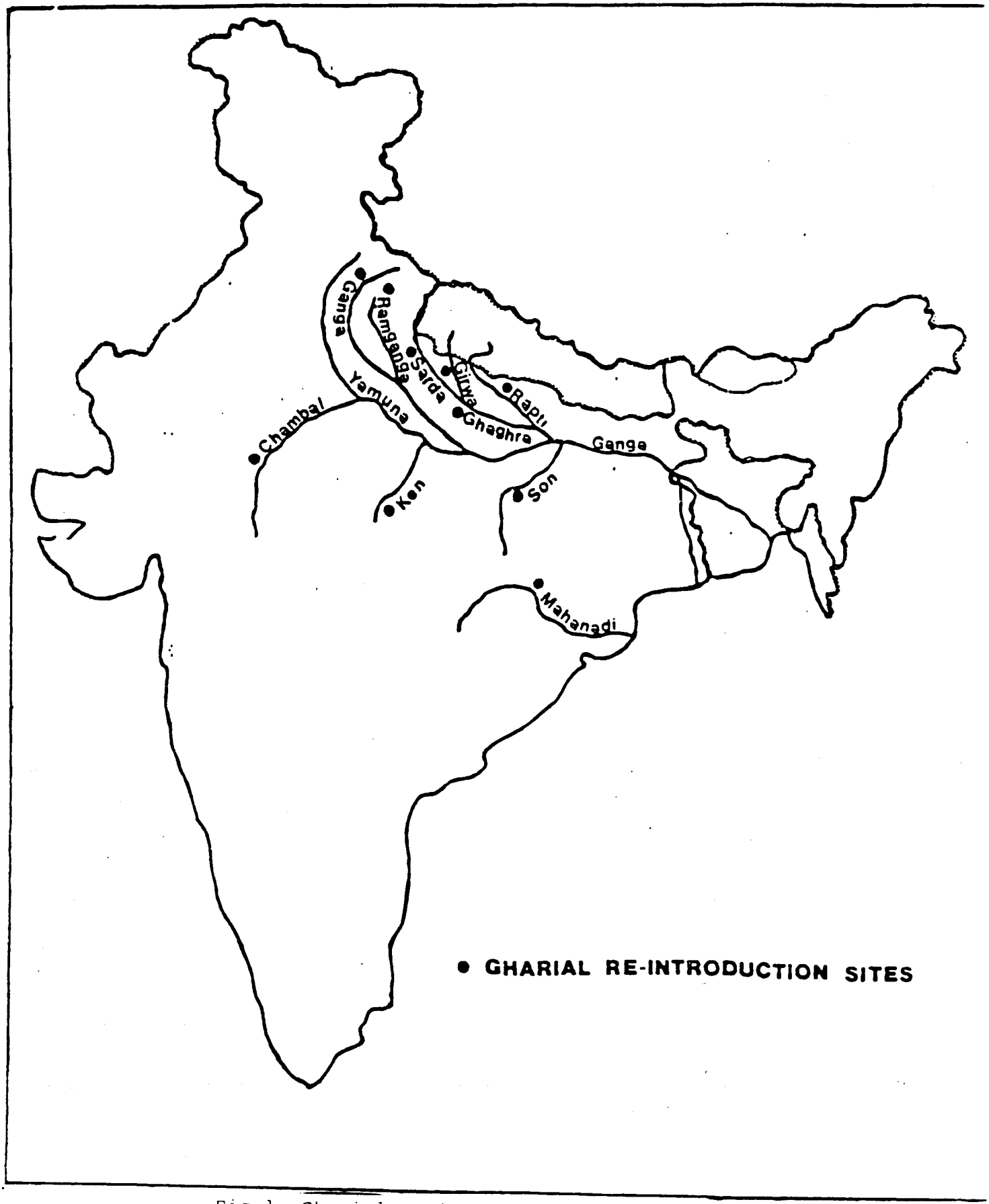

Fig.1 Gharial re-introduction sites in different rivers in India

Table No. 3. List of protected areas for gharial protection.

Sl. No.	Protected Areas	River	State
1.	National Chambal Sanctuary	Chambal	M.P./U.P./Raj.
2.	Jawahar Sagar Sanctuary	Chambal	Rajasthan
3.	Katernia ghat Sanctuary	Girwa	U.P.
4.	Ken Gharial sanctuary	Ken	M.P.
5.	Son Gharial sanctuary	Son	M.P.
6.	Satkoshia Gorge Sanctuary	Mahanadi	Orissa
7.	Papikonda Sanctuary	Godavari	A.P.
Other Protected Areas			
8.	Corbett National Park	Ramganga	U.P.
9.	Dudhwa National Park		U.P.

