CROCODILES

Proceedings of the 10th Working Meeting of the Crocodile Specialist Group

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

convened at

Gainesville, Florida, U.S.A., 23 to 27 April 1990

Volume 2

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FOREWORD

The two volumes of this PROCEEDINGS are a record of the presentations and discussions that occurred at the 10th Working Meeting of the Crocodile Specialist Group in Gainesville, Florida, U.S.A. 23 - 27 April 1990. The manuscripts are unreviewed and unedited. The CSG PROCEEDINGS, by definition, are records of what occurred at the meeting. They are not tomes filled with articles that were critiqued, edited, revised, and polished subsequent to the meeting. Apart from preparing a table of contents, cut-and-pasting captions to figures, compiling the articles alphabetically by author, and numbering the pages consecutively, the papers are published just the way they were submitted. For this reason, they appear in a variety of formats and typefaces. James Perran Ross was the managing editor.

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

IUCN - The World Conservation Union was founded in 1948, and has its headquarters in Gland, Switzerland; it is an independent international body whose membership comprises states (irrespective of their political and social systems), government departments, and private institutions, as well as international organizations. It represents those who are concerned about man's modification of the natural environment through the rapidity of urban and industrial development and the excessive exploitation of the earth's natural resources, upon which rest the foundations of his survival. IUCN's main purpose is to promote or support action which will ensure the perpetuation of wild nature and natural resources on a world-wide basis, not only for their intrinsic cultural or scientific values but also for the long-term economic and social welfare of mankind.

This objective can be achieved through active conservation programs for the wise use of natural resources in areas where the flora and fauna are of particular importance and where the landscape is especially beautiful or striking, or of historical, cultural, or scientific significance. IUCN believes that its aims can be achieved most effectively by international effort in cooperation with other international agencies, such as UNESCO, FAO, and UNEP, and international organizations, such as World Wide Fund for Nature (WWF).

The mission of IUCN's Species Survival Commission (SSC) is to prevent the extinction of species, subspecies, and discrete populations of fauna and flora, thereby maintaining the genetic diversity of the living resources of the planet. To carry out its mission, the SSC relies on a network of over 2,500 volunteer professionals working through more than 90 Specialist Groups and a large number of affiliate organizations, regional representatives, and consultants, scattered through nearly every country of the world.

A program of monitoring and recovering of Caiman's populations in Argentina with the aim of management

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ARGENTINA

The north of our country is the southern limit of the geographical distribution for two species of caimans historically overexploited either legally or illegally. We are talking about caiman latirostris and Caiman yacare.
The distribution area for C.latirostris (Apendix I CITES), involves the provinces of Misiones, Corrientes, Entre Rios, Formosa, Chaco, Santa Fe, Santiago del Estero,Salta and Jujuy, up to 32 south latitude. For C. yacare (Apendix II CITES) the general area is coincident but it seems to have a higher concentration in the area of the country not going further the 30 south latitude. Anyway it is possible that in many places of this Provinces where these species were common, they have totally disappeared.
Even though it does not exist any population study as regards this fact, it is obvious that the numerical retrocession of the Argentine caimans has become dramatic in the last year, although in certain areas fairly abundant populations of one or other species can be found as C. latirostris in Chaco and Santa Fe or C. yacare in Corrientes, in places that are not visited by hunters either because they do not know the place or due to its difficulty to arrive .
Although fortunately, the illegal trade of both species up to now is very not encouraged due to the increasing application of CITES at world level, it is also a fact that the captures continue in the forest, and this could get worse with the permission of quotas to export skins in bordering countries, which could direct argentine products, due to budgetary and structural difficulties in public agencies to control either furtivism or frontiers. In addition to this, we have the constant modification of habitat, favored by the lack of massive campaigns of information as regards importance and potentiality of the resource.
It is minimal the benefit that caimans brig to local inhabitants because, even though their meat is edible and tasty it is not a usual dish in their diet and as regards

their leather the retribution is minimal because there is not a market price.
Summing up what have been already mentioned, we can say that if this present situation goes on, it is highly probable that the populations of caimans in Argentina continue being exploited till its near extinguishment, benefitting only a few, and without any profit for wild populations, local inhabitants or the country.

WORK PROPOSAL

The management of animal's life under their different modalities, is in general the most feasible alternative to ensure the preservation of these species. In no way it will be feasible to keep endlessly restriction to the use of wild fauna, while at the same time, human needs increases.
This programme proposes a management alternative for caimans which could be defined as "Self-repopulation by Ranching with monitoring of Population Tendency". It basically consists of identifying caimans populations, evaluate them with index of relative density and apply the Ranching System, replacing to their environment all possible specimens at nine month of age, monitoring the impact of this experience on the population under discussion.
A programme like the one proposed in based on the awareness of the actual possible availability of means and people, and what it is even more important, the potential use that is going to be given to the information got, in such sense it must be considered that:

1) Due to its actual volume and the population status it is ridiculous to think of a direct exploitation (commercial hunting) in Argentina.
2) It is no possible to start Ranching works, deriving from the beginning eggs to the market, because, on the one hand we do not know the effects of this practice on our populations and on the other hand we come from a situation of obvious populational depression.
3) Evidently we cannot begin a Ranching and repopulation work that embraces the whole country.
From what we have mentioned above it arises that the programme must define study areas that can be handled in the provinces, considering different types of habitats and

species.

The choice on the working areas is essential for the success of the programme and must correspond to certain characteristics:

-) They must not be very large.

-) They must have defined limits.

-) During flood seasons they must not be completely covered.

-) During dry seasons, they must have some water.

-) They must account on caiman's populations from time ago.

-) There must be a knowledge of reproduction it that area.

-) The place must allow the counting of animals.

Ten sampling places have been chosen up to now in the whole country (two each province) with very different surfaces and characteristics. Our purpose is to have in each sampling unit an amount of about seven or ten nests (to have a national total of 70 to 100). The size of each area shall be given by the surface that must by covered to final such amount of nests. As an example we have a sampling area at the headwaters of Mirinay river (Corrientes) with a surface of 5 km of length and another one at Salado river (Santa Fe) with a surface of 45 kms.

The program shall be carried out in such different places as the esteros del Ibera (marshy land of Ibera) in Corrientes, the watershed of Salado river in Santa Fe; the cutwaters and the headwaters of Gualeguay river in Entre Rios and the inland lagoons, and the dry river bed of Bermejo river in Chaco and Formosa.

GENERAL METHODOLOGY

The self-repopulation program has three well differentiated work lines that nevertheless must harmonize perfectly well and that can be roughly defined as:

1) Monitoring to evaluate the population tendency.

2) Nest identification and eggs harvesting in the zone of influence of the monitoring area.

3) Final eggs hatching and controlled nurturing of the just born up to their freeing.

1) In order to monitore the populations in the chosen sampling areas, night counting shall be carried out with high power lights from a small boat during three consecutive days in each area and the information shall be recorded according to the characteristics of the place as animal per linear kilometer in (current's flow) or animals per hectare in lagoons or marshy lands. Enviroment temperature, water temperature, direction and speediness of wind and ligh conditions shall also be recorded.
When possible, the size and species of the animals shall be recorded. Two visits each year shall be carried out to each area of the sampling, one in November (December to other one in February) March. Before beginning with the programme in the months of September/October we are going to make a practise visit in order to define the observation circuit.
2) When making the first visit for monitoring in each area the nests shall be identified in what we shall call "influence area" of monitoring. This means that they must be within the area in question, or near enough to make an impact on the counted population. When making the second visit eggs shall be harvested,marking them by nest and recording the amounts of eggs, date and exact placement of the nest. The harvested eggs shall be moved in plastic bowls and shall be protected from excessive temperatures up to their arrival to the provincial Ranching station.
3) Each province shall have a ranching station in which eggs harvested for its hatching at 30/32 C with a humidity of 95% shall be received. The just born animals shall be marked by nest and shall live in climatized environment with a temperature gradient of 25 C: to 33 C. Feeding shall be given ad libitum three times a weeks and shall consist of meat and bovine viscera, river fish and conventional balanced food for carnivorous, adding vitamins, mineral supplements.
When going the second year to the sampling area (first visit), the feasible individuals shall be freed in the exact point of harvest. In this moment the cycle begins again.

GENERAL PURPOSE

As a conclusion a program like this must answer this three essential questions:
1) Is the ranching helpful to recover caiman's populations?
2) It is possible to derive to commercial channels a percentage of the harvested eggs?
3) If so, which is the percentage that allows to exploit caimans, keeping a rate of population recovery?

ACKNOWLEDGMENT

I want to tell thanks to Dr. Obdulio Menghi from CITES , Dr. Jorge Cajal from Dirección Nacional de Fauna Silvestre , Dr. Juan Villalba Macías and Mr. Tomas Waller from TRAFFIC (Sudamerica) for his encouragement and suggestions.
I want to tell thanks too to the Fundación Esteban Astort for the soupporting of first part of the study.

Exogenous Vitamin C for Captive Propagated Alligators

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INTRODUCTION

Vitamin C (L-ascorbic acid) is synthesized in sufficient amounts to satisfy the needs of most non-primate animals, yet it is generally included in the diets of captive alligators in rather large amounts (McNease and Joanen, 1981; Staton, 1987). The more primitive species of birds (Galliformes, Anseriformes, etc.) have been shown to synthesize vitamin C in the kidneys while some species (Passeriformes) produce the vitamin in the liver only. Yet a few species appear to be unable to synthesize the vitamin at all (Chaudhuri and Chatterjee, 1969).

Most fishes appear to synthesize vitamin C, but some cannot. Channel catfish, salmon, and trout require the addition of rather high levels of ascorbic acid to prevent scoliosis and lardosis. (Halver, 1972; Lovell, 1973).

Knowledge of the vitamin C requirement in the diet of the alligator and/or the ability of the alligator to synthesize this vitamin is relevant since ascorbic acid functions in collagen synthesis and may contribute to better quality hides. Ascorbic acid has been shown to function in the formation of procollagen and is necessary for the biosynthesis of collagen and cartilage, tissue formation and repair and calcification of bone (Lim and Lovell, 1978). Ascorbate has been reported to be the reducing agent, involved in the hydroxylation of proline and lysine in the formation of collagen and cartilage (Wilson and Poe, 1973).

This study was undertaken to determine the need for supplemental dietary vitamin C when alligators are fed a diet consisting of various animal by-products and minerals.

Materials and Methods

Thirty-two alligators, hatched in August 1987, were taken from the wild at the J. D. Murphee Wildlife Refuge near Port Arthur, Texas on October 1, 1987. The animals were kept together in temperature controlled pens at the Sam Houston State University Poultry Center. They were fed ground frozen nutria during the adjustment period. On December 4, 1987, they were individually toe-tagged, weighed and measured (total length and heart-girth) and distributed randomly into two adjacent pens of equal size; 16 animals per pen.

The 8'x16' concrete floored, plywood enclosed living quarters were apportioned into equal dry and wet areas with a water depth range of 5-10 cm in each pen. The water temperature in each pen was maintained at about 30 degrees Celsius by circulating water through pipes from a large gas water heater.

A basal diet formulated from all-dry processed nutrients (Table I) mixed with water to make a stiff dough was fed with nutria until the animals were gradually converted to the 64 percent crude protein formulated diet.

Table I. Composition of the basal diet.

Ingredients	Percent
Blood meal	10.0
Dextrin	6.0
Dicalcium phosphate	3.0
Feather meal	30.0
Fish meal	10.0
Gelatin	2.5
Mineral mix (Jones & Foster)	2.0
Poultry by-product meal	30.0
Poultry oil	5.0
Sodium chloride	0.3
Vitamin pre-mix	1.2
Total	100.0

Prehension and deglutition of this type of feed by alligators presented a problem. A workable solution was found by mixing the dry powder-like feed with water to a stiff-dough and pressing it down on a tray then cutting it into small bite-sized squares and piling it upon the tray for feeding. Animals in each pen were fed the same dry weight of feed. About 2 hours after feeding all the water was drained from the pens, the area cleaned and filled with warm fresh water.

On January 26, 1988 ten (10) animals from each pen were picked at random and were checked with a full-length dorso-ventricle x-ray for evidence of skeletal abnormality. January 28, 1988, all animals were weighed and measured as before and 3 ml. of blood was drawn from the heart for analysis. The animals were then placed on their respective experimental diets. Animals in pen 1 received the basal diet (Table I) while those in pen 2 were fed the same basal diet plus added ascorbic acid at 1,000 mg/kg. The level of ascorbic acid added was equal to the vitamin C present in a commercially prepared vitamin premix sold to alligator farmers in the region (Table II).

Table II. Commercially prepared vitamin premix sold to alligator farmers in the region less vitamin C.

SPECIFICATIONS	PER 1 LB	UNITS
Vitamin A	1,800,000.000	I.U.
Vitamin D_3	200,000.000	I.U.
Vitamin E	5,000.000	I.U.
Riboflavin	1,000.000	mg.
Pantothenic Acid	2,760.000	mg.
Niacin	4.500	gm.
Choline Chloride	86.433	gm.
Vitamin B_{12}	1.350	mg.
Folic Acid	90.000	mg.
Biotin	20.000	mg.
Pyridoxine Hydrochloride	1,000.000	mg.
Menadione Sodium Bisulfite	4,283.000	mg.
Thiamine Mononitrate	1,000.000	mg.
Ethoxyquin	5.000	gm.

Fed at 1.2% of the diet.

The animals were weighed and measured as before on March 4, April 15, and June 1, 1988. The same animals that were x-rayed and sampled for blood analysis initially were again x-rayed and their blood samples analyzed again at the termination of the study. At this time, the tips of the tails from 5 animals in each treatment were excised and frozen in liquid nitrogen for histological comparisons.

Analysis of variance using the general linear model procedure (Statistical Analysis Systems, 1979) was applied to all data at the 95 percent confidence level.

Duncans Multiple Range Test was used as a means separation procedure.

Results and Discussion

The data obtained under the conditions of this study showed no evidence that the American alligator (Alligator mississippiensis) benefitted in any way by the addition of L-ascorbic acid at 1,000 mg/kg to a 64 percent crude protein diet consisting primarily of processed animal by-products. There was no significant difference in vitamin C blood plasma levels of L-ascorbic acid supplemented alligators over controls (Table III). One may conclude that excess vitamin C is readily removed by the kidneys and that alligators are probably capable of synthesizing sufficient vitamin C to maintain a relative hemeostatic level of the vitamin in the blood or that this particular diet contained high enough levels of the vitamin that it did not become limiting to alligator growth and development. The latter is not likely since losses of ascorbic acid activity due to processing techniques of animal by product feed ingredients is known to be excessive (Hilton et al, 1977).

Table III. Mean plasma vitamin C levels of alligators as affected by supplementation with vitamin C.

Treatment	1/28/88	6/1/88
	----------mg/dl	---------
Control	2.1143	1.9429
Vitamin C	2.2500	2.3714

Histological examination revealed no morphologic expressions of a vitamin C deficiency as described in man and guinea pigs (Follis, 1958) in any of the animals observed in this test. Examples from specimens exhibited in Figures 1-4 show no morphologic abnormality in the connective tissues of the vertebrae of alligators fed diets with no added vitamin C.

The skeletal radiographs showed no evidence of lardosis or scoliosis in any of the 20 animals x-rayed. There were no abnormalities detected in any of the intercellular substances such as collagen, osteoid, dentine or vascular endothelium. There were no differences in the skeletal structure of any of the animals x-rayed at the beginning (Figure 5) or at the end of the study (Figure 6).

Average weight gains, heart girth, and total length of alligators were not significantly different over the 125 day experimental period (Table IV). Tables V, VI, and VII show the average weights, total body length, and heartgirth respectively, at the various dates of measurement. There was no indication of elevated plasma cholesterol and/or triglyceride levels of animals in this experiment as reported by Hilton et al., (1977) in vitamin C deficient salmon fish (Tables VIII and IX).

Table IV. Mean heartgirth, total length, and weight increase over the 125 day experimental period.

	Hg	L	Wt
	---------cm-------		---g---
Control	8.14	23.71	1338.68
Vitamin C	7.44	24.01	1306.96

Table V. Mean weight of alligators as affected by supplementation with vitamin C.

Treatment	1/28/88	3/4/88	4/15/88	6/1/88
	-----------------	g	----------------	
Control	473.94	744.88	1196.47	1812.62
Vitamin C	450.31	620.80	1075.07	1757.27

Table VI. Mean length of alligators as affected by supplementation with vitamin C.

Treatment	1/28/88	3/4/88	4/15/88	6/1/88
	cm			
Control	56.894	62.750	71.087	80.600
Vitamin C	56.587	60.133	69.333	80.700

Table VII. Mean heartgirth of alligators as affected by supplementation with vitamin C.

Treatment	1/28/88	3/4/88	4/15/88	6/1/88
	cm			
Control	12.9313	15.3750	17.8667	21.0733
Vitamin C	13.8000	14.4667	17.4333	20.5200

Table VIII. Mean blood plasma cholesterol of alligators as affected by supplementation of vitamin C.

Date	1/28/88	6/1/88
	mg/dl	
Control	96.630	176.250
Vitamin C	109.430	205.000

Table IX. Mean blood plasma triglyceride of alligators as affected by supplementation with Vitamin C.

Treatment	1/28/88	6/1/88
	----------mg/dl----------	
Control	7.625	60.750
Vitamin C	10.193	52.710

These findings appear to indicate that captive reared alligators do not require an exogenous supply of vitamin C at the level provided (1000 mg/kg) in this experiment, and tend to support the hypothesis that alligators can synthesize sufficient Vitamin C endogenously or that the basal diet used in this study contained sufficient levels to meet the needs of this vitamin by the alligator.

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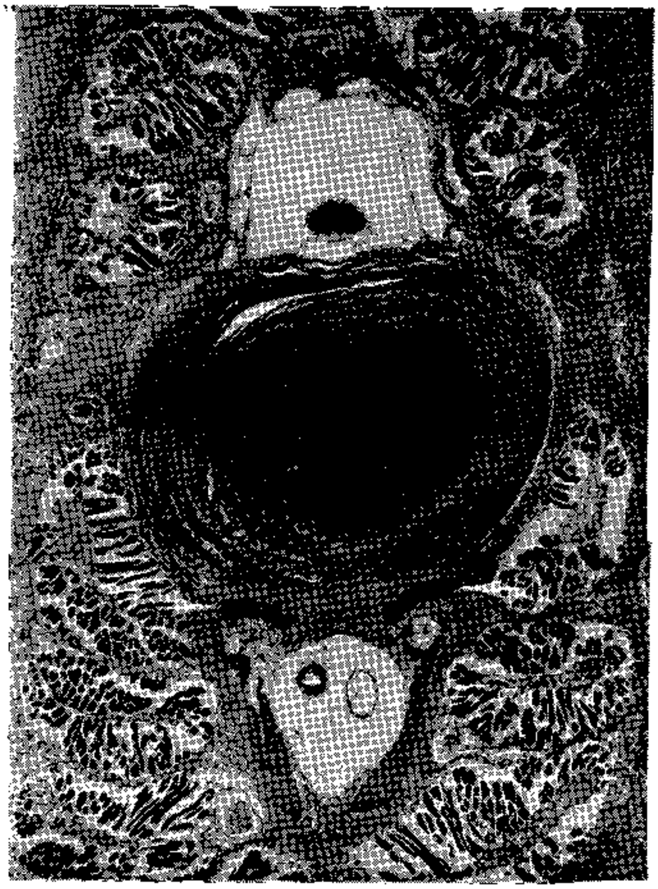


Fig. 1. TX 5633, alligator fed no vitamin C. Transverse section of a tail vertebra. The large white space at top is the spinal canal. The spinal cord is the dark ellipsoid structure. Below the canal is the cartilage model destined to become the body of that vertebra. At horizontal white arrows are growth plates which form the ventral part of the vertebral body. The tissue surrounding the vertebra is cross-sectioned muscle tissue. Note that the cartilage is stained deeply basophilic with hematoxylin.

H&E, x 25.

Fig. 2. TX 5633. This is the area at the left white arrow of Fig. 1 at higher resolution. The cartilage cells are developing normally. They become ballooned and are penetrated by vessels. At oblique arrow heads are normal and abundant osteoblasts. At vertical arrow head is an osteoid seam. Everything is normal.

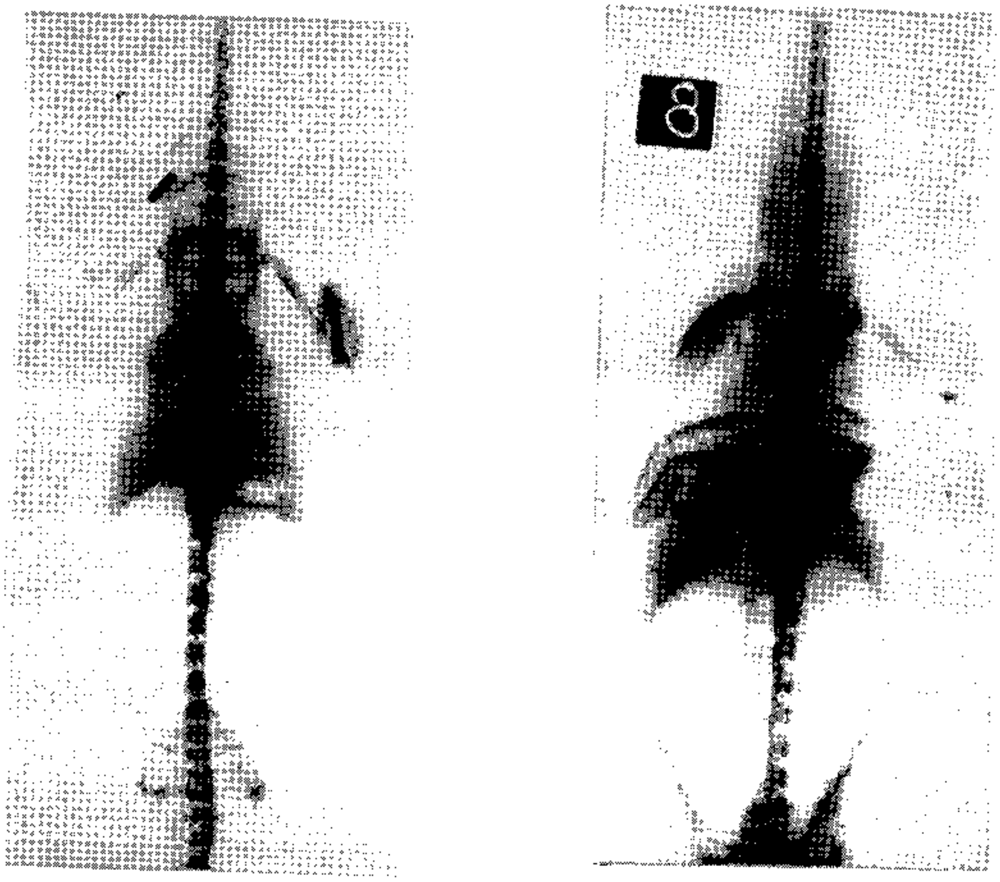
H&E, x 180.

Fig. 3. TX 5648, alligator fed no vitamin C. The picture shows the lower part of the cartilage model destined to become the vertebral body. Conversion of cartilage into bone is well under way. The degenerating cartilage cells are pale, the cells enlarge and become penetrated by blood vessels. Bone is formed by osteoblasts (in front of arrow heads). The osteoblasts are abundant and normal. This is a normal picture.

H&E, x 180.

Fig. 4. TX 9460, alligator fed no vitamin C. The picture of the vertebral body shows plenty of bone trabeculae. Under polarized light, these trabeculae exhibit normal absorbance of birefringent light: the collagen in bone is normal. This is a normal picture.

H&E, x 110, polarized light exposure.



Pen 1 Pen 2

Fig. 5. Initial x-ray of two alligators made (1/26/88) previously fed nutria from hatching (8/87).

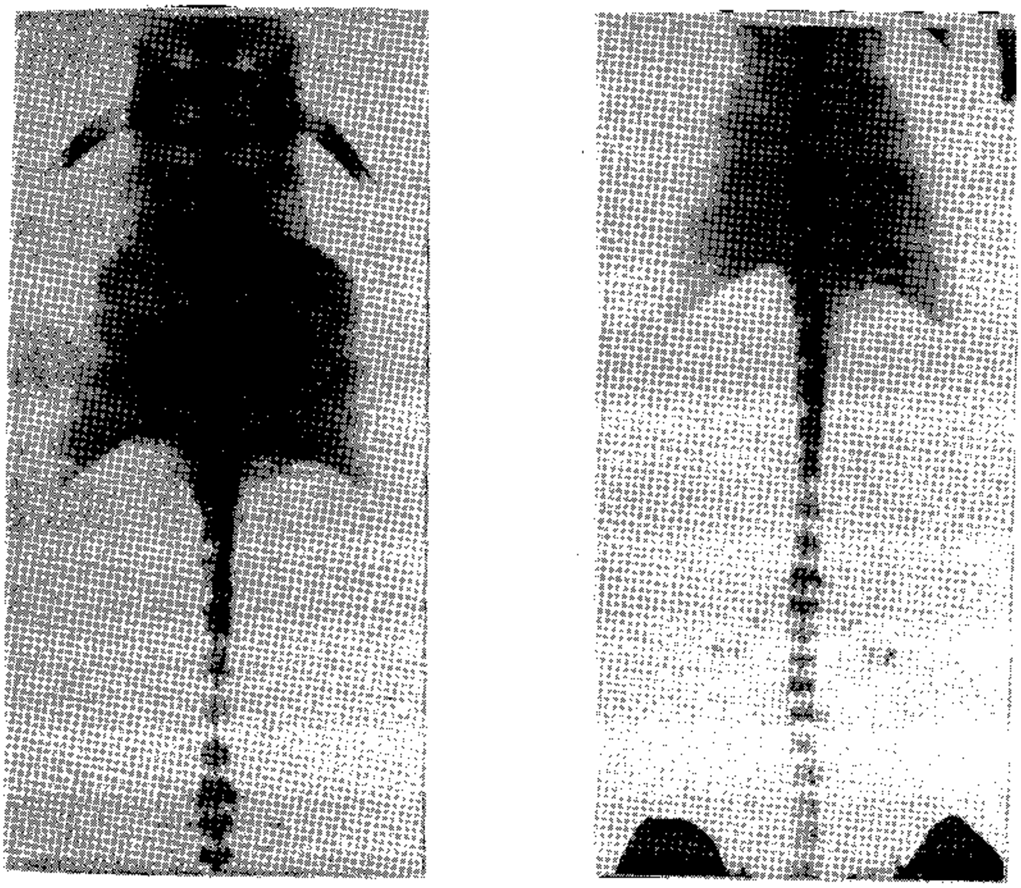


Fig. 6. X-ray of the same two animals shown in Figure 5 made (6/1/88) at the termination of the test. A typical alligator from pen 1 fed the basal diet with no added vitamin C. A typical animal from pen 2 fed the basal diet with added L-ascorbic acid.

Specialized Equipment and Techniques Used in Alligator Management and Research

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Alligators occur in habitats that are often inaccessible and inhospitable to man and their wariness and ability to submerge when threatened necessitates the use of specialized equipment and techniques to capture them. The purpose of this presentation is to familiarize the reader with some of the techniques and equipment used by the Florida Game and Fresh Water Fish Commission (Commission). Although many of the tools and techniques we use are also used by crocodilian biologists worldwide, we hope some of our modifications will be of use to others.

AIRBOATS

Alligators inhabit most waters of the state, ranging from shallow emergent marsh to deep open water lakes and rivers. However, much of an alligator biologist's efforts are concentrated in shallow water and emergent marsh. Outboard motors and typical boats require at least 24 inches (61 cm) of unvegetated water to operate. Airboats, on the other hand, require virtually no water depth and can transit dense emergent marsh that would be virtually impassible to an outboard.

Airboats come in two basic types, either metal or fiberglass hulled with an automotive or aircraft type engine. Hull length normally varies from 11-18 feet with the extreme being 36 feet (11 m) long, twin-engine tour boats operating in the Everglades that can transport 40-50 people. The purchaser of an airboat should match the hull and engine type, hull length, horsepower, and rigging to his needs. Prices range from $10,500 for a 12 foot fiberglass boat with a 150 hp aircraft engine and trailer to $18,500 for an 18 foot fiberglass hull with a 300 hp aircraft engine and trailer. Metal hulls are generally more expensive.

Possible options that may increase your efficiency are: polymer bottoms (decrease drag), tool boxes, trim tabs (boat handling), sprayers (decrease drag), hour meter, tachometer, grass rake, bilge pump, engine cowling (engine cooling), seat covers, drop axles (loading and unloading), submersible trailer lights, electrical outlets, dual batteries, battery switch, large capacity fuel tank (40 gal.), and dual seats.

SOURCES

Apache Airboats
700 N.E. 4th Street
Okeechobee, FL 34972
Ricky Lightsey
813/763-2326

Combee Airboats
P.O. Box 570
Lake Hamilton, FL 33851
James Combee
813/439-5258

Hoffman Airboats
Inverness, FL
Dick Hoffman
904/726-7677

Airboats Unlimited
Rt. 5, Box 1115
Bainbridge, GA 31717
912/246-5760

ELECTRONICS

Intercoms

We primarily use airboats to conduct night-light surveys, however, the high noise level prevents normal conversation between the driver and passenger. Intercoms are used to overcome this problem. Without an intercom, two skilled persons are needed, one to operate the boat and one to collect data. With the use of an intercom, the boat operator can also collect data and transmit it to the passenger, who is required only to record the data. Two types of intercoms are in use by Commission alligator biologists. The most common is a standard aircraft intercom with aircraft headsets. The primary make and model is a Telex TC 200 intercom. The TC 200 comes from the factory with a voice activated intercom, however, we find that the engine noise continuously activates the intercom. Therefore, our radio technicians convert the TC 200 to a push to talk intercom by installing a PT-300 push to talk switch, which permits communication only when the switch is engaged. To complement the intercom, we use two noise attenuating Davey Clark H10-40 headsets. Additional passenger headsets can be added by purchasing expansion modules from Telex. The total cost of the intercom system is approximately $700. Less expensive components are available such as the Sigtronics Model SPO-20 intercom, which cost $160 versus $225 for the TC 200 and headsets such as the Telex D-950 which cost $100 each versus the H10-40 which cost $214 each.

The second type of intercom is an FM radio intercom which is available through electronic and radio outlets. A two radio set can be purchased for approximately $70. However, it does not come with noise attenuating headsets and consequently must be modified by incorporating the ear speakers into common noise protection headsets. These systems are battery operated but can be converted to operate from the boat's electrical system by a radio/electronics technician.

A wide variety of aircraft intercoms can be purchased through many aviation electronics supply companies.

LORAN

LORAN is a navigational aid used in the U.S. primarily for coastal navigation. It has recently been adopted for aeronautical use and is being used increasingly in land navigation. The LORAN readout can be in LORAN numbers or latitude and longitude. We use it for aerial transects and nest locations which can be transferred to a map using latitude and longitude. We use a marine model which costs approximately $600. Aviation models generally cost between $1,500 and $3,000. Intended purchasers should research LORAN theory and performance before purchasing a specific make or model. Many makes and models of LORAN are currently available through marine or aircraft electronics suppliers. Additionally, a "Global Positioning System," (GPS), utilizing satellites is slated to come on-line over the next few years. The GPS will likely replace LORAN and be available anywhere within the crocodilians' range.

Radios

Radios are used to communicate between boats and aircraft, boat-to-boat, and boat-to-truck or other ground stations. We primarily use radios to direct egg collections from a helicopter. One or two airboats equipped with aircraft compatible radios greatly facilitate egg collections. We use battery operated portable radios equipped with aircraft headphones on boats that are compatible with existing aircraft radios, which allow the aircraft pilot and observer to talk over the aircraft radio, to other aircraft, control towers, to each other, and to the collection boat via a single radio. The only limitation we have encountered is that our portable radios have limited life batteries which are not capable of extended use. Consequently, connection to the boat's electrical system would be very beneficial.

Additionally, one-way radios are used to relay instructions to collection boats equipped with an inexpensive transistor radio that will receive radio signals within the aircraft frequency band. This radio is available through local electronics distributors for about $15. Portable aircraft frequency band radios can be purchased through aircraft electronic suppliers for approximately $400-$500 (Kenny Rice, Fish and Wildlife Coop Unit or Alan Woodward, Commission).

CAPTURE EQUIPMENT

Live Capture

In the course of various studies, it is necessary to capture alligators ranging in size from hatchlings to large adult males. The following are various techniques we use.

Snatch hooks.--Snatch hooks consist of weighted treble hooks attached to a restraining line which are thrown over an alligator and snatched into its hide. The alligator is subsequently pulled in and subdued. The size of the hook and line should be matched to the size of the alligators to be captured. Additionally, snatch hooks can be used in conjunction with a rod and reel for longer distance and the ability to play (tire out) a large alligator. A limitation to using snatch hooks is that the hook may penetrate and cause a wound. Snatch hooks can be purchased from fishing tackle outlets.

Snares.--Wire snares attached to a restraining line and fastened to a pole are used to capture alligators from a boat. This method requires approaching the alligator stealthily and placing the snare over its snout and around its neck. The restraining line is then pulled, which tightens the snare, which detaches from the pole. The alligator can take out line, be played (tired out), pulled to the boat and subdued. We primarily use locking snares, which have a mechanism that prevents loosening the snare while tension is being applied. Consequently, these can be used in conjunction with a float attached to the restraining line which does not have to be held or attached to the boat. Locking snares can also be set at crawls and culvert openings.

Murphy Traps.--Murphy traps are basically locking snares used at a bait station (ATTACHMENT 1). The advantage of set snares is that the capture team does not have to remain at the capture site. A proper set-up will allow the snared alligator to back off into the water and submerge to await its captors.

A modification of the standard Murphy trap is the floating Murphy (Alan Woodward, Commission) which can be set in water, which greatly enhances the trap's effectiveness. Snares can be purchased from Raymond Thompson, 15815 Second Place West, Lynnwood, Washington, 98036,.U.S.A., telephone (206) 743-0783, or other trapping suppliers.

Pilstrom Tongs.--Pilstrom tongs are commonly used by herpetologist for handling snakes. their rigid construction also makes them useful in capturing alligators up to 36 inches (91 cm) long. Pilstrom tongs consist of a tubular aluminum pole with a plier-like attachment on one end and a squeeze trigger on the other. The pliers are clamped down on the alligators neck or tail and it can be lifted to the hand or dropped in a collection bucket. Tongs are available through Pilstrom Tongs, Inc., Fort Smith, Arkansas, for approximately $40 for a 48 inch (122 cm) long tong.

Catch Poles.--An animal restraint noose pole can be used to capture three- to six-foot alligators. These poles are made with a heavy cable on poles four (1.2m) to 12 (3.6m) feet long (Ketch-All Company, San Diego, CA).

Harpoons.--Small harpoon darts or heads are also used to capture alligators over eight feet (2.42m). These darts are smaller, 1.5 inches (3.75cm), in length than the heads described in the harvest harpoon, but are made in the same fashion.

Harvest Capture

Set Hooks.--Set hooks consist of a baited fishing hook attached to a restraining line. The restraining line can be attached to a fixed point or float. The bait is suspended above the water at a height dictated by the intended alligator's size. Bait selection should be based on the animals normal prey, however, we have found that aged beef or pork lung works very well. The consistency of the lung allows it to float while aging increases the bait scent, providing greater attraction. Additionally, a floating bait can be thrown out to a target animal.

The restraining line is attached to the suspension device using a method that will allow the alligator to pull the line free. We have used clothes line pins, rubber bands, tape, and notched sticks. The restraining line length is determined by the situation, however, enough line should be provided to allow the alligator to submerge and lie on the bottom. Baited hooks may also be used in conjunction with a rod and reel.

Harpoons.--Harpoons are used primarily to take alligators at night by stealthy approach. Harpoons are especially effective when a number of specific sized alligators need to be collected. We use a harpoon comprised of a detaching head constructed of 3/8 inch (9.5 mm) diameter stainless steel rod approximately 2 inches (5 cm) long, a driver constructed of 1/4 inch (6.4 mm) stainless steel rod approximately 3 inches (8 cm) long, and pole constructed of 1/2 inch (1.3 cm) galvanized pipe or 2.25 inch (6 cm) diameter wood doweling approximately 10 feet (3 m) long (ATTACHMENT 2). If wood doweling is used, weight should be added to the harpoon end to enhance harpoon penetration. The harpoon head is attached to a restraining line with a short length of steel cable. The restraining lines length should be sufficient to allow the alligator to sink to the bottom and be strong enough to pull it to the surface and subdue it. Additionally, a float is usually attached to the end of the restraining line. Commonly, a gallon (4 liter) size plastic container is used. However, the line can be attached to the bow of the boat and the boat's weight used to tire the alligator. No source of commercially constructed harpoons is available.

Bangsticks.--Bangsticks or power heads are primarily used by divers to kill sharks or other fish by discharging a firearm cartridge upon contact. We have found that these weapons also can be very effective for killing alligators. Bangsticks are available in a variety of pistol, rifle, and shotgun calibers. We recommend either a .38/.357 magnum to .44 magnum pistol or .12 gauge shotgun caliber. Caution must be exercised when using a bangstick: they should not be discharged above the water's surface. Although no manufacturer approved bangstick is offered for use on alligators, they can be purchased through diving equipment shops for $40 to $75.

DATA COLLECTION

Length Measurement

Length measurement of alligators can be accomplished by incorporating a tape measure into a narrow grove in a board and applying fiberglass resin over the tape. Smaller alligators can be measured using such boards with a right angle board on the end. The alligator is then stretched out along the board by holding its snout against the right angle board and pulling its tail out along the tape measure. Similarly, larger alligators can be measured using a tape measure incorporated into a longer board. We often do this in conjunction with our weighing apparatus.

Weighing

Weighing of large alligators is accomplished by a number of ways depending on the facilities available. A scaffold can be erected at relatively permanent sites. The scaffold is used in conjunction with a chain hoist, weighing board (ATTACHMENT 3) and combination of spring scales. Five hundred pound (227 kg) scales are the largest we have been able to acquire. Consequently, we normally use 1 or 2, 500 pound scales to weigh large alligators. Spring scales must be attached by a method that allows them to pull straight. Pulling at an angle will cause weighing error (ATTACHMENT 4). Another method consists of a 1,000 pound (454 kg) balance scale in conjunction with a 12 foot (3.7 m) long, 2 foot (.6 m) wide board. Both of these methods require a large boat or ground site. Large alligators can be weighed in a relatively small boat using 2 to 4 bathroom type scales in conjunction with a weighing board. A tape measure can be incorporated in the weighing board for measuring total and snout-vent lengths. Smaller alligators can be efficiently weighed in a bag or sack and suspending from an appropriate spring scale.

Spring scales can be purchased from Forestry Supply Co, 205 W. Rankin Street, Jackson, MS 39201-6126 or Ben Meadows, Inc., P. O. Box 80549, Atlanta (Chamblee), GA 30366 or other scientific, engineering, or forestry supply companies.

MISCELLANEOUS

Marsh Boards

We often find ourselves having to walk in places not intended for humans to transit. In locations with floating tussocks, dense emergent or floating vegetation, muck soil, or other locations where the substrate will not quite support a person's weight we use marsh boards which are constructed from 1 inch

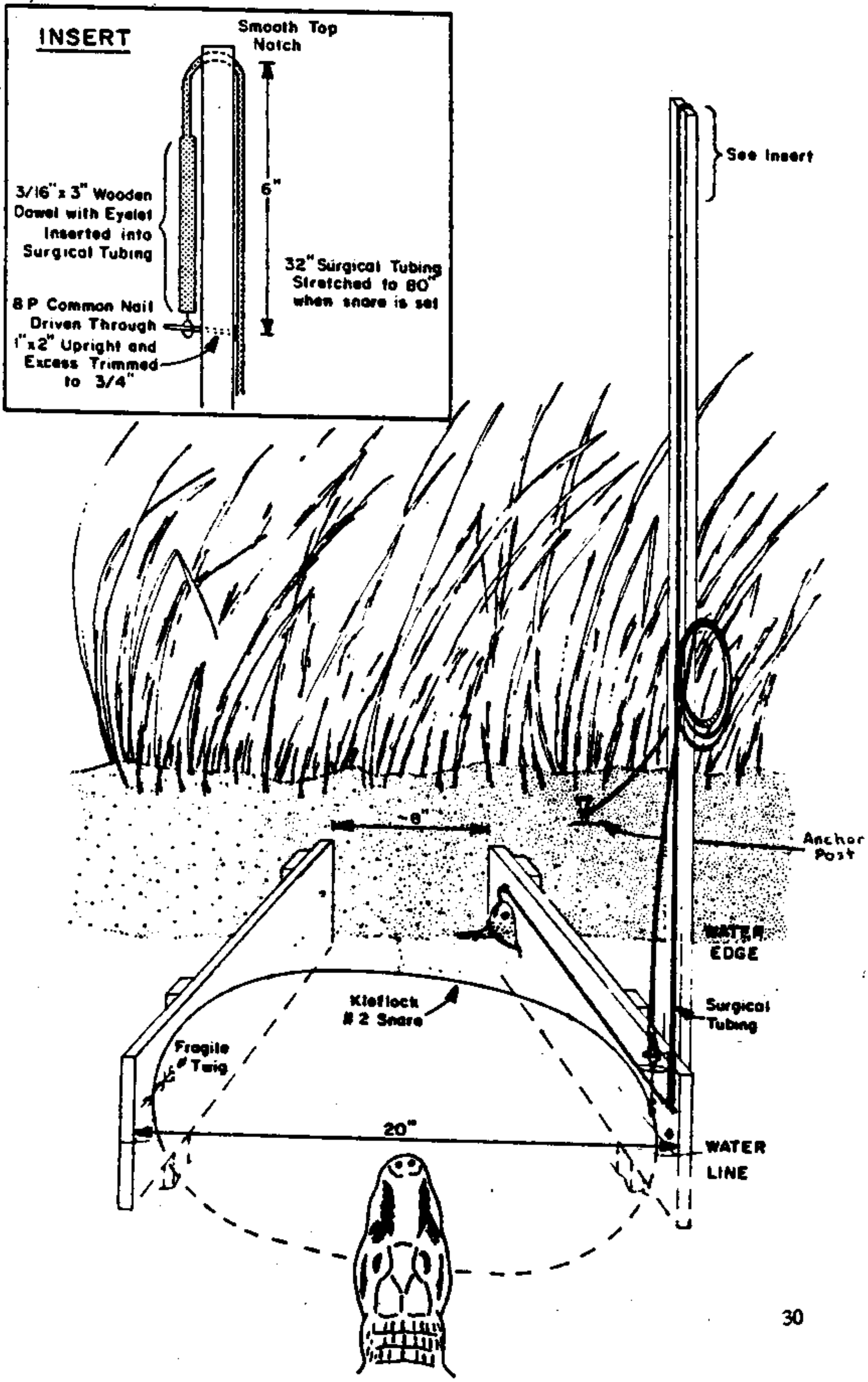
(2.54 cm) thick, 6 to 8 inch (15 to 20 cm) wide, and 6 to 8 feet (1.8 to 2.4 m) long boards. Additionally, short ropes are attached to both ends for transport and retrieval. The boards can be placed on the intended path and will, in many cases, support a person's weight. We usually carry two identical boards and lay one in front of the other.

CONCLUSION

Crocodilian research and management programs require specialized equipment and techniques to gather data or ensure successful harvests. In Florida, we have found that standardization of these techniques and equipment is virtually impossible because of the wide variety of alligator habitat types. As a result, we have modified many existing techniques and developed new ones to achieve alligator management and research objectives. Although our equipment and techniques may be only applicable to Florida wetlands, we hope this discussion will stimulate your interest in crocodilian capture techniques and equipment.

If you have questions or comments regarding any portion of this presentation, please contact any of the Commission's biologists. They should be able to answer your questions or refer you to someone who can.

Attachment I



THOMPSON'S SELF-LOCKING SNARE

REVISED SEPT., 1977

RAYMOND THOMPSON COMPANY

15815 - 2nd PL. WEST
LYNNWOOD, WASH. 98036
(206)743-0783

THOMPSON DROWNER

THOMPSON'S SELF-LOCKING SNARE

	per dozen
No. 00-20" swiveled snare for small game & birds.	$6.96
No. 0-24" swiveled (muskrat, mink, rabbits)	$7.12
No. 0-XX-30" swiveled (skunk, coon, etc.)	$8.36
No. 1-S 40" swiveled (special fox snare)	$10.40
No. 1-XX-60" long-length (beaver, lynx, etc.)	$10.80 71.45
No. 2-S-40" swiveled (special beaver-otter)	$12.90
No. 2-XX-72" long-length (beaver-lynx)	$13.20
No. 3-XX-72" long-length coyote & brush wolf)	$15.50 ←
No. 4-XX-10 ft. long-length cougar & wolf	each $3.68
No. 5-XX-10 ft. long-length for black bear	each $4.22
No. 5-S-10 ft. center swiveled for black bear	each $4.90
No. 6-XX-10 ft. for bear and grizzly	each $6.14
No. 6-S 10 ft. center swivel for big bear & grizzly	each $7.46

(S denotes swivel - XX denotes Treelock)

No. SSK-1 Survival Snare Kit--for rabbits, squirrels, birds etc. 2 snares, ties and instructions . . . . each $2.50

ADD 10% POSTAGE AND HANDLING

A simple yet amazingly effective device for saving prized pelts from wring-offs, predatory animals, or from possible trap thieves, as the animal is held below the surface. Especially effective in shallow water sets where the trap may be set in a V-shaped pocket with Drowner wire extending over bank into water ...Complete with fastening and anchoring swivels, drowning lock, and highest grade of snare double twist steel wire.

No. 1-D for muskrat, mink, raccoon . doz $13.30
No. 2-D for Beaver & Otter . . . . . . doz. $15.90
SPECIAL DROWNERS MADE TO ORDER

PLEASE ADD 10% OF ORDER FOR POSTAGE AND HANDLING

SNARE PARTS

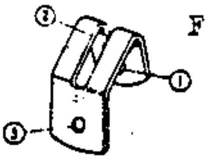


FIG. 1

Standard or Long Length Model. Fig. 1 shows the famous Thompson Snare Lock. Fig 2 shows method of using Anchor or End Fastener. Solid lines show end of Snare as it would encircle tree, pole, or stake. Dotted line shows method of inserting F (ferrule) and W (washer) through round eye in "keyhole" and into locking slot. Tension of snare wire prevents any possible shaking loose.

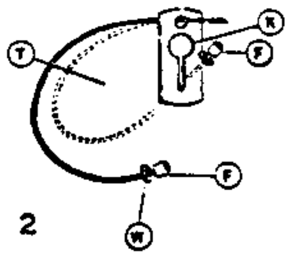


FIG. 2

Fig. 3 shows shorter swiveled snare so popular in snaring rabbits, mink, muskrat, racoon, bobcat and lynx; and ESPECIALLY ADAPTED TO BEAVER and Otter snaring. In these snares, from No. 0 to No. 2/S inclusive, anchoring is by means of soft wire through the swivel eye and around a tree, pole, or stake. In No. 5-XX and No. 6-XX snares, for big wolves and bears, a special swivel is built in the middle of the 10 foot snare, and a 5-ft. extension snare wire with regulation fastener is added. WE MANUFACTURE SNARES TO TRAPPER'S OWN SPECIFICATIONS ON SPECIAL ORDER. All our snares, No. 0 to No. 6-XX inclusive, use highest grade TWO-WAY TWIST (developed by Raymond Thompson in 1926) STEEL WIRE.

FIG. 3

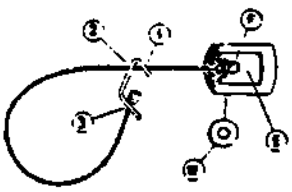


FIG. 4

REPAIR WIRES - cut to standard length with one ferrule already flattened on one end. To repair snare or drowner remove old or damaged wire, assemble parts on new wire and flatten one ferrule. Our special two-way twist wire --same as used in original snare, comes in all sizes from NO 0 through NO 3.

SNARES AND SNARING a book on professional Canadian & Alaskan snaring methods by Raymond Thompson Includes latest methods of under-ice snaring of Beaver, Mink, Otter, Muskrat and Raccoon.... With special tree and pole snaring methods.

$3.00

KETCH-ALL COMPANY

PRICE LIST OF REPLACEMENT PARTS FOR KETCH-ALL POLES

Cables complete - with Spring, Ball & Plastic

Units			Unit Price (f.o.b. San Diego)
ea.	For 3 ft.	Standard Pole	$13.65
ea.	For 4 ft.	" "	16.00
ea.	For 5 ft.	" "	18.00
ea.	For 4 to 6 ft.	Extension Pole	18.00
ea.	For 7 to 12 ft.	" "	26.75

(Above Cables are Complete and Ready to Install)

Other Replacement Parts for Ketch-All Poles

ea.	Locking Device - with Cage, Ball Bearings, Washer & Spring (designate if for Standard or Extension Pole)	$ 8.50
ea.	Tooth Guard (fits all poles)	2.70
ea.	Release Knob - with Washer (designate if for Standard or Extension Pole)	5.40
ea.	Head - complete with Hair Guard, Lock Ring and Set Screw (designate if for 7 to 12 ft. Extension Pole)	16.25
ea.	Hand Grip (designate if for Standard or Extension Pole	2.85
ea.	Chuck with Lock Ring (for Extension Pole only)	11.70

— SEE REVERSE SIDE FOR PRICES ON KETCH-ALL POLES, ETC. —

REPAIR CHARGES

On Standard Poles	$10.00 labor plus parts
On Extension Poles	12.00 " " "

Note: With proper care, the Ketch-All pole will give long and useful service; however, with continuous use, the cable and occasionally other parts may need replacing. It is usually advantageous to the owner to purchase the necessary parts and make his own repairs, or Ketch-All Company will be glad to make repairs for labor plus parts.

ketch-all company
2537 UNIVERSITY AVENUE
SAN DIEGO, CALIFORNIA 92104
TELEPHONE (619) 297-1953

PRICE LIST

(effective date April 1, 1986)

Units		Description	Unit Price (f.o.b. San Diego)
ea.	3 feet	Standard Ketch-All Pole	$ 53.20
ea.	4 feet	" " " "	60.00
ea.	5 feet	" " " "	65.50
ea.	4 to 6 feet	Extension Ketch-All Pole	81.50
ea.	7 to 12 feet	" " " "	110.00
ea.	9" x 9" x 30"	Ketch-All - All Purpose Trap	61.50
ea.	6" x 6" x 24"	Ketch-All - Rodent Trap	37.00
pr.	Large or Medium	Leather Protection Gloves	25.00

-- Prices on this Sheet firm to DEC 31 1986 ....; thereafter subject to Change without Notice --

10% Discount on Orders of $400.00 or more
Shipping Charges will be Prepaid and charged to Customer
California Sales subject to Sales Tax
Foreign Sales payable in U.S. Dollars

— SEE REVERSE SIDE FOR PRICE LIST ON PARTS —

ORDER BLANK

Individuals may use this Form. Orders obligating Municipalities, States, Federal Governments, etc. ~~must be on their authorized Form.~~

ORDER NUMBER__________ DATE__________

To: Ketch-All Company:

Please furnish items as checked (at current prices)

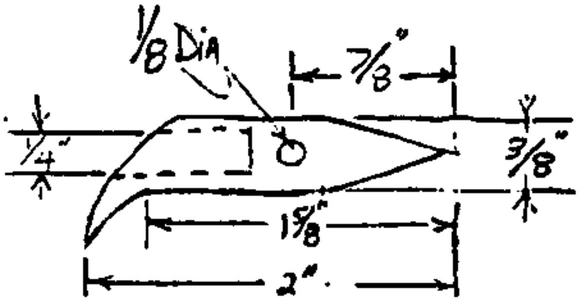
Purchaser's Name __________ Ship to __________

Address __________ Street Address __________

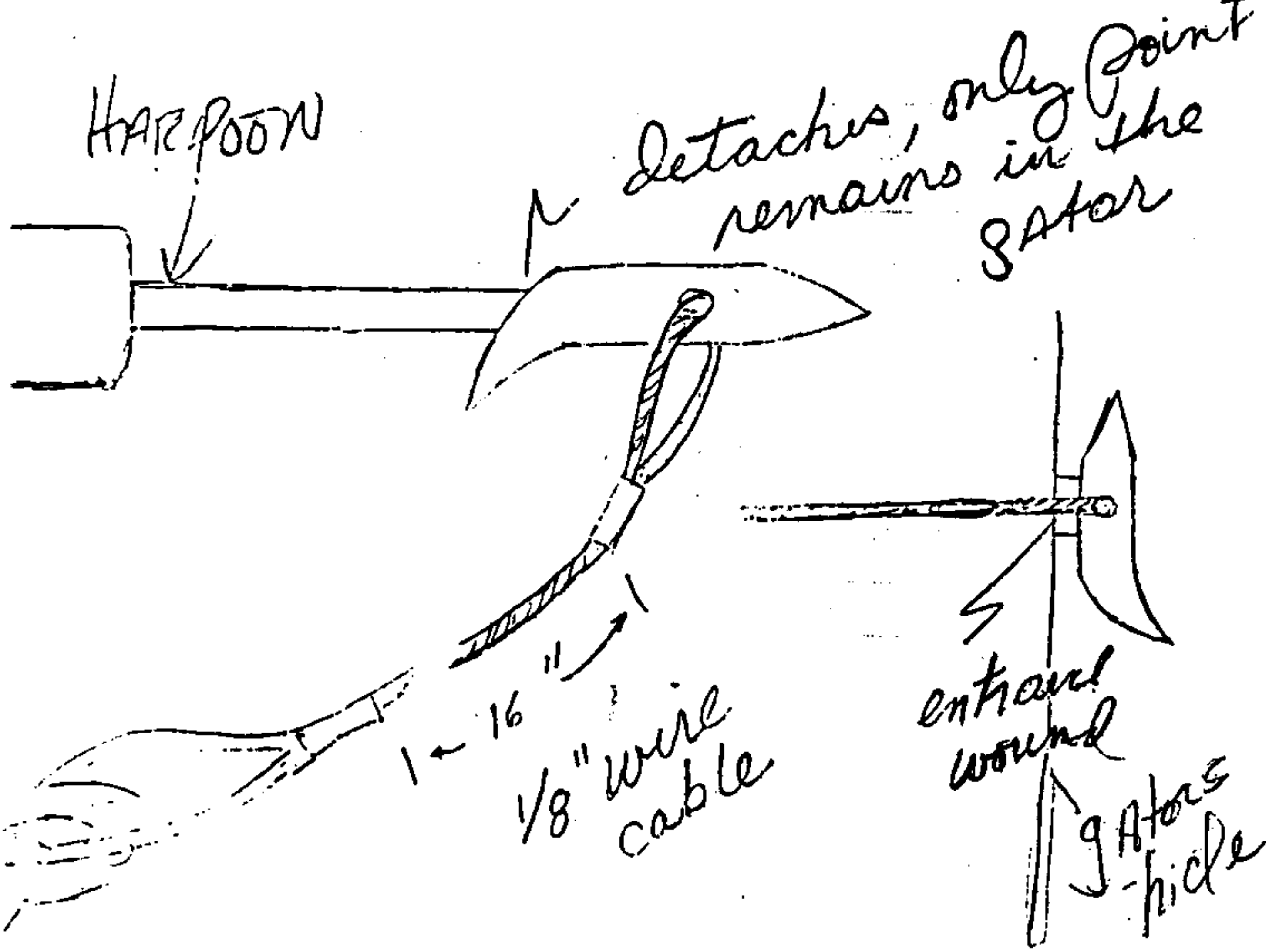
City & State __________ Zip_____ City & State __________ Zip_____

Phone (   ) (Please furnish Street Address for Shipping)

Authorized Signature __________ Title__________



Round stock 3/8"
Butt angled &
flared.



…ble Swivel

Airboat Specifications

1.0 HULL

To be latest cottonmouth design or equivalent.

1.1 Length: 13' 5"

1.2 Transom width: Eighty-eight inches (88").

1.3 Sides: Twenty inches (20") at mid-ship.

1.4 Transom Height: Lowest point needs to be not less than Eighteen inches (18").

1.5 Color: Camouflage or Dark Green

1.6 Deck: Have hinge storage area with two (2) locking frames.

1.7 Material: The hull will consist of layers of woven polyester-fiber glass material.

1.8 Bottom: Consist of no less than four (4) layers of mat; four (4) stringers thirty-seven inches (37") outside using five-inch (5") quarter by four-inch (4") fur.

1.9 Sides: Consist of three (3) layers of polyester-fiberglass at the sides; no less than four (4) layers in the chines.

1.10 WHMW Polymer: Shall be fastened to the bottom of the hull with polymer fasteners. The polymer shall extend from transom forward twelve feet (12') and a two-foot (2') piece attached to that sheet forward.

2.0 ENGINE

2.1 Remanufactured 0540 Lycoming, no less than 260 horse power to include all accessories, aircraft starter, bendix, magneto, carburetor, fly wheel and flame arrestor.

3.0 EXHAUST

3.1 Stainless steel exhaust headers with stainless steel exhaust flex to exit above transom.

4.0 ALTERNATOR

4.1 Delco; not less than 60 amps with internal exciter.

5.0 PROP

5.1 Seventy-four inches (74") installed to be no less than one inch (1") below top of transom.

6.0 **ELECTRIC FUEL PUMP**

7.0 **FUEL TANK**

7.1 To be mounted under engine; not less than 30-gallon capacity; internal fuel guage; coast guard approved.

8.0 **RIGGING**

8.1 All metal work primed with epoxy primer and finished coat shall be polyurethane paint (light green).

9.0 **ENGINE STAND**

9.1 Motor mounts shall be mounted at five points using one inch (1") and three-quarter (3/4) square tubing not less than sixteen (16) guage material.

10.0 **SEATING**

10.1 Two seats in line - rear operator bottom seat to be twelve inches (12") above magneto, passenger seat to be forward eight inches (8") lower, seating to be erected on tress design from engine stand to deck bulkhead (no legs or bracing from seating truss to floor from engine).

11.0 **SEATING STAND MATERIAL**

11.1 Shall be one-half inch (1/2") and three quarter (3/4)-EMT galvanized tubing.

12.0 **CONTROL PANEL**

12.1 Shall be mounted on right side of seat.

12.2 Control panel instruments shall include bendix aircraft starting switch; toggle switch for bilge pump, toggle switch for navigation lights; toggle switch for electric fuel pump; two-way toggle switch for electric trim tab; toggle switch for internal hull light.

12.3 Control panel guages shall include tackometer with hour meter, mechanical oil pressure, mechanical oil temperature volt meter.

13.0 **NAVIGATION LIGHTS**

13.1 Coast guard approved lights installed.

14.0 **ENGINE SHUT-OFF CABLE**

14.1 Cable mounted at control panel shall go to the carburetor to rich-lean shut-off valve at carburetor.

15.0 **ELECTRIC BILGE PUMP**

15.1 No less than 1,800 ph--outlet through side of boat.

16.0 **ELECTRIC TRIM TAB**

16.1 Installed on rear transom in the center of the hull.

17.0 **LIGHT**

17.1 Mounted under operator floor.

18.0 **ACCELERATOR PEDDLE**

Shall be mounted for operator's right foot using marine cable and trottle linkage.

19.0 **PROP GUARD**

To be constructed of 3/4 and 1/2 EMT galvanized conduit. Rear guard to have 3/4-inch (3/4") hopps. All J-bars shall be one-half inch(1/2"), not more than fourteen inches (14") apart on rear of hopps. J-bars extend forward to front of engine frame of prop guard is covered with two inch (2") x four inch (4") welded wire and welded in place.

20.0 **RUDDERS**

Shall be two feet (2') by four feet (4') airfoil design of welding aluminum fill with urethane foam for support. Rudders shall have adjustable trim taps; rudders shall pivot on nylon control.

21.0 **STEERING**

Control arm shall be at operator's hand (using latest designs); cable giving full rudder control.

22.0 **STORAGE COMPARTMENT**

Two (2) storage compartments located under the two (2) seats.

23.0 **SEATS**

23.1 Shall be of fiberglass construction with vinyl upholster, including external rain covers.

FOR YOUR INFORMATION

Any mention of brand names or suppliers of equipment described in the attached informational package does not represent endorsement by the Florida Game and Fresh Water Fish Commission. Any such names or suppliers are presented merely to identify the types of equipment that Commission biologists have found suitable for their work.

THE STATUS OF *CROCODYLUS POROSUS* IN THE SOLOMON ISLANDS

H. Messel
University of Sydney
Sydney 2006 Australia

and

F. Wayne King
Florida Museum of Natural History
Gainesville, Florida 32611, USA

INTRODUCTION. Until 1989, no systematic survey of the saltwater crocodile populations in the Solomon Islands had been undertaken and very little was known about the status of the species in those islands. During 1988, Melvin Bolton was given a consultancy by FAO with terms of reference which included:

"1. review the current situation with regard to crocodile utilization in the Solomon Islands.

2. advise on methodology for conducting surveys of crocodile habitats and monitoring crocodile populations.

3. review legislative aspects of crocodile utilization.

4. advise on implications and requirements under the CITES.

5. advise on feasibility of crocodile farming, including amongst others, economical/social viability, potential sites, funding implications and ecological sustainability of crocodile resources."

Bolton reported to FAO in Field Document No. 1, TCP/SOI/6753, May 1988; "A Feasibility Study of Crocodile Farming, Solomon Islands." Though he was only able to visit a few areas in the islands and make selected spotlight surveys on four waterways, he was able to correctly conclude:

"These selected surveys, taken together with local reports, export figures and the fact that skin-hunting is now being conducted in the most remote provinces all indicate very low numbers of crocodiles. Evidently, however, they are still very widely distributed."

Among his recommendations were:

"Impose a temporary export ban for 3 years.

"Locate suitable areas and encourage the idea of crocodile sanctuaries in support of the ranching scheme (e.g, Lauvi lagoon).

"Carry out regular spotlight counts to monitor trends in crocodile numbers.

Establish a small but efficient 'farm' at Mamara specifically designed to utilize the offal now being produced."

In July 1989, the senior author was given a 'no fee' consultancy by the CITES Secretariat, with the title "Sustainable utilization of the saltwater crocodile *Crocodylus porosus* in the Solomon Islands." The objectives were:

> "To assist the Government of the Solomon Islands in establishing the comprehensive management plan for the species through:
>
> "i) a field survey of the distribution and status of the saltwater crocodile in the Solomon Islands, and
>
> "ii) an assessment of the effects of the current exploitation on the wild population.
>
> "To prepare, if appropriate, a proposal to transfer the population of the Solomon Islands from Appendix I to Appendix II on behalf of the CITES Parties."

The field survey was made during the period 26 July--8 September 1989 -- see sailing times in Appendix I. It was a complex and unusually difficult operation. The junior author paid his own fare to Australia and assisted the senior author with the survey, at no fee.

The present paper presents the results, conclusions and recommendations resulting from the survey.

METHODS. The survey methods for repeatable night spotlight censusing of crocodile populations are given in detail in Monograph 1 of "Surveys of Tidal River Systems in the Northern Territory of Australia and Their Crocodile Populations." This publication is one of 20 monographs on crocodile surveys by Messel and co-workers and published by Pergamon Press. Since the Solomon Islands crocodile survey was only concerned with number, size class, and distribution of crocodiles, it was not essential to measure and record a number of parameters usually recorded in a survey. State of the tide, amount of bank exposed, water salinity and temperature were monitored. Salinity measurements indicate whether the aquatic habitat is a freshwater system or otherwise. This matter is of importance as it generally determines the suitability of the particular waterway as a potential breeding area -- see Monograph 1, page 100.

Normally, with a team of three, surveys are made at a speed of 20 to 30 km per hour and cover from 40 to 100 km per night before the tide rises and the amount of exposed bank decreases to less than 60 cm making it harder to see the crocodiles. This definitely is not the case in the Solomon Islands. The number of waterways which are both worthwhile surveying and are surveyable are few and usually scattered widely. They most often are very short because of hills or mountains inland. Just getting to important crocodile habitats often takes more than 24 hours, and a day or two finding and negotiating with the traditional landowners of the area, but then only 15 minutes are required to survey it, perhaps 2.5 km in all.

On a number of occasions a dugout canoe or a 3m aluminum dinghy with two paddlers was used to survey small lagoons. Even with a 6m canoe and a 9.9 horsepower outboard motor, surveying speeds were painfully slow. Lagoons with dangerous coral reefs and narrow streams with numerous submerged obstacles precluded surveying at high speeds. Survey speeds on even relatively clear waterways were often very slow when the canoe carried 3 to 9 people in addition to the 3-man survey team; 2 survey learners, village chiefs, traditional landowners, and hunters, all insisting on being present.

RESULTS. These are presented and discussed separately for each of the general areas surveyed.

1. Temotu Province (Santa Cruz Islands).

During the nights of 29-31 July 1989, the following waterways were surveyed (for zero starting points see Santa Cruz Islands, Nendo Island, 1:50,000 scale map, sheet 10/165/16):

	Longitude	Latitude
Luemoanda Bay and River	159°59.6'E	10°46.3'S
Matimi Lagoon and Lake	166°02.7'E	10°47.6'S
Mblamoli Lagoon	166°06.6'E	10°43.6'S
Tepiai Lagoon	166°03.2'E	10°46.4'S
Reef (Akamboi) Island	166°07.8'E	10°42.7'S

Midstream distances surveyed and the numbers of crocodiles sighted were:

	km	number sighted
Luemoanda River	2.8	2
Luemoanda Bay	2.2	0
Creek 'A' at km 5.5 on Luemoanda River	0.5	0
Creek 'B' at km 3.2 on Luemoanda River	0.5	0
Creek 'C' at km 2.9 on Luemoanda River	0.5	0
Creek 'D' at km 1.8 on Luemoanda River	0.5	0
	7.0	2
Matimi Lagoon	2.6	2
Matimi Lake perimeter	2.0	4
	4.6	6
Mblamoli Lagoon	4.8	0
Tepiai Lagoon	4.2	2
Reef Island Lagoon	1.2	0
	10.2	2
Total	21.8	10

Shoreline distances surveyed were much greater. Though the surveyable distances appear small, it essentially represents all of the surveyable available habitat in the systems. Only Matimi Lake, which is freshwater, and Luemoanda River and the creeks in Luemoanda Bay, which have a large freshwater flow, contain good crocodile breeding habitat.

The size classes of the 10 animals sighted were: 1(H), 1(2-3'), 1(3-4'), 1(5-6'), 1(7-8'), 4(EO<6'), 1(EO), where H stands for 'hatchlings' and EO stands for 'eyes only.' EO are those animals for which a size estimate could not be obtained.

A slide of a (7-8') crocodile was sighted on the northern beach of Luemoanda Bay. Morris Leuba, near Matimi Lake, had 5 hatchlings and 2(2-3') animals in a pen. In addition, we sighted and measured 11 freshly salted crocodile skins from animals ranging in size from 2' to 7' in length. Matimi Lake was shot out just prior to our survey, even though the skins were less than the minimum size and apparently illegal under present Solomon Islands law.

The above results speak for themselves. It appears that we viewed a remnant population on the verge of extinction. Local people reported that creeks entering Graciosa Bay and streams on the north coast of Nendo Island once supported substantial crocodile populations, but these were shot out.

Both Utupua and Vanikolo Islands of the Santa Cruz group in Temotu Province are also known to contain some crocodiles (hunters have recently shipped hides from there); however, habitat there is less extensive than on Nendo Island. We were unable to obtain transportation to and from these islands within a reasonable time frame and thus could not survey them.

2. Makira (San Cristobal) Province.

During the nights of 7-9 August 1989, the following waterways were surveyed (for zero starting points see San Cristobal 1:50,000 scale maps, sheets 10/161/7, 10/161/11, and 10/162/13):

	Longitude	Latitude
Nasuraghena Passage Lagoon	161°14.9'E	10°47.5'S
Marau Island Lagoon	162°10.8'E	10°48.9'S
Marou Bay area	161°30.2'E	10°28.1'S

Midstream distances surveyed and the numbers of crocodiles sighted were:

	km	number sighted
Nasuraghena Passage Lagoon	3.2	2
Marau Island Lagoon	5.3	0
Marou Bay area	14.6	2
Total	23.1	4

The 23.1 km surveyed represents the best remaining crocodile habitat on Makira Island and, according to local hunters, crocodiles are rarely seen elsewhere. Generally speaking, Makira Island contains only marginal habitat for crocodiles. Sailing time to and from the widespread areas surveyed was 27 hr 30 min.

The size classes of the 4 animals sighted were: 1(4-5'), 1(5-6'), 1(7-8'), and 1(8-9'). One (3-4') crocodile was being captively reared on Malaupaina Island of the Three Sisters Group of islands. We anchored at Malaupaina and examined two freshwater swamp nesting areas on the northern end of the island. The swamps were mostly dry and no old nests were sighted.

No suitable anchorages exist on Malaulalo or Ali'ite Islands, the two other island in the Three Sisters group. None of the traditional landowners or elders of these islands were present (they were away on Ulawa Island, some 50 km distant) when we visited Malaupaina Island and we were informed that Ali'ite Island had been closed by police for investigation. Habitat on all three of these islands is very marginal for crocodiles. Stories about large populations of crocodiles on Ali'ite Island must remain just that, hearsay, until confirmed.

3. Malaita Province.

During the nights of 11-14 August 1989, the following waterways were surveyed (for zero starting points see Malaita 1:50,000 scale maps, sheets 9/161/5, 9/161/6, and 9/161/10):

	Longitude	Latitude
Taha River area	161°23.5'E	9°27.4'S
Mara Masike Passage	161°23.5'E	9°27.4'S
Lake Korea	161°28.3'E	9°39.1'S
Si'ua River	161°3.4'E	9°17.9'S

Midstream distances and the numbers of crocodiles sighted were:

	km	number sighted
Mara Masike Passage	17.5	0
Taha River, km 0 to 2.4	2.4	0
Taramata Creek at km 1.9 on the Taha River, km 1.9 to 5.0	3.1	0
Creek behind Marihote Island, km 0.7 to 1.4	0.7	0
Huro River, km 1.5 to 3.5	2.0	1
Maariki Maero Channel, km 2.8 to 5.9	3.1	0
Su'u Horihori Creek, km 4.9 on Maariki Maero Channel to km 6.7 where it connects with the Huro River	1.8	0
Lake Korea perimeter	2.4	5
Si'ua River	7.7	1
Total	40.7	7

Taha River, Taramata Creek, Lake Korea, and the Si'ua River provide excellent crocodile habitat. We surveyed most of the best crocodile habitat known to people on Malaita and where reportedly there used to be large crocodile populations. The odd crocodile is sighted sporadically in the marginal habitat which dominates the waterways of Malaita. Sailing times to these are usually long and as we found, not fruitful. Kwaimbaita River on the eastern side of Malaita was 'reported' to have crocodiles in good numbers. Ndai Island was another such area. We were unable to visit them.

The size classes of the 7 animals sighted were: 2(2-3'), 1(6-7'), 1(7-8'), 2(EO>6'), and 1(EO). Only in Lake Korea did we sight a small range of size classes. It appears that on the island of Malaita we were viewing a very small remnant population, rapidly approaching extinction.

At the Taha River, hunters presented skins of 3 large crocodiles for sale. Skins also have been sent in recent months from the Si'ua River area. At Eliote village, off the Mara Masike Channel, we viewed 11(4-5') crocodiles in captivity. They were in excellent condition. The villagers told us that in 1986, they captured, killed, and ate the mother. The eggs in her nest were taken and hatched and the 11 healthy animals came from these. The villagers stated they only hunt crocodiles in the February-March nesting period. They wait until the nest is built; then surround the mother and nest with a stake fence. The mother is then killed and eaten. The eggs are taken for hatching. In February 1989, three females were killed in this fashion. None of their eggs hatched. A more effective method of destroying the crocodile resource is difficult to imagine.

4. Isabel Province.

During the nights of 16-20 August 1989, the following waterways were surveyed (for starting zero points see Santa Isabel 1:50,000 maps, sheets 8/159/7 and 7/158/10):

	Longitude	Latitude
Baravale Passage and Ortega Channel area	159°33.8'E	8°22.5'S
Havi Bay area	158°20.4'E	7°33.4'S
Venao Bay area	158°27.1'E	7°37.9'S
Ghahirahobo Island	158°23.3'E	7°38.0'S

Distances surveyed and numbers of crocodiles sighted were:

	km	number sighted
Baravale Passage and Ortega Channel	9.0	0
Loghai River at km 3.9 on Ortega Channel	2.3	0
Nasihe Creek at km 6.4 on San Jorge Island side of Ortega Channel	1.1	1
Tukmasiu River at km 2.4 on Baravale Passage	1.7	1
Toutoru River at km 2.5 on Tukmasiu River	0.6	0
Kokoibutu River at km 3.1 on Toutoru River	1.3	0
Ravihi Creek at km 3.1 on Toutoru River	1.0	0
Kakaburu Creek at km 1.7 on Baravale Passage	1.2	0
Havi Bay and its creek of 0.5 km at km 4.5	5.7	1
Sukupeda Creek at km 2.7 on Havi Bay	1.8	0
Malasu Creek at km 4.0 on Havi Bay	0.9	0
Ghahirahobo Island Lagoon perimeter	2.0	15
Venao Bay	4.1	2
Ogasa Bay at km 0.2 on Venao Bay	1.6	1
Hulaghi Bay at km 1.3 on Venao Bay	0.9	0
Creek 'A' at km 2.5 on Venao Bay	1.1	0
Total	36.3	21

Santa Isabel Island, like Malaita, contains mostly marginal crocodile habitat, although a number of the rivers above have good to excellent habitat. Practically all of the creeks and rivers have a large inflow of freshwater.

The size classes of the 21 crocodiles sighted were: 7(H), 3(2-3'), 1(3-4'), 1(5-6'), 4(EO<6'), 4(EO>6'), and 1(EO). The 15 crocodiles sighted in Ghahirahobo Lagoon constitute a small but important population, probably resulting from a single pair of breeding adult crocodiles. We sighted the belly slide of a (9-10') crocodile between the lagoon and the sea.

The remainder of the results indicate a widely scattered remnant number of crocodiles.

