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Crocodile farming and conservation, the example of Zimbabwe

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Crocodile farming is an important and lucrative activity in Zimbabwe which provides meat for human consumption and skins for the luxury leather industry. Because it gives an economic value to this otherwise unfriendly animal, farming crocodiles has a positive side effect on the conservation of this species in the wild. This paper gives an overview of the crocodile industry in Zimbabwe.

Keywords: crocodile farming; wildlife utilization; conservation

Introduction

During the 1950s, crocodiles were heavily hunted in Zimbabwe. Adult crocodile numbers were assumed to be relatively low on the middle Zambezi in the early 1960s (Child, 1987). At this time, crocodile farming was being established. This provided motivation for protecting the wild crocodile population to allow the farmers consistent egg collections from the wild. Another beneficial side effect of crocodile farming was the impetus given to research into farming problems and to understanding and monitoring the wild populations.

Crocodile farming and its association with species conservation in the wild is an example highlighting the strong belief in Zimbabwe that, in many circumstances, giving an economic value to an animal will help its conservation in the wild.

The Nile crocodile

There are 23 species of crocodile-like animals around the world: eight species of alligators and caimans, two species of gharials and false gharials, and 13 species of true crocodiles (Hutton and Webb, 1990) including the Nile crocodile, the species farmed in Zimbabwe.

The Nile crocodile (*Crocodylus niloticus*) is the most widespread of the three crocodile species found in Africa. The others are the false gharial (*Crocodylus cataphractus*) and the dwarf crocodile (*Osteolaemus tetraspis*). An average Nile crocodile is 3.5 m long, but a 7.9 m crocodile was observed in lake Kioga in Uganda (Simon, 1993).

Nile crocodiles are biologically similar to other crocodile species: their corporal temperature is variable; their growth in length is fast for the first years of their life, then slows down progressively. In the wild, sexual maturity is reached when the total length is 2.9–3.3 m for males, and 2.4–2.8 m for females, usually between 19 and 35 years of age depending on the ambient temperature (Cott, 1961; Hutton, 1984). The Nile crocodile shows one breeding season per year and, in Zimbabwe, the eggs are usually laid in September (Blake, 1974; Hutton, 1984). The nest is a hole made in the ground. The incubation takes about 90 days, but variations are important due to temperature. Sex is

determined by the incubation temperature which at 34°C produces males, while females are produced with a constant temperature of 30°C. Males are territorial during the breeding season. Mature females have a territory all year round, but associate with males to form breeding groups during the mating season. The female is protective of the nest during the incubation period and, at hatching, she helps the newly born out of the nest and carries them in her mouth to the water where she keeps them for at least 6 weeks (Games, 1990). It seems difficult for the newborn to get out of the nest without help from the mother. In lake Kariba area, the average number of eggs per nest was 45, but there were considerable variations with 20–90 eggs per nest having been observed (unpublished data from the Department of National Parks and Wildlife management).

Young crocodiles, less than 1.2 m long, eat invertebrates such as insects and crustaceans. From 1.2 to 4.0 m long, their diet includes bigger animals, particularly fish. Big crocodiles feed on mammals (Cott, 1961).

Nile crocodiles occur throughout Africa south of the Sahara, but are absent from the arid areas of northeast (Ethiopia, Somalia) and southwest (Namibia). This species' territory extends along the Nile river as far as lake Nasser while it is also found in Madagascar. They live in freshwater habitats, along rivers, lakes, wetlands, estuaries and mangrove swamps. This type of habitat makes it technically difficult to estimate their number in the wild (Taylor *et al.*, 1992).

Crocodile farming

BACKGROUND

The Nile crocodile is listed on Appendix II of CITES; therefore its international trade is controlled, and farming the Nile crocodile actually helps its conservation in the wild. Crocodile farming was authorized for the first time in Zimbabwe in 1966. The particularity of this activity is that it depends on regular offtakes from the wild. Quota of eggs or live animals are removed from the wild and are incubated or bred in a controlled environment allowing better survival rates. It is estimated that 92% of the eggs can be removed from the wild without any effect on the wild population (Craig, 1992); indeed, a large proportion of eggs and newborns would be destroyed in the wild by predators or die because of environmental conditions such as drought, flood or suboptimal temperatures (Blake, 1974; Hutton and Webb, 1990). In 1991, over 58 000 eggs were collected, most from lake Kariba. A portion of the farmed crocodiles is released into the wild, contributing to a better survival rate of the species. The crocodiles returned to the wild are 1.2–1.5 m long, and their number correspond to 2% of the viable eggs collected (J.M. Hutton, personal communication). Farmers also produce their own breeders.

In Zimbabwe the number of crocodile farms has increased from seven farms in the 1980s to 44 farms nowadays and some 120 000 crocodiles are now bred (C. Foggin, 1994; unpublished). These farms are concentrated around towns such as Harare and Chiredzi, and along lake Kariba. They are represented by the 'Crocodile Farmers' Association of Zimbabwe', or CFAZ.

