CHAPTER 6

The Management of Crocodiles in Zimbabwe

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THE Nile crocodile, *Crocodylus niloticus* (Laurenti 1768), is the only crocodilian native to Zimbabwe a small landlocked country on the great southern African Plateau, where it forms the watershed between the Zambezi and Limpopo Rivers. Although the whole country lies within the tropics, the climate in much of it is mild, due to altitude, and this affects the distribution of crocodiles. Their range prior to 1900 has not been documented, but it is safe to conclude that they occurred along all suitable rivers up to 1500 m above sea level, with reliable annual breeding below 1200 m.

Rapid human population growth, from around 700,000 people in 1900 to some 8.25 million today, has not greatly affected this range, although there has been a marked reduction in numbers and some loss of habitat. Against this, crocodiles have benefitted from the construction of numerous dams, especially those located below 1500 m.

Crocodylus niloticus is reported as widespread and common in much of Africa south of the Sahara, although it is limited to areas where habitats are suitable and where it can be tolerated by people. Numbers appear to be generally low in West Africa. The International Union for the Conservation of Nature and Natural Resources (IUCN) lists the species as endangered (Honegger 1979; Groombridge 1982; IUCN 1982) and it is on Appendix I of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), apart from the Zimbabwean population which is acknowledged as being "out of danger" and which was transferred to Appendix II in 1983 (CITES 1984a).

The Nile crocodile was placed on Appendix I prior to the acceptance of the "Berne Criteria" (CITES 1976; Conference Resolutions 1.1, 1.2 and 1.3) for listing, delisting or transferring species between the CITES appendices. Many African Parties to CITES question the appropriateness of the Appendix I listing for *C. niloticus* and at least four, including Zimbabwe, entered a reservation against it when they became parties. At a recent meeting in Brussels (CITES 1984b), the 24 African parties present unanimously agreed to try and have *C. niloticus*, throughout its range, transferred to Appendix II. Each nation would then agree to preset an annual export quota, to better control international trade, while countries concerned with the status of their populations could nominate a zero quota.

This chapter describes crocodile management in Zimbabwe within the setting provided by the species' biology and the country's philosphy towards the conservation and use of wildlife, as provided for in legislation and in the supplementary policy directives flowing from it. Zimbabwe recognises wildlife, in most of its many and varied forms, as a renewable natural resource which can and should be used correctly for the benefit of both the resource and the people on whose land it occurs. Depending upon the land-use policy for a given piece of land, such use may be consumptive or non-consumptive and, in the case of consumptive use, the benefits are often economic through the marketing of the animals or their products.

Crocodile conservation has benefitted greatly in Zimbabwe through the commercial use of the species, mainly through crocodile rearing stations operated by private enterprise under strict Government supervision. It was for this reason that the Department of National Parks and Wild Life Management, which is both the Scientific and the Management Authority for Zimbabwe in terms of CITES, worked hard to have the crocodile population transferred from Appendix I to Appendix II at the Fourth Meeting of the Conference of the Parties in Gaborone in 1983 (CITES 1984a). Had we failed, it would have represented a major set-back for the conservation of our crocodiles, with every likelihood of them degenerating into agricultural pests,

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Pages 49-62 *in* WILDLIFE MANAGEMENT: CROCODILES AND ALLIGATORS ed by Grahame J. W. Webb, S. Charlie Manolis and Peter J. Whitehead. Surrey Beatty and Sons Pty Limited in association with the Conservation Commission of the Northern Territory.

with irresistible, emotionally-charged political demands for their extermination outside protected areas.

LIFE HISTORY

In Zimbabwe, Nile crocodiles lay their eggs in September, in a hole-type nest next to permanent water. The mean clutch size on Lake Kariba is 45 eggs (Blake 1974), but as the number of eggs in a clutch is a function of female size and age (Cott 1961; Hutton 1984) this mean is likely to change with the age structure of a population. If undisturbed, females attend their nest until the eggs hatch, about 90 days later. Incubation may be extended where temperatures are suboptimal (Blake and Loveridge 1975; Hutton 1984). The temperature of incubation also determines the sex of hatchlings. In areas of Zimbabwe above 900 m incubation temperatures are suboptimal and females predominate (Hutton 1984). Egg losses may be high, mostly due to predation by the Nile monitor, *Varanus niloticus*, and are enhanced when attendant females are disturbed by human activities like boating. Catastrophic losses can occur; in one year almost all eggs in one part of Lake Kariba were lost due to a severe hail storm.

Hatchling mortality is probably more than 95% in all wild populations (Blake 1974; Blake and Loveridge 1975; Hutton 1984) and although subsequent juvenile mortality is reduced, they remain susceptible until about 1.2 m total length (Hutton 1984). Where growth is slow, a high probability of mortality may exist for six or more years.

Both sexes generally attain sexual maturity at sizes over 2.5 m total length. However, differences in growth rates both within and between populations, mean that this may take 10 to 35 years. Temperature, through its effect on growth and sex ratios, has a profound effect on the population dynamics of these animals (Hutton 1984).

The Nile crocodile is an opportunistic feeder. Arthropods predominate in the diet of juveniles, but are replaced by increasingly large vertebrates as the animals grow (Cott 1961; Hutton 1984). Predation on humans and their livestock is quite substantial and hardly a year passes without several human fatalities. Indeed, crocodiles cause more human deaths in Zimbabwe than all other wild animals combined (Castle 1971; Hutton, unpublished data).

HISTORICAL PERSPECTIVE

There has always been conflict between crocodiles and the rural people who depend on natural water bodies for their domestic needs and for those of their livestock. This has intensified with human population growth, especially since the mid-1940's when numbers entered a phase of exponential growth. Loss of habitat and habitat deterioration have been partially off-set by the appearance of numerous dams, especially since 1950.