At Kia village, we viewed 3 hatchlings captured in Ghahirahobo Lagoon and 1(3-4') and 1(4-5') animals captured in the Allardyce Bay area.

5. Western Province.

A. Choiseul. We surveyed two sample areas in Choiseul, chosen by a knowledgeable hunter, during the nights of 23-24 August 1989 (for zero starting points see Choiseul 1:50,000 scale maps, sheets 7/157/1 and 7/157/6):

	Longitude	Latitude
Oaka Harbour area	157°18.6'E	7°21.3'S
Ndoroko River and Lelenggavana Inlet area	157°9.6'E	7°19.8'S

Distances surveyed and numbers of crocodiles sighted were:

	km	number sighted
Oaka Harbour	3.2	2
Vendele Creek	1.5	0
Kasu River	0.5	0
Oaka River	3.5	0
Lelenggavana Inlet	3.0	0
Ndoroko River	2.7	0
Total	14.4	2

The amount of remaining suitable, available crocodile habitat on Choiseul appears to be very limited and even that is disappearing quickly as more and more gardens are planted along the waterways. There are a few brackish lagoons inland from the sea which have difficult access and are reported to contain a few remaining crocodiles. We visited one of these during the day but were unable to survey it at night. A 2 m dugout canoe would have to be dragged in to survey it. This would not be a safe operation, especially if a large crocodile did inhabit the lagoon.

It is apparent that the saltwater crocodile is on the verge of disappearing from Choiseul and that we viewed two of the remnant ones. Both of these (8-9') animals were sighted during the day. We also viewed 3(3-4') crocodiles in captivity at Keala, taken from the lagoon on the unnamed island across from Arariki on Vaghena Island.

B. Vella Lavella. We surveyed one area on Vella Lavella, requested by the Minister of Natural Resources. Ngokosoli Creek, draining the thermal area on Vella Lavella into Paraso Bay, the Bay and the village freshwater lagoon were surveyed on the night of 25 August 1989 (for zero starting points see Vella Lavella 1:50,000 scale maps, sheet 7/156/11):

	Longitude	Latitude
Ngokosoli Creek area	156°39.2'E	7°37.8'S

Distance surveyed and numbers of crocodiles sighted were:

	km	number sighted
Ngokosoli Creek	1.0	0
Paraso Bay	1.4	0
Village Lagoon	0.3	0
Total	2.7	0

Villagers living on the lagoon near the mouth of Ngokosoli Creek reported sighting a large crocodile in the village lagoon, a belly slide leading from Ngokosoli Creek, and the taking of a dog and chickens by the crocodile. They also reported the killing of a female crocodile and its young some 4 years ago. We viewed what may have been an old belly slide but could not confirm it.

The water temperature of freshwater Ngokosoli Creek was a high 33.5°C and a high sulfur smell prevailed. The stream can only be negotiated by survey canoe for one km upstream because of rapid shoaling and even this can only be done with safety at high water. The stream is heavily fringed with coconut and sago palms and the area is under intensive cultivation. The village lagoon, also intensely fringed with palms, was surveyed at night using a small dugout canoe. No crocodiles were sighted by us and we can only conclude that the village lagoon is visited occasionally by the odd remnant crocodile in the area.

We were told that other areas on Vella Lavella were reported to have even fewer crocodile than the Paraso Bay area.

C. Rendova. The two small inland freshwater lakes and the two lagoons on Renard Cove, Mbusana Bay, were surveyed on the night of 27 August 1989 (for zero starting points see Rendova 1:50,000 scale maps, sheet 8/157/10):

	Longitude	Latitude
Renard Cove	157°21.7'E	8°33.7'S

This area had been visited by Belden Pitu in 1986 when he took some 20 crocodiles from the lakes. He declared that he saw 'numerous' crocodiles large and small, especially in the larger of the two lakes. We were told by locals that no one had been hunting in the area since his visit in 1986. They were wrong; someone had cleared the large lake of crocodiles, sometime before our arrival.

Distances surveyed and numbers of crocodile sighted were:

	km	number sighted
First lagoon	0.9	0
Second lagoon	1.3	1
Large lake	0.5	1
Small lake	0.3	9
Total	3.0	11

The size classes of the 11 crocodiles sighted were: 6(H), 2(2-3'), 1(5-6'), 1(EO>6'), and 1(EO).

Unfortunately, there are few freshwater lakes, such as the above, and many of these have been cleared of crocodiles. Note that survey of such lakes is a difficult matter. Access to them is often through rough, swampy, and dense terrain and either a small dugout canoe or aluminum dinghy must be carried in and out.

Rendova Island, like most of the Solomon Islands, contains only marginal habitat for crocodiles. Streams appearing on the map are usually short and unnavigable. Lake Rana on the southeast peninsula of Rendova is reported to have had crocodiles. No suitable anchorages exist in the area and access to the lake is unusually difficult. We are unable to say whether or not hunters have cleared the crocodiles from this area.

D. Tetepare. Because of reported crocodiles in the small lake at Tavara on Waugh Bay, the lake and bay were surveyed on the night of 28 August 1989 (for zero starting point see Rendova 1:50,000 scale maps, sheet 8/157/10).

	Longitude	Latitude
Tavara Lake	157°27'E	8°41.8'S

Distances surveyed and numbers of crocodiles sighted were:

	km	number sighted
Tavara Lake	1.0	0
Waugh Bay	1.3	0
Total	2.3	0

Tavara Lake has good habitat for crocodiles, though the presence of numerous workers on the surrounding coconut plantation could account for the zero count. This is an excellent lake for consideration for restocking with crocodiles.

E. Other Areas Sailed To, But Found Not Worth Surveying. We were given the names of crocodile hunters in the New Georgia Group of islands who we contacted for suggested areas to be surveyed. This yielded no new areas worth surveying, but did allow us to view four groups of captive crocodiles which the owners, in desperation, hoped would provide the nucleus for four crocodile farms. The places and individuals visited were:

Hombupeka -- K. Yahata is a hide and shell dealer who buys crocodile skins brought to him from Western Province areas and specially from around the New Georgia Group of islands. We sighted his 10 captive animals, 7(2-3'), 1(3-4'), and 2(4-5'). He is hoping to use these as a tourist attraction.

Nusa Hope -- Sae Oka is an elderly and knowledgeable former crocodile hunter who, six years ago, recognized that the crocodile resource was disappearing rapidly in the Solomon Islands. He obtained eggs from the wild and reared in captivity 2(6-7') and 1(7-8') crocodiles. which were in excellent condition. He also obtained from the wild, in 1988, 11(H), and 7(3-4') animals. He stated that crocodiles were now sighted only sporadically and usually killed by individuals sighting them. He stated that surveying would prove unrewarding.

Mbareho -- Ronald Davis, a crocodile hunter in this area, had two captive crocodiles, 1(5-6'), and 1(7-8'), both in excellent condition. His area had been shot out and since there no longer were any crocodiles to hunt, he gave us a 12 gauge shotgun to return to Belden Pitu.

Peava, Nggatokae Island -- Geffry Nate showed us the 15 crocodiles he and his father were raising for a crocodile farming operation. Dr. Colin McQueen of the Veterinary Division in Honiara originally encouraged them in this undertaking. All 15 animals were in good condition and a new enclosure was being erected for them. The 13(4-5'), 1(5-6'), and 1 (6-7') animals had all been obtained from the Russell Islands. Geffry stated that crocodiles were now rarely sighted in the area of Nggatokae Island and that it was most unlikely that any would be sighted during a survey. He said he wished he could tell us otherwise. This was why they had to obtain their crocodiles from the Russell Islands, which they did in 1987.

Apparently, only a widely scattered remnant number of crocodiles remain in the Western Province.

6. Central Province.

A. Russell Islands. We surveyed the one area in the Russell Islands, where it was believed that a small remnant population of crocodiles still existed, even though the area had been heavily hunted during 1988 and 10 crocodiles shot there.

Lake Tatae, Momoluon Island, was surveyed on the night of 1 September 1989 (for zero starting point see Russell Islands 1:50,000 scale maps, sheet 9/159/1):

	Longitude	Latitude
Lake Tatae	159°05.5'E	9°08.5'S

This lake proved to contain the second best population of crocodiles that we encountered in our survey of the Solomon Islands. The 27 crocodiles sighted along the 1.5 km perimeter of the lake were in the following size classes: 18(H), 1(6-7'), 1(7-8'), 1(EO<6'), 4(EO>6'), and 2(EO).

Hunting of crocodiles on the lake during 1988 could account for the absence of the (2-6') size classes.

B. Florida Islands. Areas worth surveying for crocodiles are few on the Florida Islands. According to Peter Beata, an old time crocodile hunter on the Islands, the best remaining area was Utuha Passage with a number of small creeks running into it. Our daytime survey of the area revealed that the main creek draining the Passage had a village on it. There were gardens along the creek, upstream of the mangrove section. We were pleasantly surprised when we surveyed the area on the night of 3 September 1989 (for zero starting points see Florida Islands 1:50,000 scale maps, sheet 9/160/2):

	Longitude	Latitude
Utuha Passage area	160°18.4'E	9°04'S

Midstream distances surveyed and numbers of crocodile sighted were:

	km	number sighted
Utuha Passage	9.9	1
Tambahi Creek at km 0.0 on Utuha Passage	0.5	0
Kirighi Creek at km 9.8 on Utuha Passage	1.0	2
Total	11.4	3

The size classes of the 3 animals sighted were: 2(7-8') and 1(8-9').

It is interesting to note that we spotted more crocodiles in Central Province than in any other, except for Guadalcanal.

7. Guadalcanal Province.

During the nights of 4, 6, and 7 September 1989, we surveyed three areas (for zero starting points see Guadalcanal 1:50,000 maps, sheets 9/160/11, 9/160/14, and 9/160/16):

	Longitude	Latitude
Likoro Lagoon	160°36'E	9°34.1'S
Lauvi Lagoon	160°23.9'E	9°53.1'S
Makina-Warekau area	160°48.8'E	9°49.8'S

Distances surveyed and numbers of crocodiles sighted were:

	km	number sighted
Likoro Lagoon perimeter	0.5	0
Lauvi Lagoon perimeter	9.8	92
Makina-Warekau area	5.5	0
Total	15.8	92

The number and size classes of the crocodiles sighted in Lauvi Lagoon were 9(H), 31(2-3'), 10(3-4'), 1(4-5'), 1(>7'), 26(EO<6'), 4(EO>6'), and 10(EO). The 43 percent of the animals that could not be approached to allow an accurate size estimation resulted, first, from their being very wary, which could be accounted for by their continued hunting, and, second, because there were floating mats of grass along the lagoon shore which could not be penetrated by a small dinghy and kept us away from the animals. Lauvi Lagoon turned out to be the last major stronghold of the saltwater crocodile in the Solomon Islands.

The two other areas surveyed on Guadalcanal produced results similar to those found on most of the other Solomon Islands -- no animals found or only scattered remnants of a former population found.

We sighted captive animals on Guadalcanal at three places. Charles Rickson has 1(7-8') crocodile at Kopiu village; Betikama High School near Honiara has 1(9-10') crocodile; and Belden Pitu has 54 crocodiles in the following size classes: 14(2-3'), 21(3-4'), 6(4-5'), 11(5-6'), and 2(6-7').

DISCUSSION.

A. Habitat. Generally speaking, the habitat for crocodiles in the Solomon Islands is at best, marginal. There are no extensive wetlands and few long meandering rivers, the preferred home of the saltwater crocodile, as there are in Papua New Guinea and Australia. Most island rivers and creeks rise in the steep hills and mountains immediately behind a narrow coastal fringe of vegetation and as a consequence are unusually short. Because of heavy rainfall, the input of freshwater is high and the rivers, creeks, and springs are normally fresh down to within a few hundred meters of their mouths. Some of these provide good habitat for crocodiles and the alluvial soils are excellent areas for village gardens. Farmers treat the crocodiles as vermin and quickly clear them from the area. With an annual human population growth of over 3 percent, pressure for use of fertile soils is great. The crocodile has little or no chance for survival in such areas.

The coasts of most of the islands in the Solomon Island chain are fringed by coral reefs, and many shallow, mangrove-fringed bays contain numerous patch reefs as well. For crocodiles, this is formidable terrain and is used when they are excluded from more favorable areas or when travelling from one area to another.

Though the Solomon Islands lacks extensive freshwater swamps, it does have a small number of freshwater or brackish lakes, often shown on maps as lagoons. These are found on small islands, some 50 to 100 m from the seashore, or up to 2 km inland on the larger islands. Access to these lakes can be very difficult. They are often drained to the sea by very small creeks. These lakes appear to now provide the last haven of refuge and breeding areas for the remaining crocodiles in the Solomon Islands. Unfortunately, there are only a few of these lakes scattered throughout the island chain that are remote enough not to be negatively impacted by nearby villages. Hunters are also well aware of the lakes, as are hopeful 'crocodile farmers' who obtain their crocodile stock from the lakes. Most have been cleared of crocodiles or are severely depleted.

B. Status. It is apparent that there remains only one small real population of saltwater crocodiles in the Solomon Islands; Lauvi Lagoon on Guadalcanal. The next two largest populations are in Lake Tatae in the Russell Islands and in Ghahirahobo Lagoon on Santa Isabel.

In separate columns in the Table below we show the numbers and size classes of crocodiles sighted in Lauvi Lagoon, in Lake Tatae, in Ghahirahobo Lagoon, and those found in all other localities, and the totals. Those sighted in other localities consisted of a number of stragglers -- the widely scattered surviving remnant of a once healthy population. Sadly, the crocodile resource of the Solomon Islands essentially has been destroyed.

Number of Crocodiles

	Lauvi	Ghahirahobo	Tatae	Other Locales	Total
Hatchlings	9	7	18	7	41
2-3' (0.6-0.9 m)	31	3		5	39
3-4' (0.9-1.2 m)	10	1		1	12
4-5' (1.2-1.5 m)	1			1	2
5-6' (1.5-1.8 m)				4	4
6-7' (1.8-2.1 m)			1	1	2

>7' (>2.1 m)	1		1	9	11
EO<6' (<1.8 m)	26	2	1	8	37
EO>6' (>1.8 m)	4	1	4	4	13
EO	10	1	2	3	16
Total	92	15	27	43	177

Another way of viewing this is shown in the Table below where we have divided the waterways surveyed into enclosed lagoons (virtually freshwater lakes), saltwater lagoons with openings to the sea, rivers and creeks (mostly freshwater), and saltwater bays and channels. The number of these surveyed, distances surveyed, and numbers of crocodiles sighted in them is shown also.

	Number	Distance (km) surveyed	Crocs sighted
Enclosed lagoons	10	20.3	153_{41}
Saltwater lagoons	8	23.5	7
Rivers and creeks	30	47.7	8
Bays and channels	20	81.5	9
Total	68	173.0	177_{41}

Over 86%, 153 out of 177, of the crocodiles were sighted in the freshwater lagoons and from the previous Table it is evident that almost all (134) of these were sighted in three lagoons only. Of the 177 crocodiles sighted, 41 were hatchlings, denoted by the subscript figure in the Table above, and every one of these hatchlings were sighted in the enclosed freshwater lagoons. Not one was sighted in the 30 rivers and creeks surveyed, many of which had excellent breeding habitat. These waterways had been essentially cleared of breeding stock and only stragglers remained.

It is perhaps surprising that 7 animals were sighted in the saltwater lagoons and 9 in the bays and channels. These areas are normally used by immature crocodiles that the large breeding animals exclude, will not tolerate in the breeding areas, or they are animals moving from one area to another. The number we found in these areas is probably indicative of the hunting pressure in the breeding areas in freshwater lagoons and rivers and creeks. Note also the few animals sighted in the (4-7') classes. Though Messel has pointed out repeatedly that there is a severe biological 'bottleneck' for animals in these size classes which normally would account for their scarcity (for instance, see the population model in Monograph 20 of his survey series published by Pergamon Press), the populations sighted in the Solomon Islands are so small that it would be surprising of this was so here. It is likely that a number of these animals are included in the three EO classes.

One may ask what fraction of the crocodile containing habitat was surveyed by us. It is difficult to answer this with precision. Almost all of the areas, which knowledgeable hunters felt were worth surveying, were surveyed.

In the case of enclosed lagoons, some 80 percent of those worth surveying, were surveyed. The same applies for saltwater lagoons, although there were many more which could have been surveyed, had local hunters and inhabitants not stated emphatically that the area had been essentially cleared of crocodiles. We probably did not survey more than a few percent of surveyable bays and channels. Since only remnant straggler crocodiles remain, one might occasionally be sighted in almost any bay or even the open sea. Under these circumstances all kinds of correction factors -- depending on an individual's imagination -- can be applied to the number of crocodiles sighted during the course of the survey.

Because of the few animals we encountered, using statistical means to gain an estimate of the actual number of crocodiles in the Solomon Islands is meaningless. We believe that there may be another freshwater lagoon or two equivalent to Ghahirahobo or Lake Tatae that was not surveyed, but there certainly is not another equivalent to Lauvi Lagoon. Based on surveying experience in Australia, we can generously assume that the sighting fraction for crocodiles in the enclosed lagoons was only 50 percent. In addition to cover the unsurveyed waterways, the number of crocodiles seen in the saltwater lagoons, and rivers and creeks, can be liberally multiplied by 10 and that of the bays and channels by 20. This produces a 'guesstimate' of $[2(153+42)+(10x7)+(10x8)+(20x9)] = 720$ crocodiles, as a maximum.

It should again be stressed that, other than in the small enclosed lagoons, the remaining crocodiles are widely scattered throughout the some 900 islands of the chain and the chance of breeders meeting must be small.

C. 'Custom Crocodiles.' At several locations during this survey, we were told by local people that the reason we were not finding many crocodiles was because these were 'custom crocodiles' which can only be seen by a few traditional Solomon Islanders; that the crocodiles were there, but that we could not see them. Significantly, these comments always came from villagers and not from local crocodile hunters. If the ability to see crocodiles is a trait unique to 'customary islanders' than the leaders of the survey team, who collectively have 40 years experience studying 17 of the 25 recognized species and subspecies of crocodilians in more than 15 nations, during which they have censused, captured, and handled more than 100,000 live crocodilians and have examined over 1,000,000 crocodilian hides, have surely earned the right to see any crocodiles customary or not.

D. Number of Crocodiles in Former Times. How many crocodiles were there in the Solomon Islands in former times? One will never know for certain because, as elsewhere, no previous systematic survey of the crocodile population had been carried out. Furthermore, in former times, records of exports of crocodile skins were not maintained and even in recent times records have been scant. We are this compelled to rely upon information provided by former and present day crocodile hunters. It is difficult to assess the reliability of such information other than by obtaining it from many hunters on different islands. This we did.

The following broad picture emerges. Apparently the crocodile, even though it, along with the shark, appears on the national emblem of the Solomon Islands, has been looked upon generally as vermin and treated as such. Thus when Australian expatriate hunters, who become well acquainted with the Solomon Islands during the second world war, started shooting crocodiles in the late 1950s and during the 1960s and early 1970s they were welcomed. Many of the older hunters and guides who helped us with the present survey, worked gladly with the expatriates to help shoot out the crocodiles. One of the Masters of our survey vessel, Harry Mamata, was one such individual who helped. On all the islands we surveyed, the name of Dennis Rome came up time and time again as one of the expatriate shooters. Freddie Forsythe Kaye was another name which was mentioned. Every one of the indigenes stated that the crocodile resource had been large and could be gauged by the fact that in the 1950s and 1960s the hunters obtained, on average, 4 to 5 skins of large animals each night. On some nights, they obtained as many as 20 large animals. During the present survey, only in Lauvi Lagoon did we sight a few large animals and because of their wariness only one could be approached.

Apparently, even though the majority of the habitat for crocodiles in the Solomon Islands is marginal, the population size was large and must have taken a very long time, measured in centuries, to reach that size. We are unable to say more than perhaps it was a large as the crocodile population of Australia, but less than that of Papua New Guinea. We cannot substantiate this estimate further.

E. Protective Measures. By the mid-1970s, the valuable crocodile resource had been severely depleted and the expatriate hunters departed. The indigenes, however, continued to hunt the animal both as vermin that occasionally attacked humans, pigs, dogs, and chickens, and because crocodile hide prices were high. They provided valuable supplementary funds for individuals of a local subsistence economy. By this time, India, Australia, and Papua New Guinea had recognized the danger of losing the crocodiles and took steps to implement management plans, ensuring the survival of the species and their eventual utilization on a sustained yield basis. The Solomon Islands was at this time in the throes of gaining independence and did not follow the lead of India, Australia, and Papua New Guinea. The killing continued, without general recognition that a valuable economic resource was being destroyed. Even as late as 1982, an expatriate hunter was welcomed to help clear the remaining vermin crocodiles. However, in 1972, legislation was enacted to prohibit the export of skins smaller than 50 cm wide in the belief that it might help protect the crocodile resource. By allowing the adult breeders to be killed off, it did the opposite.

In the Solomon Islands, crocodiles are grouped with fish in the Fisheries Act of 1972. 'Fish' is defined as 'any aquatic animal, whether piscine or not and includes...crocodile and turtle, and young and eggs thereof ...."

Regulation 10 of the Act covers crocodiles and in '977 was changed to read:

"Any person who sells or exposes for sale--any crocodile or crocodile skin the belly width of which is less than 50 centimeters...shall be guilty of an offence...."

"Provided that this regulation shall not apply in relation to any crocodile, or skin of any crocodile...reared in a farm licensed under any Regulations...."

As far as we have been able to ascertain, this regulation had not been enforced. The export of skins of crocodiles of all sizes taken from the wild have been, and continue to be, sanctioned. At any rate, since saltwater crocodiles do not start breeding until they are at least 2 m (females) to 3.5 m (males) long and have a belly width of 45 cm, enforcement of the legislation would ensure that the crocodiles breeding resource would be severely depleted -- as it has been -- and perhaps, finally be totally destroyed.

F. Crocodile Skin Exports. Mr. Youichi Takehara, Managing Director of Horiuchi Trading Company of Tokyo, Japan, kindly supplied figures for crocodiles imported by his company from the Solomon Islands -- see Table below.

Mr. Henry Isa, Principal Conservation Officer of the Environment and Conservation Division, Solomon Islands Ministry of Natural Resources, provided the following figures for the export of crocodile skins from the Solomon Islands:

	Belly inches	Value (S.I.$)
1985	4163	10,405
1986	4350	10,873
1987	6445	32,093
1988	4772	99,852

Study of the information supplied by Mr. Takehara and Mr. Isa indicates that Horiuchi Trading Co. has been importing roughly one half of the crocodile skins exported from the Solomon Islands. Furthermore, the Takehara Table indicates that the number of imported skins with belly widths 20 inches or greater (> 50 cm) has decreased from 63 in 1983 to 28 in 1988. The 1989 figures could be aberrant since hunters were encouraged to get every skin they could this year. At several places, during the course of our survey, we were welcomed because villagers believed we had come to clear out the remaining few crocodiles.

Crocodylus porosus hides imported from the Solomon Islands by Horiuchi Trading

Width	'83	'84	'85	'86	'87	'88	'89	Total
4"			2					2
5		1	4					5
6	3	12	4	1	1	5	1	27
7	8	15	7	3		2	3	38
8	19	6	5	5	1	4	4	44
9	26	13	6	6	16	4	8	79
10	21	10	8	19	12	6	14	90
11	22	11	7	15	7	3	7	72
12	34	22	14	22	33	15	11	151
13	46	12	10	16	19	6	13	122
14	30	13	8	10	20	7	5	93
15	26	18	6	14	7	7	12	90
16	31	5	6	2	15	5	12	76
17	15	8	6	4	8	3	3	47
18	13	4	9	9	11	4	11	61
19	16	6	7	5	6	8	7	55
20	20	6	10	7	9	3	7	62
21	7	6	4	4	7	4	6	38
22	13	4	4	9	4	6	5	45
23	8	4	6	2	6	4	6	36
24	1	2	3	5	4	3	1	19
25	5	4	6	2	1	2	1	21
26	1	2	3	2	1	1	1	11
27	2	1	1	3	1	1	1	10
28	1	1		3	1	1		7
29		2		1				3
30	1	1	1		1			4
31				1		1		2
32	1						1	2
33	1							1
34	1		1	2				4
35			1			1		2
36								0
37	1							1
38		1						1
39						1		1
40								0
41			1					1
42		1						1
43		1						1
44					1			1
45								0
46				1				1
47								0
48						1		1
Total	373	192	150	173	192	108	140	1,328

G. Crocodile 'Farms' and Ranching. During the course of the survey, every opportunity was taken to visit crocodile 'farms.' These 12 so called farms contained from 1 to 54 animals each. The number and size classes of the captive animals seen in each 'farm' are given in the Results. The Table below shows the size classes and total captive crocodiles seen.

Captive Crocodiles

Size in Feet (meters)	Number of Crocs
Hatchling	19
2-3' (0.6-0.9)	23
3-4' (0.9-1.2)	34
4-5' (1.2-1.5)	33
5-6' (1.5-1.8)	13
6-7' (1.8-2.1)	5
>7'	4
Total	131

CITES defines captive propagation as intensive management under captive conditions which reliably will produce an F_2-generation (second generation) from parents born or hatched in captivity. Such an operation which produces offspring from parents bred in captivity is defined as a 'farm.' Operations which obtain eggs or young from the wild, not from captive parents, for rearing in captivity is defined as a 'ranch.' Farms are closed-cycle operations independent of the wild populations, while ranches are open-cycle operations dependent on wild eggs or young.

There is no viable crocodile farm in the Solomon Islands at the present time and there is unlikely to be one unless a much more professional approach is taken. One or two, or even 54, immature animals does not constitute a crocodile farm. It takes 8 to 10 years for a female and 15 to 16 years for a male *C. porosus* to reach breeding size. None of the captive animals seen in the 'farms' had bred in captivity, and since none of the 'farm' enclosures contained pools sufficiently large and deep (>1.5 m), it is unlikely that they ever will breed under the current husbandry conditions. The existing 'farms' cannot even operate as ranches since, without a healthy wild population, neither eggs nor hatchlings can be collected from the wild for stocking the ranches.

Practically every hopeful crocodile farmer we spoke to expressed great interest in crocodile farming and wanted more information on it. They were most anxious to commercially farm the very resource which so many of them as hunters had helped to destroy in the wild. Most of them expressed sorrow at not having realized what impact their hunting was having.

Every commercially successful crocodile enterprise in the world depends to a varying degree upon tourism and/or ranching. Lauvi Lagoon is the only site in the Solomon Islands which in the near future might, with proper protection and effective management, become a tourism/ranching enterprise. Other lagoon sites will require stringent protection for at least 5 to 10 years before their populations will have recovered sufficiently to allow any sustained yield exploitation. However, this will require careful annual checking before any animals are taken.

H. Conclusions and Recommendations.

1. Crocodiles in the Solomon Islands have been and still are generally looked upon as vermin, and not as a valuable resource.
2. The crocodile resource of the Solomon Islands has been severely depleted and only a very small, widely scattered remnant population remains.
3. Unless urgent and strict measures are taken to protect the species, the saltwater crocodile may soon become extinct in the Solomon Islands.
4. There is, at present, no commercially viable crocodile farm or ranch in the Solomon Islands and this will not change unless immediate action is taken now to conserve the wild population.
5. The remaining crocodile resource is so small that a crocodile ranching proposal is out of the question for a number of years.
6. There does not exist in the Solomon Islands any effective legislation to protect and conserve the crocodile.
7. Few Solomon Islanders, with the exception of the crocodile hunters, are aware that the crocodile populations are so dangerously depleted.

We recommend that:

A. The wild crocodile population of the Solomon Islands remains on Appendix I of CITES.
B. A total export ban on crocodile skins of all sizes and from all sources in the Solomon Islands immediately be established and effectively implemented. Such a ban should remain in effect for a minimum of 5 years, after which it should be reviewed.
C. A permanent ban on skins taken from the wild, whose belly width is greater than 45 cm should be imposed to protect the breeding stock.
D. The Solomon Island central government and provincial authorities immediately commence the task of educating the public about the vital importance of conserving their natural resources and national heritage, including crocodiles, for the future benefit of their citizens.
E. The central and/or provincial governments find some way to protect and conserve the remaining crocodile resource. We recognize that in the Solomon Islands, wildlife belongs to the traditional landowner, but if the scant resource is to be saved the governments must find a way of convincing the landowners to protect the wild populations and their habitats. Special areas such as the freshwater lagoons should be given priority consideration.
F. The governments discourage taking crocodiles from the wild to stock so called 'farms' which are unlikely to become economically viable, except as a tourist attraction.
G. The status of the crocodile populations in Lauvi and Ghahirahobo Lagoons, and in lakes Tatae, Korea, and Matimi and those in Renard Cove be monitored annually.

Acknowledgements

There are many agencies, organizations, and people to thank and without whose help the exceedingly complex and difficult survey could not have been completed. First is the CITES Secretariat which labored hard to raise the funds for a survey which it felt was urgent and long overdue. Second is the Solomon Islands Ministry of Natural Resources which wholeheartedly encouraged the survey. We sincerely thank each and every one of the numerous individuals in the dozens of places we surveyed, though they are simply too many to name individually.

For the entire survey period, the survey ship, the 'MV Memory', had the following staff:

Master - John Johnson Hiru
Second Master - Harry Mamata
Engineer - Debster Foli
Crew - George Waletofe, Silvaror Dodo, John Sorova, and Ludavico Albert

How these individuals sailed the vessel at night through reef strewn waters, over thousands of kilometers, without an echo sounder or radar, remains a mystery to us. Perhaps the traditional wooden sailing talisman which Harry Mamata had bound to the upper mast of the vessel had something to do with it. It was given to him by his father many years ago and has stood this incredible sailor in good stead ever since.

Gerry Whewell, Conservation Officer in the Ministry of Natural Resources, in addition to being the active representative from the Ministry, first acted as a'survey-learner observer' and soon mastered the basics of the intricate technique of crocodile surveying. He is the only individual in the Solomon Islands today who should be able to carry on the future task of monitoring the crocodile populations. Samson Dioko is now a well-trained survey canoe driver and paddler. Hans Wagner, well known naturopath from Sydney kept us in good health with his preparations of excellent Solomon Islands fruit and vegetables during the last two weeks of the survey.

Appendix 1.

Sailing Times To and From Survey Areas

SANTA CRUZ		
Sat 29 Jul -- Lata -> Dedu on Nendo Island by canoe; 0600-0900 hr	3 hr	
Tue 1 Aug -- Luemoanda -> Lata by canoe; 0630-0930 hr	3 hr	
MAKIRA		
Sun 6 Aug -- Kaonasugha -> Na Mugha, Star Harbor; 0745-0930 hr	6 hr	
Tue 8 Aug -- Na Mugha -> Marau Island Bay; 0700-0930 hr	2 hr	30 min
Wed 9 Aug -- Marau Harbor -> Manawai Harbor; 0310-0850 hr	5 hr	40 min
Thu 10 Aug -- Manawai Harbor -> Tawarogha -> Malaupaina Island, Three Sisters Group; 0000-0830 hr and 0900-1250 hr	12 hr	20 min
MALAITA		
Fri 11 Aug -- Malaupaina Island -> Apio; 0100-0800 hr	7 hr	
Apio -> Taha River; 1000-1100 hr	1 hr	
Sat 12 Aug -- Taha River -> Apio; 1917-2058 hr	1 hr	40 min
Sun 13 Aug -- Apio -> Su'upeine Bay for Lake Korea; 0715-0835 hr	1 hr	20 min
Su'upeine Bay -> Ahenawai; 2020-2135 hr	1 hr	15 min
Mon 14 Aug -- Ahenawai -> Apio; 0620-0625 hr		5 min
Apio -> Rutaorea; 0735-1040 hr	3 hr	5 min
Rutaorea -> Rohinari in Waisisi Harbor; 1205-1225 hr		20 min
Waisisi Harbor -> Si'ua Bay; 1320-1340 hr		20 min
Tue 15 Aug -- Si'ua Bay -> Talakali; 0300-0715 hr	4 hr	15 min
Talakali -> Auki; 0830-0920 hr		50 min
SANTA ISABEL		
Wed 16 Aug -- Auki -> Leleghia; 0000-0805 hr	8 hr	5 min
Leleghia -> village near Potofa'a Creek; 0850-0910 hr		20 min
Potofa'a Creek -> Kaevanga; 0925-1000 hr		35 min
Kaevanga -> Kaipito River; 1025-1045 hr		20 min
Kaipito River -> Kaevanga; 1230-1250 hr		20 min
Thu 17 Aug -- Kaevanga -> Leleghia; 1100-1120 hr		20 min
Leleghia -> Kaevanga; 1950-2010 hr		20 min
Kaevanga -> Kia; 2240-1430 hr	15 hr	50 min
Fri 18 Aug -- Kia -> Havi Bay; 1610-1700 hr		50 min
Sun 20 Aug -- Havi Bay -> Imauku Bay; 0830-1005 hr	1 hr	35 min
Imauku Bay -> Hulaghi Bay; 1055-1130 hr		35 min
Mon 21 Aug -- Hulaghi Bay -> Kia; 0635-0930 hr	2 hr	55 min
Kia -> Arariki, Vaghena Island, Choiseul; 1100-1610 hr	5 hr	10 min
WESTERN PROVINCE		
CHOISEUL		
Mon 21 Aug -- Arariki -> First Unnamed cove north of Arariki; 1640-1655 hr		15 min
Tue 22 Aug -- Unnamed cove -> Keala; 0640-1005 hr	3 hr	25 min
Keala -> Ruravai; 1035-1040 hr		5 min
Ruravai -> Oaka Harbour; 1630-1650 hr		20 min
Thu 24 Aug -- Oaka Harbour -> Posarae; 0630-0730 hr	1 hr	
Posarae -> Ndoroko River; 0815-0845 hr		30 min

VELLA LAVELLA		
Fri 25 Aug -- Ndoroko River -> Liangai; 0400-0840 hr	4 hr	40 min
Liangai -> Paraso Bay; 0950-1030 hr		40 min
Sat 26 Aug -- Paraso Bay -> Noro, New Georgia; 1800-0020 hr	6 hr	25 min
RENDOVA		
Sun 27 Aug -- Noro -> Mburuku; 0620-0900 hr	2 hr	40 min
Mburuku -> Renard Cove, Mbusana Bay; 1045-1220 hr	1 hr	35 min
TETEPARE		
Mon 28 Aug -- Renard Cove -> Tavara, Waugh Bay; 0655-0810 hr	1 hr	15 min
Tavara, Waugh Bay -> Mburuku, Rendova; 2000-2200 hr	2 hr	
GHIZO		
Tue 29 Aug -- Mburuku -> Gizo; 1010-1535 hr	5 hr	25 min
NEW GEORGIA		
Wed 30 Aug -- Gizo -> Noro; 0840-1135 hr	2 hr	55 min
Noro -> Hombupeka; 1145-1300 hr	1 hr	15 min
Hombupeka -> Nusa Hope; 1320-1520 hr	2 hr	
Nusa Hope -> Ilemi; 1630-1930 hr	3 hr	
Thu 31 Aug -- Ilemi -> Mbareho; 0500-0810 hr	3 hr	10 min
Mbareho -> Patutiva; 0925-1010 hr		45 min
Patutiva -> Mbisuana; 1015-1210 hr	1 hr	55 min
Mbisuana -> Mbatuna; 1230-1250 hr		20 min
Mbatuna -> Peava, Nggatokae Island; 1335-1530 hr	1 hr	55 min
Peava -> Yandina, Russell Islands; 1605-0055 hr	8 hr	50 min
RUSSELL ISLANDS		
Fri 1 Sep -- Yandina -> Loun, Loun Island; 0830-0825 hr		25 min
Loun -> Kaelenga, Alokan Island; 0855-1000 hr	1 hr	5 min
Kaelenga -> Lake Tatae, Momoluon island ; 1050-1105 hr		15 min
Momoluon Island -> Yandina; 2035-2210 hr	1 hr	35 min
FLORIDA ISLANDS		
Sat 2 Sep -- Yandina -> Mboromole; 2230-0715 hr	8 hr	45 min
Sun 3 Sep -- Mboromole -> Siota; 0945-0950 hr		5 min
Siota -> Utuha Passage; 1000-1005 hr		5 min
Utuha Passage -> Salesape; 1400-1450 hr		50 min
Salesape -> Utuha Passage; 1530-1620 hr		50 min
GUADALCANAL		
Mon 4 Sep -- Utuha Passage -> Rere; 0300-1000 hr	7 hr	
Tue 5 Sep -- Rere -> Manikaraku; 0630-0915 hr	2 hr	45 min
Fri 8 Sep -- Manikaraku -> Mbarande; 0200-0730 hr	5 hr	30 min
Mbarande -> Honiara; 0815-1030 hr	2 hr	15 min
Total Sailing Time	178 hr	40 min
Total Distance Sailed		2,818 km

Appendix 2.

List of Localities Indicated by Numbered Arrows on the Maps in Figures 2-8

1) **NENDO ISLAND**, Lata - 26-29 July, 1-5 August
2) Dedo Station, near Nanggu - 29-31 July
    Reef Lagoon
    Tepiai Lagoon
    Mblamoli Lagoon
3) Lord Howe Island - 28 July
    Lord Howe Island lagoon
    Matimi Lake
4) Luemoanada River - 31 July-1 Augus
    Luemoanada River
    Other nearby rivers
5) **MAKIRA ISLAND**, Kira Kira - 6 August
6) Kaonasugha Harbour - 6 August
7) Na Mugha Anchorage - 6-8 August
    Nasuraghena Passage and lagoon
8) Marau Island (near 162°10.8'E, 10°48.9'S) - 8-9 August
    Lagoon behind Marau Island
9) Marau Island (near 161°30'E, 10°31'S) - 9-10 August
    Mwaera Bay
    Maro'u Bay
    Unnamed bay and stream behind Marau Island
    Small unnamed lake on Marau Island
    Manawai Harbour
10) **THREE SISTERS ISLANDS**, Malaupaina Island, Su'uta'ata'a Harbour - 10-11 August
    Unnamed interior salt marsh
11) **MALAITA ISLAND**, Mara Masike Passage, Apio - 11-12 August, 14 August
12) Mara Masike Passage, Taha River - 12-13 August
    Taha river
    Taramata creek
    Huro creek
    Su'u Horihori creek
    Maariki Maero Channel
    Maariki Paena Channel
    Mara Masike Passage
13) Su'upeine Bay, Lake Korea - 13 August
14) Waisisi Harbour, Rohinari village - 14 August
    Haurakeni lake
15) Si'ua River - 14-15 August
    Si'ua River
16) Talakali village (opposite Laulasi) - 15 August
17) Auki - 15-16 August
18) **SANTA ISABEL ISLAND**, Thousand Ship Bay, Leleghia - 16-17 August
    Baravale Passage
    Ortega Channel
    Tukmasiu river
    Toutori river
    Kokoibutu river
    Ravihi river
    Kakaburu river
    Nasi'he creek

19) Kia - 18 August
20) Havi Bay - 18-20 August
Havi Bay
Sukupeda creek
Malasu creek
21) Ghahirahobo Island - 20 August
Ghahirahobo Island
22) Hulaghi Bay - 20-21 August
Venao Bay
Hulaghi Bay
Ogasa Bay
Unnamed bay
23) CHOISEUL ISLAND, Veghena Island - 21-22 August
24) Keala Island, Keala; Roraimboko Island, Ruruvai; Oaka Harbour - 22-24 August
Oaka Harbour
Oaka River
Kasu River
Vendele creek
25) Posarae - 24 August
26) Ndoroko River - 24-25 August
Ndoroko river
27) Small unnamed lake off Tonggoa Channel near Sambe Point - 24 August
28) VELLA LAVELLA ISLAND, Liangi Village - 25 August
29) Paraso Bay - 25-26 August
Paraso Bay
Ngokosoli creek
Unnamed lagoon near village
30) NEW GEORGIA ISLAND, Noro - 27 August
31) RENDOVA ISLAND, Mbusana Bay, Huntsuzu Cove (Renard Cove) - 27-28 August
Unnamed saltwater lagoons
Large unnamed freshwater lake
Small unnamed freshwater lake
32) TETEPARE ISLAND, Waugh Bay, Tavara - 28 August
Waugh Bay
Unnamed freshwater lake
33) RENDOVA ISLAND, Mburuku (Ughele) - 28-29 August
34) GHIZO ISLAND, Gizo - 29-30 August
35) NEW GEORGIA ISLAND, Hombureka Island - 30 August
36) Nusa Hope - 30 August
37) Viru Harbour, Ilemi - 30-31 August
38) Mbareho Island, Mbareho Village - 31 August
39) Patutiva village - 31 August
40) Mbisuana village - 31 August
41) Mbatuna - 31 August
42) Nggatokae Island, Peava - 31 August
43) RUSSELL ISLANDS, Mbanika Island, Yandina - 1-2 September
44) Alokan Island, Kaelenga - 1 September
45) Momoluon Island - 1 September
Tatae Lake
46) FLORIDA ISLANDS, Nggela Pile Island, Salesape - 3 September
47) Nggela Sule and Nggela Pile Islands, Mboromole - 3-4 September
Utuha Passage
Kirighi river
Tambachi river

48) GUADALCANAL ISLAND, Rere - 4-5 September
Tanangaoa river
Likoro lagoon
49) Manikaraku - 5-8 September
Danae Bay
Passage between Danae Bay and North-West Bay
50) Lauvi Lagoon - 6-7 September
Lauvi Lagoon
51) Mbarande - 8 September
52) Honiara - 22-29 July, 8-14 September

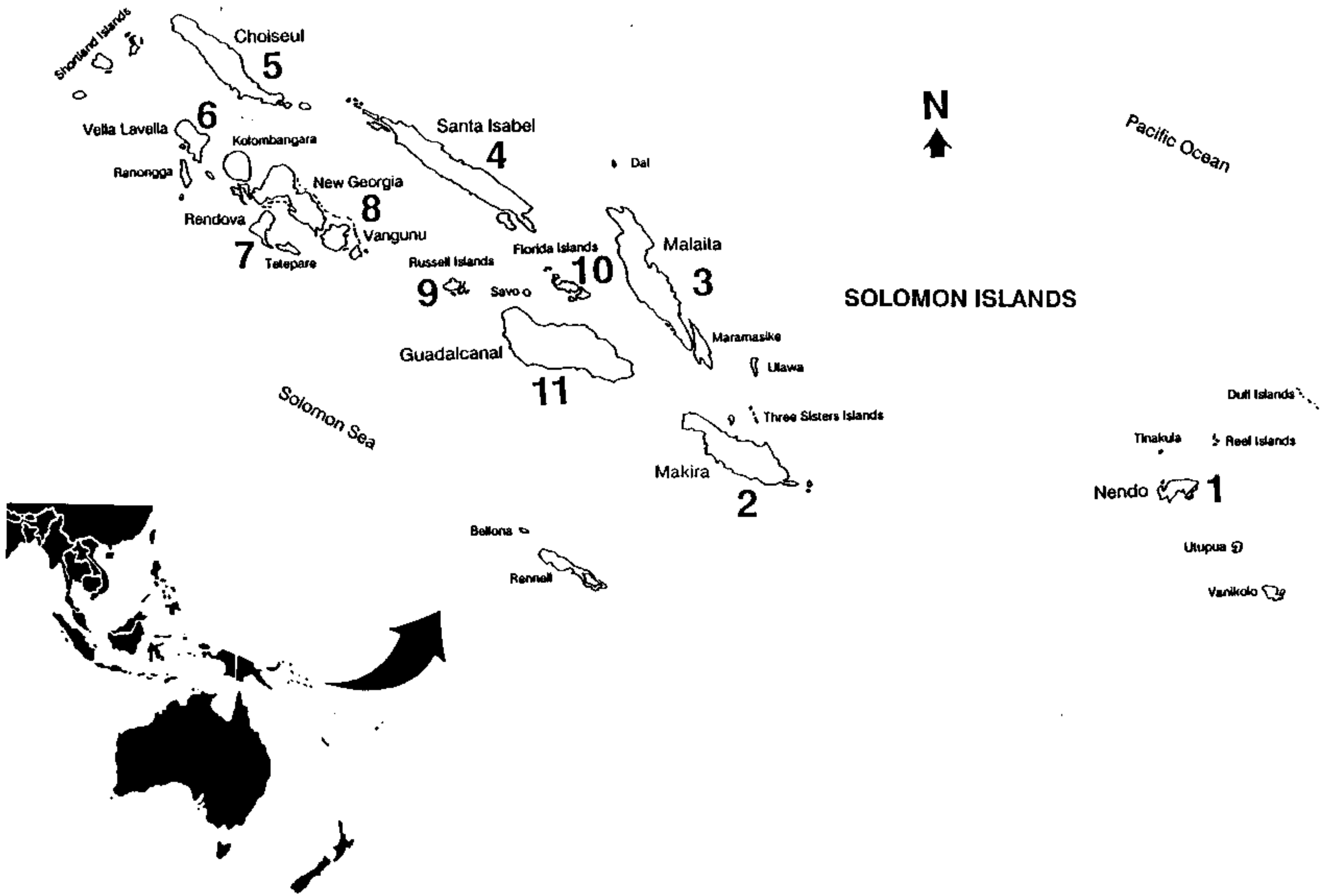


Figure 1. Solomon Islands. Numbers indicate the order in which the island groups were visited.

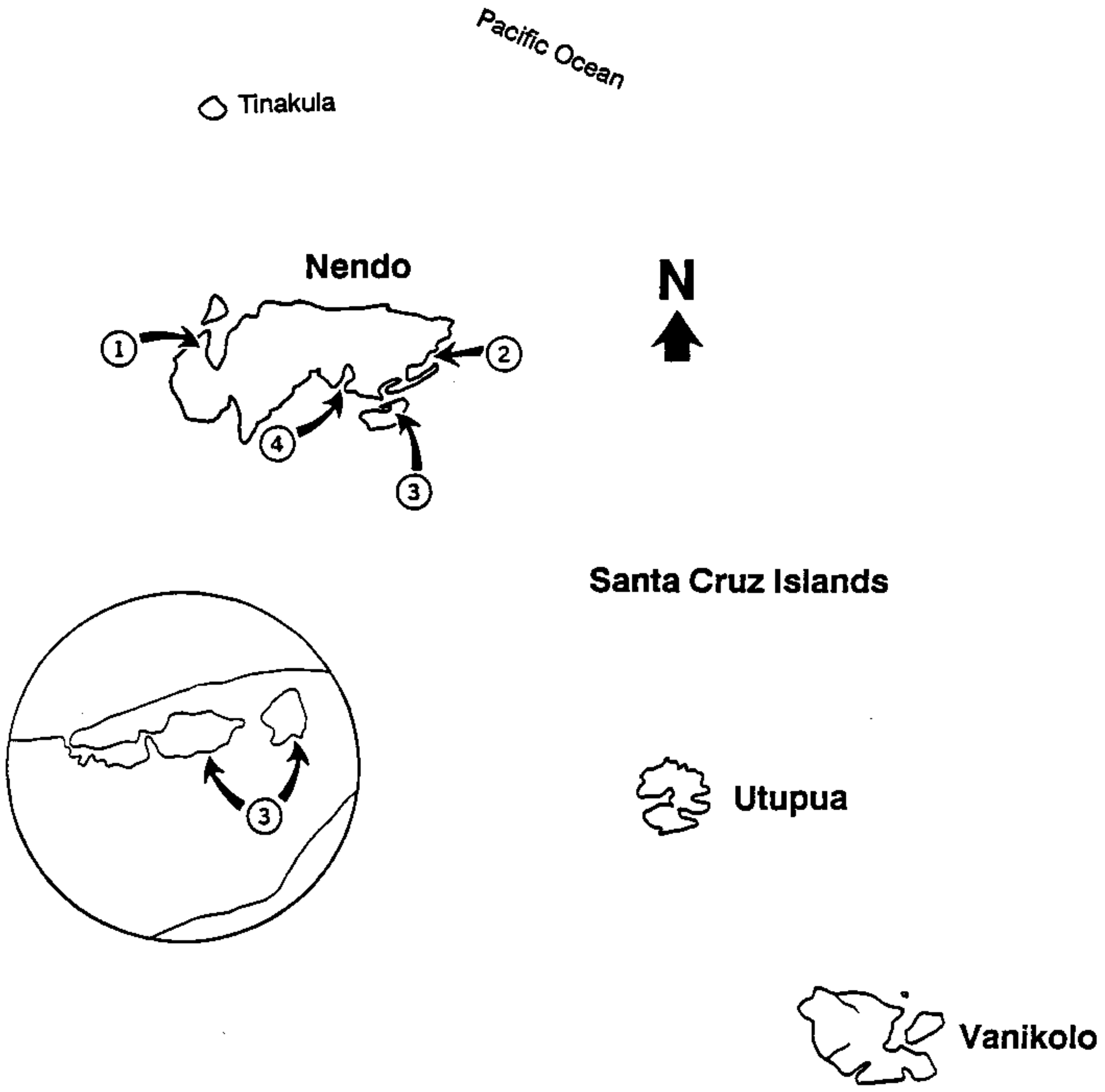


Figure 2. Santa Cruz Islands (= Temotu Province). Numbered localities are listed in Appendix 2.

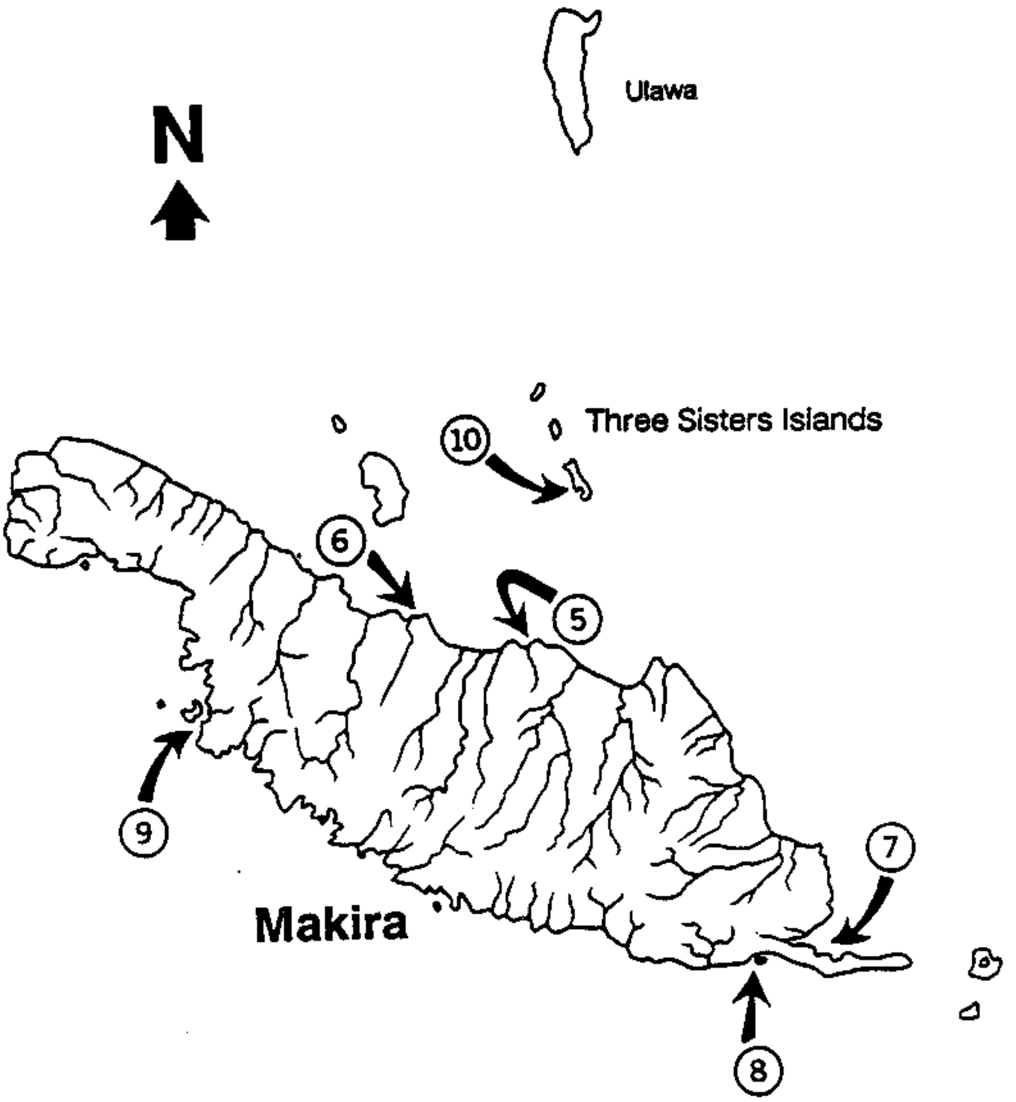


Figure 3. Makira Island (= San Cristóbal). Numbered localities are listed in Appendix 2.

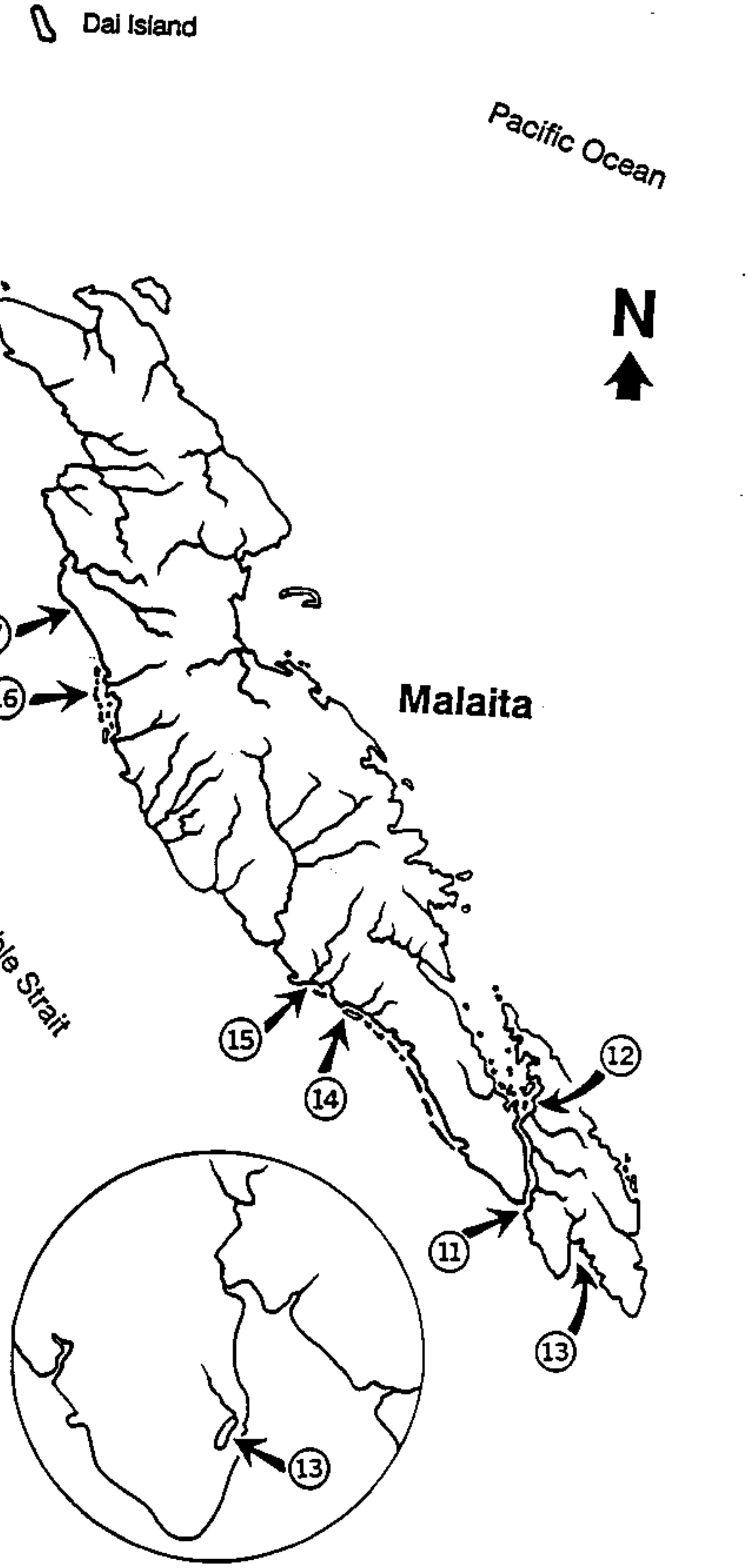


Figure 4. Malaita Island. Numbered localities are listed in Appendix 2.

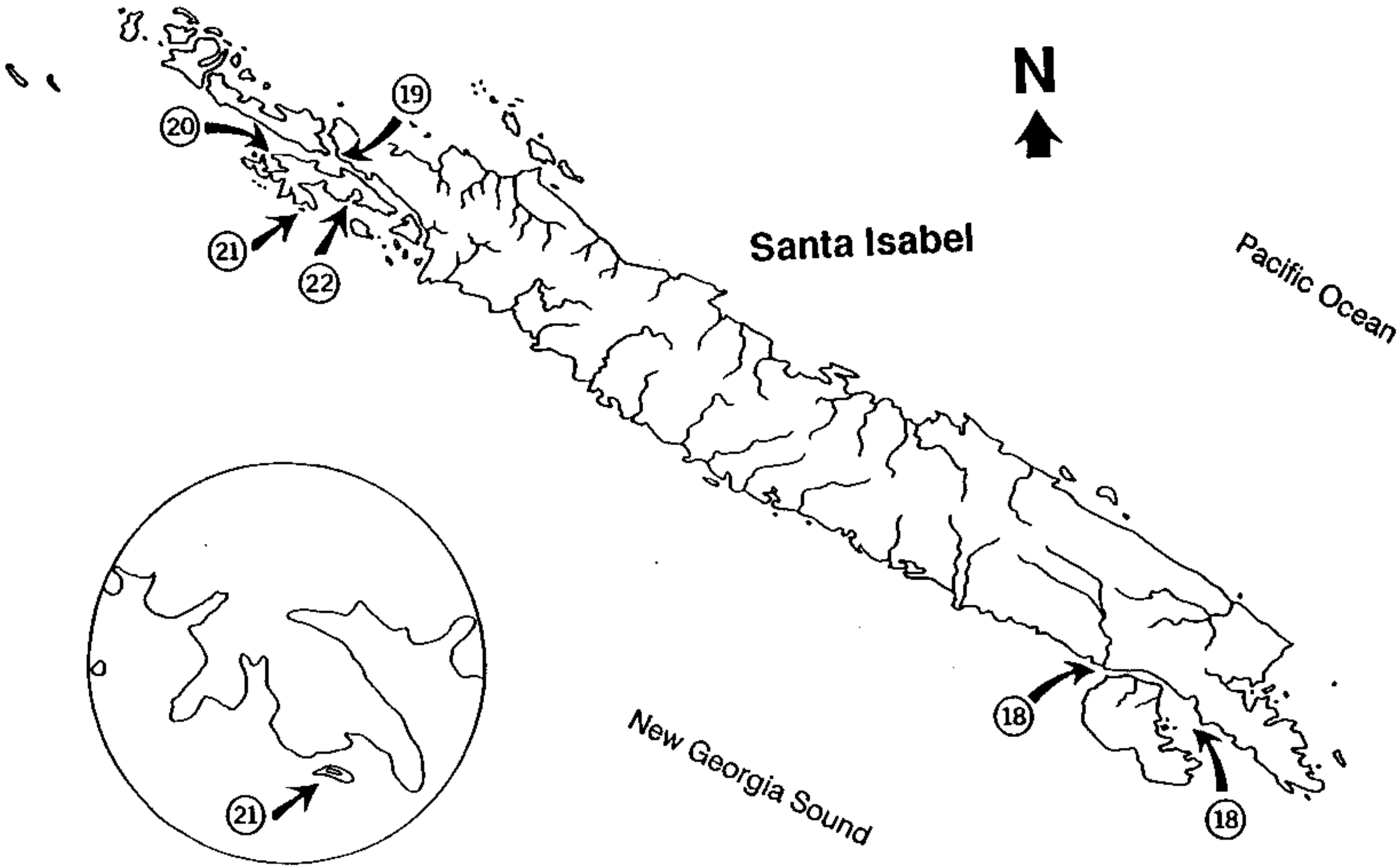


Figure 5. Santa Isabel Island. Numbered localities are listed in Appendix 2.

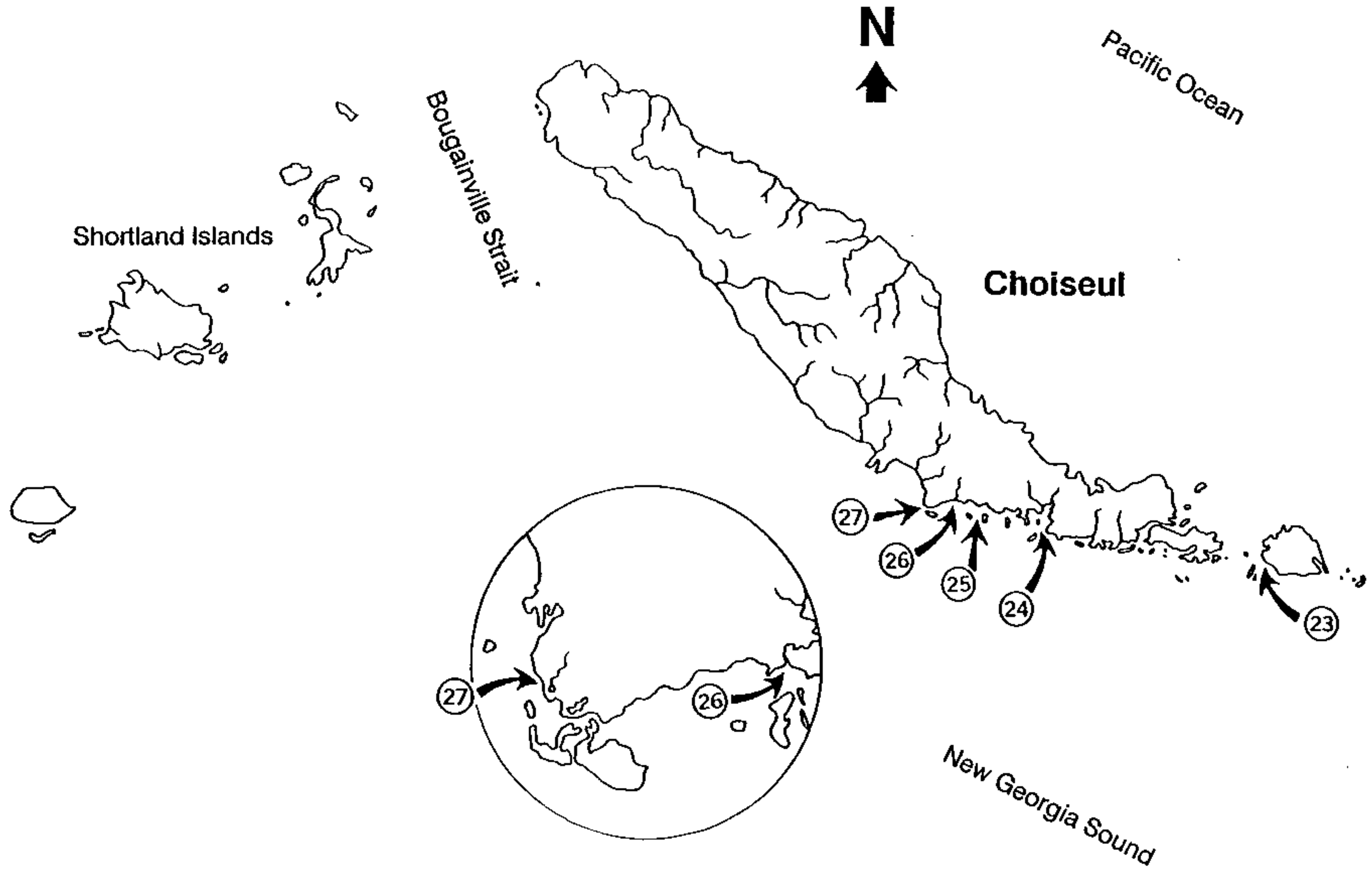


Figure 6. Choiseul Island. Numbered localities are listed in Appendix 2.

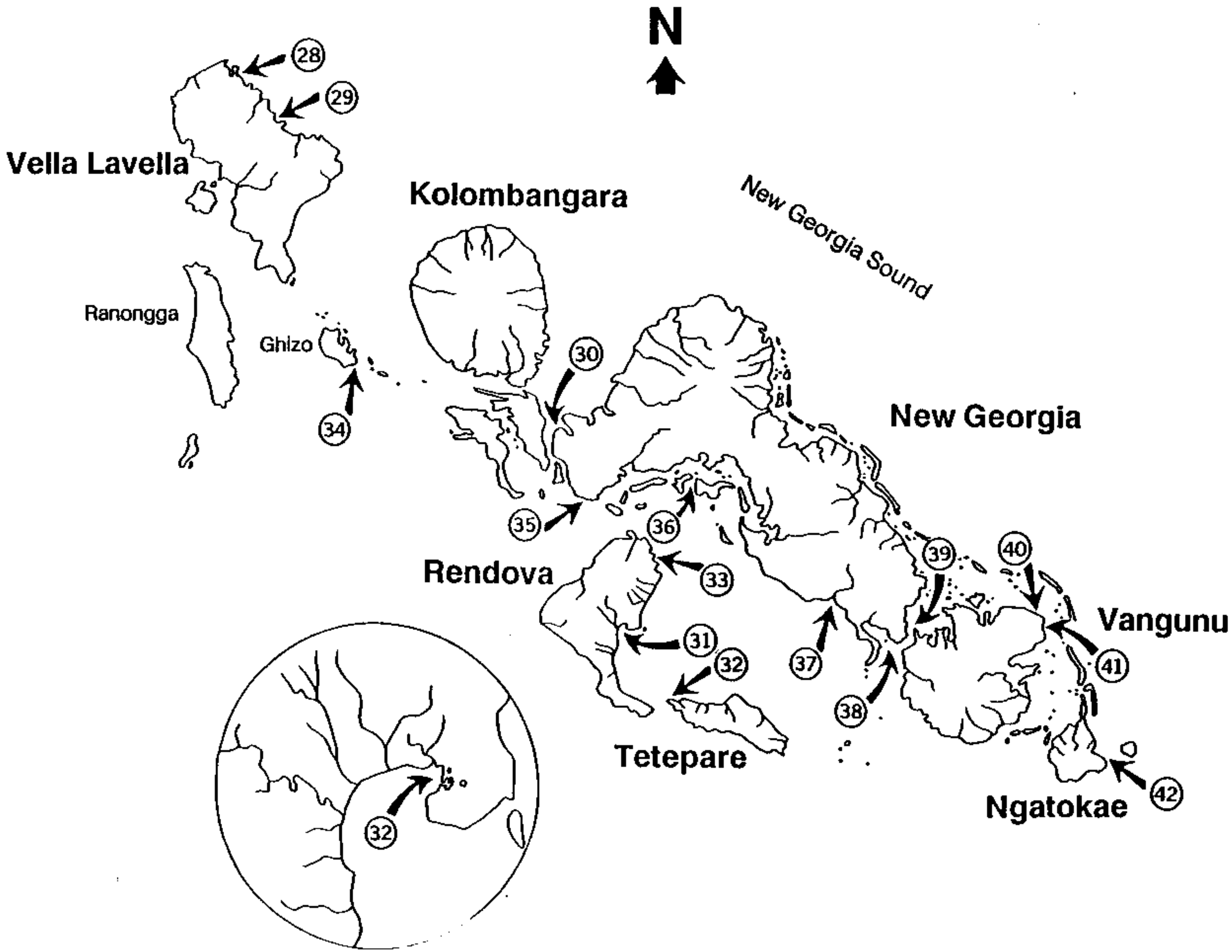


Figure 7. New Georgia Group of Islands. Numbered localities are listed in Appendix 2.

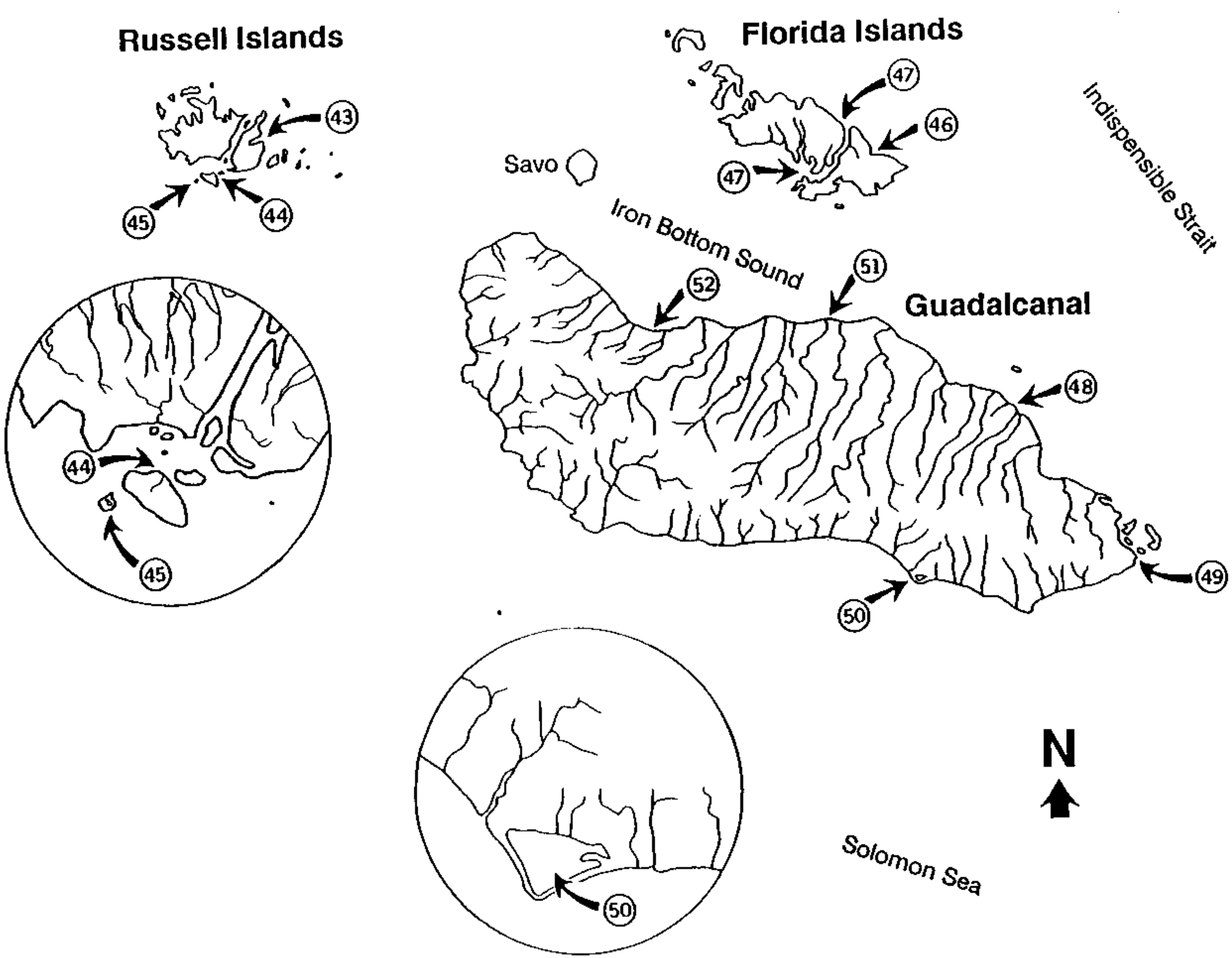


Figure 8. Russell Islands, Florida Islands, and Guadacanal. Numbered localities are listed in Appendix 2.

Food preference and fish atractability in young Nile Crocodile.

Morpurgo,B., Gan-Shmuel Crocodile farm, Israel
Gvaryahu,G., and Robinzon, B. , Department of Animal Science, Faculty of Agriculture, the Hebrew University of Jerusalem, POB 12 Rehovot 76100 Israel.

Introduction

Fish is considered to be an importent element in the diet of young Nile Crocodiles in nature (Cott, 1961). On crocodile farms, Nile Crocodiles are usually fed a meat mixture containing fish, beef, and a vitamins and minerals supplement (Hutton, 1987; Lawrance & Loveridge, 1988).
A distinct preference exist for live food (Pooley, 1962), and young Nile Crocodiles eat more live fish and frogs than sliced meat. Crocodylus johnstoni preferred dead whole fish to chopped fish (Webb et. al., 1983).
In the present study by using a cafeteria experimental regimen, the preference for four different types of feed was determined:
1. Live fish; 2. Dead fish; 3. A choped meat mixture; 4. Live chicks.
Importance of motion, freshness, color, size, shape and particular species of fish was tested as to its attractability for the Nile Crocodile.

Methods

A flock of 500, 15 month old Nile Crocodiles at the Gan-Shmuel Crocodile farm, were used for this experiment. The flock was maintained in a round 75 m^2 windowless chamber in which the middle area (67%) was covered with water. Water temperature was controled at 30°C. Light was provided only during feeding times. Food attractability was examined using a two choice cafeteria preference test (Robinzon et. al., 1980) where following each observation, the fields of food presentation were 180° rotated. The following feeds were assayed: Live fish, dead fish (both ornamental fish of the Ciprinids), live newly hatched broiler chicks and chopped meat with a vitamines and minerals supplement. Each feed was tested when paired to each of the others.

Four repetitions of each pair were conducted in randome order. Following the termination of this stage, the same experimental design was used in order to determine the role of freshness, size, colour and shape/species as determinants in fish attractability. The first three factors were examined by using colored ornamental Ciprinids of 2-8 cm in length. In the freshness study fresh dead fish (grade A), dead fish stored in 0°C for 24 h before presentation (grade B) and fish stored at -20°C for a week and defrosted before presentation (grade C) were used. For the fish's size effect we used fresh dead fish scattered to "small" (2-8 cm) and "big" (8-15 cm) size groups were used. The color effect was examined using two types of ornamental Ciprinids: Red-orange (colored) and black-gray (dark). The effect of the species types was determined in a cafeteria test using dark Ciprinids and dark Tilapias. Data was analyzed using the non-parametrical Mann-Whitney U-test (Sigel, 1956).

