THE REARING OF CROCODILES FOR COMMERCIAL AND CONSERVATION PURPOSES IN RHODESIA

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THE Nile Crocodile, *Crocodylus niloticus*, was not classified as a game animal in Rhodesia prior to the introduction of the Wildlife Conservation Act of 1961. Previously only the permission of the land-holder was required in order to hunt it. Nor was there any restrictions on the sale of skins prior to 1961, with the result that the crocodile was hunted indiscriminately on private land and in most African areas (permission being readily given as it was regarded as a danger to life and livestock). Only on Crown land, National Parks and Game Reserves was no hunting allowed, but even in these areas it was subjected to (fairly heavy) illegal hunting.

The Wildlife Conservation Act (1961) classified the crocodile as a game animal to the result that it could only be hunted under licence and should no longer be sold unless the skins were under a cropping permit. Probably as a result of these measures, and aided by the remoteness and inaccessibility of some stretches of the major rivers, the crocodile was not exterminated.

The great reduction in the populations, and the reduced chances of successful nesting below the Kariba Dam due to unseasonal flooding as a result of spilling (Attwell[1]) were viewed with concern by the Department of National Parks and Wildlife Management. Consideration was given to the setting up of departmental research into breeding of crocodiles (for restocking) at Binga on Lake Kariba in 1963, and at Nyamomba on the Zambezi river downstream of the Kariba Gorge, in 1964. Neither of these schemes was implemented due mainly to lack of finance. In 1966 however, the Department agreed to the establishment of private crocodile rearing stations. It was considered that they might prove to be a source of legitimately obtained skins (hopefully stopping trading in illegally-obtained skins) and in addition provide young crocodiles for restocking purposes. Note: a 'rearing' station differs from a 'farm' in that the former does not operate independently of natural populations - quotas of natural laid eggs are collected to permit for the wild, whereas a farm would breed its own young.

1. CROCODILE REARING POLICY

Rearing by private individuals was accepted in principle, subject to the following main conditions in 1965:

1. Provided applicants satisfied the Department as to their *bona fides* and capital resources, the possibility of leasing sites to them on certain Crown land would be considered; such leases to be for an initial period of 10 years with option to renew.
2. Provision should be made for absolute containment of the crocodiles.
3. Permits to capture immature crocodiles and to take crocodile eggs would be subject to the condition that young equivalent to 10% of the crocodiles captured or eggs collected would be returned to the wild at an age to be determined by the Department.
4. In so far as rearing stations established on Lake Kariba were concerned, fishing by accepted *commercial* methods (e.g. gill nets) to provide food for stock would not be authorised. This was due to the fact that the Lake had already been divided up into concessions for commercial fishing and such concessions had been granted.

Three year old crocodiles unpacked from travelling crates awaiting release.

The age laid down in terms of (3) above was set at three years, as it was considered that the crocodiles, which would then be c. 1-1,2 metres in length, would stand a good chance of survival. At a later stage while the number to be released was maintained at 10% of crocodiles captured, young equivalent to only 5% of eggs taken were required by the Department.

Releasing three year old crocodile into Ruziruhuru Bay, Lake Kariba.

The Department is carrying out research into survival of hatchlings in the wild but it will be several years before this can be evaluated. It is generally agreed that survival rate is very low. Most mortality takes place during the first year of life (Cott[2], Pooley[4]) and it is assumed that juveniles in the wild of 0,45 metres in length, the size favoured by collectors, represent the few remaining survivors. For this reason the collection of immature crocodiles is no longer allowed, and further, the collection of juveniles is in any event considered uneconomic by the rearing stations.

II. PERMITS

Permits (see Appendix A for typical permit) are issued on an annual basis, being re-issued each year, providing that the conditions of the previous permit have been complied with and that the farm is being managed in a satisfactory manner. There are three stations operating at the present time. Two on the shores of Lake Kariba and the third on the Zambezi river upstream of the Victoria Falls. Appendix B shows the stocks at the 5 stations which were actually established in terms of the Permit.

III. COLLECTION OF LIVE CROCODILES AND EGGS

1. Areas. Collection of eggs has been done in areas along the Zambezi river (including Lake Kariba) and along some of its more important tributaries, such as the Deka, Gwaai, Senkwi, Ruziruhuru, Mwenda, Sengwa and Umniati (Sanyati). As the Senkwi and Mwenda rivers border on the Chete Game Reserve, collecting is only allowed on the west bank of the Senkwi and the east bank of the Mwenda. Collecting is allowed only on the upper reaches of the Ruziruhuru river which lies outside of the Chete Game Reserve. There are few suitable nesting areas on the newly established shoreline of Lake Kariba.