Zimbabweans have no tradition of eating crocodiles or their eggs, but the destruction of both was viewed, and still is in some areas, as a social service to the community. Historically, this type of hunting probably had little effect on either the numbers or their distribution. Wholesale destruction of Nile crocodiles, for their skins, commenced soon after the Second World War and peaked in the 1950's. Many accessible populations were brought to the point of extinction. For example, few animals over 1 m long survived along the parts of the middle Zambezi now submerged by Lake Kariba. In over two years of intensive fieldwork in the area (1959-1961), I saw tracks and individuals amounting to no more than a dozen individuals.

From 1961 crocodile numbers have recovered in response to legal protection and a pragmatic management policy. Today Nile crocodiles are once again widespread and relatively abundant in areas where they can be tolerated. The nation-wide population is estimated at over 50,000 individuals in the wild with another 28,625 in captivity at the end of December 1983.

LEGISLATION AND MANAGEMENT OBJECTIVES

Crocodiles received a measure of legal protection throughout Zimbabwe with the promulgation of the *Wild Life[1] Conservation Act*, early in 1962. Before that they were protected in National Parks, which were the only class of protected area. National Parks then covered 4.3% of the country and included little suitable habitat for crocodiles. From 1961 the foundations were laid for the present Parks and Wild Life Estate which recognises six classes of protected area, includes 12.7% of Zimbabwe, and contains substantial prime crocodile habitats.

Crocodile numbers responded immediately as skin hunting declined to zero, although many local communities remained hostile towards the species. The *Parks and Wild Life Act*, 1975, broke with traditional wildlife legislation in Africa and, apart from consolidating the present system of protected areas, conferred the "ownership" of most wildlife onto the landholder on whose land it occurred. Mechanisms exist to prevent abuses, but in general, landholders have the discretion of using their wildlife as they deem best. All benefits from such use accrue to them, and there are no State hunting licences nor country-wide hunting seasons (Child 1977, 1983).

Footnote: [1] Wildlife remains as two words in the legal sense in Zimbabwe.

The rationale behind this legislation is that there is no-one better able to conserve wildlife than the person on whose land it occurs. Also, the motivation for conserving wildlife, even if basically for aesthetic or emotional reasons, can be compounded if it can be fortified by an economic justification. The legislation recognises that it is impractical to attempt to safeguard a species through legislation and law enforcement alone, unless local people are at least tolerant towards it. Many species are easily eliminated without breaking the law, by using means such as fences or habitat manipulation.

Law enforcement can be largely ineffective if it is against public opinion. This is especially true of large predators like crocodiles, lions (*Panthera leo*), leopards (*P. pardus*), and cheetahs (*Acinonyx jubatus*), or large dominant herbivores such as elephants (*Loxodonta africana*), which seriously compete with legitimate human livelihoods. Unless the people on whose land these animals occur can derive some benefit from them, the animals are no more than pests and are of less value than the few maize plants they destroy or the occasional scrub goat that they may kill. As such, they are destroyed at every opportunity.

Few Governments in Africa, at least, are in a position to ignore human interests in favour of those of animals. As a consequence, actions to conserve a species must be justifiable in terms of its value, in tangible human terms, at the national and, more particularly, at the local level.

The concepts finally embodied in the 1975 Act were tested over the previous 15 years and have now been applied for nine years. There can be no doubt that they have favoured wildlife conservation on privately owned land. With the increasing contribution of wildlife to the national economy, more land has been set aside for nature conservation and budgetary allocations have increased. People, including decision-makers and farmers who were opposed to most wildlife on farms, now tolerate or actively encourage and conserve it, often because of its economic value.

The correct use of wildlife has emerged as an economically significant form of land use, especially in areas of low agricultural potential (Child 1984). It provides one of the few opportunities for countering land degradation and gives an alternative means of achieving sustainable rural production, especially on marginal farmland. If the 1975 legislation has produced a problem, it is that private land-holders have been encouraged to permit their land to become overstocked with wildlife through under-harvesting.

Different problems apply on communally occupied land, where wildlife is a communal asset and where the provisions of the Act have been applied effectively for only four years (since Independence in 1980; Child 1983). These problems are not unique to Zimbabwe nor to Africa in general, but it is interesting that despite them, the application of this philosophy has resulted in some very positive public responses. These include the setting aside of protected areas by communities that could ill-afford to lose productive land.

It would be foolish to be over-optimistic too early, in what is an ongoing process affecting the livelihoods of poor people. However, it is fair to conclude that because of the rationale behind the Zimbabwean legislation, it has a better chance of success than any dictatorial measures imposed by a central government treating wildlife as government property. This attitude, enshrined in so much legislation around the world, singles out wildlife, especially terrestrial vertebrates, for different treatment from the other renewable resources in the ecosystems of which it is an integral part. The logic behind such treatment, which ignores ecological realities, is obscure, unless perhaps it is based on pure emotionalism.

It is interesting that the spirit of CITES, as enunciated in the preamble to the Convention, and which we knew nothing about when we drafted our legislation, has a very similar tone. The Convention clearly recognises the central role of the people on whose land a species occurs, in the conservation of that species. It sets out to provide a very valuable tool for extending such domestic efforts, by controlling international trade in the species and their derivatives. Unfortunately the strong inherent qualities of the Convention are being seriously undermined by two opposing forces. On the one hand it is being discredited through its lax application by certain Parties (CITES 1984a), which is especially disturbing when these Parties include major consuming countries. Of equal, or even greater concern to the viability of CITES, are those nations which have stricter domestic measures for the importation of the derivatives of non-indigenous species, than are required by CITES.

In the case of Zimbabwe's crocodiles, the domestic legislation is implemented in terms of guidelines contained in a formalised Policy Document (see below), which represents a ministerial directive and takes into account our international obligations as defined by CITES. Examination of this document shows that the harvesting of crocodiles and their eggs from the wild is to be strictly controlled. This control is exercised in all protected areas, apart from National Parks where the species is fully protected, as well as in a number of gazetted rivers. Action is in hand to extend this protection to all rivers, but in a fashion that does not undermine the spirit of the legislation.

