CHAPTER 31

Crocodile Farming in Zimbabwe

Jonathan M. Hutton[1] and Kevin R. Van Jaarsveldt[2]

THE success of Zimbabwe's crocodile conservation programme, which is based on sustained-yield utilization, has been well documented in the literature (Blake and Loveridge 1975; Shwedick 1979; see Child Chapter 6), and is reflected in the movement of Zimbabwe's population of *Crocodylus niloticus* from Appendix I to Appendix II of CITES, in 1983.

Utilization is achieved through crocodile ranching and farming, which have developed in the country over the last twenty years. Various aspects of crocodile production have been reported during this time (Blake 1974, 1982), but ideas and technology are in a continual state of flux; they are influenced as much by personalities as they are by science. This chapter gives a brief overview of the crocodile industry in Zimbabwe — the rationale behind it, the technology presently applied to it, the results obtained to date and the prospects for future development.

BACKGROUND

The five stations which raise crocodiles commercially in Zimbabwe, do so from a mixture of ranching (where eggs are collected from the wild) and farming (where adults are kept in captivity for the production of eggs). In both cases eggs are collected from nests and artificially incubated for at least part of the development time. Zimbabwe's main crocodile populations are legally protected so that rearing stations can only collect eggs or obtain breeding stock under permit from the Department of National Parks and Wild Life Management. Breeding animals invariably come from the Department's "problem" animal control programme: in 1984, 10 people within Zimbabwe were killed by crocodiles. The total quota for the annual egg harvest is set from the results of monitoring the wild population, but quotas for particular stations depend partly on their hatching and raising success. The annual quota for any one station has never exceeded 2500 eggs.

Captive production supplements, but is not intended to replace the wild harvest. Only from biological necessity, based on population monitoring, would the value of the wild populations of *C. niloticus* be lessened by reducing quotas of wild eggs.

Stations are required to make available to the Department, for restocking, a number of 1.2 m total length (TL) juveniles equivalent to 5% of the eggs collected. Juveniles of this size appear to be largely free of intraspecific predation (Hutton 1984). In reality, for a number of years the Department has taken only a few of these crocodiles, mostly for research. The wild population is large and probably expanding (Taylor, Loveridge and Blake, unpublished data), making restocking an unnecessary (and unpopular) option. Nevertheless, the "5% requirement" is still retained in the permit conditions.

It is argued that crocodile rearing stations provide and make conspicuous an economic incentive to maintain wild crocodile populations. This is certainly true at the policy-making level. In 1985 the industry is expected to realize the equivalent of over Z$1 million in foreign exchange earnings while Spencer's Creek Crocodile Ranch — one of the two stations which caters for tourism — was visited by some 35,000 tourists in 1984. Despite this benefit to Zimbabwe, at this stage the industry offers little in the way of tangible benefits to the people who live in areas with crocodiles as their "neighbours"; in 1984, humans destroyed over 38 crocodile nests along the upper Zambezi River (R. Gee, unpublished data). It appears these nests were destroyed by fishing communities (usually fishing illegally) in retaliation for net damage. Worse for the crocodile population in the area is the entanglement and death of adult crocodiles in fishing nets. No data are available on the magnitude of this problem, although it is known to occur frequently.

Clearly, rural communities should be involved in Zimbabwe's crocodile conservation policy, but providing them with a tangible benefit from it is not simple. Crocodile eggs are delicate and their collection by largely uneducated rural people proved unsatisfactory when tested. Suggestions that rearing stations should pay for eggs have been resisted where the nests are on land with communal tenure, because, again, the benefits would not accrue

[1]Department of National Parks and Wild Life Management, P.O. Box 8365, Causeway, Harare, Zimbabwe.
[2]Crocodile Farmers Association of Zimbabwe, P.O. Box 2569, Harare, Zimbabwe.
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directly to the individuals most affected by the crocodiles. In 1985, a number of people living along stretches of the Zambezi River where crocodiles were most unpopular, were employed by the rearing stations to act as "wardens". Their task was to both locate and protect crocodile nests until the eggs could be collected. In addition, the Department is undertaking a sociologically orientated study of the problem.