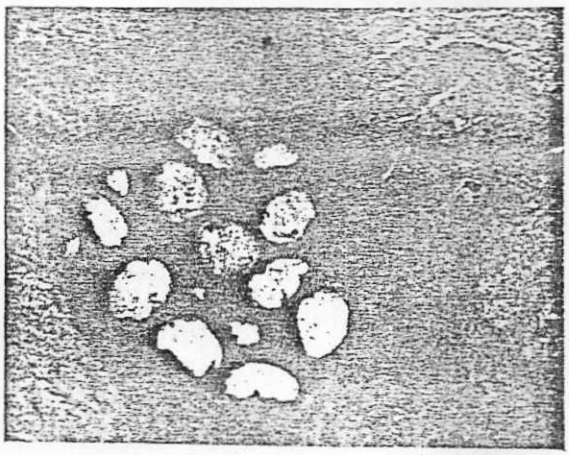
2. Live Crocodiles. Juvenile crocodiles were captured at night from small boats after being located with the use of spotlights. As stated previously the number of juveniles captured by this method has proved uneconomic for the stations. One operator also states that wild crocodiles brought into the pens take considerable time to settle down and do not show the same rapid growth as reared animals.

3. Eggs. *(a) Collection* (see Appendix B for numbers taken). This usually takes place in November; the main laying period in Rhodesia is September to early October, with hatching taking place some ninety days later in December or early January.

The areas favoured by crocodiles for nesting are usually remote and can only be reached by boat or on foot. The nest is usually situated in a sandy area with ready access to water and shade. It is of interest to note that G. Hall *(pers. comm.)* located nests from 7-15 m above water level on the Zambesi River below Kariba. It is probable that these nests were isolated by a drop in the river level due to the closing of flood gates at Kariba. He noted females being unable to relocate their nests presumably due to the water receeding as much as 700 m with the closure of the flood gates. Such sudden lowering in water level is, of course, unnatural (Attwell[1]).

Once the general locality of the nest is known, the nest itself is located by driving a steel spike into the sand. When an egg is struck it can be felt or if pierced, sand sticks to the end of the stake when it is withdrawn. The upper surface of each egg is marked before it is removed and the eggs are packed into transport boxes (in the case of Kariba and Spencer Creek Stations, direct into hatching boxes). Care is taken to see that the eggs are packed the same way up as they were in the nest. In the past embryos have been found to have

Crocodile nest in sandbank, Mwenda Basin, Lake Kariba.



stopped developing or to have died through strangling with the umbilical cord due, it is thought, to turning of the egg. Pooley[9] suggests that eggs should be collected soon after being laid, especially if the journey back to the hatchery involves a considerable distance over rough road. With the eggs in an advanced state of incubation there is danger that the delicate system of blood vessels or the yolk sac will rupture.

Collection in Rhodesia is carried out when incubation is advanced for the following reasons:

(i) with the need to return young crocodiles equivalent to 5% of eggs taken, the collectors avoid taking rotten and infertile eggs (early in the season these are not apparent);

(ii) collectors feel that development is more likely to be arrested if the eggs are taken in the early stages (research on this aspect is being undertaken by the University of Rhodesia in conjunction with the Department);

(iii) eggs require care for a shorter period. Pooley[9] suggests that nests should be raided only every alternate year, because of possible abandonment of nest sites if eggs are removed annually due to the more frequent disturbance factor. While only one site has been kept under observation to date (Mwenda, Lake Kariba) there appears to be no reduction in the number of nests on the site. This may be due to the fact that this site is one of the few favourable nesting sites in the area. In the Zambezi river below Kariba there does appear to be a decline in nesting, but this could be due to loss of nests from unseasonal flooding or heavier human pressure due to patrolling of the Rhodesian/Zambian border. The Mwenda site and the Sengwa site (first exploited in 1972) will continue to be monitored to test Pooley's concern.

The number of eggs per nest in Rhodesia varies from 14 to 77. The average number of eggs per nest in Rhodesia is 45 (from a statistically significant samole) as compared with 54.9 for Uganda, 56.2 for Zambia (Cott[2]) and 45 for Zululand (Pooley[5]). The lower number in Rhodesia and Zululand could be due to a younger population than that recorded by Cott. It is generally accepted that larger, and therefore older females lay more eggs. As previously stated, Rhodesian crocodile populations generally, but particularly those of the Zambezi River, were severely reduced in the 1950's. The crocodiles breeding today were probably too small to be worthy of collection at that time and have now reached sexual maturity. This suggestion will be investigated from the data obtained from the rearing stations which are required to complete nest cards (see section VIII).

(b) Incubation and hatching. In the wild, the nest is protected against predators for the whole of the incubation period by the female. At hatching time the croaking of the young in the eggs stimulates the female to unearth the eggs, and so release the young (Cott[2,3]). There is no record of hatchlings being able to break through the hard crust of soil which forms over the nest without help from the mother.

Two methods of incubating eggs have been developed. These are by means of the simulated nest and the hatching box.

The simulated nest consists of a series of rectangular "boxes" constructed on the ground with cement brick walls. Each box is approximately 200 x 160 cm and 60 cm deep, and is designed to hold several clutches of eggs. When the eggs are brought from the field, they are packed the right way up into the simulated nests in moist sand. The nest area is fenced to keep out predators, but is open to the sky. The sun on the nests for a certain time each day provides the sole source of warmth. Plastic sheeting is placed over the nests in times of heavy rains. When it is thought that the hatching is imminent, the side of each nest is struck in order to stimulate the young to croak. Once a good chorus is established, the actual clutch from which the sound is coming is located and opened up to allow the hatchlings to break free. The hatchlings are then placed in a small holding pen for twenty-four hours before being transferred to a larger area.