POLICY — CONSERVATION AND MANAGEMENT OF CROCODILES

1. Background

1.1. It is generally accepted that the crocodile is a key component in many aquatic ecosystems; is a valuable natural asset as a source of high grade leather, if wisely exploited; is a valuable tourist attraction, and is of immense scientific interest as the only surviving member of the long extinct archosaurian group of reptiles. It may also be a problem animal and conflict with genuine human interests under certain circumstances, but is vulnerable and comparatively scarce in parts of Zimbabwe (and elsewhere in Africa) due to past over-hunting and the modification of its essential habitats.

Zimbabwe does, however, still have significant populations, whose conservation is sensible, practical and profitable, provided that the resource is afforded adequate protection leading to proper scientific management wherever this is appropriate.

2. Policy

2.1. Crocodiles will be fully protected in all National Parks with a view of nurturing optimum populations commensurate with the availability of suitable habitats. This protection will ensure that significant breeding sites are demarcated against undue human disturbance. In most Recreational Parks, crocodiles will be tolerated only in so far as their presence is compatible with the recreational activities permitted in each such Park. Those in Ngezi Recreational Park will be afforded similar protection to that enjoyed by populations in National Parks while crocodiles and their rationalised use will be encouraged where appropriate in Lake Kariba.

2.2. Crocodiles will be conserved in all Safari Areas and on all land and in any water for which the Department is directly responsible for the control of the wildlife resource, including those rivers where the hunting of crocodiles is regulated in terms of section 2.3. of this document. Conservation of wild populations as applied in this section shall be directed towards the optimised exploitation of the populations, wherever this is compatible with legitimate human interests and the requirements of this document and shall take into account the following constraints:

(i) The Director will not authorize the harvesting of wild crocodiles as the basis of a skin industry, unless he is satisfied that this can be undertaken on a sustained and economic basis, or is necessary for management;

(ii) Any hunting of crocodiles for recreational purposes will be in line with the spirit and the requirements of section 2.5. of this document; and,

(iii) The harvesting of wild laid eggs will be strictly controlled and in accordance with the criteria laid down in section 2.4.

2.3. The conservation of wild populations will be encouraged throughout the country, where appropriate, but where necessary or desirable the exploitation of any significant wild populations in any river in Zimbabwe will be regulated in terms of section 48 of the Parks and Wild Life Act, 1975. These measures will apply especially to those rivers having crocodile populations which are shared on a year round basis by one or more properties or land classes. However, their implementation will seek a realistic compromise between all interested parties, taking overall national and regional interests fully into account.

2.4. The harvesting of wild laid eggs in any area mentioned in 2.2. will be only by permit issued by the Director in relation to a predetermined quota or quotas for any given season. Except where the collection of eggs is authorised for research purposes, the collector will undertake to make available to the Department suitably sized crocodiles for conservation purposes. The number of such crocodiles will be calculated as 5 per cent of the eggs harvested, or permitted to be harvested, and their sizes will be determined by the Director. They will be used for restocking denuded habitats, augmenting wild populations, departmentally sponsored research, or for meeting the Department's international obligations as set out in section 2.10.

2.5. Problem crocodiles in serious conflict with legitimate human interests will be destroyed where it is not possible to capture them for relocation elsewhere or for breeding and research purposes. Mature crocodiles, and more especially large individuals, represent a considerable biological investment and their destruction under any circumstances will be discouraged. Where they become problem animals every effort will be made to effect their capture.

2.6. The Departmental Interpretative Service will seek to educate the public as to the biological and economic value of crocodiles and in so doing will aim to counteract the public stigma often directed against them.

2.7. Commercial rearing stations will be encouraged, but their number will be limited where their activities are dependent upon the

Table 1. Permits for crocodile rearing stations issued in Zimbabwe. "*" indicates the stations from which most of the information on rearing in this Chapter has been derived.

NAME	LOCATION	OPERATIONAL (i.e. Permits Valid)
1. M. J. Fullerton	Binga, Lake Kariba	Dec. 1965 to Dec. 1967
2. Kariba Crocodile Farm*	Kariba, Lake Kariba	Dec. 1965 to present
3. R. F. Baxter	—	April 1966 to Dec. 1966
4. C. Bower	Karoi	Aug. 1966 to Dec. 1967
5. Binga Crocodile Farm*	Binga, Lake Kariba	Aug. 1967 to present
6. Mini Crocodile Farm	Mlibizi R, Lake Kariba	Oct. 1967 to Dec. 1969
7. Spencer Creek Crocodile Farm*	Victoria Falls	Jul. 1971 to present
8. Sengwa Mouth Rearing Station*	Sengwa R, Lake Kariba	Oct. 1977 to present
9. Rokari Rearing Station*	Bumi R. Lake Kariba	Nov. 1981 to present
10. V. H. Bristow	McIlwaine/Harare Area	Nov. 1983 to present

contained the necessary safeguards. This was a bold decision when it is recalled that crocodile populations were then only just recovering after the heavy commercial hunting of the 1950's. Little was known of the biology of the species, its management in the wild or in captivity, and the concept of sustained economic use of wildlife was in its infancy. The economics of managing African wildlife, except as a tourist attraction or source of valuable hunting trophies, had yet to be adequately demonstrated.

A clerical officer who was a keen amateur herpetologist with a special interest in chelonians, and who understood the emerging Departmental determination to test the economic potential of wildlife as a tool for its proper conservation and use, was appointed to lead the crocodile management programme. This may be hardly a point to include in a somewhat technical chapter, yet it is highly relevant to this case study. It is on such thin threads that technical advances so often hang when an emerging concept is being pursued in an emerging country. But for the decisions to test the concept and to appoint a committed person to undertake it, it is unlikely that the conservation of Nile crocodiles and our knowledge of the species, would have developed anywhere near as quickly as it has. Full credit is due to the bureaucrat, P. J. Evans, to the former clerical officer with a love for reptiles, D. K. Blake, and to the pioneer crocodile farmers for spawning and nurturing the highly technical management programme outlined below.