Magnusson (1984) made a number of observations regarding the captive propagation of crocodilians in general, and concluded that for species with low value skins, such as *Caiman crocodilus*, neither farming nor ranching was likely to be economically viable. Unfortunately, the impression is given that crocodile farming and ranching *per se* are of dubious value, when in fact these methods of exploiting species with high quality "classic" skins are in many ways preferable to direct hunting of wild populations.

Commercial rearing stations in Africa are almost all privately funded and impinge little, if at all, on the limited budgets allocated to government wildlife agencies. Capital investment in rearing facilities creates a commitment to sustained-yield harvesting, perennial employment and honesty in trade. If correctly managed, a harvest of eggs will yield many more skins than a harvest of live animals; mortality of wild eggs and juveniles can exceed 95% and the killing of adults erodes the reproductive "capital" of the population. In addition, any "mistakes" in the calculated levels of exploitation are likely to be far less serious to the population if only eggs and/or hatchlings are being harvested. From the viewpoint of the total value of a crocodile industry, the size and quality of skins can be controlled on rearing stations, and the time of slaughter can be varied to take advantage of short-term market fluctuations.

The role that rearing stations play in public education should not be dismissed lightly. Many thousands of people visiting crocodile farms and ranches realize for the first time that there is an economic value in having sound crocodile conservation programmes.

TECHNOLOGY

Egg Collection

Blake (1974, 1982) described the methods of collecting and handling eggs that are used in Zimbabwe, and a similar system continues today, with the exception that aircraft are being used increasingly to locate nesting females.

Eggs are collected after they have been developing for some 50 days in the wild nests. Although not rigorously tested, experienced collectors maintain that the probability of embryonic mortality is highest in eggs collected during the first few weeks after laying. In addition, "late" collection allows dead, infertile and badly damaged eggs to be rejected, and thus these do not accrue against the quota.

A disadvantage of this strategy from the point of view of optimising the egg harvest, is that by the time of collection a significant proportion of eggs have already been lost to predation (unmeasured along the Zambezi River, but up to 40% elsewhere in Zimbabwe) and perhaps other causes. "Early" collection would allow these eggs to be utilized, and would allow more eggs to be collected for the same impact on the wild populations. In addition, there is mounting evidence that incubation conditions strongly influence the subsequent growth and survival of hatchlings (see Lang Chapter 30 and Joanen *et al.* Chapter 51). With optimum incubation conditions and "early" egg collection, it may be possible to exert control on a hatchling's future performance; this possibility is currently under investigation.

Some stations are now collecting the eggs laid in captivity as soon as they can (before the embryo has attached to the shell membrane), and incubating them artifically for the full period of development. However, because of the vast areas over which wild eggs are collected in Zimbabwe, it will never be possible to collect them within a few hours of laying. But even this may not be as critical as is commonly believed. In Zambia, flooding of the Luangwa River necessitates that eggs be collected early, within a few weeks of laying, yet egg mortality has been low (K. Asherwood, unpublished data). Earlier collection may be practical in Zimbabwe and, if so, will be encouraged.

Since 1969, rearing stations have been required to submit information on the fate of every clutch collected to the Department (see Child Chapter 6), but as yet there has been no quantification of collecting efficiency, natural predation and hatching success, nor even the mapping of the exact location of nests. Stations are now assisting the Department to get this information.

Incubation

Similar incubation techniques are used on each of the rearing stations. Eggs are packed in moistened vermiculite or sand within styrofoam boxes (Blake 1982). These are stacked, approximately 30 cm apart, on wooden shelves in a room that by various means has its temperature maintained between 28°C and 34°C. Experience has taught that heating is easier and more accurately controlled than cooling.

With the exception of one or two notably poor seasons, four of the five rearing stations regularly achieve an 80-95% successful hatch of wild eggs. Given that most of the embryonic development

within these eggs takes place under natural conditions, it is unlikely that better hatching success can be achieved with the "late" collection strategy employed.