The hatching box method consists of a "Kaylite" box, having walls 3,5 cm thick, the internal measurements of the box being 45 x 42 cm and 25,5 cm deep. A trapdoor 25 x 25 cm is cut into the top of the box. This box holds up to 60 eggs comfortably. As previously stated, the boxes are packed directly at the nest site and are filled to capacity with the soil in which the eggs were originally laid.

Both the Kariba and Spencer Creek stations have substituted soil with vermiculite or Kaylite chips on an experimental basis in the field to reduce weight when collecting, with satisfactory results. Once the boxes have been transported back to the station they are laid out on the floor of the "hatchery". At Kariba this is presently a temporary structure of poles and tarpaulins which is kept heated by the use of a small gas ring with an optimum temperature of c 32,0°C. being retained in the boxes. This temperature approximates that recorded at nest sites.

At Spencer Creek a hatching room has been constructed which is heated to the necessary temperature by electric fan/heaters. The boxes are kept sealed during incubation, with the exception of one or two which are opened periodically to check the temperature of the soil in the box. The moisture content of the soil in the boxes remains constant provided the boxes are kept sealed. When the young are heard croaking in a box, that box is removed from the hatchery and the eggs are uncovered. This allows some of the young to emerge from the eggs, the remaining eggs usually hatching a short time later.

One of the main problems with both methods is the large proportion of premature hatching that occurs. Some young emerge with the yolk sac still attached while with others the umbilical area is still so thinly covered that the slightest snag will tear it open. This premature hatching would appear to be caused mainly by opening up the nest too early, which in-

fluences the young to leave their eggs. Hall and Yates *(pers. comm.)* state that, provided they are not disturbed, young crocodiles will make no attempt to emerge from the egg for up to 24 hours after pushing out the tip of their snouts (after cutting through the shell with the egg tooth). They also state that any undue noise around the hatching boxes will set the young croaking, and that unless a box of "croakers" was removed from the hatchery immediately it would set off the boxes nearby, resulting in premature emergence. It is considered that once a method of insulating the individual nests from outside disturbance and other nests is found, premature hatching will be reduced considerably. Also, once operators can identify, from a threshold of croaking noise, that the majority are ready to emerge, the figure will be cut further.

Pooley[5] recorded that nests opened up by the parent often contain eggs that require another week for hatching. He also indicates that there may be a variation of up to 21 days between the first and last crocodiles emerging from a nest, but this was from nests that had been moved.

Both methods of hatching are equally successful and hatching at 85% or more is regularly achieved. The reasons for the low hatch at the Victoria Falls Station have not been ascertained but could be due to eggs having to be transported over rough roads for long distances. Some losses were definitely due to the soil in the boxes being very damp during collection resulting in inhibited development of the embryo, possibly due to fungal infection. It is considered, however, that the hatching box method will probably prove the better in the long term. The simulated nest has the disadvantage that clutches in the same box can set each other off croaking. It is also liable to be effected by adverse weather conditions, such as hailstorms and unseasonal changes in temperatures.

4. Breeding. The keeping of adults for breeding purposes was rejected as being uneconomical due to the high cost of feeding and the low number of eggs obtainable from females. This attitude may have to change in the future depending on the availability of eggs from the wild. In fact the station at Victoria Falls has started building up a breeding population.

That crocodiles will breed successfully in captivity in Rhodesia has been proved an several occasions, both by a private individual and by the Department. In each case, considerable care has been taken to simulate natural conditions in the holding areas and to offer the captive animals adequate space.

IV. ENCLOSURES AND PONDS

With crocodile rearing being in its early stages of development, the most suitable types of enclosures and ponds required for the young have not as yet been determined conclusively. The types of enclosures and ponds in use are described below:

1. Kariba Crocodile Rearing Station. *(a) Hatchling Enclosures.* There are six hatchling enclosures built adjacent to each other. Each enclosure is approximately 7,3 x 4 metres with a central pond some 5,5 x 2 metres. The pond is sloped from the rear to the front, being about 30 cm deep at the front. The pond, surrounding area and the walls of the enclosure, to a height of one metre, are smooth plastered. The walls of the enclosures are constructed of concrete blocks and are 2,4 metres high. At the front of the enclosure is a viewing window and entrance door. Each enclosure has poles across the top over which is stretched wire. Over sections of this reed mats have been placed to provide shade.

The wires over the top are to prevent predators entering (see Section VII) and shutters can be placed over the viewing windows at night for the same reason.