AN OVERVIEW OF THE BREEDING TECHNIQUES

Offtake from the wild

In Zimbabwe, eggs are collected in November. The nests are found in sandy areas close to the water, and are detected by probing the ground with a metal rod. Some 5–10% of

collected eggs are discarded (Hutton and Webb, 1990), the others are kept carefully in carrying containers or placed directly in incubation boxes, maintaining the position they had in the nest (Blake, 1974).

Incubation

There are two methods for incubating eggs, the artificial nest or the incubation box. Both of them give similar hatching rates of 75–90% (number of eggs hatched/number of eggs found in the nest).

In the artificial nest, the eggs are placed in humid sand, and are kept warm only by the action of the sun. The incubation area is protected from predators with fences and brick walls buried in the ground. The noise of the hatchlings pipping out warns the farmer of the right moment to dig them up.

With the incubation box method, about 60 eggs are positioned in an insulated container filled with soil from the wild nest, sand or vermiculite. The boxes are then placed in an incubator maintained at 32°C, the approximate temperature of the wild nests. The boxes are closed to maintain a high humidity (99%). At hatching, once again the high pitched chirping noises of the young tell the farmer of the moment to open the box (Blake, 1974).

Rearing

Crocodiles like to swim or rest on dry land whenever they feel like it. Their food must be palatable and offered out of the water to attract the crocodile which, contrary to accepted ideas, feeds only when the food is unspoiled. Therefore the pens are always divided in two areas, one with water and one dry. The minimum surface area necessary for hatchlings is 0.09 m^2 per animal, 0.18 m^2 per yearling, and 0.3 m^2 for a 2–3-year-old crocodile (Blake, 1974). The water is kept warm, preferably at 32°C, with pipes coming from a central heating system, and running along the pens in the water. In such a warm and humid environment, cleanliness is of major importance. The water is replaced and the pens, often made of concrete, are scrubbed daily.

The growth rate is variable, due to variation of temperature in the pens and also to competition for food. It is therefore advisable to group the animals in the same pen according to their size instead of their age. The growth curve of Nile crocodile (Fritz *et al.*, 1992) shows that they are in average 55 cm long at 3 months, 85 cm around 6 months, and 110 cm at 1 year. They are slaughtered when they reach 1.2–1.5 m long (Hutton and Webb, 1990) at around 2–3 years of age.

The hatchlings are fed once a day with ground, minced or chopped food, while crocodiles of 1.2 m long are fed every two days on bigger pieces. A young crocodile kept at 30–32°C eats on average 15–20% of his live-weight each week (Hutton and Webb, 1990). The diet includes fresh fish, poultry and red meat from abattoir waste, hunting operations and from natural mortality of livestock (Foggin, 1992) supplemented with a standard vitamin mix.

Mortality in hatchlings can be 5–15% and is usually due to stress-related diseases. When the crocodile reaches 0.7 m long it becomes more resistant and tolerant to mismanagement, and mortality decreases then to 0–2%, still often stress-related. When animals are stressed they huddle in piles, are excitable, have reduced appetite, loose weight. Stressful stimuli may be high or fluctuating temperatures, dehydration, noise, handling, nutritional deficiencies or inadequate stocking densities. Chronic stress reduces immunity giving an opportunity for diseases to appear (Hutton and Webb, 1990).

Breeders

On a farm and in good conditions, females can reach 1.8–2.0 m in 6 years. At this stage they can begin to breed, but good fertility and hatchability are not reached before 8 years of age. Breeding begins earlier on the farm than in the wild, and this may be due to the higher rate of growth at the beginning of the life of a farmed crocodile. Indeed, if a wild animal is caught when 1.8–2 m long, and fed thereafter as the other farmed crocodiles, it will not breed before 30 years of age (Hutton and Webb, 1990).

The breeders are kept in pens attempting to recreate at best their natural environment (Blake, 1974) with a pond, sandy areas and some vegetation.

There are two reproduction systems: small breeding pens with about eight females to one male, or a big pen covering many hectares with a maximum of 300 females and 60 males. The former is by far the most usual. The females are of similar size and the selected male is older and 20–40% bigger than the females. The surface area of the pond must be 8–10 m^2 per female if only recently caught from the wild, and 4–5 m^2 for females bred on the farm. Of the females, 90–100% can breed for at least 20 years (Hutton and Webb, 1990).

Slaughter

The crocodiles are either shot in the brain, or physically restrained and their spinal cord severed between the skull and the first spinal vertebra. In the latter case, the brain and the spinal cord are then destroyed with a steel rod; the local reflexes are then prevented which is an advantage for skinning (Hutton and Webb, 1990).

Diseases on the farm

The warm wet crocodile rearing environment is ideal for the spread of pathogenic organisms. The main transmissible diseases found on farmed crocodiles are infections with *Adenovirus* and *Poxvirus*, chlamydiosis, salmonellosis (*Salmonella typhymurium*) and coccidiosis.

Adenovirus infections are mainly found on crocodiles of 5 months of age or younger and would be partly responsible for the development of runts (Foggin, 1992). Pathological signs include chronic hepatitis, enteritis and pancreatitis (Foggin, 1987).