Under the present system, precise temperature control within the incubation rooms is difficult to attain and short-term extremes are prevented by the buffering effect of the vermiculite or sand used as packing. One station, planning to incubate eggs with a view to maximizing hatchling survival, has built a simple, inexpensive and more efficient incubator, in which hatching success to date has been excellent (R. Lowe, unpublished data). This incubator is a small (10 m^2 floor), well insulated room which is plastered and painted with enamel for hygiene. The eggs are stacked, without packing medium, in shallow plastic trays. High humidity is maintained either by a continuous flow of water or by having sufficient standing water. Temperature is controlled by a fan-heater, with a sensitive thermostat, and is constant to within ±0.5°C. If high hatching success continues, all rearing stations may eventually switch to this type of incubator.

Hatching

At the time of collection, the eggs within a wild clutch commonly contain embryos at different stages of development (Hutton 1984; Pooley 1969); this is partly due to differences in the incubation environment at different levels through a wild nest (Hutton 1984). When hatching occurs, it may do so over a period of several days or even weeks if the hatchlings are allowed to emerge undisturbed. Blake (1974) reported premature hatching, but this was largely the result of assisting the hatching of embryos not yet fully developed. The "croaking" sound that emerging hatchlings make will stimulate neighbouring fully developed embryos to both "croak" and hatch, but it is unclear whether or not it induces premature hatching — some stations isolate boxes of "croakers", whereas others leave them amongst the developing clutches.

The recommended procedure at hatching is as follows. Hatchlings which emerge unaided are washed and toe-clipped with a clutch-specific sequence. Each clutch of hatchlings is then placed in a dry concrete pen or plastic tray (approximately 1 m^2, within a hygienic, well ventilated room which is disinfected daily. Here they are allowed to "harden-off" for 24-48 hours at temperatures of 30-33°C. Eggs that do not hatch spontaneously may be assisted, and if so, assisted hatching is carried out under strictly hygienic conditions. Premature hatchlings and those with abundant residual yolk for different reasons, are given an extended "hardening-off" period. They are kept dry except for a short daily swim in clean, shallow water dosed with tetracycline (20 mg l^{-1}).

The above procedure has improved immediate post-hatching survival, but as yet, not all stations follow it.

Care of Hatchlings

The quantity and quality of crocodiles surviving to the end of their first year of life has shown great variation both between and within stations — mortality on the most successful station has ranged from 5 to 55% in consecutive years.

Hatchlings are very susceptible to stress. Garnett (1983) quantified the effects of handling stress on *Crocodylus porosus* hatchlings, and Lang (see Chapters 28 and 30) reviews information on stress caused by temperature and social behaviour considerations. The following are considered to have contributed to stress in Zimbabwe, and consequently to have increased mortality on the rearing stations: extreme temperatures (high and low); overcrowding; rough handling; inadequate size grading (resulting in dominance hierarchies being established); inadequate attention to routine (feeding, cleaning etc.); and, inadequate nutrition.

Temperature is very clearly a factor contributing to mortality. Extremely high temperatures stress crocodiles, and death occurs at body temperatures around 40°C. However, the main problem in Zimbabwe relates to temperatures being too low. More hatchlings die in September, at the end of the cool season, than in February, immediately prior to the cool season, or November when the hot season is well advanced. Low cool season temperatures suppress appetite, digestion and growth. As noted by Blake and Loveridge (1975), if ponds are heated, there is a substantial reduction in mortality and an increase in both food consumption and growth.

All rearing stations appreciate the importance of inadequate temperatures and have attempted to overcome them in different ways. Unfortunately, it is not certain how effective their efforts have been, and what are considered optimum temperatures for *C. niloticus* in Zimbabwe may still be underestimated. Coulson and Hernandez (1983) report that the ideal temperature for maximal appetite and growth in *Alligator mississippiensis* may be as high as 32°C, whereas "At temperatures below 25°C, appetite is reduced greatly and below 20°C, is gone entirely. Renal impairment is seen at any temperature below 18°C . . .". Lang (see Chapter 30) recommends that temperatures between about 25°C and 35°C should be available to captive crocodilians, so that they can select their body temperatures. In Zimbabwe a constant temperature of 32° is preferred.