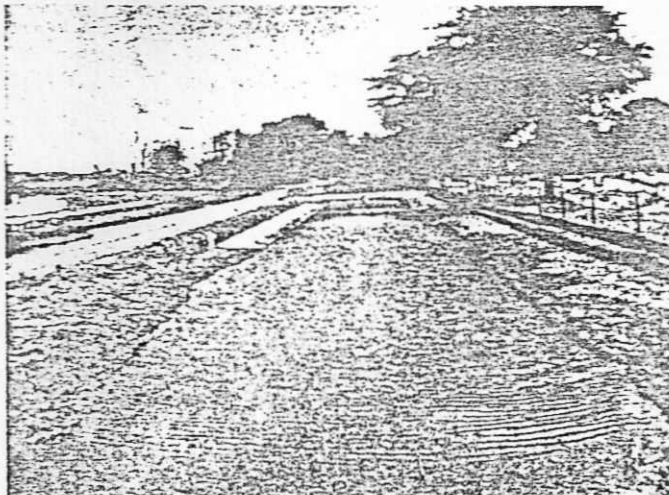
The pond and surround were originally constructed of slate, but as stated this is now smooth plaster. This surface is preferable for maintaining the high level of hygiene necessary for rearing healthy crocodiles.

Food is placed around the edge of the ponds, where the crocodiles eat it immediately or swim off to eat it elsewhere. Food is provided in the evening and the pond cleaned out the next day.

(b) Enclosures for yearling and subsequent age groups. Most of these have earth ponds varying in length (average 27,5 m) and approximately 3 m wide and 1,2 m deep. Concrete feeding platforms have been built alongside each pond, and are used in order to avoid the banks of the ponds being contaminated with unconsumed food. The enclosures are surrounded by walls made of concrete blocks, each wall being just over 1 m in height and 2 m from the side of the ponds.

The advantage of earth ponds is that they are far cheaper to construct than concrete ponds. They can also carry a fish population whereas fish cannot be kept in concrete ponds due to the regular draining and scrubbing out. Fish in the ponds help to clean up waste food taken into the water and possibly also serve to some extent as food for the crocodiles, but as the water is extremely muddy they must prove difficult for the crocodiles to catch. With concrete being limited to

Yearling pens at Kariba rearing station.



feeding platforms there is little likelihood of damage to belly skins.

One of the disadvantages of earth ponds is that the crocodiles tend to burrow under the banks, in some cases burrows extending under the walls of the pens. These burrows, which are below water level for most of their length, are utilised for retreats from cold or disturbance. Another problem is that visibility is reduced so that an accurate check on numbers cannot be kept.

2. Binga Crocodile Rearing Station. *(a) First year enclosures.* The ponds and surroundings are finished in smooth cement, each pond being c. 18 x 2 m and 60 cm deep. Cement ponds are utilised due to the fact that the substrate is unsuitable for the construction of earth ponds.

(b) Second- and third-year enclosures. Some of these contain double, others single ponds. The double-pond enclosures are c. 25 x 14 m with the two ponds in the centre, each pond being the same size as in the first-year enclosures.

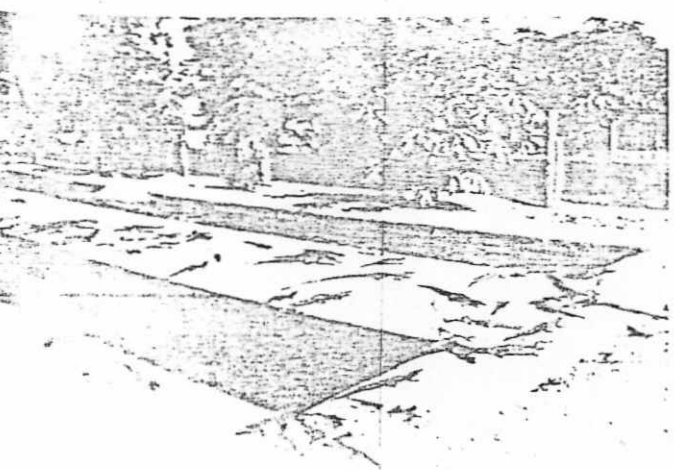
The area between the ponds is laid with concrete, as is an apron about one metre wide on the other sides of the ponds. The ponds and these concreted areas are all finished in smooth cement. Ramps in each pond allow the crocodiles to climb out of the pond easily, the sides of the ponds being vertical and not sloped.

The single-pond enclosures are 14 x 7,3 m with the pond running down the centre. The pond, c. 12 x 2 m and 60 cm deep, is of the same construction as in the larger enclosure.

The walls of the enclosure consist of metal sheets topped with wire mesh. The area between the walls of the enclosure and the pond aprons have been covered with coarse river sand, shade being provided by the growing of Pawpaw trees.

The maximum number of crocodiles held in the enclosures with double ponds is 100 two-year olds or 50 three-year olds. The smaller pens hold up to 30 second-year and 20 first-year crocodiles. It is considered

Concrete ponds at Binga rearing station.



Four year old crocodiles at Spencer Creek rearing station.

that each young-of-the-year should have available a minimum area of 0,09 m^2, each yearling 0.18 m^2, and each third-year, 0,27 m^2 or more.

The ponds are cleaned out each morning. It is of interest to note that the second- and third-year crocodiles have become so accustomed to this cleaning that they leave the water when the attendants enter it to clean the ponds.

(c) Weir Use. A weir has been constructed on a stream course and enclosed with metal sheeting. This is used for the fourth year crocodiles awaiting cropping.

3. Spencer Creek Crocodile Ranch. This station only started operating in mid-1971, with a total of 295 three and four-year old crocodiles purchased from the Binga rearing station.