Uses of Wild Crocodile Populations

Besides their value in conservation and as tourist attractions, wild crocodile populations are used in three ways in Zimbabwe:

1. Very small numbers of large animals (3 to 5 per year) are offered as huntable trophies;
2. Problem animals are caught where possible and used as breeding stock in rearing stations, or if surplus, are exported to approved institutions (e.g. surplus large males for display purposes); and,
3. Annual quotas of eggs are harvested to provide what is still the main source of stock on the rearing stations.

Harvesting of Eggs and Young

The practice of capturing young crocodiles for raising was stopped after about 500 animals had been caught during the first four years of the programme (1966-1969) (Blake 1974). These animals had survived early juvenile mortality, were expensive to catch and took a considerable time to "settle" under captive conditions.

Permits to collect a quota of eggs are now issued annually to each rearing station. In effect these permits allocate a collecting area, thereby preventing local over-harvesting. The issue of a permit is subject to satisfactory performance over the previous year and to the Department being assured that the wild population in question can sustain the harvest. Stations prefer to collect eggs in early November, 50 to 60 days after laying, when embryonic development is sufficiently advanced and the embryos can withstand relatively rough treatment. Nesting grounds are often remote and eggs need to be transported by boat and/or over rough roads. Collecting eggs at such a late stage avoids both late embryonic and early post-hatching mortality, which are high in the wild (Cott 1961), but does not avoid early embryonic losses, which can result from predation, flooding (which usually occurs later in the season) and other causes.

Nests are located with a probe and only fertile eggs that appear to be alive are collected and counted against the quota. Individual clutches are packed in leaves (or other suitable material) in styrofoam boxes, with the nest orientation of each egg maintained (to minimise damage to embryos). Details of total clutch size, numbers of eggs collected and rejected, nest characteristics and any other relevant observations are recorded on an individual nest data sheet, which has provision for subsequent incubation details.

Incubation

At the rearing stations, clutches are repacked into stryofoam boxes containing moistened vermiculite (an extremely light micaceous ore), and are then incubated in insulated buildings at approximately 32°C. The progress of the clutches and the eventual hatching success is entered on the record card. Blake and Loveridge (1975) reported 73.6% successful hatching (up to 1973), but 88.6% is now being achieved on the five stations in full operation. This increase reflects improvements in both selecting and handling live eggs.

Hatching occurs in late December and hatchlings are placed immediately into well-shaded, clean, temporary pens (or styrofoam boxes) for a few days. This acclimation period allows the yolk sac to be resorbed; they are not fed at this stage.

Rearing

Batches of 200 to 300 hatchlings are placed into rearing pens, the preferred type of which has two concrete ponds (10-15 m long by 1.5 m wide by 60 cm deep); one always contains water for the hatchlings while the other is drained and cleaned. At nine to ten months of age they are transferred to larger pens, which allows the hatchling pens to dry out and "sterilise" in the summer sun, in readiness for the next season. Seventy to eighty per cent of hatchlings normally survive into their second year, although several stations have experienced at least one year in which mortality was higher.

After their first year or so, young crocodiles are grouped by size rather than age, which ensures a better distribution of food among individuals within a pen. The pens used at this stage are about 20 × 8 m with good shade. Each pen has a central concrete pond about 1 m deep with gravel or grassed surrounds. The pens are cleaned regularly and stocked with 150 to 200 "yearlings", which is reduced to 75 to 100 as the animals approach slaughter size.

Earthern ponds were experimented with because they were perceived as being more "natural". The crocodiles burrowed into the banks making control difficult, and the pens were difficult to clean. Never-the-less, some evidence suggests growth may be enhanced in the last year before slaughter if animals are placed in earthern ponds (see Blake 1982).

Ambient temperatures, hygiene and the quality of the food have all proved to be important husbandry considerations. The foods used by individual stations are largely determined by availability, but a minced mixture of whole fish (e.g. the Lake Tanganyika sardine, *Limnothrissa miodon*) and red meat, with a vitamin supplement (especially Vitamin A), has proven satisfactory. The ratio of fish to meat in such mixtures is varied, being high for hatchlings and predominantly red meat for older rearing stock.

Cropping

Crocodiles are usually slaughtered when about 1.5 m long, when the belly skin is about 35 cm wide, but this varies with market demand and other factors. Each animal is shot in the head with a 0.22" short bullet, which causes minimum disturbance to others in a pen. The carcass is washed thoroughly before the back skin is removed ahead of the belly skin. Both portions are then layered in salt for at least 24 hours before the belly skins are rolled and kept in a cold room ready for export. Heads and feet are made into tourist trophies and the eviscerated carcasses are fed back to the crocodiles. No market for meat has yet been established.

Captive Breeding

Despite initial reservations about the costs of keeping breeding stock, the rearing stations now hold significant numbers of breeding adults (278 in 1984; Fig. 1) which produce an increasing proportion of their annual egg requirements (Fig. 2). Breeding stock has come from captured problem animals, selected animals grown-out for that purpose and, in the last year, animals caught specifically for that purpose by the Department (Blake and Coetsee 1984).

