

## EARTHWATCH INSTITUTE FIELD REPORT

**Project Title:** Crocodiles of the Okavango

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**Position/Affiliations:** Senior Lecturer and Department Chair, Department of Conservation Ecology, University of Stellenbosch, South Africa

**Research Site:** Okavango Delta, Botswana

**Local Management Status of the Research Site:** RAMSAR Site and World Heritage Status pending

**Scientific names of primary species being studied:** *Crocodylus niloticus*

### Key Research Objectives:

1. Determine, through systematic sampling of the various Okavango biomes, the distribution, status and abundance of *C. niloticus* in the Okavango system.
2. Compile a database on movements, home-range and dispersal patterns of the various size classes of crocodiles.
3. Study various aspects of the reproductive biology of the Nile crocodile.
4. Study the diet, feeding habitats, metabolic rates and morphometrics of various size classes of crocodiles.
5. Investigate the mating system and population genetic structure of the Okavango's Nile crocodiles.
6. Determine the health status of the crocodile population.
7. Provide information on crocodylian parasites.
8. Determine the extent of the crocodile/human conflict in the region.
9. Build capacity by developing local expertise and by providing a unique opportunity for collaboration between African scientists.
10. Provide scientific expertise and detailed biological information to assist crocodile farmers in Botswana and other parts of Southern Africa.
11. Highlight the conservation implications of the study and to provide management recommendations to the Department of Wildlife and National Parks (DWNP).

**Date this report was completed:** July 2005

### Data Collection and Results

a) Give a concise account of the data you have collected during the past field season.

As in 2003, we continued with data collection for all phases of the project. Please see the results summary below for further details.

b) What progress have you made towards achieving your original objectives?

During 2004 we made great progress towards achieving all of our original objectives, and in particular we commenced with the temperature-dependent sex determination project (part of Objective #3) and with the genetics study (Objective #5). See below for preliminary results.

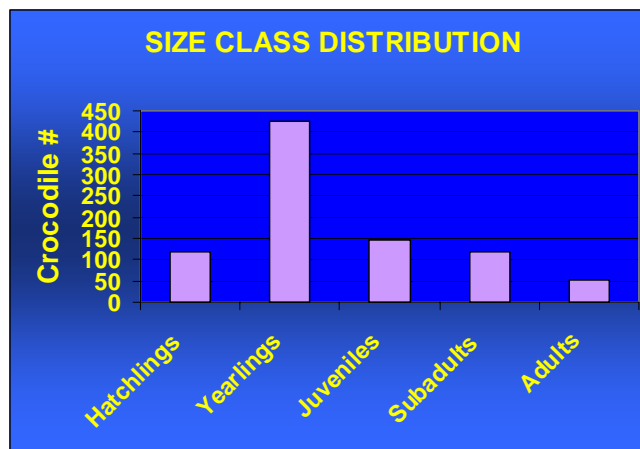
c) Please provide a summary of your results.

**A. Population ecology study (Objective #1 and 2)**

**1. Mark-Recapture Project**

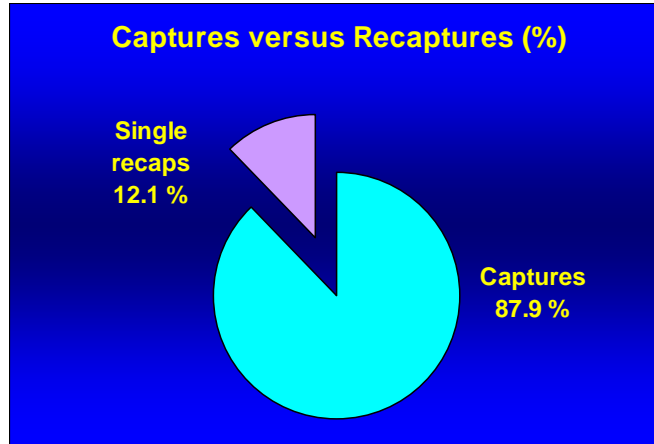
We have had a very successful three years of research with regards to the population ecology aspects of the study. By the end of December 2004, the research team had captured, processed, tagged and released 1159 crocodiles of various size classes. This total figure includes: 993 different individuals, 112 crocodiles which were recaptured once, 21 crocodiles that were recaptured twice, 1 crocodile that was recaptured 4 times and 1 individual that was captured 5 times.