Results

In general, live fish were significantly preffered to all other forms of feed. Dead fish were the second choice, while live chicks were preferred to chopped meat (Fig. 1).

Freshness played a significant role in fish attractability and as the grade declined so did the preference (Figs. 2,3,4). The crocodiles preferred "small" to "big" fish (Fig. 5) and colored to dark (Fig. 6). Ciprinids were significantly preferred to Tilapia, however this preference was not immediately demonstrated within the first minute but following several minutes of consumption instead (Fig. 7).

Discussion

The crocodiles preferred fish, both live and dead to chicks or ground meat. Since fish, but not chicks or ground meat are present in the crocodiles natural habitat, it is possible that the preference for fish is the manifestation of an innate attraction for this feed (McFarland, 1987). Motion seemed to be a component in the fish attractability, since live, jerking fish seemed the choice feed.

The ground meat was the least preferred. This is in accordence with Webb et. al. (1983) observations of *Crocodylus jhonstoni*. In an experiment where ground meat with vitamins and minerals supplement was compared to fish and chicks, no difference in growth rate and general appearence of the crocodiles was noted (Morpurgo et. al., in preparetion). Thus, the value of work invested in the laboreous preparetion of the ground meat is questienable.

The freshness of the dead fish affected immediatly preference and the crocodiles allways preferred the fresher fish. This agrees with previous observations both in the natural habitat (Cott, 1961) and in captivity (De-Vos, 1982). As for the nature of cues by which the crocodile detects the freshness, further study is needed. As Hutton (1987) has demonstrated, the crocodiles preferred fish of a suitable size for immidiate swallowing over the larger ones. When presented with dark Ciprinids and Tilapias, preference for the Ciprinids was demonstrated following the first five minutes. Since the Tilapias have hard back fins and the Ciprinids are completly smooth it is reasonable to assume that the crocodiles prefer the latter to the former. However, it seems that the crocodiles have no method to differentiate between the two species and they had to figure out the location of the more agreeable fish, whenever the fish were presented. The crocodiles in the present experiment were accustomed to Tilapias and ornamental Ciprinids which were provided to them on a regular basis. Since, the ration of ornamental Ciprinids useually contained many colored speciments while that of the Tilapias only dark ones, it is possible that the crocodiles immediate attraction to colored Ciprinids over dark ones, was the manifestation of the previous experience and that the color served as an acquired cue for their ability to differentiate between Ciprinids and Tilapias, this cue was lacking when both the Ciprinids and the Tilapias were dark.

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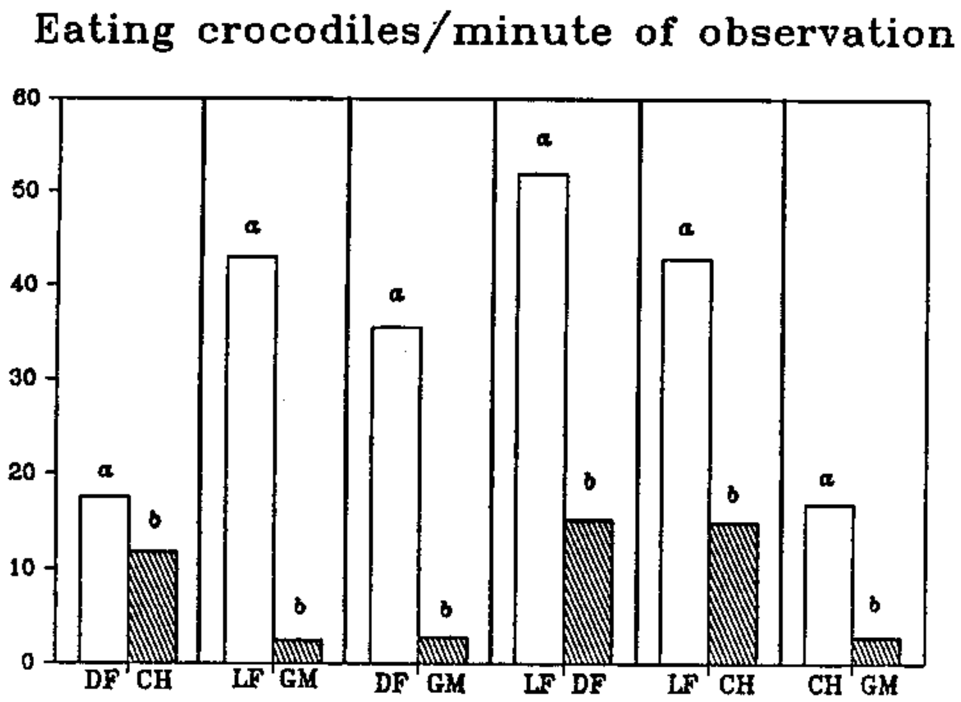

Figure 1.

Number of eating crocodiles (average for a minute of observation, in a total period of 10 min.) in a cafeteria regimen where the following feeds were compared: Dead fish (DF); Live fish (LF); Live chicks (LC) and Ground meat (GM).

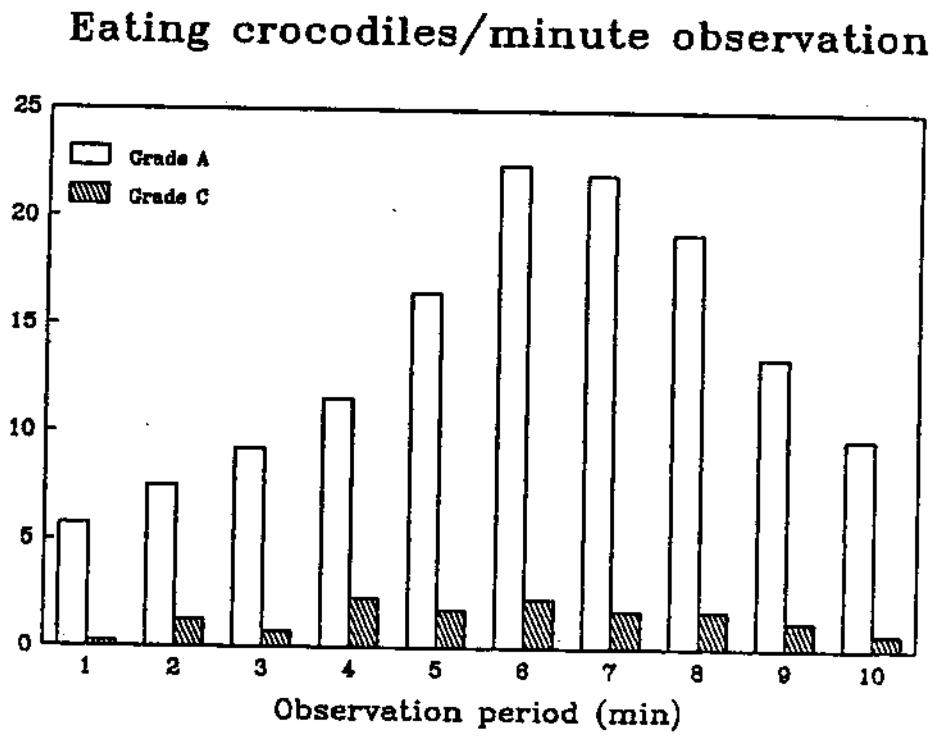

Figure 2.

Number of eating crocodiles at each minute of observation in a cafeteria regimen where fish of grade A and C were compared.

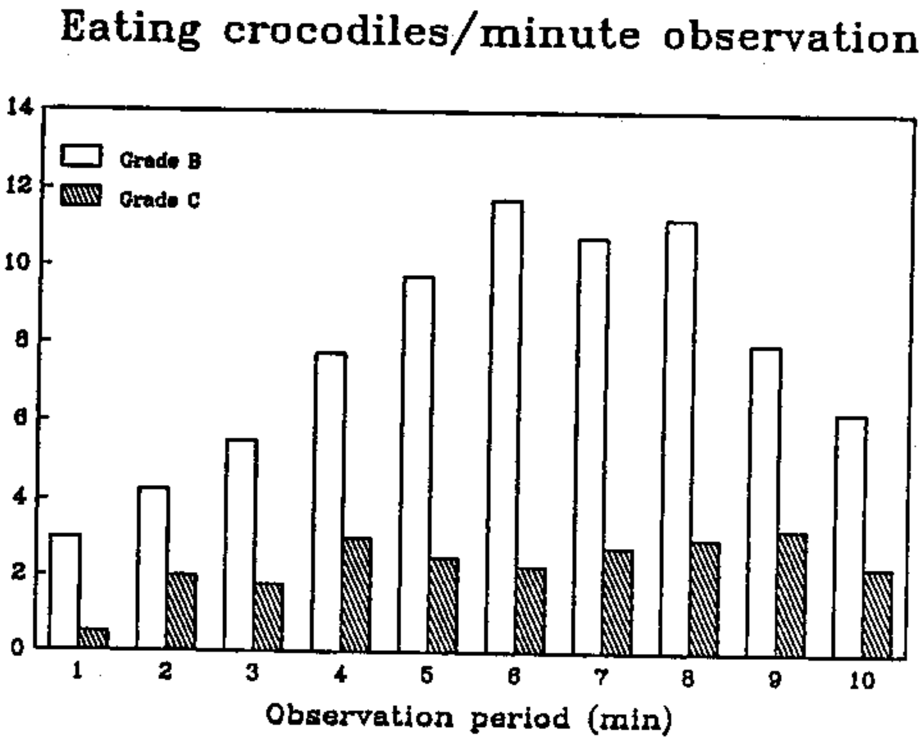

Figure 3.

Number of eating crocodiles at each minute of observation in a cafeteria regimen where fish of grade B and C were compared.

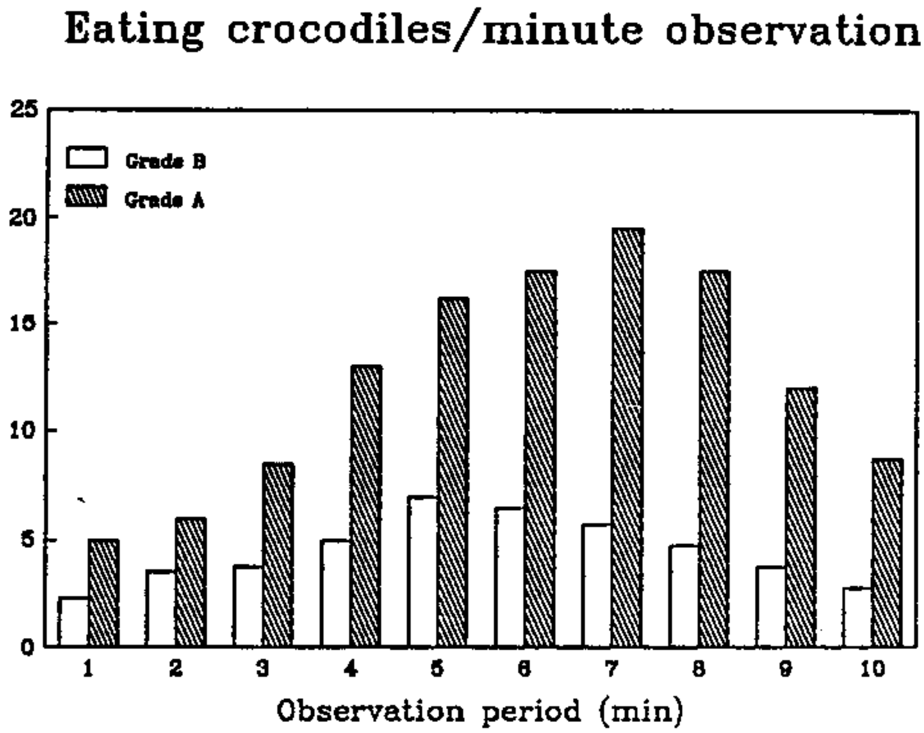

Figure 4.

Number of eating crocodiles at each minute of observation in a cafeteria regimen where fish of grade B and A were compared.

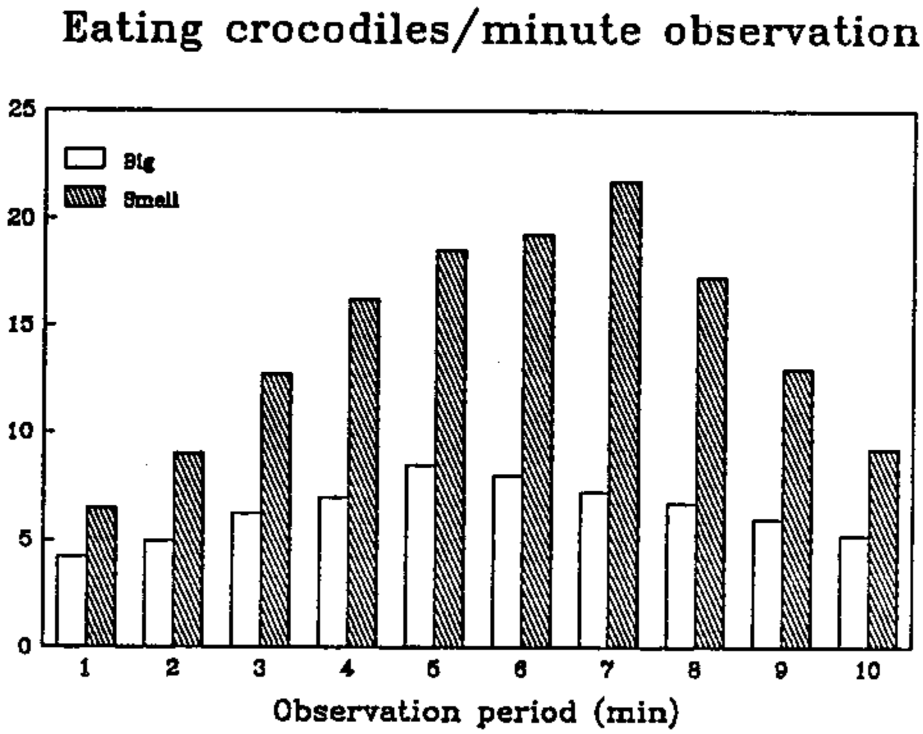

Figure 5.

Number of eating crocodiles at each minute of observation in a cafeteria regimen where big and small fish were compared.

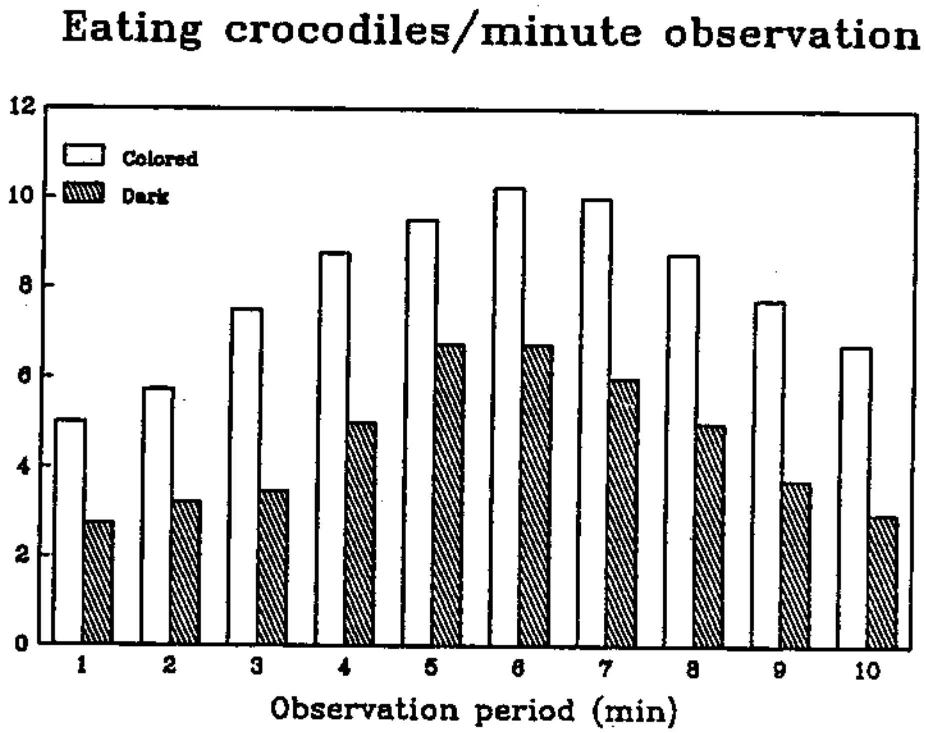

Figure 6.

Number of eating crocodiles at each minute of observation in a cafeteria regimen where colored and dark Ciprinids were compared.

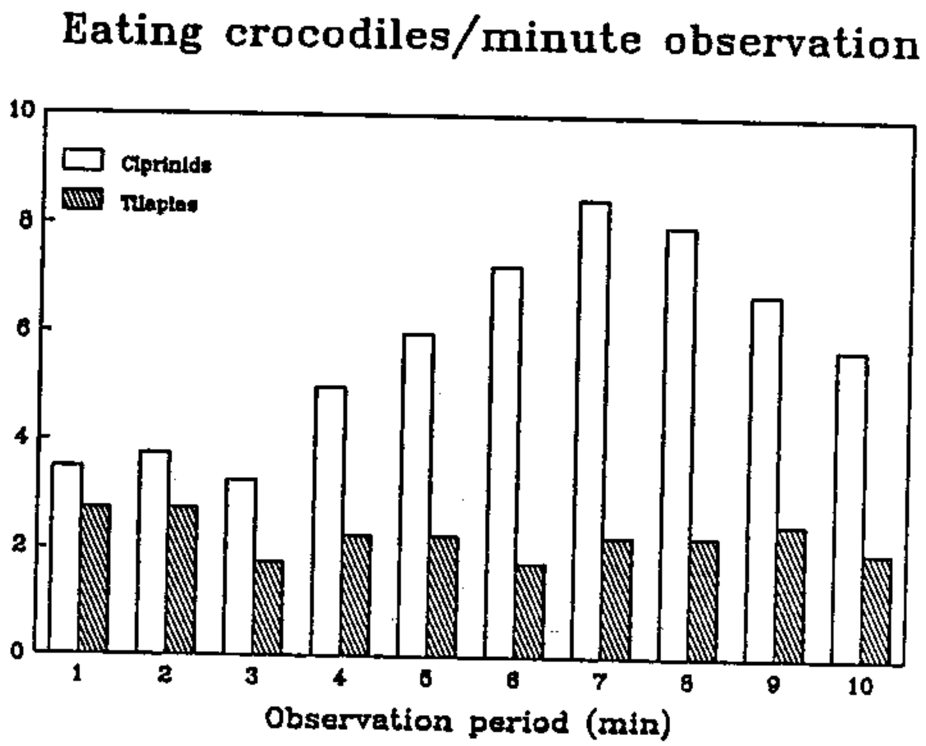

Figure 7.

Number of eating crocodiles at each minute of observation in a cafeteria regimen where dark Ciprinids and Tilapias were compared.

TRANSPORTATION AND ARTIFICIAL INCUBATION OF AMERICAN ALLIGATOR EGGS

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Abstract.--One hundred twenty-eight American alligator (*Alligator mississippiensis*) eggs were collected and incubated to test the effects of four incubation materials and transportation methods on hatching success. The four nest materials tested were marshhay cordgrass (*Spartina patens*), maidencane (*Panicum hemitomon*), grass hay (*Paspalum notatom*), and sphagnum peat (*Sphagnum* sp.). No difference in hatching success was found among the nest materials. Sixty-four eggs were transported cushioned (10 cm foam rubber under the transportation container) and 64 were transported noncushioned (no cushioning under the transportation container); no difference in hatching success was found between transportation methods. Thirty-two eggs were collected to test the effects of wet and dry incubation units on egg hatchability. Hatching success did not vary between the incubation units. Seventy-eight eggs were collected on 5 dates at biweekly intervals during the incubation period to test time of collection on egg hatchability. Hatching success of alligator eggs did not differ among collection dates.

Alligator farming is increasing in Louisiana as an economic venture. In 1986, 14 commercial farms were operating in the state (Sheldon and Joanen 1986). By 1988, the number of commercial farms had grown to 64 and further expansion of the industry was expected (La. Dept. Agri. 1989). A major problem for commercial operations is obtaining hatchling alligators for use as growing stock. In the past, alligator farmers maintained breeding alligators in enclosures, collected eggs from nests within the enclosures, and artificially incubated the eggs to produce growing stock. Maintenance of breeding alligators is expensive and labor intensive. In 1988, landowners began to collect eggs from nests of wild alligators and to sell them to alligator farmers (La. Dept. Agri. 1989).

Several studies have been conducted on artificial incubation of alligator eggs (Chabreck 1971, 1978; Ferguson and Joanen 1982; Joanen and McNease 1975, 1977, 1979). Studies have dealt with collection techniques, incubation temperatures, temperature dependent sex determination, and collection time.

Advantages of artificial incubation include the elimination of natural losses and predation (Pooley 1973, Blake and Loveridge 1974, Chabreck 1978), and elimination of weather related mortality (Joanen and McNease 1977, Chabreck 1978). Additionally, rearing young alligators in controlled environments reduces hatching year mortality as compared to that experienced in the wild (Joanen and McNease 1979).

Studies do not agree on the proper time of egg collection. Pooley (1971) recommended early egg collection. Conversely, Blake and Loveridge (1974) indicated that collection shortly after laying had a detrimental effect on hatching success compared to later egg collection. Chabreck (1978) concluded that the hatching rate of alligator eggs could be maximized by delaying egg collection until the fourth week of incubation.

The objectives of this study were to determine the effects of different incubation materials on hatching success of alligator eggs, to test the effects of cushioned and noncushioned transportation on hatching success, to evaluate the effects of time of collection on hatching success, and to determine if different types of incubators influence hatching success.

The authors are grateful to personnel of the U. S. Fish and Wildlife Service for assistance during the investigation.

DESCRIPTION OF STUDY AREA

Alligator eggs for this study were collected on Lacassine National Wildlife Refuge (LNWR) in southwestern Louisiana. The refuge contains a 6,478-ha freshwater impoundment referred to as Lacassine Pool. Eggs were collected from the northern portion of Lacassine Pool.

Selective, commercial harvesting of alligators is conducted on the refuge under strict regulations. Alligator harvesting was resumed in 1983 after 32 years with no harvest. In that interim, the alligator population increased from an estimated 500 to 10,000 individuals (Brown and Yakupzack 1983:27).

The 30-year (1951-1980) average annual temperature for the area (southwest division of Louisiana) was 19.7 C with monthly mean temperatures ranging from 10.2 C (January) to 27.8 C (July). Mean temperature for 1988 was 19.0 C, with a mean low temperature of 7.3 C in January and a mean high temperature of 27.5 C in August. Monthly temperatures for the study period were May (22.3 C), June (25.3 C), July (27.1 C), and August (27.4 C) (USDC 1988).

The 30-year (1951-1980) average annual precipitation for the study area was 145.6 cm, with mean monthly precipitation ranging from 8.8 cm (October) to 16.2 cm (July). Precipitation for 1988 was 145.8 cm, and monthly precipitation for the study period was May (7.3 cm), June (16.4 cm), July (13.26 cm), and August (8.6 cm) (USDC 1988).

The two major plant communities in Lacassine Pool are the emergents and floating-leafed/submergents. Maidencane and bulltongue (*Sagittaria lancifolia*) are the most abundant species in the emergent community. Other emergents include spikerush (*Eleocharis* spp.), waterhyssop (*Bacopa* spp.), giant cutgrass (*Zizaniopsis milaceae*) and pennywort (*Hydrocotyle* spp.) (Carbonneau 1987:7).

METHODS

Nest Materials and Transportation Study

Egg Collection

Alligator eggs were collected on July 1, 1988 from nests on LNWR. Nests were located by aerial searches of the Lacassine Pool and marked by dropping a marker at the approximate nest location. Nests were then located by ground searches from an airboat.

Four nests were located and 32 eggs were collected from each nest. Eggs were selected from various positions in the nest and cracked eggs were not selected. Each egg was marked to indicate the upright position as deposited in the nest (Chabreck 1978). The eggs from each nest were randomly separated into 2 groups of 16 eggs each. The 2 groups were placed upright into separate metal containers (130 L) containing material removed from the nest to cushion and stabilize the eggs. Thus, 16 eggs from each nest were placed into one of 2 containers, with approximately 10 cm of nest material placed between each clutch.

Transportation

Eggs were transported from the Lacassine Pool in an airboat and transported 160 km by a covered 1/2 ton pickup truck to Louisiana State University, Baton Rouge, on the same day as collected. One of the containers was transported on a 10-cm thick foam rubber pad (cushioned) and the other was transported without padding (noncushioned). Transportation from the collection site to Baton Rouge took approximately 4 hours. Upon arrival, eggs were stored overnight in a temperature control room at 32 C. The following day, eggs were separated into groups as described later and placed in incubators.

Incubation Materials

Four incubation materials were tested; marshhay cordgrass, maidencane, grass hay, and sphagnum peat. Marshhay cordgrass was collected from alligator nests found in brackish marsh on the Rockefeller Refuge (ca. 30 km south of the study area). Maidencane was collected from natural nests at the same time eggs were collected. The grass hay had been baled at the LSU farm, Baton Rouge, Louisiana the previous year and stored in a dry area. The sphagnum peat was uncut, long-fibered peat purchased from a commercial source. Marshhay cordgrass and maidencane were moist at the time they were collected. They were further moistened with warm tap water from a mist-type spray bottle before being used for incubation medium. Grass hay and sphagnum peat were dry when obtained and were thoroughly saturated by soaking in water approximately 1 hour before being used as incubation medium. The sphagnum peat had a high water holding capacity and excessive water was removed before the peat was placed around the eggs.

Incubation Containers

Eggs were incubated in plastic containers (30 x 30 x 15 cm) each fitted with a wooden lid to help slow evaporation. Water was placed 2 cm deep in the containers to provide moisture. A 2.5-cm thick wooden board was placed in the bottom of each container to keep the eggs above water. Moistened nest material was placed to a depth of 10 mm under and 10 mm over the eggs.

The 16 cushioned and 16 noncushioned eggs from each nest were divided into 8 groups of 2 eggs each. The 2 eggs from each group were placed in separate plastic mesh bags (10 x 10 x 30 cm) then placed in separate incubation containers. Bags were labeled to identify nest and method of transportation. The 8 containers were separated into 4 groups of 2 replications each and 1 group was assigned to each of the 4 nesting materials for testing. The remaining cushioned and noncushioned eggs were divided and grouped in the same manner and placed in the same 8 containers so that each container held 2 eggs from each of the 4 nests.

Incubation

Eggs were incubated in low temperature incubators (Precision model 818). The incubators were equipped with a solid state heat proportioning circuit to achieve sensitive temperature control ($\pm$ 0.1 C). Incubators were equipped with a circulating fan to provide even air distribution throughout the chamber and to assure temperature uniformity. Mercury maximum-minimum thermometers were placed in the incubators to indicate temperature and to indicate mechanical failure of the internal temperature thermometer.

All eggs were incubated in low temperature incubators at a constant temperature of 31.5 C and checked twice weekly to ensure that proper moisture (determined by visual observation) was maintained. When the nest material was drying it was apparent when the lid was removed from the incubation container. The surface of the nest material would be light in color and appear dry and brittle to the touch. Nest materials were dampened as needed with a mist-type spray bottle. At the estimated time of hatching, approximately the third week of August, eggs were inspected at 2-day intervals and young that had hatched were removed.

Date of Collection Study

A study was conducted to determine if time of alligator egg collection influenced hatching success. Two nests were located adjacent to a perimeter levee of Lacassine pool. Eight eggs were randomly collected from each nest at two-week intervals for 8 weeks. Eggs were collected on 1, 14, and 29 July and 12 and 26 August 1988. The eggs were marked, cushioned, transported and incubated as previously described. The 16 eggs from each collection period were incubated in the same container in sphagnum peat.

Incubation Unit Study

Eggs were collected on 1 July 1888 and were marked, transported as previously described, and placed in incubation units. Two types of incubation units, a dry unit and a wet unit, were tested. The dry unit was a low temperature incubator (Precision model 818), and the wet unit was a humidity chamber (Conviron model E-15). The dry unit had no free water in the unit and the air within the chamber was not humid. The wet unit circulated free water, and the air within the chamber was saturated with moisture so that the humidity was maintained at 100%.

Thirty-two eggs were placed in the 2 types of incubators. Sixteen eggs from each of 2 nests were randomly selected, and 8 eggs from each nest were placed in each type of incubation unit. Incubation containers were similar to those previously described. No cover was placed on containers in the wet unit, but incubation containers in the dry unit were covered with a lid to maintain a high moisture level within the container. Eggs were incubated in sphagnum peat at a constant temperature of 31.5 C.

RESULTS

Incubation Materials and Transportation Study

Nests and Incubation Materials

Thirty-two eggs from each of 4 nests were incubated in 4 different incubation materials, and hatching rates were compared. Of the 128 eggs incubated, 82% hatched. The number of eggs hatched did not differ among nests ($F = 0.6172$; 3, 21 df; $P = 0.574$) or incubation materials ($F = 2.263$; 3, 21 df; $P = 0.068$) (Table 1).

Table 1. Number of eggs hatched from each nest[a] according to incubation materials. Eggs collected 1 July 1988 on Lacassine National Wildlife Refuge, Cameron Parish, Louisiana.

Nest Number	Incubation Materials				Nest Mean
	Spartina patens	Panicum hemitomon	Paspalum notatum	Sphagnum sp.	
1	6	8	8	4	6.5
2	7	8	7	6	7.0
3	6	6	7	5	6.0
4	6	7	7	7	6.8
Mean	6.3	7.3	7.3	5.5	6.5

[a]Thirty-two eggs were incubated from each nest with 8 eggs in each incubation material.

Cushioned vs. Noncushioned

The 128 eggs used for the incubation material study were also used for the transportation study. Sixty-four eggs were transported cushioned and 52 of these (81.3%) hatched. The other 64 eggs were transported noncushioned and 53 (82.8%) hatched. Data analysis showed no difference in hatchability between eggs transported cushioned and noncushioned ($F = 0.205$; 1, 21 df; $P = 0.638$).

Collection Date Study

Seventy-eight eggs for the collection date study were collected at 2-week intervals for 8 weeks beginning on 1 July

1988. Three fertile eggs did not hatch and in 2 of these embryos were dead before the collection date, thus their death could not be attributed to the time of collection. With only 1 fertile egg not hatching, it is obvious that collection dates did not influence the hatching rate. Because of the similarity of hatching success among collection dates, data were not tested statistically.

Incubation Unit Study

Thirty-two eggs were incubated in wet and dry incubation units to determine if the units affected egg hatching success. Sixteen eggs were incubated in each unit. Fourteen eggs hatched in the wet unit and 15 eggs hatched in the dry unit. Because of the similarity of hatching success between units, differences in hatching success were not tested statistically.

DISCUSSION

Incubation Materials

Nest materials used for this study included marshhay cordgrass and maidencane, which are common nest materials in the wild, and grass hay and sphagnum peat which are incubation materials readily available to alligator farmers. Chabreck (1971) indicated that organic materials are best for artificial incubation material.

Hatching rates did not differ among the 4 nests or the 4 incubation materials used in the study. However, eggs in grass hay and maidencane had a 90.6% hatching rate. Eggs in marshhay cordgrass had a 81.3% hatching rate, and 68.8% of the eggs hatched in sphagnum peat. The hatching rate in the sphagnum peat was affected by the high number (10) of faulty eggs. Whether the eggs were infertile or the embryos were killed by excessive moisture in sphagnum peat at the onset of the study could not be determined. However, eggs incubated in sphagnum peat to test differences between incubation units had a 90.6% hatching rate.

Differences in drying time among marshhay cordgrass, grass hay, and maidencane were not observed. Their water holding capacities appeared equal, and the incubation materials required moistening about twice each week. Sphagnum peat held more moisture, held it longer, and required moistening only once each week.

Care should be taken when using sphagnum because of its high water holding capacity. If an excessive amount of water is present, the embryos may not properly exchange respiratory gases and may die. With proper wetness, sphagum peat will not contain surplus water that can be squeezed from the material.

Ferguson (1981) reported that the structure of the alligator eggshell is not very porous at the time of laying. The lack of pores increases shell strength, prevents damage as the eggs are dropped in the nest, and helps prevent dehydration of the eggs. As incubation progresses, extrinsic acidic degradation of the eggshell increases the shell porosity. The increased porosity allows for the exchange of respiratory gases and water vapor from the enlarging alligator embryo. Ferguson stated that this may explain why alligator eggs artificially incubated without proper incubation medium failed to hatch or died when abnormally tough eggshell did not allow the baby alligator to escape from the egg (Ferguson 1981).

Cushioned vs. Noncushioned

Pooley (1971) suggested that Nile crocodile (*Crocodylus niloticus*) eggs be cushioned during transportation. He recommended that transportation containers be placed on a bed of dried grass 30 cm deep. The 128 eggs used for the incubation materials study were similarly handled and placed in transportation containers that were transported cushioned and noncushioned. The cushioned eggs were transported with a 10 cm foam rubber pad under the transportation container from the time they left the nest until reaching the laboratory in Baton Rouge. The only padding the noncushioned eggs received was from nest material removed from the natural nest at the time of collection and placed in the containers. This natural nest material was used in cushioned and noncushioned containers and was placed between clutches to protect the eggs and prevent excessive drying. One hundred and five of 128 eggs hatched with almost equal hatching rates in eggs from each transportation method. Statistical analysis indicated that cushioning as provided in this study was not effective in increasing the hatching rate of eggs.

Collection Dates

Previous studies indicated that egg collection after the fourth week produced the best hatching success (Blake and Loveridge 1974; Joanen and McNease 1975; Chabreck 1978). However, Chabreck (1978) reported that adequate hatching results could be obtained from early collection if proper collection methods were used. Later studies by Ferguson (1981), Joanen and McNease (1981), Ferguson and Joanen (1982) also found that eggs could be collected early in the incubation period with acceptable hatching success.

Eight eggs were collected from each of 2 nests during 5 collection periods; however, 1 nest had only 6 eggs the last collection date. Three fertile eggs did not hatch and only 1 of these could have been affected by the time of collection. It was collected 1 July. The other 2 fertile eggs that did not hatch were collected 24 August, and the age of the dead embryos revealed that death had occurred in the second or third week of development, which was 5 to 6 weeks prior to the collection date (24 August). No difference was found in hatching success between early and late egg collection. However, we followed the recommendations of Chabreck (1978) and maintained eggs after collection in the position as found in the nest.

Incubation Units

Thirty-two eggs were collected 1 July 1988 to test the effects of wet and dry incubation units on egg hatching success. The eggs were collected from 2 nests with 16 eggs removed from each nest. Eggs were incubated in sphagnum peat. The wet unit provided high humidity (100%), and the incubation material did not require that water be added during the study period to keep the eggs from drying. The free water in the bottom of the incubation containers in the wet unit did not require refilling. The incubation material in the dry unit required that water be added biweekly even though egg containers were covered to decrease evaporation. Free water in the bottom of the incubation containers in the dry unit had to be refilled every 2 weeks because of evaporation. Fourteen fertile eggs in the wet unit hatched and 15 fertile eggs in the dry unit hatched.

If a large number of eggs is being incubated, a wet unit would greatly decrease the workload because biweekly moistening of incubation material is not required. However, a wet unit may not be available to most farmers, and if a temperature controlled dry room is used, it is imperative that proper moisture be maintained in the incubation medium. Optimum moisture level was not quantified, but excessive moisture may be more damaging to eggs than inadequate moisture.

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A comparison of 3 survey methods for estimating relative abundance of rare crocodilians

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INTRODUCTION

Night count surveys are used widely to census crocodilian populations. Night counts are used for relative abundance estimates and for actual population estimates (Magnussen et al 1978; Messel 1981; O'Brien 1983; O'Brien and Doerr 1986). Other methods of surveying include aerial day and night counts (Graham 1968; Parker and Watson 1970), aerial counts of nests (McNease and Joanen 1978), daytime surface counts and counts of basking animals (Thompson and Gidden 1972). Each of the above mentioned methods has its own advantages and disadvantages. Problems involving costs, logistics, and analytical interpretation must be weighed in deciding the best method to use.

Although night count surveys have been successful, alternative techniques are noteworthy. Night counts are burdensome for wildlife personnel accustomed to working with diurnal species. Daylight counts are more convenient but may have problems with visibility of animals that move away from the water edge to bask. Daylight aerial counts can cover large and inaccessible areas in a short time period but may be expensive in more remote parts of the world.

In view of the advantages of each method, this study was developed to compare surface day and night counts and aerial day counts for surveying crocodilian populations. I considered the alligator population in North Carolina as representative of a low density crocodilian population. North Carolina is the northern limit of the alligator'range, and densities ranged from 0.16/km. in the southern part of the state to 0.075/km (O'Brien and Doerr 1986) in the northern part of the range.

METHODS

Survey routes were established in 2 areas of the North Carolina coast (Fig. 1): 10 routes in the southern part of the state and 4 routes in the central portion. The 14 survey routes consisted of 3 river, 5 lake and 6 estuarine routes ranging in length from 5.5 to 16km. Survey routes were established arbitrarily to: 1) use routes with known presence of alligators based on prior surveys and 2) to clump survey routes for aerial counts. Each estuary and river route was surveyed twice with each method. Lake routes were surveyed twice by air but only once by surface day and night counts because of time and access constraints.

Aerial surveys were made in a Piper Super Cub from approximately 90 m altitude and at a speed of approximately 130 km/hr. Height and speed were checked every 2 minutes to assure consistency. I counted visible alligators and recorded start and stop times for each survey. Air surveys were conducted between 0900 and 1200 on 4 days from 17 - 23 April 1980.

Surface day counts and night counts for a given route were conducted on a single day and used similar procedures. I used a 3m flat-bottomed johnboat with a 9.9 hp outboard motor in all surveys. The boat was operated at 10-15 km/hr down the middle of a river, or approximately 100 m from the shoreline of a lake or estuary. Total time of each survey depended on route length and averaged 1.3 hours. Day counts began between 0900 and 1100 and night counts began 1 hour after sunset. A 12-volt, 200,000 candlepower was used on night surveys to detect eye reflections of alligators. Day and night count surveys were conducted from 24 April to 14 May 1980.

Data analysis compared the 3 survey methods using $\log_{10}$ transformation of the density of observed alligators as the dependent variable in an analysis of variance model (Snedecor and Cochran 1967). The $\log_{10}$ transformation was used to reduce heterogeneity of variance. The design treats survey method and water type as cross-classified factors, with survey routes nested within water types and with repeated measurements on survey routes. The data set was analyzed as a whole, partitioned by water type, and partitoned by survey method. In the overall model, factors were tested using the appropriate mean square, determined by partitioning the components of variance, as the error term. Components of variance were also examined. All data analyses used procedures of the Statistical Analysis System (SAS 1985).

RESULTS AND DISCUSSION

<u>Survey Method Comparisons</u>

Visibility was considered excellent under all conditions except when aerial counts were conducted on rivers traversing wooded areas. Here, canopy closure over water occasionally made observation difficult or impossible.

An average of 0.15 (range 0-0.63) alligators/km/route/survey was observed on aerial counts, 0.087 (range 0-0.50) alligators/km/route/survey on surface day counts, and 0.29 (range 0-1.86) alligators/km/route/survey (Table 1; Fig. 2). Although survey routes were selected to minimize the frequency of 0-observations, 36% of aerial, 52% of surface day, and 30% of night count surveys resulted in no alligators being observed. Zero-observations tended to be paired for repeated observations on individual routes, reducing mean number of alligators observed, within route variability, and the ability to detect factor differences using F-Tests.

Analysis of variance indicated no significant differences ($P>0.05$) in observed alligator densities for the 3 methods, and no significant differences ($P>0.05$) in alligator densities for the 3 water types (Table 2). The comparison of survey methods by water type (Table 3) showed no significant differences in alligator densities ($P>0.05$). The comparison of water types by survey methods (Table 4) also showed no significant differences in alligator densities.

Significant differences ($P<0.05$) in density were detected for survey route and for the survey method by survey route interaction (Table 2, 5). Observed alligator densities were significantly different between survey routes on rivers, but not on lakes or estuaries. Variability between route within water types accounted for 37% of the total sum of squares (Table 2), indicating high spatial heterogeneity in alligator densities between routes within water types. The survey method by survey route interaction accounted for 42% of the total sum of squares and indicated that within certain routes, the survey methods yielded different results. Day surface counts on estuarine routes were extremely low compared to other methods. Night counts on lake routes were very high compared to other methods (Table 5).

Advantages and Disadvantages of the 3 Methods

There are several logistical and biological considerations that may influence the choice of survey method appropriate for a particular situation. Crocodilian behavior, season, agency resources, and habitat differences must be considered when choosing a method.

Surface day counts require the least equipment and are the most easily scheduled. Although highly desirable from a logistical viewpoint, there are many 0-counts (52% of all surveys) associated with surface day counts in this study. This suggests that alligators may be less visible during surface day counts than during aerial or night counts.

Several explanations for reduced visibility exist. Alligator activity changes seasonally (Smith 1975) from primarily diurnal patterns early in the season to primarily nocturnal in late spring and summer (Hagan 1982). During the day, alligators may readily terminate basking if the sky turns cloudy or when body temperatures approach optimal levels. Alligators in the water are more difficult to observe from the ground during the day because of surface reflection from the sun and because of the low profile usually exhibited. These considerations suggest that season, time of day and weather conditions are critical in scheduling surface day counts.

Aerial counts and surface day counts are subject to many similar problems. Activity patterns and weather should be considered when scheduling aerial counts. Zero-counts during aerial observations (36%) were not significnatly different from 0-counts during night counts (30%), indicating that visibility is satisfactory if the alligators are active. Aerial counts have a distinct financial advantage of being capable of covering large areas in a single flight and are advantageous when a large sample is required in a short time period. The aerial count is most effective in open marsh and lake habitats and least effective in swamps and bottomland hardwoods where canopy closure can block visibility.

Night count methods are preferable because they work in all habitats and coincide with the nocturnal activity pattern of crocodilians. Eye reflections are excellent targets at night, visible at long distances and in situations where the animal might otherwise go undetected.

Design Considerations

Because this study was conducted in areas of very low alligator densities, the results may not be applicable to comparisons of methods for censusing more abundant populations. The low densities and large between-route variance observed in this study made it difficult to detect differences due to methods.

Although the choice of method gives similar results in this study, higher densities and more uniform distributions of crocodilians may result in differences in census methods. Experiments such as this should be replicated to determine if census methods are sensitive to the density and distribution of target populations.

A second consideration for establishing censuses of crocodilians is the determination of the number of survey routes and the number of replications per route. Bayliss (1987) recommends that when conducting surveys to determine relative abundance, precision of estimates is especially important. Assuming a repetition on a single route costs approximately the same as conducting an additional survey on a new route, the deciding factors become the cost of establishing a new route and the reduction in variance resulting from repeated measurements versus additional survey routes. An analysis of the components of variance (Table 4) for each survey method shows that the between route variance component (Var{Route[Water Type]}) tends to be much higher than the within route variance component (Var{Error}) for low density populations. The ratio of between route variance to within route variance is 6.5:1 for aerial counts, 3:1 for day counts, and 5.4:1 for night counts. Because there is much less variation within than between routes for each method, little is gained by repeating surveys on the same route unless the cost of establihing a new route becomes prohibitive.

This point is illustrated by determining the sensitivity of the standard error (SE) to changes in the number of routes and the number of repeated measurements on routes (Snedecor and Cochran

1967, pp 531-534). SE is calculated as the squareroot of Var(Route[Water Type])/r + Var(Error)/nr, where r=the number of routes and n=the number of replications on a route. SE falls dramatically (Fig. 3) in response to increasing the number of routes surveyed by any of the 3 methods. The reduction in SE due to replication, however, is relatively insignificant at any of the levels evaluated. For example, 10 routes surveyed 4 times at night (40 surveys) result in a SE of 0.236, but 14 routes surveyed only once at night result in a SE of 0.212 (Fig. 3). The cost of developing a new route must be very high before it becomes economical to consider repeated surveys on existing routes as a way to increase precision. An optimal allocation of sampling effort, therefore should attempt to maximize the number of routes surveyed in order to maximize the precision of the survey.

CONCLUSIONS

1. No significant differences in observed alligator densities were detected between 3 survey methods when compared over 3 water types or when compared by water type.

2. No significant differences in observed alligator densities were detected between the 3 water types when compared over all survey methods or when compared separately by each method.

3. Significant differences were detected in routes within water type, suggesting a high degree of spatial heterogeneity in alligator observations.

4. Significant differences were found for the survey method by route interaction, indicating that methods may perform differently in different habitats.

5. Night count surveys may be the best choice of the 3 methods if behavior, ease of observation, and non-zero counts are considered. Aerial counts are best for surveying large areas rapidly and for surveying open habitats.

6. When surveying low density crocodilian populations, the number of routes surveyed should be maximized and the each route should be surveyed only once.

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Table 1. Mean alligator density, range, and number of surveys (N) for aerial, surface day and night counts on rivers, lakes and estuaries.

Survey Method	N	Mean	Range
Aerial	28	0.24	0.0 - 1.02
Day	23	0.14	0.0 - 0.80
Night	23	0.47	0.0 - 3.00
Water Type			
River	18	0.13	0.0 - 0.37
Lake	20	0.30	0.0 - 1.86
Estuary	36	0.13	0.0 - 0.87

Table 2. Analysis of Variance of the $\log_{10}$ transformed alligator densities using aerial, surface day and night count surveys in river, lake, and estuary habitats.

Variable	d.f.	M.S.	F-Value[1]
Water Type	2	1.804	1.25
Route(Water Type)	11	1.444	13.42[2]
Survey Method	2	1.979	2.57
Survey Method x Route(Water Type)	26	0.748	7.14[2]
Error	32	0.108	
Total	73		

[1] F-tests are calculated using Water Type vs. Route(Water Type), Route(Water Type) vs. Error, Survey Method vs. Route(Water Type), Survey Method x Route(Water Type) vs. Error.

[2] $P < 0.0001$

Table 3. Analysis of variance of the $\log_{10}$ transformed alligator densities by water type for aerial, surface day and night counts.

<u>River</u>

Variable	d.f.	M.S.	F-Value[1]
Survey Method	2	0.089	1.92
Route	2	3.241	69.96[2]
Survey Method x Route	4	0.046	0.40
Error	9	0.115	
Total	17		

<u>Lake</u>

Variable	d.f.	M.S.	F-Value
Survey Method	2	2.152	3.12
Route	4	0.928	1.34
Survey Method x Route	8	0.690	6.80[3]
Error	5	0.102	
Total	19		

<u>Estuary</u>

Variable	d.f.	M.S.	F-Value
Survey Method	2	0.712	0.64
Route	5	1.138	1.02
Survey Method x Route	10	1.121	10.62[2]
Error	18	0.106	
Total			

[1] F-tests are calculated using Survey Method vs. Survey Method x Route, Route vs. Survey Method x Route, and Survey Method x Route vs. Error.

[2] $P < 0.0001$

[3] $P < 0.05$

Table 4. Analysis of variance (including estimates of variance) of the $\log_{10}$ transformed alligator densities by survey method, for river, lake and estuary habitats.

Aerial

Variable	d.f.	M.S.	F-Value[1]	Variance Estimate
Water Type	2	0.066	0.05	
Route (Water Type)	11	1.329	13.92[2]	Var(Route(Water Type))= 0.617
Error	14	0.095		Var(Error)= 0.095
Total	27			

Surface Day

Variable	d.f.	M.S.	F-Value	Variance Estimate
Water Type	2	0.664	0.82	
Route(Water Type)	11	0.806	5.98[3]	Var(Route(Water Type))= 0.410
Error	9	0.135		Var(Error)= 0.135
Total	22			

Night

Variable	d.f.	M.S.	F-Value	Variance Estimate
Water Type	2	2.122	2.22	
Route(Water Type)	11	0.954	9.61[4]	Var(Route(Water Type)= 0.532
Error	9	0.099		Var(Error)= 0.099
Total	22			

[1] F-tests are calculated using Water Type vs. Route(Water Type) and Route(Water Type) vs. Error.

[2] $P < 0.0001$

[3] $P < 0.01$

[4] $P < 0.001$

Table 5. Mean density of alligators (per km) by survey method for each water type.

Survey Method	River	Lake	Estuary
Aerial	0.13	0.19	0.13
Day	0.12	0.14	0.044
Night	0.15	0.66	0.21

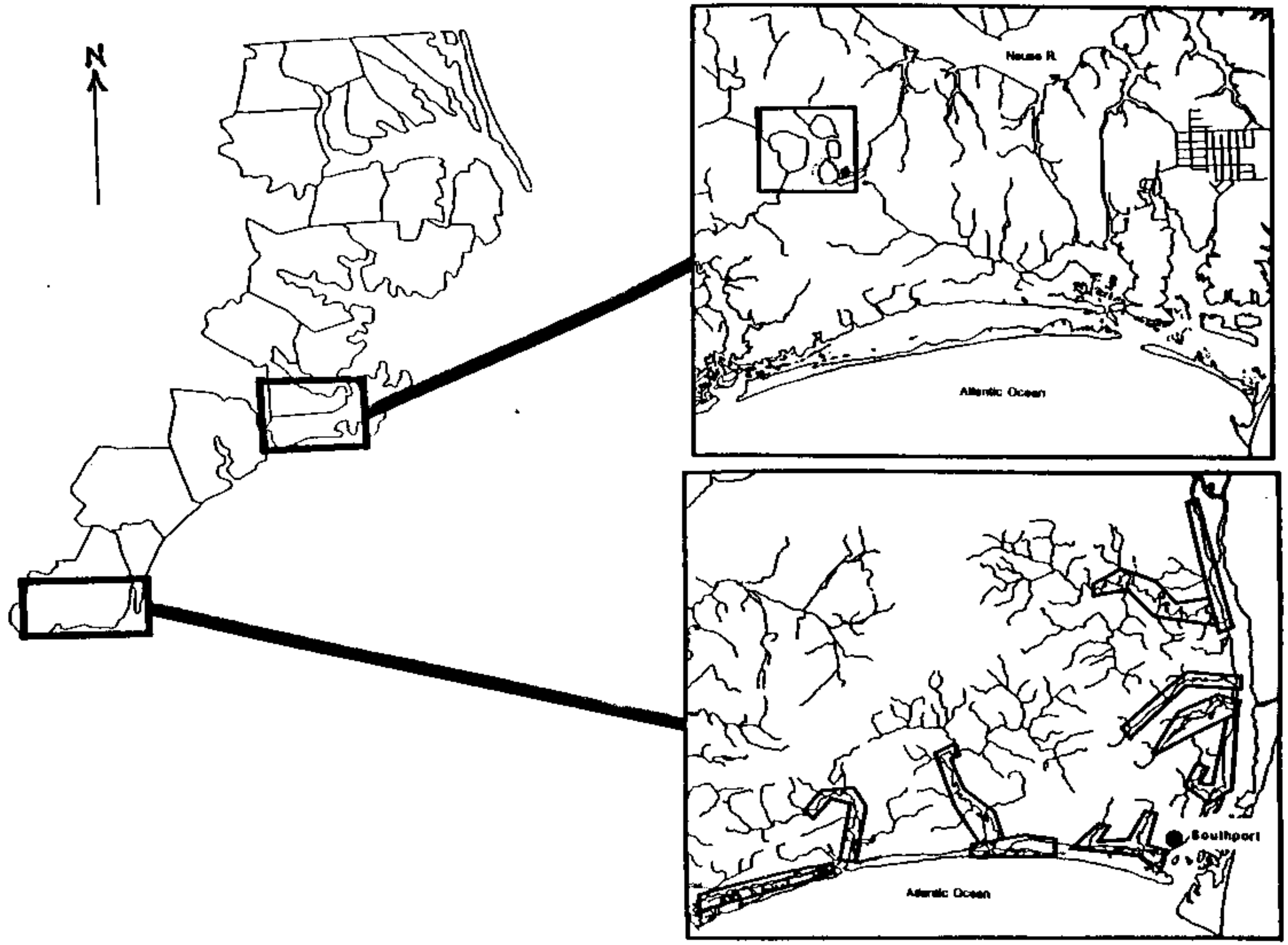

Figure 1. Location of 2 study areas and survey routes used to compare aerial, surface day and night count surveys in coastal North Carolina.

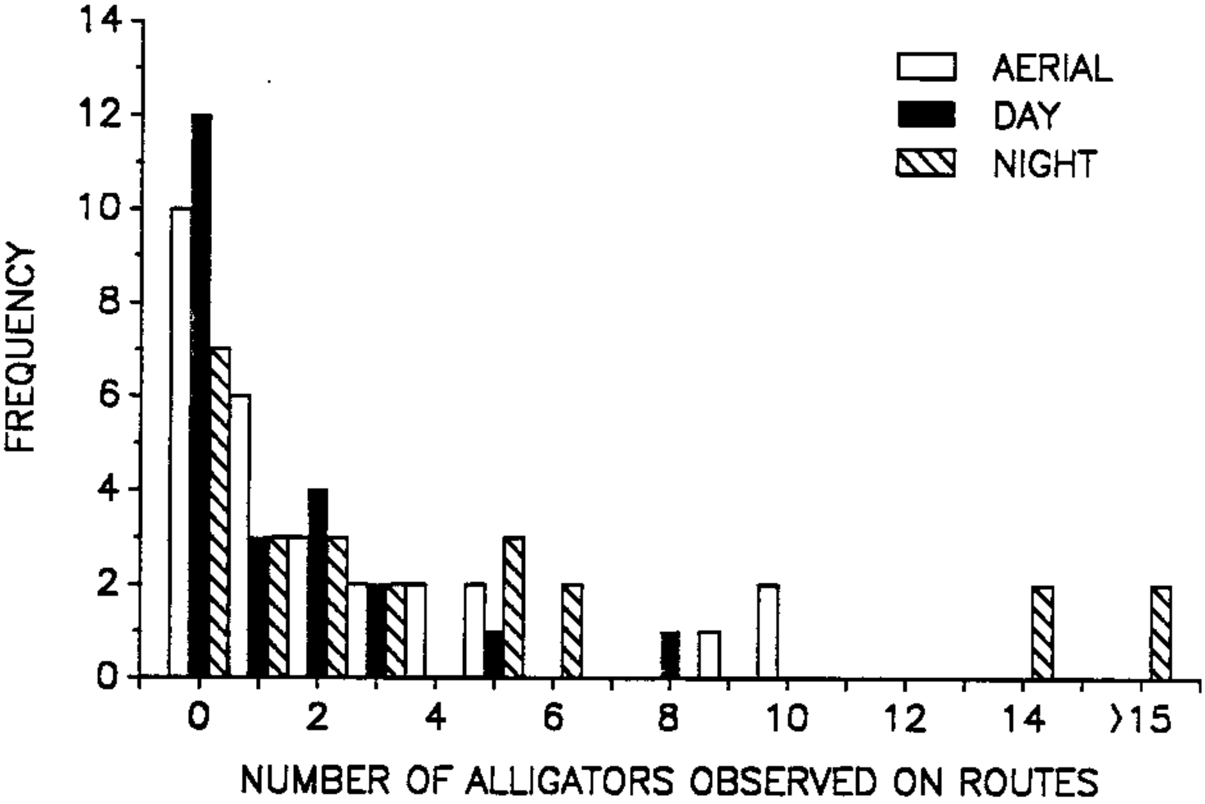

Figure 2. Frequency of alligator observations on aerial, surface day and night count surveys.

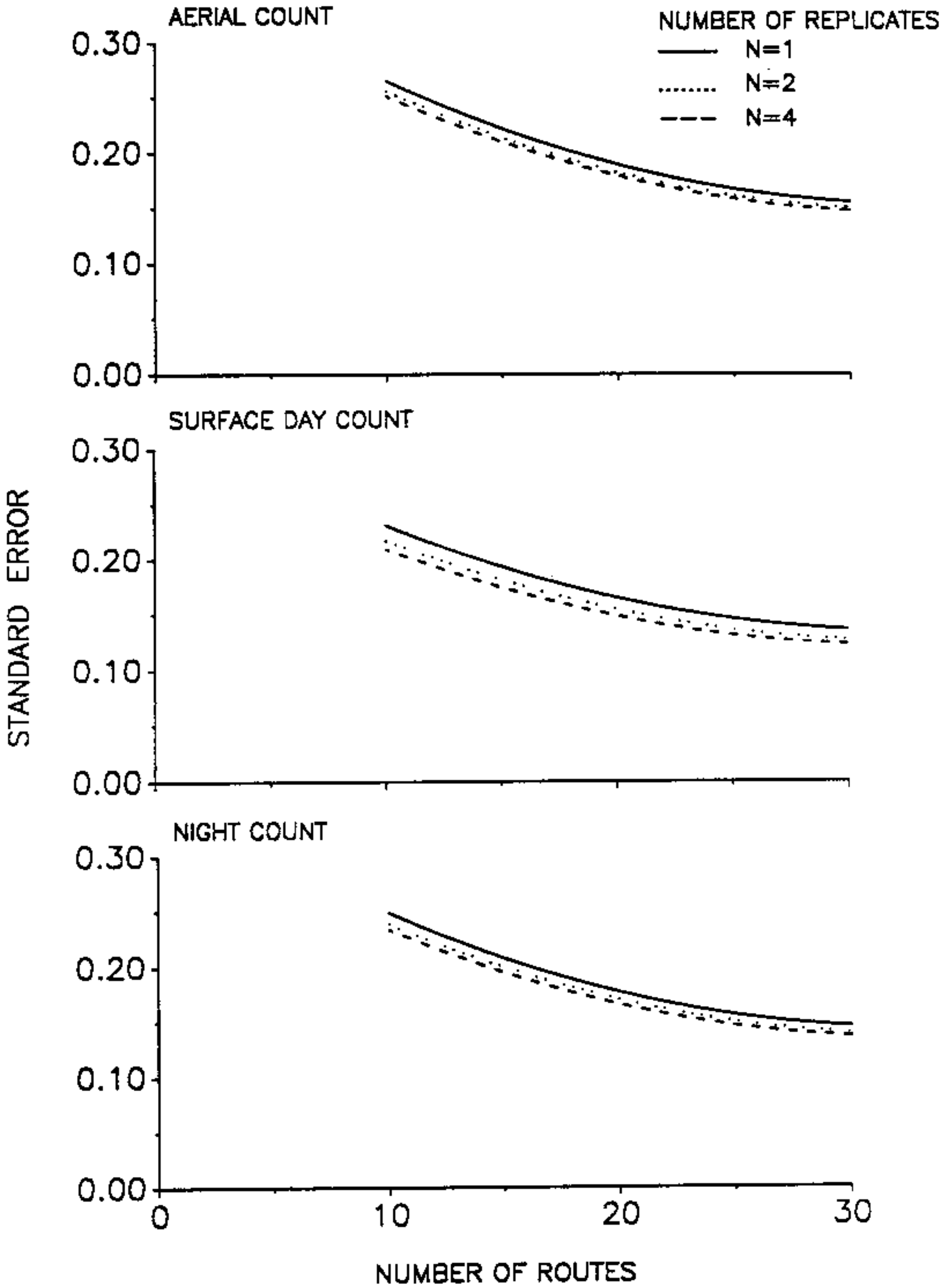

Figure 3. Reduction in standard error due to increasing the number of replications per survey route (n) and due to increasing the number of survey routes for aerial, surface day and night count surveys.

FEEDING, REPRODUCTION AND GROWTH IN CAPTIVE *Melanosuchus niger*

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ABSTRACT

A captive population of *Melanosuchus niger* was studied in northern Bolivia. The feeding status of the population was evaluated both by quantity and quality of the food. Data on reproductive biology and growth were collected and compared with data from literature about *Melanosuchus niger* and other species, and analyzed to evaluate the success and perspectives of the program.

INTRODUCTION

Crocodilians include some of the most valuable and heavily traded species in international commerce because of their high quality skin, this led to worldwide species depletion and extensive illegal trade (Gaski & Hemley 1988). At the peak time for the demand of these goods in the 1950s and 1960s, numerous species became endangered (Hemley 1989), *Melanosuchus niger* among them.

Hunting of *Melanosuchus* began in Bolivia in 1942 (Medem 1983; cit. by King and Videz-Roca 1987). It is estimated that an average of 685 skins of *Melanosuchus* (caiman) and *Caiman crocodilus* (lagarto) were extracted each day between 1940 to 1955 from the Beni plains in Bolivia (Claure 1986). In 1961 the Supreme Decree No.05912 established a minimum size of 2.1 m for caimans hides and prohibited hunting of the species from 31 July to 1 January (King and Videz-Roca 1987). Nevertheless, hunting continued. A minimum of 31691 caiman hides were exported between 1978 and 1985 (Claure 1986). Recently (1990) an "Ecological Pause" was declared by the Government of Bolivia, banning all wildlife trade. We hope that this new governmental guideline will be enforced with strong actions and heavy sanctions against the illegal trade.

Knowledge about *Melanosuchus* is not very good. The most complete work about morphology, physiology, ethology and ecology of the species has been done in Perú (Otte 1978). Medem (1963, 1981, 1983) reports on some aspects of its distribution, ecology, morphology, growth and parasites. Information about its distribution and conservation is reported by Plotkin et al. (1983). Herron (1985) provides more recent information about status, growth and spatial relationships of the Perú populations. King and Videz-Roca (1987) make the most recent review of the population status in Bolivia, and there is a report about the management of the Melanosuchus population at the hacienda "El Caimán", the farm where this study took place (Groves 1988).

The main goals of this work were to get some information about the reproductive biology and growth for Melanosuchus niger. The study had to be conducted in captivity because of the low population densities in Bolivia which would require too much time and budget to get some information. The captive management of crocodilians for conservation and commercial purposes is very important worldwide at present, so the importance of these data for the conservation of Melanosuchus is high and will be useful for future captive rearing programs and conservation efforts.

STUDY AREA

The study area is located at the Hacienda "El Caimán", which is a commercial purpose farm situated in the department of La Paz, in northern Bolivia. The climate is similar to most tropical regions of the amazonian part of Bolivia, so it is similar to the Melanosuchus natural habitats climate.

The farm had, at the time of the study (November 1988 to September 1989), five pens (Table 1), and a total population estimated at 130 adults and subadults and a number of juveniles and hatchlings which changed sharply during the study. These changes will be described in the results.

Table 1. Description of the pens.

Pen	Tot. Area	Pond area	# caimans	TL range
I	1.5 Ha.	0.25-0.75 Ha.	30	1.5 - 3.5 m
II	0.87 Ha.	0.35-0.50 Ha.	33	1.5 - 3.5 m
III	0.95 Ha.	0.35-0.45 Ha.	45	1.5 - 3.5 m
IV	200 m	14-30 m	**	TL < 1 m
V	0.40 Ha.	0.003-0.40 Ha.	2	3.5 - 4.2 m

Notes.- Pond area is described as a range because it depends on the season.
** this number changed during the time of study.

It was not possible to catch the caimans in pens I, II, and III, because of the big size of the ponds, the big size of the caimans and the lack of help, so both the exact number of animals and the sex ratio are unknown. The number of animals in each of these pens was estimated by spotlight counts during several nights and the numbers given in Table 1 are the maximum number of animals ever counted in each pen. Also the TL was estimated by estimating the length of the skull (SL) and/or the distance between the anterior corner of the eyes and the tip of the nose (HL), and transforming these data to total length by the equations:

$$TL = -67.46 + 8.39\ SL\ \ [mm] \quad (1)$$
$$TL = 106.28 + 16.69\ HL\ [mm] \quad (2)$$
(Pacheco, not publ.)

These relations have an r=0,99 and significance to 99,5 % according to the "t" test of Student (Spiegel 1969).

The two caimans in pen V are males and were separated because of their large size and their potential danger for the other caimans (Monroy, pers. comm.).

Pen I is the "breeding pen", although pens II and III have both adult caimans.

Pen IV is never cleaned up, not even changed the water.

METHODS

The feeding status was evaluated by the food quantity and quality given to the caimans at the farm. For the juveniles, special attention was given to the quantity of food consumed. For this purpose, the food was weighed before being offered to the caimans and the remains were weighed the day after, during three months. A witness quantity of food was left to the same weather conditions, but out of the reach of the caimans and other animals, to test the weight loss or gain of the food attributable to the weather, which was considered in the calculation of the food consumed. It was not necessary to do this for the adults, because they never left any food. The weight (W) of the caimans of pens I, II and III were estimated by the equation (3):

$$\log W = 1.0753 + 0.0029\ TL \quad (3)$$
(Pacheco, not publ.)

This relation has an r=0,97 and significance based on the "t" Student test of 99.5 % (Spiegel 1969).

The data to build the equations (1, 2, and 3) was strengthened with data from specimens collected in Bolivia by Jose Lobao Tello (JTB 233, JTB 234, JTB 235, JTB 236, JTB 237, and JTB 238), studied at the Florida Museum of Natural History in Gainesville.

The reproductive success was evaluated based on available data from past years (given by the caretaker of the farm), and data collected during the reproductive season of 1988-1989.

For the growth study, the caimans were marked by clipping one or two dorsal tail scales (Bustard and Choudhury 1981), and the following measures taken: body length (BL) from the tip of the snout to the anterior end of the cloaca [mm], total length (TL) from the tip of the snout to the end of the tail [mm], and weight (W) [g]. Measures were taken in November 1988, February 1989, and September 1989. The 1989 hatchlings were not marked until they reached 7 months of age. This study was seriously affected by the high mortality of the juveniles, but the data are good enough to draw some preliminary conclusions.

RESULTS

a. Feeding status.

The estimated biomass of adults and subadults (caimans from pens I, II, and III) was 6762 Kg. The food offered was about 200 Kg per week (slaughterhouse remains, red meat and occasionally fish) at the beginning of the study, and 450-500 Kg per week since June 1989 (almost only fish). This means 2.95% of the body mass per week at the beginning, and 6.65 - 7.39 % of the body mass later. Usually the caimans remained very excited and visited the feeding station long after the food had been finished.

The caimans were seen catching fish (which live in the pond) and trying to capture birds (<u>Casmerodius</u> <u>albus</u>, <u>Jacana</u> <u>jacana</u>, and <u>Anhinga</u> <u>anhinga</u>) which visit the pond frequently.

The initial biomass (May 1989) of juveniles was 7443 g (fifty 1989 hatchlings, seven juveniles from 1988 and one of unknown age). The final biomass (September 1989) was 6640 g (34 hatched in 1989 and 1 of unknown age). The average quantity of food consumed was 7 % of the body mass per week, ranging from 5.1 to 8.3 % of the body mass per week. The food offered consisted always in fresh red meat, although since April, a light trap was put in the pen, about 15 cm above the water level, for about 4 hours each night, to attract insects, but this light trap did not work properly every night.

Besides the insects attracted by the light trap, the juveniles, except the oldest (830 mm TL) were seen catching insects during the day and eating frogs and toads

(Leptodactylidae and Bufonidae) which were provided by the observer (dead or alive) or catched by themselves along the shoreline of the pond.

The farm is located very far from the urban areas (see Study area). The food for the caimans was provided until 1987 from the remains of the slaughterhouse, the cattle was sacrificed at the Hacienda and transported by plane to the consume centers. Since 1988 the cattle is brought alive to the cities, so the food became scarce and very expensive. Red meat is provided (when available and in small quantities) by the slaughterhouse of the Hacienda "El Dorado" (part of which is "El Caimán") at Bs. 2.5/Kg (about 0.8 $US/Kg). Fish is provided by the people at Bs. 0.75/Kg (about 0.24 $US/kg).

Neither the adults nor the juveniles are ever given added vitamins and minerals.

b. Reproductive biology and success.

Data from past years were provided by the caretaker, Mr. Rolando Monroy, and are described in Table 2:

Table 2. Data on reproductive success from years prior to the study.

Year	# nests	Eggs/nest (Averg.)	Natality %
1981	5	38	64,7
1982	4	37	78,0
1983	4	36	10,2
1985	4	34	71,1

In 1987 two nests were found and of an unknown number of eggs, only 12 hatched in 1988 (Monroy, pers. comm.); seven of those caimans still survived in November 1988, but died in June 1989.

The nest building occurs some days to near a month prior to the egg laying, which occurs between middle October to early December; The incubation lasts 93 to 96 days and the hatching takes place from late January to early March (Table 3.).

Seven nests were found in 1988, six of them (A to F) in the "breeding pen" (pen I) and one (nest G) in pen II. The eggs of all but the nest G were collected by the caretaker 4 to more than 20 days after laying (Table 3), and incubated in an artificial nest built up by himself. Eggs from nest G were not touched until the hatching time, when we had to remove them from the nest because hatching could not take place, because of the nest material compactation. The hatchlings were vocalizing from 7:00 a.m. to 5:30 p.m, but could not hatch. Just after the eggs were removed from the nest, hatching began. For almost all nests, hatching occurred with a few days or even two weeks between the first and the last hatching (eggs from the same nest). The nests found during the study are described in Table 3.

Table 3. Nest characteristics and success.

Ne	D x d x h	L.Da	Et/Eb	Collt.	Ha.	F.H.	L.H.
A	190x150x55	26-O*	35/4	04-N*	3	5-F	7-F
B	220x220x60	06-N*	23/4	10-N	9	9-F	15-F
C	180x180x50	10-O*	41/2	04-N*	10	31-J	5-F
D	190x190x50	?	38/12	04-N*	0	-.	-.
E	180x170x50	?	38/3	04-N*	5	2-F	5-F
F	180x170x50	04-D	35/0	08-D	3	11-M	11-M
G	170x150x47	08-N	37/1	-.	26	9-F	25-F

Notes.- Ne=nest; D and d=diameters at the base [cm]; h=height from the ground to the top of the nest [cm]; L.Da=egg laying date; Et=total number of eggs; Eb=eggs broken; Collt.=date of egg collection; Ha.=number of hatched eggs; F.H.=date of first hatching; L.H.=date of last hatching; N= November, D=December, J=january; F=february and M=march; *=data provided by the caretaker.

The eggs are white and the shell is rough. Measurements of six eggs are provided: 47 x 86; 49 x88; 50 x 88; 51 x 89; 52 x 92; 52 x 93. Only one egg was weighed (just before hatching): 150 g.

The average hatching success for nests A to F (the eggs incubated in the artificial nest) was 15.6 %, and 70,3 % for the nest G (from which the eggs were not removed until the hatching time). Most of the eggs from the artificial nest which did not hatch contained only decomposed material, only a few of them contained dead embryos. All the eggs not hatched from the nest G contained completely developed dead embryos, it might be possible that these eggs had been damaged during the collection.

All but the nest D received some kind of protection by the female, they stood near the nest (5 to 20 m from it) all the time for 2 to 4.5 months. Except females of nests C and G, all the other females attacked man when approached their nests.

The temperature in the nests (in the egg chamber) was recorded for some nests and as many times as was possible and/or the female allowed. The results are described along with measurements in the artificial nest in Table 4:

Table 4. Average temperatures in the egg chamber.

Nest	Artif.	A	C	F	G
Avg. temp.	30,14	28,5	28,59	29,25	28,48
Std. dev.	1,28	0,93	0,56	0,25	0,53
# of obs.	11	11	11	2	22

The Table 4 shows clearly that the temperature in the artificial nest was higher than those of the nests built up by the female caimans. The variations in the ègg chamber temperature were also greater in the artificial nest, as is shown in Fig. 1., where the temperatures of the nest C, the artificial nest, the environment temperature and the water temperature in the pond at a depth of 5 cm are compared.

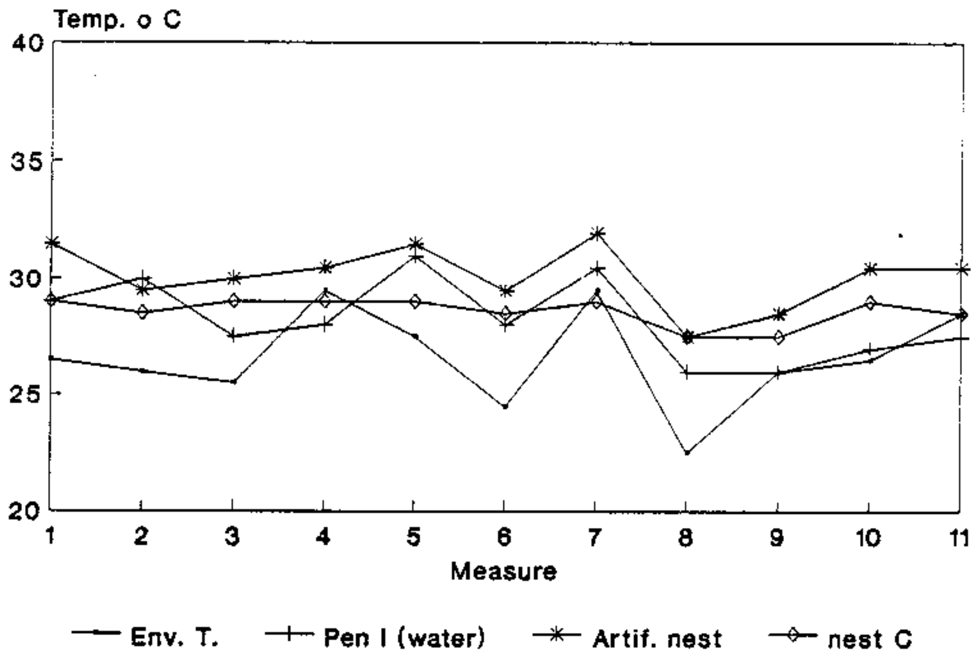

Fig. 1. Variations in the temperatures of the artificial nest, one of the natural nests, environmental temp. and water temperature in one of the ponds at a depth of 5 cm.

c. Growth.

The caimans hatched in 1988 were measured and marked (in November 1988) at the age of 9 months and measured again at the age of 12 months, after which they died. Some of the hatchlings of 1989 were measured, but not marked just after hatched (age of 0 months), and measured and marked at the age of 7 months. Finally, the two juveniles of unknown age (the only two caimans older than one year born at the farm) were measured and marked in November 1988, and only the oldest, number 09 (the other died shortly after the first measurement), was measured again 3 and 10 months later (see Table 7).

The average, standard deviation, maximum and minimum measurements for body length (BL), total length (TL) and weight (W) of the individuals of known age are given in Table 5.

Table 5. Measurements by age.