PRESENT STATUS

Population estimates and counts have been made sporadically by various investigators. Among the 34 protected areas in India where all three crocodilian species are protected (Singh, *et al.*, 1984) gharial receives protection in 9 (3%) areas. In a total of 13 crocodile sanctuaries in India 7(54%) sanctuaries with an area of 2986 Sq. Km. are specially created for the protection of gharial. In U.P. an area of 520 sq. Km. of Corbett National Park is offering protected area for gharial in the Ramganga River. Successful captive breeding of gharial has been reported for the first time from Nandankan Biological Park, Orissa (1981) followed by Kukrail Crocodile Rehabilitation Centre, U.P. (1989) and Madras Crocodile Bank, Tamil Nadu (1989) (Fig. 2).

The monitoring studies conducted in different parts of the Country revealed that the numbers and distribution of gharial have changed markedly over the last 15 years. Presently, the important rivers where large number of gharial can be seen are Chambal, Ramganga and Girwa. According to Singh *et al* (1984) the gharial population in the Country, before releasing any animal, was 230 including 72+ adults and by 1984 the population has been increased to 2518 including wild, released and captive animals. The status surveys conducted in different rivers indicated that the gharial population have recovered due to conservation

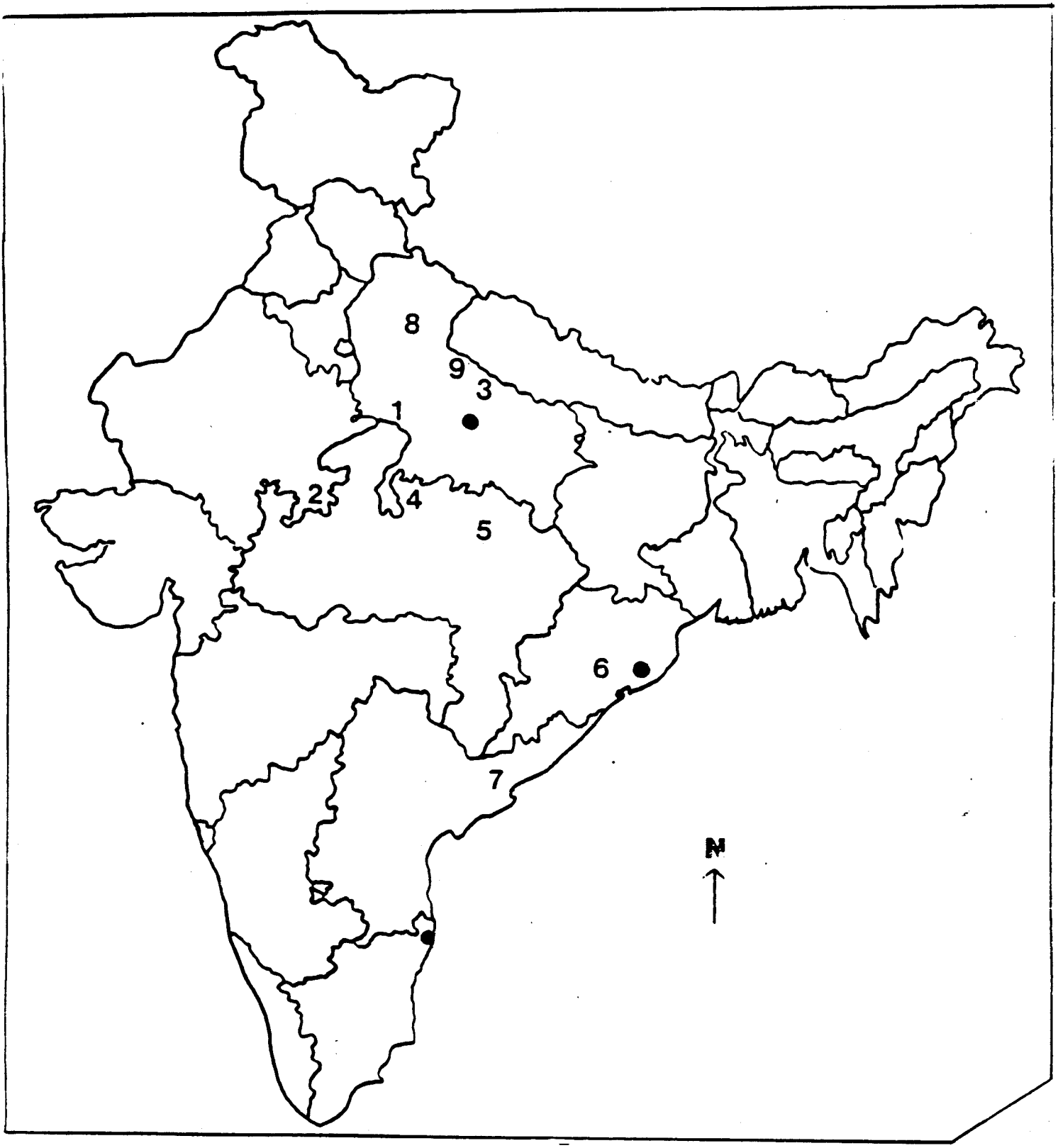

Fig.2 Gharial protected areas and captive breeding centres in India.
See text and table 3 for area names.

managment programmes. But Mahanadi river requires a fresh effort for management (Singh, 1991).

Out of 609 gharials released in Mahanadi only about 25 including 10 in the Satkoshia Gorge, are seen today (Sharma, S.S. in the Samaja, Cuttak, Orissa, 26.11.91). Similarly, in both Ken and Son rivers less number of gharial are seen than released. Intensive population surveys and studies were continued in the Chambal river. Population monitoring was also continued in the Katerniaghat Sanctuary by the Uttar Pradesh Forest Department. These studies indicated that more than 1100 gharial are present in the Chambal river and over 50 individuals in Girwa river. No data is available on population figures in other rivers, as systematic census has not been carried out. Out of all rivers inhabited by Gharial maximum number of gharial are found in the Chambal river. The total population in India is estimated to be more than 1500 animals in the wild. The census figures from the Chambal river are shown in Table 4.