The distribution pattern of the larger four size classes (yearlings, juveniles, sub-adults and adults) in Figure 1 shows the typical age/size class distribution for a long-lived reptile. What is of concern here is the low number of hatchlings, indicating low recruitment into the system. This is primarily due to: (i) a three-fold decrease in the total number of nests laid since the mid 1970's (see this report); (ii) an exceptionally high predation rate of nests (primarily by *Varanus niloticus*); (iii) egg collection practises by crocodile farmers and (iv) wanton destruction of nests by fishermen and reed-cutters (pers obs). The much higher total result for yearlings, however, indicates that there may well be recruitment into the population (at a larger size class) from further upstream in parts of north eastern Namibia. If this is indeed the case, trans-boundary management options and conservation strategies will have to be carefully considered.



**Figure 1: Size class distribution of captured crocodiles from January 2002 to December 2004. Preliminary results indicate low recruitment of hatchlings into this population.**

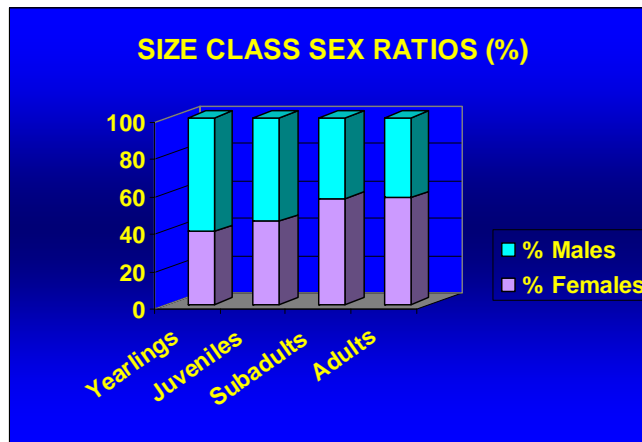
By the end of December 2004, we were recapturing approximately 12.1% of previously tagged crocodiles (Figure 2) [this figure only includes crocodiles recaptured once]. Although recaptures are important, we need to first tag a substantial proportion of the population throughout the delta region before any conclusions with regards to total population size can be made.



**Figure 2:** The total number of crocodile captures versus recaptures (all size classes) in the study area from January 2002 – January 2005.

In February 2005 the research team will commence with one of the recapture phases of the project. During a recapture phase (which occurs twice a year), only previously surveyed areas are visited and an effort is made to recapture as many of the previously captured animals as possible. By the end of the first two recapture phases and combined with the aerial and nest site surveying, the research team hopes to start with the modelling aspects of the study in order to determine the effective population size of the Okavango crocodiles.

Although our results are fairly preliminary at this early stage of the project, the male:female sex ratio in yearlings and juveniles is biased towards the majority males, whereas in the larger size classes the male:female sex ratio is biased towards females (Figure 3). In many other reptilian studies there tends to be a bias towards females in the larger size classes. More long-term data is required to substantiate this finding.



**Figure 3 :** Size class sex ratio of crocodiles captured in the Okavango Delta from January 2002 – December 2004.

## 2. Aerial Surveys

Aerial surveying is generally considered to be the cheapest and quickest way of estimating the relative size or density and distribution of a population (Graham, 1988). Repetitive aerial counts of exposed crocodiles to determine whether the population is stable, increasing or decreasing has been used in a number of studies of crocodilian population dynamics throughout the world.