Measurement	0 Months	7 Months	9 Months	12 Months
BL [mm]	131,42	178,24	182,71	189,14
Std Dev.	3,07	8,83	7,74	8,87
Maximum BL	136,00	205,00	193,00	203,00
Minimum BL	125,00	160,00	170,00	179,00
TL [mm]	283,61	367,27	404,71	415,29
Std Dev.	8,86	19,92	20,22	21,78
Maximum TL	300,00	422,00	431,00	447,00
Minimum TL	266,00	325,00	371,00	383,00
W [g]	75,61	130,59	210,00	223,29
Std Dev.	13,16	24,30	43,75	46,41
Maximum W.	93,00	186,00	290,00	288,00
Minimum W.	57,50	75,00	160,00	152,00

Based on the data presented in Table 5, we can calculate the average increment in BL, TL and weight for our sample (Table 6):

Table 6. Average increments in the measurements, considered by age.

Age	Total average increments			Average/month		
Months	BL	TL	Weight	BL	TL	Weight
0 - 7	46.8	84.6	54.9	6.7	12.1	7.8
7 - 9	4.5	36.5	79.4	2.2	18.2	39.7
9 - 12	6.4	10.6	13.3	2.1	3.5	4.4
0 - 12	57.7	131.7	147.7	4.8	10.9	12.3

The differences between the increments in TL and BL are attributed to individual differences in the BL/TL relation, and the different sample size for the different age classes.

The data for the two juveniles of unknown age are presented in Table 7; growth data are presented only for the specimen number 09, because the other one (S/N) died shortly after the first measurement. Increment/month (I/mo.) is given in [mm].

Table 7. Measurements for the juveniles of unknown age.

Number	BL	I/mo.	TL	I/mo.	W	I/mo.
S/N	295	-.	650	-.	1000	-.
09:						
Initial	367		798		2100	
3 months	383	5.3	831	11.0	2139	13.0
10 months	415	4.8	875	7.7	?	?

The average growth in TL for the first 12 months of age is 10.9 mm/month, very similar to the average growth of caiman number 09 (unknown age), at least for the first three months after the initial measurement. Based on this apparent regular growth, we can assume that this individual (09) had been growing an average of 11 mm/month. Then, if we take the average TL of the hatchlings (283,6 mm) we could expect that an average animal, with an average growth rate would reach a length of about 812 mm in four years, so our individual number 09 might have been four years old, and the other one (S/N) might have been 3 years old.

DISCUSSION

The diet of both the adults and juveniles seem to be poor in quality, at least at the beginning of the study, monodiets (only fish or meat) do not fulfill all nutritional requirements, and usually lack A and D vitamins, and minerals, specially Ca (Whitaker et al. 1979).

The quantity of food offered to the adults at the beginning of the study (2.95 % of the body mass per week) was poor. The quantity offered later (6.65 - 7.39 % of the body mass per week) was within the limits suggested by Joanen and McNease (1987) of 6 % of the body mass per week plus vitamins, and 10 % (Groves 1988). Yet this diet lacks vitamins and minerals suggested. Likewise we have to be cautious about the estimated biomass of caimans at the farm, because we do not know the exact number of animals (see Study area). We have also to consider the unknown amount of food catched by the caimans in the ponds, even if it is not large.

The quantity of food consumed by the juveniles (7 % of the body mass per week) is very poor compared with the amounts suggested by other authors, 25 % for the first year and 18 %

for the second and third year for Alligator mississippiensis (Joanen and McNease 1987), 20 % for Melanosuchus niger (Groves 1988), and 24 - 34 % of the body mass per week for Caiman Crocodilus (Rodriguez 1989). But as stated above, the juveniles were always fed in excess, this means that the juveniles always left some food. However we have to consider the food catched by these caimans (specially insects and amphibians) which could be a great supply of food for them and also a better source of vitamins and minerals than the red meat alone.

The egg laying period found in this study coincides with that given by Herron et al., (in press), who report egg laying occurring in October in Perú, and slightly differs from that given by Medem (1963) who says that Melanosuchus lay eggs from September to November in Bolivia.

Nest sizes are similar to that found by Herron et al. (in press) 220 x 190 x 50 cm, but different from the 150 x 80 cm size reported by Hagmann (1902); cit. by Medem (1963). The egg sizes given by the same author (52 x 86 - 56 x 97 [mm]) are almost similar to those found in this study.

Herron et al. (in press) report a incubation time of 88 days, which differs only slightly from ours (93 - 96 days). Medem (1961); cit. by Vasquez (1981) reports a incubation time of 62 - 93 days; we never found such big range.

The reproductive success in years prior to the study was irregular (Table 2), with hatching rates ranging from 10.2 to 78 %, and the mortality of those caimans was near 100% (only two animals older than one year were found at the beginning of the study). This problem continued with the 1988 hatchlings, all of which died before 16 months of age. It also affected the 1989 hatchlings: from 56 hatched from January through March, only 34 survived by September 1989.

Observations during the collections of eggs from the nests, and the higher and more variable temperatures in the artificial nest where the eggs were incubated, suggest that the irregular hatching rate in years prior to the study and the year of study itself could be attributed to improper management of the eggs during both the collection from the nests and the incubation. One proof for this hypothesis is the fact that nest G (from which the eggs were not removed) had higher hatching success.

The growth of the Melanosuchus (1.1 cm/month for the first four years) at the farm is poor compared with the growth of other species in captivity, Crocodilus moreleti reaches a TL of 105 cm in three years, (Hunt 1980), this means an average of 2.27 cm per month. Joanen et al. (1987) observed that Alligator mississippiensis reaches a TL of 933 - 1041 cm in 12 months and 1035 - 1181 cm in 18 months. For Crocodylus acutus, Rodriguez and Rodriguez (1989) reported an average growth rate of 2.2 cm/month for the first 467 days of life. Rodriguez (1989) reported a growth of 2.03 mm/day, about 6.1 cm/month for Caiman crocodylus.

There are few data about the growth of Melanosuchus niger; data of a caiman which grew from 90 cm to 275 cm in seven years is provided by Dowling & Brazaitis (1966); cit. by Medem (1983); this means about 2.2 cm/month.

Data from another animal are as follows:

Sept 1977	TL=62.5 cm
May 1979	TL=66.9 cm
May 1981	TL=79.0 cm
Jan 1982	TL=85.3 cm

Water temperature was 19 - 24 °C (Medem 1983); this means an increment of about 0.4 cm/month.

Otte (1972) separates Melanosuchus niger in size classes, giving a maximum total length of 49 cm for the 1 year specimens, a range of 50 - 79 cm (TL) for 2/3 year specimens, and 80 - 109 cm (TL) for 3/4 - 5/6 year specimens. These data support the estimate of 4 years for the individual number 09, initially of unknown age.

In Perú, wild Melanosuchus ranging in size (body length) from 25 cm - 116 cm showed an average growth rate in body length (BL) of 8.6 cm/year (this means 0.71 cm/month), with range 5.6 to 12.0 cm/year, which is 0.46 to 1.0 cm/month (Herron, in press). Then, our data of 0.48 cm/month (BL), ranging from 0.21 to 0.67 cm/month for the one year individuals, and 0.48 to 0.53 cm/month for the four year individual are near the lower limit given by Herron's observations.

The mortality and low growth rates might be attributed to the poor food quality and quantity, and to the lack of hygienic care both of which contribute to illness propensity. Bacterial infections, like Salmonella can destroy a captive rearing program by reducing growth rates, skin quality and increasing mortality (Crocodiles as a Resource for the Tropics 1983).

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BASIC CROCODILE FARMING/RANCHING METHODS IN REMOTE AREAS

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CONTENTS:

INTRODUCTION

Crocodile farming in Africa and in most other countries started in the mid 1960's. As the populations of wild crocodilians continued to decline through over-exploitation and habitat destruction, farming and ranching became an acceptable form of utilising a valuable natural resource. Inevitably too, because the leather industry required the most valuable hides, namely of *Crocodylus porosus*, *C. niloticus* and *Alligator mississippiensis*, the major proportion of the research effort focussed on ecological studies and management programmes designed to safeguard these three species, and, over the years, into all aspects of husbandry and captive propagation. Some impressive technological advances have been made in this field, also important management related aspects of the species bio-chemistry, physiology and behaviour. There is now available an impressive volume of data contained in numerous scientific journals and in three books that have been published in recent years. There is no doubt that the Crocodile Specialist Group, through the holding of nine meetings in several countries over the period 1971 to 1990, has managed to generate considerable regional input and enthusiasm into many avenues of crocodilian research, and the number of delegates attending this, the 10th CSG meeting is proof of that.

The crocodilian congress 'Production and Marketing Strategies for the 1990's' organised by the American Alligator Farmers Association at Tampa, Florida, in February 1989, was also a very important milestone in crocodilian conservation.

However, if one analyses the research findings and reports that have appeared in recent years, the bulk of these are concerned with and favour capital intensive, high technology, high production commercial farming and marketing strategies which are predominantly First World Agriculture. Small, capital poor, low level technology or subsistence farming projects, which are mainly Third World Agriculture, have been largely neglected.

My views on this were re-inforced when in a letter dated 19 January 1990, Prof. Wayne King wrote that a paper I had presented at the 1st Working Meeting of the Crocodile Specialist Group, held in New York, March 1971 had been identified as one that should be included and translated into Spanish, for a compendium on crocodile farming to be made available for the 100 or so new farms that are underway in Central and South America.

My presentation for this workshop has been written for the aspirant farmers living in remote regions, perhaps without electricity, refrigeration, incubators and controlled environment rearing units, or the benefit of a nearby veterinary laboratory and/or knowledgable personnel at hand to advise on husbandry and management problems. In fact, it is an update of the 1971 paper "Crocodile Rearing and Restocking".

1. LOCATION OF A CROCODILE FARM OR RANCH.

When selecting a site, several factors should be considered.

1.1. WATER

1.1.(a) The volume of water available throughout the year, especially over drought periods. The distance to pipe water to the ponds, or via irrigation furrows, whether a bore-hole, a windmill or mechanical pump is required and the relative efficiency and costs of these systems.

1.1.(b) The storage of water should be considered. Provision of reservoirs or supply tanks can be important and in the event of failure of pumping equipment such a reserve supply may prove vital to the health and survival of the stock. A system of recycling water may be practical whereby water pumped from a river to storage tanks is gravity fed back through the ponds, drained into a series of interconnected well vegetated ponds, or through an area of natural swamp back to the source of supply.

1.1.(c) Water quality should be investigated. Samples should be tested for salinity, acidity, effluent from industrial operations, agricultural pesticides and fertilisers, or for chemicals that may be undesirable from natural mineral springs. River water that flows from an area densely populated by humans and livestock may well be contaminated. Samples should be sent for bacterial analysis.

1.1.(d) Water clarity is also a factor to be considered especially if pumped directly from a river carrying a heavy silt load straight to the ponds. Apart from the management problems of not being able to see the crocodiles, or perhaps find dead animals in the water, pools become more difficult to clean, and pipelines become clogged with silt and sludge. This problem can be eliminated by drawing water from a well close to the river so that water pumped percolates through the sand or mud and is thus filtered. Filtered beds of gravel, or pumping water into settling tanks may be required.

2. EFFLUENT DISPOSAL.

2.(a) Liquid Effluent.

In remote sparsely populated areas the discharge of large volumes of contaminated water from crocodile ponds back into a river system may not be a problem. On the other hand in some localities it could pose a health problem to humans. This aspect has to be investigated and discussed with officials of the departments concerned with water affairs, and health before the project is built. Provision may have to be made for the building of effluent treatment dams.

2.(b) Solid Effluent.

Apart from water from crocodile ponds, there is solid effluent from food processing. Offal disposal pits are recommended for this purpose. (See Fig.). They are an efficient and inexpensive method of dealing with this problem, as opposed, for instance, to fuel burning incinerators.

2.(c) Utilisation of Effluent.

As previously mentioned the provision of a series of shallow effluent dams for the disposal of water rich in nutrients direct from the crocodile ponds has advantages. Firstly, because large volumes can be disposed of by evaporation. Secondly, these ponds, when stocked with fish, can produce substantial and regular harvests of fresh fish for the crocodiles. Thirdly, after filtering through natural well-vegetated ponds, this water can be re-cycled.

3. FOOD SUPPLY

The economic viability of the project depends to a large extent on the availability and regular source of good quality food. (See section on DIET). This falls into three categories:

Red Meat: Donkeys, horses, mules, goats, wild game etc.

Fish: Freshwater, marine and trash fish, deep-frozen fish etc.

Poultry: Day-old chicks and mortalities of adult birds from poultry farms, poultry condemned for human consumption etc.

The cost of food, must also include transport and/or deep freeze costs per Kg that is purchased - bone meal, carcass meal or vitamin supplements if these are to be used.

Costs should take into account that 40 - 45 Kg of food is required to grow a hatchling up to culling size.

4. CLIMATE

Crocodile hatchlings do best at 30 - 34°C for maximum growth and below 20°C growth is minimal. Thus the location of the project is most important and if available, temperature data for the proposed area should be studied carefully. Winter temperatures and the duration of cold or cooler weather, the incidence of frost, and prevailing wind force and chill factor are of particular importance.

5. REARING PONDS

5.1. Type of pond

The type of rearing ponds to be built depends on the nature of the soils and the availability of building materials. Natural earth dams are suitable where the soil type is of clay or heavy loam with good water retaining properties, and these dams are inexpensive to build. In sand areas it may be feasible to use a heavy grade of plastic irrigation sheeting, or a cement lining to seal ponds, but in shale or sites where underground rock formations are found, cement dams will be required.

5.2. Siting of ponds

The ponds should be sited to receive the maximum amount of sunshine, particularly over the winter months. The direction of local prevailing winds should be taken into account and the drainage of the ponds is important. If these are built on a sloping hillside drainage is far easier than if the ground is level. The drainage system must be efficient as it is not desirable to allow water fouled in the ponds to stagnate near to the rearing pens.

6. BUILDING REQUIREMENTS

In order to maintain up to 2000 or more crocodile hatchlings it is useful to have the following:

6.1. General office

A structure of about 4,5 m x 3 m x 2,1 m for keeping of records, storage of drugs and as a general office for the owner or manager. A toilet and wash basin is built adjacent to the office.

6.2. Room for freezers

A structure of 3 m x 3 m x 2,1 m for housing x 2 paraffin or gas operated deep freeze units of 10 cu.ft. capacity each are useful for storage of fresh frozen food.

6.3. Food Preparation Shed

A similar size structure built over a 3 x 3 m smooth-plastered concrete slab with the floor sloping to a central drain which acts as a food preparation shed. This is open on one side and this and the door should be fly-screened. The drainage pipe sunk into the centre of the floor can be led to underground soak pits, but preferably to effluent dams stocked with fish, and into which effluent from the hatchling ponds is also drained.

In this shed, sawn off logs, or robust cutting blocks are needed and wooden cutting boards for cutting on and to serve as feeding trays. Heavy duty butcher's steak knives, meat saws and machettes are used to process animal carcasses, poultry and fish. Hooks suspended from a roof beam are useful for hanging and skinning carcasses. Cut up food for immediate feeding is packed onto the feeding trays, the remainder packed into plastic bags for freezing.

6.4. Storeroom

A fourth building for the storage of tools, fish netting equipment, outboard motors, spades etc. is also useful.

These buildings can be constructed of cement blocks and good ventilation via windows and air bricks is necessary. Roofing can be corrugated asbestos or iron, reeds or grass, or alternatively the entire complex can be constructed of bush poles with reed walls and roofed with reeds or palm leaves.

6.5. Labour force

A labour force of three workers is needed for the preparation of food, actual feeding, pond maintenance, fishing and gear maintenance etc. for this number of animals.

6.6. Offal Disposal Pit

This is a simple but effective way of disposing of unwanted offal i.e. the intestines, rumen and stomach contents of large animals, skulls, hooves, poultry feathers, fish heads and innards. This unit (Fig. 1) should be sited at least 100 m distant from the food processing area or nearest ponds and serves the purpose of dealing with disposal of offal, and eliminates flies and the odour of rotting material from, for example, an open pit. These units can be made by using plastic or rubber refuse bins if the ready-made fibre glass models are not locally available.

7. RECOMMENDED TYPES OF REARING PENS

7.(a) Single unit cement rearing pen

An important requirement is that the pools should be at least 60 cm in depth, otherwise the water becomes too hot in summer. The pool floor should be sloped towards the drain outlet pipe, to facilitate cleaning and washing away of uneaten food particles. Ideally the outlet pipe should be 10 cm in diameter, with a stopcock outside the enclosure, so that the pool can be cleaned and emptied both efficiently and quickly. It is essential to place a screen in the drain pipe to prevent crocodiles escaping or from being sucked out of the pool during cleaning. After some time, stagnant ponds may become difficult to clean because of the rich growth of algae on their sides. Hard-bristle scrubbing brushes are needed to dislodge this growth. Small amounts of copper sulphate in the water will help control algae, if used regularly.

The entire pond and apron of the enclosure must be smoothly plastered to facilitate cleaning. It is useful to have a water supply point close to each pool from which a hosepipe can be led to pressure-spray and clean the entire pool and its apron.

An important part of the design is a partly-submerged and gently-sloping ledge, some 45 cm in width, around the perimeter of the pool. This provides a shallow resting zone for the crocodiles and allows easy access into the water. This ledge is also important in that the crocodiles rest there when feeding, and it also prevents them scraping their bellies and damaging their claws on entering or leaving the pool. The amount of space around each pool is calculated to allow ample basking room for each animal, and an area of shade must likewise be provided.

It is advisable to roof over the entire pen with wire netting, or criss-crossed strands of wire, against predators. The wire netting sides of the pens should not be larger than 1 cm mesh, otherwise hatchlings will injure themselves by trying to climb through this. Young crocodiles can climb vertical wire netting with ease and will escape unless the enclosure is either roofed or its side walls sloped inwards at an angle of 20°. A skirting board (planking, sheet iron, tin or plastic sheeting) placed against the wire netting flush with the floor prevents them from climbing up the fence to a height, and then dropping back onto the concrete below.

These pools are useful for summer because they can be scrubbed clean and because the volume of water used is small. Normally they need only be emptied, cleaned and refilled every third day and there is no wastage through seepage.

The main disadvantage is that cement is a cold surface in winter and crocodiles will be prone to respiratory ailments. If local winter night temperatures of the water or of the air are likely to fall to the 7,2°C, this type of pond would not be suitable. Care must be exercised while cleaning these pools, to avoid a crocodile injuring itself by falling into the empty pool. See Fig. 2.

7.(b) Trickle system cement rearing pen

The advantage of this system is that during hot summer weather, when crocodiles are feeding at their maximum rate, small uneaten food particles, faeces and urine, are not trapped in the pool. The constant dilution of the pond's water ensures a low bacteria level. The pool is drained and scrubbed clean weekly, as is the entire floor of the pen which is smoothly plastered. The enclosure embodies the same design requirements as seen in Fig. 3 .

The pool should be circular or cone shaped, at least 50 cm deep at the edges and 60 cm in the centre. An earthenware bend of 10 cm in diameter is sunk flush into the centre of the floor and into this fits a rubber plug. In this a 5 cm diameter hole is bored, through which a 66 cm length of polythene pipe is fitted vertically into the plug so that it can be pushed in or pulled out as required. A wire mesh shield is fitted over the top of this outlet pipe to prevent the escape of small crocodiles. Water is fed constantly into this pool, circulates, and is siphoned out at the same rate as the inflow.

It is helpful to attach string wire handles to the rubber drain plug, so that it can easily be pulled out when the pool is to be cleaned.

7.(c) Isolated earth rearing pond pen

These are ideal for use in climates where low winter temperatures are likely to cause respiratory illness in the young animals. Earth pools are easy and cheap to build and are a 'natural' habitat where vegetation can be planted, small live fish introduced, while insects, frogs and other creatures attracted to the dams will be an important addition to the diet and health of the crocodiles.

During cold weather the crocodiles will burrow into the mudbanks and thus survive nights of heavy frosts. Because of their burrowing capabilities it is important to provide a strip of land, 4 m wide, between the pool's edge and the boundary fence. This is particularly important if the pool is situated at the bottom of a hill such that its lower bank is artificially built up. Where pools are excavated on a level site this precaution is not necessary. The crocodiles burrow into the bank above normal water level and may tunnel beyond the fence line. Normally this will not matter since the burrows will be well below ground level, but if the pool stands on a hill slope the lower fenceline should be buried deep enough to intercept the burrows.

The enclosure fence should be of 1 cm diameter mesh netting for young crocodiles, buried to a depth of 1 m, to exclude burrowing predators. Because these pens are a natural habitat, birds may become a nuisance, either as a threat to the crocodiles or as food competitors. The pens therefore should be roofed, for which a broad-mesh grid made of 14 guage wire is suitable.

In areas where the soil is porous or sandy the floor of an earth dam can be sealed with concrete or plastic irrigation sheets. A layer of earth conceals this artificial floor.

Drainage is effected by a central pipe and the water siphoned out as in the previous system. The disadvantages of earth dams are that they require a larger volume of water to allow for seepage, and require more maintenance. Earth dams cannot be efficiently cleaned. Even if they are provided with a system of constantly circulating water they eventually become fouled, particularly during hot weather when feeding rate is at its maximum. Ideally, one should have only half of the available number of pools occupied at a time, so that they can be used in rotation. In this system, the animals can be moved to fresh pools when necessary, leaving the 'used' pools to be drained and allowed to dry out and bake in the sun. After a period of rest these will be clean and ready for use again. (See Figures 4 and 5).

When the crocodiles are to be removed from an earth dam they will prove difficult to capture with a hand net since most will take refuge in their burrows. A simple capture method is to make tubes from 1 cm mesh wire netting about 45 cm in length which are firmly pushed into the burrow entrance and their bases packed around with mud. The tubes are tilted upwards at a slight angle and held in place by prop-sticks. The pool is then drained completely and when the crocodiles venture out, they can be easily caught.

7.(d) Double-Unit Cement Pond System

This system (See Figure 6) was found to be the most efficient for management purposes. A major advantage is that with two ponds, they can be drained and refilled on alternate days, which is less stressful to the crocodiles which soon learn to move over to the full pond when the other starts emptying.

Secondly, the inflowing water may be colder than the water in the ponds, so that by moving to the full pond, the crocodiles are not subjected to a sudden change in temperature which is harmful.

Thirdly, the design allows for normal drainage of ponds, but the floor of the pen sloping towards the lower section where the overflow skim weirs are set into the concrete, allows for better hygiene. The entire pen can be flooded so that the individual ponds overflow over the perimeter lip and grease, fat and oil, is skimmed off the surface of the water and the entire pen floor hosed down and cleaned. This improves overall hygiene and reduces the incidence of eye infections and fungal infections.

With the gently sloped access area, the crocodiles can emerge easily from the pond, and this reduces the risk of injuries caused by 'piling' when a worker commences scrubbing the empty pond floor. The animals also do not attempt to jump or climb one over the other to escape from the pond, a practise that results in injuries.

Another advantage is that during cold weather or at night, heavy transparent plastic sheeting can be overlaid on a framework of poles over one of the ponds, about 30 cm above the surface. This raises the temperature considerably and also provides shelter from cold wind and rain.

Note also that as with the other units, the corners are rounded and this reduces the tendency of hatchlings to form piles.

8. HATCHERY DESIGN

The hatchery must be sited a good distance from the rearing ponds to avoid the danger of disease transported by flies, attracted to discarded egg-shells and in turn to food in the pens. It must have a sunny aspect and be situated away from footpaths and roads for the reason that developing embryos are sensitive to vibration, and undue disturbance near nests can cause premature hatching.

The hatchery of 11 m x 10 m is suitable for accommodating 25 clutches of eggs. (See Fig. 7) It can be constructed by using 12 cm diameter poles, spaced at 2,5 m intervals, buried to a depth of 1 m, while protruding above ground to a height of 1,85 m. Galvanised wire 4 mm diameter is nailed around the framework of poles at roughly 30 cm levels between the floor and the roof as a frame for chicken or bird mesh (1,5 cm diameter wire netting).

The wire netting is buried to a depth of 60 cm around the perimeter to exclude burrowing predators, and tied to the galvanised wire. Along the top of the perimeter fence a 30 cm strip of wire netting prevents crocodiles from climbing out and escaping. It may also be necessary to use wire criss-crossed over the hatchery to exclude avian predators.

The gates, 90 cm wide and about 1 m in height and opening at a height of 60 cm, can be left open when the hatchery is inspected without risk of hatchlings escaping.

If desired, the passageways may be roofed with 70% shade cloth, reeds, or palm leaves to provide shade and shelter during rain for personnel checking and walking within. During heavy rains and storms each nest should be covered over with a sheet of plastic, canvas, rubber mat or similar material e.g. empty fertiliser bag to prevent excessive nest flooding and lowered nest temperatures.

The hatchery can be constructed by using plastic sheets, shade cloth, a thick layer of reeds or bamboo, or poles if wire netting is not available.

9. LOCATION OF NESTS AND EGGS

9.(a) From a boat, crocodiles may be seen plunging off the riverbank or from lake shore at the approach of a boat or the sound of a motor and the site is then investigated.

9.(b) Claw marks and scrapes on the lip of the riverbank caused by crocodiles emerging or entering water usually indicate nest sites during the breeding season.

9.(c) Walking along a riverbank or lake shore, crocodiles may either be found lying up over nests, guarding them from nearby, seen walking or running off, or heard crashing through the undergrowth or splashing into the water.

9.(d) Nest sites are generally characterised by a bare patch of soil (for hole nesting species) surrounded by flattened vegetation. The surface soil is sometimes found to be moist, may have a strong odour, or imprints of belly scutes r claws may be seen.

Tapping with one s fingers on the surface and over a suspected nest m y indicate whether there are in fact eggs buried. Th reverberation above the nest is distinguishable rom the more solid, densely packed surrounding subs rate.

However at color al nesting sites where several females may have laid close together, or have scraped away the grass c vegetation some 2 - 3 m in length, it becomes more ifficult to locate the eggs. Here a metal rod, such s is used in welding, some 40 to 50 cm and 4 mm in diam ter is used to probe the soil. By probing, then ta ping gently on any obstruction beneath the surf ce one can quite easily distinguish whether it is a oot or a clutch of eggs. Employing this method save a great deal of time.

10. HARVESTING E GS

It is preferable to collect eggs soon after being laid especially if th journey back to the hatchery involves a consi erable distance over rough roads. With eggs in an dvanced stage of incubation there is the danger that ne delicate system of blood vessels or the yolk sac ill rupture. Excessive jolting, bumping and nois can also bring about premature hatching and the e crocodiles have a poor survival rate.

Unfortunately it is seldom possible to determine when wild laid eggs h ve been laid, apart from destroying one from each cl tch to examine its contents and this is wasteful. Ho ever the following precautions should be observed.

Collection shoul preferably take place during the cooler hours of ne early morning or late afternoon. If a nest has to be opened during the heat of the day, do so as quickly as possible. Avoid placing eggs on the hot sand or xposed to the sun and pack them into the transport co tainers, then into the shade as soon as possible. Pr longed exposure can kill the embryo or cause prematu e hatching.

Each egg is mark d on its upper surface with a felt tipped koki, bal point or non-toxic pen to show how it was positioned i the nest. Some eggs may be found to be placed at an cute angle, almost vertical to the nest so bottom a d top should be marked accordingly. Each egg removed and marked is carefully packed and positioned witho t rotating it, transported and finally incubate in the same position as it was found in the nes . Each clutch is kept separate and incubated accord ngly. When hatching commences it is then easier to d termine from which clutch the croaking sounds ome, and this eliminates the unnecessary disturbance of digging up other eggs that may not yet be full term and ready to hatch. Also, so that it is easier to calculate when after the first hatchlings emerge from a particular clutch, how many days the remaining eggs should be left before manually opening these to assist them to hatch.

11. TRANSPORT OF EGGS

Corrugated cardboard boxes, plastic crates, wooden boxes or polystyrene boxes are all suitable for egg collection. The latter type have the advantage of being lightweight, waterproof and maintain the eggs at an even temperature.

The boxes must contain straw, dry grass, or even leaves, rushes or aquatic vegetation gathered near the nest site onto which the eggs are carefully packed and with thick padding between each layer and between individual eggs to cut down on movement or denting if eggs roll around inside the box. The packing can be liberally sprinkled with water until almost soggy to maintain a high humidity in the box during transport.

Alternatively eggs may be packed in sand from the nest but the weight of a full box, the distance it may have to be carried from the nest sites to a vehicle, boat, canoe or other craft is not very practical. Also the vibration during vehicular or boat transport, causes the sand to shift leaving the eggs to rub one against another, and breakages or dented eggs are the result.

Once packed, each container with a separate clutch must be clearly marked, and a note of the date of collection and clutch size recorded.

For transport by vehicle it is essential to lay at least a 30 cm thick layer of dried grass or similar padding as a mattress on the back of the vehicle to cushion the bumping and jolting of travel over rough roads or terrain. The boxes too should be firmly wedged in position, if necessary with packing between them to prevent movement of these.

Shade is again important and a vehicle canopy is useful, or cut, well-leafed branches may serve the same purpose.

It is obviously better to transport eggs back to the hatchery as soon as possible, but this largely depends on prevailing temperatures. Suitably packed eggs can be transported by air, boat or road for several days, but when the internal air temperatures of the transport boxes fall to and below the 28-30°C level, there is likely to be a high mortality of eggs.

12. PRE-INCUBATION PROCEDURES

When the eggs have been transported to the hatchery, and before artificial incubation starts, the following procedures should be followed:

12.1. A nest record card for each clutch of eggs collected should be prepared, recording serial number, date collected, locality and clutch size.

12.2. The eggs from each clutch collected should be carefully examined for the following: the number of pierced, dented, flattened, rotten or cracked eggs. Rotten or addled eggs can generally be detected by odour, a glazed or discoloured, opaque, or greyish, blue-green shell colouration, or because these eggs weigh less than healthy eggs, or because the contents of these suspect eggs when gently shaken, are obviously full of liquid, in comparison to healthy eggs. Healthy eggs develop an opaque white spot on the upper surface within 24 hours of being laid if they are fertile. Eggs, or some of the eggs examined in each clutch that do not show this spot may be considered to be infertile. This white spot extends laterally and forms a complete band by about 4 days, and this band expands until it is of even width at 9 - 10 days.

12.3. Record details of the number of damaged or suspect eggs on the nest record card. All cracked, pierced or rotten eggs should be removed from the clutch to be incubated because these will go rotten in the nest and apart from attracting ants and various insects, can contaminate and spoil healthy eggs, particularly if they leak fluid onto others below them. Various fungal growths may develop and spread, also gases which are harmful to healthy eggs.

13- ARTIFICIAL NESTS

Within the hatchery, artificial nests are excavated in the soil in parallel rows, allowing a footpath 1,5 m wide between rows, and spacing nests 1 m apart. A nest cavity of 45 cm in diameter is adequate, even for large clutches and should be dug to a depth of about 50 cm. The eggs are then buried in the same position as found and removed from the wild nests. Packing eggs one layer on top of the other allows for and promotes humidity. The soil should be damp enough to squeeze a handful into a form. The depth at which the top layer should be buried below the surface depends on the soil type. In heavy loam or clay, they should be 15 to 20 cm deep and in fine river sand 30 to 40 cm deep. It is advisable if possible to bury them in the same soil type as was found in the wild.

A suitable nest temperature range is in the region of 28° to 34°C at an average depth of 30 cm. This should be checked at intervals. In the early morning and at two-hourly intervals through the day till dusk. From these temperature recordings it will be possible to establish whether soil should be removed, or added over the nest site to achieve the desired nest temperature range.

Each nest site must be identified by its serial number and preferably date of collection and clutch size as well. This is essential so that the progress of individual clutches can be monitored e.g. the date on which hatching commences, as some eggs from a clutch may hatch earlier than others, some prematurely, whilst others may require up to an additional 14 days of incubation. Generally, once hatching commences and the hatchlings are seen to be normal, the remaining eggs are not left to incubate more than 10 days. If the hatchlings are premature (i.e. with extended abdomens) the remaining eggs may be left up to 14 days, after which period they are manually opened and should survive even if still premature. Often perfectly developed unhatched crocodiles become entangled with the umbilical cord within the egg and are unable to hatch out, or the actual shell may be abnormally thick. Unless these eggs are opened the young will perish.

In areas of low summer rainfall or over drought periods it is advisable to check the moisture content of the soil of one or two sample nests weekly. If necessary the nests can be sprinkled with water until the soil around the eggs is suitably damp for it is essential to maintain a humidity level in excess of 80% and preferably higher. These inspections should be done either in the early morning or late afternoon. In fact even if the young are heard croaking in a nest during the heat of a very hot day, rather leave them and then open the nest when it is cooler.

As incubation progresses, the egg shells may crack extensively and pieces may peel off. Providing the nest soil is suitably damp this is not harmful. Should the soil become dry, the inner rubbery skin of the egg will harden and adversely affect hatching success. Dried out eggs should be thoroughly wetted to soften the skin.

The incubation period and nest temperatures vary from one species to another. For the Nile Crocodile - from 84 - 90 days at 28° to 34°C, on average. The Spectacled Caiman 70 - 90 days at 28° to 32°C; American Alligator 65 - 70 days at 28° to 34°C. But the period of incubation depends on weather conditions and nest temperatures, and incubation may thus extend for up to 7 to 14 days beyond the normal period.

If after collecting newly laid eggs the normal incubation period for them elapses, without any sign of hatching, the nest should be visited twice daily and the surface gently patted. This action often triggers a response from the young who then commence croaking or yelping to indicate that they are ready. The soil is then scraped away and the hatchlings placed into suitable containers and removed from the hatchery. The reason for this is that other nests of eggs not quite ready, may also be stimulated to croak and when dug up are found to be premature. Eggs that do not immediately hatch may be covered over again and the procedure repeated over successive days until either they do hatch naturally, or need to be manually opened. This is the reason why nest record cards, recording dates, numbers hatched, and the number of eggs remaining in each clutch, are essential to management.

No attempt should be made to break the umbilical cord of a hatchling still attached to the empty egg-shell. This cord will soon dry out, become brittle and snap off of its own accord. After opening a nest all the egg shells, rotten eggs or dead embryos must be removed from the hatchery as well as soil impregnated with fluids, to avoid attracting insects.

Initial trials involving collection, transport and artificial incubation of eggs as described, resulted in a hatching success of 76,62% and with experience a higher percentage should be feasible.

14. POST HATCHLING CARE

Hatchlings are normally kept for at least 24 hours before being placed in the rearing pens, and then only if the umbilicus has completely closed and the cord has come away cleanly. Any that may be premature (shown by the extended yolk sac) are retained until such time as the yolk sac has been absorbed and the umbilicus closed.

It is advisable to maintain these newly hatched animals in a dry room or, if in an outdoor enclosure, this must be predator proof, and allow for sunlight as well as an adequate area of shade. Newly hatched and young crocodiles tend to form piles and death by suffocation commonly occurs if too many are placed in one area. Small compartments housing a maximum of 20 to 30 hatchlings eliminates this hazard, and also makes it easier to grade the crocodiles into size groups. Hatchlings from young females may only measure 25 cm, whilst larger females laying bigger eggs can produce 34 cm long offspring.

The floor of the post hatchling area should be kept as clean as possible and thoroughly washed with a strong solution of Potassium permanganate or chlorine and scrubbed after removal of each group of young, as umbilical infections are a cause of mortality of newly hatched young. As a precaution the umbilical area of each hatchling can be sprayed with Gentian Violet aerosol when they come in from the hatchery.

15. POST HATCHLING MORTALITIES

Mortality often is related to embryo development caused by too low or too high temperatures during incubation. It appears to run in clutches and hereditary factors may be responsible. Eggs incubated at high temperatures of 35°C and over may produce hatchlings with arched or laterally twisted spines, spiral tails, stump tails and jaw deformities. But if the farmer has collected wild laid eggs already in an advanced stage of development, from nests inadequately covered by soil, he has little control over the progeny from these eggs.

Likewise, a high proportion of embryo failures may be attributed to low nest temperatures as well as humidity levels and the importance of incubating within the recommended range - particularly safeguarding against sudden fluctuations of temperatures, cannot be over-emphasised.

16. STOCKING RATES

There is usually a tendency on commercial farms to over-stock rearing pens. This leads to greater competition for food, an increase in fighting and bullying by the stronger, more aggressive individuals, which in turn results in a greater number of injuries and wounds and possible sources of wound infections.

A lower, or sensible stocking rate results in a more even growth rate per crocodile, but most important is the fact that the overall health of the crocodiles is of a higher standard than in an overcrowded pen. Thus disease problems are reduced and the symptoms easier to detect, as are injured animals in a smaller group.

Joanen and McNease (1979) also comment that careful attention must be given to keeping stocking densities at a safe level, i.e. no more than one alligator per 0,3 m^2 per animal.

For C. niloticus opinions differ. Blake (1974) considers that each young of the year should have available a minimum area of 0,09 m^2. After a year, 0,18 m^2. Van der Riet (1987) prescribes a stocking density of 0,56 m^2 per animal.

The stocking densities as described for types of pens recommended herein for C. niloticus were found to be satisfactory.

An advantage of housing young stock in individual pens from 5 to 8 m apart, as opposed to ponds adjacent to one another, is that there is less danger of an infectious disease spreading rapidly from one pen to another. The cleaning of pens, the stress and disturbance when capturing sick, injured, or sick animals for grading purposes and transfer to other pens, is much reduced.

But in the planning and design layout of the rearing pens the cost factor has of course got to be considered. Even so, there should be additional pens allowed for intensive care of sick, injured or weaker animals, no matter what overall layout is decided on.

It is essential to maintain a register of numbers of animals per pen, including mortalities, and also to keep track of numbers and movements when animals are size graded during the first year of growth.

17. DIET AND NUTRITIONAL REQUIREMENTS

The diet, growth and nutritional requirements of the Nile crocodile has been reported on in numerous publications and the dietary deficiencies, diseases and effect on growth reported on in some detail.

There are basically two classes or size groups of crocodiles for the commercial farmer to be concerned about. These are:

a) Hatchlings and up to the 1,5 m size group ready for culling and

b) Adult breeding stock, or those animals in excess of 2,5 m in total length.

In the natural state the first group subsist on aquatic and shore-line insects, spiders, snails, tadpoles, frogs and fish fry. Later, taking crabs, shrimps and prawns, frogs and fish as well as some of the smaller creatures.

Adults on the other hand require a much larger volume of food and in nature would take a greater percentage of fish, crabs, reptiles, birds and mammals - from small to quite large prey. In fact, a considerable change in diet.

For the commercial farmer who may house up to 3000 - 5000 crocodiles in category (a) it is almost impossible to obtain, or even approximate the diet and volume of food normally eaten by these young animals. Several of us have tried various kinds of insect and light traps, but with somewhat unsatisfactory results. The large scale breeding of mealworms, crickets, fresh water snails, frogs such as platannas, fish etc. are all schemes that have been thought of from time to time. All are labour intensive, and at best would be a valuable dietary additive to feeding a few thousand hatchlings - but never by weight be sufficient to feed a large population all year round.

Some crocodile farmers are fortunate in that they live alongside lakes, rivers and pans where fish can be readily harvested or where fish can be farmed. Others live in areas climatically unsuitable for fish farming and are thus dependant on artificial foods. In this category are included poultry in a variety of forms. Day-old chicks, broilers, adult fully feathered or plucked birds etc. Usually the mortalities from poultry farms - culled hens or deep frozen chickens that have exceeded shelf life.

Secondly, varieties of commercially available salt water fishes can be purchased from time to time from the larger distributors, at fairly reasonable prices. But, like the poultry industry, the supplies are likely to be seasonal and cannot be relied upon.

The third category is that of red meat, which includes horses, donkeys, beef, goats etc. This is also not a guaranteed supply, usually the most expensive food to buy and deep freeze facilities for bulk consignments may be necessary. Otherwise transport and labour costs can be very high merely to process a small consignment.

Most of the commercial farmers feed a bulk diet of poultry - and include a certain amount of offal such as lungs, oesophaegus, spleen and donkey meat. A few have access to venison by-products, but this is normally low grade food.

Nutritional deficiencies result from these diets. The most frequently encountered being calcium deficiencies from feeding a mono diet of chicken. It is also doubtful whether adults extract sufficient calcium from chickens alone for egg production and calcium in some form should be added.

Bone meal or carcass meal which is inexpensive and commercially available in 25 kg bags has been found to be satisfactory. Lack of calcium in the diet may only become apparent in young stock towards the end of their first year and is often irreversible. Common symptoms are permanent posterior paralysis, kinking of the spine, uneven growth of the jaws, and failure to regenerate teeth.

Another problem frequently encountered is gout. This is often caused by overfeeding and encountered more commonly during the winter months. It may be caused by fatty foods - some breeds of poultry seem to be particularly fatty or from oily fish. It is recommended that fat should be cut from red meat portions when feeding to crocodiles.

Coulson and Hernandez (1983) describe the metabolic depression that occurs when temperatures fall to below 20°C. The animals then cannot synthesize protein efficiently. Gout ensues, normally seen as paralysis of the limbs, enlarged or distended limbs and digits, and unless food is withheld until the animal recovers, an accumulation of urates can be deposited in the kidneys and joints leading to organ malfunction, locomotory difficulties, and eventually mortality. Bloat is very similar and no food should be offered until the animals regain a normal appearance.

Wallach and Hoessle (1968) reported mortality of alligators from steatitis. In all cases the cause was attributed to low vitamin E content in the diet compounded by the presence of a high percentage of long chain polyunsaturated fatty acids or rancid fish oils in their diet of smelt, a marine fish species. They found evidence that rancid or unsaturated fatty acids oxidize vitamin E making it unavailable to the animal. Vitamin E has the function of preventing oxidation of adipose tissue.

Lance et al (1983) are of the opinion that as in other animals fed diets of marine fish, reproductive failure almost invariably occurs and this is attributable to a low vitamin E level. They postulate that an animal that produces a clutch of 30 - 40 eggs each weighing approximately 60 g in one night, would have to mobilize a considerable amount of vitamin E to ensure embryonic survival of the entire clutch.

Severe vitamin E deficiency is fairly common in crocodilians held in zoological collections. Two pairs of Morelets crocodiles C. moreletii held at Atlanta Zoo failed to produce viable eggs until taken off a diet of marine fish (Hunt 1980).

McNease and Joanen (1981) reported that a variety of quality food in the diet is better than a monodiet. And that fish alone may not be suitable for a high degree of reproductive success in alligators.

One of the questions to be answered is "What is the difference in palatibility and nutritional value between deep-sea, marine, estuarine and fresh water fish species?" In various trials conducted, it was found that a deep-sea fish known commercially as 'small-jacks' was totally unacceptable to all size and age classes of crocodiles. Even though the animals were deprived of any food for some days prior to the trials. Yet, other species of 'saltwater' or 'marine' and/or estuarine fish species such as mullet, grunter, perch, kob slinger etc. were very acceptable. (See Pooley 1982).

A marine species known in the commercial trade as 'Hake no. 6' was readily eaten and obviously acceptable to all size and age classes of crocodiles.

What of freshwater species? Is there any difference in nutritional value between the various indigenous species in our lakes and river systems? Apparently there is, for according to Blake (1974) an analysis of the main food (Vundu) a catfish (in Zimbabwe) Heterobranchus longifilis showed it to be extremely low in vitamins, especially vitamin A. The flesh was found to have a high fat content which inhibits the absorption of fat content which inhibits the absorption of fat-soluble vitamins, such as A, D, E and K. This suggested that the high incidence of enteritis on Zimbabwean farms was caused by a low nutritional diet and consequent lack of resistance to enteritis.

In Reichenbach-Klinke (1965) contained in Blake (1974), mention is made that a lack of vitamin A can inhibit the action of the tear glands from producing the saline wash which normally lubricates the eyes and nasal passages of some reptiles.

In other words whilst a diet of fish such as catfish, tilapia, tiger fish, mudfish and kapenta may be suitable for growing out young stock, fish are not suitable for adult animals. Behler and Joanen (1980) also commented that a change in diet from marine fish to an equal mixture of fish and a small marsh animal, Nutria, plus a multivitamin mineral additive dramatically increased fertility rates of Chinese alligators under study.

Several workers have commented on the importance of maintaining young stock at high temperatures e.g. in the 30 to 32°C range. In controlled rearing units or open ponds where animals are lying on a cold substrate such as cement, where temperatures may fall to as low as 20°C overnight, problems are bound to occur. Food intake is greatly reduced. The action of certain digestive enzymes and body metabolism is impaired. Digestive disorders generally lead to a loss in condition and quite frequently to a susceptibility to bacterial and even respiratory infections, particularly if temperatures fluctuate considerably between night and day.

Another problem encountered is that of nutritional loss of frozen foods through incorrect feeding methods. In this case red meat was frozen in large blocks in open containers at minus 30°C. Daily a block of meat was removed, thawed until sufficient for a meal could be cut off for that day's feeding, then the block returned to the deep freeze, and this was repeated for several days. The outer layer of meat was freeze burned. The loss of blood and fluids was considerable and after some six weeks of this practise, seven-month-old animals developed paralysis of the hind limbs, a bunching of muscles over the lower spine and in severe cases, arching of the spine. Death occurred from drowning.

The sick animals responded rapidly to injections of vitamin B1 and paralysed animals regained the use of their limbs. It is recommended that all frozen food be packed in strong plastic bags to retain fluids and to avoid freeze burn, that food should not be thawed quickly by immersion in hot water - a process that also leaches out nutrients and the use of fans to thaw food is recommended. Partially frozen food should of course never be fed.

As Foggin (1981) and others have pointed out prolonged use of a monodiet is likely to lead to deficiencies.

My personal recommendation is to feed a diet of 50% red meat including livers and hearts if available, 25% poultry and 25% fish. Whole day old chickens are recommended for young stock and easily manageable pieces of bone for adults. Care should be exercised with ribs and these should be chopped into small sections as they can cause swallowing problems. For those who have not tried the 'alligator premix' recommended by McNease and Joanen (1981) the following is the formula. Added to the food at the rate of 1%:

Specifications	Per 1 lb.
Vitamin A	1,800.000.00 USP U
Vitamin D3	200.000.00 IC U
Vitamin E	5.000.00 IU
Riboflavin	1.000.00 MG
d-Pantothetic Acid	2.760.00 GM
Niacin	4.50 GM
Choline Chloride	86.43 GM
Vitamin B12	1.35 MG
Folic Acid	90.00 MG
Biotin	20.00 MG
Pyridoxene Hydrochloride	1.000.00 MG
Menadione Sodium Bisulfite	4.283.00 MG
Thiamine mononitrate	1.000.00 MG
Inositol	5.000.00 MG
Para-Amino Benzoic Acid	5.000.00 MG
Ascorbic Acid	45.000.00 MG
Ethoxyquin	5.00 GM

Any crocodile farmer will know that his animals respond to live prey such as fresh fish, with tremendous enthusiasm. Hatchlings in particular can be induced to commence feeding more easily by feeding live prey than by placing cut up or minced food at the waters edge. To my mind the mincing of food, whilst less labour intensive than chopping it up into small pieces, of correct particle size, is not satisfactory. There is a considerable loss of fluids, the animals tend to trample it and then cannot pick it up. It also creates a greater deal of fouling, creates more work in maintaining pen hygiene and consequently can lead to bacterial and disease problems.

There is an argument as to the merits of feeding poultry plucked, or whole and completely feathered. Gastric compaction can occur from accumulation of feathers which being light do not always pass easily through the system, but this has not yet caused problems in my experience. The use of small, easily bred and easy to feed small animals like rabbits and guinea pigs has surprisingly not been tried on any scale and this would be a valuable addition to any diet. Presumably though these animals are commercially too valuable to feed to crocodiles.

However when one considers the cost today of an adult female crocodile, the fact that she only produces one clutch of eggs annually, that the eggs may all be infertile, or that she doesn't lay at all because of a diet deficiency, then the feeding of these animals may not be as expensive as it seems.

Finally, it seems that of all the problems that can occur in commercial farming of crocodiles, our lack of understanding of what constitutes a balanced diet is probably the avenue requiring the most research. It also seems that as in nature where all size groups of crocodilians feed off a wide variety of organisms, captive animals too should be fed whenever possible in the same manner.

18. FOOD PREPARATION

In preparing food it is important to reduce it to pieces that can be swallowed without difficulty. Large fish should be cut into elongated rather than square pieces since the bones can cause damage during swallowing. Similarly, live whole fish should not be too large lest the dorsal fins cause damage to the reptile's throat and gullet. Before deep freezing large fish should be scaled and gutted, their heads and fins removed and washed before being deep frozen. The hearts and livers are excellent food but feeding of intestines and other innards is not recommended.

All food must be completely thawed out before feeding and surplus, or uneaten food must never be re-frozen, since repeated thawing permits bacteria to multiply rapidly so that eventually the crocodiles are being fed bacteria-laden contaminated food.

The concrete slab should be hosed down and scrubbed with hard bristle brooms after food processing.

A spring balance is useful for weighing food and a record book for recording the date, prevailing air temperature, mass fed, pen number, percentage wastage, and remarks is most important.

19. FEEDING

The most desirable method is to estimate the amount of food that each group will consume at each meal. by establishing a regular pattern, feeding at the same time each day, it becomes easier to calculate how much is required, particularly when the mass fed, and amount wasted per pen is weighed and recorded. The crocodiles become accustomed to the routine and food is then consumed while still fresh. In the hot summer months crocodiles will feed daily, but feeding rate will slacken off towards the onset of the colder months when temperatures start to fluctuate each day. It is then wise to start reducing the feeding frequency and quantities fed until food is required perhaps only every second or third day, according to local climatic conditions. Generally young crocodiles will refuse food when the air or water temperature falls below 60°F (15,6°C) and it is wise to discontinue feeding then, as certain enzymes necessary for digestion are not activated. Even in mid-summer sudden cold spells may occur and at these times it is not worthwhile offering food, or trying to coax them into feeding until the weather warms up again.

During hot weather conditions it is preferable to feed in the late afternoon or evenings, after the animals have basked, their body temperatures are raised, and they will be hungry.

The use of flat planks, or similar feeding boards results in less wastage of food, cuts down on the amount of uneaten food that remains in the sand, gravel or grass verges of the ponds, which soon becomes contaminated, or eliminates the problem of spreading food out onto the hot cemented perimeter of the pond, which is obviously an undesirable practise.

When feeding, the boards should be spread around the pool perimeter (up to 8 to 10 individual boards) so that the crocodiles do not have to climb over one another, or compete, bite or fight unnecessarily to reach it. Because of the more rapid evening temperature drop in winter it may be necessary to feed at an earlier hour of the afternoon.

In cemented ponds the area where food is laid out should be cleaned and scrubbed daily and any uneaten food removed from the water with a handnet, while in the earth ponds, if these are stocked with scavenger fish, this problem is solved.

20. REARING AND HYGIENE

Young crocodiles are more delicate than is generally realised and a thorough knowledge of their behaviour and requirements under captive artificial conditions is essential if rearing is to be successful. Many disease symptoms are easily overlooked if the observer is not familiar with the normal behaviour of crocodiles under a variety of conditions. It is essential to know how they normally walk, swim, bask, thermo-regulate, sleep and feed in relation to the time of day, the air and water temperatures, and during cold conditions, rain and at night, and how their behaviour may change at different seasons of the year.

The more time the owner or manager spends observing the animals, the greater are his chances of successfully rearing them. He will soon notice that from a clutch of eggs hatched, some individuals will be aggressive, others less so. Others may be shy and some extremely timid. There may be a considerable difference in size range. The growth of some will be rapid, the majority at a fairly even rate and that a few hardly grow at all, and may be classed as runts.

The regular grading of animals into size classes is important to eliminate unnecessary bullying which can lead to stunted growth of the weaker animals. But it must also be borne in mind that the young are extremely sensitive to stress as from loud noises, sudden disturbance, excessive movement and activity in their pens, and especially from handling as in capture for measuring, grading or moving to other quarters.

An advantage is to train staff who work daily with the animals and who by experience learn to recognise for instance, the appearance of normal faeces from healthy animals, as opposed to diarrhoea in sick specimens. Who daily prepare the food into portions of suitable size, ensure that the food is fresh, that uneaten food is removed from the ponds, and that water is changed regularly and the ponds scrubbed clean. The emphasis should be on observing strict hygiene to the extent of using only one scrubbing brush or broom and the same feeding boards per pen. Also using footbaths containing a strong disinfectant at the door to each pen to eliminate the possibility of cross transfer of bacteria.

Even with the strictest of hygiene procedures, young crocodiles are still susceptible to a variety of diseases and diagnosis is often difficult and only learned by experience.

It is recommended that staff should become thoroughly aquainted with the animal's internal anatomy to be able to distinguish between healthy and diseased organs. If there is a veterinary or pathological laboratory, or if contact with a veterinary officer in the region is possible, samples should be despatched for examination, or the veterinarian consulted. Also that animals found freshly dead (not floating in the water) should be autopsied. The methods recommended are those outlined by Verseput (1986) and are as follows:

20.1. Collection of Laboratory Specimens

20.1.(a) Sterile Samples.

1. These should be taken as soon as the carcass has been dissected.

2. They should be taken with sterile forceps and scissors. (Flaming of the instruments just before use will suffice).

3. The specimen size should be about 5 x 5 x 2 cm.

4. The specimen should be dropped into a sterile container and the container immediately sealed.

5. A separate container must be used for each organ taken.

6. A separate set of instruments should be used for the stomach and the intestines as these will become contaminated with gastro-intestinal contents.

7. The containers must be marked with the crocodile's identification, the date, the organ and name of the farm.

8. Specimens which are not sent off immediately must be kept in the refrigerator until despatch.

9. If the specimens are to be sent a long distance they should be packed in ice in an insulated container.

20.1.(b) Formalinised Samples

Blocks of tissue, no thicker than 1 - 2 cm should be cut from the organs with a sharp knife and placed in vials of a 10% formalin concentration with water, and the samples must be completely immersed. The vials or containers must also be suitably labelled.

For further details on methods of rearing, hygiene, nutritional requirements, the collection and preparation of laboratory specimens, common ailments, diseases and treatments, refer to Blake (1974), Foggin (1987), Joanen and McNease (1979), Friedland (1986), Pooley (1982), Van der Riet (1987) and Verseput (1987).

21.

Common Ailments	Possible Cause	Treatment
Broken limbs, ribs or neck, snout tip damaged or animal found dead near perimeter fence.	Faulty pen design. Crocodile may have climbed up the side of the wire netting enclosure and fallen from a height, or fallen into an empty pond.	Bind broken limb with waterproof adhesive tape. Isolate animal and avoid handling. Place skirting board 45 cm high round inside of the perimeter fence to prevent climbing. Before draining pond, herd all animals into the water so that they remain in the pond, until this has been drained.
Abdominal swelling in recently hatched crocodile. (Umbilical abscess)	Poor hygiene in hatchery. Soil around nest fouled.	Normally too advanced when noticed but to avoid this incidence, routinely spray the umbilicus of all hatchlings soon after they hatch, with gentian violet or merthiolate.
Deformities during growth, arched spines, soft mandibles, animal trembles when handled, or spasmodic jerking of limbs, head and tail. Loss of teeth or teeth growing out crookedly.	Vitamin and/or calcium deficiciency in diet.	Improve the diet to provide balanced nutrition. Add carcass or bone meal, and/or add vitamin drops to the food.

Common Ailments	Possible Cause	Treatment
Eyes exude water or mucus. Animal lies with jaws agape, often with head up at an acute angle. Nostrils blocked with mucus, breathing laboured.	Respiratory ailment, animal subjected to drought, chilling caused by sudden change in weather, possibly viral and not a bacterial infection. Autopsy will reveal congestion in nasal passages, throat and lungs.	The pond water can be treated with Terramycin soluble powder (as per instructions supplied). If animals exhibit early symptoms and are still feeding - mix 500 mg|kg and feed x 3 days. Consider moving animals to earth dams where they can burrow. Erect screens to provide shelter from prevailing cold winds.
Food accepted then later discarded at feeding times, or animals go off food for several days.	Change in temperature, normal behaviour at the onset of colder weather. Excessive handling such as after grading and capture of animal, or excessive noise, disturbance at pens, or food mushy and not fresh, or sudden change from normal diet.	Reduce feeding rate by 50% if change in temperatures responsible or cease feeding if air temperature below 20°C. Check quality of food.

Common Ailments	Possible Causes	Treatment
Simple cuts, nails worn, toes raw or bleeding. Small cuts in belly skin and thoracic region.	Faulty pond construction crocodiles damage claws and continually scrape over rough concrete lip of pond when entering or climbing out of pool.	Re-plaster lip of pond to provide a smooth surface. Apply merthiolate or spray wounds with gentian violet.
Throat red and inflamed. Animals repeatedly scratch at eyes and ears. May cease feeding.	Certain algae cause irritation. Poor hygiene, greasy water because pools not cleaned. Check water for acidity, salinity and chlorine levels which may be too high. Dirty river water (high silt level) may be responsible.	If animals housed in a natural pond, remove to a fresh one. Drain pond and allow to bake dry in the sun. If a cement pool, change water more frequently, or employ a trickle system and treat water with copper sulphate for algae.
Toes and feet of the animal become swollen. It may have difficulty in climbing out of the pond. The limbs too may appear to be distended.	Possibly gout or kydney disease which results from inadequate protein metabolism. Vitamin A deficiency is a common cause.	The addition of Abidec vitamin drops (as per instructions supplied) to the food is beneficial and should be continued if animals are obviously not getting sufficient Vitamin A in their food.

Common Ailments	Possible Cause	Treatment
Crocodiles found dead in pen or at bottom of pool. No sign of injury.	Drowning. Below 15°F (7,2°C) hatchlings lose muscle control and balance in water. Sunstroke may be the cause. Dissect and check for obstruction in gut, or fish bones, other objects in intestines and gut.	Check overnight water and air temperatures. (These should be recorded routinely.) Move animals to earth dams where they can burrow for warmth. Ensure adequate shade available for entire population in a pen. Check that labourers take care in not damaging animals when sweeping ponds with hard bristle brroms.
Teeth missing, gums and tooth sockets spongy and discoloured. Scars around snout and jaw. Tongue normally yellow may be spotted with fungal patches.	Overcrowding, fighting at feeding times. Gingivitis infection of mouth, palate or tongue (fungal infection)	Reduce pen population or grade out larger animals if necessary. Ensure food portions are small enough to be swallowed easily. Check on pond water hygiene. Use copper sulphate, or potassium permanganate regularly in water. Spray infected areas, internally and externally with gentian violet aerosol spray.
Hatchling found dead in hatchery - no apparent cause.	Possibly suffocation. hatchlings tend to pile up on top of one another for warmth and security.	If piling observed in the hatchery, sub-divide compartments and house smaller numbers in each.

Common ailments	Possible causes	Treatment
Animals develop small light grey wart-like growths usually starting on the head and spreading rapidly across the body as isolated warts, which, after a few days turn almost black in colour. Eventually the belly scutes are affected. The usual cause of death is cachexia and dehydration.	Pox-virus infection. This is extremely infectious and usually results in an epidemic.	Use ESB[3] soluble powder mixed in the pond water (as per instructions supplied) or with food at 1,5 g/kg for x 3 days. Also spray the severe infections with gentian violet aerosol as secondary organisms may adhere to the warts and blindness can result.
Animals become paralysed in one or both hind limbs and tails. Eyes close or partly close, pupils may appear enlarged. Animal may gape, may raise head or tail in convulsive spasms. Faeces bloodstained or severe diarrhoea evident. Animal may also appear dehydrated, the skin dry and with cracks, especially around the jaws.	Viral hepatitis, enteritis or septicaemia and/or bacterial infection e.g. *Salmonella* sp. Infections can cause very high mortality in epidemic form and unless a specific laboratory diagnosis is obtained - difficult to treat.	Treatment with Terramycin soluble powder in the water or injected intra-muscularly at 10 mg/kg once a day for 9 days, or Gentamycin 2,5 mg/kg in every 72 hours for 5 treatments Isolate all sick animals immediately to reduce cross infection. Sterilize all feeding boards, disinfect drains, treat ponds with strong solution of permanganate of potash or chlorine. Discard any suspect food.

Common Ailments	Possible Causes	Treatment
Belly distended (bloated) animal moves sluggishly, finds difficulty in walking.	Insufficient roughage in diet, sudden change in diet, constipation or over-feeding, particularly when weather cool, or after a large meal eaten there is a rapid drop in temperature.	Provide whole small fish, crabs etc. with food, coarse carcass meal, but preferably cease feeding until bloat subsides and animals shape returns to normal. If cold weather persists, reduce frequency of feeding.
White spots on skin, between digits, sloughing scales on digits or ventral surface, or brownish slime around the vent, behind the limbs and in severe cases, along the neck, belly and basal regions of tail.	Fungal infection. Poor hygiene, excessive grease or oils from fatty meat or fish. Animals housed indoors, or lack of sunshine, floor of pen damp, or animals living in stagnant water.	Cleanse drain and scrub algae from ponds, treat water with chlorine or copper sulphate or permanganate of potash. Ensure that there is sufficient basking space and that the surface is dry and clean. Spray animals with gentian violet or paint with Lugols iodine.
Eye injury (fresh wound) or eyes exude matter. Animals repeatedly scratch at eyes which may partly close and in severe infections eyelids take on a dark colour preceding blindness.	Sharp object in pen. Check netting wire around perimeter of pen. Eye infection caused by dirty water, grease and oils on pond surface, or possibly a viral infection. May occur after dust storm, or very cold weather.	Treat eyes with Chloramide ointment daily, or spray eyes with aerosol chloramphenicol.

21.(a) RECOMMENDED DISINFECTANTS AND DRUGS.

21.(a)1. Mouth, Palate Infections and Fungus
Lugols iodine. Spray on with plastic garden spray or Chloramphenicol 5% gentian violet aerosol.

21.(a)2. Wounds on Adult Animals
Coopers Wound Oil (contains vegetable oil, oleo resins, germicidal agent). Can be sprayed on from distance using plastic garden spray. or Wound Oil (containing chloracresol 0,5% M/V).

21.(a)3. Treatment of Worms
Panacur 10% (Hoechst) contains fenbendazole. Dose at 1 ml/9 ml water/per kg food x 3 consecutive feeds/days.

21.(a)4. Coccidiosis
ESB[3] soluble powder (Ciba-Geigy) contains 30% sulphachloropyrazine. Dose 1,5 g/kg with food x 3 days, or mix in water as per instructions.

21(a)5. Viral Hepatitis, Enteritis, Diarrhoea, Respiratory Infections.
Terramycin Soluble Powder (Pfizer) contains oxytetracycline hydro-chloride 55 mg/g. Mix powder with food 500 mg/kg x 3 days or mix in water as per directions.

21.(a)6. Vitamin Deficiencies
Abidec drops (Parke-Davis) contains vitamins A5000iu, D,4000iu, B1, 1mg, B2, 0,4 mg, B6, 0,5 mg, nicotinamide 5 mg, ascorbic acid 50 mg/ml. Use as directed.

21(a)7. Opthalmia (Eye Infections)
Chloramphenicol/5% with gentian violet-aerosol spray (CAPS) or Chloramide ointment (containing 5% chloramphenicol, 15% sulphacetamid and 1500 iu vitamin Ag. Use daily.

21.(a)8. Skin(Fungal) Infections
Aerosol Chloramphenicol/gentian violet spray. Disinfect pond water with Potassium permanganate 10 p.p.m. or Chlorine at 4 p.p.m. or Copper Sulphate at 10 p.p.m.

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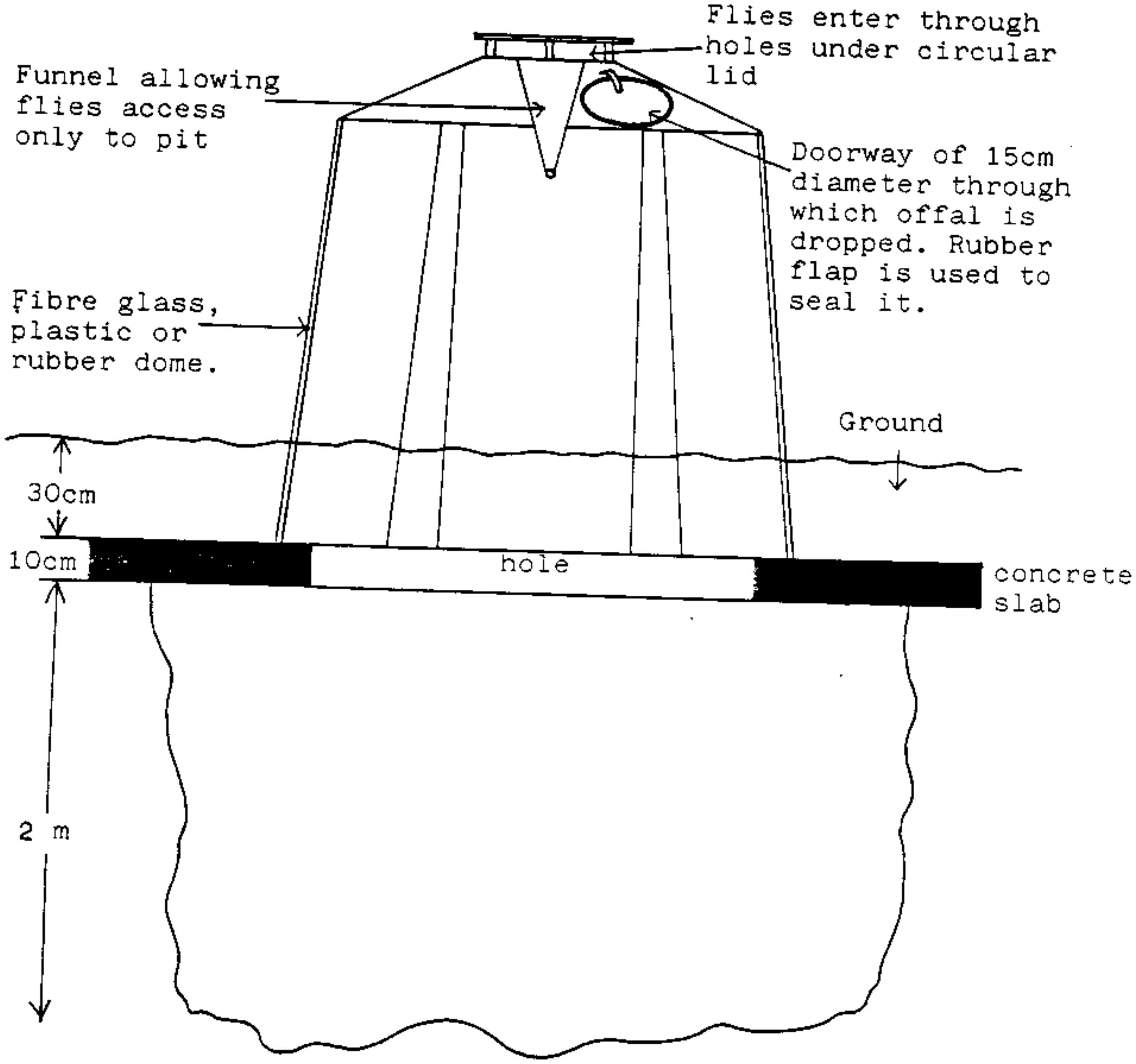
Figure 1. Offal Disposal Pit



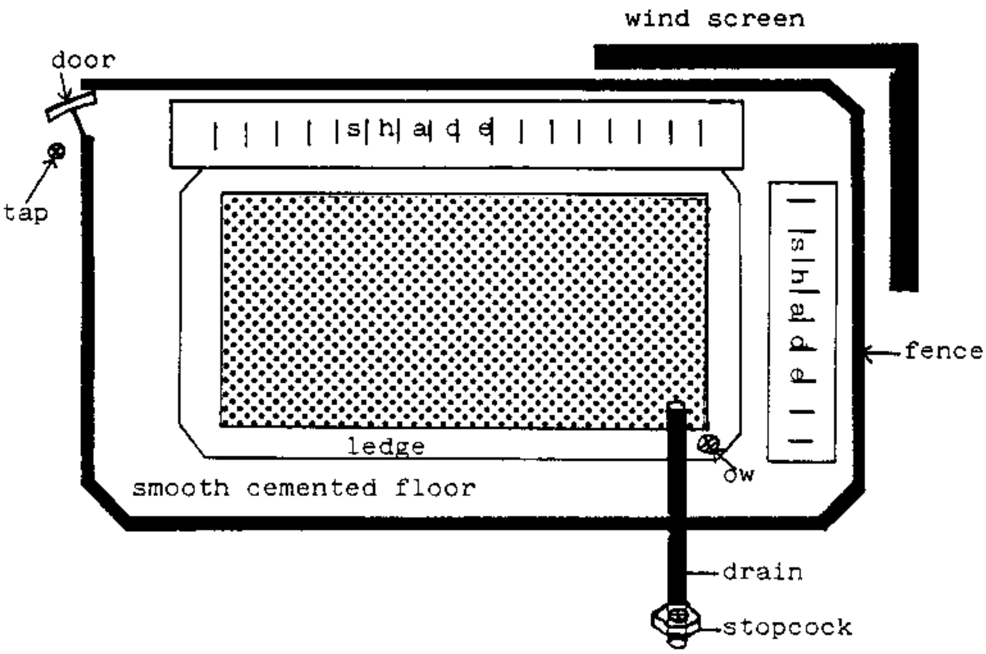


Figure 2. Single-Unit Cement Rearing Pond (Plan View)

Pen size 9 x 6 m (54° sq.) Pool size 7 x 4 m (28° sq.)
Inclined 45 cm wide smoothly plastered ledge. Pool depth of 60 cm to halfway up the ledge. Shade of reed screens or 70% green shade cloth supported on a frame x 75 cm off the floor.

ow = overflow weir, so that oil or grease can be flushed off the surface water via the drain pipe to which it is connected underground.

Wind screen of reeds x 2 m in height.

Stocking density = 100 hatchlings to the age of 1 year.

Perimeter fencing of 1 cm diameter wire netting, reeds or poles.

Note that corners have been eliminated to prevent piling.

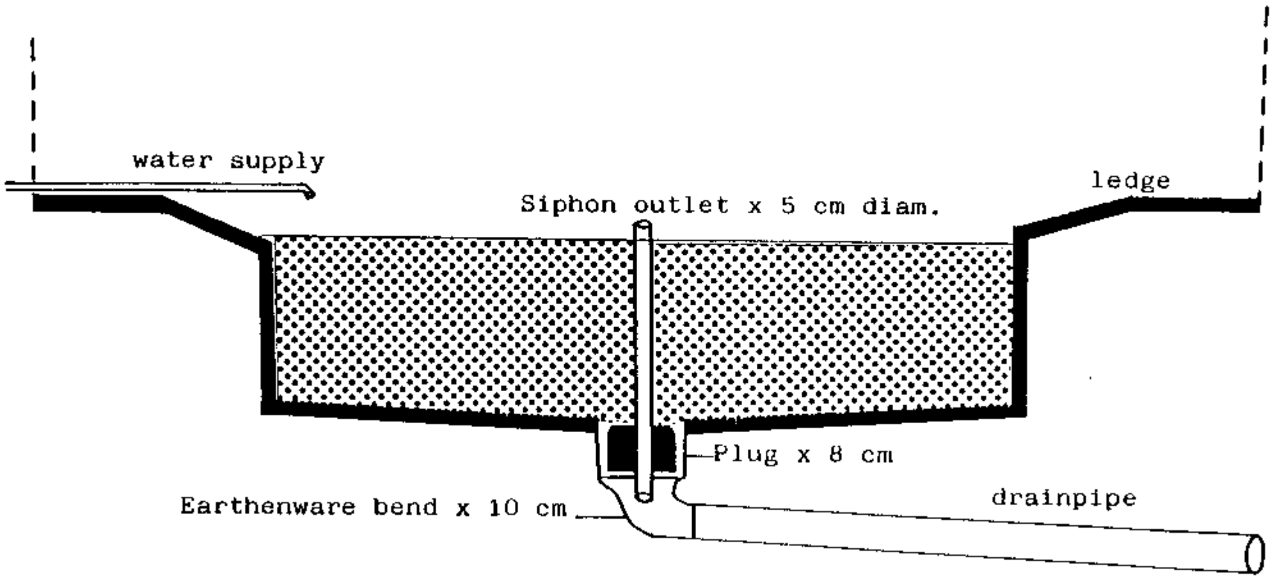


Figure 3. Trickle-system cement rearing pond.

Pool size x 10 m and Pen size x 14 m diameter

Depth = 60 cm Ledge = 45 cm

Shade requirements as per Fig.

Stocking density = 100 hatchlings to the age of 1 year.

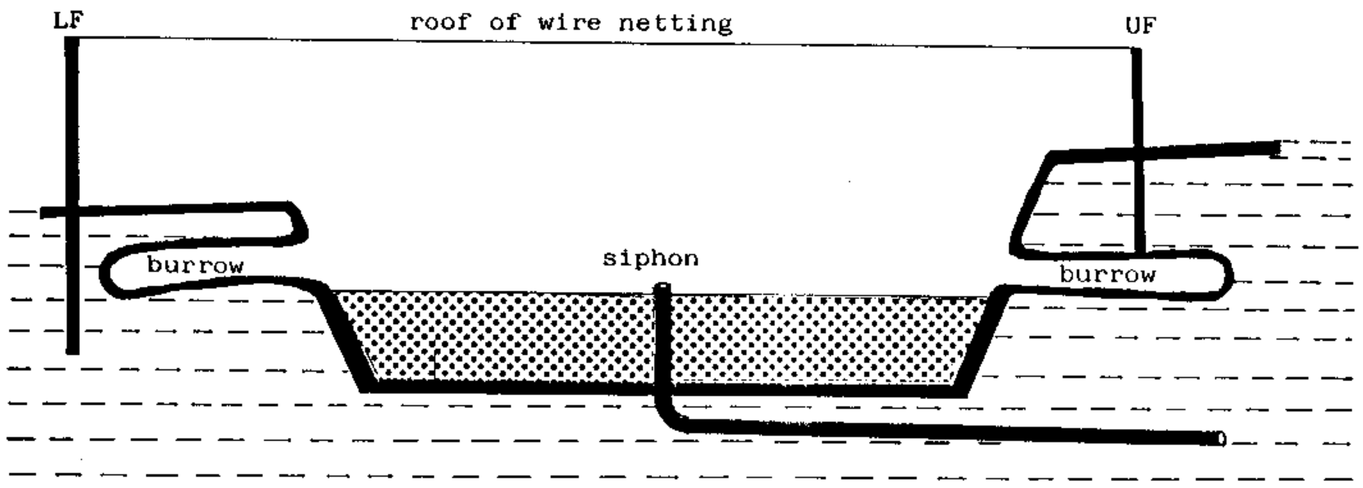


Figure 4. Single-unit Earth Rearing Pond.