Table No. 4. Census of estimated population of gharial and No. of nests in the Chambal river.

Year	No. of Animals (all sizes)	No. of Nests	No. of Nesting Sites
1978	107	12	6
1984	451	28	?
1985	605	33	7
1986	628	37	10
1987	-	45	12
1988	804	50	15
1989	-	57	15
1990	982	-	-
1991	-	60	15
1992	-	-	-
1993	-	64	15
1994	1100+	64+(?)	15(?)

Gharial were seen in large groups (more than 20) in different areas in the Chambal river (Singh, 1985). The nesting population was also greatly increased in the Chambal river. According to Rao (1988) 12 nests were located during 1978. Every year the figure have increased and during the 1993 nesting period around 64 nests were located from the Chambal river (Table 4). The breeding records in the Chambal river revealed that number of nests and nesting sites in early 1990's have greatly increased over the figures in late 1970's. Although number of nests increased in 5 years period from 50 in 1988 to 64 in 1993 the nesting sites have not been increased (Fig. 3). This shows that there is a saturation of suitable nesting sites for the increased breeding population in the Sanctuary. Gharials were also successfully breeding in Girwa and Ramganga Rivers (Basu, 1991).

These results show that the crocodile conservation programme in India is a great success. The gharial population are increasing, particularly in the Chambal river, due to release of captive reared animals, highly protected habitat with security against possible dangers (Rao, 1990).

CURRENT PROBLEMS:

a. Rehabilitation of gharial

The problem identified in India for gharial conservation is that the cost for operation of rehabilitation centres is very high. There are not sufficient protected areas identified for releasing of captive reared animals. All rehabilitation centres have reduced their activities by collecting very few eggs from wild. At present emphasis is only given to protect the wild animals, there by reducing the expenditure for captive rearing programme.

b. Human-gharial Conflict

There is an increase of human population in the bank-side villages along most of the gharial inhabited rivers which resulted a conflict between crocodiles and people. The impact of human activities like agriculture, sand mining and fishing on gharial population and its habitat is very high. With the increase of human encrochment in the gharial habitat, there is a loss of suitable habitat which made the gharial to live in few isolated small stretches of the rivers.