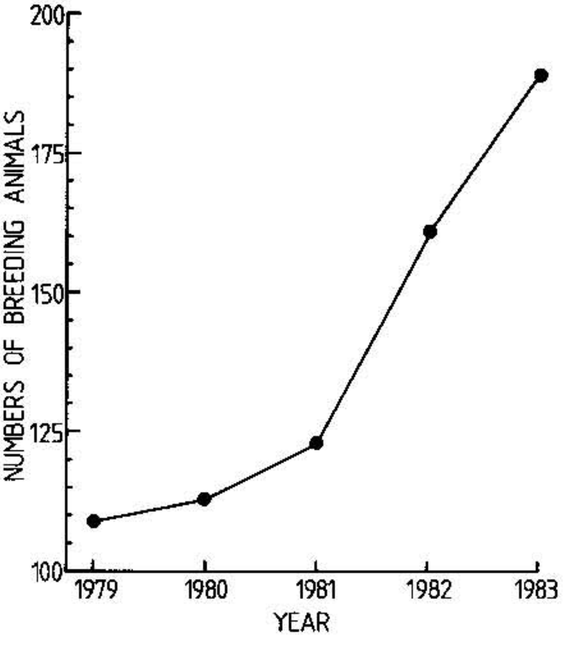

Fig. 1. Numbers of *Crocodylus niloticus* maintained on rearing stations in Zimbabwe for breeding purposes.

Pens for breeding animals vary greatly in form, but in general have fairly deep water and enough nesting sites for all females. If landscaped, they can also make a rather spectacular tourist attraction. One male can serve up to 20 females, so the sex ratio in breeding pens is strongly biased towards females; this also prevents males fighting each other.

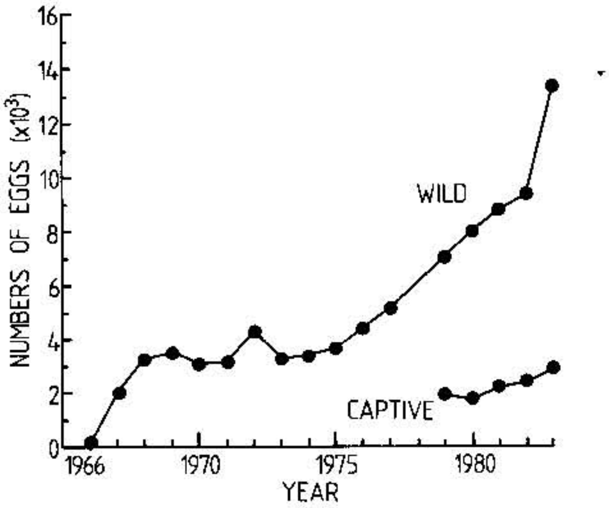

Fig. 2. Numbers of *Crocodylus niloticus* eggs collected each year from wild and captive nests in Zimbabwe.

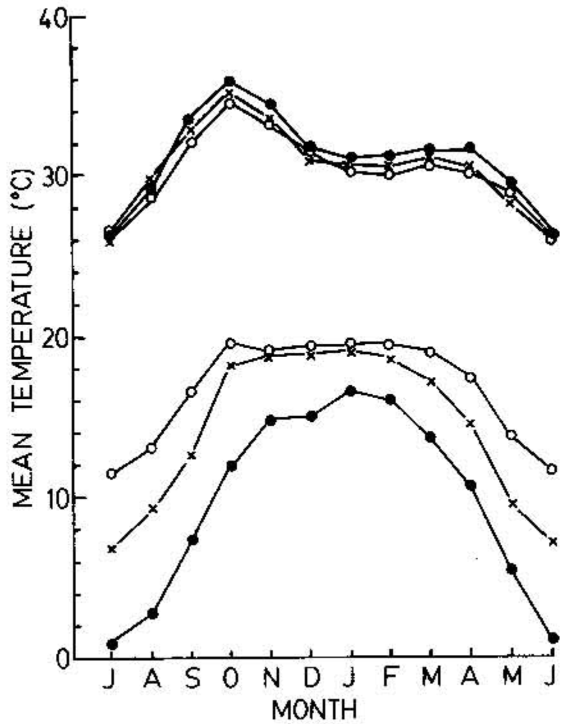

Fig. 3. Mean monthly maximum and minimum temperatures at three crocodile rearing stations in Zimbabwe: Binga (open circles) and Kariba (crosses) on the shores of Lake Kariba, and Victoria Falls (closed circles) (based on Anon 1978).

Mortality

Diseases (see Foggin Chapter 36) have caused slight to severe losses, and appear to be mainly a secondary manifestation of sub-standard husbandry. Injuries can occur during feeding, particularly if large animals have not been fed for some time, and losses have resulted from suffocation (crowded pens), heat stroke (inadequate shade or water), drowning (in very cold weather) and predation (by mammals and birds).

Climate may play an important role in both the survival and growth rates of captive crocodiles. The mean monthly maximum temperatures for Kariba, Binga and Victoria Falls stations are similar (Fig. 3), but the minimum temperatures show considerable variation. The Binga data may be affected by the position of the weather station, however this does not apply to Victoria Falls; minimum temperatures are 4°C to 6°C lower than at Kariba. Frost data (Miss I. P. Kaseke, unpublished data) show that Kariba and Binga do not experience frosts, whereas at Victoria Falls, temperatures fell below 0.0°C on 18% of days between May and August, below -2.0°C on 5.5% of days and below -4.0°C on 0.9% of days (data from fourteen years). Low winter temperatures may be a factor contributing to higher mortality at Victoria Falls station.

Business Management

Two stations offer tourist facilities, including conducted tours, interpretative displays and curios for sale. Returns from these sources contribute substantially to the running costs and, in one case, largely justify the location of the station (at a major tourist destination) in what would otherwise be a sub-optimal environment for crocodile production. The interpretative services offered by this station, have done much to modify public opinion in favour of crocodiles and the humane use of them.

Monitoring

Rearing stations submit monthly stock returns to the Department and are subject to frequent spot checks by Departmental officers. The returns detail the numbers of eggs, hatchlings, rearing and breeding stock on hand, together with the number on hand the previous month, and the differences subdivided into appropriate categories (e.g. deaths, cropped, sales, hatched).

Domestic sales require permits issued under Section 65 of the *Parks and Wild Life Act,* 1975. Zimbabwe has accepted more stringent conditions for the export of crocodiles and their products, than are normally required under CITES for an Appendix II species entering international trade.