Pool size = 10 m and Pen size = 18 m diameter.

LF = Lower fence buried x 1 m below surface.

UF = Upper fence in upper bank of the hillside,
is not buried as deeply to prevent escape.

Depth of pond = 60 cm Outlet pipe of 5 cm diameter.

Stocking density = 50-60 hatchlings to the age of 1 year.

Fig. 5. An example of a rearing pond made from bush poles, with a mud pond and substrate. Note that there is no dry, basking area for the crocodiles, and no shade provided. The wet, muddy conditions are ideal for a build up of bacteria. There is a high incidence of disease and mortality in ponds of this type.

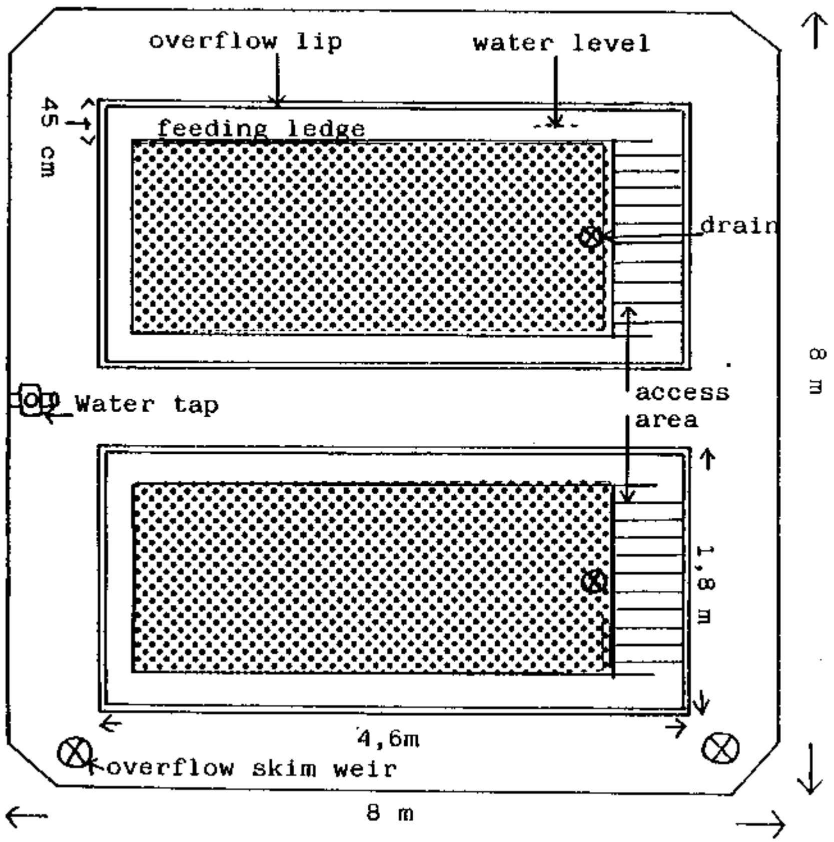


Figure 6. Double-unit Cement Pond

Pen Size = 8 x 8 m (64 m^2)
Pond Sizes = 4,6m x 1,8 m (8,28m^2) each (A & B)
Pond Depth = 65 cm to middle of ledge
Perimeter Ledges = 45 cm wide around pond
Overflow lip = 2 cm above pen floor level.
Floor smoothly plastered as with feeding ledges and slopes towards overflow skim weirs.
Access area = 80 cm sloped from floor to the lip of the pond.
Drains = 50 cm diameter pipes covered by grids
Overflow Skim Weirs = 50 cm diam. pipes covered by grids, sunk into the floor.
Stocking Density= 100 hatchlings for one year.

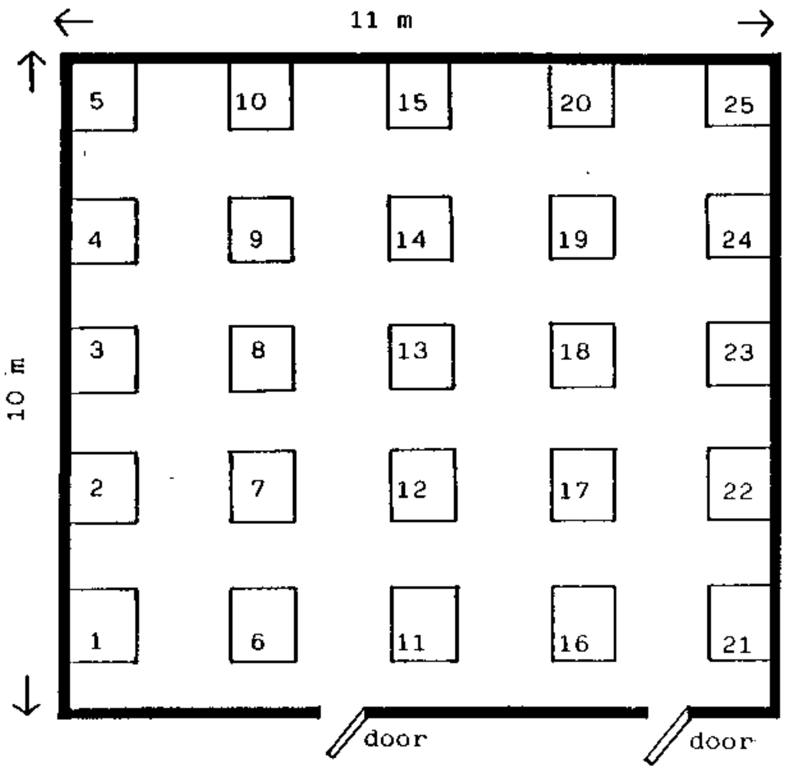


Figure 7.

Showing a hatchery designed to accommodate 25 nests x 45 eggs. average clutch = 1125 eggs capacity.

Area = 11 m x 10 m (110 m^2)
Nest area = 1 m^2 per nest
Walkway = 1 m - 1,5 m between nests.

WORK PLAN FOR CROCODILIAN MANAGEMENT IN ORISSA, INDIA DURING 1990-1995

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ABSTRACT

In pursuance to the broad guidelines of a National Action Plan, the present work plan for the state of Orissa highlights the priorities.

INTRODUCTION

The crocodilian management programme in India was launched first in the state of Orissa where all the three native species still occurred in their natural habitats in 1974. The three species are: the Gharial (Gavialis gangeticus), the mugger (Crocodylus palustris) and the estuarine crocodile (Crocodylus porosus). The habitats which were identified for the management of gharial were in the river Mahanadi and for the estuarine crocodile were in the estuaries of rivers Brahmani and Baitarani. The assosiated sanctuaries were the Satkoshia Gorge Sanctuary (796 sq.km.) and the Bhitarkanika Sanctuary (672 sq.km.), respectively. Muggers were known to occur in several places but a systematic status survey was not conducted. The Hadgarh Sanctuary (191 sq.km.) overa tributary of river Baitarani was identified to form the major area for muggers. In due course the Similipal Tiger Reserve (2750 sq.km.) with its perennial river systems has emerged as the main mugger area in the state.

The conservation approach was to minimise losses of eggs and hatchlings and rehabilitate juvenile crocodilians in the identified protected areas (Bustard, H. R. in F.A.O., 1975). The captive rearing units were located at Tikarpada, Dangmal and Ramatirtha for the gharial, estuarine crocodile and mugger, respectively. From 1981 the unit at Tikarpada has also become a mugger-producing unit. From 1976 captive breeding programme for all the three species were launched in phased manner at the Nandankanan Biological Park.

SITUATION - OVERVIEW

1. Protection of remaining population and habitat:

The initial populations of different crocodilians in Orissa were: (Singh, Kar and Choudhury, 1986)

Species	Year	Location	Adult(M:F)	Juvenile	Total
Gharial	1975	Mahanadi	4 (2:2)	4	8
Mugger	1975	Mahanadi	1	?	?
	1979	Similipal	virtually extinct.		
Est.Croc.	1977	Bh.Kanika	34	64	98

The State's Wildlife (Protection) Rule, 1974 is enacted in line with the provisions of the Wildlife (Protection) Act, 1972 of the Government of India. Therefore, all three species are treated as Schedule-I species. Creation of the special crocodilian sanctuaries and the launching of the conservation scheme generated greater awareness and better protection to all the species. The best protected species and habitat are the muggers in Similipal where 'Project Tiger' is in operation. The estuarine crocodiles are well protected in Bhitarkanika but with off and on human-based conflicts. Both Similipal and Bhitarkanika are managed for final elevation from the status of sanctuaries to national parks. That shall virtually eliminate man-crocodile conflict from the limits of these protected areas. In the Satkoshia Gorge Sanctuary and the adjoining river Mahanadi gharials have no more been killed and the habitat pressures have been regulated.

2. Rebuilding natural populations:

Wild-laid eggs were collected and incubated in hatchery set-ups, the young crocodilians were reared in simulated natural conditions and when attended a length of about 1.2m (reduced to 60cm for mugger) these were rehabilitated in the identifie d protected areas. The following information is an update of Kar (1989).

Species	Egg-source	Young-source	Release of young croc. Place	nos.
Gharial	Gandak (Bihar), Narayani-Kali(Nepal), Chambal(M.P.), Captive-breeding at Nandankanan.	Tikarpada, Katerniya-ghat(U.P.), N.kanan.	R.Mahanadi	610
Mugger	Tamilnadu, Captive-breedings at N.kanan, Rama-tirtha, Tikarpada.	Tamilnadu, N.kanan, Ramatirtha, Tikarpada.	R.Mahanadi	153
			R.Budhabalanga	99
			R.West Deo	72
			R.Khairi	67
			Total	391
Est.croc.	Bhitarkanika, Captive-breeding at N.kanan.	Dangmal	River systems in Bhitarkanika	1,050

Periodic monitoring of the released crocodilians have been carried out in Mahanadi and Bhitarkanika. Regular monitoring of the muggers is carried out in Similipal (Sagar and Singh, 1990). During 1988 January 25 gharials and 433 estuarine crocodiles were counted in their respective released habitats. These indicate a sighting success of 4.5% and 40.0%, respectively. The sighting rates for mugger in Similipal have ranged from 12.1% in r.Budhabalanga through 34.7% in r.West Deo to 71.6% in r.Khairi according to March 1990 reports.

The present stock of crocodilians in captivity are as follows:

Location	Gharial	Mugger	Est.Crocodile
N.kanan	151	18	3
Tikarpada	12	89	0
Dangmal	0	0	356
Ramatirtha	0	109	0
Total	163	216	359
Breeding females	6	10	2
males	1	6	0

The state of Orissa no more obtains its supply of eggs or young crocodilians from outside. Captive breeding has been maintained at a modest level keeping in pace with the release requirements. Search for additional sites for release of gharial and mugger is maintained. The state, however, do not have any other site for the release of estuarine crocodile because of the very specific mangrove habitat requirement by the species. The Bhitarkanika sanctuary is proposed to be extended from the Brahmani-Baitarani estuaries to the Mahanadi estuaries where an area of mangrove habitat is being declared as the Batighar Sanctuary. The addition may offer scope for the growth of the existing population in Bhitarkanika.

Natural breeding of gharial resumed in 1984 after a lapse of over ten years in river Mahanadi. Sighting of young muggers in Similipal and Mahanadi indicate that the species have resettled in these habitats. Nesting incidence in Bhitarkanika have increased over the years from six nests a year to over ten nests and the population of the estuarine crocodile have recovered well. Collection of wild-laid eggs have been stopped, for all species.

The sighting successes have been particulalrly low for gharial (4.5%) and mugger in r.Budhabalanga (12.1%). The situation for gharial is more complex: the sanctuary includes only about 30km of the river, the stretches of the river which can form good juvenile zones are outside the limits of the present sanctuary, the sanctuary experiences disturbances due to navigation by large country boats and fishing, and fishing activities including river-bank-camping are more outside the sanctuary thus prohibitting any further extension of the limits of the existing sanctuary. After declaration of the sanctuary in 1976 detrimental fishing practices were stopped and other forms of traditional fishing for livelihood was regulated. Bamboo rafting through the sanctuary was considered most detrimental and have been stopped. Inspite of the best possible positive efforts, gharial rehabilitation in Mahanadi in this part, i.e., the part downstream of Hirakud Reservoir have resulted with only limited success. The future of gharial remains to be experimented in the upstream of Hirakud and in the Brahmani river.

The management of Similipal have come to a decision to make a last release of 15 muggers in r.Budhabalanga in the tourism zone. Release of mugger in the Satkoshia Gorge Sanctuary cannot be continued further because the released muggers have settled well in an otherwisely designated gharial sanctuary. Inspite of the present regulation of captive breeding pr ogramme there is a standing potentiality of producing 100 live yearlings every year. The future requirement for the species, therefore, is to locate alternate release sites or avenues for channeling away the captive breeding products.

The estuarine crocodile do not create a problem of 'plenty' in captivity because wild-laid eggs are not collected and captive breeding results have not been encouraging because of the want of male crocodiles (Kar, 1989). On the contrary, the problem of 'plenty' in nature is often highlighted in the press because of 'nuisance crocodiles' appearing near villages outside the sanctuary. This has resulted in scenes in the State Assembly. The following list shows the type of crocodile news in the local language news papers. The list for the period concerned, i.e., December 1987 to July 1989, is only suggestive and not complete because we have not made a systematic survey of all the local news papers.

Date	Newspaper	Type of news
Dec.21'87	Prajatantra	human-kill
Jul.28'88	Prajatantra	human and cattle kills
Aug.18'88	Prajatantra	cattle kills: croc menace
Aug.24'88	Prajatantra	seven human kills and several cattle kills...why commercial farming not taken up as envisaged in original plan...Rs.4.35 crores spent since 1975
Sep.01'88	Prajatantra	in 3-months several human kills and 4-pairs cattle kills...people to revolt if nuisance croc not killed
Sep.18'88	Prajatantra	croc-menace
Sep.29'88	Sambad	human-kill (fisherman)
Oct.01'88	Prajatantra	in one year: 15 human-kills and several cattle-kills
Jul.27'89	Sambad	authorities "worried" because of too many crocodiles.

The situation with respect to the estuarine crocodile warrants continuation of active habitat management and attendance at nuisance crocodile spots.

MANAGEMENT PRIORITIES

1. Gharial (*Gavialis gangeticus*):

Objective 1. Improve management of the Satkoshia Gorge Sanctuary for continued breeding and survival of gharial in Mahanadi downstream Hirakud Reservoir.

Action 1.1. Support the present proposal under 'Project Elephant Scheme' to promote the sanctuary as an elephant reserve. This will ensure improved control and management of the riverine habitat.

Action 1.2. Commence research to highlight the significant wetland ecosystem in the Satkoshia Gorge trans-Mahanadi.

Objective 2. Restore the original distribution pattern.

Action 2.1. As a research project release and monitor gharial in the mouth of Deodhara nallah in Hirakud Reservoir with necessary habitat improvement.

Action 2.2. Conduct survey of r.Brahmani to locate possible release sites.

Objective 3. Promote captive breeding at Tikarpada.

Action 3.1. Arrange an adult male gharial.

Action 3.2. Take up captive breeding as a research project to highlight hormonal levels, significance of vitamin-E therapy and improved captive breeding results.

Action 3.3. Initiate research programme in Nandankanan as in Action 3.2.

Therefore, backed by strong research inputs gharial releases shall continue in Mahanadi and other suitable rivers by obtaining releaseable stocks from captive breeding at Nandankanan and Tikarpada.

2. Mugger (Crocodylus palustris):

Objective 1. Maintain 'gene pool reserves' in the wild in at least three places.

Action 1.1. Similipal Tiger Reserve:
- -Periodically monitor the status of the rehabilitated populations in rivers Khairi, West Deo and Budhabalanga.
- -Release upto 15 muggers in r.Budhabalanga.

Action 1.2. Satkoshia Gorge Sanctuary (Mahanadi):
- -Monitor the status of the generated population.

Action 1.3. Conduct survey in Koraput and release juveniles in suitable reservoirs, backed with a systematic monitoring programme.

Objective 2. Improve on the results of captive breeding.

Action 2.1. Initiate research programme similar to Actions 3.2. and 3.3. (Gharial), at Ramatirtha, Nandankanan and Tikarpada.

Monitoring of rehabilitated populations will assume significance. This will be adjuncted with rehabilitation in Koraput and research programme for better results from captive breeding.

3. Estuarine crocodile (Crocodylus porosus):

Objective 1. Improve the level of management of Bhitarkanika sanctuary for better habitat restoration.

Action 1.1. Pursue the proposal to manage Bhitarkanika as a National Park.

Objective 2. Generate a system to better attend the calls relating to 'nuisance crocodiles'.

Action 2.1. Develop a relevant unit under the management of Bhitarkanika.

Action 2.2. Launch a campaign on learning to 'live again with crocodiles'.

For the estuarine crocodile, habitat management, public education and generating public support shall assume importance.

WORK SCHEDULES

The work plan in the above include three broad aspects: (i) habitat management, (ii) research for monitoring and captive breeding, and (iii) handling 'nuisance crocodile' calls. All these aspects are not new but have been maintained at a low key during the 1980s. Any effort to quicken the pace of progress of any of these aspects shall require additional resource in terms of man power and finance. Even to take up research programmes fresh recruitments have to be made because the experienced research personnel of the state are now engaged in research on broader aspects of wildlife management, and a timely requisitioning of their services for crocodilian work is often a problem. Therefore, the time schedules indicated below depend largely on ultimate administrative sanction followed by financial allocations.

Year	Quarter	Action:Gharial	Action:Mugger	Action:Est.Cr.
1990	2nd,3rd	Administrative and financial approval of the broad scheme and the annual plan 1990-91.		
	4th	3.1., 2.1.	1.1.,1.3.	2.1.,2.2.
1991	1st	1.2.,2.2.	1.3.,2.1.	
	4th	3.3.,3.2.		

FINANCIAL IMPLICATIONS

The aspect of improvements in habitat management is handled by the wildlife wing of the State in a phased manner. In principle Government of India have also supported the moves of the state government in these regards. A specific mention is required for the other items under the work plan. Gross financial requirements are as follows.

1.	Survey of new habitats for rehabilitation of gharial and mugger:	...	Rs.30,000
2.	Monitoring of managed populations of crocodilians: 7 areas for 5 seasons.	...	7,00,000
3.	Experimental release and monitoring of gharial in Deodhara (upper Hirakud)	...	3,00,000
4.	Wetland ecology study in Satkoshia Gorge Sanctuary	...	1,20,000
5.	Captive breeding improvement studies.	...	1,00,000
6.	Nuissance crocodile control including public education	...	3,50,000
	Total during 1990-1995:	...	Rs. 16,00,000

S U M M A R Y

Orissa have all three species of Indian crocodilians. During 1970s there were 8 gharials, 98 estuarine crocodiles and very low populations of mugger. By the beginning of 1990 1,050 estuarine crocodiles, 610 gharials and 391 muggers have been released in protected habitats. Collection of eggs from nature have been stopped and captive breedings have been kept at a low key. Yet, 359 estuarine crocodile, 155 gharial and 216 mugger are available as captive stock. Sighting success for released crocodilians have ranged from 4.5% low for gharial to 34.7-71.6% for mugger. The rate for the estuarine crocodile is 40.0%. Broad management priorities have been identified: (i) improvement in the order of habitat management, (ii) survey of new release sites for gharial and mugger, (iii) periodic monitoring of released crocodilians, (iv)experimental release and monitoring of gharial in Mahanadi upstream Hirakud reservoir (v) study to highlight Satkoshia Gorge Sanctuary as an important wetland sanctuary, (vi) study to improve captive breeding, (vii) generate public support near estuarine crocodile habitat through public education and handling 'nuisance crocodiles'. A financial requirement of Rupees Sixteen Lakhs is envisaged for aspects other than habitat management.

A C K N O W L E D G E M E N T S

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EFFECTS OF NEST AND EGG CHARACTERISTICS ON SIZE AND EARLY DEVELOPMENT OF AMERICAN ALLIGATORS

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Abstract. - The effects of incubation temperature, egg volume, and nesting habitat on length, weight, and sex of American alligator (*Alligator mississippiensis*) hatchlings and on length and weight of 13-month-old alligators was determined. Mean incubation temperature differs by habitat and was highest in low marsh nests and lowest in high marsh nests. Variables most highly correlated with mean nest temperature were egg volume, clutch size, mean ambient temperature, and nest volume. Mean egg volume of levee nests was larger than that of high marsh nests and low marsh nests, suggesting that older, larger females selected levee nesting habitat. Hatchling length and weight were positively related to egg volume and incubation temperature. Egg volume and incubation temperature were related to nesting habitat and nest within habitat. Alligator size at 13 months of age differed by nest, suggesting that genetic factors also influence growth in alligators. Females were produced from eggs incubated at low temperatures and appeared to be handicapped by a large amount of absorbed abdominal yolk that hindered their mobility and increased their vulnerability to predation.

Several studies of temperature sex determination (TDS) in reptiles revealed that incubation temperature is often influenced by the microhabitat chosen as a nest site (Ferguson and Joanen 1982, 1983; Webb and Smith 1984; Standora and Spotila 1985).

Studies conducted by Ferguson and Joanen (1982, 1983) and Joanen et al. (1987) comprise the only published research on TSD in the American alligator. Their experiments were conducted in brackish marsh; however, additional research is needed in other areas, since alligators occupy a variety of wetland habitats (Neill 1971:197-206).

The objectives of our study were to investigate nesting habitat of alligators in a freshwater marsh and to determine the effects of egg and nest characteristics on hatchling sex and growth.

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STUDY AREA DESCRIPTION

The study was conducted on Lacassine Pool, a freshwater impoundment on Lacassine National Wildlife Refuge in southwestern Louisiana. The refuge consists of 12,869 ha of marsh and water bodies, and Lacassine Pool was created by enclosing 6,478 ha with a low levee. Dense, emergent stands of maidencane (*Panicum hemitomon*), bulltongue (*Sagittaria lancifolia*) and spikerush (*Eleocharis* spp.) dominated the marshes. Large open ponds were present and contained underwater and floating plants.

Average monthly temperatures for the study period were June (27.3 C), July (28.4 C), and August (27.6 C). The 30-year (1951-1980) average monthly temperatures for these months were June (26.7 C), July (27.8 C), and August (27.6 C) (USDC 1986). Average monthly precipitation for the study period was June (17.0 cm), July (10.2 cm), and August (8.5 cm). The 30-year average monthly precipitation for the same months was June (10.7 cm), July (16.2 cm), and August (13.5 cm) (USDC 1986).

Within and bordering the pool, 3 habitats on which alligators could construct their nests were distinguished, i.e., levee, high marsh, and low marsh. We used the terms high marsh and low marsh to describe dry marsh and wet marsh, respectively. Ferguson and Joanen (1982, 1983) used the term "wet marsh" to describe habitat "where the base and central core (egg cavity) of the nest are always very moist". Typically, low marsh is wetter and not firm (flotant). They used the term "dry marsh" to describe habitat "where the base and central core of the nest are not so moist". Typically, high marsh is drier and firmer than low marsh. Additionally, they defined a levee as an "either artifically or naturally raised area of dry ground, frequently beside a canal, where the nest base is on firm dry ground and where the nest contains much less moisture". Their categorization of nesting habitats were used in our study.

METHODS

Six alligator nests were monitored and included 2 levee nests, 2 high marsh nests, and 2 low marsh nests. Temperatures within nests were measured with Omega Type T thermocouples and hand-held digital thermometers (Omega 450 ATT thermocouple Thermometer). This equipment utilized a copper-constantan alloy and had a resolution of 0.5 C and an accuracy of $\pm$ 0.8 C with $\pm$ 0.1% readings. Within each nest, 6 thermocouples were positiioned around the eggs at the following locations: one was placed at the bottom-center of the clutch; one at the top-center of the clutch; one on the north side; one on the east side; one on the south side; and one on the west side.

Temperatures were monitored in 12-hour shifts, alternating from noon to midnight and midnight to noon shifts with 24 hours between shifts. Therefore, nests were monitored 24 hours out of every 72-hour period. During each 12-hour shift, incubation temperatures were recorded three to six times, and we attempted to obtain at least one reading every 4 hours. The nests were monitored over a period of approximately 60 days during incubation.

On 14 August 1986 eggs were removed from nest 3, because the yet unhatched young could be heard calling from the nest during the previous shift. Eggs were removed from the remaining five nests on 15 August. The egg cavity was partitioned vertically into quadrants corresponding with north, east, south, and west; each quadrant was divided horizontally into an upper and lower layer. Thus, each egg cavity consisted of eight sections or units. The eggs of each unit were placed in a plastic-mesh bag, and each bag was tagged to identify the section of the egg cavity. The bags with egss were placed in 40-l metal containers and were cushioned and covered with nest material for transportation to the laboratory.

At the laboratory the length and width of eggs were measured, and the eggs were returned to the metal containers, covered with moist nest material, placed in a temperature-controlled room, and held at 32 C until they hatched. The volume of each egg was calculated from length and width measurements using the equation for volume of an ellipsoid (James and James 1976:131).

Length (tip of snout to tip of tail) and weight of hatchlings were measured, and hatchlings were individually tagged in the webbing of each hind foot with small monel tags. Approximately once each week during the hatching period, young hatched the previous week were transported to a commercial alligator farm and brooded until they reached a size that permitted accurate sexing, i.e., a total length of approximately 63.5 cm (Joanen and McNease 1978). Most hatchlings had reached a size (63.5 cm) that allowed reliable sexing by August 1987. On 20 November 1987 all alligators in this study were weighed and measured, and individuals less than 63.5 cm were later dissected and sexed in the laboratory.

RESULTS

Egg Number and Size

Clutch size in the six nests varied from 32 to 45 eggs (mean = 37.3). Mean egg volume ranged from 41.8 cm^3 (n = 26) from nest 5 to 70 cm^3 (n = 14) from nest 2. Mean egg volume differed among nesting habitats (F = 459.22; 4, 90 df; P < 0.0001). Mean egg volume from high marsh nests was smaller than mean egg volume from low marsh nests, and mean egg volume from levee nests was larger than mean egg volume from either marsh nest. Additionally, mean egg volume differed among individual nests by nesting habitats (F = 318.68; 4, 90 df; P < 0.0001). Mean egg volume also differed among individual nests (F = 346.31; 2, 90 df; P < 0.0001). The six nests contained 224 eggs and produced 141 (62.9%) healthy hatchlings. Unfortunately, tags were lost from 102 hatchlings before sexing and final measurements, and further identification was not possible.

Incubation Temperature

Mean incubation temperature differed by nesting habitat (F = 102.42; 2, 522 df; P < 0.0001). Mean incubation temperature was highest for low marsh nests, intermediate for levee nests, and lowest for high marsh nests. Mean incubation temperature differed by nest (F = 91.82; 5, 519 df; P < 0.0001). Highest mean temperatures were found in nests 3 and 2, respectively, while lower temperatures were recorded from nests 6, 4, 1, and 5, respectively.

In one correlation analysis the only variable highly correlated with nest temperature by hour by nest was clutch size (0.56153). In another correlation analysis the variables most highly correlated with mean nest temperature by nest for the entire incubation period were egg volume (0.92287), clutch size (0.82354), mean ambient temperature by nest for the entire incubation period (0.70614), and nest volume (-0.50298). The variables most highly correlated with mean quadrant temperature by quadrant within nest for the entire incubation period were egg volume (0.91225), clutch size (0.80120), and mean ambient temperature by nest for the entire incubation period (0.68264).

Size of Hatchlings

Mean length of hatchlings from six nests ranged from 21.5 cm (n = 23) from nest 5 to 24.4 cm (n = 20) from nest 3. Mean hatchling weight ranged from 31.9 g (n = 23) from nest 5 to 55.3 g (n = 20) from nest 3. Hatchling length was most strongly correlated with hatchling weight (0.70711), egg volume (0.67174), and mean nest temperatures during the entire incubation period (0.65334). Interestingly, egg volume was strongly correlated with mean nest temperatures during the entire incubation period (0.92287) and with hatchling weight (0.92245). Hatchling weight was also highly correlated with mean nest temperatures during the entire incubation period (0.86973).

Mean hatchling length differed among nesting habitats (F = 155.39); 2, 98 df; P < 0.001). The longest hatchlings were produced in low marsh nests with a mean incubation temperature of 32.5 C. Medium-sized hatchlings were produced in levee nests with an average temperature of 32.1 C. And the shortest hatchlings were produced in high marsh nests with a mean incubation temperature of 30.7 C. Additionally, mean length of hatchlings differed among nests within nesting habitats (F = 12.64; 3, 98 df; P < 0.0001) and quadrants within nests by nesting habitat (F = 2.79; 40, 98 df; P < 0.0001). Mean hatching length differed slightly among incubation temperatures (F = 5.31; 1, 137 df; P = 0.0227), but the greatest difference was among nests of origin (F = 17.45; 5, 137 df; P < 0.0001).

Mean hatchling weight differed among nesting habitats (F = 199.74; 2, 97 df; P < 0.0001). Heaviest hatchlings were produced from low marsh nests, medium-sized hatchlings from levee nests, and lightest hatchlings from high marsh nests. Additionally, mean weight of hatchlings differed among nests within nesting habitats (F = 34.56; 3, 97 df; P < 0.0001); however, mean hatchling weight did not differ among quadrants within nests by nesting habitat. Mean hatchling weight was also slightly affected by incubation temperature (F = 7.44; 1, 136 df; P = 0.0072), but was most affected by the nest of origin (F = 8.23; 5, 136 df; P < 0.001).

Size at Age 13 Months

Mean length of juvenile alligators from the six nests at 13 to 14 months of age ranged from 64.3 cm (n = 21) from nest 5 to 94.1 cm (n = 6) from nest 3. Maximum juvenile length was 109.2 cm and minimum juvenile length was 46.4 cm. Mean juvenile weight ranged from 982.8 g (n = 21) from nest 5 to 2929.5 g (n = 24) from nest 2. Maximum juvenile weight was 4762.8 g and minimum juvenile weight was 453.6 g.

Mean juvenile length at 13 to 14 months of age differed among nesting habitats (F = 48.52; 2, 45 df; P < 0.0001). The largest individuals were produced from low marsh nests and shorter individuals were produced from levee and high marsh nests, respectively. Mean juvenile length also differed among individual nests within nesting habitats (F = 4.24; 3, 45 df; P = 0.0101); but mean juvenile length did not differ by quadrants within nesting habitats by nest.

Mean juvenile weight at 13 to 14 months of age differed among nesting habitats (F = 35.51; 2, 45 df; P < 0.0001). The heaviest individuals were produced from levee and low marsh nests, while lighter individuals were produced from high marsh nests. Mean juvenile weight also differed among individual nests within nesting habitats (F = 4.11; 3, 45 df; P = 0.0116); but mean juvenile weight did not differ significantly by quadrants within nesting habitats by nest.

Incubation Temperature and Sex of Alligators

The sex ratio of hatchlings from every nest was significantly different from the expected 1:1. Hatchlings produced from levee nest 1 and the high marsh nests 4 and 5 were all females. The sex ratio for hatchlings produced from levee nest 2 was 11 males: 1 female (8.3% females) (Chi^2 = 16.7, df = 1, P = 0.005). Low marsh nest 3 produced hatchlings with sex ratio of 7 males: 1 female (12.5% females) (Chi^2 = 4.5, df = 1, P = 0.05). And low marsh nest 6 hatchlings had a sex ratio of 1 male: 4 females (80.0% females) (Chi^2 = 5.4, df = 1, P = 0.025). Moreover, the sex ratio of all hatchlings produced from the six nests combined was 32 males: 55 females (63.2% females), which was significantly different from the expected 1:1 (Chi^2 = 6.08, df = 1, P = 0.025).

Characteristically, temperatures of male-producing quadrants were $\leq$ 30 C only up to 1.2% of the incubation period. They ranged from 30.1 C to 33.9 C from 84.2 to 97.4% of the incubation period, and they were $\geq$ 34 C from 2.6 to 15.8% of the incubation period. More importantly, for male-producing quadrants, the mean percent frequency (n = 15 quadrants) of time spent incubating was 0.2% at $\leq$ 30 C, was 89.8% at 30.1 C to 33.9 C, and was 10.0% at $\geq$ 34 C.

Temperatures of female-producing quadrants were $\leq$ 30 C from 0.0 to 42.0% of the incubation period. They ranged from 30.1 C to 33.9 C from 58.0 to 98.7% of the time, and they were $\geq$ 34 C from 0.0 to 10.5% of the time. Moreover, for the female-producing quadrants, the mean percent frequency (n = 28) of time spent incubating was 16.5% at $\leq$ 30 C, 81.7% at 30.1 C to 33.9 C, and 1.0% at $\geq$ 34 C. Also, the mean incubation temperature of nest quadrants with males were produced at an average incubation temperature of 32.8 C, while females were produced at an average incubation temperature of 31.2 C.

DISCUSSION

Egg Number and Size

Levee nests contained larger eggs than high marsh nests and perhaps low marsh nests, but too few eggs were measured in low marsh nests to accurately ascertain their size. Within nesting habitats, egg volume of levee nest 2 was greater than that of levee nest 1. For low marsh nests, data were collected only from nest 6, and no comparison could be made of that habitat. For dry marsh nests, egg volume of nest 4 was larger than that of nest 5.

Among individual nests, nest 2 had the largest egg volume, followed by nests 1 and 6. Nests 4 and 5 contained the smallest eggs.

Ferguson (1984) and Ferguson and Joanen (1983) reported a relationship between age of the female alligator and clutch and egg size. They noted that young (< 15 years old) females laid small clutches of small eggs, middle-aged (15-20 years) females laid large clutches of large eggs, and old (> 30 years) females laid small clutches of very large eggs. Chabreck and Joanen (1979) reported a positive size-age relationship for Louisiana alligators. Clutch and egg size, therefore, are indicative of age and size of the nesting female. Similarly, Wilkinson (1985:53) reported a positive relationship between the average egg size, clutch volume, and body length of female alligators in South Carolina.

Our findings indicate that a relationship may exist between nesting habitat and age and size of the nesting females. Older and larger females, i.e., females in peak reproductive condition, may be selecting levee habitat for nesting. Other studies (Joanen 1969, Deitz and Hines 1980, and Wilkinson 1985:49) reported that levees were often utilized where available; however, Carbonneau (1987:18) found no levee nests in his study area, which included 9.08 km of levees at Lacassine NWR.

Several researchers in Louisiana (McIlhenny 1935:39, Joanen 1969, Carbonneau 1987:18) have documented the proximal location of the nest to the female's den. Thus, "nest site selection" is dependent upon the type of habitat the female selects for her home range. Levees are generally associated with deep-water canals on Lacassine NWR, and large females may be the only females that are able to survive in deep-water habitat. Smaller females that occupy this habitat may soon be eliminated. Large male alligators are known to inhabit deep-water canals (Joanen and McNease, 1972), and Rootes (1989) reported that large males in canals often consume other alligators as large as 2.1 m long. This would explain why smaller females are not inhabiting deep-water canals. Canal habitat provides an abundance of prey but appears to be under-utilized even by large females at Lacassine NWR. Factors that may be limiting the utilization of this habitat are the greater vulnerability of alligators to harvest (Rootes 1989) and disturbance by large male alligators and humans.

Size of Hatchlings

Hatchling length was affected by nesting habitat, by nests within nesting habitats, and by quadrants within nests by nesting habitats. Additionally, hatchling length was slightly affected by incubation temperature but was primarily affected by nest of origin. Hatchling weight was also affected by nesting habitat and nests within nesting habitats, but not by quadrants within nests by nesting habitats. Although, hatchling weight was more affected by incubation temperature than was hatchling length, the nest of origin had the greatest affect on hatchling weight.

Hatchling length and weight differed among nesting habitats. Low marsh nests produced the longest, heaviest hatchlings; levee nests produced hatchlings of intermediate length and weight; and high marsh nests produced the shortest, lightest hatchlings. This relationship may reflect a correlation between mean incubation temperature and nesting habitat or mean egg volume and nesting habitat. Interestingly, egg volume was strongly correlated with mean quadrant temperature and hatchling weight.

Within nests 1 and 4 there was no significant difference in hatchling length by quadrant. However, there were significant differences in hatchling length by quadrant in the remaining 4 nests. No discernible relationship or trend was found between mean quadrant temperature and hatchling length. Ferguson and Joanen (1982, 1983) reported that within 6 nests monitored in the field, heaviest hatchlings were obtained within nests from low temperatures, while lightest hatchlings were produced at high temperatures. In our study, hatchling weight did not differ significantly by quadrants within the nests.

For the four nests with sufficient egg data (nests 1, 2, 4, and 5), hatchling weight was positively correlated with egg volume. The highest mean incubation temperature was recorded from the nest having the largest eggs, and the lowest mean incubation temperature was recorded from the nest having the smallest eggs. However, because of limited sample size, the relationship found in our study between egg volume, incubation temperature, and hatchling weight certainly warrants further study.

Size at Age 13 Months

Mean length and weight of juvenile alligators at 13 to 14 months of age differed among nesting habitats and between nests within nesting habitats, but did not differ among quadrants within nests by nesting habitats.

Juvenile length by nest followed the pattern of hatchling length and weight. The longest and heaviest hatchlings subsequently were the longest and heaviest juveniles at 13 to 14 months of age, while the shortest and lightest hatchlings became the shortest and lightest juveniles.

Moreover, within the group of nests (nests 1, 2, and 6) that had identical mean hatchling lengths (23.5 cm), it is interesting to note that the heaviest hatchling group became the longest of the juvenile group, the group of medium weight hatchlings became intermediate in length, and the lightest hatchling group became the shortest of the juveniles.

Incubation Temperature and Sex of Alligators

The temperature that produced males differed from the temperature that produced females. Males were produced at an average incubation temperature of 32.8 C, and females were produced at an average incubation temperature of 31.2 C.

Ferguson and Joanen (1982, 1983) reported that levee nests (34 C) yielded 100% males, high marsh nests produced both males and females, and low marsh nests (30 C) produced almost all females. In our study, males were produced from the warmest nests; however, the warmest nests included two low marsh nests and one levee nest. Although the two levee nests were similar in several respects (e.g. located on the same slope of the same levee, similar in size, made of the same nest material, etc.), incubation temperatures of nest 1 were consistently lower than those of nest 2. One difference between the two nests was egg volume, with nest 2 having the largest egg volume. This would support the idea that embryonic metabolic heat is a contributing factor of incubation temperature within nests. If the metabolic heat of the embryo was contributing to the incubation temperature, then large eggs generating the most heat, and ultimately large females laying large eggs, would produce male hatchlings. This relationship certainly requires further investigation.

In our study, the sex ratio of hatchlings was 63.2% females. Similarly, Ferguson and Joanen (1982, 1983) reported a sex ratio at hatching of 1 male:5 females (83.3% females) in their study area. A sex ratio skewed towards females at hatching would be expected in the American alligator, because male hatchlings apparently are produced from eggs incubated at a smaller range of more stable temperatures than females.

Interestingly, the sex ratio of sub-adult and adult alligators was reported to be skewed heavily towards males (37% females for all size classes combined; n = 4610) at Lacassine NWR (Rootes 1989). This further supports the theory by Schulte (1989) that female hatchlings contain much absorbed yolk, are less active, and are heavily predated the first year after hatching; while male hatchlings are more active and are better able to survive.

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REHABILITATION OF MUGGER CROCODILE (*CROCODYLUS PALUSTRIS*) IN SIMILIPAL TIGER RESERVE, ORISSA, INDIA

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S U M M A R Y

Crocodylus palustris were considered to be extinct in the perennial waters of Similipal Tiger Reserve by 1980. The terrestrial and aquatic habitats, encompassing an area of 2750 sq km, are under active conservation management since 1973. Between April 1981 and February 1990 a total of 238 captive reared juvenile muggers have been released in the Reserve. Out of 99 muggers released in river Budhabalanga, 12.1% excluding wild-bred hatchlings are seen at present. In river West Deo 34.7% of 72 released are seen with some wild-bred hatchlings. In river Khairi (Fig. 1), where 25 muggers were released in April 1989 at Ransaguda, 16 were seen after 44 weeks within a stretch of 900 mt upstream and 1400 mt downstream the point of release. Sightings were only 1 to 3 during the monsoon(Fig. 2). The future plan for mugger in Similipal include (i) a last release in river Budhabalanga in January 1991, (ii) regular monitoring of the wild populations, (iii) continuation of captive breeding programme at Ramatirtha for research, education and to make available juveniles for restocking elsewhere.

INTRODUCTION

The Similipal Tiger Reserve is one of the eighteen Tiger Reserves to ensure perpetuation of the tiger in its traditional ecosystem. The Project Tiger was launched in India in 1973. Two years later, in 1975, the crocodile conservation project was launched in the state of Orissa as a part of the joint effort of the Government of India, U.N.D.P. and F.A.O. of the United Nations. The mugger management project was established at Ramatirtha in the outskirt of Similipal Tiger Reserve. It operated under the direct supervision of the Field Director of the Tiger Reserve. At that time management of mugger in natural habitats were viewed for Hadgarh Sanctuary and Similipal Tiger Reserve. The present paper overviews the management and monitoring of the mugger crocodile (Crocodylus palustris) in Similipal Tiger Reserve.

STATUS IN 1979

The Similipal hills form one of the most rich water-shed areas of the Orissa state. The major perennial river systems constitute: Budhabalanga in the north, Khadkei and Khairi-Bhandan in the north-west, West Deo in the south-west, Salandi in the south and East Deo and Sanjo in the east. Results of survey conducted in November-December 1979 had indicated that the mugger had virtually become extinct in the Similipal Tiger Reserve area. The exact reasons for the extinction of muggers from Similipal were not clear. However, the survey party had taken note of adverse factors like (i) fishing by using explosives and nylon nets, (ii) fire in the river banks forming nesting sites, and (iii) natural effects of activities of wild boar and monitor lizards.

CAPTIVE BREEDING AT RAMATIRTHA

Ramatirtha is located on the banks of river Khairi-Bhandan, 1.5km west of National Highway no. 6. The nearest town is Baripada (100km) in the same district Mayurbhanj. Airports at Calcutta and Bhubaneswar are 280km and 300km, respectively. Nearest market is at Jashipur, 4km away. The place experiences upto 165cm annual rainfall and a temperature range of 8°C in December-January to 41°C in May.

The facilities available include (i) one egg hatchery, (ii) one set of ten hatchling pens-- each with a concrete pool measuring 2x2x0.3m with 1m width vegetated basking land all around, (iii) one set of twelve yearling pens, each holding about 36,000 litres water over a surface area of 32 sq.m. and having basking areas of 1.5 to 2.0m width all around, (iv) one breeding exclosure with land over 974 sq.m. and water over 1810 sq.m. and holding over 2.263 million litres water in three pools of 0.826, 0.233 and 1.189 million liters connected with narrow channels, (v) two water pump houses on the river bank, (vi) two water tanks with holding capacities of 1,45,000 liters and 40,000 liters, (vii) one small laboratory, (viii) four halls, and (ix) eleven residential buildings.

The captive breeding programme was started with young muggers brought in phases from the Tamil Nadu Forest Department and Madras Crocodile Bank. Captive rearing was commenced in 1979 and first breeding took place in 1984.

Year	Total eggs	Total hatchlings	Survival		
			Numbers	%from eggs	% from hatchlings
1984	29	14	08	27.5	57.1
1985	76	33	26	34.2	78.7
1986	207	107	74	35.7	69.1
1987	79	35	31	39.2	88.5
1988	110	54	50	45.4	92.5
1989	110	51	50	45.4	98.0

During the past two years greater attention have been paid to improved husbandry conditions. Periodic health checks, study of each mortality report and approach to rectify physical deformities at the early stage of their appearance, revealed possible nutritional deficiencies. Suitable feed supplements were used and survival rates have been improved. The main supplements are: (i) a mineral salt-mix in the proportion of 30-35g per Kg of pork fed to breeding adults and other juveniles, and (ii) one 500mg Ostocalcium tablet for every juvenile every 15 days. In order to improve the rate of fertility of eggs and the hatching success, before the 1990 breeding season vitamin-E have been administered at a dose of 400mg per adult for ten days. The breeding group now constitutes two males and four females. During 1986 there were upto 13 adult females.

Other aspects of research at the captive breeding center are: (i) territory occupation in relation to all phases of breeding to draw attention to spacio-temporal control measures needed to human activities in a mugger sanctuary, (ii) growth and survival of young muggers living in simulated natural conditions with the group of breeding adults, and (iii) sex-ratio in muggers when eggs are incubated in-situ under shade and under direct sunlight.

RESTOCKING IN SIMILIPAL

Three river systems have been used for the restocking programme. These are rivers Budhabalanga, West Deo and Khairi. Since the natural populations had virtually become extinct, the attempt was to restock with animals from any particular geographic region. Therefore, all releases have been with muggers directly procured from the state of Tamilnadu or produced through captive breeding of Tamilnadu strains at Ramatirtha and Nandankanan. There is, however, a possibility that strains from different localities in Tamilnadu have got mixed for 'natural selection' to play its role through offsprings of the restocked muggers.

Out of the total 238 number of muggers released, 94 were brought from Tamilnadu, 12 from Nandankanan captive breeding project and 132 from the Ramatirtha project. These have been released in rivers Budhabalanga (99 nos.), West Deo (72 nos.) and Khairi (67 nos.). The details of releases are as follows.

Dt. of release	River/Place in STR where released	Stock from which place	Total nos. released	Sex M/F	Scute clipping used
'81 Apr.18	R.Budhabalanga	TN	60	-	-
'85 May 26 '85 Jun.09	R.West Deo	TN	18	8/10	-
'86 Nov.30	R.West Deo	RT	26	-	-
		TN	16	8/8	-
'87 Dec.06	R.Budhabalanga Jambu bridge	RT	39	-	L3
'88 Feb.24	R.West Deo: Patabil nalla	NK	12	1/11	L4 (male) R4 (female)
'89 Apr.24	R.Khairi: Ransaguda	RT	25	-	L5
'90 Feb.08	R.Khairi: Kultapur	RT	42	10/32	L6 (male) R6 (female)
			total 238		

Stock: NK: Nandankanan; RT: Ramatirtha; TN: Tamilnadu.
Sex: F: female; M: Male
Scute clipping code on double-row tail whorls: L: left; R: right; digits 3, 4, 5 and 6: the serial number of the scutes on left or right counted from behind to front.

MONITORING RESULTS FROM RIVER KHAIRI

All rivers in Similipal have rapids dotted with small stretches of deep pools. These deep pools have formed the main territories of the rehabilitated muggers. Because of rocky nature, the rivers are unsuitable for navigation. Walking along the banks is generally difficult because of the terrain. Furthermore, because of a high concentration of the tiger and elephants monitoring expeditions have always presented risks of encountering with these animals. During the monsoon, from June through October ground leeches are innumerable. Under such circumstances, monitoring has been kept limited to a stretch of 10km in river Khairi. From the point of mugger release the streches are 6km in the downstream and 4km in the upstream. The river bank has been marked along both the direction at every 100 metres interval with increasing numerals.

Counting of muggers have been done by walking along the banks during the peak known hours of basking during the day. At the time of preparation of this report data on regular monitoring were received for 44 weeks. There were, in an average 3-4 observation days every week. No observation could be recorded during the weeks ending July 24, September 11, October 02 and October 30. Rainfall during the study period, measured at Upper Barha Kamda in the south and Ramatirtha in the north-west of monitoring zone (Fig. 1), were 252cm and 166cm respectively. The ambient temperature during the study period ranged over 4-41°C at Upper Barha Kamda and 9-41°C at Ramatirtha.

During the first week of monitoring, that is, 25 April to 01 May 1989 the number of muggers sighted ranged from 2 to 11. Only 1 to 3 muggers were sighted during the monsoon period of 25 July to 23 October 1989. Thereafter, the rates of sighting were better. During the 44th week, beginning on the 20th February upto 16 muggers were sighted out of the total 25 released on 24 April 1989 (Fig. 2).

With respect to the place of release, the locations of 16 muggers sighted during the 44th week of monitoring are as follows (dt. 23 February 1990).

Distance from the place of release in meters	Numbers of mugger sighted	
	upstream	downstream
0 - 100	0	1
100 - 200	2	0
200 - 300	0	0
300 - 400	1	1
400 - 500	0	3
500 - 600	2	0
600 - 700	0	2
700 - 800	2	0
800 - 900	1	0
900 -1000	0	0
1000 -1100	0	0
1100 -1200	0	0
1200 -1300	0	0
1300 -1400	0	1
1400 - beyond	0 (upto 4000 meters)	0 (upto 6000 meters)
Total	8 numbers (from 100 - 900 meters)	8 nos. (from 0 - 1400 m.)

After the first ten months of release 16 of the 25 (64%) muggers remained within a stretch of 2.3km — 900m in the upstream and 1400m in the downstream.

Previous records of movement of muggers back in the wild are those of (i) one 170cm young that moved over 1.5km in nine months, (ii) two muggers, 56.9cm and 54.3cm long which moved over 10.8km in 18 months, and (iii) seven of eight muggers confining to a stretch of 3km in a post-release duration ranging from 3 months to 4 years. These movements refer to a lake habitat in Orissa (Acharjyo and Mahapatra, 1978, Singh, 1985), river Mahanadi in the Satkoshia Gorge Sanctuary (Singh, 1983) and river Krishna in Andhra Pradesh (Choudhury and Bustard 1982), respectively. The data from Khairi in Similipal Tiger Reserve are for a much larger number of muggers and the monitoring was done continuously from the date of release. A low rate of sighting in the study area during the monsoon may be because of movement of the juveniles into the smaller tributaries and creeks to avoid the current of the main river and follow the movement of prey-fish, as have been suggested for similar movements of gharial (Bustard and Singh, 1983).

A comparison of the data on movement of mugger under different studies cited in the above, with those of gharial (Bustard and Singh, 1983; Singh, 1985) suggest that out of these two sympatric species, muggers move less. It is true, however, that the first few weeks after release is a 'wandering or exploring phase' for both the species. The absence of 9 of the 25 muggers released in river Khairi indicates that these have shifted out of the study area either during the initial 'exploring phase' or during the monsoon floods. Soon after the monsoon we had reports about two juvenile muggers that entered a village pond situated close on the banks of, and getting flooded with waters fr om, river Khairi at about 45km downstream from the point of release. The muggers had returned back to the river before more information could be collected on these.

The second release in river Khairi was conducted during February, the 8th, 1990 with 42 juveniles. After one month, 32 (76.1%) of the juveniles were localised within a stretch of 2km of the point of release.

SIGHTING RECORD FROM OTHER RIVERS
(January 1990)

In river Budhabalanga a total of 99 muggers have been released between 18 April 1981 and 05 December 1987. Twelve of those are sighted at present. The locations of these are at Jambubridge:2, downstream the bridge: 1, Balidarha:3, Chhatadarha:2 and Manikidarha:4.

In river West Deo a total of 72 muggers have been released between 26 May 1985 and 24 February 1988. Locations known for 25 of these are at Tinadiha (6), Mankeda-darha near Sapaghara field (4), Chhuagada (7) and Patabil bridge (8).

Compared with the data from Khairi, where 71.6% of the released muggers are sighted, the data for Budhabalanga (12.1%) and West Deo (34.7%) are low. Nevertheless, hatchling muggers have been sighted in the latter two river systems suggesting that the rehabilitated muggers have settled down to natural breeding in Similipal Tiger Reserve.

FUTURE PLAN FOR MUGGER IN SIMILIPAL

1. There will be no further release in rivers West Deo and Khairi.
2. In river Budhabalanga 15 juveniles will be released in the last week of January 1991. This will constitute the last release of captive-reared mugger in Similipal Tiger Reserve.
3. The wild populations in all the rivers will be monitored to assess the trend every year.
4. Round-the-year monitoring will continue for the releases conducted in river Khairi with base camps from Kabataghai and Jenabil.
5. The captive breeding unit at Ramatirtha shall continue until the State Government decides otherwise. The products of captive breeding will be supplied, when not required for Similipal, for releases elsewhere in the state or for purposes to be decided by the Government.
6. Research and education activities at Ramatirtha shall continue.

SUMMARY

Crocodylus palustris were considered to be extinct in the perennial waters of Similipal Tiger Reserve by 1980. The terrestrial and aquatic habitats, encompassing an area of 2750 sq.km., are under active conservation management since 1973. Between April 1981 and February 1990 a total of 238 captive reared juvenile muggers have been released in the Reserve. Out of 99 muggers released in river Budhabalanga, 12.1% excluding wild-bred hatchlings are seen at present. In river West Deo 34.7% of 72 released muggers and wild-bred hatchlings are seen. In river Khairi, where releases have been made since April 1989, 71.6% are seen when reports last came in. During a thorough monitoring over 44 weeks, out of 25 muggers released at Ransaguda in river Khairi 16 young ones could still be seen within a stretch 900m upstream and 1400m downstream the point of release. During the monsoon sightings were from 1 to 3 muggers. The future plan for mugger include (i) last release in January 1991, (ii) regular monitoring of the populations in the wild, (iii) continuation of the captive breeding unit at Ramatirtha for research, education and supply of captive reared juveniles for restocking elsewhere.

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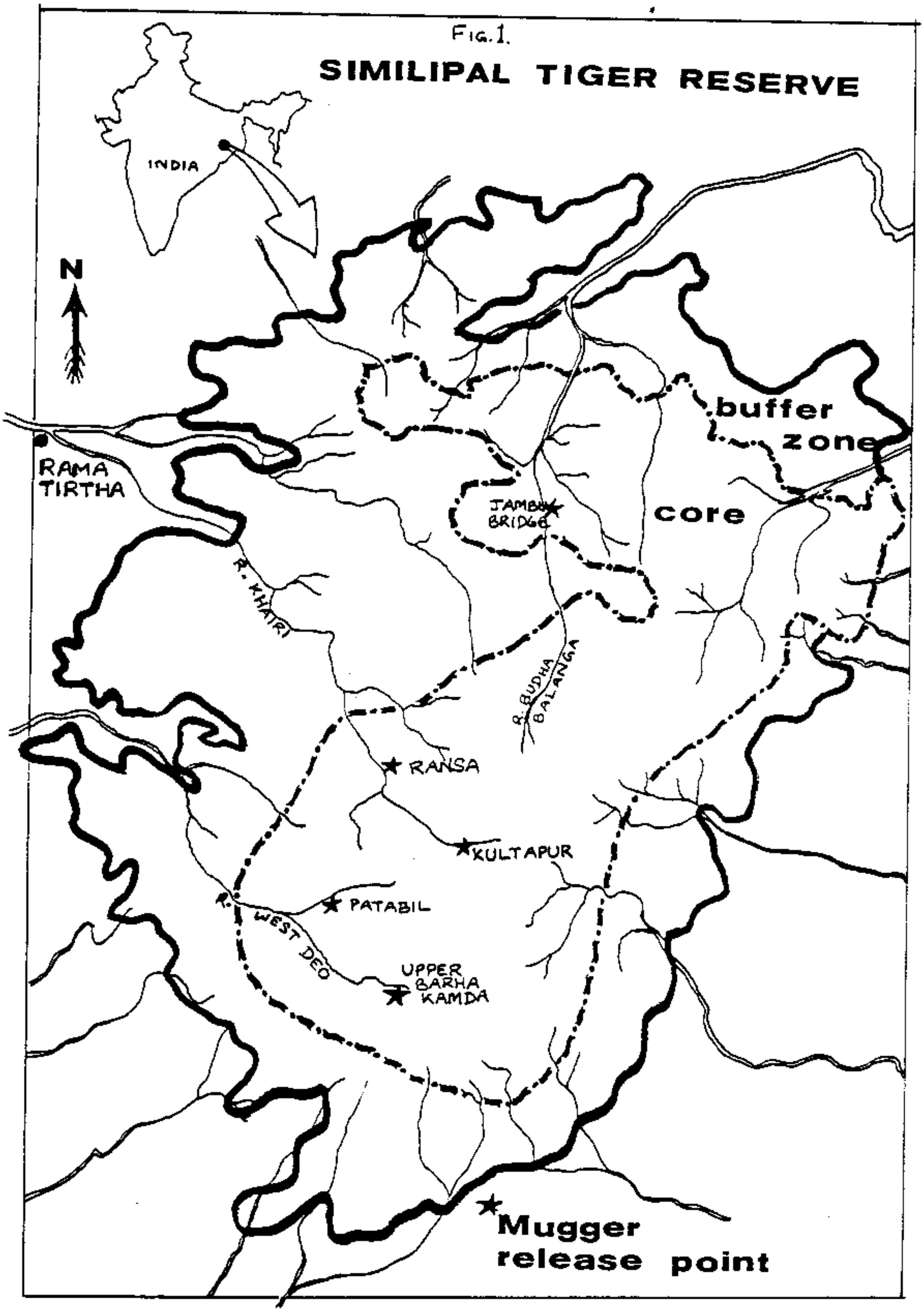
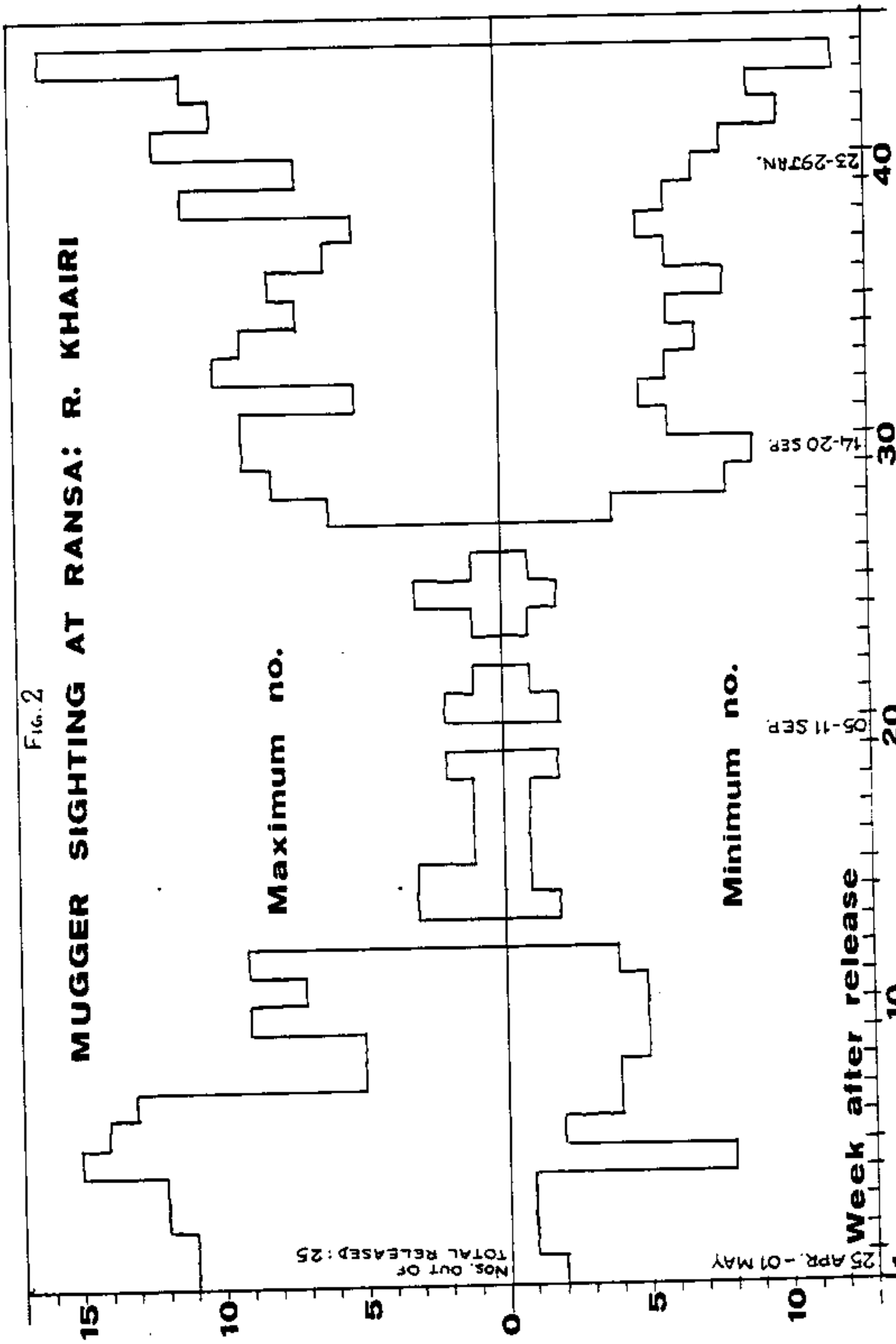


Fig.1.
SIMILIPAL TIGER RESERVE
INDIA
N
RAMA
TIRTHA
buffer
zone
core
JAMBU
BRIDGE
R. KHAIRI
R. BUDHA
BALANGA
RANSA
KULTAPUR
PATABIL
R. WEST DEO
UPPER
BARHA
KAMDA
Mugger
release point

Fig. 2


MUGGER SIGHTING AT RANSA: R. KHAIRI
Maximum no.
Minimum no.
Week after release
NOS. OUT OF TOTAL RELEASED: 25
25 APR. - 01 MAY
05-11 SEP.
14-20 SEP.
23-29 JAN.
15
10
5
0
5
10
1
10
20
30
40

CROCODILE FARMING IN SOUTH AFRICA - THE IMPACT OF FARMING TECHNOLOGY ON PRODUCTION EFFICIENCY

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The Nile crocodile (Crocodylus niloticus), which is indigenous to Africa and Madagascar, used to flourish in large numbers from the Cape of Good Hope northwards into Palastine. Through the years the crocodile populations in Africa dwindled, largely because of man's intervention. In certain areas where large numbers used to roam only a few animals may be found today. It is estimated that the total wild population of the Nile crocodiles in South Africa today number about eight thousand individuals, a figure which includes the populations within protected areas such as the National Parks.

In South Africa the population of Nile crocodiles is on Appendix I of CITES and protected by provincial legislation. Prospective and present crocodile farmers are therefore not permitted to

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*Coordinators: Crocodilian Study Group of Southern Africa

harvest eggs, hatchlings or broodstock for commercial purposes. Though these reptiles are protected in the wild there are, at present, no programmes in motion to restock any areas.

Crocodile farming as a commercial venture has however become popular in South Africa with about 25 farms being operated at present. The industry as a whole is however still in its infancy with a limited number of hides being marketed.

Table 1 Number of *Crocodylus niloticus* hides marketed from South Africa during the period 1979 - 1989

Year	Number of hides marketed
1979 - 1984	0
1985	579
1986	83
1987	658
1988	1884
1989	4623

Crocodiles were initially imported from Zimbabwe and later from Botswana where, according to the CITES classification, these reptiles were listed as Appendix II animals. The lack of suitable stock, with respect to both hatchlings and broodstock has lately become a major problem for farmers. The demand by new entrants, who are obliged to purchase captive bred stock from a few of the existing farms, has caused prices to rocket. The price of breeding females has increased from about US $225 only four years ago to an excess of $3800 at present. Hatchlings up to 3 months of age that were sold for $19 a few years back are now reported to sell well in excess of $75 each.

The data presented in Table 2 reflects the times when farms where established indicating that, with the exception of three farms, development took place mainly during the last decade. From this Table the present sizes of these farms, with regards to the number of breeding females, can be deducted. Fourteen of the farms are at present registered with CITES with a fifteenth application being processed at the moment.

Table 2 Time of establishing the farm and the current number of females

Farms established			Number of females	
Year	Number of farms	Cumulative	Number	Cumulative
1970 - 1975	1	1	460	460
1976 - 1980	2	3	62	522
1981 - 1985	13	16	1307	1829
1986 - 1989	8	24	392	2221

It is of interest to note the diverse backgrounds of the people investing in or who is involved with the management of the crocodile farms. Their primary activities may be as medical doctors, property developers, baking technologist, persons involved in the building industry, game, pig or poultry farming, fruit, vegetable or sugar cane production. Very often their experience in the various professions or industries are reflected in the crocodile farms with which they are involved. Consequently, the technology employed at the various farms may differ substantially. The farms further differ with respect to the extend that tourism is utilized as a source of revenue, some realizing a higher income from tourism than from the production unit. In developing the present production technology, two broad approaches are now being established:

- Primary producers, with their own broodstock, rearing their hatchlings until slaughter or selling them to other producers.

- Secondary producers, who buy hatchlings for the sole purpose of raising them for culling purposes.

Specialization of this nature may contribute significantly to the success of the industry in the future.

The management approach and the technology employed by the primary producers may differ substantially, an aspect which is often reflected in the production efficiency of the enterprise. Examining the different farming methods employed at these units are therefore of value.

BROODSTOCK ENCLOSURES

A male to female ratio of roughly 1 to 5 is favoured on most farms. Some broodstock enclosures are designed to accommodate one male with an average of five females, while others may house only two females with one male. Other farms have very large enclosures with as many as ten males and fifty or more females in a single enclosure. There are different schools of thought as to which of these approaches are the ideal. No comparative data is however available from which reliable conclusions can be drawn on their reproductive performance. Though not supported by scientific evidence it does seem as if a higher conception rate may be obtained in the larger enclosures. The design of these enclosures is of paramount importance in order to prevent male dominance, thus excluding certain males from the breeding process with a resultant lower percentage of females laying fertile eggs, a factor which add to the number of nonpaying residents in the enclosure.

The design of the enclosures vary with some being a single pond with concrete enclosed laying areas, each large enough for one female to enter at a time, while others are multiple ponds with nesting areas of soft sandy strips well above the water line. Some enclosures may be totally functional while others may be beautifully landscaped natural areas with waterfalls and cascading water. It is of interest to note that controlled tourist activity has no marked effect on the females.

Irrespective of the choice of enclosure it is essential that the animals are properly tagged and the female's nest site identified so that accurate records can be kept of the female's reproductive performance.

Table 3 Female record card

Tag No: .... Origin of Female:..................

Date	Enclosure No
....	....
....	....
....	....
....	....

Date	Size (total length)
....	....
....	....
....	....

Reproduction

Date	No. of Eggs	No. Damaged	No. Incubated	No Hatched	Comments
....	....	....	....	....	....
....	....	....	....	....	....
....	....	....	....	....	....

Identifying marks/scars: ....

Medication: ....

Comments: ....

....

....

....

Without proper records it is possible that a certain female may contribute nothing at all to the productivity of the unit, without the farmers even knowing.

At present the following situation prevails in the breeding units (Table 4).

Table 4 Reproductive efficiency during the 1989 - 1990 breeding season

Farm	Number of females in unit	Breeding interval	Number of nests	Number of hatchlings	Female* productivity index
A	130	-	100	3655	28,13
B	132	-	55	2002	15,17
C	300	-	44	1175	3,92
D	19	-	2	93	4,89

*Female productivity index = Number of Hatchlings/number of Females kept

INCUBATION MANAGEMENT AND TECHNOLOGY

All the producers are making use of artificial incubators. The eggs are removed within 24 hours of lay, placed into hatching containers, be it baskets or boxes with vermiculite as the most popular incubating medium. Incubators vary from fairly primitive, yet effective systems to very sophisticated micro-processor controlled units within which temperature is maintained at 31 ±

$0.1^{o}C$ and RH at 90%. Though various farmers experienced problems with incubators in the past with hatching percentages varying between 0% and 70%, results seem to be more promising at present with the average hatchability of ± 75% with the 1989-1990 hatch.

Table 5 Hatching efficiency during 1989 - 1990 hatch

Farm	Number of nests	Ave number of eggs/ nests	Ave hatcha= bility %	Number of hatchlings
A	100	43	85	3655
B	55	52	70	2002
C	44	39	68,5	1175
D	2	50	93	93

HATCHLING MANAGEMENT

The successful rearing of hatchlings will be determined by the management and nutritional programmes to which the young reptiles are subjected. Farmers aim to slaughter stock at eighteen to twenty four months of age but due to a lack of proper records at most farms it is difficult to quantify the degree of success achieved in this respect (Table 6). A general growth period of 24 - 30 months seems to be a norm.

Table 6 Time required for hatchlings to reach slaughter length of ± 1,35 meter

Farm	Range (months)
A	21 - 36
B	18 - 24
C	16 - 30

The treatment of the hatchlings as from hatch will however be crucial in order to shorten the rearing period. The approach adopted does however vary substantiallly between farms.

While some enterprises place hatchlings in water immediately after hatch, others keep the hatchling dry for a few days to "harden up". Food is often withheld for the first 7 - 10 days of their lives. These practices may affect the vitality of crocodiles significantly with a dramatic affect on their subsequent growth. No scientifically based data on the pro's and con's of these practices has been located.

The effect of hatchling pens must not be underestimated. It has been shown with various other species that group size and population density may effect the performance of animals in an intensive unit significantly. The present designs of rearing enclosures differ dramatically in shape and size, where-as no consistent norm is being used when it comes to group numbers or stocking density. In general a norm of six reptiles per square meter until 6 months of age may suffice. Some units utilize circular buildings with holding areas of 8 meters in diameter and a surface to water ratio of 1:1, using heated water to control temperature. Others use large, specially-designed buildings, capable of accommodating several thousand hatchlings under one roof with approximately 150 reptiles per pen. Scientific evidence on the optimal group size and/or stocking density for Nile crocodile hatchlings and rearing stock is lacking.

Most of the producers strive to maintain the temperature within the grow-out units at around 31°C. There are some producers who place their rearing stock out into open air camps at the age of 9 - 10 months where they are kept until culled. This practice may have a significant effect on growth performance.

Heat is generated by means of electric fan heaters, water heated by coal, diesel or electricity and heat exchange pumps. The cost effectiveness of the various sources must be considered. Though 31°C may be the optimal temperature for maximal growth, it might not be optimal when growth rate, feed conversion, stocking density and heating costs are taken into consideration.

Table 7 Running cost of heating the rearing units

Heat source	Cost (Cent.kwh^{-1})
COAL	1,28
DIESEL	12,00
ELECTRICITY	
Elements	10,28
Heat Exchange	3,43

Although most producers aim at slaughtering their stock at the age of 18 to 24 months, it seems as if this objective is not being attained.

RECORD KEEPING, TAGGING AND MARKING

Growth performance can only be monitored accurately if hatchlings are properly tagged. This, unfortunately, is seldom done with only a few hatchlings being tagged by the producers at present, making it impossible to describe and evaluate the growth performance on the various farms. Results obtained from two producers who were marking their hatchlings are presented in Table 8.

Table 8 Growth performance of tagged hatchlings

Farm	Length at 90 days of age (mm)	
	Average	Longest
A	482	607
B	348	530

With regards to females, the situation is very much the same. If females are not individually tagged, nests cannot be properly identified and it is then difficult to link nests to specific females in consecutive years. Linking hatchlings to females to monitor fertility and hatchability is often impossible.

Those females that are marked are usually marked with numbered Aussie cattle tags made of plastic. Unless great care is taken when applying the tags, they do not stay on for more than a year or two. The loss of tags contribute to poor record keeping.

NUTRITION

The availability of protein is becoming a major limiting factor with sources diminishing every year as more crocodile farmers enter the industry and wastage is being minimized or better utilized by the other industries.

Only a few farmers have access to a regular source of red meat, the majority of enterprises being dependent on mortality chickens as food source. Consequently the diet of crocodiles on any particular farm will depend very much on what is readily available in the area. Due to the lack of sufficient protein sources in certain areas, farmers have to travel further to collect carcasses with some farmers sending vehicles as far as 120 miles to collect even moderate loads of protein.

In situations where an actual diet is compiled it may consist of a mixture of muscle and liver with some producers including fish. A typical diet with these ingredients would have the following composition as presented in Table 9.

Table 9 Typical diet fed to hatchlings and juvenile crocodiles

Components		%
Bone meal		2,00
Beef muscle		50,30
Liver		5,00
Fish (e.g. *Clarias gariepinus*)		17,57
Fish meal		7,84
Cooked starch		14,29
Mineral and Vitamin mix		3,00
Composition on dry-matter basis		
Energy	($MJ.kg^{-1}$)	16,30
Crude protein	(%)	45,00
Fat	(%)	6,31
Calsium	(%)	1,55
Phosphor	(%)	1,14

We are at present conducting trials with Nile crocodiles using wet and dry diets with protein levels of between 45 and 48% on a dry-matter basis. In these diets cooked maize starch is utilized as an energy source with seemingly satisfactory results.

GENERAL

At present some of the farms are situated in areas where water is scarce, temperature extremes are unsuitable for crocodile farming and availability of protein is a limiting factor. Other factors such as disease control, irregular grading of the growing hatchlings and rearing stock as well as ineffective management procedures have negative effects on the overall productivity of the units.

When the productivity of the units is measured in terms of the number of hides marketed, a distorted figure may be obtained due to the fact that new entrants are at present relying heavily on existing producers for stock. It is also possible that existing producers are relying on the sale of stock to new entrants and are therefore not exploiting or developing marketing opportunities to their full extent.

Many farmers are also retaining animals for future breeding projects or merely as an investment. All these factors have contributed to the increase in the price of live animals which has been so dramatic that it is now virtually impossible for new entrants to venture into this type of farming without substantial financial backing.

CONCLUSION

Despite the fact that more than $16 m has been invested in the South African industry in recent years, the industry is still very limited when measured in terms of hide output. Producers will have to become more refined in their farming methods with respect to husbandry techniques and general sound management principles.

Better communication amongst the different producers and the sharing of knowledge could enhance the development of crocodile farming in South Africa and the profitability of the individual operators.

Pelletized alligator feed: an update

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INTRODUCTION

The development of practical feeds for farmed alligators (*Alligator mississippiensis*) has been the objective of research conducted at or sponsored by Rockefeller Wildlife Refuge for many years (McNease and Joanen, 1981; Joanen and McNease, 1985a; Staton, 1988; Staton et al., 1988; in press a,b,c,d). Until recent years, vitamin-supplemented nutria (*Myocastor coypu*) has been considered the best practical diet for the large-scale feeding of alligators under intensive culture. In a previous report (Staton et al., in press a), a detailed analysis of nutria meat was presented along with alligator responses to the supplementation of nutria meat with a semi-practical and commercially prepared, pelletized alligator feed (Burris Mills & Feed, Inc., Franklinton, LA). In these studies, excellent growth was achieved with relatively high levels of supplementation (60-70% of dietary dry matter) of nutria meat with the dry diets.