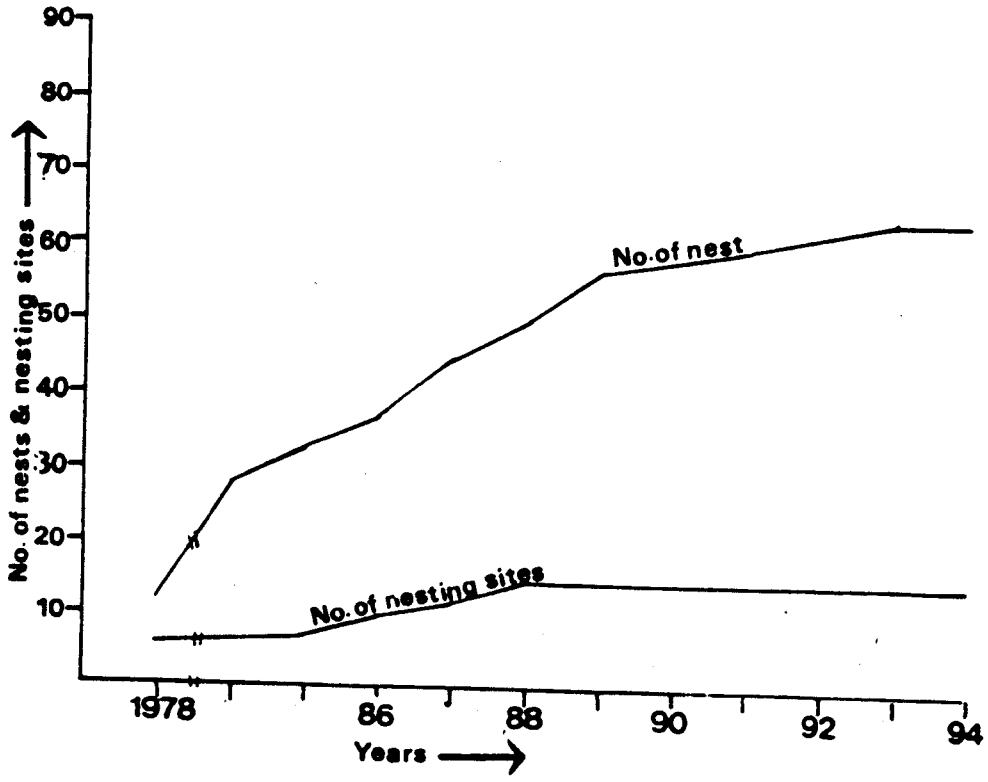

Fig.3 Number of nests in different nesting sites along Chambal river during 1978-1994

FUTURE GHARIAL MANAGEMENT

The continued survival of gharial in different rivers will depend increasingly on the Govt.'s capacity to manage population in the protected areas. The protected areas like National Chambal Sanctuary and Katerniaghat Sanctuary should be considered as core areas and other gharial sanctuaries act as buffer for introduction of the species. The Chambal river has the capacity to produce more than two thousand hatchlings every year. but post-monsoon survival of the young ones is estimated to be 6% only. It is necessary to control this high loss by collecting maximum number of eggs, hatch them in captivity and release them after monsoon to assist mortality in monsoon floods. It is very essential for protection of key breeding sites in the most productive gharial habitats.

The decline and/or non-survival of gharial population in the Mahanadi needs to manage human-crocodile interface with sensitivity. It is a challenging proposition to manage community attitudes towards gharial conservation. The locals will support proposals for crocodile conservation only after fulfilling their demands.

SUSTAINABLE USE

Conservation through sustainable use has proven to be very sucessful for a number of crocodilian species, when carried out under carefully planned and rigorously controlled management programmes (Messel & King, 1992). Instead of harvest of commercial sized animals directly from the wild, use of captive reared crocodilian product from wild laid eggs, which have high mortality rate, is recommended. This practice of ranching is economically feasible for sustainable use projects for crocodilians (Messel & King, 1992). Since gharial breeds in large semi-natural enclosures, cost for captive breeding for commercial exploitation is very high. It is much cheaper to collect the wild laid eggs, incubate in controlled temperatures and use the young ones after releasing some percentage of animals in the wild.

The nesting population in the National Chambal Sanctuary is around 64. Considering the clutch size as 38.4 (Rao, 1988) and hatching success at gharial rehabilitation centre as 87% the annual production of gharial in captivity will be around 2000 if we collect and incubate all wild laid eggs. Rearing success upto sub adult stage at different centres is more than 50%. If this figure is also taken in