Parts and derivatives may only be exported with a valid CITES export permit, bearing a serially numbered security stamp. Each skin bears an individual, serially-numbered, self-locking plastic tag, attached to a specified postion on the margin of the skin. The required position for this tag is varied from time to time. Tags come in two pieces and once clipped together, cannot be separated without destroying them. Prior to issue, the two sections are kept separately under strict security by the Crocodile Farmers' Association and the Department, respectively.

The Department has an enviable record in law enforcement, both at home and abroad. There has not been the slightest hint of any malpractices involving crocodiles for about five years and we are confident that if they are occurring, then they are at very low levels.

RESTOCKING

Early permits to capture young crocodiles or to collect eggs from the wild, contained a provision that required permit holders to supply the Department with well-grown individuals, of about 1 m in length, equivalent to 10% of the number of eggs or young taken. These animals were used for restocking denuded or depleted habitats. The proportion was later reduced to 5%, which was more in line with the expected natural rate of juvenile survival (Blake and Loveridge 1975).

To date 910 animals have been returned to the wild with some 30 additional animals being used for research or donated to sister conservation agencies in Africa, as allowed for by policy. Released animals have prospered, judging from both subjective observations and from the results of a mark-recapture programme. Growth rates among animals released into the wild were less than among siblings maintained in captivity (Blake and Loveridge 1975).

In recent times there has been no need for restocking, as adequate populations exist in the habitats suitable for *C. niloticus*. Accordingly, although permit conditions still entitle the Department to animals equivalent to 5% of the number of eggs collected, the option has been enforced very sparingly over the last decade.

EFFECTIVENESS OF MANAGEMENT

Response of the Wild Population

There is no estimate of the total population of Nile crocodiles from the early 1960's, when numbers were at their lowest ebb in Zimbabwe. However, in response to the management programme, numbers have increased significantly in suitable habitats. In 1982, the Nile crocodile population in Zimbabwe was estimated as at least 50,000 well-grown animals (CITES 1984a).

Of this total, some 40,000 animals were estimated to occur in the Zambezi River system, including the southern shore of Lake Kariba and the major tributaries feeding into it from the south. In the lake alone, where crocodiles were rare in 1959-1961, Taylor *et al.* (1982) estimated the population along 790 km of shoreline in the Matusadone National Park area to be 7013 ± 2121 (95% confidence limit), or 9.3 ± 1.2 crocodiles per kilometre. Extrapolated to the whole southern shore of the Lake (the northern shore is in Zambia) this gave a population estimate of 29,342 ± 3786.

Crocodile populations in the Zambezi River downstream of Lake Kariba were less depleted by the heavy hunting of the 1950's. Subjective observations indicate they are now more abundant than they were then, but few hard data are available. Aerial surveys between the Rukometjie and Chewore River mouths, indicate 20-40 crocodiles over about 1 m in length per kilometre (Cumming, unpublished data), for a total population estimate of 1600 to 3200 along 80 km of river.

Much of this recovery has been due to natural recruitment, with the restocking programme being important where the species had either disappeared or persisted in very low numbers.

Rearing Stations

There were several enthusiastic beginners who never really got off the ground, which is to be expected with this type of venture. Of the five rearing stations authorised between 1963 and 1967, two are still in operation: they were joined by others in 1971, 1977, 1981 and by a sixth in 1983. This has been in line with a policy of permitting only a cautious increase in the number of rearing stations, as the pooled experience within the industry improved and the Department's confidence in the ability of expanding wild populations to sustain the enterprises, grew. Today, we can assess the performance of the rearing stations in the context of events which have occurred since 1965.

The numbers of eggs collected from the wild increased from around 3000-4000 in 1968 to 13,319 in 1983 (Fig. 2). The numbers of eggs laid in captivity has been increasing year by year, as stations acquire breeding stock and as the clutch sizes increase with the increase in age and size of captive females. In 1983, 2876 eggs were produced from captive females, which represented 17.8% of the total egg intake (21.6% of the wild harvest).

Hatching success of eggs collected from the wild is 88.6% (over five years), although this may improve to 90-95%, which has been obtained in some years (Table 2). With captive laid eggs on the two most experienced stations, 72.7% hatched successfully, although one station achieved 96.9% in 1983. This represents satisfactory progress in a relatively new management technique, involving a significant proportion of young breeding females. Hatching success for all eggs, on five stations, over the last five years, is 85.7% (Table 2).

Mortality during the first year of life amounted to 32.4% of the hatchlings produced between 1980 and 1983 (Table 3), although if one station's results

Table 2. Hatching success of *C. niloticus* eggs collected from the wild or obtained from females nesting in captivity. "*" data from Victoria Falls and Kariba farms only.

		Hatching Rate								
		Source of Eggs						Total		
		Wild			Farm					
Station	Year Eggs Laid	No.	Hatched	%	No.	Hatched	%	No.	Hatched	%
Kariba	1979	1323	1183	89.4	565	338	59.8	1888	1521	80.6
	1980	2019	1666	82.5	292	241	82.5	2311	1907	82.5
	1981	1847	1693	91.7	310	222	71.6	2157	1915	88.8
	1982	1687	1296	76.7	602	466	77.4	2289	1762	77.0
	1983	1876	1826	97.3	505	480	95.0	2381	2306	96.9
Sub-total/Mean		8752	7664	87.6	2274	1747	76.8	11,026	9411	85.3
Bumi	1981	1055	999	94.7	–	–	–	1055	999	94.7
	1982	2020	1886	93.4	–	–	–	2020	1886	93.4
	1983	1889	1791	94.8	–	–	–	1889	1791	94.8
Sub-total/Mean		4964	4676	94.2	–	–	–	4964	4676	94.2
Sengwa	1979	2067	1985	96.0	–	–	–	2067	1985	96.0
	1980	2145	2078	96.9	–	–	–	2145	2078	96.9
	1981	2079	1966	94.6	–	–	–	2079	1966	94.6
	1982	3854	3312	85.9	–	–	–	3854	3312	85.9
	1983	3572	3258	91.2	24	–	–	3596	3258	91.2
Sub-total/Mean		13,717	12,599	91.8	–	–	–	13,741	12,599	91.8
Binga	1980	2047	1789	87.4	–	–	–	2047	1789	87.4
	1981	2491	2145	86.1	–	–	–	2491	2145	86.1
	1983	2518	2209	87.7	60	–	–	2578	2209	85.7
Sub-total/Mean		7056	6143	87.1	–	–	–	7116	6143	86.3
Victoria Falls	1979	1889	1329	70.4	1341	936	69.8	3230	2265	69.9
	1980	1868	1536	82.2	1499	1008	67.2	3367	2544	75.6
	1981	1296	1076	83.0	1895	1375	72.6	3191	2451	76.8
	1982	770	–	–	1790	–	–	2560	–	–
	1983	1053	928	88.1	1819	1352	74.3	2872	2280	79.4
Sub-total/Mean		6876	4869	79.7	8344	4671	71.3	15,220	9540	75.4
Total/Mean		41,365	35,951	88.6	10,618*	6418*	72.7*	52,067	42,369	85.7