The Burris Mill product is now in widespread use as a feed supplement in the alligator industry. Nevertheless, the availability of a commercially prepared diet which can provide the total nutrition of farmed alligators is still a high priority. The experiments reported on here were conducted in an effort to yield information which could lead to the improvement of commercial alligator feed. Specifically, we detail alligator responses to modification of the protein and amino acid composition of this diet.

METHODS AND MATERIALS

Animals and housing.---These experiments were conducted at Rockefeller Wildlife Refuge, Grand Chenier, Louisiana, using pens and feeding/cleaning procedures which have been previously described (Joanen and McNease, 1976; 1977; Staton et al., in press a). In each experiment, twelve tanks containing alligators were assigned to each of four diets such that there were three replicates per diet.

All experiments were conducted with alligators which originated from eggs that were artificially incubated according to methods described elsewhere (Joanen and McNease, 1976; 1985a,b). At the initiation of experiments I and III, alligators were 6 months old and averaged 695 and 662 g body weight, respectively. Experiment II was conducted with 6 week old alligators averaging 108 g body weight at the beginning of the experiment. The three experiments lasted 8, 18, and 8 weeks, respectively.

Diets.---In experiment I, Burris Mills 45% protein alligator feed (described in detail in Staton et al., in press a) was fed either as a total ration or supplemented with methionine (DL-methionine as 0.2% of diet), lysine (L-lysine, 0.9% of diet), or both methionine and lysine (0.2 and 0.9% of diet, respectively).

In Experiment II, the Burris Mills 45% product was modified by supplementing with a high-protein premix (Table 1) which raised the protein composition of the supplemented diet to 54% of diet while maintaining methionine and isoleucine composition (expressed as a percentage of protein) constant. Both the 45% and 54% protein diets were then fed with or without further amino acid supplementation. The result of these amino acid supplementations was to raise methionine content by 0.4% of dietary protein and isoleucine content by 1.0% of protein.

Table 1. Experiment II: High-protein supplement used to raise protein content of the 45% protein Burris Mills alligator feed to 54%.

Ingredient	%
Fish Meal	37.00
Feather Meal	18.90
Blood Meal	13.40
Isolated Soybean Protein	9.90
Gelatin	8.00
Cysteine	0.30
DL-Methionine	0.15
Poultry Fat	8.00
Carboxymethyl Cellulose	2.00
Vitamins	1.00
Potassium Carbonate	0.60
Sodium Chloride	0.50
Trace Mineral Premix	0.20
Selenium Premix	0.05

In experiment III, a Burris Mills 56% protein alligator feed was tested. The control diet consisted of the blend of nutria meat and the 45% protein Burris Mills alligator feed currently used in the alligator industry. The 56% protein product was feed either as the sole diet or supplemented with either chicken liver or a premix (Table 2).

Table 2. Experiment III: Contributions made to 56% protein experimental diet by a premix used as 3% of dry ingredients.

Ingredient	Contribution to Experimental Diet (%)
Isoleucine	0.4
Potassium Carbonate	0.6
Arginine	0.9
Vitamins	0.6
Taurine	0.5

In all experiments, dry diets were used by adding water (50% by weight) prior to feeding or mixing with the meat component. Where necessary to create dietary treatments, the amino acid modifications described above were made by dilution.

RESULTS

Experiment I.---The greatest source of variation in alligator production criteria was the particular tank in which alligators were raised. Diet did not significantly influence alligator performance in this experiment. The effect of methionine on feed conversion and of lysine of feed consumption approached significance, and it is possible that such effects would have proved significant in an experiment of longer duration.

Experiment II.---Protein levels was the single factor influencing alligator production criteria in this experiment. Gains in body weight and total length were significantly improved by increasing the protein level of the diet. The influence of protein level on feed conversion approached significance (P>0.063). Significant differences between tanks did not exist as in the previous experiment.

Experiment III.---The control diet, consisting of the 45% Burris alligator feed/nutria meat blend supported greatly superior performance compared with other diets (Table 5). This was true despite the fact that consumption of the control diet was significantly less than other diets. However, wastage of the remaining diets was apparent. Hence, consumption and feed conversion data many not be reflect true consumption. Despite feed wastage, feed intake of alligators in this experiment did not appear to be restricted.

Table 5. Experiment III: Performance criteria of alligators as influenced by diets consisting of the nutria meat/45% protein Burris Mills alligator feed or a Burris Mills 56% Protein alligator diet, fed as the sole ration or supplemented as shown.

Diet	-- Gain in --- Body Weight	Total Length	Dry Matter Consumption	Dry Matter Feed:Body Weight Gain
	-- g --	- cm -	---- g ----	---- g/g --
45% Burris/Nutria	743[a]	165[a]	6157[a]	1.20[a]
56% Burris	272[b]	106[b]	11743[b]	6.44[b]
56% + Chicken Liver	345[b]	119[b]	12258[b]	5.08[b]
56% + Supplement	280[b]	113[b]	11367[b]	7.20[b]
------ Mean ------	410	126	10381	4.98
------ SEM -------	56	5	623	1.30
ANOVA P>F (Diet)	.001	.001	.001	.046

DISCUSSION

The dietary protein requirement of alligators is apparently greater than 45% of diet. Staton et al. (in press b) reported a digestible protein requirement of 42.5-48.7% of dry matter - or approximately 48-54% as manufactured. Hence the 54-56% protein diets of experiments II and III would appear to satisfy the protein requirement. These protein levels are similar to the protein content of the commercially-used blend of Burris 45% alligator feed and nutria meat, but these manufactured rations did not support performance equivalent to that pellet/nutria meat combination. Thus other factors account for the lack of performance of alligators fed the higher protein manufactured diets. In the present experiments, manipulation of amino acid levels did not result in improved performance. Only with the protein deficient diets of experiment I did the effect of amino acid supplementation approach significance.

Further refinements of current feeds and feeding methods are apparently needed to have complete, cost-effective nutrition totally supplied by pelletized feeds. Part of that improvement may be expected to result from nutritional improvements. Other factors, however, including management and manufacturing, are sure to be involved. After adjustments in protein level - with corresponding attention to energy (see Staton et al., in press) - improvements in the method of preparing and offering the feed appear to hold the greatest promise in achieving the goal of total nutrition for optimal performance with commercially prepared feeds. Recently, it has been reliably reported (D. Burris, pers. comm.) that a group of farmed alligators fed exclusively with the 45% protein Burris alligator pellet have achieved growth equal to that of other farmed alligators fed any other diet. The difference between this field experience and experimental results reported here and elsewhere appears to lie in the manner in which the diet was offered. Complete feeding farmed alligators with pelletized diets thus seems achievable in the near future.

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Processing Yields From Farmed Crocodiles (*Crocodylus porosus* and *Crocodylus novaeguineae*) From Papua New Guinea

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INTRODUCTION

Over 3000 saltwater crocodiles (*Crocodylus porosus*) and 11000 freshwater crocodiles (*Crocodylus novaeguineae*) were harvested at the Mainland Holdings crocodile farm in the last 12 months. Because of the quantity of hides and meat that we produce, we seek to improve our methods of planning culls to meet cash flow requirements and market needs. To develop such procedures, it is necessary to predict the amount of marketable product available from live farm stock, sometimes many months in advance. This report outlines one approach we have recently used to achieve this.

METHODS

During 1980-1982, records of the size (total length, live and salted belly width, body weight) and growth of thousands of crocodiles on the farm were collected. Additional data on thousands of animals were obtained during culls of the past year. We have used random samples (Table 1) of these data to develop species-specific predictive relationships between length, weight, and belly width(s), within the sample limits defined below.

Meat processing yields were determined for a total of 44 *C. novaeguineae* and 36 *C. porosus*. Immediately after skinning, the heads, feet and viscera were removed to produce a "dressed carcass". The legs were removed at the shoulders and hips and were not further processed. The remainder of the dressed carcass was divided into tail and "upper body" (torso) portions before deboning and defatting. Tail girth was measured at the base of the tail at the point of maximum diameter, usually 3-4 scale rows from the rear edge of the hind leg. Descriptive statistics of the sample are given in Table 2.

Records on 1989-1990 feed consumption and live body weights in pens, each containing several thousand crocodiles, have allowed precise estimates of feed conversion and body weight gain. These estimates of growth, combined with hide and meat yield information have made possible predictions of future product availability.

RESULTS

Size Relationships.---In terms of farm management and the ability to make size estimates from feed consumption and conversion data, we have found body weight to be the most useful overall indicator of crocodile size. Therefore we have analyzed size relationships in terms of body weight. Table 3 shows that belly width (both live and salted) and total body length are quadratically related to body weight within the limits of our sample.

Tail girth (TG) was directly related to body weight. Across species, the predictive relationship was TG = 23.6 + 1.095*BW ($P<0.001$, $R^2 = .899$), where tail girth is expressed in cm and body weight in kg.

Meat Yields.---Meat yields, expressed as percentages of body weight, are presented in Table 4. Yields were generally similar for the two species and sexes, but statistically significant differences existed. Some, but not all differences were due to a species-related size difference in the samples. For example, legs comprised a smaller percentage of body weight for *C. porosus* than *C. novaeguineae*. This is a function of greater body size in the saltwater sample and the fact that, expressed as a percent of body weight (BW), hindlegs (HLP) and forelegs (FLP) were smaller for larger animals (HLP = 6.434 - 0.191*BW + 0.003*B2; $P<0.001$; $R^2 = 0.388$; FLP = 3.744 - 0.202*BW + 0.005*BW2; $P<0.001$; $R^2 = 0.381$). Linear regression analysis of the other yield criteria did not show a significant influence of body weight. Thus other differences appear to be species and sex related. Saltwater crocodiles had slightly larger tails and more tail meat than freshwater crocodiles. Overall meat yield, expressed as a percentage of body weight, was slightly greater for saltwater crocodiles. Across species, females tended to have proportionately larger upper bodies and more upper body meat than males.

DISCUSSION

Using the regression equations developed above, it is possible to determine the amount of skin or meat products available given some knowledge of the liveweight of crocodiles in a pen. However, we do not regularly weigh crocodiles during growout as this reduces food consumption and growth. Instead, we can make use of our records on feed consumption and feed conversion to estimate average body weight of crocodiles in pens. Using these estimates, the potential yield of meat and skins can then be calculated. For example, given (1) a pen stocked with 300 freshwater crocodiles with an average weight of 5.0 kilograms; (2) dry matter feed consumption of 3000 kilograms over six months; (3) dry matter feed conversion of 2:1; and (4) zero mortality, a new average body weight of 10.0 kilograms can be calculated. Based on an average body weight of 10.0 kilograms, it can be estimated from the equation (1989 sample) in Table 3 that 31.2 x 300 = 9360 cm of salted belly skin are available. Likewise, from average yield figures in Table 4, it can be estimated that 300 x 6.55 = 1965 kg of dressed carcasses can be produced.

Similarly, it may be desirable to predict the future market value of a pen of 300 saltwater crocodiles averaging 5.0 kilograms body weight - say, in 5 months. Our growth records suggest that these animals would average 8.5 kilograms with 5 additional months of growth. From Table 1, it can be calculated that an 8.5 kilogram saltwater crocodile would average 29.5 cm in salted belly width. Thus the pen could be expected to produce approximately 29.5 x 300 = 8850 cm of saltwater belly skins. Similarly the 300 x 8.5 = 2550 kilograms of live body weight in the pen should (using average saltwater yield percentages from Table 4) produce approximately 1670 kilograms of dressed carcasses, 153 kilograms of legs, 581 kilograms of bone-in tail, 372 kilograms of deboned/defatted tail meat, and so on. These calculations take on meaning, of course, in the estimation of future economic returns to the farming operation.

To ensure good management practices as well as to increase the accuracy of the estimating procedures discussed here, it is important to maintain variability in body weights as low as possible. This has been done by segregating crocodiles according to species and size (0.5 kg size classes for most pens). In the future it may be possible to segregate sexes.

Table 1. Descriptive statistics on samples of crocodiles used to determine size relationships.

	C. novaeguineae		*C. porosus*	
	Females	Males	Females	Males
1980-1982 SAMPLE				
Body Weight (kg)				
Mean (N)	8.4(97)	9.0(96)	10.4(91)	12.2(90)
Range	0.9-27.4	1.7-26.4	1.2-27.0	1.2-39.8
Std. Dev.	5.8	5.6	7.6	9.8
Total Length (cm)				
Mean (N)	118(97)	121.5(96)	135.0(91)	137.1(90)
Range	66-184	77-165	80-191	76-213
Std. Dev.	27.7	24.5	32.6	36.2
Live Belly Width (cm)				
Mean (N)	29(97)	30(96)	32(91)	33(90)
Range	14-49	15-47	15-50	16-57
Std. Dev.	9	9	11	12
Salted Belly Width (cm)				
Mean (N)	36(29)	37(30)	40(30)	41(30)
Range	28-43	32-43	31-46	26-51
Std. Dev.	3	2	4	5
1989 SAMPLE				
Body Weight (kg)				
Mean	7.1(77)		9.4(75)	
Range	2.4-16.3		2.5-25.0	
Std. Dev.	3.4		6.7	
Salted Belly Width (cm)				
Mean	27(77)		29(75)	
Range	18-36		18-44	
Std. Dev.	4		7	

Table 2. Descriptive statistics on samples of crocodiles used to determine meat processing yields.

	---C. novaeguineae--		----- C. porosus----	
	Females	Males	Females	Males
Body Weight (kg)				
Mean (N)	9.5(20)	9.7(23)	11.3(26)	15.5(10)
Range	6.9-12.8	6.3-13.2	7.5-16.3	10.3-21.0
Std. Dev.	1.8	2.1	2.3	3.1
Tail Girth (cm)				
Mean (N)	35.7(14)	35.6(24)	36.0(22)	40.4(10)
Range	30.5-40.0	31.5-39.5	31.0-42.0	35.5-45.0
Std. Dev.	2.7	2.4	3.0	2.9

Table 3. Regression equations for the prediction of total length, live belly width, and salted belly width from live body weight of crocodiles, Crocodylus novaeguineae and C. porosus, within sample limits described in Table 1.

Dependent Variable	Equation[1]	P>F	R^2
--------------------Crocodylus novaeguineae------------------			
Total Length (cm)	$69.7+7.734*BW-0.158*BW^2$	0.001	0.968
Live Belly Width (cm)	$12.2+2.655*BW-0.052*BW^2$	0.001	0.964
Salted Belly Width (cm)			
1980-1982 Sample	$20.6+1.310*BW-0.018*BW^2$	0.001	0.847
1989 Sample	$12.7+2.800*BW-0.095*BW^2$	0.001	0.954
----------------------Crocodylus porosus--------------------			
Total Length (cm)	$79.2+7.009*BW-0.110*BW^2$	0.001	0.966
Live Belly Width (cm)	$13.5+2.273*BW-0.035*BW^2$	0.001	0.966
Salted Belly Width (cm)			
1980-1982 Sample	$21.6+1.092*BW-0.010*BW^2$	0.001	0.886
1989 Sample	$15.7+1.908*BW-0.034*BW^2$	0.001	0.967

[1]The independent variable (BW) being live body weight in kg.

Table 3. Experiment I: Performance criteria of alligators as influenced by the supplementation of the 45% protein Burris Mills alligator feed with DL-methionine and/or L-lysine.

Added Methionine	Added Lysine	8 Week Body Weight Gain	4 Week Dry Matter Consumption	4 Week Dry MatterFeed: Body Wt. Gain
---- % of Diet ----		---- g ----	---- g ----	---- g/g ---
0	0	478	4978	2.44
0.2	0	485	4950	2.18
0	0.9	484	5380	2.53
0.2	0.9	474	5096	2.34
------ Mean ------		480	5099	2.37
------ SEM -------		13	130	0.12
ANOVA P>F				
Tank		.002	.001	.021
Methionine		.918	.260	.108
Lysine		.824	.075	.347
Methionine X Lysine		.513	.379	.809

Table 4. Experiment II: Performance criteria of alligators as influenced by the supplementation of the 45% protein Burris Mills alligator feed with protein and amino acids (methionine and isoleucine).

Protein Level % of Diet	Added Amino Acids	-- Gain in --- Body Weight	Total Length	Dry Matter Consumption	Dry Matter Feed:Body Weight Gain
		-- g --	-- cm -	---- g ----	--- g/g ---
45	-	439	147	7115	1.35
45	+	433	150	7439	1.43
54	-	474	276	6852	1.20
54	+	490	307	7196	1.30
------ Mean ------		459	220	7151	1.30
------ SEM -------		9	22	130	0.12
ANOVA P>F					
Protein		.002	.001	.601	.063
Amino Acids		.549	.468	.404	.537
Protein X Amino Acids		.259	.551	.982	.713

Table 4. Meat yields (as a percentage of body weight) from Crocodylus novaeguineae and Crocodylus porosus.

	C. novaeguineae Females	C. novaeguineae Males	--C. porosus-- Females	--C. porosus-- Males	Overall
	%	%	%	%	%
Dressed Carcass	66.1	64.9	66.3	64.7	65.9[1,2,3]
Legs					
Hind legs	5.1	5.2	4.3	4.1	4.8[1,2]
Forelegs	2.4	2.5	1.9	1.8	2.2[1,2]
Tail					
Total	20.6	19.9	22.3	23.3	21.3[1,2]
Meat only	13.4	13.1	14.3	14.9	13.8[1,2]
Upper Body					
Total	38.1	37.3	37.8	36.9	37.6[3]
Meat only	18.5	17.3	18.5	18.1	18.1[3]
Total Meat[4]	31.9	30.3	32.8	32.9	31.8[1,2,3]

[1]Significant differences ($P<0.05$) exist between species-sex combinations.
[2]Significant differences ($P<0.05$) exist between species.
[3]Significant differences ($P<0.05$) exist between sexes.
[4]Deboned and defatted tail and upper body meat only; excludes legs.

SOUTH CAROLINA ALLIGATOR PROGRAM UPDATE

Thomas Swayngham - South Carolina Wildlife and Marine Resources Department, P.O. Drawer 190, Bonneau, SC 29431-0190

On April 1, 1988, the South Carolina Wildlife and Marine Resources Department implemented the Alligator Control Program to evaluate and resolve nuisance alligator complaints. The program also oversees any commercial business involving alligators and their products as well as evaluating possibilities for expansion of program activities.

The alligator in South Carolina has made a tremendous comeback since coming under protection in 1964 due to threat of extinction. They have recovered to the point where a 1983 census estimated a statewide population of 100,000 animals. The alligator was reclassified in July of 1987 as threatened due to similarity of appearance statewide. Prior to that time it had been classified as endangered along the coast and threatened inland.

The range of the alligator in South Carolina generally extends from the coast inland to the fall line. The fall line is the limit of navigable waters and delineates the Coastal Plain from the Piedmont physiographic region. Approximately 75% of the state's alligator population is concentrated in the fresh and brackish coastal wetlands. About 80% of these areas are remnant impoundments once used for the cultivation of rice, some of which have been restored for use as waterfowl impoundments.

The recovery of the alligator has been accompanied by the rapid residential and resort development of coastal areas, resulting in increased numbers of encounters between people and alligators. This led to a corresponding increase in nuisance complaints. With the past ineffectiveness of nuisance alligator relocation efforts due to the refusal of animals to stay in their new areas, this program implemented a controlled harvest of identified large nuisance animals.

The Coastal Plain of South Carolina has been divided into 5 alligator districts. Each district has a coordinator who receives and evaluates the complaints in that area. The coordinator, who is a Law Enforcement Captain or Wildlife Biologist, decides which animals are a genuine threat to people or property and need to be removed. When an alligator has been classified as a threat, the coordinator writes a collecting permit and forwards it to an alligator agent, who captures and kills the animal. Alligator agents are private individuals working under special contract with the Department. They receive no salary but may sell the meat and any other products, excepting the hide, from the animals they take. The hide is sold by the

Department with 50% of the proceeds going to the agents, 42.5% going to the Department and 7.5% going to the hide grader and seller.

Alligator complaints numbered 550 in 1988 and 458 in 1989 in South Carolina. Three hundred and seventy-one (371) alligators were taken in 1988 and 268 were taken in 1989. This decrease in complaints is probably the result of two things; the 371 alligators removed in 1988 were not present to cause problems in 1989 and, there was more publicity about the program in 1988 which probably generated more complaints. It will be interesting to see the effect that Hurricane Hugo will have on the number of complaints this year, since a good deal of prime alligator habitat has been adversely affected by the storm.

Preliminary notes on the status and conservation of **Caiman latirostris** in the State of Sao Paulo, Brazil. Directions of the captive breeding, reintroduction and management program.

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Introduction

The interest on breeding broad-snouted-caiman (**Caiman latirostris**) in captivity has increased in Brazil in the last years. It may be due to better awareness of the public opinion about the environmental problems of the country, including the risk of extinction of many species, and the search of new productive species for a critical market. Generally the farmers have only utilized the alligator-farm model, in despite of the differences between both of the species in relation to body size, growth capacity, skin features and commercial value. This issue can be responsible for management mistakes, death of animals, waste of resources and discredit of wildlife management as an economical choice in Brazil.

Status

Historial: The human colonization began in Brazil by the Atlantic shore and Sao Francisco/Parana river systems, where the biggest cities flourished and most of the population grew up. This was, however, the original distribution zone of the broad-snouted-caiman. Therefore, this species underwent the frontal impact of Brazilian human colonization. The hunt and habitat destruction were the consequences that brought the species to the threat of extinction(Fig 1)

Current: Our current survey in the State of Sao Paulo has been based on night counts and people accounts in the districts of Anhembi, Agudos, Bauru, Limeira, Mococa and Piracicaba. We have found groups from 1 to 15 animals in habitats such as open rivers, dams, marshes, swamps and even in decanting ponds of industrial or human drainage. We have also found 2 pinus-leaf nests which were the only available material to the nesting female. This preliminary results show the possibility of the species being colonized in this new habitats and adapting itself to the new conditions. However, it is necessary to quantify the presence of the species in the environment in terms of its populational dynamics in order to have a conclusive idea (Fig. 2)

Conservation:

The broad-snouted-caiman is an endangered species (VANZOLINI, 1972; IUCN, 1982 and BERNARDES **et alli**, 1990). The hunt is prohibited in Brazil by the Federal Law No. 5.197 from 03.01.1967 and the captive breeding is regulated by the governmental decrees Nos. 132/88 from 05.05.1989 and 250/88 from 22.08.1988. The international trade of its products is refused by CITES (KING, 1973).

The decrease of industrial polution has permitted a certain recovering of the species in some places of Sao Paulo State. We have been told the appearing of broad-snouted-caiman in Piracicaba river, next to the city, at the same time as its water polution decreases.

The hunt still occurs in the State in despite of the law. It is mainly done as a hobby by men from little or middle riverain counts, who use rifles to kill caimans, capibaras, deers etc at night. They utilize the meat in special dishes and take the skin as a game trophie. The real dammage of this activity on the caiman remaining population is still unknown, but is undoubtly considerable. The private properties have more protection against hunters because of the some land owners' increasing awareness of environmental issues.

Directions of the captive breeding, reintroduction and management program

Captive breeding: We are carrying out a 1 1/2 year-old captive propagation program, aiming at the reintroduction in nature and the furnishment of captive born individuals for caiman-farmers. In 1989 we had 34 hatchlings in 2 nests at our quarters in Piracicaba. From 1990 on we are going to manage breeder groups in most of the Brazilian zoos, through the Sociedade dos Zoologicos do Brasil - SZB (Brazilian Society of Zoos), considering the demographic and genetic aspects of the captive populations, according to FOOSE **et alli** (1986). Agreeably to the Reptile Census from SZB, there are 279 broad-snouted-caiman in captivity in Brazil (60 males, 48 females and 146 indetermined). Other 18 animals (9 males, 3 females and 6 indetermined) must be added because they were not listed by the Census. From this total number 55 were born in captivity last year.

Reintroduction: We are also carrying out a survey of most adequate and priority places for the reintroduction of the species in the State of Sao Paulo. This study includes from the analyses and description of biotic and abiotic sites components up to the environmental impact evaluation, according to GYSEL & LYON (1980).

Management purposes: The economical potential of the broad-snouted-caiman increases its management and conservation perpectives. However its geographical distribution is quit heterogenous in social-economical terms. This zone includes from highly industrialized areas to under-developed agricultural regions. Consequentely, the management system to be adopted must be a function of the feature above.

The avian crop of the State generates a great amount of scraps and discards like carcasses of cockerels and hens dead during the produtive cycle, and male young chickens of laying-hen lineages. This material can be offered as a low cost food to the caiman-farmers, in the vicinity of avian-farmers (VERDADE **et alli**, In press). Where there is no low cost food available, the best management system problably is the introduction or reintroduction of the species in dams (even into the cow- or agricultural-farms) and hydreletric power stations. Some years later the population exceedings could be exploited. The adequate management system according to local conditions could be a possible economic utilization of the broad-snouted-caiman, through the trade of skin, meat, souvenires, tourism and chase, assuring, this way, its conservation.

Anyway, it is important to stress that any management plan must begin with the captive propagation, besides short-term captivity studies about feeding, reproduction, behavior and sanity, and long-term field studies about ecology and behavior. The first ones must increase the reproduction efficiency and hatchling/young growing, through the enhance of nesting females, decrease of incubating eggs loss, and correct animals feeding.

Fig. 1: Geographical distribution of <u>Caiman latirostris</u> (BRAZAITIS, 1973 and IUCN, 1981)

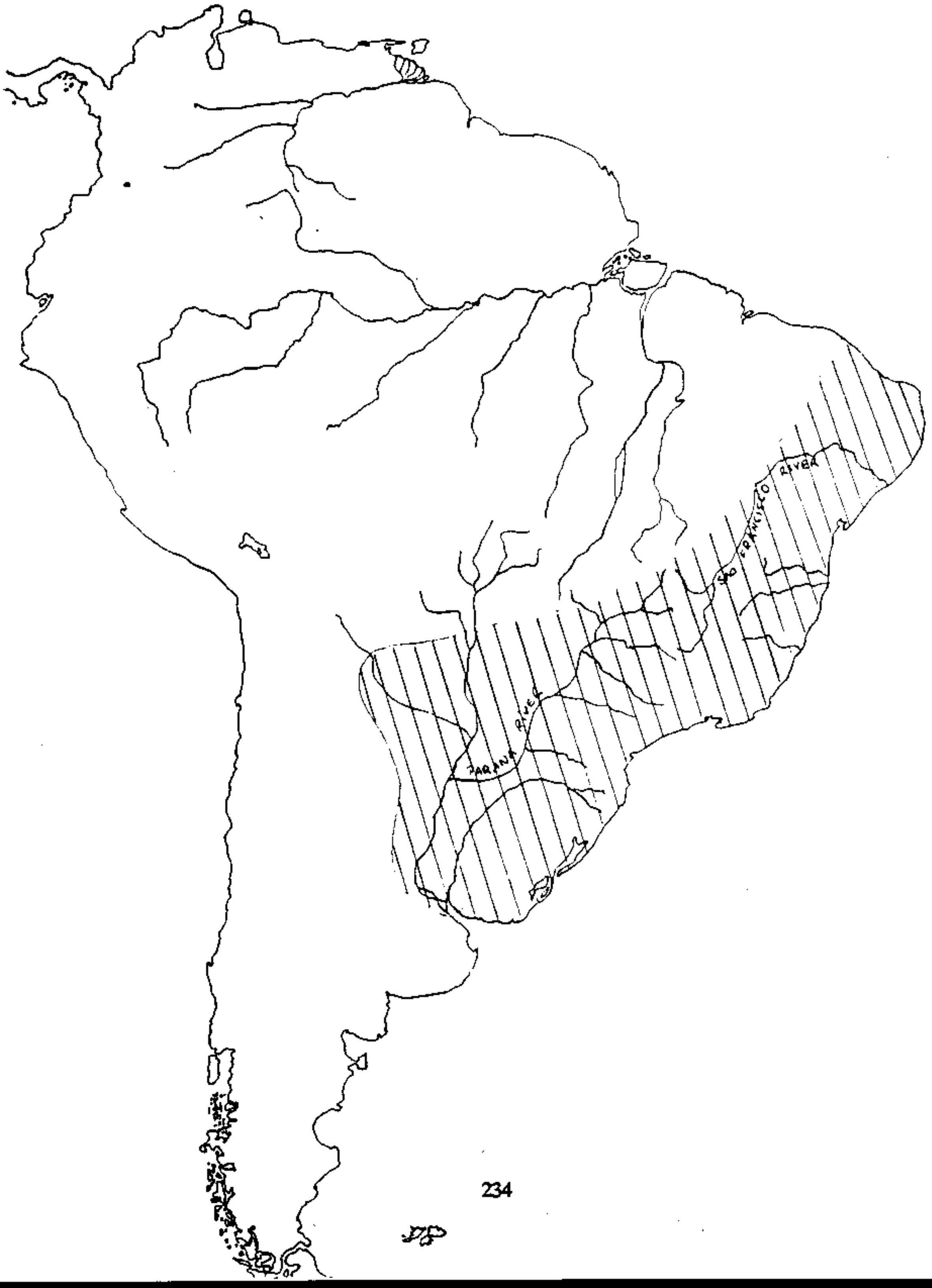

Fig. 2: Places surveyed in the State of São Paulo

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The Establishment of the First Major Crocodile Breeding Center in West Africa

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It was exactly ten years ago, in March 1980, that the crocodile project in Ivory Coast began. This project was undertaken under the authority of the Ministry of Agriculture, Water and Forests to conserve the three species of crocodiles native to Ivory Coast by integrating them into the economic development of the country.

I would like to give a brief overview of the results gathered during field research and by running an experimental croc farm which lead finally to the establishment of a breeding center in the Abidjan National Zoo.

The comparative biology of the three species reveals a clear separation of their ecological niches, reducing interspecific concurrence.

Crocodylus niloticus prefers areas of land and water exposed to open sunlight, basking on rocks in rivers and lagoons, and living in burrows beside remaining waterpools. Crocodylus cataphractus prefers shaded areas, living in rivers under dense vegetation in the rainforest and in savanna rivers surrounded by extensive gallery forest. Females rely upon abandoned leaf litter nearby permanent water courses for nest construction. Osteolaemus tetraspis prefers small stagnant pools in swampy areas. They are nocturnal terrestrial hunters and have been observed feeding on large annelids and other invertebrates. The female constructs a mount nest similar to C.cataphractus, but often far from water courses.

The typical habitat of each species can be found all over the distribution area of crocodiles in Ivory Coast, but with different frequencies. This means on the one hand that the frequency to meet a certain crocodile species in a given biotope depends on the percentage of its habitat represented there, and on the other hand that none of the three species will completely lack in a given area. These findings have been verified by telemetric studies.

Since 1981 "Projet Crocodiles" has had its base at the Abidjan National Zoo. Rearing and breeding facilities have been constructed on the Zoo grounds. Between 1981 and 1984 crocodiles of the three species where hatched at the zoo from eggs produced by captive females and from nests collected in the wild.

species	wild	zoo
C.niloticus	44	13
C.cataphractus	88	56
O.tetraspis	34	0

In January 1990, it was determined that the zoo reared crocodiles had reached potential breeding size. The former wild captured, reproductive males were removed from the breeding enclosure in order to allow for the establishment of larger breeding groups. These groups are now comprised of the zoo's remaining breeding females and those raised in the rearing enclosures.

species	no.	sex	size
C.niloticus	9	M	2.0 m
	11	F	1.7 m
C.cataphractus	9	M	2.0 m
	30	F	2.0 m
O.tetraspis	8	M	1.3 m
	4	F	1.3 m

We hope that we have created, a permanent base for future crocodile conservation in Ivory Coast. It is our goal to provide offspring for restocking purposes and for the possible future development of integrated management.

It is also our goal to establish a network for continuous research in the national park systems, that would be accessible to international researchers and provide training and education for Ivorians and parties from other african countries.

We would like to suggest that the CSG consider the potential for crocodile conservation and research in Ivory Coast. We ask for the support of the IUCN-CSG in our efforts towards these goals and particularly for Ivory Coast becoming a member of CITES. We invite you to consider Abidjan as you select locations for future meetings such as this one.

Effects of Blasting on Nile Crocodiles, *Crocodylus niloticus*.

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10th Working Meeting of the IUCN/SSC Crocodile Specialist Group.

EFFECTS OF BLASTING ON NILOTICUS

Nine years after entering the fascinating world of the Nile Crocodile, 1989 looked to be a year of great promise at Crocodile Creek.

72 adult, captive-bred, females ranging from 2.4 meters to 3.2 meters, 10 to 15 years of age, were likely to produce in the region of 2655 eggs. Allowing for 15% infertility, a crop of 2257 viable hatchlings was expected, these calculations having been concluded by Dave Blake and Tony Pooley independently.

Construction of the (N2) National Highway was due to commence, which when completed would provide splendid views of the farm, river and subtropical environs with improved access and an increase in tourism.

Everything was about to go with a "bang" and so it did. Within 2 kilometers of the farm on May 22nd, Contractors detonated 1220 kgs of explosive followed by 925 kgs, less than 1 km away June 14th, and 2850 kgs June 27th (in all 6270 lbs). By the evening of 29th June 1989, 26 juvenile, female, crocodiles in 1 m to 1.2 m range were dead.

Our immediate thought was that local early-winter temperatures combined with a virus was causing the problem. Deaths of this size over the 8 preceding years ranged from 0 to 2 per annum average.

Blasting continued. By plotting a graph of deaths and superimposing a graph of blasting dates, a pattern emerged indicating that blasting could indeed be responsible. Inspection of stock in open ponds revealed the following:

1. Bite marks on jaws and heads
2. Cessation of feeding
3. Dilated pupils, no response to light stimuli
4. Reptiles extremely skittish
5. Later reptiles became very sluggish and lethargic and remained in fixed locations day or night.
6. Paralysis of one hind leg. After a lapse of a week or so despite having been relocated in a controlled environment at ± 32°C minimal feeding occurred.
7. Quality of skin deteriorated, breaking between segments into septic lesions.
8. Dehydration of body and apparent anorexia.
9. Loss of balance, inner ear was obviously damaged, necks in spasm, some crocodiles staggering like drunks.
10. Pink to reddish discoloration of the skin under the crocodile belly.
11. Diarrhea in a number of cases.

Results of veterinarian examinations and autopsies of animals that died between 22/27 June revealed nothing. The reptiles appeared in good healthy condition but were suffering from a "severe lack of life."

Subsequent detailed autopsies indicated:

1. Aeromonus hydrophilia was isolated from an organ.
2. Non-Specific except for hyperemia and acute ulcerations of the gastric mucosa.
3. Severe septicemia with generalized abscessation, which was subsequently found to be Salmonella and concluded to be a secondary pathogen that had entered the body system from the gastro-intestinal tract as a result of chronic stress. At this point treating the entire ailing stock for Salmonella, involving, a five-day oral program was considered. I rejected the idea as the additional stress of handling weak juveniles would have more likely killed them. Fortunately, this management decision was correct as no further Salmonella was detected in autopsies.

By now, we were convinced that blasting was causing chronic stress in the crocodile population at Crocodile Creek. Obviously one could not obtain an order to halt construction of a National Road without scientific proof, so a study of

BLOOD COLLECTION AND ANALYSIS
was undertaken by
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BIOLOGICAL RESEARCH CENTRE
UNIVERSITY OF DURBAN/WESTVILLE
NABLE. R.S.A.

To Dr. Thurman and his associates my grateful thanks for their dedication and scientific approach. Dr. Thurman's report follows:

Very little information is available as to blood sampling techniques in crocodiles, and even less is available for the blood hematology and chemistry values. A project was therefore undertaken to establish a methodology of blood collection, and to determine the normal blood values of crocodiles.

MATERIALS AND METHODS
ANIMAL MODEL

To determine normal blood values, five crocodiles were selected at random from a group of two year crocodiles that were housed under optimal conditions at the University of Natal. These crocodiles were accustomed to frequently handling and were part of growth study experiments.

To determine the effects of stress on crocodiles, five crocodiles were selected from the affected two year old group at the crocodile farm. Selection was based on signs of ill-health namely, dilated pupils, sluggish reaction to external stimuli, and the presence of diarrhoea in some cases.

BLOOD COLLECTION

Due to the hard, leathery integuementum of crocodiles, palpation of peripheral veins was unsuccessful and cardiocentesis was selected as the method of choice. On autopsies, it was noted that the heart was situated centrally on the mid-line and relatively caudal to what one would expect in a mammal. The dermal plates in the crocodile make a V-shaped pattern on the ventral axillae region between the fore-legs. Using the caudal most part of this V as a reference, the heart in juvenile crocodiles (n = 10) was located on the mid-line and 5-6 dermal plates caudal to the reference point. At a later stage, adult crocodiles (n = 2) were bled by cardiocentesis using a similar method, the heart was also located 6 dermal plates caudal to the reference point. The heart could not be auscultated or palpated in any of the crocodiles. In the most emaciated sick crocodiles, an apical heart beat was sometimes observed.

No chemical resistant was necessary in the juvenile crocodiles. The animal's jaws were taped closed and then were held in dorsal recumbency. In this position, they all lay perfectly still during the entire procedure.

Cardiocentesis in all animals was performed using a Venojet Multi-sample blood collecting needle (22G x 1½) and a Vacutainer Tube with or without anticoagulant depending on the blood tests required. Prior to cardiocentesis the area was disinfected with a solution of 5% chlorhexidine in alcohol (Hibitane).

The needle was inserted between the dermal plates and directed cranially at an angle of approximately 45° for about 2 cm. Once located, the movement of the myocardium was reflected to the needle confirming cardiac puncture.

A volume up to 10 ml of blood would be rapidly withdrawn from all animals by this method. The control group showed no adverse effects following this method of sampling and no pain reaction was observed on cardiocentesis.

HEMATOLOGY

All reptiles possess nucleated erythrocytes, leukocytes, and thrombocytes. For this reason, the use of automated white-cell counters will give spurious results. The number of red cells can be approximated with automated counters, but accuracy is best obtained with the hemocytometer and standard counting procedures. White blood cell counts and haemoglobin were measured by manual methods.

Most Romanowsky-type stains will give satisfactory results; Lugol's, Wrights stain, Kleineberger-Nobel, and Jenner-Giemsa are preferred for permanent mounts. Methylene blue may be used for non-permanent, quick-screening examination of blood films. In this particular study, both Wright's and Jenner-Gienmas stains were used. The Wright's stain was preferred when examining the red blood cells, whilst the Jenner-Giemsa stain was preferred for the differentiation of white blood cells.

BIOCHEMISTRY

Serum electrolytes were measured using the following:

Sodium and potassium - Astra Analyzer which employs ion selective electrodes.

Calcium - Cobas Mira Analser and the Roche Calcium MTB test kit.

Magnesium - atomic absorption.

Osmolality was measured using an automatic micro-osmometer which employs the freezing point technique.

Glucose was measured using the Astra Analyzer and the glucose oxidase method.

Lactate was measured by the Monotest which uses the enzymatic UV-method.

Cholesterol and triglycerides were measured by the enzymatic colormetric test using the Boehringer Mannheim Hatachi 737.

Total protein was measured by the biuret method using the Boehringer Mannheim Hatachi 737.

Lactate dehydrogenase and Alkaline phosphatase were measured by the "Optimized standard method" using the Boehringer Mannheim Hitachi 37.

Creatine kinase was measured by the kinetic UV test and the Cobas Mira Analyzer.

RESULTS

Under the most enlightened conditions of captive husbandry, a certain bias resulting from the stress of captivity must be imposed on the Nile Crocodile. This may introduce artifacts into the data obtained in the case of wild crocodiles but would suggest our figures are accurate for farmed crocodiles.

HEMATOLOGY

The mean hematological values obtained from the control group (n = 5) are given in Table 1. From these values it is apparent that the Nile crocodile has a very low leucocyte count (X 1,5 x 10^9 l^{-1}) in comparison to mammals. The haemoglobin level (X 11,3 g l-1) approximates those values found in mammals. The hematocrit is approximately half that of mammals (X 0,25).

The red blood cells are biconvex, oval and with a centrally located nucleus. Reticulocytes, polychromatic juvenile RBC, and megakaryocytes were identified particularly on the blood smears of stressed animals.

The lymphocyte is variable in size but is approximately that of the RBC. With the Jenner-Giemsa stain, the nucleus is large and stains dark blue. The cytoplasm is finely granular; stains light blue and will sometimes contain azurophilic and/or hyaline inclusions. The monocyte contains a single, indented nucleus and is frequently large than the lymphocytes; the cytoplasm is finely granular and stains light blue to blue-grey.

The neutrophil is characterized by its usually non-segmented nucleus with scalloped edges; a basophilic cytoplasm that contains basophilic, eosinophilic granules, and fibrillar strands.

The heterophil is a granulocyte with fusiform, red or fibril-shaped intracytoplasmic inclusions or granules that stain intermediately between those of the eosinophil and those of the basophil. The nucleus is eccentrically located.

The eosinophil has spherical, bead-like eosinophilic granules, the nucleus is pale blue and is usually centrally located. The eosinophil may degranulate in response to a systemic disease process without lysing.

The basophil is commonly observed and is characterized by intensely staining dark blue spherical or rod-shaped granules.

The thrombocyte is an elliptical cell that is smaller than the RBC. The cytoplasm stains a pale blue. The large, dense, centrally located nucleus stains a dark blue. The thrombocyte is capable of phagocytosis of haeme pigment, bacteria, and amorphous cellular debris.

The plasma of crocodiles is colourless but if a blood is collected after eating, the plasma may be very lypaemic due to the high level of triglycerides.

On examination of the hematology results from the stressed group the following was apparent:

a) There was a lowered WBC.
b) The haemoglobin values were lower than the control group.
c) The hematocrit tended also to be slightly lower than the control group.
d) A pronounced decrease in the basophil count was noticed in the stressed group.
e) The neutrophils in the stressed group were classified as toxic neutrophils due to the extensive vacuolation of the cytoplasm.
f) Atypical monocytes were present in the stressed group.
g) A general shift to the right was apparent in the stressed group.
h) In the red blood cells of the stressed group, anisocytosis and macrocytosis was present, the RB crocodile also stained irregular, mitotic figures and juvenile RB crocodile were present.
i) There was also a marked decrease in platelets.

TABLE 1

MEAN HAEMATOLOGY VALUES FROM HEALTHY TWO YEAR OLD NILE CROCODILES (n = 5)

PARAMETERS	N	X	SD	CV%
B-WBC x 10^9 $^-1$	5	1,5	0,37	24,7
B-Hb g $^-1$	5	11,3	1,7	15,0
B-Ht	5	0,25	0,01	4,6
Differential White Cell Counts				
(Leucocyte)				
Lkc - Neutrophils	5	0,50	0,07	13,3
Lkc - Lymphocytes	5	0,21	0,05	23,4
Lkc - Monocytes	5	0,05	0,03	64,8
Lkc - Eosinophils	5	0,02	0,04	25,0
Lkc - Basophils	5	0,22	0,08	36,2

TABLE 2

COMPARISON OF HAEMATOLOGICAL VALUES OBTAINED FROM THE HEALTHY VS STRESSED NILE CROCODILES

PARAMETERS	CONTROL GROUP	STRESSED CROCODILES			
	x	1	2	3	4
B-WBC x 10^9 $^{-1}$	1,5	1,0	1,6	1,0	1,0
B-Hb g $^{-}$l	11,3	7,0	9,0	7,2	8,8
B-Ht	0,25	0,22	0,24	0,22	0,29
Differential White Cell Counts (Leucocyte)					
Lkc - Neutrophils	0,50	0,24	0,52	0,73	0,35
Lkc - Lymnphocytes	0,21	0,50	0,30	0,23	0,47
Lkc - Monocytes	0,05	0,11	0,02	0,01	0,05
Lkc - Eosinophils	0,02	0,01	-	-	0,01
Lkc - Basophils	0,22	0,03	0,12	0,02	0,04
Atypical monocytes	-	-	0,04	0,01	-
Heterophils	-	-	-	-	0,08

COMMENTS:

Macrocytosis		+	++	+	+
Toxic Neutrophils		+++	++	++	+++

TABLE 3
MEAN SERUM CLINICAL BIOCHEMISTRY VALUES FROM HEALTHY TWO YEAR OLD NILE CROCODILES (n = 5)

PARAMETER	N	X	SD	CV%
Sodium m mol $^{-1}$	5	153,8	1,48	1
Potassium m mol $^{-1}$	5	3,8	0,54	14
Calcium m mol $^{-1}$	5	2,97	0,09	3
Magnesium m mol $^{-1}$	5	0,92	0,06	6
Osmolality m mol $^{-1}$	5	328	3,4	1
Cholesterol m mol $^{-1}$	5	35,8	5,4	15
Triglycerides m mol	5	7,05	3,6	51
TSP g $^{-1}$	5	50,2	2,8	5
LD u $^{-1}$	5	301	32,4	10
ALP u $^{-1}$	5	64,2	17,9	27
CK u $^{-1}$	5	211	69,5	33
Glucose m mol $^{-1}$	5	5,9	0.9	15
Lactate u mol $^{-1}$	5	22,1	6,8	30
Cortisol n mol $^{-1}$	5	<27	-	-

TSP = Total Serum Protein
LC = Lactate Dehydrogenase
ALP = Alkaline Phosphates (Liver Damage)
CK = Creatinine Kinase (Liver Damage)

TABLE 4
COMPARISON OF MEAN CLINICAL BIOCHEMISTRY VALUES OBTAINED FROM THE CONTROL VS STRESSED CROCODILES

PARAMETER	CONTROL GROUP X	STRESSED X	
Sodium m mol $^{-1}$	153,18	107,8	
Potassium m mol^{-1}	3,8	5,7	(A)
Calcium m mol $^{-1}$	2,97	2,5	
Magnesium m mol $^{-1}$	0,92	1,36	
Osmolality m mol $^{-1}$	328	251,8	
Cholesterol m mol $^{-1}$	35,8	6,2	(B)
Triglycerides m mol $^{-1}$	7,05	0,92	(C)
TSP g $^{-1}$	50,2	69,4	
LD u -1	301	74	
ALP u $^{-1}$	64,2	437	
CK U $^{-1}$	211	9187	(D)
Glucose m mol $^{-1}$	5,9	6,8	
Lactate m mol $^{-1}$	22,1	3,11	

(A) Potassium readings of 3,8 to 5,7 indicated cellular damage similar to leveled found in stressed sharks.
(B) Cholesterol: Dr. Thurman initially thought this was significant but later discarded these results as he felt the method of obtaining this particular data could be improved.
(C) Triglycerides readings of 7,05 to 0,92 indicated a lack of feeding.
(D) Creatine Kinase readings of 211 to 9187: This figure was checked 5 times and was found to be correct. A reading of 200/300 is similar in mammals. In antelope capture programs if figures approaching 1000 are recorded, animals are released immediately for fear of stress related deaths.

BIOCHEMISTRY

The results obtained from the control animals are given in Table 3. The small standard deviations and co-efficient of variation obtained for most values supports that these results may be taken to approximate normal biochemistry values for crocodiles.

In the comparison of the biochemistry values between the two groups the following was observed in the stressed group:

a) A pronounced low hyponatremia (107,8 m mol 1-1).
b) A high hyperkalemia (5,7 m mol l^{-1}).
c) A low osmolality (5,7 m mol l^{-1}).
d) A low cholesterol (6,2 m mol l^{-1}) and triglyceride (0,92 m mol l^{-1}) levels.
e) An increase in serum alkaline phosphatase (437 ul^{-1}).
f) A marked increase in ceratin kinase (9187 ul^{-1}).
g) Low lactate level 3,1 (3,1 m mol l^{-1}).

DISCUSSION

The general appearance of the red blood cells in the stressed group is typical of what one would see in a megaloblastic anaemia due to a folvate/Vit B_{12} deficiency. This can be ascribed to the state of anorexia that was present in the stressed group. This can be further substantiated by the low serum total lipid value observed.

The WBC crocodile observations were consistent with that of a general stressed condition.

The biochemistry values obtained between the two groups were again characteristic of the type of values one would expect in a group of animals exposed to prolonged stress.

Blasting having ceased at this point the ill animals continued to die with a peak when heavy earth vibrating equipment was operating in close proximity the farm. Further deaths occurred during capture and relocation to five separate localities. Only three further deaths occurred between October and December 1989. No further medication was used. By 31st March 1990 a considerable improvement was observed in the stock with only two exceptions. The remaining adult female breeders that were in poor condition looked healthy and active.

CONCLUSION

1. The death of 123 Niloticus crocodiles, all females, (this is not significant for all juveniles on the farm were females for sale as breeders at a later stage) between approximately 80 centimeters and 2,18 meters was a direct result of blasting which caused chronic stress, this debilitated the system and secondary infections killed the animals.

	EXPECTED	ACTUAL	%
Eggs	2655	712	26%
Hatchlings	2257	222	9.8%

The numbers of hatchlings in the 1990/91 and 1991/92 seasons could well be far under normal expectations.

It was necessary to relocate, in 8 days, ±500 reptiles 80 centimeters to 4 meters over 5 farms 100 to 900 kilometers from Crocodile Creek. Our heartfelt thanks to the noted Natal members of the Nile Crocodile Association and Crocovanga for their help and assistance. Education and tourist facilities have been closed, but we hope to reopen them at some undetermined time in the future.

This experience has opened up further examples of stress in crocodilians which we intend to investigate.

RECOMMENDATION:

My strong recommendation to consultants and existing farmers is to be mindful of major developments in the immediate vicinity of new or existing farms.

- - - -

Watson P.A.I. 1900 "Effects of Blasting On Niloticus" 10TH Working Meeting of the IVCN/SSC Crocodile Specialist Group.

Paper Presented at the
10th Working Meeting of the IUCN-SSC
Crocodile Specialist Group, Gainesville, Florida,
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CROCODILE MANAGEMENT AND RESEARCH IN THE NORTHERN TERRITORY: 1988-90.

by

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In this paper we summarise the progress that has been made with crocodile research and management in the Northern Territory since the previous Crocodile Specialist Group meeting (Lae, October 1988).

MANAGEMENT PROGRAMS

Both species of crocodilian (*Crocodylus porosus* and *C. johnstoni*) in the Northern Territory are on Appendix II of CITES. *Crocodylus johnstoni* has always been on Appendix II, whereas *C. porosus* was transferred from Appendix II to Appendix I in 1979, and the Australian population was transferred back to Appendix II after the meeting of the Parties of CITES in Buenos Aires (1985). A limited experimental ranching operation was proposed (Webb et al. 1984; CCNT 1986a,b), which has now been tested thoroughly and deemed to be both practical to operate and to have a minimal impact on the wild populations (Webb et al. 1989; Manolis and Webb 1990)

In line with the three-year review procedure outlined (Webb et al. 1984), the management programs were reviewed between 1988 and 1989, and in January 1990 a new management program, covering both *C. johnstoni* and *C. porosus*, was approved by ANPWS (CCNT 1990).

The monitoring programs for both species continue, and the stringent regulatory system remains unchanged. The new program expands the areas from which *C. porosus* eggs can be collected (originally restricted to three river systems), and establishes an overall limit on the maximum numbers of each age group, of each species, that can be removed from the wild, for any purpose (including problem crocodiles and research), each year. In the first year (1990) these limits are:

	C. porosus	*C. johnstoni*
Viable Eggs	10,000	4000
Hatchlings	400	6000
Juveniles	400	1000
Adults	200	200

The new management program establishes the flexibility needed to extend the commercial value of crocodiles back to landowners, regardless of whether their particular parcel of land contains nesting habitat or not. It is envisaged that all animals will be caught alive and relocated to farms, and that the number of farms (currently 4) will expand gradually - commensurate with the availability of stock.

ATTACKS

Since October 1988, *C. porosus* has been responsible for serious attacks on four people in the Northern Territory (Howard River, Daly River, Croker Island). Although none of these attacks was fatal, they received considerable media coverage, and activated a small "anti-croc" lobby, calling for the "culling" of wild populations to reduce numbers and improve public safety.

Overall, the response from the public was objective and rational. It is now widely accepted that crocodiles are an important economic resource, and culling for the sake of reducing numbers *per se* is not as desirable as the current management program, which aims to keep wild populations high while selectively harvesting limited numbers to support the industry in a sustainable way. There is no doubt that the economic value of crocodiles in the Northern Territory is the single most important incentive for having large wild populations of *C. porosus* throughout the coastal wetlands.

PROBLEM CROCODILES

As part of the public safety campaign within the Northern Territory, "problem" crocodiles are removed from the wild and assigned to crocodile farms. Such animals are broadly defined as those attacking livestock, or residing in settled areas, or areas of priority recreational use where their presence constitutes a risk to people (CCNT 1986a).

During 1988 and 1989, 278 problem *C. porosus* were dealt with (146 and 132 in each year respectively). Of these, 221 (79.5%) were distributed to crocodile farms, 52 (18.7%) were relocated in the wild, 4 (1.4%) died at capture and 1 (0.4%) was shot. Most of the animals came from Darwin Harbour (66.5%) and Gove (18.3%).

During the same period, 13 *C. johnstoni* were also regarded as "problem" animals. Four were relocated back into the wild, 6 died at or soon after capture, and 3 were taken to a crocodile farm.

C. POROSUS EGG HARVESTS

The *C. porosus* egg harvest was again carried out largely by G. Webb Pty. Limited on behalf of the Conservation Commission. In addition to the management areas, which have now been harvested since the 1984/85 season, preliminary surveys and harvests were carried out in new areas. Attempts were made to reach nests before significant mortality occurred, but of the 6497 eggs examined, 26.3% were dead before collection. This is similar to previous nesting seasons (28.7% and 25.0% in 1986/87 and 1987/88 respectively). The majority of eggs collected with dead embryos had either flooded (>33%) or overheated (>29%): in addition, 6.5% of eggs were infertile (7.0 and 9.3% in previous seasons). Of the viable eggs incubated, 90.5% produced hatchlings; incubation success was 94.8% in 1986/87 and 89.3% in 1987/88.

Crocodylus porosus egg harvests have now been carried out as research exercises for 5 successive seasons. To date, no significant impact on the size of the *C. porosus* population in harvested areas has been detected (Fig. 1). For this reason, the revised management program (CCNT 1990) allows egg harvesting in new areas and the major research effort will now be directed at those areas.

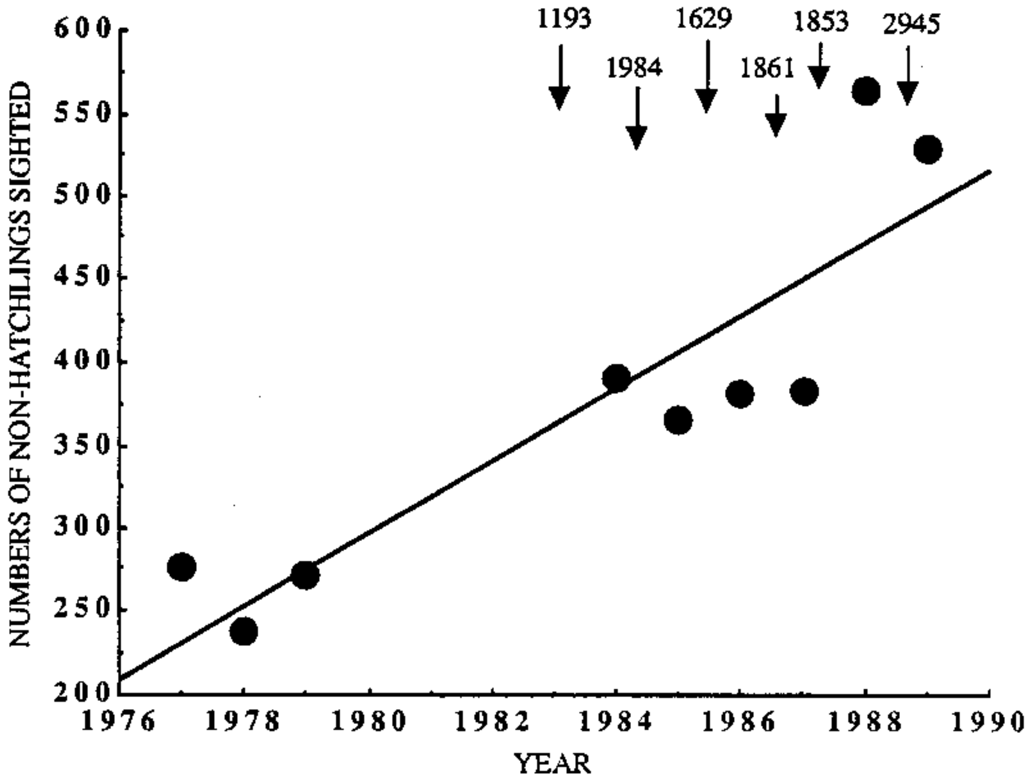

Figure 1. Annual spotlight counts of non-hatchling *C. porosus* in the mainstream of the Adelaide River, Northern Territory, have increased from around 250 in the late 1970's, to over 500 in the late 1980's. Yet between 1983 and 1989, 11,465 eggs have been harvested from the population.

C. JOHNSTONI EGG AND HATCHLING HARVESTS

In 1989, 1910 *C. johnstoni* eggs were collected from the Finniss and Reynolds Rivers. Of these, 1625 (85.1%) were considered viable and incubated. The remainder were either infertile (2.9%), probed (1.1%) or dead before incubation (10.8%). Hatchlings (N = 964) were distributed to the crocodile farms. In addition, 787 eggs were collected from the Mary-McKinlay River for incubation experiments (see below): 524 hatchlings resulted whose post-hatching performance under farm conditions is being monitored.

In addition, *C. johnstoni* hatchlings were collected from the field in 1988 and 1989 (1813 and 3400 respectively). Most (79.4%) came from the Daly River.

Analyses of spotlight count survey data (see below) indicate no significant negative impact of the egg and/or hatchling harvests.

POPULATION MONITORING

Crocodylus johnstoni

Annual spotlight surveys were carried out in all *C. johnstoni* management areas (CCNT 1986b) in 1989. Helicopter surveys of most of these areas were also carried out, and preliminary analyses indicate that this method is a viable alternative to the time-consuming and more expensive spotlight surveys. The results of the *C. johnstoni* surveys have now been analysed, and they are consistent with their being a minimal impact of the harvests.

The Daly River is one of the main rivers from which *C. johnstoni* hatchlings have been harvested. The river was subdivided into 9 survey segments separated by rockbars and waterfalls (total distance = 196.3 km) and harvesting was restricted to the upstream 91.9 km and the downstream 68.5 km; the central area of 35.9 km has been surveyed but not harvested.

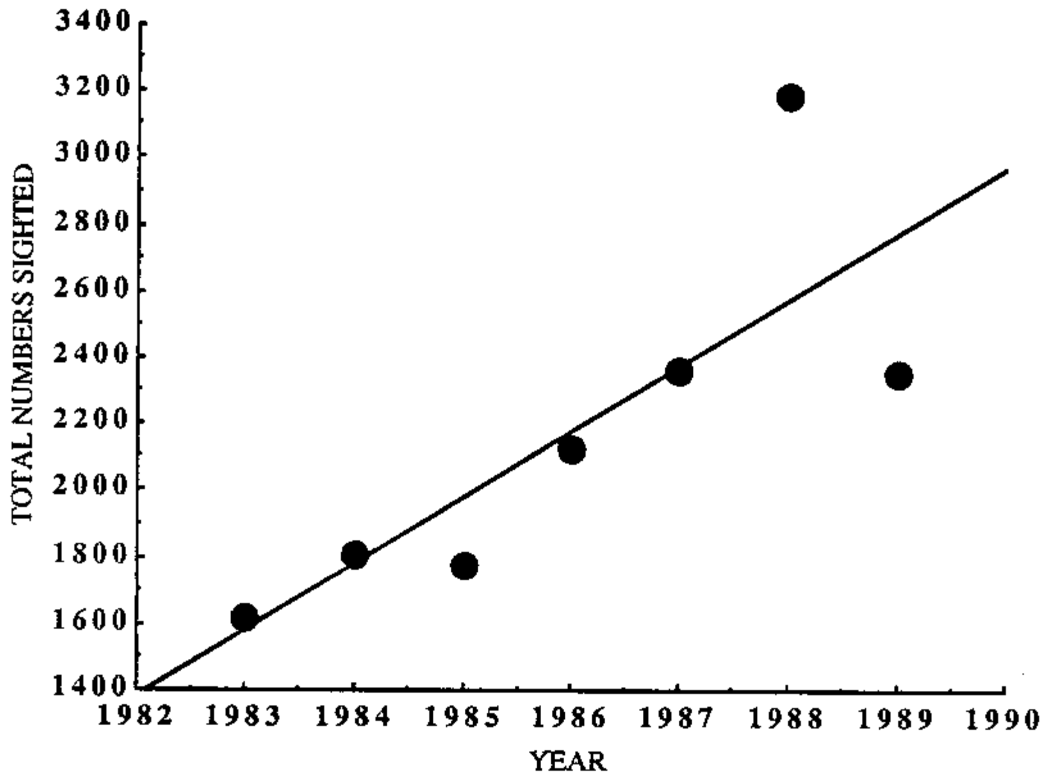

Figure 2. Total numbers of *C. johnstoni* counted by spotlight in the annual surveys of the Daly River between 1983 and 1989.

Overall, the population of *C. johnstoni* in the Daly River has continued to increase (Fig. 2) regardless of the harvest of some 866 eggs and 9627 hatchlings between 1983 and 1989 (Table 1).

Regardless of the annual variation in counts, the exponential rate of population increase (r) was positive in all 9 survey sections within the Daly River (Table 2), although only in 3 (two harvested and one non-harvested) did it reach significance at the 5% level. The natural logarithm of numbers sighted was regressed against year to estimate **r** (the regression line slope)(Caughley 1980). To express **r** as a mean percentage change, the exponent of **r** was used [percentage change = $(e^r - 1)*100$]. Among the harvested sections, **r** varied from 0.34 (a 40% increase per year) to 0.02 (a 2% increase per year), indicating that different sections of the harvested population are increasing at vastly different rates.

Table 1. Numbers of *C. johnstoni* hatchlings and eggs harvested from the Daly River between 1983 and 1989.

Year	Hatchlings	Eggs
1983	825	548
1984	1317	318
1985	0	0
1986	928	0
1987	2297	0
1988	1560	0
1989	2700	0
Total	9627	866

Table 2. Annual spotlight counts in 7 harvested and 2 non-harvested sections of the Daly River. r = the exponential rate of increase; SE = standard error; P = the probability that r is due to chance.

	Non-harvested		Harvested						
Section	1	2	3	4	5	6	7	8	9
km	14.3	21.6	31.0	15.5	22.0	18.9	39.4	17.1	16.5
1983	171	-	-	216	448	139	172	205	95
1984	240	197	70	233	400	95	283	164	-
1985	292	247	109	197	297	114	177	210	132
1986	203	346	112	199	263	173	413	210	206
1987	220	331	229	303	520	91	303	201	166
1988	303	470	383	422	567	165	423	235	223
1989	195	358	343	275	393	150	330	200	165
r	**0.02**	**0.19**	**0.34**	**0.08**	**0.03**	**0.04**	**0.12**	**0.02**	**0.11**
SE	0.04	0.04	0.05	0.04	0.06	0.05	0.05	0.02	0.04
P	0.65	<0.01	<0.01	0.11	0.62	0.47	0.08	0.34	0.03

When harvested and non-harvested sections are combined (Table 3), it is clear that the populations in both sections of river have increased significantly since 1983; the non-harvested population at approximately 12% per year, and the harvested population at 10% per year. There is almost certainly interchange of animals between the harvested and non-harvested populations, which confounds detailed interpretation of results.

Table 3. Exponential rates of increase (r) and their standard errors (SE) for the harvested and non-harvested sections of the Daly River. P = the probability that r is due to chance.

	$r \pm SE$	P
Non-harvested	0.11 ± 0.03	0.02
Harvested	0.09 ± 0.03	0.03
Total	0.09 ± 0.03	0.02

In both harvested and non-harvested areas of the Daly River, the percentage of juveniles in the population (<1 m long) has remained high, indicating that recruitment has not been adversely affected by the harvests. In the original surveys 66% of all animals sighted had their sizes estimated, whereas in the 1989 survey, this had dropped to 36%. The reduction in the percentage of adults suggests that the level of wariness among them may be increasing, rather than their numbers dropping. The number of hatchlings encountered in 1989 was greater than in other years (Table 1), which is inconsistent with a significant decline in the adult population.

Table 4. Changes in the size structure *C. johnstoni* population in the Daly River between the first (1983-84) and last (1989) surveys, as revealed in spotlight surveys. Results refer to the percentage composition of crocodiles that were both sighted and had their sizes estimated (those sighted as "eyes only" have been ignored).

	Juvenile (<1 m)	Subadults (1-1.5 m)	Adults (>1.5 m)	Sample Size
Non-harvested				
1983/84	68.7%	28.9%	2.5%	201
1989	71.2%	27.2%	1.6%	191
Harvested				
1983/84	55.3%	38.7%	6.1%	690
1989	65.2%	32.8%	2.0%	647
Total				
1983/84	58.2%	36.5%	5.2%	891
1989	66.6%	31.5%	1.9%	838

Taken together, the results from the Daly River demonstrate unequivocally that the harvests have not resulted in a population decline.

The results for all river systems monitored regularly by spotlight counts are in Table 5. The mean exponential rate of increase for all rivers is 0.050 ± 0.018, indicating that the population has been expanding at about 5% per year over the period of study. The mean rate of increase in the harvested rivers (0.082 ± 0.015) was greater than that in the non-harvested rivers (-0.031 ± 0.018), which suggests that harvesting may have a positive effect on the population size.

Table 5. The exponential rates of increase (**r**) and their standard error (SE) for *C. johnstoni* spotlight counts in harvested and non-harvested rivers in the Northern Territory. N = number of years surveyed; P = the probability that **r** is due to chance.

River System	Years	N	r ± SE	P	Notes
East Baines River	82-86	3	-0.002 ± 0.039	0.97	Non-harvested
Katherine Gorge	80-88	9	-0.084 ± 0.037	0.06	Non-harvested
Mary River (D/S)	84-88	5	-0.014 ± 0.086	0.88	Non-harvested
Moyle River	84-88	4	-0.025 ± 0.200	0.91	Non-harvested
MEAN (Non-harvested)			-0.031 ± 0.018		
West Baines River	83-88	6	0.045 ± 0.069	0.55	Harvested
Daly River	83-89	6	0.091 ± 0.025	0.02	Harvested
Finniss River	83-89	7	-0.004 ± 0.071	0.96	Harvested
Mary River (U/S)	84-89	6	0.048 ± 0.051	0.40	Harvested
Reynolds River	84-89	6	0.075 ± 0.113	0.54	Harvested
Victoria R. (D/S)	82-86	5	0.154 ± 0.085	0.17	Harvested
Victoria R. (Mid.)	82-88	7	0.094 ± 0.055	0.15	Harvested
Victoria R. (U/S)	83-86	3	0.159 ± 0.040	0.16	Harvested
Victoria R. (Pigeon)	82-86	4	0.084 ± 0.047	0.22	Harvested
Wickham River	82-87	5	0.070 ± 0.066	0.36	Harvested
MEAN (Harvested)			0.082 ± 0.015		
MEAN (All Rivers)			0.050 ± 0.018		

Crocodylus porosus

Annual spotlight surveys were carried out in 8 rivers in 1989, including those from which eggs were harvested. For each river or creek surveyed, the natural logarithm (to the base e; ln) of density was plotted against years since protection, and the slope of the regression line used as an estimate of the exponential rate of increase (r). This was done in two stages, firstly using data up to 1988, which was then used to predict a density for 1989 (which can be compared with the observed density) and then for all data up to 1989, which will now be used to predict a density for 1990.

Table 6. The exponential rate of increase (r) and predicted densities for 1988 and 1989 using the data in Appendix II for rivers in which there have been more than 3 surveys. In the few instances where no crocodiles were spotted in a particular creek, in any one year, 1 sighting has been added so that a logarithm value could be computed. P = the probability that r is due to chance.

Survey Area	N	Years	r	P	Pred. Den.	Obs. Den.	Total 1989
Adelaide R. mainstream: 0-64.5 km	7	77-88	0.042	0.05	3.99	4.26	307
Adelaide R. mainstream: 0-64.5 km	8	77-89	0.044	0.02	4.27		
Adelaide R. mainstream: 64.5-117 km	12	77-88	0.063	0.01	4.69	4.82	289
Adelaide R. mainstream: 64.5-117 km	13	77-89	0.064	<0.01	4.93		
Adelaide R. sidecreeks	8	77-88	0.032	0.29	1.12	0.95	113
Adelaide R. sidecreeks	9	77-89	0.026	0.29	1.10		
Blyth R. mainstream	14	75-88	0.015	0.26	3.87	5.19	478
Blyth R. mainstream	15	75-89	0.022	0.08	4.25		
Blyth R. sidecreeks	12	75-88	-0.011	0.69	1.41	1.26	11
Blyth R. sidecreeks	13	75-89	-0.009	0.68	1.20		
Cadell R. mainstream	14	75-88	-0.002	0.89	3.00	2.46	166
Cadell R. mainstream	15	75-89	-0.007	0.58	2.84		
Daly R. mainstream	6	79-88	0.095	<0.01	3.43	3.29	311
Daly R. mainstream	7	79-89	0.093	<0.01	3.72		
Finniss R. Bullcoin	5	84-88	-0.055	0.58	7.36	8.50	34
Finniss R. Bullcoin	6	84-89	-0.035	0.59	7.67		
Finniss R. Patj Patj	5	84-88	-0.112	0.63	4.36	6.06	40
Finniss R. Patj Patj	6	84-89	-0.065	0.67	4.86		
Liverpool R. Gudjerama Creek	11	76-88	0.035	0.33	1.58	1.97	13
Liverpool R. Gudjerama Creek	12	76-89	0.043	0.14	1.79		
Liverpool R. mainstream	12	76-88	0.048	<0.01	2.42	2.43	202
Liverpool R. mainstream	13	76-89	0.048	<0.01	2.54		
Liverpool R. Maragulidban Creek	12	76-88	0.051	0.06	1.90	1.81	17
Liverpool R. Maragulidban Creek	13	76-89	0.050	0.03	1.97		
Liverpool R. Morngarrie Creek	12	76-88	-0.082	0.03	0.71	2.50	10
Liverpool R. Morngarrie Creek	13	76-89	-0.043	0.24	0.96		
Liverpool R. Mungardobolo creek	12	76-88	0.078	0.01	2.57	1.80	19
Liverpool R. Mungardobolo creek	13	76-89	0.067	0.01	2.49		
Liverpool R. Toms Creek	9	76-87	0.127	0.06	1.09	0.38	2
Liverpool R. Toms Creek	10	76-89	0.086	0.12	0.08		
Reynolds R. Deep Hole Billabong	5	84-88	-0.184	0.52	0.40	0.67	3
Reynolds R. Deep Hole Billabong	6	84-89	-0.111	0.55	0.47		
Reynolds R. Horseshoe Billabong	5	84-88	-0.140	0.52	1.74	6.88	3
Reynolds R. Horseshoe Billabong	6	84-89	0.056	0.76	3.79		
Reynolds R. McEddy's Lagoon	5	84-88	0.149	0.45	7.56	12.25	51
Reynolds R. McEddy's Lagoon	6	84-89	0.218	0.14	12.11		
Reynolds R. Noaklies Billabong	5	84-88	0.187	0.32	27.30	30.00	39
Reynolds R. Noaklies Billabong	6	84-89	0.183	0.15	36.55		
Reynolds R. Welltree Lagoon	5	84-88	-0.122	0.31	5.06	11.60	59
Reynolds R. Welltree Lagoon	6	84-89	-0.003	0.97	7.79		
Tomkinson R. mainstream	12	76-88	0.044	0.02	2.89	2.57	228
Tomkinson R. mainstream	13	76-89	0.040	0.01	2.91		

Clearly (Table 6), the numbers of non-hatchlings seen in spotlight counts has fluctuated greatly from year to year, and few of the areas that have been surveyed recently (since 1984) are showing a significant increase or decrease in density. The mean value of **r**, for all areas surveyed by spotlight in 1989 is 0.037 ± 0.016 (SE; range 0.218 to -0.111), which is appreciably less than the mean derived from all rivers which have been surveyed in all years [0.081 ± 0.008 (Webb et al. 1989)]. This indicates that the sample of rivers and creeks spotlight surveyed annually were ones with relatively high densities of non-hatchlings when the survey programs were initiated.

The relationship between the densities predicted for 1989 (from data up to 1988) and those recorded in 1989 are on Fig. 3. The slope of the regression line [$LnDENS_{obs} = 0.20 + 0.97LnDENS_{pred}$ ($R^2 = 0.74$; $P = 0.0001$) is close to unity, indicating that the data now available can be used to predict mean results reasonably precisely: it may not be necessary to survey these rivers and creeks annually.