Although inadequate temperatures and other sources of stress are commonly the predisposing factors in mortality, the ultimate cause of death is usually disease (see Foggin Chapter 36), which can often be avoided with appropriate management.

In order to reduce stress generally, the Department currently favours small, outdoor, concrete pens, each about 3 x 3 m and stocked with 50

hatchlings. These are considered superior to the larger pens holding 200-300 animals at the same density. Within the smaller pens temperatures are more easily regulated, hygiene can be strictly maintained and disease control is more efficient. Insulating the concrete of the pool and walls, and covering pens with black plastic sheeting when the ambient temperatures begin to fall, can maintain higher temperatures at night (Siziba 1985). Overheating can be prevented with shade cloth arranged to provide a mosaic of full shade, 50% shade and full sunlight over both the water and surrounding land. It is recommended that strict feeding and cleaning routines be maintained, and that the pens be cleaned daily, disinfected weekly, and always refilled with clean bore or domestic water.

Hatchlings are moved into these pens in early January after the "hardening-off" period. They are graded in March/April before the onset of the cool season, and again in October, when the hot season is well advanced and they are being moved to new accommodation. The hatchling pens are then sterilized with formalin and sun-baked for as long a period as possible before the next batch of hatchlings is introduced into them.

Experience has shown that regardless of the facilities available, or the quality of information and extension services, hatchlings will only be raised successfully if their management is approached seriously and without compromise — they require "first-rate" management.

Care of Rearing Stock

Blake (1974) described the variety of pens used for rearing stock (yearlings and older). Each design has proved adequate, but a double concrete pond results in an equal distribution of animals and a minimum of stress during cleaning. Adjacent ponds are drained, cleaned and refilled on alternate days and the crocodiles are thus never denied access to water. Corners and vertical sides are avoided, and oval ponds with a saucer shaped profile are considered most effective. As with hatchling pens, a mosaic of shade is provided. Separate feeding platforms are being built on some stations, which allow the crocodiles to retreat into a trough of shallow water with their food, lessening contamination of the main pond.

Some stations have earthen "finishing" ponds, but the belief that these promote better growth than concrete pens has still to be substantiated. However, earthen ponds are inexpensive and when properly managed do not appear to be less successful than concrete ones. If management is inadequate, efficient cropping is difficult in earthen ponds and problems of hygiene, burrowing and escape may be encountered.

Feeding

Blake (1982) noted that the diet of captive crocodiles in Zimbabwe is virtually restricted to kapenta (*Limnothrissa miodon*), a sardine-like fish, and game meat (particularly elephant) obtained as a by-product of controlled hunting and on-going population reduction programmes.

On most stations, fresh kapenta is favoured for hatchlings. If only red meat is fed, deficiency syndromes soon appear and a supplement of vitamins, calcium, trace elements etc., is always added. Continual monitoring of food quality is encouraged, and some stations even add a supplement to fresh kapenta.

As noted by Magnusson (1984), the political climate of Zimbabwe has changed and the human population is growing rapidly. Although the financial justification of crocodile farming is unlikely to change, social pressures against the continued feeding of crocodiles with game meat are anticipated and alternative sources of protein are being examined. One station is diversifying into ostrich farming with a view to producing skins (for the luxury leather trade) and meat to maintain the production of crocodiles.

Cropping, Flaying and Curing

Blake (1982) described the manner in which cropping occurs, and Van Jaarsveldt (see Chapter 39) discusses flaying and curing in a separate chapter.

EFFICIENCY AND MARKETING

Efficiency, the proportion of incubated eggs which results in saleable skins, varies greatly between stations, but is generally low relative to conventional agricultural production (Hutton and Brennan 1985). An annual average of 9600 eggs were collected by stations in the years 1978 to 1982, while an average of 3400 animals were cropped in 1983 and 1984; an efficiency of about 35%. This is considered unsatisfactory by both the Department and the Crocodile Farmers Association of Zimbabwe (CFAZ), and as a result, a set of minimum standards are being established for each stage of the rearing process. Any station which does not consistently achieve these standards will be penalised by a reduction of its quota of wild eggs. An overall efficiency of 80% is anticipated and by 1987, with increased eggs from captive stock, an estimated 10,000 skins should be produced annually.