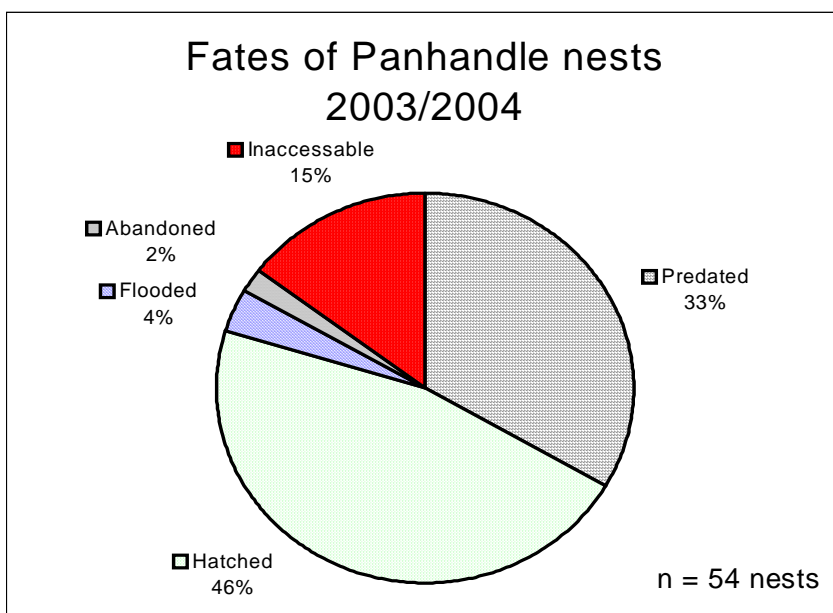
An aerial survey was undertaken from 17<sup>th</sup>-19<sup>th</sup> November 2003 in a Cessna 182, in order to count crocodile nests on the main channel of the Okavango river. The research team ground-truthed all sites shortly after the aerial survey. However, it was decided that aerial surveying is not an effective method for counting crocodile nests in the Okavango ecosystem.

The first aerial survey, counting adult crocodiles, was carried out by the Crocodile Research Team, in the southern regions of the delta from 10 -14<sup>th</sup> August 2003. The survey was undertaken in collaboration with the Crane Working Group. The survey was unfortunately not as successful as hoped as it is often difficult to accurately count two species at the same time. The research team have finally secured a plane and the necessary funding to carry out our first thorough aerial survey of the entire delta system planned for June/July 2005.

## 3. Nesting Surveys

During the past 3 nesting seasons the Okavango Crocodile research team have surveyed the entire Panhandle region of the Okavango, from Moheumbo to Duba Island, in search of crocodile nests. A local guide (Mr Amose, from Shakawe) who has collected eggs for crocodile farmers since 1990, was employed by the research team to assist in locating nests and verifying the presence of eggs.

In the **2002** nesting season 53 active nests were found. In the **2003** nesting season a total of 54 active nests (Figure 4) were recorded from 243 potential nesting sites; 79 % of nests that were active between 1990 and 2001 were not active in 2003.



**Figure 4: The fate of nests in the Panhandle region of the Okavango Delta during the 2003/2004 nesting season.**

A very similar pattern of nesting was found in the **2004** nesting season with a total of 50 active nests. The area between Shakawe and Mohembo, once a prime nesting area, is now devoid of nests. According to our guide, nests were repeatedly destroyed over the years by local residents and are now permanently abandoned. There is a distinct lack of nests in previously used sites immediately along the main river channel. We can only surmise that pressure from local residents (fisherman and reed-cutters) and the increased tourism in the area has resulted in crocodiles moving away from these areas. The drastic decrease in the total number of crocodile nests laid per year since the mid 1970s is a major concern. A previous study makes mention of over 150 nests (in Hutton, 1992). The number of nests in an area is related to the breeding segment of the population and therefore to population size (Graham, 1987). A drastic decrease in the number of nests can only indicate a drastic decrease in the number of breeding females and/or males. With continued monitoring of nests over a number of years, we will have a more accurate idea as to what is actually occurring within the breeding sector of the population. However, the wanton destruction of nests and the removal of eggs by crocodile farmers needs to be addressed immediately.