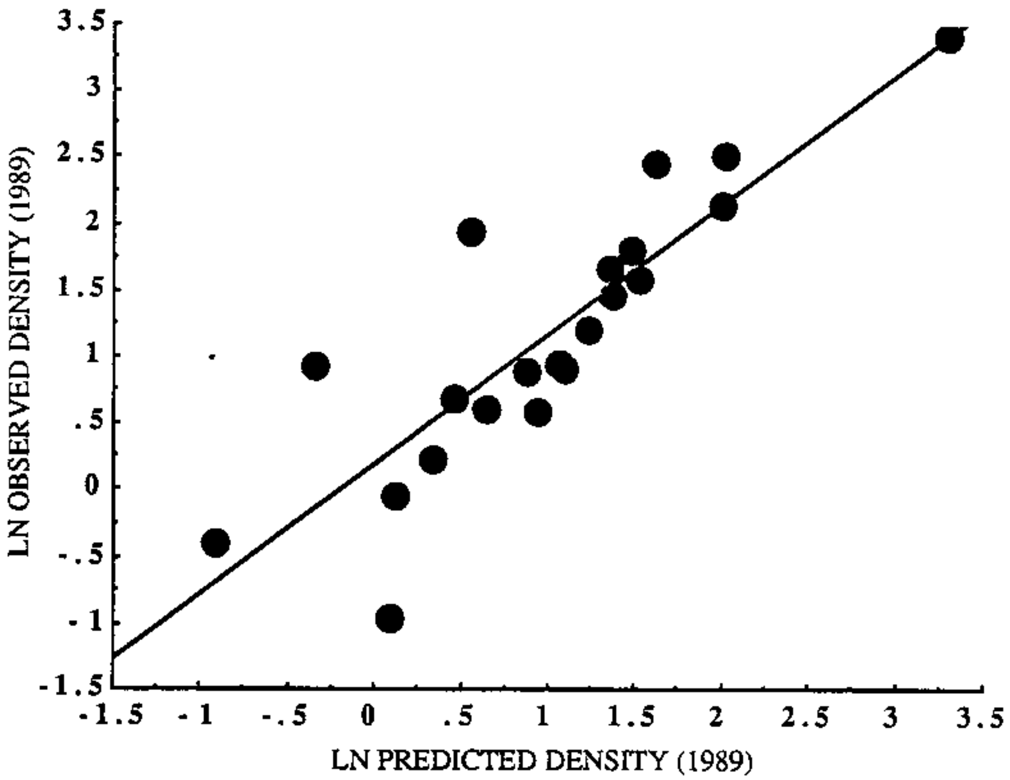

Figure 3. The relationship between predicted and observed densities for the rivers and creeks surveyed by spotlight in 1989 (Table 6).

The major monitoring effort in 1989 was devoted to a helicopter survey of 10 km sample segments, in 70 tidal rivers and creeks, around the complete coast of the Northern Territory (between the Western Australian and Queensland borders). As pointed out previously (Webb et al. 1990), *C. porosus* is a highly mobile animal, and a total population monitoring program should ideally be based on annual samples from a large number of rivers rather than detailed surveys within a few rivers, each year.

In order that the extensive historical data base of spotlight counts not be lost with the changeover to helicopter surveys, a procedure was adopted for correcting the spotlight counts to helicopter count equivalents (Webb et al. 1990). This meant that prior to the helicopter survey carried out in 1989, a predicted result was available from the historical data: in this case, a mean density of 0.635 ± 0.066 (SE) crocodiles sighted per kilometre (predicted from 'Year' alone), or 0.599 ± 0.042 (predicted from 'Year', 'Rainfall' and 'Hatchling Density' using a multiple regression formula). The mean helicopter count from the sample areas was 0.666 ± 0.084, which was consistent with the predicted result (Fig. 4). It is also consistent with our assumption that the procedure used to correct the historical spotlight count database to a helicopter count data base, had not resulted in gross errors.

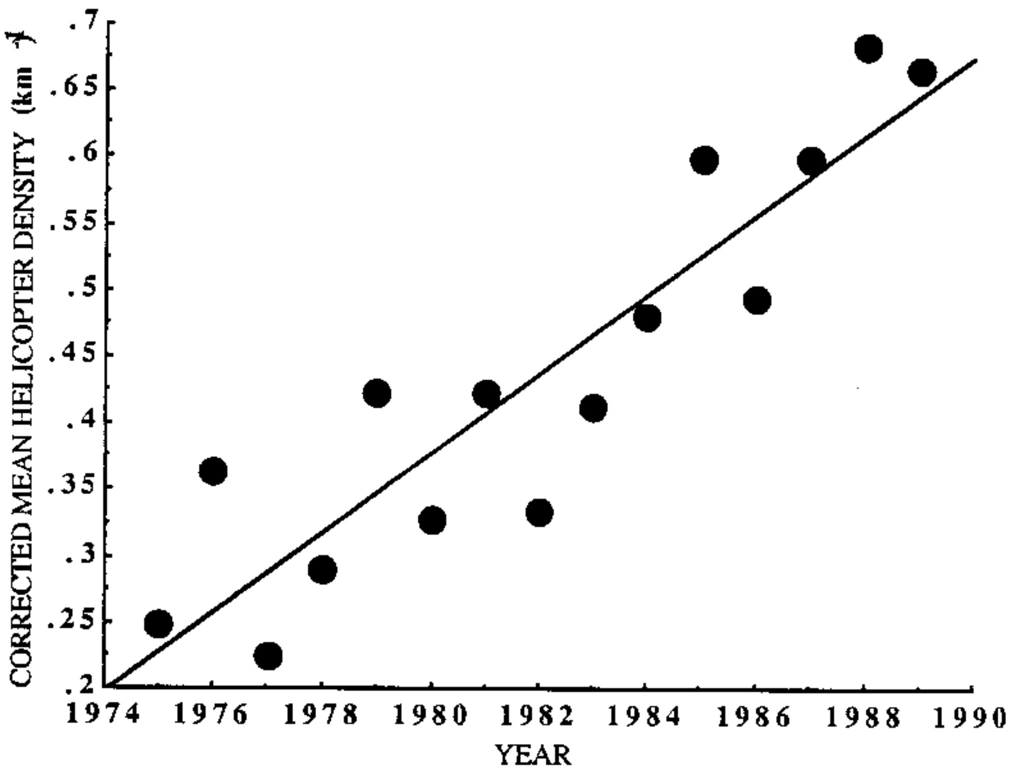

Figure 4. The relationship between the mean density of non-hatchling *C. porosus* (helicopter count equivalents) and year. Values between 1975 and 1988 were derived by correcting spotlight counts; the 1989 value is the first real helicopter count. The regression line, using all data, can be used to predict a mean helicopter count density for 1990 (0.676 ± 0.064 crocodiles km^{-1}).

These results can be used to estimate total population size. If it is assumed that over long periods of time the tidal population represents a constant proportion of the total population, then the mean trend (the regression line) should be a good index of the total population size. This assumes that annual fluctuations in the mean density from year to year (Fig. 4) reflect short-term changes in the proportion of the total population visible in tidal rivers in particular years. In 1984, the total wild population (hatchlings and non-hatchlings) was estimated to be at least 40,000 (Webb et al. 1984). As mean density has increased from 0.50 km^{-1} to 0.65 km^{-1} between 1984 and 1989 (a 30% increase), the total population in 1989 is now estimated as at least 52,000 *C. porosus*.

SKINS AND FLESH

During the two year period (1988-89) 2367 *C. porosus* and 1543 *C.johnstoni* skins were exported from the Northern Territory, mostly to Japan. A total of 20,497 kg of flesh was produced and retailed, mainly to the restaurant trade. Most flesh was sold in the form of whole carcases (Manolis and Webb 1990).

CROCODILE FARMS

Details of crocodiles held on the four crocodile farms in the Northern Territory, at 31 December 1989, are in Table 7.

Table 7. Numbers of crocodiles held on Northern Territory crocodile farms, as of 31 December 1989, according to monthly reports.

Farm	*C. porosus*	*C. johnstoni*
Farm A	4803	1471
Farm B	2566	7025
Farm C	1814	398
Farm D	0	6707
Total	9183	15,601

At one farm, 61 *C. porosus* nests were laid during the 1988/89 season and 64 during the 1989/90 season, and at another, 11 nests were laid in each season. One additional *C. porosus* nest was laid at a local Darwin zoo each year. Combing all data, for the 1988/89 season there was an average of 12.2 hatchlings produced per nest. In 1989, 23 *C. johnstoni* nests were laid in captivity in one farm, with an additional nest at a local Darwin zoo; 6.8 hatchlings were produced per nest.

RESEARCH

The progress made with various research programs being undertaken in the Northern Territory is discussed briefly below. Most of this work has been funded by the Northern Territory Government through the Conservation Commision of the Northern Territory, but other establishments are involved in collaborative programs (Macquarie University; James Cook University of North Queensland; University of New England; University of New South Wales).

1. Life history strategies of *C.johnstoni*

Harvey Cooper-Preston's work on *C. johnstoni* life history strategies is now winding up. A considerable effort has been devoted to using growth lines in the leg bones and nuchal osteoderms as morphological age-indicators. This is by no means a straight-forward exercise, and it heralds caution for those attempting to use the same method on other species. Her study is now able to use samples from marked *C. johnstoni* in the McKinlay River, recaught after 10 and 11 years.

2. Predicting the time of nesting for *C. johnstoni*

Smith (1987) analysed time of nesting in the McKinlay River area, using data collected in 5 seasons; he demonstrated that the median day of nesting (which ranged from 13 August to 12 September) could be predicted from the mean maximum air temperature in May - three months before nesting. His data also allowed the mean day of nesting to be predicted from the same May temperatures. In 1989, mean maximum May temperature was 32.3°C, which predicted a mean and medium day of nesting of 27 and 26 August respectively. The observed mean and median day of nesting in 1989 (Fig. 5) was 22 August 1989, indicating a prediction error of 4-5 days.

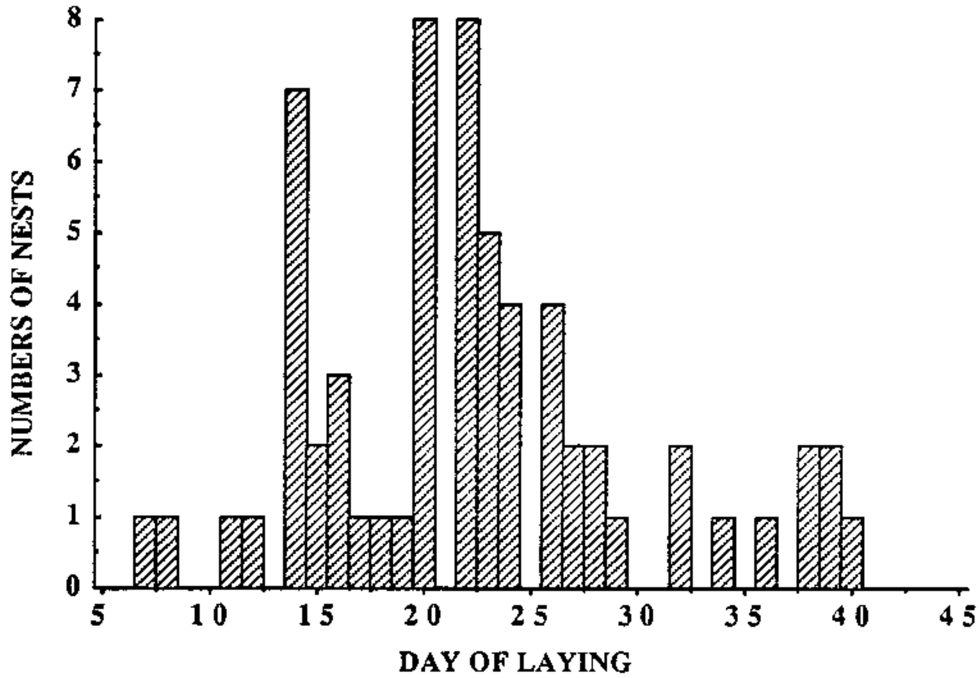

Figure 5. Date of laying for 62 *C. johnstoni* nests located in the McKinlay River, in 1989. Day 5 = 5 August, etc.

3. Sex Determination

Research continues into the histology, histochemistry and development of the gonad of *C. johnstoni* and *C. porosus* embryos.

The relationship between incubation temperature and sex in embryonic *C. johnstoni* is different from that in most crocodilians: no constant incubation temperature produces 100% males (Webb et al. 1987), even though 100% males are produced in some wild nests. An obvious hypothesis which could explain this result, is that the mechanism of temperature-dependent sex determination is sensitive to daily fluctuations in temperature as well as to the mean temperature. This possiblity was tested in 1989 (Table 8).

Table 8. The results of incubating *C. johnstoni* eggs at three constant and one fluctuating temperature. Individual clutches were split between the four treatments; excess eggs were placed in the fluctuating temperature treatment.

Temperature (°C)	31	32	33	31-33
No. of viable eggs	148	148	151	177
Died during incubation (%)	23.6	8.8	9.9	16.9
Hatched- total (%)	76.4	91.2	90.1	83.1
Hatched- normal (%)	73.0	86.5	80.1	73.4
Hatched- abnormal (%)	3.4	4.7	10.0	9.6
Mean incubation time (d)	75.8	70.2	67.2	70.8
Sex ratio (proportion males)	0.00	0.39	0.07	0.41

The results indicate a series of temperature effects on hatching success and hatchling quality. There was no significant difference between the sex ratio from the fluctuating (31-33°C; mean = 32°C) and corresponding constant temperature (32°C). Although a possible influence of fluctuating temperature *per se* on sex determination cannot be totally rejected with these data (it may need larger fluctuations, or fluctuations around a different mean temperature), there may be other reasons why no constant temperature produces 100% *C. johnstoni* males. A significant difference between field incubation and laboratory incubation with this species, is that in the field nest temperatures increase throughout the incubation period [from around 28-29°C at laying to 32-36°C at hatching (Smith 1987)]. A steadily increasing incubation temperature may be needed to induce "maleness", as is suggested a switch experiments carried out in the laboratory (Webb et al. 1987). Placing young, cool eggs into a high constant temperature incubator (as is usually done) may also induce a degree of thermal shock, which could in turn affect sex determination.

4. Predicting the annual extent of *C. porosus* nesting

Using the accumulated data on *C. porosus* nesting (1980/81 season to 1988/89 season) from Melacca Swamp, 40 km east of Darwin, an attempt was made to predict the number of nests (containing eggs) made annually, from a variety of environmental variables. The most accurate predictive relationship was with the Southern Oscillation Index (SOI) in June-July (Fig. 6). The SOI is a measure of the cyclic pattern of air pressure movement across the Pacific Ocean, and it is used to predict the onset of the wet season in northern Australia.

The SOI is correlated with local air pressures and water heights, but neither of these, as independent variables nor in combination, gives as precise a prediction as the SOI. The amount of unexplained variation is so little (Fig. 6) that it is difficult to avoid the conclusion that female *C. porosus* are responding to environmental conditions in June-July, some five months before the onset of nesting (November) and six months before the peak of nesting (December-January).

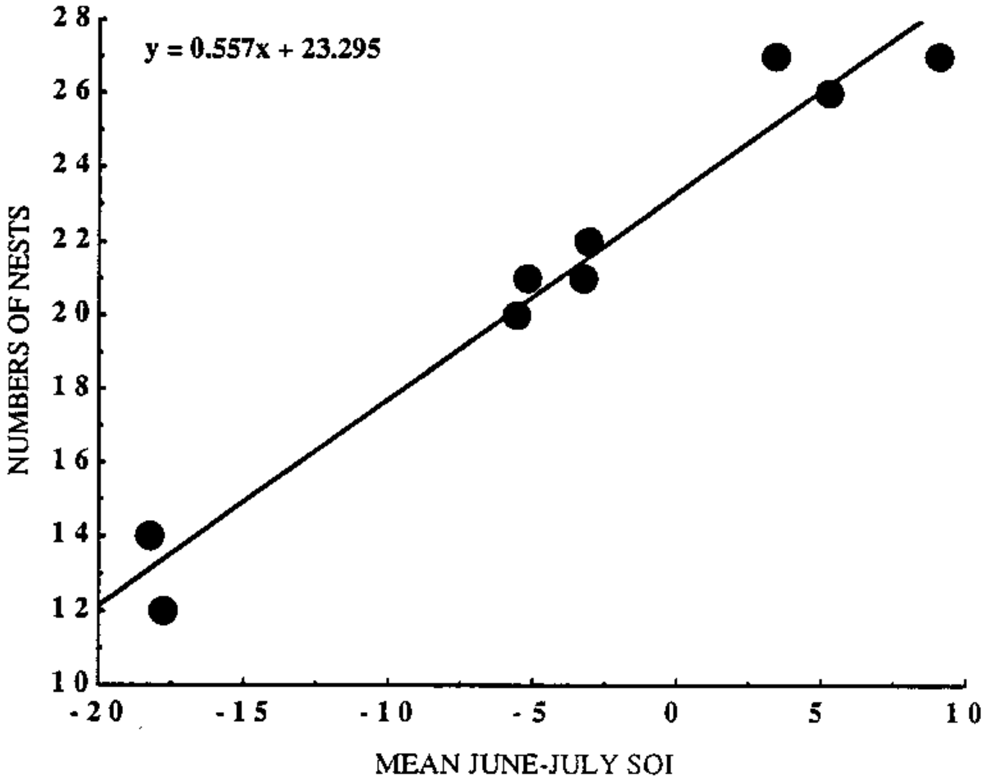

Figure 6. The relationship between numbers of *C. porosus* nests in Melacca Swamp each year (laid between November and May) and the mean June-July Southern Oscillation Index (SOI), five months earlier.

The SOI in June-July 1989 (+7.5) predicted that the 1989/90 season would be one of the "best" years for nesting (predicted 27.5 nests) since the study began. Up until April, some 32 nests have been located and it is possible that a few more will be made in April-May. That the predicted value underestimated the real nesting effort may reflect random variation not yet accounted for, but it is worthy of note that during 1989 the water buffalo were eradicated from Melacca Swamp. There has been a striking revegetation of open channels within the Swamp, and this season, for the first time in a decade, nests were being made in new areas. The removal of buffalo may have contributed to the increased nesting effort.

5. Husbandry research on *C. porosus* hatchlings

As reported previously (Manolis and Webb 1989; Manolis et al. 1989), a series of experiments have been undertaken on the factors that affect growth in newly hatched *C. porosus*, within the first month of life. The results indicate distinct preferences for certain food types, and strong clutch specific effects on those preferences, and on the extent of feeding and growth (Table 9).

These same trials were used to test a variety of different raising parameters, and as a consequence we adopted a standard diet and feeding procedure [32°C water temperature; night-feeding; constant sound (radio); semi-darkness; hide-boards; 75% wild pork meat + 25% chicken heads; 2% calcium-phosphorus powder; 1% multivitamin supplement). With this procedure we then tested one-day versus two-day feeding, at five different temperatures (Table 10).

Table 9. The percentage increase in body weight, within the first month of life, of *C. porosus* hatchlings fed a variety of different foods. CH = chicken heads; Pork = feral pork; Fish = marine fish.

Clutch	Fish/CH	Fish	Buffalo	Pork	Prawn	Chicken
A36	-	-	53.4	57.0	64.6	48.1
A37	-	-	50.6	17.3	6.0	13.1
F40	68.7	-	-	-	-	44.8
M92	29.6	-	-	-	-	17.1
B1	-12.0	-	24.6	21.2	11.5	-
F9	-10.4	-8.7	2.7	30.1	-	-
M12	6.5	-1.5	-19.9	20.2	-	-
F19	-	-	35.9	39.0	-	-
F29	-	-	25.7	28.2	-	-

Analyses of food conversion rates indicates that the efficiency with which hatchlings convert food with two-day feeding (mean = 40%) is greater than that with which they convert food with one day feeding (28%) (Table 11). From one to two months of age the differences in conversion rates between one and two day feeding were still very apparent (mean difference = 56%). At 32 and 33°C, conversion rates with two day feeding were over two times higher than with one day feeding (25.9 and 24.2% versus 12.1 and 11.3% for 32 and 33°C respectively.

6. Feeding, growth and food conversion rates of wild, juvenile *C. porosus*

Although numerous studies have described the types of prey taken by wild crocodilians and the rates at which wild crocodilians grow, none have attepted to quantify the food conversion rates in the wild. We quantified growth rates, rates of feeding and food conversion rates for wild, juvenile *C. porosus* (30-120 cm TL) in a tidal river (Adelaide River) (Webb and Hollis 1990).

Results indicate that the mean conversion rate was 82.4% (i.e. 82.4% of the wet weight of food eaten was converted to body weight). This is appreciably higher (2-3 times) than conversion rates obtained for similar-sized animals raised in captivity under controlled conditions. Wild, juvenile *C. porosus* eat much less than their captive counterparts (4% body weight per week versus 21-27%), but use the food they eat far more efficiently (Webb and Hollis 1990).

Table 10. Percentage increase in body weight and head length after one month, for *C. porosus* hatchlings raised under five temperature regimes (see above). Animals were fed either each day (1D) or every second day (2D). For 31 to 34°C each treatment consisted of the same mix of 5 clutches (13 hatchlings). Data for 30°C are from 4 of the 5 clutches (10 hatchlings in 1D and 12 in 2D).

	T°C	% Increase in body weight				% Increase in head length			
		Mean	SE	Min.	Max.	Mean	SE	Min.	Max.
1D	30	66.8	12.80	13.8	127.6	21.2	1.07	17.3	25.9
2D	30	63.2	7.35	14.6	92.3	20.1	1.35	11.3	26.8
1D	31	89.3	9.90	31.2	127.0	24.5	0.88	19.2	30.2
2D	31	47.3	10.58	-1.0	100.0	19.1	1.15	13.2	25.7
1D	32	103.1	13.73	15.8	199.6	26.9	1.37	19.5	37.9
2D	32	93.3	5.23	67.9	119.9	25.5	1.12	20.7	32.1
1D	33	86.7	15.38	-2.7	161.6	25.8	1.44	16.7	34.0
2D	33	71.7	6.10	39.4	109.0	24.2	0.77	17.6	27.2
1D	34	85.3	17.00	-6.4	152.5	25.5	1.77	14.8	32.1
2D	34	87.0	7.73	33.3	127.7	24.9	0.97	19.1	30.2

Table 11. Foood conversion rates (CR; percentage of wet weight of food converted to body weight) of *C. porosus* hatchlings, within the first month of life, raised at different temperatures, and fed either each day (daily) or every second day (2 days).

T°C	CR (%) Daily	CR (%) 2 days	Difference (%)
30	27	44	61.0
31	33	36	10.5
32	29	42	44.5
33	26	37	43.1
34	26	38	46.0
Mean	28	40	41.1

7. Use of development rates to predict hatching dates for *C. porosus* eggs

In a previous study (Webb et al. 1987), we presented a method of giving unknown-aged *C. porosus* embryos a "30°C Age" (the age they would be in days had they been incubated at constant 30°C), and presented development rate coefficients for predicting hatching dates at temperatures between 28°C and 34°C. During the 1987/88 and 1988/89 wet seasons we tested these predictions at 32°C with 152 wild clutches collected from the field when between 2.1 and 93.0 days (87.5% less than 40 days) of age [30°C Age; mean incubation time at 32°C is 80.1 ± 2.1 (SD) days (Webb et al. 1987)]. The development rate coefficient used was 1.261 (Webb et al. 1987), which means that at 32°C the amount of development that takes place in 1 day is 1.261 times the amount that takes place in 1 day at 30°C.

The results indicated that smaller eggs tended to complete their development earlier than larger eggs (Table 12). Without correcting for this bias, the mean error between predicted and observed hatching dates was 0.72 days, which was reduced to 0.01 days after correction (Table 13). The variation around this mean is expressed in Table 14.

Table 12. Correction factors to be added to predicted dates of hatching, for *C. porosus* eggs, to account for egg size.

Egg length range (mm)	Correction (d)
65.1-67.5	-2.1
67.6-70.0	-1.8
70.1-72.5	-1.6
72.6-75.0	-1.3
75.1-77.5	-1.0
77.6-80.0	-0.7
80.1-82.5	-0.4
82.6-85.0	-0.1
85.1-87.5	+0.2
87.6-90.0	+0.4

Table 13. Mean difference between predicted and real days of hatching for clutches of wild *C. porosus* eggs before and after correction for egg size. SD = standard deviation; SE = standard error.

Season	Mean Difference (d)	SD	SE	Range (d)	No. of Clutches
Uncorrected					
87/88	0.84	1.98	0.25	-4 to 4	63
88/89	0.64	2.31	0.25	-5 to 8	89
Both	0.72	2.18	0.18	-5 to 8	152
Corrected					
87/88	0.11	1.96	0.25	-4 to 3	63
88/89	-0.07	2.18	0.23	-5 to 7	89
Both	0.01	2.09	0.17	-5 to 7	152

Table 14. Proportion (%) of *C. porosus* clutches for which hatching dates were predicted within certain time periods. For example, after correction for egg size, 91.4% of clutches hatched within 3 days of the predicted date; had the predicted dates been corrected for egg size, 92.1% would have hatched within 3 days. Numbers in brackets are cumulative totals.

Days	Uncorrected		Corrected	
0	18.4	(18.4)	15.1	(15.1)
1	29.6	(48.0)	35.5	(50.7)
2	27.0	(75.0)	28.3	(78.9)
3	16.4	(91.4)	13.2	(92.1)
4	3.9	(95.4)	4.6	(96.7)
5	2.6	(98.0)	1.3	(98.0)
6	0.7	(98.7)	1.3	(99.3)
7	-	(98.7)	0.7	(100.0)
8	1.3	(100.0)	-	-

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An Overview of Alligator Management in Florida

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INTRODUCTION

Since 1977, when the American alligator (Alligator mississippiensis) was reclassified in Florida from the federal status of endangered to threatened, the Florida Game and Fresh Water Fish Commission (Commission) has established and supported management programs that provide for limited consumptive utilization of the alligator resource while contributing to long term conservation objectives. Through sustained-yield harvests, lethal control of nuisance alligators, and alligator farming, programs and industries have been developed which are committed to the wise management and sustained utilization of alligators in Florida.

The Commission's alligator management program, the Commission's nuisance alligator control program (NACP) and the alligator farming industry function as the mechanism for utilization of Florida's alligator resource. The Commission's alligator management program has implemented harvest strategies which allow the utilization of wild alligators at several demographic levels including collection of eggs and hatchlings and direct harvest of alligators > 1.2 m in length. The NACP serves as an effective method for lethal removal of specific wild alligators that present a potential threat to humans or domestic animals. The alligator farming industry, in addition to captively propagating alligators, utilizes ranched alligators through Commission programs that permit the collection of eggs and hatchlings from public and private wetlands. The purpose of this paper is to provide an overview of these program elements and to summarize the associated harvest or production levels.

THE COMMISSION'S ALLIGATOR MANAGEMENT PROGRAM

An alligator management program proposal was implemented by the Commission in 1987 (David, Fla. Game and Fresh Water Fish Comm., unpubl. report) following the enactment of state legislation that established an alligator harvest license and tag fee structure. As outlined in the proposal, monies generated through commercial utilization of alligators support management programs and provide economic incentives for user groups to become active in support of alligator and wetland conservation issues. This concept, whereby the economic value of a wildlife resource is directed back into overall management and conservation has been termed "value-added conservation" (Hines and Percival 1987, Hines and Abercrombie 1987). The concept of value-added conservation was fundamental to the development and implementation of the Commission's alligator management program. Currently this program is in the early stages of growth and development, and, as a result, the overall benefits of value-added conservation have not been fully realized. Some positive effects, however, are being seen. Revenues generated from license and tag fees already serve as a major source of funding for management programs, and the constituency of users with a vested interest in conservation of alligators and their wetland habitat is increasing substantially each year.

Operational harvest programs, which fall under the umbrella of the alligator management program, focus on 2 distinct demographic segments of alligator populations including alligators > 1.2 m in length and alligator eggs and hatchlings. Harvest strategies are organized into the following 4 program components: (1) the harvest of alligators > 1.2 m in length from public waters; (2) the collection of alligator eggs from public waters; (3) the collection of alligator hatchlings from public waters; and (4) the collection of eggs and hatchlings and the harvest of alligators > 1.2 m in length from private lands.

Harvest of Alligators > 1.2 m from Public Waters

This program component was implemented statewide in 1988 on 25 public wetland systems and expanded in 1989 to 32 public wetland systems. Commission rules require that wetland systems or alligator management units (AMU) open to harvest must be "comprised of specified wetlands, lakes, rivers or other water bodies that may be reasonably grouped for the purposes of study, analysis or management" (Fla. Game and Fresh Water Fish Comm. 1989).

The methodology for determining sustainable harvest levels on AMU's was developed through experimental harvests conducted on 9 Florida lakes during the 1980's (Hines and Abercrombie 1987, Woodward et al. 1987). Results of these studies indicated that approximately 15% of alligators > 1.2 m in length could be harvested annually without measurable impacts on population levels (Table 1).

Using experimental harvest results as a basis for establishing harvest levels, Commission rules limit harvest quotas on each AMU to no more than 15% of the estimated harvestable population (Fla. Game and Fresh Water Fish Comm. 1989). Harvestable population levels are estimated for each AMU based on annual night-light surveys conducted during May by Commission biologists.

Trappers are selected randomly each year from alligator harvest permit applications. In 1988, 5,855 applications were received, and 238 trappers were selected. Interest in the program increased substantially as a result of publicity generated the first year such that, in 1989, over 20,000 applications were received for 228 available harvest permits. Following selection, each trapper is required to complete a Commission-sponsored training program prior to issuance of harvest permits and harvest tags (Fla. Game and Fresh Water Fish Comm. 1989).

A $250 resident alligator trapping license ($1000 nonresident) and a $50 trapping agent's license (for an assistant) is required for harvest and possession of alligators. Alligator harvest permits authorizing harvest of up to 15 alligators > 1.2 m in length from designated public waters and 15 numbered harvest tags, to be attached to each alligator immediately upon harvest, are issued to each trapper.

During the harvest season (September 1 through September 30), trappers are permitted to take alligators 1/2 hour before sunset to 1/2 hour after sunrise using restricted methods that will secure a restraining line to the animal (Fla. Game and Fresh Water Fish Comm. 1989). Experimental harvest data suggest that the timing of the harvest as well as the harvest methods direct harvest pressures away from reproductively active females. Additional regulatory controls designed to strictly impede any illicit trade developing as a result of legitimate alligator harvest include the following: (1) alligators must be killed and tagged immediately; (2) a harvest report form must be completed and accompany the alligator hide until validation (3) hides must be skinned according to specific skinning instructions provided with the harvest permit; (4) all hides must be presented to the Commission for validation (validation involves inspection of hides for compliance with skinning instructions, applying a federally issued CITES [Convention on International Trade in Threatened and Endangered Species of Flora and Fauna] tag in place of the harvest tag, and assessing a validation fee of $30 per hide); (5) hides must be validated within 30 days of the close of the harvest season; and (6) alligator meat intended for sale must be processed at a licensed processing facility (Fla. Game and Fresh Water Fish Comm. 1989).

Trappers harvested 87% (2,988 alligators) and 91% (3,118 alligators) of the statewide quotas in 1988 and 1989 respectively. Male alligators were reported by trappers on harvest report forms to comprise 70% of the harvest in 1988 and 66% in 1989. The average length of all alligators harvested in 1988 and 1989 was 2.3 m.

Egg Collection from Public Waters

In 1988, the Commission conducted a pilot alligator egg collection program on 3 wetland systems. This pilot study was implemented to assess the operational feasibility of authorizing egg collection on public waters by farming industry representatives. The resulting eggs were transferred to permitted farms for artificial incubation, rearing, and slaughter. The pilot program demonstrated that proposed biological and regulatory controls were adequate to monitor egg collection activities and ensure that eggs collected from the wild could be equitably distributed to licensed alligator farms for captive rearing.

In 1989, the egg collection program was fully implemented under Commission regulations governing the collection of alligator eggs from the wild (Fla. Game and Fresh Water Fish Comm. 1989). The number of alligator farms permitted to receive eggs from the wild was limited to the first 30 applicants meeting special facility requirements. This limit was established to ensure that enough eggs could be distributed to each participating farm to make wild egg collections economically worthwhile for the farmer (David, Fla. Game and Fresh Water Fish Comm., unpubl. report).

Studies conducted on Florida lakes from 1981 through 1986 (Table 3) indicated that 50% of the annual production of relatively dense alligator populations could be harvested on a sustained basis (Percival and Jennings 1987, Hines and Abercrombie 1987). As a result of these findings, Commission regulations prohibit the annual collection of eggs from more than 50% of the nests on any collection area (Fla. Game and Fresh Water Fish Comm. 1989). Egg collection areas are established annually by the Commission after on-site inventories are conducted by Commission biologists to assess each area's potential for egg removal. Nest collection quotas are subsequently determined each season based on the number of nests observed by Commission biologists during aerial nest surveys.

Regulatory guidelines facilitate organized egg collections by establishing 2 egg collection groups and designating one individual for each group as the egg collection coordinator (Fla. Game and Fresh Water Fish Comm. 1989). The egg collection coordinator represents his group in all aspects of directing and conducting permitted activities. Only licensed alligator farmers or their agents are permitted to participate in the actual collection of eggs. The following regulatory requirements provide for biological and operational control during egg collection activities: (1) egg collections must be conducted under the supervision of Commission personnel; (2) the number of nests opened cannot exceed the total nest quota; (3) all eggs from each opened nest must be collected; (4) eggs must be presented for inspection and inventory by Commission personnel before exiting the collection area; and (5) a fee of $5 per egg is assessed for every egg retained by the participants (Fla Game and Fresh Water Fish Comm. 1989). In the first 2 years of operation, over 12,000 eggs have gone to alligator farms as a result of harvest from public wetlands (Table 2).

Hatchling Collection from Public Waters

In 1987, the Commission implemented a program component that permits eligible alligator farmers to collect alligator hatchlings from public waters. Establishment of conservative harvest levels for juvenile alligators was based on research findings that indicate this population segment can withstand significant annual harvest pressure (Percival and Jennings 1987). Conservative hatchling collection quotas were established for each county in Florida based on an evaluation of U.S. Fish and Wildlife Service wetland inventories (U.S. Fish and Wildlife Service 1982) and estimates of associated alligator occupancy rates (Neal 1985, Fla. Game and Fresh Water Fish Comm., unpubl. data).

Only licensed alligator farmers eligible to receive alligator hatchlings from the wild and their licensed agents are permitted to participate in this program. Hatchling quotas for each county are randomly assigned to permitted farms based on their specified preference of collection areas. Hatchling collections are permitted from September 15 through November 1. Additional regulatory controls over collection activities are as follows: (1) hatchlings can not be collected until after the Commission has conducted a total captive hatchling production inventory on the permittee's farm; (2) the Commission must be notified in advance of collection activities; (3) hatchlings must be tagged immediately upon capture with Commission issued web tags; (4) a fee of $15.00 per tag is assessed prior to issuance of hatchling tags; and (5) a hatchling collection form must be completed prior to leaving the collection site and must accompany hatchlings until delivered to the permittee's farm (Fla. Game and Fresh Water Fish Comm. 1989).

After 3 seasons of alligator hatchling collections (1987 through 1989), harvest rates have averaged only about 40% of the annual statewide quota of 10,200 hatchlings. Collection totals included 3,908, 4,062, and 4,415 hatchlings in 1987, 1988, and 1989 respectively.

Alligator Management on Private Lands

In 1988, alligator harvest programs were implemented on private lands in Florida. Pilot studies on 2 private ranches beginning in 1985 provided the operational and biological basis for this program component (Woodward et al. 1987). The potential benefits from realizing value-added conservation are probably greatest under this program component relative to other program components. It allows participating landowners to sustain direct economic benefits from wetlands previously considered a liability unless drained or altered for agricultural, industrial, or residential development. These positive economic incentives for wetland conservation on private lands can be realized through ranching or sale of access to alligator eggs and hatchlings and harvest of alligators > 1.2 m in length (Woodward et al. 1987).

The Commission establishes harvest quotas on private lands following evaluation of habitat inventories and population surveys conducted by consulting wildlife biologists employed by the landowner. To conduct or verify habitat inventories, nest and hatchling pod surveys, and surveys of alligators > 1.2 m in length, the wildlife biologist must meet the certification requirements of The Wildlife Society (Fla. Game and Fresh Water Fish Comm. 1989). Quotas for removal of eggs and hatchlings represent up to 50% of the observed nest or hatchling pod inventories. Harvest quotas for alligators > 1.2 m in length represent up to 15% of the estimated population in this size range.

To initiate an alligator management program on private lands, the landowner must submit a written application which requires selection of management goals, harvest options, and a verified alligator habitat inventory. From 1988 through 1990, applicants were required to own or have under lease at least 405 ha of alligator habitat on one property or adjoining properties (Fla. Game and Fresh Water Fish Comm. 1989). However, recent changes in Commission rules will allow, in 1991, participation of landowners or lessees with a surveyed population of at least 100 alligators > 1.2 m in length (Fla. Admin. Weekly 1990). If the landowner meets the application eligibility requirements, the Commission will issue an Alligator Management Program Permit. To harvest and possess alligators, the permittee or his designees and their agents must purchase an alligator trapping license ($250) and/or an alligator trapping agent's license ($50).

A harvest period of May 1 through May 30 was established for alligators > 2.7 m in length in 1988. This harvest period was extended to July 31 in 1990. The harvest period established for alligators > 1.2 m in length was September 1 through September 30 in 1988 and extended to October 15 in 1989. Additional regulatory requirements for harvest programs on private lands include: (1) restricted methods of take for alligators > 1.2 m in length; (2) immediate tagging with Commission issued harvest tags; (3) completion of harvest report forms which must accompany hides at all times until validation; (4) Commission validation within 30 days of the close of the harvest season and payment of a $30 per hide validation fee; (5) fee payment for egg collection permits ($2.50 per egg) and hatchling tags ($7.50 per tag) prior to collection; (6) immediate tagging of collected hatchlings; and (7) mandatory transfer of collected eggs and hatchlings to alligator farms permitted as eligible to receive eggs and hatchlings from the wild (Fla. Game and Fresh Water Fish Comm.

1989). Eggs and hatchlings can be retained for captive rearing by the landowner only if he is licensed and permitted as an alligator farm eligible to receive eggs and hatchlings from the wild.

Alligator management programs were implemented on 7 properties encompassing 29,543 ha of wetlands in 1988 and 21 properties encompassing 64,346 ha of wetlands in 1989, while 36 applications encompassing 70,812 ha were submitted in 1990. The numbers of eggs collected and alligators > 1.2 m in length harvested increased between 1988 and 1989 (Table 4). The number of participants is expected to increase again in 1991 and 1992 as longer harvest seasons and less restrictive application requirements are implemented.

NUISANCE ALLIGATOR CONTROL PROGRAM

A pilot program conducted during 1977 demonstrated the efficiency and feasibility of lethal removal of nuisance alligators by contracted private trappers (Hines and Woodward 1980). Prior to this pilot program, nuisance alligators were relocated by Commission personnel at great expense and with limited success (Hines and Woodward 1980). In 1978, the Commission implemented the nuisance alligator control program (NACP) statewide by contracting approximately 55 private trappers for removal of nuisance alligators under the supervision of Commission personnel (Jennings et al. 1989). Through commercial utilization of nuisance alligators, NACP trappers receive significant economic returns while providing a valuable service at relatively low administrative cost to the state.

NACP trappers are regulated by Commission rules that require specific qualifications including residency within the region of operation, ability to capture and handle wild alligators, and having available the necessary time and equipment (Fla. Game and Fresh Water Fish Comm. 1989). If trappers meet qualifications, they must enter into a contract with the Commission and annually purchase a $250 license to take and possess alligators. In 1989, 45 NACP trappers were under contract and licensed to harvest nuisance alligators through permits issued by the Commission (Jennings et al. 1989).

The operational activities of this program are directed and coordinated by Commission personnel (NACP coordinators) in each of 5 regional offices. When nuisance alligator complaints are received by Commission personnel in regional offices, information on the behavior and size of the alligator along with degree of perceived threat is recorded and evaluated prior to issuance of a harvest permit. If Commission personnel determine the alligator is a potential threat to humans or domestic animals or is creating a public safety hazard, a harvest permit is issued to a NACP trapper residing near the complaint location. The harvest permit allows the trapper 45 days to remove the specific nuisance alligator. As in other harvest programs, alligators must be tagged immediately upon capture with a Commission-issued harvest tag. Within 185 days of harvest and before hides can be transferred to licensed hide buyers, NACP trappers must have all hides validated by the Commission and pay a $30 validation fee for each hide (Fla. Game and Fresh Water Fish Comm. 1989).

From 1978 to 1989, the number of nuisance alligator complaints increased from 4,914 to 9,867 (Woodward et al. 1987, Jennings et al. 1989) (Table 5). During this period, the number of nuisance alligators harvested increased from 1,871 to 4,230 with a mean of

2,656 taken annually (Woodward et al. 1987, Jennings et al. 1989). Woodward et al. (1987) and Jennings et al. (1989) discuss possible reasons for these increases which include human population growth in close proximity to alligator habitat, gradual increases in alligator densities, greater public awareness and acceptance of the NACP, and increases in public perception of alligator threat in response to rare, isolated attacks.

ALLIGATOR FARMING IN FLORIDA

Although alligator farming is not administered directly under the umbrella of the Commission's alligator management program, the industry plays an important role in the production, rearing, and utilization of alligators in Florida. Licensed alligator farms are permitted by the Commission to captively propagate alligators provided they meet modest facility and housing requirements. Additionally, up to 30 alligator farms which have at least 186 m^2 (2,000 ft^2) of drainable rearing pens may qualify for a permit to receive eggs and/or hatchlings produced in the wild. For further regulatory requirements and establishment of collection areas and harvest quotas, refer to previous sections in this paper on egg and hatchling collection from public and private waters.

Additional alligators from the wild are available to farms through ongoing research activities. Since 1987, the alligator farming industry, has been supporting a study on alligator egg viability. The U.S. Fish and Wildlife Service, Florida Cooperative Fish and Wildlife Research Unit, is conducting this research using eggs collected annually from 6 Florida wetland systems. In return for funding this project, the alligator farming industry receives the hatchlings produced from artificially incubated eggs at the end of each annual research period. From 1987 through 1989, 14,187 hatchlings were produced and subsequently distributed to alligator farms as a result of these activities (Table 3).

Currently, 48 farms are licensed to captively propagate alligators in Florida including 30 farms which are permitted to receive eggs and hatchlings produced in the wild. Historically, statewide production of juvenile alligators from captive breeding efforts has been low (David, Fla. Game and Fresh Water Fish Comm., unpubl. report). However, with an 18% annual increase in the number of licensed farms since 1982, expansion of existing farms, and improved incubation and husbandry techniques, production has increased from 1,000 in 1981 to a current level of about 10,000 hatchlings per year (David, Fla. Game and Fresh Water Fish Comm., unpubl. report). As a result of ranching programs, the number of wild-produced hatchlings placed on farms has increased to a level of approximately 20,500 in 1989 (David, Fla. Game and Fresh Water Fish Comm., unpubl. report). Harvest levels on alligator farms have increased substantially in recent years in response to these increases in juvenile stock (Table 6). This trend is expected to continue over the next several years as production levels increase and more hatchlings become available from wild sources in Florida and other southeastern states (David, Fla. Game and Fresh Water Fish Comm., unpubl. report).

SUMMARY

Though production levels are expected to continue to increase on alligator farms in the near future, the number of nuisance alligators requiring removal and the number of wild alligators available for sustained commercial harvest on public lands is limited. The number of nuisance alligators harvested annually will probably continue to increase gradually as Florida's human population continues to encroach on alligator habitat, but programs aimed at informing and educating the public on how to live with alligators could minimize these increases. The number of wild alligators available for harvest from public waters will probably stabilize between 4,000 to 5,000 during the next few years as public waters suitable for sustained harvests become fully utilized.

The amount of private property suitable for harvest of wild alligators also is limited; however, only a small percentage of these lands are currently involved in alligator management. As a result, this relatively young component of the alligator management program has the greatest growth potential. More than two thirds of Florida wetlands are under private ownership. As more landowners become familiar with this program and recognize the value of alligators, participation and subsequent harvest levels should continue to increase.

In conclusion, the Commission's alligator management programs and the alligator industry have demonstrated the feasibility of managing alligators to provide immediate and long term ecological, aesthetic, and economic benefits. The high economic value of products derived from alligators should continue to stimulate broad interest in managing wild and captive alligators for sustained utilization in Florida.

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Table 1. Annual harvest of alligators > 1.2 m in length from experimental harvest areas in Florida, 1981 through 1989.

Year	Number harvested
1981	350
1982	379
1983	277
1984	271
1985[a]	1,172
1986[a]	1,202
1987[a]	1,016
1988[a,b]	836
1989[a,b]	1,059

[a] Experimental harvest expanded from 3 harvest areas to 9 harvest areas.
[b] Experimental harvest included under regulatory and operational protocol of statewide harvest on public lands.

Table 2. Alligator egg harvests from public waters in Florida during 1988 and 1989.

	1988	1989
Number of egg collection areas	3	5
Nest collection quota	145	296
Number of eggs collected	5,707	9,975
Eggs retained by participants	4,302	7,884
Hatch rate of retained eggs	79%	82%
Number of resulting hatchlings	3,410	6,438

Table 3. Wild hatchling alligators transferred to commercial alligator farms in Florida as a result of research activities.

Study				
Egg and hatchling removal	Egg viability	Hatchlings collected	Hatchlings produced from eggs	Total Hatchlings
1981		2,031	0	2,031
1982		1,308	182	1,490
1983		1,151	2,273	3,424
1984		60	2,918	2,978
1985		0	3,449	3,449
1986		0	4,075	4,075
	1987	132	4,400	4,532
	1988	0	3,964	3,964
	1989	0	5,701	5,701
Totals		4,682	26,952	31,634

Table 4. Alligator harvests from private lands in Florida, 1988 and 1989.

	1988	1989
Egg collection quota	2,050	1,350
Number of eggs collected	768	1,166
Hatchling collection quota	80	160
Number of hatchlings collected	80	160
Harvest quota - alligators > 1.2 m in length	255	699
Number harvested - alligators > 1.2 m in length	180	577

Table 5. Harvest of nuisance alligators in Florida, 1977 through 1989.

Year	Complaints received	Alligators harvested	Alligators harvested/ complaint
1977[a]	709	535	0.75
1978	4,914	1,871	0.38
1979	4,639	1,679	0.36
1980	4,024	1,590	0.40
1981	4,931	1,871	0.38
1982	6,124	2,169	0.35
1983	5,955	1,871	0.31
1984	7,289	2,201	0.30
1985	6,432	3,023	0.47
1986	6,018	3,049	0.51
1987	7,288	3,853	0.53
1988	10,305	4,464	0.43
1989	9,867	4,230	0.43

[a] Harvests resulting from the pilot nuisance alligator control program implemented in an 11-county area in Florida.

Table 6. Harvest of farm-reared alligators in Florida, 1978 through 1989.

Year	Alligators Harvested
1978	335
1979	220
1980	89
1981	284
1982	244
1983	184
1984	738
1985	1,339
1986	3,921
1987	6,479
1988	7,572
1989	16,482

The effect of high temperature and increased day length on growth and survival of captive Nile crocodile, Crocodilus niloticus during the cold season in Kenya.

By

A. Zilber[1], Y. Yom-Tov[2] and D. M. Popper[3]

The experiment took place at Mamba Village, a crocodile farm near Mombasa, Kenya and coinceded with the cold season in Kenya.

Two months old crocodiles were reared in groups of 80 animals each in round 2.2 m^2 concrete ponds with 0.8 m high walls. The floor sloped gently towards a central drain which was 15 cm below the level of the wall basis. The floor was completely covered to a level which enabled the crocodiles to raise their body above the water only near the walls. The ponds were covered by a roof made of 1:1 ratio of glass and asbestos which prevented air flow but enabled direct solar radiation. An ad libitum food, a minced mixture of fish, chicken and red meat supplimented with minerals and vitamins was provided once daily at sunset on raised trays which were removed before sunrise. After the trays were removed the ponds were drained, washed and refilled with clean well water daily.

The animals were reared under 3 treatments with 4 repetitions:-

1. Ambient day length without heating (Water temperatures: 23°C - 32°C)
2. Ambient day length with heating (Water temperatures: 29°C - 34°C)
3. Extended day length and heating (Water temperatures: 29°C - 34°C).

Heating was provided by aquarium heaters placed in the centre of each pond. The day was extended by two, 0.6 m long neon tube lamps in each pond which operated from 1 hour before until 2 hours after sunset for the entire experiment.

All the animals were weighed and total lengths were measured at the beginning of the experiment and after 2, 4 and 5 months. Dead animals were removed counted and replaced by equal sized crocodiles in order to maintain the experimental density.

The result were as follows:-

(a) The weight/length ratios were highly correlated without significant differences between the repetitions and treatments in heated ponds, but the control animals had W/L ratio which was significantly smaller than expected.

(b) Extended day length had no effect on growth and survival.

(c) Heating had a positive effect on both growth and survival. Significantly, highest mortality was observed at the unheated ponds.

The above demostrated the well known effect of temprature on crocodiles and reptiles in general, but the fact that extended day length did not effect growth or survival may be associated with the feeding habits of Nile crocodiles which are active during day and night.

The full results of this study will be published eleswhere.

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The effect of stocking density on survival growth and body condition of captive Nile Crocodile, Crocodilus niloticus

Ariel Zilber[1], Dan M. Popper[2] and Yoram Yom-Tov[3]

Two months old Nile Crocodiles, Crocodilus niloticus were reared in round concrete ponds of 6 m radius, each divided into 8 equal sections, under 4 density treatments with two repetition each. The experiment was divided into 2 periods:-

The density treatments were as follows:-

(1) Initial densities were of 6, 9, 12 and 15 individuals per m^2 and the numbers were reduced by 10% at the end of each 2 months interval. The experiment lasted 10 months and the final densities were 3.94, 5.91, 7.80 and 9.78 individuals per m^2.

(b) During the second period, which started with one year old crocodiles the initial densities were 7.5, 10, 12.5 and 15 individuals per m^2. The numbers were reduced as in experiment (a) and the final densities after 10 months were 4.94, 6.57, 8.21 and 9.85 individuals per m^2, respectively.

The bottom of the ponds sloped gently towards the central drain and the water level was kept so that a radius of 5 m was water covered. The walls were 1.2 m high and the ponds were covered by a sloping asbestos roof. Water was supplied through taps at the centre and sprinkles at the water perimeter. Food, fresh mixture of chicken, fish and red meat was provided once daily ad libitum. Water temperature ranged between 26 - 34°C and air temperature 24 - 40°C and were equal in all treatments.

The animals from each repetition were sampled bi-monthly. Twenty five animals were randomly taken, weighed and measured for total length. Dead animals were removed and recorded.

The results were as follows:-

1. The weight/length ratios were highly correlated without any significant difference between the repetition and treatments.

2. The above stocking densities had no effect on growth rate during any of the periods.

3. Similary there was no effect of biomass on growth rate during any of the periods.

4. Survival was significantly and negatively affected by density during the first cold season (4 months, July - November 1988), when the crocodiles were under 8 months old.

5. No effect of density on survival was observed during the remaining 16 months.

The results suggest that Nile Crocodiles can be successfully reared with no ill effects at the above densities and that temperature has a deterimental effect on survival at high densities of very young crocodiles.

Full results of this experiment will be published elsewhere.

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The effect of light regime and temperature on growth rate, survival and body condition of young captive Nile Crocodiles, *Crocodilus niloticus*.

By

Ariel Zilber[1], Yoram Yom-Tov[2] and Dan M. Popper[3]

Twelve groups of 8 months old crocodiles were kept for 5 months in round 2.2 m^2 concrete ponds with 0.8 m high walls. The ponds bottom were gently sloped towards a central drain and fully covered by water at a level which enabled the crocodiles to raise their body above the water only near the walls. An ad libitum minced mixture of chickens, fish and red meat together with 1,000 I.U of Vitamin D per 12 kg food was offered once daily on exposed concrete trays, which were placed in the ponds after sunset and removed before sunrise. After the trays were removed the ponds were drained, washed and refilled daily.

The animals were reared under 4 treatments (3 repetitions each) as follows:-

1. Complete cover of asbestos and glass, 1:1 area ratio, which prevented air flow, and allowed direct solar radiation.

2. Complete asbestos cover, prevented air flow and light penetration.

   These two treatments included continous water flow of 28.5°C - 31°C, which kept both water and air temperature similar in both.

3. Exposed ponds with a complete shade of plywood placed 5 cm above the rim of the walls, enabled air flow and partial illumination.

4. Exposed ponds enabled free airflow and direct sunlight.

All the animals were weighed and total lengths were measured at the beginning of the experiment and after 3 and 5 months. Dead animals were removed, counted and replaced by equal sized crocodiles in order to maintain the experimental density.

The results were as follows:-

Treatment 1 resulted in significantly better growth and survival. The next best results in growth were obtained from treatments 2, 4 and 3 in this order. Significantly highest mortality was observed under treatment 3.

The above suggest that a combination of high temperature and direct solar illumination result in improved growth and survival.

These results contradict common belief by crocodile and alliagtor farmers that darkness is essential for optimal growth.

Full results of this experiment will be published elsewhere.

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The Relations Between the Growth of Weight and Length With the Exuviations of the Young Alligators Before Hibernation

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ABSTRACT

This article discussed the reason why during the feeding of the young alligators the growth of body weight did not sychronize with the growth of their total length.

The reason for this phenomenon is exuviations. Before hibernation, there are two exuviations in the young Chinese Alligators. At that time the growth mode is a period of the growth of skeleton and epidermis with a prominent increase in total length. While in the other periods are principally for the increase of their body weight.

A batch of 340 young alligators of 1984 was selected for the primary inspection of their growth in the early stage. Two major phenomena were found in this inspection:

1. During hibernation, the bodies of young alligators still kept growing slowly.
2. In the feeding, we found that the climax of growth in weight and in length were at intervals.[1]

For the further clarity of this phenomenon, another batch of young alligators of 1985 was taken out as the material for minute inspection on their growth during hibernation. And a report on this result had been written out in 1987.[2]

Still another batch of young alligators of 1986 was taken out for the minute survey on their growth before hibernation.

This paper will report the young alligator's law of growth and appearing this phenomenon's cause before hibernation.

Material and Method of This Inspection

1. Material: A batch of 108 young alligators of hatching in 1968 was taken at random from 5 nests for this inspection.
2. Method: With the precaution of avoiding the differentiation from their birth origin, the material are divided into 5 groups according to their original nests. Then feed, inspect, and measure them separately; make record on the amount of food taken and make weekly records on weight, on total length, and on the lengths of the trunk and the tail.

Results

1. In all of the periodical measurements obtained numerical values, if according to the velocity of the body-weight growth for criterion, then every group can be divided into 5 stages.

The increase's t-value test in weight and in length, and dates in 5 groups on 5 stages were listed in Table 1 and shown contrastively.

2. With the purpose of finding out the relationship between the growth of the trunk and the tail on different growing stages. The measurements of the trunk and the tail were also listed in Table 1. But obviously the growth of the trunk and tail was irregular.

3. It was found in the inspection that the young alligators underwent 2 exuviations before hibernation. But there was a variation in exuvium time and dates of exuvium process was also differed in every nest, however it was common in all nests that the exuvium process was a process in motion and all could be divided into 3 stages.

1) First stage (free stage): At the first stage of exuviation the epidermis of the young alligators begin to be loosen from the understructure of the skin and prepare to drop away. This time in appearance there was no sign of exuvium or there was exuvium only in a few places and a few crackages in some

places. However the whole body turned into grey colour and the colour was much deeper at the join-tsof the scales.

2) Second stage (flourish-exuviation stage):

The epidermis 1" on the lower jaws
2" on the abdominal parts of neck, trunk and tail
3" on the 2 sides of neck, trunk and tail
4" on the all parts of limbs

All kept cracking into small pieces and exuviating. But in the 2 exuviations the thick bony scales on the dorsal part exuviated very late. the head bone did not exuviate, instead it grew thicker and larger, only exuviated very thin epidermis. The young alligators like to soak in water with exuviated skins floating around them, looked very much like grey woolly hair growing all over their bodies.

3) Third stage: This was the last stage with most part of the body covered with a sheet of new skin. Only in a few places there were still some remaining exuviating old skin attached on the new skin. This time, it might be said: an exuviation came to its completion.

The dates in procession of the 3 stages of the 2 exuviations on all the 5 groups of young alligators were listed in Table 2.

4. Taking the 5 stages of growth of the young alligators in Table 1 as base, the amount of food eaten converted in every week's average take-food quantities and take-food rates(weekly food consumption / body weight). There were shown in Table 3. It can be seen that the values were variant in all 5 stages.

Discussion

1. From the values of weight and length in Table 1, it can be seen clearly that stages I,III,V are the climax for the growth of weight and stages II,IV are the climax for the growth of length. And the growth of weight and length were at interval

with a regular order. It is because:

1) Not only all mean body weights in the 5 stages proved in conformity with the above-mentioned law, but the magnitudes in t-test (mainly in I,III,V stages) all proved distinction existence.

2) In the values of the climax of total length increase, the I stage of group No. 6 was the only exception among the 5 groups. Because in that stage the climax of body weight and total length turned out at the same time; as to the magnitudes of t-test (mainly in II,IV stages) there was no difference only in the stage II of group No.6 and in the stage IV of group No.2. In stage IV of group No.1 even though t t , but in stage V, t t ,so it inversely proved that there was existence distinction. So, as a whole, in all stages, they complied to this law.

2. In the 5 groups, the time for 3 climax of increasing body weight started 24-52 days, 45-101 days, and 80-132 days,with the feeding of young alligators. Compared with the 2 climax of 1984's batch (20-40 days and 84-91 days) the time relatively conformed with each other. Being ill before hibernation, so there was no third climax in 1984's batch.[1]

3. From the observation of feeding, the time-interval between the 2 exuviations before hibernation varied greatly. The longest time-interval was 21 days (group No.16), while the shortest only 1 day, in which there was almost no interval and one exuviation just continued on to the next. It was an exception. (see Table 2)

4. There was a grest time distinction and with no law in each exuviation in every group of young alligators. It seemed that there was a law from the time taken in the 2 exuviations in a nest. If the former was a long exuviation, then the later was a short one, otherwise it reverse. May be this phenomenon was for to adapt the hibernation of the young alligators with the help of self-biological clock make adjustment on secretion. (see Table 2)

5. Table 3 proved: Whether the stages were divided according to the increase of body weight (Table 1) or divided according to the amount of food consumed by the young alligators. Eventhough there was no regular formula, but as usual we can get an approximate result: 5 stages.

6. If the total time of days in the 3 periods of the 2 exuviations listed in Table 2 were to be compared with the stages in Table 1, then the total time of stage II,IV in Table 1, approximately coincided with the time in the 2 exuviations in Table 2.

7. As mentioned above, we deemed that before the coming of exuviation (including also a few days at the beginning and in the end of exuviation), the growth mode of the young alligator was mainly for the increase of its body weight. While during the exuviation almost all the nutritions were used up for the growth of a new larger spidermis and skeleton. So there was little increase of body weight, and sometimes even a decrease. But there was a rapid increase in the length of the young alligators. That was why the growth of body weight of the young alligator did not synchronize with growth of total length.

Reference Literatures

[1] Zhang Zhengdong et al.: The Growth Rates of Young Chinese Alligators in Captivity. Acta Herpetologica Sinica 5(3):: 217-222 (1986)

[2] Zhang Zhengdong et al.: The Growth of young Chinese Alligators During Hibernation. Acta Herpetologica Sinica 6(3): 16-20 (1987)

Table 1. Every group's numerical values of length were be surveied in the 5 stages, which were divided upon the velocity for growth of the body-weight.

numbers of group	numbers of stage	beginning value	I numbers	I t	II numbers	II t	III numbers	III t	IV numbers	IV t	V numbers	V t
1#	DATE & n	Sept. 27	Sept.27 --Oct.4	n=19	Oct.4 --Oct.18	n=19	Oct.18 --Nov.8	n=19	Nov.8 --Nov.15	n=19	Nov.15 --Dec.13	n=19
	body weight	25.894±1.500 (22—29)	30.184±1.851 (25.5—34)	7.637	33.763±2.520 (30—38)	4.855	37.763±4.037 (29—46)	5.348	39.026±3.806 (28—45)	0.563	46.000±5.281 (35—57)	4.543
	total length	22.852±0.500 (21.8—23.2)	23.068±0.451 (22.1—23.8)	1.356	23.915±0.666 (22.6—25.3)	4.459	24.326±0.772 (22.5—26.1)	1.708	24.842±0.728 (23.6—26.8)	1.812	25.578±1.166 (23.5—28.7)	2.093
	trunk length	6.484±0.118 (6.2—6.7)	6.547±0.163 (6.1—6.8)	1.310	6.736±0.189 (6.3—7)	3.190	6.762±0.306 (6.3—7.3)	0.305	7.000±0.324 (6.3—7.3)	1.130	7.245±0.374 (6.2—8.2)	3.551
	tail length	12.084±0.253 (11.6—12.5)	12.505±0.223 (12.2—12.9)	5.273	12.926±0.347 (12.3—13.7)	4.318	12.963±0.469 (11.8—13.7)	0.268	13.163±0.481 (12—14)	0.630	13.826±0.665 (12.8—15.3)	3.423
2#	date & n	Sept.25	Sept.25 --Oct.16	n=24	Oct.16 --Oct.23	n=24	Oct.23 --Dec.4	n=24	Dec.4 --Dec.11	n=21	Dec.11 --Jan.3	n=20
	body weight	24.145±1.262 (21—26)	29.833±2.173 (25.5—34)	10.949	29.875±1.872 (27—34)	0.013	37.229±3.826 (30—45.5)	9.560	38.428±2.953 (32.5—42)	0.250	46.125±3.545 (40—54.5)	7.412
	total length	22.191±0.457 (21.6—22.9)	22.837±0.489 (21.9—24)	4.662	23.170±0.592 (22.6—24)	2.545	23.887±0.678 (22.9—25.3)	4.387	24.442±0.778 (22.8—25.4)	1.923	24.670±0.700 (23.3—26.7)	0.651
	trunk length	6.162±0.149 (5.9—6.5)	6.375±0.189 (6.1—6.8)	4.214	6.416±0.164 (6.2—6.9)	0.778	6.625±0.243 (6.1—7.2)	3.396	7.014±0.247 (6.5—7.5)	12.993	6.815±0.295 (6.4—7.2)	2.261
	tail length	11.750±0.219 (11.3 12.2)	12.187±0.277 (11.7 12.7)	12.011	12.270±0.238 (11.9 12.8)	1.036	12.587±0.387 (12—13.5)	3.350	13.004±0.443 (11.8 13.8)	2.705	12.775±0.477 (11.6 13.6)	0.234
6#	date & n	Sept.22	Sept.22 --Oct.6	n=21	Oct.6 --Oct.13	n=21	Oct.13 --Nov.3	n=21	Nov.3 --Nov.17	n=21	Nov.17 --Dec.16	n=21
	body weight	23.714±1.230 (22.5—26.5)	27.976±1.579 (25—32)	9.444	28.380±1.981 (23.5—33.5)	0.709	35.380±3.484 (28—41)	7.809	35.952±3.702 (27.5—42)	0.505	44.000±4.928 (34—53)	11.093
	total length	21.666±0.657 (19.6—22.5)	22.657±0.574 (21—23.4)	5.075	22.923±0.658 (22—23.9)	1.361	23.576±0.768 (21.3—24.3)	2.886	24.100±0.781 (21.7—25.3)	2.137	24.820±0.878 (23.5—26.5)	2.966
	trunk length	5.990±0.147 (5.7—6.3)	6.423±0.168 (6.1—6.7)	8.619	6.404±0.212 (5.9—6.8)	0.312	6.538±0.196 (6.2—6.8)	2.070	6.909±0.267 (6.3—7.2)	5.062	7.280±0.282 (6.8—7.8)	4.265
	tail length	11.457±0.296 (10.6—11.7)	12.004±0.351 (11.2—12.5)	5.382	12.080±0.383 (10.9—12.6)	0.652	12.347±0.400 (11.2—13.1)	2.095	12.675±0.484 (11.3—13.5)	2.424	13.104±0.504 (11.8—13.8)	2.614
8#	date & n	Oct.7	Oct.7 --Oct.21	n=22	Oct.21 --Oct.28	n=22	Oct.28 --Nov.4	n=22	Nov.4 --Nov.25	n=22	Nov.25 --Dec.16	n=22
	body weight	26.931±1.995 (22.5—30)	31.772±2.657 (27—37.5)	6.699	32.295±2.831 (27.5—37)	0.617	34.954±3.070 (28.5—40.5)	2.917	32.931±3.772 (32—46)	2.855	45.272±8.069 (39—54)	4.175
	total length	22.759±0.633 (21.2—23.7)	23.209±0.638 (22.3—24.5)	2.291	23.750±0.724 (22.1—25.4)	2.567	23.681±0.758 (21.9—25.4)	0.301	24.359±0.884 (22.1—26)	2.666	24.777±0.771 (23.1—26.1)	1.632
	trunk length	6.372±0.100 (6.2—6.5)	6.609±0.210 (6.1—7)	4.631	6.990±0.279 (6.5—7.6)	4.985	6.518±0.285 (6—7.3)	5.407	6.792±0.225 (6.4—7.4)	5.081	7.218±0.222 (6.8—7.5)	4.270
	tail length	12.031±0.329 (11.2—12.6)	12.404±0.430 (11.5—13.3)	3.154	12.677±0.464 (11.6—13.6)	1.976	12.100±2.176 (11.6—13.5)	1.188	13.063±0.515 (11.7—14.2)	1.972	13.107±0.487 (12.2—13.8)	0.276
16#	date & n	Oct. 1	Oct.1 --Oct.22	n=22	Oct.22 --Oct.29	n=22	Oct.29 --Dec.3	n=22	Dec.3 --Dec.10	n=22	Dec.10 --Dec.16	n=22
	body weight	26.545±1.075 (23.5—29)	32.227±2.146 (29.5—35)	10.844	32.886±2.010 (30—38)	1.026	39.340±2.225 (34.5—42)	8.408	40.068±3.181 (34—46)	0.776	42.340±2.725 (35.5—47.5)	[illegible]
	total length	22.327±0.518 (20.3—22.9)	22.663±0.571 (21.1—23.7)	2.112	22.186±0.502 (21.6—24)	2.337	23.550±0.652 (21.7—24.7)	2.024	24.095±0.697 (23.5—25.5)	2.616	24.045±0.640 (22.8—25.1)	0.241
	trunk length	6.368±0.160 (6—6.6)	6.459±0.172 (6—6.7)	1.763	6.636±0.118 (6.4—6.9)	2.540	6.663±0.169 (6.4—7)	0.592	6.895±0.187 (6.4—7.3)	4.199	6.750±0.236 (6.5—7.5)	0.833
	tail length	11.850±0.440 (10—12.4)	11.395±2.049 (10.3—12.3)	0.994	12.343±0.441 (10.8—13)	2.116	12.304±0.480 (10.7—13)	0.413	12.500±0.451 (10.8—13.2)	1.361	12.295±2.154 (11—13.4)	0.426

$t_{0.05,19}=2.093$ $t_{0.05,20}=2.086$ $t_{0.05,21}=2.080$ $t_{0.05,22}=2.074$ $t_{0.05,24}=2.064$

Table 2. The period of two exuviation of young alligators before hibernation

stages of exuviation		the first exuviation				days of interval	the second exuviation			
		the free stage	the flourish-exuviation stage	the end	whole days		the free stage	the flourish-exuviation stage	the end	whole days
No. of group	1#	Oct.1 --Oct.8	Oct.10--Oct.25	Oct.28	28	4	Nov.2 --Nov.6	Nov.10--Nov.15	Nov.20	19
	2#	Oct.9 --Oct.15	Oct.16--Oct.25	Nov.5	27	17	Nov.23 --Nov.28	Dec.1--Dec.6	Dec.8	16
	6#	Sept.30 --Oct.6	Oct.7--Oct.13	Oct.17	18	8	Oct.26 --Nov.5	Nov.8--Nov.18	Nov.22	28
	8#	Oct.13 --Oct.18	Oct.19--Oct.23	Oct.26	14	1	Oct.28 --Nov.5	Nov.8--Nov.18	Nov.25	29
	16#	Oct.16 --Oct.21	Oct.23--)ct.29	Nov.5	21	21	Nov.27 --Dec.3	Dec.4--Dec.8	Dec.12	16

Table 3. The changes of take-food of the every group in 5 stages

stages / No. of group	stage I: average body weight in this stage	stage I: average quantity of take-food every week	stage I: take-food rate	stage II: average body weight in this stage	stage II: average quantity of take-food every week	stage II: take-food rate	stage III: average body weight in this stage	stage III: average quantity of take-food every week
1#	28.039g.	3.50g.	12.48%	31.973g.	5.60g.	17.51%	36.763g.	4.62g.
2#	26.989g.	4.41g.	16.33%	29.854g.	4.90g.	16.41%	33.352g.	4.90g.
6#	25.845g.	3.78g.	14.62%	28.178g.	4.48g.	15.89%	31.880g.	5.32g.
8#	29.351g.	5.60g.	19.07%	32.038g.	4.06g.	12.67%	33.624g.	4.97g.
16#	29.386g.	4.90g.	16.67%	32.556g.	4.55g.	13.97%	36.113g.	5.67g.

stages / No. of group	stage III: take-food rate	stage IV: average body weight in this stage	stage IV: average quantity of take-food every week	stage IV: take-food rate	stage V: average body weight in this stage	stage V: average quantity of take-food every week	stage V: take-food rate
1#	12.56%	39.394g.	5.74g.	14.57%	42.513g.	7.21g.	16.96%
2#	14.60%	38.507g.	6.44g.	16.72%	42.475g.	10.01g.	23.56%
6#	16.68%	35.666g.	5.18g.	14.52%	39.976g.	6.65g.	16.63%
8#	14.78%	36.942g.	5.67g.	15.34%	42.101g.	7.91g.	18.78%
16#	15.70%	39.704g.	8.54g.	21.50%	41.454g.	9.10g.	21.95%

IUCN/SSC CROCODILE SPECIALIST GROUP

Workshop on Trade in Crocodilian Products

Presented Summaries and Trade Statistics

24 April 1990

10th Working Meeting of the CSG
Gainesville, Florida
23-27 April 1990

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INTERNATIONAL CROCODILIAN SKIN TRADE: TRENDS AND SOURCES

Richard Luxmoore
CSG Deputy Vice-Chairman for Trade Monitoring

CITES annual reports give an estimate of the international trade legally carried out under the terms of the Convention. Table 1 shows the minimum net trade in classic crocodilian skins (i.e. all alligators and crocodiles except caimans) indicated by CITES reports. The data for 1987 indicated a total trade of some 115,000 skins while those for 1988, which are as yet incomplete, show a trade of around 112,000. When the full data are available it is likely that this will rise to around 140,000 classic skins. The total has been increasing in recent years, and has more or less doubled since 1984.

Consideration of the species involved shows that most of the increase has been attributable to skins of _Alligator mississippiensis_ obtained from wild harvests and ranching in Louisiana and Florida. Supply of _Crocodylus niloticus_ has also increased, owing mainly to the new systems of management, ranching and quota schemes, introduced in a variety of African countries. The number of skins of _Crocodylus porosus_ has also increased to a lesser extent up to around 10,000 skins from ranch production in Australia and the quota scheme in Indonesia. _Crocodylus novaeguineae_ is the main classic skin in trade and the supply has remained fairly constant.

In the 1970s the trade was much higher, probably in the region of 300,000, owing mainly to the larger export of _C. niloticus_ from Africa, many of which entered Europe under the terms of the reservations held by Italy and France. These were dropped in 1984, and the resulting reduction in trade can clearly be seen in Table 1. Today there is very little evidence of illegal trade in _C. niloticus_ skins, and the major illegal trade is believed to be in skins of _C. porosus_ and _C. novaeguineae_ from South East Asia.

Trade in _Caiman_ skins is very much larger, and CITES annual reports indicate that it was up to 400,000 in 1988 (Table 2). the majority of these came from Venezuela with smaller quantities from Bolivia, Guyana, Argentina, Honduras and Colombia. There is also known to be a substantial illegal trade in _Caiman_ skins, principally to Singapore and Thailand, taking the total to something over a million skins a year.