Enclosures for all age groups have cement brick walls approximately 1,3 m high, some of which are topped with a fence consisting of wire mesh with two strands of wire above it. Each enclosure is approximately 21 m x 9 m with a pond 15 m x 1,8 m running down the middle.

The ponds are constructed of cement blocks with a smooth cement surface. They have sheer sides approximately 70 cm deep. As at the Binga station cement ponds are utilised because the substrate is unsuitable for the construction of earth ponds. Each pond is surrounded by a cement platform approximately 75 cm wide, which is used as feeding platform. Between this and the walls of the enclosure the area is either gravelled or grassed.

Shade is provided in the pens either by using natural trees or shrubs, or by suspending lengths of hessian across the enclosures.

4. Heating. Consideration has been given to different methods of heating ponds during the winter period for two main reasons: to prevent deaths due to drowning through low water temperatures and to encourage feeding throughout the winter to maintain growth.

The main method of maintaining water temperatures

Feeding four year old crocodiles at Kariba rearing station.

Feeding three year old crocodiles at Binga rearing station.

is by pumping fresh water into the ponds at night from natural sources where the water maintains a higher temperature throughout the night than in concrete or earth ponds. Plastic sheeting spread over the ponds in order to reduce radiation has proved partly effective. Electrical heating is being considered.

V. FOOD

Cott[2] shows that the diet of juveniles crocodile up to one metre in length can be divided into two stages. In the first stage, from hatching to a length of half a metre, the diet consists entirely of insects, frogs and spiders, with insects forming the bulk of the diet. In the second stage, half a metre to one metre long, the diet becomes more catholic with crabs, molluscs, fish, reptiles, birds and mammals being introduced. However, the bulk of the food still consists of insects.

In captivity, to feed insects only involves too much effort. Powerful lamps have been hung over the ponds at night to attract insects, but this can only supplement the diet to a limited extent. The Binga station stopped this practice as it is feared that insects injurious to the crocodiles might be attracted by the light, such insects not normally occurring in aquatic vegetation.

It has therefore been necessary to find an economic alternative diet. At first the young crocodiles were fed mainly a diet of the catfish *Heterobranchus longifilis* (the Vundu). The fish were gutted and chopped into pieces small enough for the various age groups to cope with. The pieces of fish were covered in bone meal (at Binga cod liver oil was also added), in order to make up any lack of nutrients. This diet has not proved satisfactory due to irregular catches and its low nutritional value (see Section VII). Limited gill netting has been allowed for the capture of bream *(Cichlids)* and tigerfish *(Hydrocynus vittatus)* but catches have not been large enough to provide regular feeds. The Kariba station tried utilising fish gills purchased from a fish processing plant at Kariba but these did not prove satisfactory.

The main alternative diet offered at Victoria Falls and Kariba consists of lung and spleen purchased from the Cold Storage Commission. This is supplemented by the addition of a powder containing vitamins and trace elements. This feed is proving very satisfactory, but is expensive due to the long distances over which it has to be transported; Kariba being supplied from Salisbury, a distance of 367 km by road and Victoria Falls from Bulawayo, a distance of 472 km by rail. Binga's isolated position makes the transport of this feed uneconomic.

Since the beginning of 1974 the Kariba Station has been feeding its hatchlings on fresh Lake sardine *Limnothrissa miodon* which are purchased. This food is proving very satisfactory, and good growth and condition are being obtained.

Meat from the wild which is used from time to time consists of baboon *(Papio ursinus)*, buffalo *(Syncerus caffer)* and elephant *(Loxodonta africana)*, the supply of these being irregular as they are only shot when crop raiding.

Investigations into artificial feeds have been carried out. A Milling company in Bulawayo experimented with feeding crocodiles on a fortified meal. While good growth resulted from this, the feed had to be cooked and made up into balls for feeding and if taken into the water by the crocodiles it soon dissolved and was wasted. For this reason it was considered impracticable and the investigations have been discontinued.

VI. GROWTH

Cott[2] gives a growth rate of 28 cm per annum for the first seven years of growth for captive crocodiles. After 2,1 m the growth rate drops rapidly to 3,6 cm per annum for captive specimens and 4,0 cm per annum for free-living specimens.

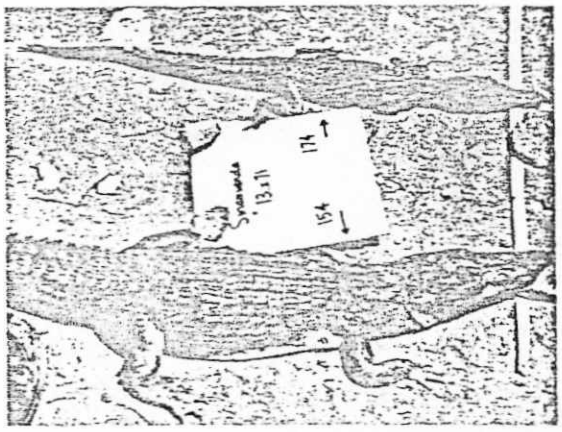
Cott's figures for free-living specimens are based on a crocodile known as "Beadle" which was captured in 1935 as a hatchling and kept in a fish pond for just over three years. It was then released into a pan in Wankie National Park.