#### **4. Dispersal rates**

In order to gain a better understanding of basic population processes, it is essential to have firsthand knowledge of the distribution and movements of individuals within a population. Four concepts are important when studying movements of individuals: territory, home-range, dispersal and migration. Using both recapture/resighting of marked animals and radio-telemetry we have been documenting habitat preference, short and long-term movements and home-range behaviour of various size classes of crocodiles. We have attached radio-transmitters to 9 crocodiles, ranging from 2.0 – 3.5m in total length. We were able to track 3 adult animals (2 females and 1 male) for 20 months (at which stage the batteries in the transmitters died). The crocodiles very surprisingly remained within 5.0 km of the initial capture site for the duration of the experiment. Unfortunately the Okavango system is not conducive to radio-tracking due to the tall nature of papyrus plants. We were only able to relocate the 3 above mentioned crocodiles on a regular basis as they did not move much. We have been unable to relocate the majority of the other radio tagged crocodiles. The research team is currently investigating the possibility of utilizing satellite transmitters in the future. For this technique a large financial sponsorship is required.

However, from our mark-recapture study we have collected fascinating data on movements, survivorship and growth rates of crocodiles of various size classes. This is the first study of survivorship and growth rates of wild Nile crocodiles and requires continuous long-term monitoring.

### **B. Reproductive Biology Study (Objective 3)**

#### **1. Habitat suitability model**

Essential breeding habitat of the Nile crocodile is being lost due to pressure from increasing human activities. With no spatial models indicating suitable crocodile nesting

habitat, land-use planners and decision makers will fall short of providing any meaningful protection to crocodile nests. The results of this study will deal with the concepts of **human encroachment** into natural habitats, **animal-human interactions** and the protection of **keystone species** in natural environments.

Using GIS (geographical information system) technology and data collected from over 250 potential crocodile nesting sites in the Panhandle region of the Delta, the factor maps for the first suitability map were produced in 2004 and are ready to be put together into a multi-criteria evaluation (MCE). The first suitability maps to formulate a complete management plan for Nile crocodiles in the delta will be available as of June 2005. This management plan will be in compliance with various policies such as: community based natural resource management (CBNRM); the National Conservation Strategy as well as the Land Use and Development Plan for the Okavango Wildlife Management Area.

## **2. Reproductive Cycles**

The purpose of this study is to determine the reproductive cycle of the Nile crocodile in the Okavango system, with special emphasis on follicle growth and vitellogenesis, ovulation, spermatogenesis and courtship and mating. Studying reproductive patterns and their hormonal control is central to our understanding of life history patterns and necessary for structuring proper management strategies for aquatic and terrestrial ecosystems (Jassen et al., 1995; Noris, 1996).

To date we have collected blood and urine samples (to be used in the reproductive cycle study), from 30 adult and subadult males and 42 adult and subadult females. Additionally, 15 sperm samples have been collected from adult and subadult males. The hormonal analysis of samples will commence in February 2005. Preliminary results for this study will be available by September 2005.

## **3. Ultra-sound Project**

Ultrasound imaging of crocodiles commenced in June 2003 using a portable battery operated ultrasound. The project is in collaboration with the University of Jena and the University of Munich in Germany. An MSc thesis was completed (Dec 2004) and two scientific publications have been produced.

Ultrasound, as a diagnostic tool which reveals anatomical structures of animals, provides extensive possibilities for applications within animal science. The ethical advantage (reduced number of animals killed for scientific studies) as well as the scientific advantage (repeated measurements within the same animal) is striking. With rising publicity and the application of ultrasound within animal sciences, there is a need for a systematic anatomical ultrasound atlas, as exists for human anatomy). Firstly, this tool would allow the reduction of sacrificed animals for calibration of ultrasound images with anatomical structures. Secondly, it would make it much easier to interpret ultrasound images while providing a standardized frame for application in order to allow reliable comparisons of ultrasound studies which are carried out by different researchers. And lastly, from an etymologic perspective, working with non-invasive techniques, such as ultrasound, means a more bio-logic approach.