Poxvirus cause a skin infection which predispose the skin for more serious secondary infections involving *Dermatophilus*-like bacteria or fungi. The mortality is very low but the incidence on the leather quality is detrimental. Factors associated with skin conditions are trauma, lack of hygiene and sunlight, nutrition (Foggin, 1992).

Chlamydiosis has only been recently diagnosed on southern African crocodiles, although this disease was already described on other reptiles (Newcomer *et al.*, 1982). Chlamydiosis is often related to an *Adenovirus* infection and causes acute hepatitis. It is potentially a zoonosis but there has not yet been any proof of transmission to man in Zimbabwe (Foggin, 1992).

Bacterial diseases are the main cause of crocodile mortality from infectious diseases in Zimbabwe, and Gram-negative bacteria are involved most of the time; necrotic enteritis, a devastating disease, often follows *Adenovirus* infection or coccidiosis. Farmed crocodiles in Zimbabwe are often carriers of *Salmonella*, mainly *S. arizonae* which may almost be considered as a normal host of their intestine. Group C *Salmonella* and *S. typhimurium* can be primary pathogens (Foggin, 1992). Obwolo and Zwart (1993) found *Salmonella*, mainly *S. arizonae*, in the intestine of 16% of the crocodiles studied (50 3-year-old animals).

Madsen and Chambers (1991) found *Salmonella* in 16.4% of meat samples from crocodile tails. Feeding crocodiles with dead animal carcasses is probably helping to increase the prevalence of this infection.

Coccidiosis can result in a high mortality although treatment is very effective. Chronic forms can be responsible for the development of runts (Foggin, 1992).

Mycoplasma are found on crocodiles aged 1–2 years and cause arthritis.

Nutritional diseases: osteomalacia involves calcium and vitamin D3 deficiency, sudden death by tetany can occur with low levels of calcium in the blood, steatitis associated with vitamin E/Se deficiency when the animals are fed on fish, and gout which might be associated with excessive supplementation of calcium (Foggin, 1992).

Production

Skin

The most valuable product from the crocodile is the hide used in the exotic leather trade. Crocodile farming developed rapidly in Zimbabwe from 1986 to 1990, to fill the demand from the leather industry. Since then the growth of the industry stopped (Foggin, 1992), due to worldwide economic recession and to the competition from alligator skin. However, in 1991 US$ 2 million was earned in hide sales from Zimbabwe. In comparison with the hide value of other crocodilians, the Nile crocodile is ranked second on the world market, after the estuarine crocodile, and before the American alligator and the new Guinea fresh water crocodile.

From skinning to transport, care of the skin is of the utmost importance. Classically-cut skins present the most valuable part – the belly – as a whole, with high dorsal cut lines. To preserve the skins from microbial deterioration prior to tanning, they are cured through saturation with salt, either with moist salt being applied directly on the skin or soaked in saturated brine solution.

Grading of the skins depends upon the holes, scars or lesions in the area of prime importance known as the 'pattern'. Down-grading to second quality implies a 25% loss in value, and the most serious damage leads to the third grade with a further 25% loss in value (Hutton and Webb, 1990).

Meat and by-products

Meat is a secondary product of the crocodile, often used to feed the other animals. Since the drop in the value of the skin, diversification is more important and the meat trade for human consumption is becoming organized.

The approximate quantity of meat produced by crocodile is indicated in Table 1 (Hutton and Webb, 1990). The meat is sold locally to restaurants, butcheries and supermarkets, fresh, frozen or smoked, and packed under vacuum. The crocodile meat is white

Table 1. Meat yield from the crocodile

Crocodile length (m)	Bone in weight (kg)	Fillet weight (kg)
0.9–1.2	0.8–3.0	0.4–1.5
1.2–1.4	2.7–6.8	1.4–3.4
1.4–1.5	4.5–11.0	2.3–5.5

and the texture may be compared either to fish or chicken meat. The tail is the most tender and appreciated part, followed by the back strap and the body. The legs and the neck are better tenderized or cubed.

Crocodile meat for export needs to be free of *Salmonella* which can be achieved, among other processes, by blanching the meat (J. Milne and B. Revol, unpublished data). Meat is exported as fresh blanched meat, vacuum-packed, and frozen.

Other crocodile items such as heads, feet, teeth, claws and back strips can be processed and retailed as curios. However, those products are not a consistent income earner.

Conclusion

Crocodile farming is an important industry in Zimbabwe which fits in with the belief that sustainable use of wildlife is a strong conservation tool. The highest percentage of eggs that can be retrieved from the wild without affecting the population (92%) would be very difficult to reach if we consider the difficulty in finding the nests. A proportion of juvenile crocodiles are released in the wild and increase the survival rate of the species. Furthermore, the eggs collected in communal areas are paid for, with the funds going to the local community, thus giving some value to crocodile nests which were previously destroyed by villagers at a much higher rate. However, interest in the conservation of the crocodile has not yet reached the local fishermen, whose lucrative activity is impaired by crocodiles damaging their nets when trying to remove the fish. It is estimated that the wild crocodile population, heavily hunted before the onset of crocodile farming, has now recovered. However, densities are lower in fishing areas by comparison with adjacent non-fishing areas (Taylor *et al.*, 1992).

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