Measurements from wild crocodiles recaptured in Lake Kariba indicate that natural growth is markedly less than that given by Cott. In only one case so far has growth comparable to Cott's figure been recorded.

That growth is dependent on food intake and proportional to competition is indicated by results obtained by the stations. Young crocodiles in their second year can vary in size by 30 cm or more. A specimen held at the Kariba Station gained in length and weight as follows:

	1971	1972	Increase
	(age 2 yrs 3 mths)	(age 3 yrs 9 mths)	
Weight	6.2 kg	14,9 kg	8,7 kg
Length	1.211 m	1,640 m	429 mm

Such increases are normally achieved by the stations and demonstrate a growth rate that is well above that projected for crocodiles of comparable age in the wild.



Comparison between captive reared crocodile (154) and wild crocodile (174) at an age of 21 months.

The variation in size of crocodiles in the same age groups, is probably due to competition at feeding time, the more dominant specimens taking most of the food. It is therefore obviously desirable to separate out different sized crocodiles into size rather than age groups, in order to obtain overall maximum growth rates.

VII. DISEASE, MORTALITY & INJURY

(a) Disease and mortality. During their initial years of rearing both the Binga and Kariba stations experienced high death rates, especially in the young-of-the-year.

Symptoms of disease were exudation of matter from the eyes, eye closure, and blocking of nostrils; the latter necessitated mouth breathing and consequently sick animals had to leave the water to avoid drowning. Out of water, they rapidly became dehydrated. The skin of the jaw tightened, pulling the teeth outwards into a fringe around the snout and lower jaw. Cracks appeared in the skin and algae spread under the scales. Digits were lost due to cracks in the feet. Finally sick animals became paralysed and died, sometimes after convulsions.

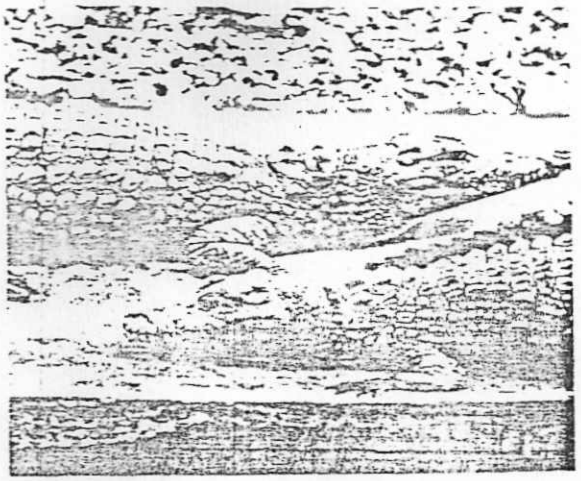
Post mortem examinations by veterinarians showed a high incidence of *Salmonella* species and *Shigella* species in the stomach and gut and the cause of death was put down to enteritis. It was believed that this was due to the lack of hygiene in the concrete ponds, cleaning being done only once a week. With nutrients being added to the water daily, contained in faeces and food scraps, pollution built up and infection followed. A more regular cleaning programme was set up in the ponds. Despite this the mortality was not reduced to any great extent.

It was then suggested that the cause of mortality was more likely due to poor nutritional status and the consequent lack of resistance to enteritis. An analysis of the main food, the Vundu (catfish), showed it to be extremely low in vitamins, especially vitamin A. The flesh was also found to have a high fat content which inhibits the absorbtion of fat soluble vitamins such as A, D, E & K. This indicated that the lack of resistance to disease could have been due to an extremely low vitamin intake. Work on reptiles (Reichenback-Klinke & Elkan[10]) showed 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.

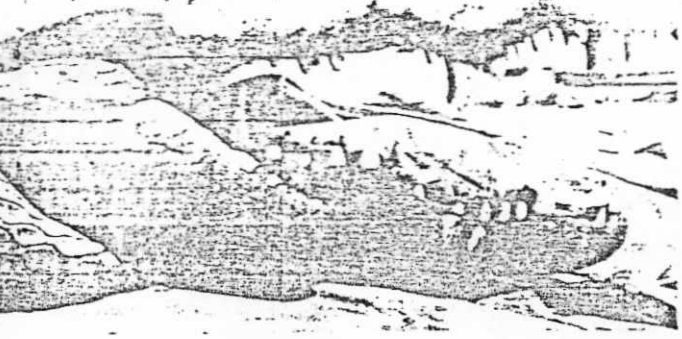
On the additions of vitamins and trace elements to the feed and with the removal of Vundu as a major food source, an almost complete elimination of mortality was achieved.

Other causes of deaths which have been recorded are:

(i) suffocation due to overcrowding. This happens in the hatching stage, when they tend to crowd together;
(ii) heatstroke due to inadequate provision of shade;
(iii) sudden drops of temperature, resulting in death from exposure if the crocodiles are out of the water or drowning if the water temperature drops drastically;
(iv) predation by the Fishing Owl *Scotopelia peli*, Marabou stork *Leptoptilos crumeniferus*, Selous' mongoose *Paracynictis selousi* and Genet *Genetta* species, Leopard *Panthera pardus*, and Leguaan *Varanus niloticus*.