Of the 59 ultrasound scans on wild crocodiles in 2003, 47 crocodiles were digesting (intestinal lumen), eight animals had just finished digestion (no intestinal lumen but moderate echoes from mucosal layer) and four animals were fasting. A tentative factorial analysis of variance (ANOVA) showed significant correlations of organ-size with Body Mass Index ( $p < 0.05$ ). However, in the 2003 field session no significant differences in organ-size (mucosal layer, muscle layer, liver) was detectable between fasting and

digesting Nile crocodiles in the wild. Within the recaptured crocodiles only one showed a significant change of mucosal thickness between capturing and recapturing. There are two perspectives connected to the disturbed population structure, which can provide explanations for this “lack of flexibility” under natural conditions: **(i)** the abundance of the top aquatic predator in the Okavango system is still low due to the commercial exploitation of crocodiles. Respective to lower trophic levels, individual crocodiles require a large food supply and feed frequently; **(ii)** 59.3% of the sample were small individuals (< 80cm), which have higher Basal Metabolic Rates (BMR) and therefore have to feed frequently. The first as well as the second perspective account for the large portion of digesting (N = 55) versus fasting individuals (N = 4) within the wild population in 2003, which is eye-catching for an opportunistic sit-and-wait predator. Two factors that support the hypothesis that the population structure is still heavily disturbed, are (i) the low number of sub-adults (1.6m – 2.3m TL) and (ii) the decline of active nest-sites (see nesting survey report). Although no reliable conclusions of seasonal effects on organ-size changes are possible, a scenario has to be considered in which seasonal effects can occur. We encountered a dramatic reduction in catching success in the 2004 ultrasounding session, which can be attributed to a large portion of the population moving into the floodplains to feed, following the highest flood waters in 20 years. All individuals caught in the main channel had empty intestines, which supports this theory. From an ecological perspective these philopatric individuals may be the so called “losers”, whereas the seasonally migrating crocodiles which “feast” in the floodplains, consequently have larger digestive organs. There may be a seasonal effect on organ-size but we were unable to test this hypothesis. All measured animals (2003, 2004, fasting and digesting) had relatively similar organ-sizes. STARCK (2004) showed that the amplitude of flexibility in organ-sizes of the digestive system of pythons declines as a function of increasing frequency of food supply. If this function is considered to occur in crocodiles as well, the only possibility for a detectable range of flexibility during the wet season would be if the high frequency of food supply would decrease before the seasonal rainfall. Then, crocodiles that fasted for several weeks followed by feeding in the floodplains could show an increase in digestive organ-size. In view of the exploitation background of the population and no proof of a seasonal fasting period before the annual rainfall, we suggest that there is no detectable range of flexibility of the digestive organs within the wild population of Nile crocodiles in the Okavango system. A straightforward explanation for the results is the relatively low abundance of crocodiles and the resulting high frequency of a food supply.

During our study it was also found that ultrasound imaging can be used to study prey degradation in the stomach of crocodiles. For example: prey items (fish) were clearly detectable at day one of the experiment. The body of fish generally had a low echogenity (dark grey areas) apart from the vertebral column in larger fish, which was ossified enough to produce a high echogenity, appearing as a segmented bright grey area. Prey items could easily be distinguished from the surrounding gastric juice, which appeared homogeneously. The gastric wall was also stretched in feeding animals.

#### **4. Temperature-dependent sex determination & global climate change**

In the 2004 nesting season research commenced on temperature-dependent sex determination in the Okavango's Nile crocodiles. Embryonic survival, developmental rates and incubation periods are all temperature dependent. Additionally, the biological effects of spatial factors (such as sun versus shade, soil depth, distance from water. etc) on sex determination are high. Recent evidence has shown that global climate change has a great effect, not only on the determination of sex, but also on nesting behaviour, habitat requirements and reproductive success of reptiles (Hays et al., 2003).

Twelve nests were used in this experiment and were all selected from the fairly well protected Phillippa channel area. Miniature data loggers were placed within each of these nests and incubation temperatures were recorded for the duration of the incubation period, in order to estimate the sex of hatchlings recruited into the Okavango Delta ecosystem.