CSG April 1990

MINIMUM NET TRADE IN CLASSIC CROCODILIAN SKINS REPORTED IN CITES ANNUAL REPORTS

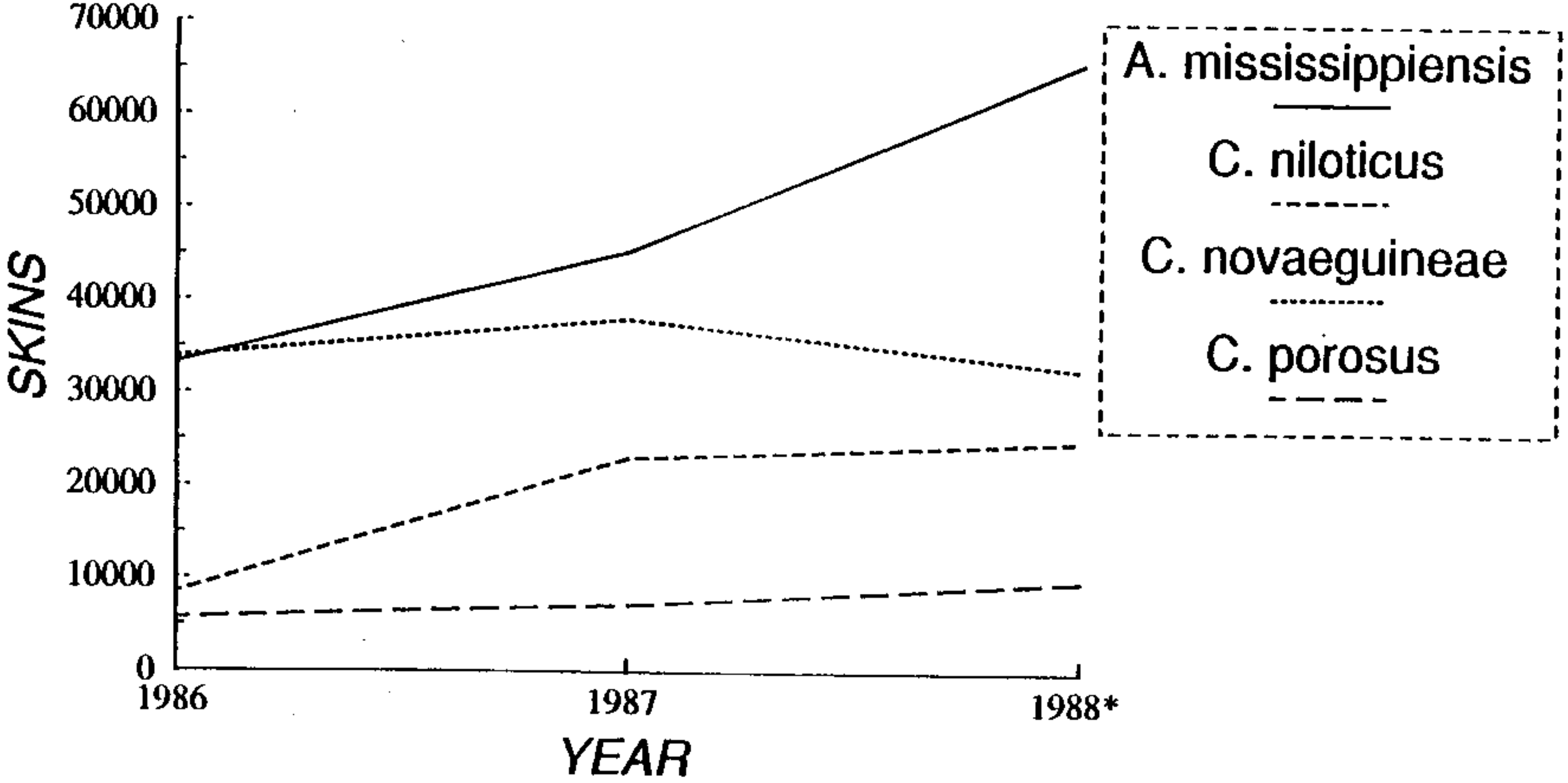
	1983	1984	1985	1986	1987	1988+	Total
<u>A. mississippiensis</u>*	20069	21519	20718	33278	45184	51637	192405
<u>C. acutus</u>	559	106	573	27	4	1	1270
<u>C. cataphractus</u>	7615	2030	0	0	149	1193	10987
<u>C. intermedius</u>	0	0	0	0	0	0	0
<u>C. johnstoni</u>	624	157	0	0	824	1240	2845
<u>C. niloticus</u>	28983	6115	9378	18480	22974	22420	108350
<u>C. novaeguineae</u>	27325	29156	43027	33938	37890	26287	197623
<u>C. palustris</u>	0	0	0	0	3	0	3
<u>C. porosus</u>	5398	5358	6497	5752	7166	9147	39318
<u>C. moreletii</u>	0	4	1	1	244	17	267
<u>C. rhombifer</u>	0	0	0	0	0	0	0
<u>C. siamensis</u>	0	800	351	605	981	7	2744
<u>G. gangeticus</u>	0	0	0	0	0	0	0
<u>T. schlegelii</u>	0	0	0	0	0	0	0
Total	90573	65245	80545	92081	115419	111949	555812

* gross exports from the USA
\+ incomplete data

Source: "World Trade in Classic Crocodilian Skins, 1984-1987"/IACTS; 1988 CITES Annual Reports

Compiled by TRAFFIC(USA)
April 1990

Minimum Net Trade in Classic Crocodilian Skins
1986-1988



Source: "World Trade in Classic Crocodilian Skins, 1984-1987"/IACTS; 1988 CITES Annual Reports

* Incomplete Data
Compiled by TRAFFIC(USA)
April 1990

MINIMUM NET EXPORTS OF *Caiman* SKINS FROM RANGE COUNTRIES

COUNTRY	1987	1988
ARGENTINA	80875 1505 kg	25830
BOLIVIA	2029	99061 413 kg
COLOMBIA	7765	14040
COSTA RICA	1998	0
GUYANA	44310	37513
HONDURAS	4036	15255
MEXICO	1	0
NICARAGUA	8	0
PANAMA	18761	0
VENEZUELA	80019 300 kg 16500 ft^2	186811
TOTALS	239802 1805 kg 16500 ft^2	378510 413 kg

Source: CITES Annual Reports

Compiled by TRAFFIC(USA)
April, 1990

UPDATE ON REGULATIONS:
How International Rules are Changing

Presented by Dietrich Jeldon

In 1975, when the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) entered into force, for the first time all 23 species of crocodilians were afforded some legal protection by means of worldwide trade regulations or trade restrictions.

Originally, CITES listed 18 taxa in Appendix I and 9 taxa in Appendix II. At that time, Appendix I crocodilians were classified as species threated with extinction and are prohibited from commercial trade. Appendix II crocodilians could have been commercially trade under a CITES "licensing" system.

Over the years, CITES has undergone a evolutionary process in regard to the rationale on crocodilian utilization. This is an encouraging sign for CITES since it shows that CITES, in some ways, is quite able to adjust to changing political circumstances.

In chronological order, the following is a brief summary of the CITES evolution on crocodilian utilization and trade in their products.

1) Some species have been downlisted from Appendix I to II (Alligator mississippiensis) and other species or particular populations have been uplisted from Appendix II to I (Crocodylus acutus and C. porosus). Specific criteria, also called the "Berne Criteria," have to be fulfilled for such transfers and were described in two resolutions (Resolutions Conf. 1.1 and 1.2) adopted at the first meeting of the Conference of the Parties (COP) of CITES in 1977.

2) At the second meeting of the COP in Costa Rica (1979), the so-called "farming" resolution, Resolution Conf. 2.12, was adopted regulating the commercial trade of captive-bred Appendix I crocodilians as well as other non-crocodilan taxa and included marking, F-2 generation requirements, etc. This resolution was followed by other resolutions at other COPs (Resolution Conf. 4.15, 6.21, and 7.10) defining the control of captive-breeding operations (registration), criteria to be met for new operations, etc.

3) The parties at the third COP held in New Delhi adopted the "ranching" resolution (Resolution Conf. 3.15) that later permitted countries such as Zimbabwe, Australia and just recently, Botswana, Malawi, Mozambique, and Zambia, to submit proposals to downlist their crocodile populations from Appendix I to II.

4) In 1985, the parties at the fifth COP in Botswana adopted a "cropping" resolution (Resolution Conf. 5.21) allowing specific criteria such as status reports and management programs (in some respects, I believe that these were questionable critiera) to transfer several African crocodile populations from Appendix I to Appendix II. At the same COP, basic requirements for a uniform marking system were introduced (country code, identification number, year, etc).

5) Last year at the seventh COP, the parties adopted further resolutions affecting crocodilians and their trade:

* Resolution Conf. 7.14 replaces the "cropping" resolution by thoroughly revising the old resolution (Resolution Conf. 5.21) such as permitting no reservation on a species downlisted under the resolution, requiring a documented management surveys and status reports, etc.

* Resolution Conf. 7.12 recommends, for the first time, the marking of live captive-bred and high-value Appendix I species such as a trial marking system using codes microchips in specimens of *Gavialis gangeticus*.

All of the above mentioned resolutions can be obtained by contacting the IUCN/SSC Trade Specialist Group, 1725 DeSales Street NW, Suite 500, Washington, DC, 20036, USA.

CSG/April 1990

ILLEGAL TRADE IN CROCODILIAN SKINS: CURRENT PROBLEM AREAS

Presented by
Ginette Hemley
CSG Vice Chairman for Trade Monitoring

The rapidly-growing international trade in crocodilian skins has presented a mixed picture of illegal trade over the last three to five years. The increasing trade in ranched and farmed skins has brought with it a growing body of regulations aimed at controlled harvest and export, while at the same time indicating an overall deregulation of trade. The capacity to enforce and monitor the expanding movement of skins has generally improved in the principal consuming regions of the European Community, Japan, and the USA, while remaining woefully weak in most of the producer regions. Singapore, an entrepot country and well-established trade and smuggling center, continues to undercut worldwide enforcement efforts by maintaining CITES reservations on three species, Crocodylus porosus, Crocodylus novaeguineae novaeguineae, and Caiman crocodilus. Consumer markets are expanding rapidly in the Far East, notably in countries that are not party to CITES such as Taiwan and South Korea.

On a regional basis, the following summaries note areas of importance with regard to current illegal trade:

Southeast Asia: Probably the most urgent problem with regard to trade in classic crocodilian skins involves the smuggling of C. porosus and C. novaeguineae from Indonesia to Singapore. Well-entrenched trade channels and Singapore's policy of non-compliance with CITES have made this the biggest "black hole" in the classic skin market. Current estimates of illegal trade, based on customs statistics and field reports, indicate that at least 10-15,000 skins are moving from Indonesia to Singapore annually, with a number of them eventually ending up in the Japanese market. Indonesia has recently made important moves to stop the illegal flow by officially banning all reptile skin trade with Singapore, apparently causing Singaporean traders to begin expanding their operations to neighboring countries like Papua New Guinea. Until Singapore withdraws its CITES reservations, this problem is likely to continue and will greatly undercut Indonesia's burgeoning crocodile management program.

Singapore has also beenlinked to recent extensiv illegal trade in caiman skins.

Thailand has recently developed into a major smuggling center for Caiman crocodilus from South America, primarily from Brazil and

Paraguay. It is estimated that at least 750,000 caiman skins were imported to Thailand in 1988 (Luxmoore, pers. comm.); the trade has apparently comntinued in 1989. Customs statistics suggest that a number of these eventually ended up on the Japanese market, while the export from Thailand to the US of manufactured caiman products has picked up markedly. Thailand is a party to CITES but lacks legislation to implement the Convention.

Japan: Japan has made important progress in the last three years in tightening import trade controls, including the removal of its CITES reservation on C. porosus in late 1989. However, continuing strong trade from Singapore (up as much as 40 percent from 1988 to 1989) and Thailand are cause for concern.

Africa: Trade controls for export of Nile crocodile from Africa to Europe have improved notably since 1984 when France and Italy dropped their CITES reservation on the species. While there do not appear to be significant problems in this trade, a number of African countries still fail to meet their CITES reporting requirements.

South America: Brazil and Paraguay continue to serve as the major centers for illegal caiman export out of the region; both countries ban exports of virtually all wildlife. Progress has been made in Colombia and Venezuela to tighten export controls; while so-called "stockpiled" skins continue to be exported from Argentina.

Mexico: Mexico remains the only country in Latin America not yet party to CITES. Well-established leather working centers and close economic ties to both the US and the EC via Spain continue to make this country an important skin "laundering" center for crocodilian skins, primarily caiman.

USA: With the booming export trade of both alligator skins and meat have come increasing reports of abuse and smuggling attempts; however, these problems are thus far largely undocumented and do not yet appear to be significant.

CSG/April 1990

ILLEGAL TRADE IN CROCODILIAN SKINS: CURRENT PROBLEM AREAS

Current Trends in US Commercial Imports of Crocodilian Hides and Products

Presented by Peter Brazaitis
Curator in Charge, Central Park Zoo

Caiman crocodilus yacare, the yacare caiman, continues to dominate as the species most imported into the United States as manufactured products, despite the fact that the species is listed as endangered under the U.S. Endangered Species Act. The race is found primarily in Brazil, Bolivia, and Paraguay where either hunting or export is banned.

Tanned as well as raw skins of yacare and *Caiman latirostris*, the broad-snouted caiman, have been smuggled in large numbers through Colombia to southeast Asia and to the United States. Tens of thousands of yacare shoes are imported directly from southeast Asia or the same shoes and styles are imported from Italy witn Italian labels. Products are often made of poorly or barely tanned skins and are misleadingly labeled "genuine alligator" or "genuine crocodile" and are sold often at the same prices as genuine alligator and crocodile. Elimination of skin tagging and marking prior to tanning and product manufacture aids illegal trade and hanpers wildlife law enforcement.

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MONITORING TOOLS: HOW FAR DO WE GO?
Education of the U.S. Consumer

Presented by Don Ashley
Ashley Associates, Inc.

In 1988, A cooperative alligator point-of-sale marketing research project was started in the U.S. to evaluate the effectiveness of distributing information and promotional material to tanners, manufacturers, and retailers about alligators and alligator products. About 1,000 Alligator Booklets were distributed throughout the industry and on-site evaluations at more than 50 retail stores were made in New York, Dallas, New Orleans, Orlando, and Miami. The primary goal was to reach retail sales clerks who are in daily contact with potential customers for alligator products and to better inform them about:

1) the availability of classic American alligator products;
2) the regulated wildlife management and farm programs that control the harvesting, processing, and distribution of alligator products;
3) the natural history of the reptile and the unique conservation success story it represents through management and utilization of a renewable natural resource.

Based on the significant support and response of manufacturers,retailers, and other producers in the industry, an updated version of the Alligator Booklet was produced in 1989 and is currently being distributed to all major U.S. markets for alligator products. In addition to the original, its emphasis was on the fact that alligator products were:

1) legal;
2) not endangered;
3) subject to numerous state, federal, and international regulations requiring tagging and annual reporting;
4) farm-raised or the product of a government regulated harvest of a renewable resource;
5) an economic incentive to manage and conserve both the species and its habitat;
6) quality products with long lasting value.

The current project is distributing 5,000 free copies of the updated Alligator Booklet in the US and making another 5,000 copies available at printing cost to tanners, manufacturers, and retailers who want to provide booklets directly to customers who pruchase or might purchase an alligator product. In addition to doubling participation by manufacturers in the second edition of the booklet, additional information was included as a result of the initial survey that incldued new information on:

1) leather;
2) differences between alligator and crocodile;
3) creative new products.

The next phase of the alligaotor point-of-sale project will be to design individual product tags that will provide key information to the customer on alligator management and marketing programs. Also, an international edition of the booklet is planned which includes information on all four of the primary classic crocodilian skins in trade. The international edition will be in five languages and distributed first in France, Italy, England, Germany, Japan and the US as well as in all hide producing countries.

The best long-term marketing strategy for crocodilian products is to first produce the highest quality products and then have the best ifnformed sales force at retail. Over time, the reputation of the classic product is enhanced and the public is better informed about the concept of managing crocodilians as renewable natural resources. The economic incentive to manage and market crocodilians can enhance efforts to conserve both the species and its habitat. Contrary to many animal rights arguments--this is real conservation. That is an important part of the message as consumers become more environmentally aware in the future. A point-of-sale marketing project is a useful first step toward these goals.

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AUSTRALIAN CROCODILIAN FARM SKIN PRODUCTION
1988-1989

Presented by John Bache
President, Australia Crocodile Farmers Association

	1988 SW	1988 FW	1988 Total	1989 SW	1989 FW	1989 Total	%Variance
HATCHLINGS							
Wild Harvest	2753*	1812	4565	3470+	5195**	8665	+89.81
Farm Bred	3586*	371	3957	5017+	501	5518	+39.45
TOTAL	6339*	2183	8522	8487+	5696	14183	+66.42
SKIN SALES++							
	1229	1008	2237	1328	518	1846	-17.48

NOTES:

SW - <u>Crocodylus porosus</u>
FW - <u>C. johnstoni</u>

* Covers 1987/1988 nesting season
\+ Covers 1988/1989 nesting season
** Includes Australian wild harvest in Western Australia
++ Includes export and domestic skin sales

PAPUA NEW GUINEA CROCODILIAN SKIN PRODUCTION 1988-1989

Presented by
Greg Mitchell
Mainland Holdings Ltd.

		1988	1989
C. novaeguineae			
Live purchases (hatchlings/yearlings)		5967	4875
Egg production	WILD	850	1299
	FARM	-	-
Skin production	WILD	12001	14415
	FARM	5204	7684
TOTAL		24022	28273
C. porosus			
Live purchases (hatchlings/yearlings)		4375	3235
Egg production	WILD	647	1198
	FARM	1500	2500
Skin production	WILD	3176	3857
	FARM	2286	3065
TOTAL		11984	13855

Total farm stock in Papua New Guinea by the end of 1990 is estimated to be approximately 42,500 head.

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AFRICAN NILE CROCODILE SKIN PRODUCTION
1990-1991

Presented by
Jon Hutton
CSG Vice Chairman for Africa

At the 1989 CITES meeting, Zimbabwe, hitherto the only African country with a CITES approved ranching program, was joined by Botswana, Malawi, Mozambique, and Zambia which received approval for their ranching programs. In addition, Ethiopia obtained a CITES export quota for ranched skins for the first time while Kenya and Mozambique obtained a second round of export quotas for ranched skins only. Only Somalia, Sudan, and Tanzania received export quotas for wild skins, Sudan's only for one year to clear stocks.

Production of ranched skins is, accordingly, expected to increase, while wild skins decline markedly.

Unfortunately, export quotas give little indication of what may actually be produced. The following schedule is advanced as a tentative prediction for exports from Africa in 1990 and 1991.

PRODUCTION OF NILE CROCODILE SKINS IN AFRICA
1990-1991

	Farm/Ranch		Wild	
Country	1990	1991	1990	1991
Botswana	2000	1000	0	0
Ethiopia	2600	3200	0	0
Kenya	2500	2500	0	0
Madagascar	0	300	0	0
Malawi	2000	2000	250	250
Mozambique	300	1000	0	0
Namibia	0	200	0	0
South Africa	4000	8000	0	0
Somalia	0	0	0	500
Sudan	0	0	5000	0
Tanzania	0	0	1000	1000
Zambia	3000	3000	0	0
Zimbabwe	20000	28000	0	0
TOTAL	34900	48700	6250	1750

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EXPORT QUOTAS FOR CROCODILIANS AGREED UPON AT THE SEVENTH MEETING OF THE CONFERENCE OF THE PARTIES TO CITES

	1989	1990	1991	1992
Crocodylus cataphractus				
Congo	600 w	600 w	600 w	600 w
Crocodylus niloticus				
Cameroon	100 w	0	0	0
Congo	150 w	0	0	0
Ethiopia		9300 r*	8800 r*	8800 r*
		20 w	20 w	20 w
		50 t	50 t	50 t
Kenya	4000 r	5000 r	6000 r	8000 r
	1000 w			
Madagascar	1000 w			
		0	2000 r	4000 r
Somalia		500	500	500
Sudan	5000 w	5040 w	0	0
Tanzania	2000 w	1000 w	1000 w	0
			4000 r	6000 r
		100 t	100 t	100 t
Crocodylus porosus				
Indonesia	4000 w	3000 w	3000 w	2500 w
		2000 r	3000 r	5000 r
Osteolaemus tetraspis				
Congo	500 w	0	0	0

r = ranched specimens
w = wild harvest
t = hunting trophies
* = including 2500 live hatchlings

Source: TRAFFIC Bulletin 11(2/3) [March 1990]

ALLIGATOR FARM PRODUCTION IN THE UNITED STATES
1989–1990

Presented by Ted Joanen
CSG Vice Chairman for North America

Farmed-raised skins did not enter the Louisiana program until 1984. That year approximately 2,000 farm-raised skins were sold. The average size of all farm-raised skins sold in Louisiana since 1984 measured was 4 foot, 4 inches (N=69,944) with a range of 3 to 6 feet. Most of the Louisiana farm-raised alligators reached marketable size in less than two years of age. Louisiana's 1989 farm production is estimated at 50,000 skins along with a 25,000 wild skin harvest. Louisiana state harvest from both farm and wild accounted for 77 percent of the U.S. alligator skin production. The economic value of the wild and farm harvest to the state amounts to about $18 million annually.

Alligator farm production in other states such as Florida and Texas is expected to increase in the near future. The 1989 farm skin production from Florida farms was 16,389. These skins averaged 4 to 5 feet long.

Texas has just approximated an egg collection program. In 1988 approximately 2,000 hatchlings were sold to Flordia farms. Skin production on Texas farms will enter the market for the first time in 1990.

<u>*Alligator mississippiensis*</u> SKIN PRODUCTION
1988–1990

		1988	1989	1990(est)
Louisiana	FARM	16,500	50,000	75,000
	WILD	23,000	25,000	25,000
Florida	FARM	7,500	16,400	25,000
	WILD	7,400	8,000	10,000
Texas	FARM	0	20	-
	WILD	1,600	1,800	-
South Carolina	WILD	350	275	-
TOTAL		56,350	101,495	135,000

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MARKET PRODUCTION AND THE IACTS REVIEW

Presented by Don Ashley
Ashley Associates, Inc.

Since 1987, the goal of the International Alligator/Crocodile Trade Study (IACTS) project has been "to obtain a better understanding on international classic crocodilian trade and evaluate its effect on the management and conservation of crocodilian resources." Through an annual report compiling CITES trade statistics and information from regional cooperators, and hide dealers, IACTS provides a yearly trade analysis on past, present, and future classic skin trade.

In the 1989 IACTS annual report, minimun net trade in classic skins was 115,491 hides based on 1987 CITES Annual reports. No CITES report was received that year from Indonesia and the volume of that unreported trade is estimated to be 30,000-40,000 classic skins. These estimates coincide with hide dealers information that total classic skin trade is approximately 150,000 hides a year. This level of trade remains at about half of the estimated trade twenty years ago (300,000) and about one-third of the peak trade in the early 1960's which may have reached 500,000 skins a year.

The number of classic skins in world trade will increase significantly in 1990 to more than 200,000 skins per year. And a further increase to about 300,000 hides is expected in 1991, returning world trade production to the estimated 1970 levels. The increase is due almost entirely to expanded production of farmed and ranched skins. After 1991 the rate of expansion in classic skin production will moderate to 25,000 to 50,000 each year and would return to the early 60s levels of estimated production of 500,000 between 1995 and the year 2000.

Based on these findings, the IACTS panel recommends:

1) All crocodilian skins should be tagged.
2) Indonesia should improve its hide tagging and CITES reporting system.
3) Japan and Singapore should drop their CITES reservation on *Crocodylus porosus*. (Note: Japan dropped its reservation in late 1989.)
4) Producer countries, Botswana and Sudan, should drop their reservations on *C. niloticus*.
5) Thailand immediately implement a hide tagging and trade reporting system.

6) Singapore should register its crocodile farms, initiate a hide tagging system, and establish a trade reporting procedure for crocodilian skins.

7) CITES export quotas should only be approved when adequate crocodile mangement plans (including habitat survey and population monitoring components), have been established.

8) Strict enforcement of managed wild harvest regulations should be implemented to better protect wild stocks.

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TABLE 1

ESTIMATED NUMBER OF CLASSIC CROCODILIAN SKINS IN WORLD TRADE IN 1989

By Species:

A. mississippiensis	45,000
C. niloticus	23,000
C. novaeguineae	65,000
C. porosus	15,000
C. johnstoni	1,000
Other	1,000
TOTAL	150,000

By Region:

United States	45,000
Africa	23,000
Papua New Guinea	45,000
Australia	2,000
Indonesia	34,000
Other	1,000
TOTAL	150,000

TABLE 2

ESTIMATED NUMBER OF CLASSIC CROCODILIAN HATCHLINGS STOCKED IN 1988

By Species:	CAPTIVE	RANCHED	SUBTOTAL
A. mississippiensis	15,000	90,000	105,000
C. niloticus	10,000	38,000	48,000 *
C. novaeguineae	–	26,000	26,000
C. porosus	1,500	13,500	15,000
C. johnstoni	250	3,000	3,250
Other	1,750	1,000	2,750
TOTAL	28,500	171,500	200,000

* The estimated number of C. niloticus hatchlings may be conservative due to uncertain collection, hatchling and mortality rates in several African countries.

By Region:	CAPTIVE	RANCHED	SUBTOTAL
United States	15,000	90,000	105,000
Africa	10,000	38,000	48,000 *
Papua New Guinea	1,000	20,000	21,000
Australia	750	5,500	6,250
Indonesia	–	17,000	17,000
Other	1,750	1,000	2,750
TOTAL	28,500	171,500	200,000

TABLE 3

ESTIMATED NUMBER OF WILD HARVESTED CLASSIC CROCODILIAN SKINS IN 1989

United States	
Alligator	30,000
Africa	
Nile crocodile	12,000
Papua New Guinea	
Freshwater and Saltwater crocodile	24,000
Indonesia	
Freshwater and Saltwater crocodiles	24,000
TOTAL	90,000

TABLE 4

TRADE FORECAST IN CLASSIC SKINS

YEAR	TOTAL TRADE	ALLIGATOR	CROCODILE
1990	200,000-250,000	100,000-125,000	100,000-125,000
1991	250,000-300,000	125,000-150,000	125,000-150,000
1992	300,000-350,000	150,000-175,000	150,000-175,000

Projected increases in classic hatchling and skin supplies beyond 1992 is more difficult because of variables like farm expansion, hatching success, nest flooding, farm failures, mortality rates and international regulations. However, if market demand and hide prices do not become a disincentive after the 300,000 hide annual production plateau is reached, then supplies will continue to increase at 25,000 to 50,000 additional classic skins a year through the 1990's. The earliest 500,000 classic hides a year would be produced is 1995 and the longer view would be by the year 2000 to reach a half million classic skins annually.

GLOBAL MARKET PERSPECTIVES: JAPANESE MARKET IMPLICATIONS OF SPECIES AND SIZE CLASS CHANGES IN THE CROCODILIAN TRADE

Presented by Noboru Ishii
Takara Tsusho Co. Ltd.

Total imports of classic crocodilian skins

All kinds of classic crocodilian skins are imported into Japan. The total value imported in 1989 for classic crocodilia skins and hides was about $US 16 million. Among these, 84 percent or about $US 13.5 million) were wet salted raw skins. This figure excludes skins of *Caiman crocodilus*.

Market share by species

The largest quantities imported into Japan in 1989 among classic crocodilian skins were of *Crocodylus novaeguineae novaeguineae* (*C. n. novaeguineae*), which is also called the "large scale crocodile." These comprised about 60 to 65 percent of total imports.

The second largest quantities s after *C. n. novaeguineae* have been *Crocodylus porosus*, also called "small scale crocodile." These comprised about 15 percent of all imports in 1989.

The third largest quantities imported were of *Alligator mississippiensis* (American alligator), which comprised about 15 percent of all imports.

The fourth species imported was *Crocodylus niloticus* (Nile crocodile), comprising about 5 to 6 percent of the 1989 imports.

Market share by producing countries

In 1989, the largest share of classic crocodilian skins came from Singapore, which supplied about 39 percent of total raw crocodile skins imported in Japan. The second country was Papua New Guinea, which supplied 20 percent. The third largest supplying country was the United States with 15 percent, while the fourth country was Indonesia, which supplied 9 percent of all skins imported to Japan.

In 1988, Papua New Guinea was the leading supplier of skins to Japan, with 34 percent of the market. This was followed by Singapore with 28 percent, and the USA with about 15 percent.

Farmed skin vs. wild skin supplies

In terms of demand and the use of farmed skins versus wild skins, in general, the following points should be considered:

Wild skins	*	expecting less supply in coming years
	*	variety of sizes (larger)
	*	higher price than farmed
	*	not dependable for stable manufacturing schedule
	*	image not so preferable in terms of conservation
Farmed skin	*	stable and sufficient supply
	*	stable price
	*	limited size selection
	*	major supply source for future business
	*	legal image

Both wild and farmed skins each have advantages, and the demand for both types varies depending on fashion and customer's needs.

However, it is increasingly difficult to get sufficient supplies of wild skins, and it is expected that fewer and fewer wild skins will be available in coming years to meet demand. In addition, higher prices are expected. It is likely that customers (manufacturers) will be considering more utilization of farmed skins in the future.

World production vs. demand

Considering current total worldwide production of classic crocodilians at approximately 150,000 skins (according to IACTS), Japan imports about 50 percent of world production as raw materials.

Besides raw materials, there are huge numbers of manufactured leather goods made from classic crocodilian skins which are imported into Japan primarily from European countries, particularly Italy, France, and F.R. Germany.

In addition to this, large volumes of finished leather goods are purchased by Japanese tourists visiting Europe.

In conclusion, we estimate that approximately 70 percent of total world production of classic crocodilian skins are currently taken by the demand of Japan. In other words, the present market of classic crocodilian skins is very much dependent on a single market.

We consider this is not a particularly healthly situation for the crocodilian industry. Although we hope and will try our best to keep our Japanese market steady in growth in coming years, we have to avoid the market being damaged by any extreme marketing changes or movements by external forces such as animal rights activists.

It is important to note that Japanese consumers are becoming increasingly sensitive and concerned about natural environment and the conservation of natural resources.

With this in mind, we consider it very important for all parties concerned with the crocodile industry, including both producing and consuming nations, to work together not only in Japan but worldwide on positive promotional efforts aimed at educating the consumer that buying crocodilian products helps conservaton of crocodiles and natural resources.

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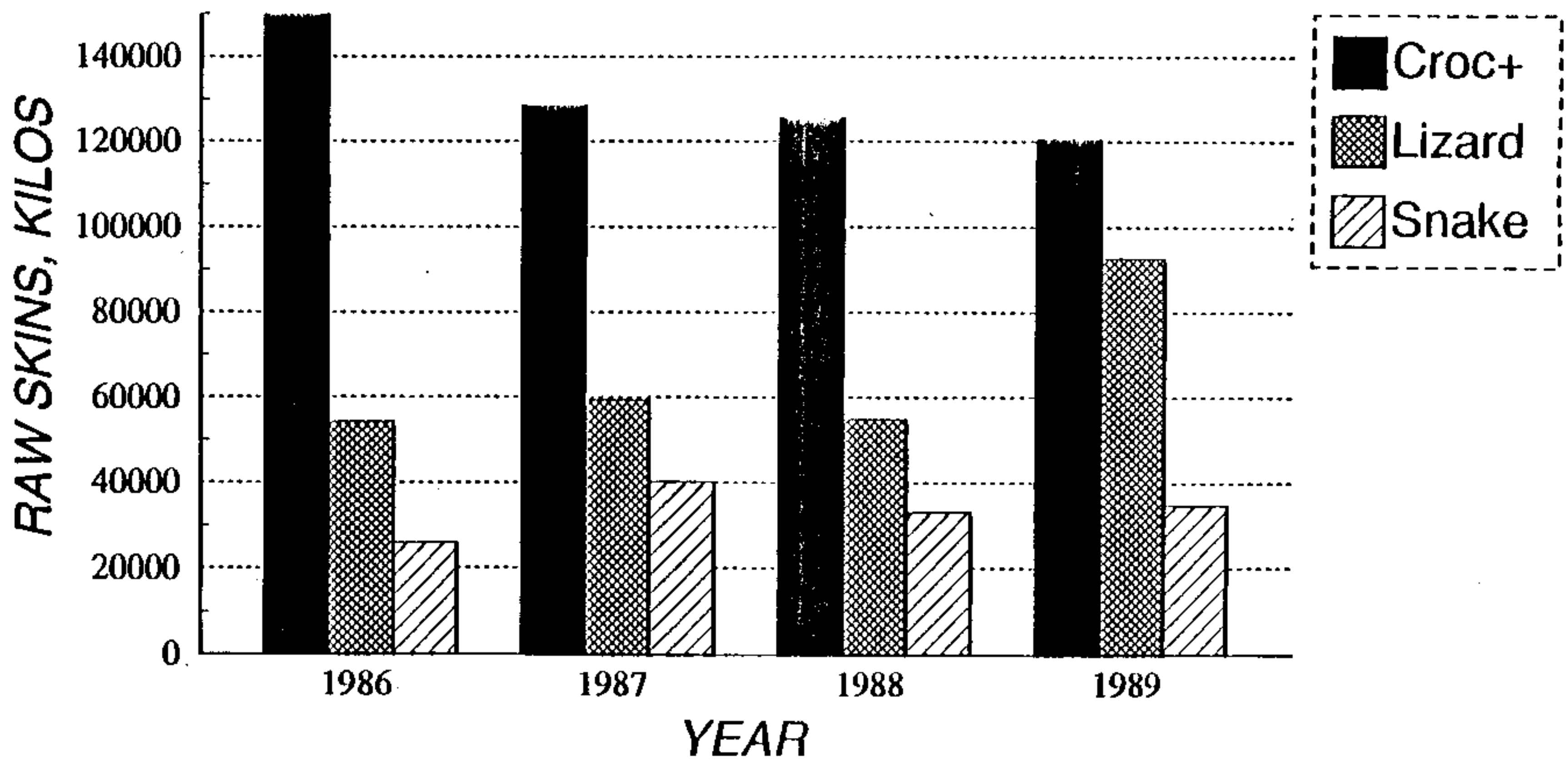
JAPANESE IMPORT OF REPTILE SKINS
1986-1989

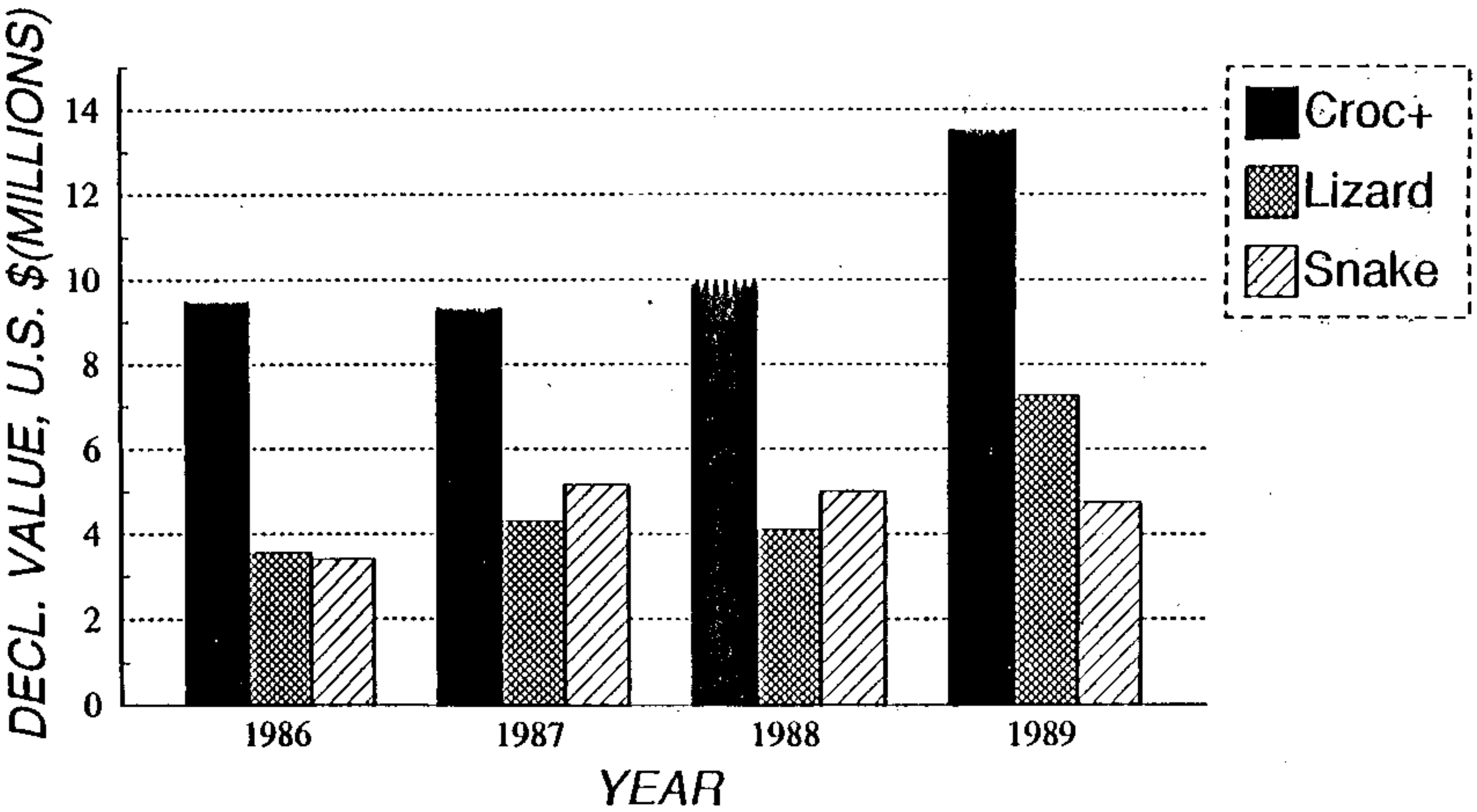


Source: Japanese customs statistics

Compiled by TRAFFIC(USA), April 1990

+ Includes crocodile, alligator and some caiman.
As much as 1/3 weight may be packing salt.

JAPANESE IMPORT OF REPTILE SKINS
1986-1989



Source: Japanese customs statistics

+ Includes crocodile, alligator and some caiman.

Compiled by TRAFFIC(USA), April 1990

GLOBAL MARKET PERSPECTIVES: EUROPEAN MARKET IMPLICATIONS OF SPECIES AND SIZE CLASS CHANGES IN THE CROCODILIAN TRADE

Presented by Kevin van Jaarsveldt
CSG Vice Chairman for Trade
on behalf of
Deputy Vice Chairman Philippe Roggwiller

Skin Sizes

18-24 cm A small market exists for very expensive small leather goods and to some extent watchstraps. Recent discussions with leading watchstrap manufacturers indicate that prices are too high by 50 percent.

25-29 cm This size range is increasing considerably in the market, as farmers try to market smaller skins to combat the higher feeding costs and accomodation problems associated with raising larger animals.

The increased number of skins of this size in the market make finished goods very expensive, as two skins are needed to manufacture a woman's handbag whereas only one skin is needed when larger sizes are used.

30-33 cm These size skins are normally included in the 25 -29 cm range, and although better, are often a small percentage of parcels.

34-40 cm There are not enough of these skins in the marketplace; they do demand a higher price.

40+ & UP These sizes are almost completely out of the marketplace, with the exception of those from wild alligators.

RECOMMENDATION: Farmed production of crocodilian skins should attempt to attend to the full range of required skins, 18 to 55 cm, and not to concentrate primarily on the 25 to 33 cm size range.

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GLOBAL MARKET PERSPECTIVES:
U.S. MARKET IMPLICATIONS OF SPECIES AND SIZE CLASS CHANGES IN THE CROCODILIAN TRADE

Presented by David Haire

U.S. trends in the use of crocodilian skin in the last 20 years have taken numerous bends and turns. During the first five to six years, the western wear industry utilized crocodilian skins, historically focusing on 7 foot animals. Later, the industry turned its focus toward the more readily available wild American alligators and less toward the more regulated and less available other crocodilians. But as prices soared for alligators and other crocodilians and competition for larger skins has increased worldwide, the industry substituted other exotic skins in the last few years.

Yet crocodilian skins are still used in the U.S. skin industry if only a on small-scale. The smaller skins are being used by a growing number of skilled leather craftsman producing classic crocodilian handbags and flat goods. And the skin industry uses farmed skins as well but higher prices, excess scarring, and bacterial damage foound in some farmed skins has limited their growth in the industry.

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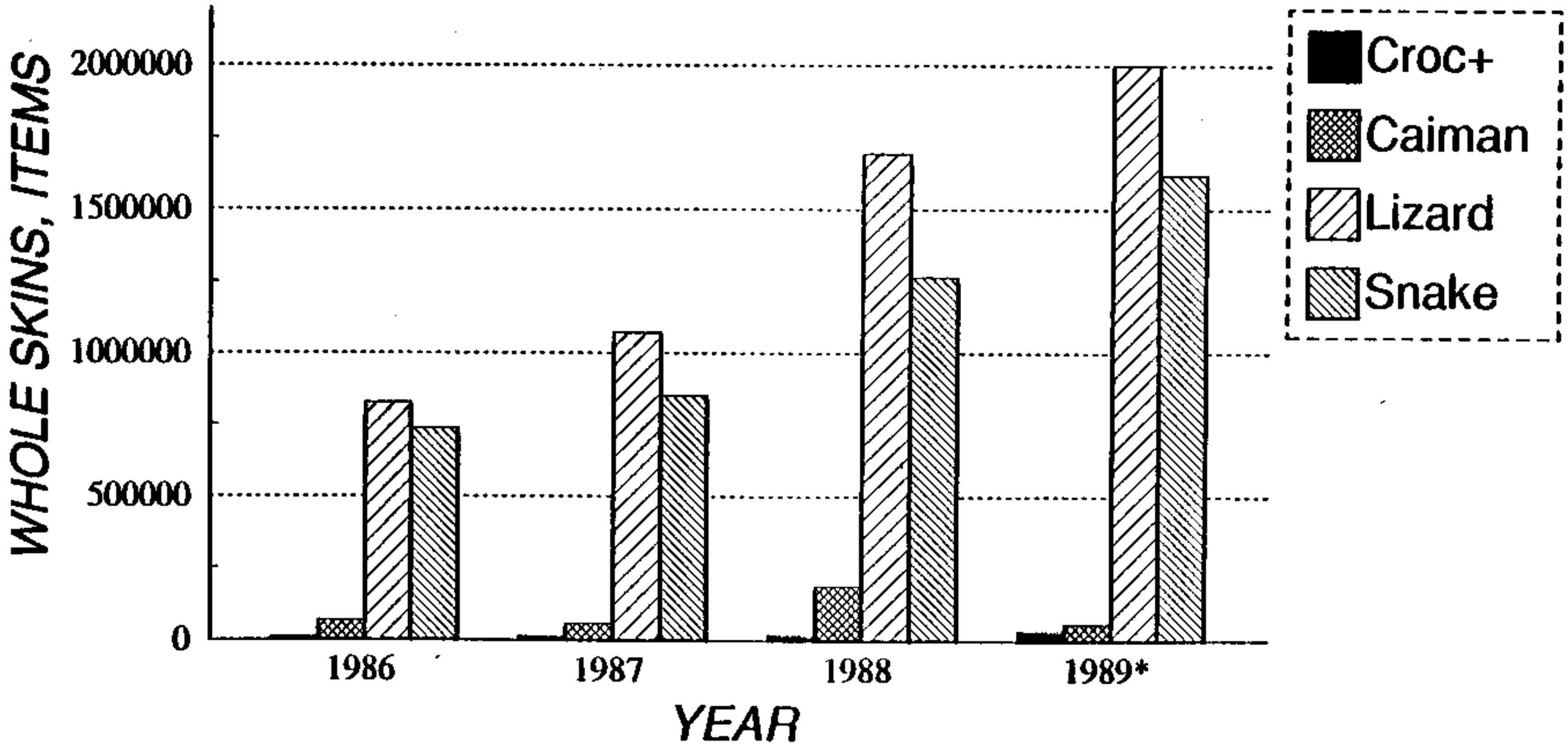
U.S. IMPORT OF REPTILE SKINS
1986-1989



Source: U.S. Fish and Wildlife Service
Computerized Import/Export Data
Compiled by TRAFFIC(USA), April 1990

* Incomplete Data
\+ Includes All Crocs except Caiman crocodilus

THE TRADE IN OTHER EXOTICS: THEIR EFFECT ON THE CROCODILIAN MARKET
Lizard, Snake, and Shark

Presented by Toshio Yamanaka
Deputy Vice Chairman for Trade of CSG

The state of the market for lizard skins in Japan in 1989 greatly expanded compared to the previous year. The total value was approximately 1.9 times that of 1988's figure according to Japanese custom statistics. Some of this may be explained by producing countries' price increases during that period. For example, the price of ring-marked lizard (Varanus salvator) skins increased from $7 per skin in January 1989 to $9 in December and is now about $10 per skin.

Nearly 60 percent of lizard skins, the core of the Japanese reptile skin industry, came from Indonesia during 1989.

The Japanese reptile skin industry would like to see the downlisting of two Appendix I species of lizards, Bengal monitor (V. bengalensis) and yellow monitor (V. flavescens). From a conservation point of view, this industry believes that such a downlisting could be beneficial in that it would lessen the trade on V. salvator.

The Japanese reptile skin industry believes that the Japanese government is now preparing to cooperate with the Bangladesh government and provide funding for additional investigation into the populations, habitats, ecology, and biology of these two varanids. With these data, the Bangladesh CITES management authority should be able to determine if the these two species should be downlisted to Appendix II.

Python skin trade is relatively stable in Japan, selling at constant prices at a moderate market demand. Python skins are used primarily for more casual woman's handbags for the younger consumer.

While shark skins are not produced in great quantities in Japan, these skins are extremely popular for use in handbags for the Japanese market while they are used mainly for watchstraps in the European market.

Sharks are a secondary catch of the Japanese tuna fishery and are usually taken only when tuna are not available, so there is not a constant supply of skins. Finished shark skins available in Japan have an estimated value of about $100,000 monthly, for both the domestic and foreign market.

In conclusion, the three types of skins mentioned above -- lizard, snake, and shark -- generally do not affect the crocodilian market at all because the price structures are different and the classes of consumers vary according to income rate. The Japanese reptile skin industry believes that crocodilian skins and these three other exotics are fully compatible in the marketplace.

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THE TRADE IN OTHER EXOTICS:
THEIR EFFECT ON THE CROCODILIAN MARKET
Ostrich and Elephant

Presented by Kevin van Jaarsveldt
CSG Vice Chairman for Trade

At a time when significant growth in crocodilian farming activities is increasing production, what is happening with other exotics?

Ostrich

Currently 100 percent of all ostrich skin trade is controlled by South African farmers through their co-op in Outshoorn and major shareholding in a Botswana tannery.

Klein Karoo Landbou Coporasi (KKLK) trade is estimated at 80,000 skins per annum:

Markets	Est. Skins	Buyers/ Agents
South Africa	7,000	-
USA	22,000	2
Europe	30,000	4
Japan	16,000	3
Hong Kong	1,000	1
Taiwan	600	1
Singapore	1,200	1
Botswana	2,000	-
TOTAL	79,800	13

It is important to note that increased ostrich farming activities in the USA, Zimbabwe, Namibia, Boputswana, Botswana, and Tanzania could increase this figure considerably by 20,000 in 5 to 7 years.

An adult ostrich produces an average of 14 sq ft of skin.

Estimated annual production is 1,037,400 sq ft valued at $25,935,000 (based upon an avg. minimum of 13 sq ft per animal x 79,800 skins per annum x avg. finished leather price of $25 per sq ft for 70/20/10 grading).

Elephants

Although out of trade due to the recent CITES Appendix I listing, it is questionable that this leather will come back into trade in the next two to four years.

Traditional source of supply:

Producer	Animals/Annum	Est. Sq. Footage
Zimbabwe	2,500	350,000
South Africa	600	60,000
Namibia	45	4,500
TOTAL		314,500

80 kg dry salted hide = 100 sq ft leather

Until the CITES ban, estimated annual production was valued at $5,346,500 (based upon 314,500 sq ft per annum x avg. finished leather price of $17 per sq ft).

With this leather possibly back in trade in 1992, the actual numbers are difficult to predict until new CITES rules are adopted. It should be noted however that under normal annual production programs, these previous numbers could be increased and may include other countries.

Markets	Market Share	Use
USA	85%	cowboy boot manufacturers
Japan	10%	small leather goods & luggage
Europe	5%	small leather goods & luggage

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THE TRADE IN OTHER EXOTICS: THEIR EFFECT ON THE CROCODILIAN MARKET
Ostrich and Elephant Trade in the USA

Presented by Dave Durland
John G. Mahler Co.

Due to the unique character of each of these leathers there seems to be less competition for consumer dollars in the US market than you might expect.

Crocodilian and elephant leathers seem to have reached a price resistance level in the US western boot market. This price resistance on the part of the US consumer seems to have more impact on crocodilian products than competiton with other exotics.

Elephant

<u>Current Market</u>: The current elephant market is very clouded by the recent CITES ban on international trade in elephant products. However, sales of elephant products in USA are strong enough to absorb present stocks in this country.

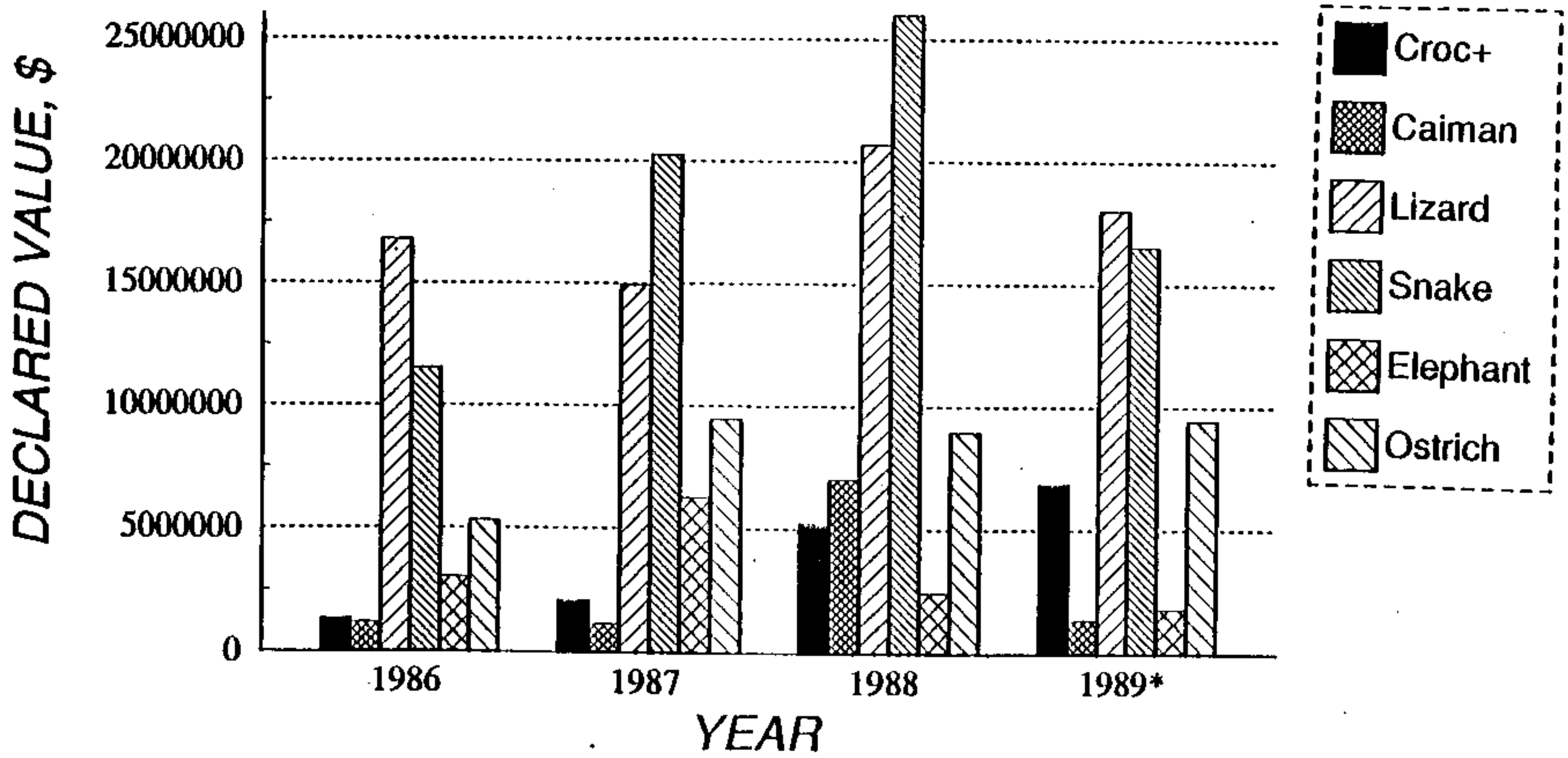
<u>Market Trends</u>: The scarcity of raw material drove prices past a level where volume business could be done in the US. When elephant leather again becomes available, once again the price will be a very important factor.

Ostrich

<u>Current Market</u>: Ostrich is still very much in demand worldwide. Supply has not yet caught up with demand. Due to the recent drought situation in South Africa, it is especially difficult now to meet market demands. Prices are advancing.

<u>Market Trends</u>: Ranching of ostriches is expanding in South Africa. Flocks are also growing in other parts of Africa, Australia, Israel, and the US. Substantial products from these newer areas are still a number of years away, however.

U.S. Declared Value of Exotic Skin Imports
1986-1989
(In 1989 Dollars)

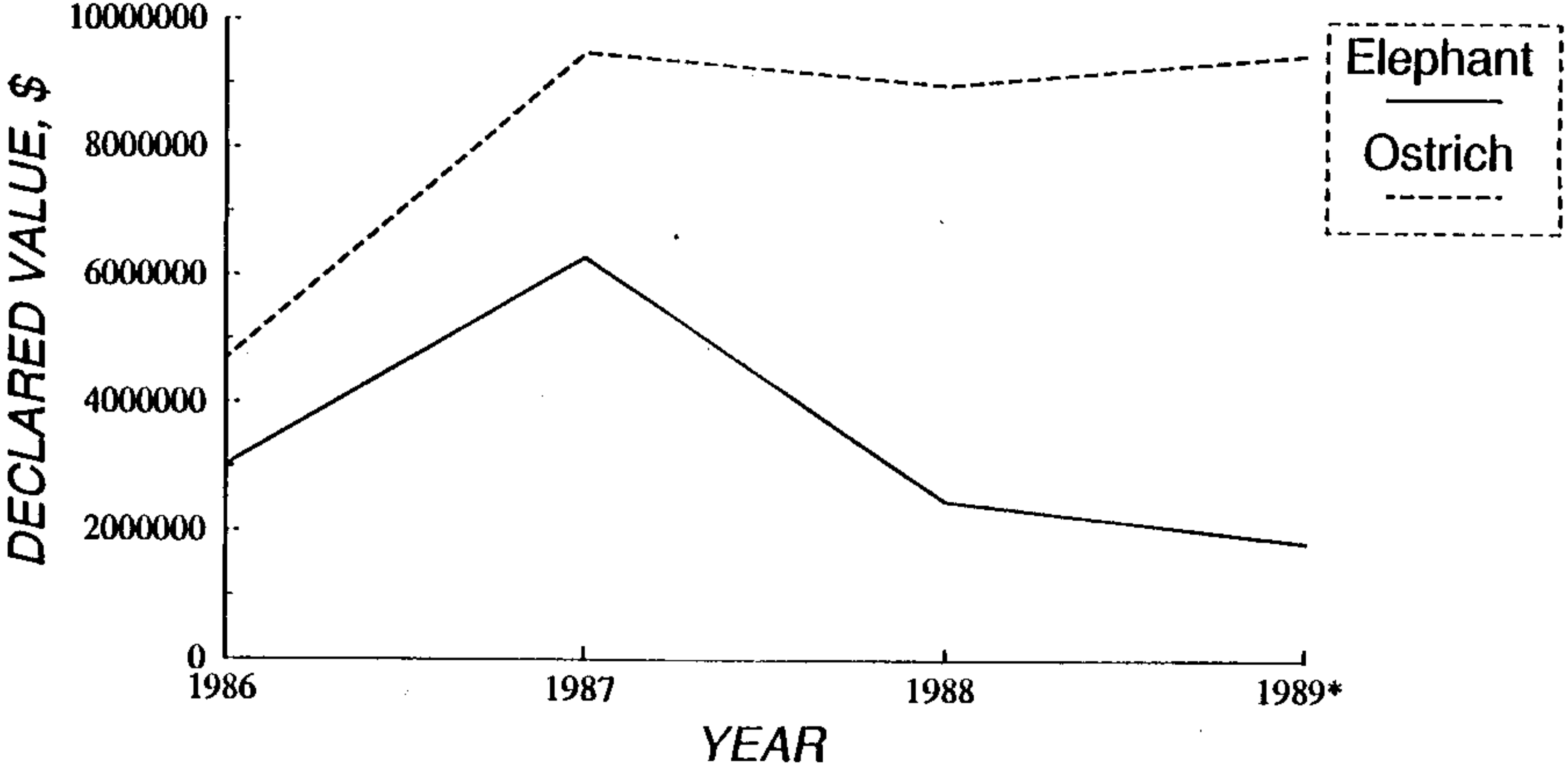


Source: U.S. Fish and Wildlife Service
Computerized Import/Export Data
Compiled by TRAFFIC(USA), April 1990

* Incomplete data
+ Includes all Crocs except Caiman crocodilus

U.S. Import of Elephant and Ostrich Skins by Declared Value, 1986-1989

(In 1989 Dollars)



Source: U.S. Fish and Wildlife Service
Computerized Import/Export Data
Compiled by TRAFFIC(USA), April 1990

* Incomplete data

INDIAN CROCODILE CONSERVATION SITUATION REPORT: ACTION PLAN FOR THE 1990's

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ABSTRACT

Since the initiation of Crocodile Conservation Project in 1975. The population of Indian Crocodilian is on an increase. Absence of suitable Action Plan has hindered in the management oriented decision making for the conservation of Indian Crocodiles. Action Plan for the conservation management of all three species of Indian Crocodiles viz. *Gavialis gangeticus, Crocodylus porosus, C. palustris* ; has been proposed with a brief discussion on the present status of each species in the country.

INTRODUCTION

Since the first meeting of the Crocodile Specialist Group that raised an alarm on the endangered status of the crocodilians in India (Honneger, 1971) and the last official status report presented in the 7th working meeting of the CSG (Singh et. al. 1986), there appears to be a sudden change, both in crocodilian conservation approach and attitudes in India. There is an "illfounded" feeling now that the Gharial (*Gavialis gangeticus*), Salt water crocodile (*Crocodylus porosus*) and the mugger (*Crocodylus palustris*) are all safe and even surplus in the country.

With over thirty six Government management crocodile rearing centres spread across the country (**Fig.1**), holding about 20,000 - 22,000 crocodiles, the feeling appears to be justified. There are even debates in the conservation circles to remove the Indian crocodilians from the schedule I list of the Wildlife (Protection) Act 1972, which now provides them total legal protection. These voices also advocate that Indian crocodilians be "commercially harvested". With no guideline or even a safe guard strategy of protection to the wild population, following such an act (harvesting) the Government has not been able to take any decision on this issue. But how safe are the Indian crocodilians in reality?

STATUS OF THE GHARIAL

The seven small isolated wild population of Gharial reported by Singh et. al. (1986), have increased many fold by re-introduction. The sub-adult size classes in protected areas have recruited into the breeding group. Increasing number of nests are now being reported from Chambal (Rao, 1988), Girwa (Basu pers. com.), Mahanadi (Kar and Singh pers. com.), with unconfirmed reports of breeding in the wild in Ramganga (Corbett National Park authorities).

The overall programme of Gharial re-introduction into the wild continues. From 1164 individuals released in 1984 to 1520 in 1986 (Choudhury and Choudhury, 1986), the number so far released stands around 2000 in 1990. While the states of Madhya Pradesh and Uttar Pradesh still continue the release programmes, there appears to be no interest by other gharial habitat states-particularly Bihar and the North-eastern states (in Brahmaputra river system). The limited number of wild habitats in the Ganges river system cannot perhaps now accommodate more Gharial. The lack of survey for locating suitable habitats has created a surplus stocks in captive rearing centres.

The situation appears even worse looking at the number of Gharials that are bred every year. Nandankanan produces over 200-250 captive bred gharial, Madras Crocodile Bank and the Kukrail Centre at Lucknow as well as Bannaghatta Zoo have also started breeding gharial. It is now expected to breed in captivity at Tikerpada, Orissa and Mysore Zoo. Where will all these go? A systematic survey of three river systems: Ganges, Brahmaputra and Indus will help locate places for all the gharial now being reared in captivity.

The Suggested Action Plan for Gharial

1. A gharial habitat survey in the Brahmaputra river system on priority basis to find suitable rehabilitation sites for the captive gharial with the objective of restoring the species to its former distributional limits.
2. Helping management authorities of Gharial Sanctuary and National Parks to draw up proper management plan.
3. Helping Gharial breeding/rearing centres to make future plans for conservation oriented stock utilisation.
4. Helping to develop 'alternate livelihood' for people who have lost right to use riverine habitats for Gharial conservation.

STATUS OF SALTWATER CROCODILE

The last two remaining habitats of the *Crocodylus porosus* in the Indian main land is now saturated with release. The Bhitarkanika Sanctuary has been restocked with over 1200 saltwater crocodile in a area of 176 sq. km. The Sundarban area may still accommodate a large number of them, unlike Andaman and Nicobar Islands where the extremely marginal esturine/mangrove habitat makes it difficult for any further reintroduction.

The man-crocodile conflict is perhaps the maximum with this species. Andaman and Nicobar Islands and Orissa, both have reported cases. With Sundarban already notorious for its man-eating tigers, another carnivore-man conflict situation cannot even be thought of.

In recent year at least four sub-adult *C. porosus* have been reported and caught in the eastern coast of India where they were known to be extinct. Does this mean, the two mainland saltwater crocodile habitat are now over crowded?

In captivity, the *porosus* now breeds in Nandankanan and Dangamal in Orissa, Vishakhapatanam in Andhra Pradesh, Madras in Tamilnadu, Bhagabatpur in West Bengal, and Kukrail in Uttar Pradesh. Where will all these go?

The Suggested Action Plan for Saltwater Crocodile

1. Consider bringing further mangrove areas under the Protected Area Network of India and select release locations. Areas in west coast have to be surveyed.
2. Minimise man-crocodile conflict situation in the long-term interest of the species.
3. Manage Bhitarkanika Sanctuary and suitable locations in Andaman and Nicobar Islands as the National Saltwater Crocodile Reserves.
4. Consider possible utilisation of the species under rural economy improvement programme.

STATUS OF MUGGER

Mugger is perhaps much more widely occurring now than before. Following the protection since 1972 and conservation programme after 1975 small remnant populations have re-established themselves. The best examples are Ranthambhore and Jawa reservoir in Rajasthan. The other states where wild populations are doing well are Uttar Pradesh, Gujarat, Orissa, Andhra Pradesh, Maharashtra, Tamilnadu, Karnataka and Kerala.

Following the reintroduction of over 2000 captive reared Muggers, this extremely adaptive species is known to have started breeding at least in 10-12 locations.

It now breeds in captivity at least in 25 locations and the number of nests (both in captivity and wild) may be over 300 per year. There are already over 12,000 juveniles being reared in captivity.

This has brought in a feeling of 'too many' mugger in the country. Looking at the adaptibilty of the species there may still be wild habitat available in almost all states for this species. In over 500 protected areas, there are water bodies as also numerous man-made reservoirs within Reserve forests that can accommodate mugger.

The Suggested Action Plan for Mugger

1. Wild egg harvesting for captive hatching to be stopped by all states.
2. States to survey protected areas for rehabilitation of mugger. (State wise action plan may be the best answer).
3. Each state to manage at least one model 'Mugger Reserve'. (An expert committee of the Central Government to prepare guide lines and help prepare management plan for such reserve).
4. The Central Government co-ordinate a 'co-operative' inter-state surplus stock disposal reintroduction programme.
5. Formulate guidelines and control of captive breeding for Mugger. (Emphasizing on objective of each captive breeding centre).

ACTION PLAN FOR 90's

Singh et. al. (1990) proposed in 1988 an elaborate action plan for the Indian crocodiles. This has been extensively commented by various agencies. A general feeling of this action plan is that it is too broad based rather than priority specific. The present proposed action plan attempts to be more specific.

1. The Ministry of Environment and Forest, Government of India has already circulated guidelines to crocodile programme operating states to stop collecting wild laid eggs in an attempt to minimise accumulating stocks. Financial support has also been provided to make room for over crowded stocks. States have been advised to cerate additional rearing facilities where the stocks can be utilized for educational purpose.

2. The wildlife officials have been asked to survey water bodies within Protected Aras's and reserve forests for feasibility of further introduction.
3. A circular has gone to states to prepare projects that will look into the prospect of 'mugger crocodile utilisation' by tribals and other ethnic groups who were traditionally the users of crocodile--both for consumptive and non-consumption purposes.
4. States not operating a crocodile conservation programme but have considerable areas with crocodile habitats are to initiate programmes for rehabilitation of crocodile with surplus stocks from other states.
5. North-eastern India and the Brahmaputra river system to be considered as the priority areas for crocodile conservation during the 1990's.

DISCUSSION

A cursory look at the re-introduction locations (**Fig.2**) and the increasing successful breeding of the re-introduced stock in the wild justifies the programme to be termed as "successful". However, we have in captivity many more crocodiles meant for re-stocking and not many locations identified where these captive stock can go. It appears hence, the unsurveyed wild areas have to be surveyed immediately as also the suitable habitat within Protected Areas should be identified as early as possible. This however is not without problems. In a populated country like India man-crocodile conflict situation can become a constant problem since habitats are shared by people, crocodile and livestock. Habitats within the protected areas are also not free from damages caused by flooding and erosion of nesting areas. A result of alienation of river courses by construction of dam for irrigation, hydro-electric project etc. degraded the habitat quality considerably. Added to this also the fast development of commercial fisheries on all water bodies with very little control on the use of suitable fishing gear that are detrimental to other aquatic fauna pose continuous threat to the survival of these endangered species.

ACKNOWLEDGEMENT

My colleagues in the Wildlife Institute of India, Dehradun helped me in preparing this paper through constant discussion and comments. Funds for the travel to attend the 10th working meeting of the Crocodile Specialists Group was provided by FAO-UNDP project in India.

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Captive Crocodile Rearing/Breeding Locations in India (1990)
(Location names given on the facing page)

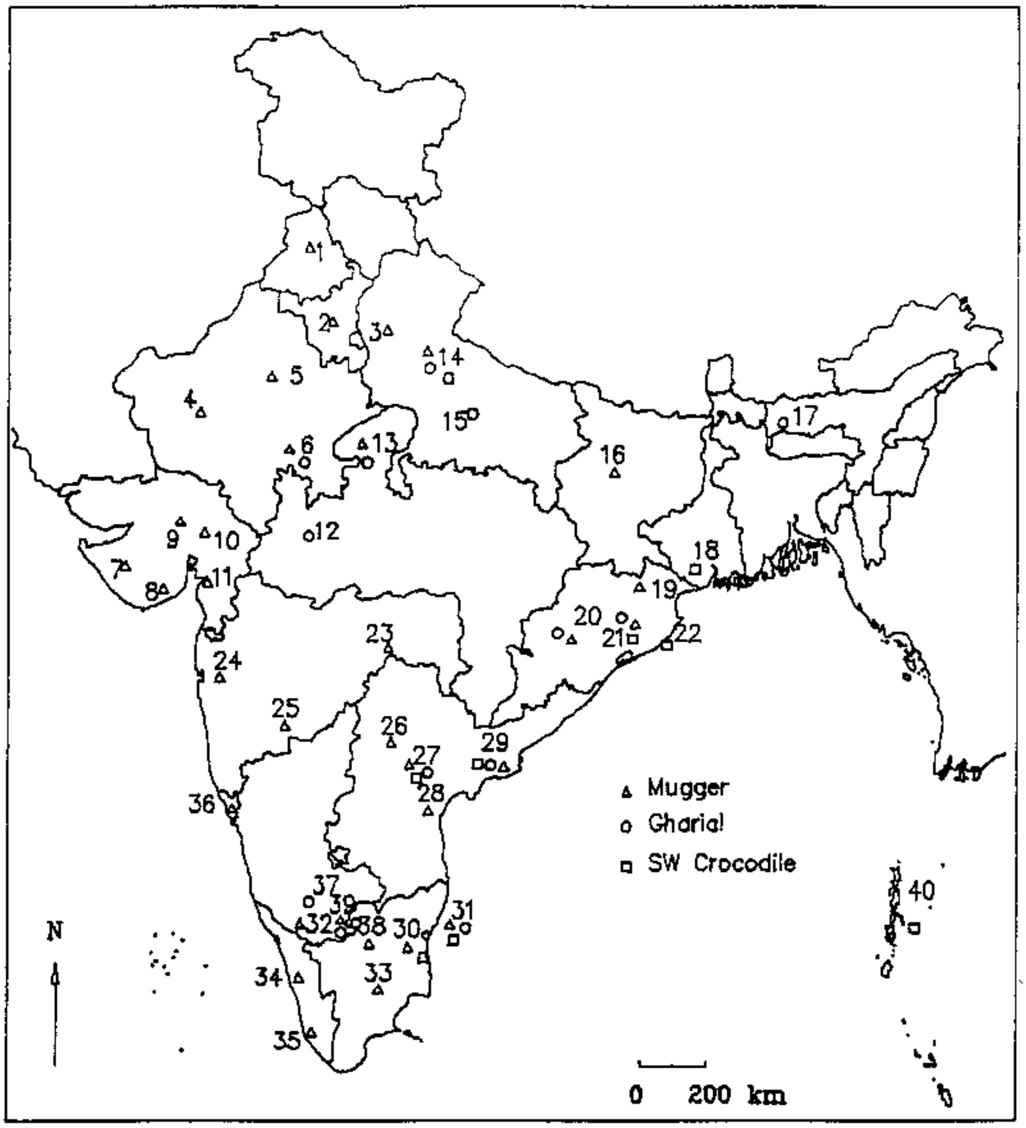

Fig - 1. Captive Crocodile Rearing/Breeding location in India (1990).
(G = Gharial, M = Mugger, SWC = Salt water Crocodile).

Sl.No.	Location	Species
1.	Chandigarh	M
2.	Kurukhestra	M
3.	Delhi	M
4.	Jodhpur	M
5.	Jaipur	M
6.	Kota	M, G
7.	Junagarh	M
8.	Sasan	M
9.	Ahmedabad	M
10.	Gandhinagar	M
11.	Barodha	M
12.	Bhopal	G
13.	Morena	M, G
14.	Lucknow	M, G, SWC
15.	Katrenia ghat	G
16.	Mutta	M
17.	Gauhati	G
18.	Bhagbatpur	SWC
19.	Similipal	M
20.	Tikarpada	M, G
21.	Nandankanan	M, G, SWC
22.	Daangmal	SWC
23.	Tadoba	M
24.	Bombay	M
25.	Sholapur	M
26.	Warangal	M
27.	Hyderabad	M, G, SWC
28.	Nagarjuna Sagar	M
29.	Vishakapatnam	M, G, SWC
30.	Sathnur	M, SWC
31.	Madras	M, G, SWC
32.	Mudumalai	M
33.	Amravati	M
34.	Peruvannamuzhy	M
35.	Neyyar	M
36.	Goa	M
37.	Bannaghata	G
38.	Hoggenakal	M
39.	Mysore	M, G
40.	Port Blair	SWC

Reintroduction Location of Indian Crocodilians (1990)

■ Locations where introduced crocodilian have bred in the wild

(Location names given on the facing page)

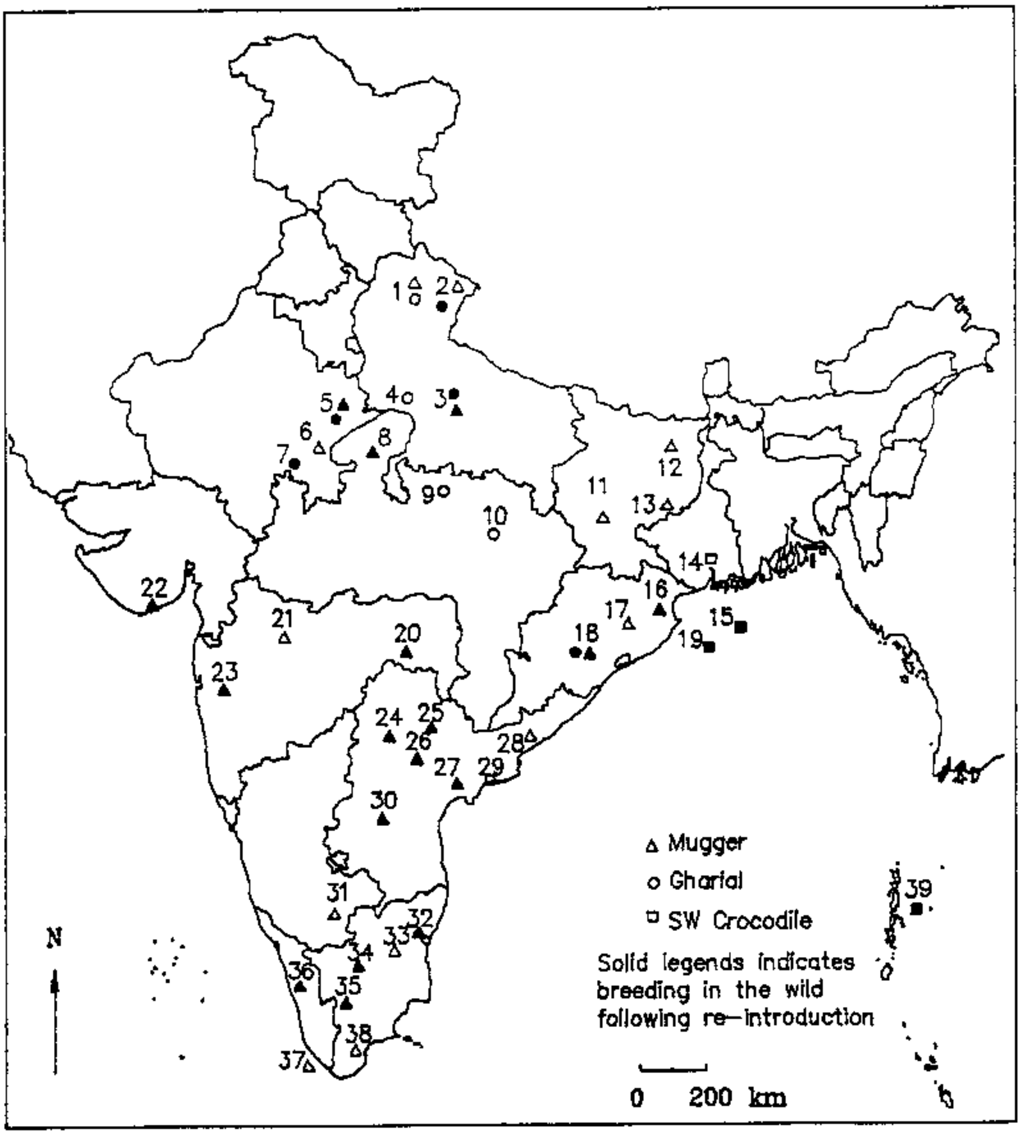

Fig. 2 - Reintroduction location of Indian Crocodilian (1990).
(G = Gharial, M = Muggar, SWC = Salt Water Crocodile)

Sl.No.	Location	Species Released
1.	Corbett	G, M
2.	Katrenia ghat	G, M
3.	Kukrail	G, M
4.	Pinahaat	G, M
5.	Rameshwar	G, M
6.	Ranthambore	M
7.	Kota	G
8.	Sivpuri	M
9.	Sone	G
10.	Ken	G
11.	Kaimur	M
12.	Mutta	M
13.	Hazaribagh	M
14.	Lothian	SWC
15.	Sunderban	SWC
16.	Simlipal	M
17.	Hadgarh	M
18.	Tikarpada	G, M
19.	Bhitarkanika	SWC
20.	Tadoba	M
21.	Melghat	M
22.	Gir	M
23.	Borivillie	M
24.	Manjira	M
25.	Sivaram	M
26.	Pakhal	M
27.	Kinnersani	M
28.	Papikonda	M
29.	Koringa	SWC
30.	Nagarjunsagar	M
31.	Bannaghata	M
32.	Sathnaur	M
33.	Krishnagiri	M
34.	Mudumalai	M
35.	Anamalai	M
36.	Parambikulam	M
37.	Neyyar	M
38.	Mundanthurai	M
39.	Andaman (North)	SWC