Crocodile in foreground with upper jaw truncated due to injury during feeding.



Problem crocodile of 3,9 m immobilised for transportation from Chikwakwa Tribal Trust Land to Kyle Research Station.

(b) Injury. While injuries can be sustained from falling into empty ponds or attempting to scale walls, they are in the main caused by fighting and accidental seizing of each other during feeding. Injuries recorded as a result of this have been partial loss of top jaw and loss of limbs. These injuries could probably be avoided if feeding was done over a wide area and at regular intervals.

VIII. RESEARCH

Rearing stations continuously investigate feeding and rearing methods. Generally the stations co-operate in providing information and in allowing their facilities to be utilised for research by members of the Department and the University of Rhodesia. Nest record cards are completed in respect of all nests opened, thus contributing to research into nesting and incubation.

In September, 1971, at the Kariba station, investigations by the University and the Department were carried out into the most suitable dosage of the drug Gallamine triethiodide for immobilising crocodiles. This research has contributed largely to the successful translocation of large 'problem' crocodiles from areas where they conflict with human interests to game reserves or research areas. (Loveridge & Blake[11]).

A number of crocodiles at the Kariba stations have been tagged for regular measuring and weighing in order to compare growth rate under artificial conditions with that in wild populations. At Spencer Creek regular growth rate measurements are made; in addition experiments in growth rate using various diets and time intervals for feeding are being carried out.

The Department is carrying out investigations into the survival rate of crocodiles returned to the wild in the Mwenda basin of Lake Kariba and maintains a breeding station at Kyle.

IX. ECONOMIC PROSPECTS

It can be assumed that three years will elapse from the establishment of a station to initial economic skin production. In 1970 the Department estimated that capital $R30 000 would be required to set up a station and maintain it until it becomes productive.

Crocodile rearing stations, producing as they do a "spectacle", have considerable appeal for tourists; at one of the stations, the opportunity is taken to interpret the crocodiles' place in the ecosystem, and the interpretation is most favourably commented on by visitors. The tourist potential of rearing stations in Rhodesia varies according to accessibility, two of the three being favourably placed in this respect and thereby deriving significant income from visitors.

The main source of income will, of course, derive from skin production. The high quality of Rhodesian produced skins has been noted by buyers.

The future for crocodile 'farming' (see note on page 315) in Rhodesia is bright, with the present demand for leather likely to increase. The world-wide catastrophic decline, due to over hunting, in the production of crocodilian skins from natural populations has resulted in a keen interest in captive-reared skins. The Rhodesian Department of National Parks and Wildlife Management is prepared to consider applications for young crocodiles for restocking from appropriate conservation organisations in other African countries.

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This article is published with the approval of the Director of National Parks and Wildlife Management and is part of the overall research project into crocodiles in Rhodesia.

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Mr. D. Higgins lecturing to tourists who are standing on a walkway over the ponds at Spencer Creek rearing station.

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PERMIT No. WLC 35(a)/ /7 **APPENDIX A**

Permission is hereby granted on the authority of the Director of National Parks and Wild Life Management in terms of paragraph (a) of section 35 of the Wild Life Conservation Act (Chapter 199), to:

.....

to take the eggs of crocodiles, for the purpose of hatching for rearing purposes.

Unless sooner cancelled, amended or modified in terms of sub-section (4) of section 37 of the Act, this permit is valid until the

for Director.

NATIONAL PARKS AND WILD LIFE MANAGEMENT

TERMS AND CONDITIONS

1. The collection of crocodile eggs shall be permitted (subject to condition 6 of this permit) in the following areas:
   (a) all Tribal Trust Land with the consent of the District Commissioner concerned.
   (b) all vacant State Land in the European Area, African Purchase Area;
   (c) all privately owned land in the European area, African Purchase Area.
2. No collection of eggs shall take place in National Land, National Parks or Game Reserves.
3. The number of eggs taken shall not exceed ..... in total.
4. The holder of this permit shall with[in] three months of the 1st December, 197 release or hand over to the Department three year old crocodiles in good condition. The number of crocodiles to be handed over or released shall be equal to 5% of the eggs *actually taken from nests* in terms of this permit.
   In the event of the Department requiring the crocodiles to be released, they will be released in the waters adjacent to where the eggs were collected. Any such release operation shall only be carried out under the supervision of an officer of the Department.
5. An officer of this Department may at any reasonable time carry out an inspection of the permit holder's records or his premises.
6. Before taking crocodile eggs from any land mentioned in this permit, the permission of the landholder or the person responsible for the administration of such land must be obtained.
7. The holder of this permit shall submit by the 15th of each month a return in respect of the preceeding month giving the following information
   (a) number of eggs collected;
   (b) number of eggs hatched;
   (c) number of crocodiles which died during month in either age or size classes;
   (d) number of crocodiles slaughtered in either age or size classes;
   (e) sales of crocodiles in either age or size classes;
   (f) other adjustments to numbers giving reasons, i.e. escape, etc.
8. The holder of the permit shall at all times take reasonable care of the eggs collected and the crocodiles hatched therefrom.
9. The holder of the permit shall at all times ensure that the crocodiles are adequately penned for rearing purposes and that they are under regular supervision by trained staff and the holder of the permit.
10. In respect of all nests from which eggs are collected a "Crocodile Egg Record" Card will be kept. These will be supplied by Dr. Loveridge of the University of Rhodesia and should be returned to him at the end of the season.
11. This permit is not transferable.