Six thermal stations were constructed at six potential nesting areas (previously utilized nesting sites). At each of these thermal stations soil temperatures were recorded at 3 different depths and at varying distances from the water (3.0 – 9.0m). Additionally, a moisture probe was placed at each station in order to produce a soil moisture profile for the specific area. Climatic data for the specific areas was also recorded.

Of the 12 nests monitored in the 2004 nesting season, 8 nests were estimated to have produced the majority female hatchlings, only 2 nests produced the majority male hatchlings and 2 nests were predated before the sex determination phase of incubation could be monitored. Female hatchlings are primarily produced at lower incubation temperatures. In general, of concern is that hatching success of crocodile nests in the Okavango Delta is low. This coupled with extremely high predation rates and wonton destruction of nests (as mentioned above) is a major conservation concern for Nile crocodiles in the Okavango. This particular study needs to be carried out once again in the 2005/2006 nesting season before any conclusions re sex determination and potential climate change effects can be made.

In the 2005/2006 breeding season eggs will be collected from wild nests and incubated at varying temperatures in order to determine the pivotal temperature for Nile crocodiles, ie: the temperature at which 50% of both female and male hatchlings are produced. Once successfully sexed, hatchlings will be released back into the wild. Laboratory established pivotal temperatures will be used together with wild nest incubation temperatures in order to determine the sex of hatchlings recruited into the system.

### **C. Diet, feeding habits and metabolic rates of wild Nile crocodiles** **(Objective 4)**

The study of diet is fundamental to truly understanding the ecology of any organism. Within crocodilians, diet shifts ontogenetically and diet affects behaviour, growth and reproductive success. The diet analysis will show predator-prey interactions and in conjunction with the fishery studies being conducted in the Okavango system, and the population ecology study of the present project, it will be possible to predict feeding frequencies for the various size classes of crocodiles. Coupled with the second part of this particular objective, namely the determination of metabolic rates, we will be able to predict a carrying capacity for crocodiles in the Okavango system.

The diet study commenced at the beginning of 2004. Stomach contents of captured crocodiles are removed using a non-invasive method adapted from that of Barr (1997). By end of 2004, we had collected stomach contents from 103 crocodiles ranging in size from 65.0cm – 2.3m. Ninety-three of the crocodiles had something in their stomachs. Samples have been weighed, sorted and digitally photographed (Figure 5).



**Figure 5: Stomach contents from crocodile #1104.**

In March 2005 we will commence with the identification of prey items. Once a prey reference series has been determined we will proceed with a digestion and assimilation rate experiment. In this experiment the differential rates of digestion of the various prey items will be determined for the smaller size classes of crocodiles. Once differential digestion rates have been determined it will be possible to establish conversion rates for the various prey items. Only once both digestion and conversion rates have been determined will we be able to move on to the metabolic rate experiment. This study requires at least two more years of research as diet is very seasonally related.

**D. Investigating the mating system and population genetic structure of the Okavango's Nile crocodile (Objective 5).**

Even though crocodylians have been around for millions of years, and as important as these creatures may be in the systems they occupy, they are still a much-understudied creature. In the past the species has been intensively exploited, undergoing a severe reduction in numbers as recently as 1969 (during the hunting period 1957-1969 it is estimated that some 50,000 animals were shot). Attempts to resume hunting quotas have repeatedly failed due to low hunter success and we can deduce that the crocodile population in the Okavango is very sensitive to relatively small perturbations. As a result of these findings the species was added to CITES Appendix I, banning all trade in the species, in 1973. However, harvesting of eggs from wild animals and indiscriminate killing of crocodiles is still taking place. Using a combination of modern genetic techniques, population assessment by means of mark-recapture techniques and information gathered on crocodylian reproductive biology the long-term study aims to confront some of the many problems hindering conservation management of this species. The genetic component of the project is making use of high-resolution molecular markers; these offer a powerful tool that has proved indispensable for parentage studies and analysis of fine-scale genetic structuring of populations. This study will not only determine important aspects of this species' population structure, reproductive and social behaviour, but will also yield possible evidence of inbreeding, the degree of relatedness among individuals and the genetic variability within this population. This project is making use of both blood samples (red cells only) and scute material obtained during the scute removal tagging system. Over 800 blood and scute samples have been collected and DNA extraction began at the University of Cape Town

in November 2004. Ample DNA has been extracted. Microsatellite markers species-specific to the Nile crocodile have been obtained. It is expected that the first results of this study will be available by mid 2005. Additional blood/scute samples are required from crocodiles in the southern region of the delta in order to fully understand population structure and gene flow within the Okavango crocodile population.