The efficient management of crocodilians is frequently hampered by the logistics of getting people into crocodilian habitats, and allowing them to work there efficiently. Modern technology has much to offer if it can be afforded.

Above: In southern USA, airboats are widely used by researchers and wildlife managers working with American Alligators (*Alligator mississippiensis*). Here, Ted Joanen, from the Louisiana Department of Wildlife and Fisheries, inspects an alligator nest in marshland. (Grahame Webb)

Below: In northern Australia, helicopters are being used more and more within crocodile research and management programmes. Here, Charlie Manolis and Anthony Smith, collect eggs from a saltwater crocodile (*Crocodylus porosus*) nest for the Conservation Commission of the Northern Territory. (Grahame Webb)

Farming crocodilians is a relatively new form of "wildlife" agriculture, being pursued in some 150 to 200 establishments around the world. In Australia, Papua New Guinea and Zimbabwe, crocodile farming is an integral part of the management programmes through which the conservation of wild crocodile populations is being acheived. Having large captive populations, which can be tapped for restocking should the need arise, is also a form of "conservation insurance.

Above: The crocodile farm operated by Mainland Holdings Pty. Limited, in Lae, Papua New Guinea, uses large concrete pens to raise juvenile stock obtained from village hunters. For many of these hunters, in remote areas, the sale of crocodiles through the ranching programme is the only form of cash income available to them. (Grahame Webb)

Below: At night, the full extent of the captive population of *Crocodylus porosus* and *C. novaeguineae* within the large pens becomes obvious. (Grahame Webb)

Table 3. Data on the mortality of *C. niloticus* hatchlings within the first year, from five rearing stations in Zimbabwe.

	Rearing Station															Total		
	Kariba			Bumi			Sengwa			Binga			Victoria Falls					
Year	Opening Stock	Losses	%	Opening Stock	Losses	%	Opening Stock	Losses	%	Opening Stock	Losses	%	Opening Stock	Losses	%	Opening Stock	Losses	%
1980	1521	688	45	–	–	–	1985	107	5	–	–	–	2257	752	33	5763	1547	26.8
1981	1907	451	24	–	–	–	2081	193	9	1774	670	38	2549	2549	100	8311	3863	46.5
1982	2108	788	37	999	94	9	c2194	c220	10	2142	509	24	2394	1482	62	9837	3093	31.4
1983	1762	326	19	1593	330	21	3209	736	23	1865	464	25	1880	726	39	10,309	2582	25.0
Total/Mean	7298	2253	30.9	2592	424	16.4	9469	1256	13.3	5781	1643	28.4	9080	5509	60.7	34,220	11,085	32.4
										Excluding Victoria Falls						25,140	5576	22.2

Table 4. Data on the mortality of *C. niloticus* greater than one year of age, from five rearing stations in Zimbabwe.

	Rearing Station															Total		
	Kariba			Bumi			Sengwa			Binga			Victoria Falls					
Year	B/F	Losses	%	B/F	Losses	%	B/T	Losses	%	B/F	Losses	%	B/F	Losses	%	Opening Stock	Losses	%
1980	1722	24	1.4	–	–	–	2078	25	1.2	–	–	–	1898	126	6.6	5698	175	3.1
1981	2258	54	2.4	–	–	–	3655	26	0.7	4170	117	2.8	2796	869	31.1	12,879	1066	8.3
1982	3275	50	1.5	–	–	–	c4541	c51	1.1	3746	427	11.4	1406	356	25.3	12,968	884	6.8
1983	3978	25	0.6	905	18	2.0	5112	185	3.6	3622	35	1.0	2473	1234	49.9	16,090	1497	9.3
Total/Mean	11,233	153	1.4	905	18	2.0	15,386	287	1.9	11,538	579	5.0	8573	2585	30.2	47,635	3622	7.6
											Excluding Victoria Falls					39,062	1037	2.7

(Victoria Falls) are excluded, the mean mortality was 22.2%. These losses are regarded seriously, and Foggin (Chapter 36) discusses both the possible causes and the ways in which they may be reduced further. Never-the-less, they should be judged in relation to an estimated 95% mortality of this age class in the wild.

Subsequent mortality is generally "low" (Table 4), but is difficult to quantify precisely because animals are sorted and penned by size rather than age, and slaughtering takes place at between 1.5 and 3.5 years of age. On the newly opened Bumi Station, where there were no older rearing stock, 10.2% of the animals were big enough to harvest at 24 months. Total mortality up to this stage was about 11%, composed of 9% hatchling mortality (1982 in Table 3) and 2% mortality amongst one-year olds (1983 on Table 4).