The Department has requested that all crocodiles and their derivatives be marketed under the auspices of the CFAZ, in order to establish a centralized marketing system. The CFAZ also recommends maximum egg quotas for each station.

Marketing is regularly reviewed and revised. For example at a recent meeting of the Department and the CFAZ it was agreed that live exports of *C. niloticus* would be restricted to animals of cropping size and the occasional large males for display purposes. From the point of view of marketing, an obvious area of concern is that the industry as a whole needs a better understanding of the intricacies of world trade in crocodilian skins.

EXTENSION AND RESEARCH

The industry is provided with extension services by the Department of National Parks and Wild Life Management, which employs a full-time crocodile specialist, and the Department of Veterinary Services. However, recommendations are often based on personal experience and on the published findings of others, as on-site research is continually hampered by a shortage of funds, a lack of experimental facilities, the remoteness of stations and a lack of scientific expertise on the part of station management in general. Recently, the CFAZ has provided experimental facilities, and two stations have acquired managers with scientific training. Critical problems have been identified and an extensive research programme is being planned.

CONCLUSION

The crocodile industry in Zimbabwe is largely dependent on eggs from the wild crocodile population, and inexpensive meat from the cropping of game animals. The future of both commodities is now threatened by Zimbabwe's burgeoning human population. To allow the industry to expand and to buffer it from unfavourable quota decisions, the keeping of captive breeding stock is being encouraged. More emphasis is also being placed on "grassroots" involvement in the crocodile industry, of poor rural communities. While the use of game meat is likely to remain economically justifiable, social pressure is being anticipated and alternative food sources are being investigated. It is expected that food, rather than the availability of eggs, will limit the size of the crocodile industry in Zimbabwe.

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REFERENCES

BLAKE, D. K., 1974. The rearing of crocodiles for commercial and conservation purposes in Rhodesia. *Rhodesia Science News* 8: 315-24.

BLAKE, D. K., 1982. Crocodile ranching in Zimbabwe. *Zimbabwe Science News* 16: 208-9.

BLAKE, D. K. AND LOVERIDGE, J. P., 1975. The role of commercial crocodile farming in crocodile conservation. *Biol. Conserv.* 8: 261-72.

COULSON, R. A. AND HERNANDEZ, T., 1983. "Alligator Metabolism. Studies on Chemical Reactions *In Vivo*". Pergamon Press: London.

GARNETT, S. T., 1983. Nutrition and farm husbandry of the green sea turtle *(Chelonia mydas)* and the estuarine crocodile *(Crocodylus porosus)*. Unpublished Ph.D. Thesis, James Cook University of Northern Queensland, Townsville, Australia.

HUTTON, J. M., 1984. The population ecology of the Nile crocodile *Crocodylus niloticus* Laurenti, 1768, at Ngezi, Zimbabwe. Unpublished Ph.D. Thesis, University of Zimbabwe, Harare, Zimbabwe.

HUTTON, J. M. AND BRENNAN, S. L., 1985. An analysis of records of the crocodile rearing industry in Zimbabwe. Internal Report to the Branch of Terrestrial Ecology, Dept. Nat. Parks Wild Life Manag., Harare, Zimbabwe.

MAGNUSSON, W. E., 1984. Economics, developing countries, and the captive propagation of crocodilians. *Wildl. Soc. Bull.* 12: 194-7.

POOLEY, A. C., 1969. Preliminary studies on the breeding of the Nile crocodile, *Crocodylus niloticus* in Zululand. *Lammergeyer* 10: 22-44.

SIMMEDICK, B. M., 1979. Conservation and utilisation of the Nile crocodile *(Crocodylus niloticus)* in Zimbabwe. Proc. 3rd Ann. Symp. on Captive Propagation and Husbandry. 10-11 August 1979, Knoxville, Tennessee.

SIZIBA, C., 1985. Design of pens for hatchling crocodiles. Unpublished Honours Thesis, Department of Engineering, University of Zimbabwe, Harare, Zimbabwe.