#### **E. Crocodiles in health and disease (Objective 6)**

Research on crocodylian biology began in the 1800's, however research on crocodylian diseases only began in earnest in the 1980's as the crocodile farming/ranching industry expanded. Crocodiles are very sensitive to stress and a high incidence of disease and mortalities were experienced initially due to poor husbandry practices. A greater knowledge of diseases in wild crocodiles may help us better understand the Host-Pathogen-Environment interactions to the benefit of the farming industry. However, although some haematological indexes are available for captive crocodiles, no literature is available on the present health of these animals in the wild. Crocodiles are terminal predators and as such are good indicators of the state of their environment. Consequently the crocodile is an ideal species to study to assess the ecology of a system, in particular to assess environmental contamination and bio-magnification of organochlorines.

This study will commence in January 2005, in collaboration with the Johannesburg Zoological Gardens and the Harry Oppenheimer Okavango Research Centre. The primary objectives of this study are to: (i) establish normal haematological and blood biochemistry values for wild Nile crocodiles; (ii) carry out a disease survey; (iii) do a gastrointestinal tract bacterial flora survey; (iv) determine levels of contaminant accumulation and to assess the impact thereof on crocodile health (possibly eventually linking this to water quality and human health).

#### **F. To provide information on crocodylian parasites (Objective 7)**

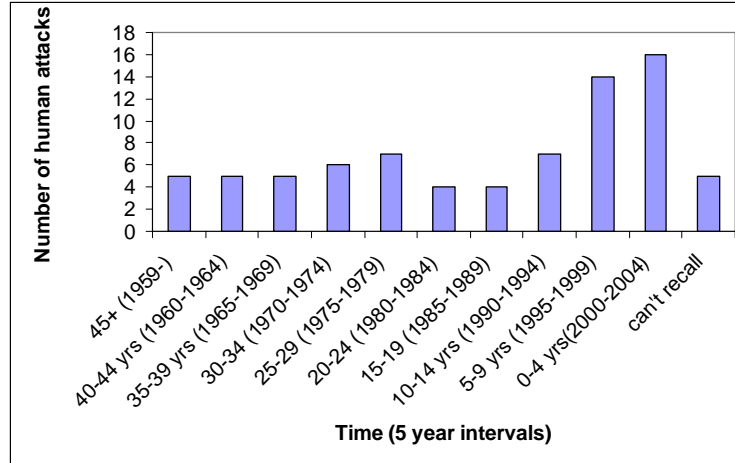
During routine blood sampling of the Okavango's crocodiles in June 2003, a heavy infection with an unknown protozoan blood parasite was detected in more than 50% of the crocodiles captured. Since July 2003, members of the crocodile research team have routinely been making blood smears of crocodile blood. At regular intervals these blood smears have been sent to a collaborator at the Rand Afrikaans University and Kingston University in the UK. The blood parasite has been identified as being a haemogregarine species. Although we have no idea what effect they may have on crocodiles, the parasites are known to cause stresses in certain lizard species. The presence of protozoans in the blood of the Nile crocodile was noted as long ago as 1906, from hosts caught in the Gambia and the Congo. Since these initial observations, two species of Haemogregarines have been described from crocodiles in Africa. The first *Hepatozoon pettiti* (Thiroux, 1910) from crocodiles in Senegal and Uganda and then *Hepatozoon sheppardi* (Dias, 1952) from crocodiles in Mozambique. The Okavango haemogregarine shows morphological and morphometrical similarities with both of these described species. However, although similar in size range and staining properties to the known species, the Okavango parasite differs in infection levels (much higher than reported from Uganda, for example) and infection is also throughout the various size classes. **This is the first record of a blood protozoan infection in crocodiles from the Okavango delta.** The taxonomic status of this parasite will only be finalized after research on its vector has been undertaken. At this stage the vector is assumed to be either the tsetse fly or the leech. This study is ongoing.