In a pooled sample representing thirteen "normal" trading years, stations disposed of 10 to 34% (mean 20.4%) of their animals, over 12 months of age, per year. Mortality in this age class was 1.6% per year (Table 4), and in most cases total stocks were being increased (Fig. 4) (about 22% per year on well established stations without undue husbandry problems). These figures reflect a low average age within the total sample and, perhaps, a cautious approach to disposing of stock on some stations. They do not include the numbers of potential slaughter stock retained for breeding purposes. At present the industry realises about US$ 334,000 in foreign exchange earnings per year.

The captive population of Nile crocodiles in Zimbabwe now constitutes a high and significant proportion of the total wild population. It is breeding successfully and several rearing stations are moving towards the CITES definition of "farms". In 1982, when the wild population was about 40,000 animals of 1 m or more in length, the captive population (January 1983) exceeded 28,000 animals (Fig. 4), of which just over 16,000 were past the period of heavy early mortality on the stations. This amounts to 40% of the estimated total population, and even if the estimates for the wild population were considerably in error, the captive population constitutes a very significant proportion.

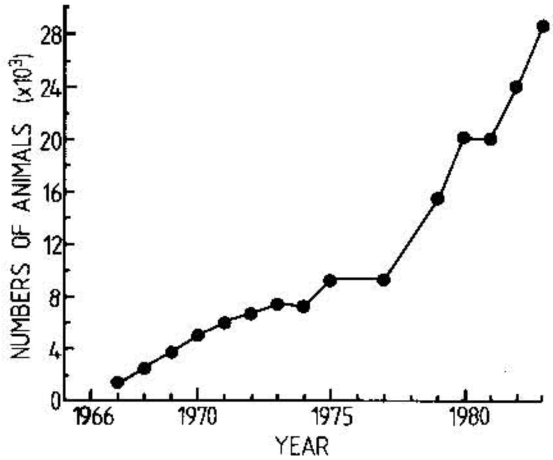

Fig. 4. Total numbers of *Crocodylus niloticus* held in captivity within rearing stations in Zimbabwe.

RESEARCH

The Department of National Parks and Wild Life Management has very limited resources with which to meet research needs, so it is essential to adhere to a policy of problem-orientated investigations. In-house crocodile research is no exception and like so much of our work, has benefitted from close collaboration with colleagues outside the Department.

The scope of completed studies and ongoing investigations includes contributions to: population dynamics and breeding biology (Hutton 1984); aerial surveys (Taylor *et al.* 1982); status assessments (Attwell 1973); crocodile farming and rearing technology (Blake 1970, 1974, 1982; Blake and Loveridge 1975, 1982; Foggin 1982; Mitchell 1974; Van Jaarsveldt 1982a, b); capture and immobilisation (Blake and Coetsee 1984; Loveridge and Blake 1972); thermoregulation (Loveridge 1984); effects of pollution (Wessels *et al.* 1980); and, legislation (Anon 1961, 1975; Child 1977, 1980, 1983).

DISCUSSION

Crocodile management in Zimbabwe provides a case study of a successful programme that has rehabilitated a species which in 1961 was threatened with extinction in much of its natural range. Several factors have contributed to the present optimistic state of affairs, which in approximate chronological order are:

1. The construction of numerous dams, including Lake Kariba, which have partially off-set habitat losses and are of major importance to the species at altitudes below 1500 metres;

2. The promulgation of the *Wild Life Conservation Act*; Chapter 199 *of* 1961, which provided crocodiles and their eggs with legal protection for the first time. It curbed effectively the wholesale, uncontrolled harvesting of wild populations, whilst permitting their controlled use for both recreation and financial reward. It removed the largely itinerant skin hunters, with no concern for the resource, and replaced them with people who had no alternative but to respect the need for sustaining and enhancing its productivity;

3. The extension of the national protected area system since 1961, when it contained limited good crocodile habitat, to the present situation where such habitats are well represented;

4. A pragmatic philosphy for the conservation of wildlife which accepts that it is a renewable resource that can and should be used wisely for the benefit of people, and thus to the advantage of the resource; it can compete successfully for space. This approach, accepted by the Department since 1959/1960 and regularised by the *Parks and Wild Life Act,* 1975, has acted to the advantage of crocodile conservation by permitting the species to realise its economic potential under the control of an effective management programme.

The process has become self-generating with the economic value of the industry being a powerful tool for crocodile conservation, even where the species is in some conflict with people. This is fostering increasing wild populations with an ability to sustain a growing industry contributing increasingly to the economy. Important spin-offs have included the higher priority justified by crocodiles in the allocation of scarce research and management resources; the provision of animals with which to restock suitable depleted habitats; the acquisition of enhanced knowledge of the species and its management; and, an appreciation by the public that crocodiles are animals worth conserving.

During the first decade of the crocodile rearing programme it appeared that the availability of wild laid eggs was the single most important factor likely to limit the size of the industry. It now seems that the availability of cheap quality food may be just as important, not only because of its importance for healthy stock, but because food is a major input cost.

Most food suitable for crocodiles is also fit for human consumption, and in a protein deficient country, this raises moral issues about the desirability of feeding people or diverting potential human food to the earning of much needed foreign exchange. It also means that the justification for rearing crocodiles, or conserving many other species in conflict with human welfare outside protected areas, is very dependant upon the producer nation being able to export the products freely.

Viewed from a small, poor, third world producer country, it would appear that one of the major challenges facing the global conservation of species such as crocodiles, is the need to facilitate legitimate trade while suppressing any illegal traffic. CITES offers an opportunity for achieving this, provided Parties are genuine in respecting each other and in applying the Articles of the Treaty in the spirit of the Convention. To act otherwise will only discredit this potentially valuable conservation tool. It will drive trade underground and favour criminal elements who have no interest in the survival of a species or the sustainable benefits to be derived from it, at the local, regional and national levels. These benefits rightly belong to the people on whose land the species occurs and who can be persuaded to conserve it through receiving tangible benefits from it.

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