APPENDIX B

HATCHING SUCCESS OF EGGS COLLECTED

ALSO COMPARING SUCCESS WITH DIFFERENT METHODS OF INCUBATING

Year	BINGA				KARIBA				VICTORIA FALLS			
	Simulated Nests				Hatching Box				Hatching Box			
	Allowed	Collected	Hatched	%	Allowed	Collected	Hatched	%	Allowed	Collected	Hatched	%
1967	2 000	2 000	1 349	67,5	—	—	—	—	—	—	—	—
1968	2 500	1 833	915	49,9	2 000	1 395	1 191	85,4	—	—	—	—
1969	2 500	2 203	1 181	53,6	2 000	1 324	1 080	81,6	—	—	—	—
1970	2 500	1 971	1 758	89,2	2 000	1 150	1 034	90,0	—	—	—	—
1971	2 500	128	119	93,0	2 000	832	730	87,7	2 500	2 250	1 650	73,3
1972	2 500	890	808	90,8	2 000	956	777	81,3	2 500	2 475	1 572	63,5
1973	1 500*	878	744	84,7	1 200*	593	540	91,1	2 500	1 801	1 249	69,4
	16 000	9 903	6 874	69,4	11 200	6 250	5 352	85,6	7 500	6 526	4 471	68,5

*Reduced at Request of Station Concerned.

COMPARISON OVER THE THREE YEARS 1971-1973

	1 896	1 671	88,1		2 381	2 047	86,0		6 526	4 471	68,5

ANNUAL STOCKS OF CROCODILES HELD BY REARING STATIONS IN RHODESIA 1966-1973

APPENDIX C

Year	Stock on Hand	Hatched	Captured	Purchased	Sub-total	Deaths	Escapes	Predated	Cropped	Live sales	Returns	TOTAL
1. BINGA: M. J. Fullstone: Established 1965. This station closed at the end of 1967.												
1966	—	80	40	—	120	2	46	—	—	—	—	72
1967	72	—	—	—	72	13	11(?)	—	—	—	48	Nil
Totals for 1966-1967	—	80	40	—	120	15	57	—	—	—	48	Nil
2. KARIBA CROCODILE FARM (PVT.) LTD. Established 1965.												
1966	—	—	10	—	10	3	—	—	—	—	—	7
1967	7	—	213	—	220	33	—	—	—	—	—	187
1968	187	1 191	30	—	1 408	2	—	—	—	—	—	1 406
1969	1 406	1 080	4	—	2 490	593	—	—	—	—	—	1 897
1970	1 897	1 034	—	—	2 931	586	124*	—	2	4	20	2 195
1971	2 195	730	1 +	—	2 926	305	—	—	145	32	35	2 409
1972	2 409	777	—	—	3 185	169	—	—	420	5	—	2 592
1973	2 592	561 =	—	—	3 153	499	—	—	506	—	—	2 148
Totals for 1966-1973	—	5 373	258	—	5 631	2 190	124	—	1 073	41	55	2 148
3 BINGA CROCODILE FARM. Established 1967.												
1967	—	1 349	—	—	1 349	—	—	—	—	—	—	1 349
1968	1 349	915	—	—	2 264	530	—	—	—	20	—	1 714
1969	1 714	1 181	—	—	2 895	829	—	—	—	4	—	2 062
1970	2 062	1 758	—	—	3 820	479	—	—	—	14	—	3 327
1971	3 327	119	—	—	3 446	601	—	—	28	198	34	2 585
1972	2 585	808	—	—	3 393	85	—	—	159	100	204	2 845
1973	2 845	744	—	—	3 589	93	—	—	246	—	—	3 250
Totals for 1967-1973	—	6 874	—	—	6 874	2 617	—	—	433	336	238	3 250
4. MINI CROCODILE FARM MUBIZI: Established 1967. This station [illegible] end of 1969												
1967	—	401	2	—	403	—	—	—	—	—	—	403
1968	403	906	106	—	1 415	152	—	—	—	—	—	1 263
1969	1 263	—	93	—	1 356	1 287	—	—	—	—	69	Nil
Totals for 1967-1969	—	1 307	201	—	1 508	1 439	—	—	—	—	69	Nil
5. SPENCER'S CREEK CROCODILE RANCH (PVT.) LTD., VICTORIA FALLS: Established 1971.												
1971	—	1 650	—	195	1 845	24	2	—	—	—	—	1 814
1972	1 814	1 572	3*	100	3 489	679	26	137	10	—	—	2 637
1973	2 637	1 249	2*	—	3 888	1 152	1	48	—	—	—	2 687
Totals for 1971-1973	—	4 471	5	295	4 771	1 855	29	185	15	—	—	2 687

*This was an agreed adjustment with the Department and represents unknown losses
=This includes 21 which were farm-laid and hatched
+Adult captured to build up breeding stock

*Adults captured to build up breeding stock