This work was presented at the Parasitological Association of Southern Africa's Annual Symposium in September 2004, and won the best poster award.

**G. To determine the extent of crocodile/human conflict in the area**  
**(Objective 8)**

A preliminary investigation into crocodile/human conflict issues took place between June and July 2004. A report has been produced and will be submitted to the relevant authorities in March 2005. This study will however be extended in 2005 – in the hopes of additionally covering the Chobe and Zambezi systems. This study is being carried out in collaboration with the Crocodile-Human Conflict Task Force of the Crocodile Specialist Group of the IUCN (International Union for the Conservation of Nature, Switzerland).

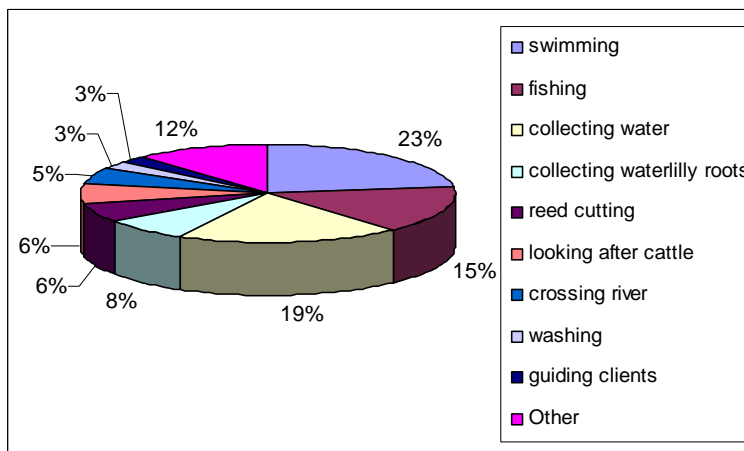
The phrase 'human- wildlife conflict' is recently being applied to management situations that involve negative interactions between humans and wildlife. These conflicts can be real or perceived, economic, social or political (Messmer, 2000). In some areas in Africa human-crocodile conflicts have become a major problem, and it is one of the driving forces behind the implementation of sustainable management programs. Crocodile-human conflict has been reported in 17 different African countries, five being in the south and eastern regions. The status of many Nile crocodile populations and the incidents of attacks are mostly unrecorded in these countries, as many wildlife authorities are poorly equipped and trained in assessment and alleviation of wildlife-human conflicts. The perception and ethics of the local people on the Nile crocodile is of great importance to the dynamics of the conflict situations that may arise and can either restrict or foster the conflict-resolution process. The generalized negative perception of most reptiles in Africa, could be a major obstacle in effective conservation of the crocodile population in Botswana. Adult crocodiles, blamed for most attacks, primarily feed on fish and are adaptive, intelligent animals that can become accustomed to human disturbance such as utilization of the river and noise (Fergusson 2004). This behavioral trait of the Nile crocodile is only a perceived cause of human attacks, but generally wild crocodiles are expected to move away from a threat and into areas that are more pristine with less anthropogenic disturbance. Conflict resolution between humans and wildlife in Botswana is managed by the Department of Wildlife and National Parks, the Problem Animal Division thereof. As in many parts of Africa, Wildlife authorities generally lack adequately trained staff (Government of Botswana, 1998) and resources to initiate an effective assessment of their Nile crocodile populations, and the Okavango system is no exception. The management of the species by the DWNP is based on inaccurate population censusing and other outdated data sources and this may result in ill-informed decisions on the alleviation of crocodile-human conflicts. Interviews were conducted with the aid of interpreters and a total of 241 interviews were conducted within 21 villages in the Panhandle region of the Okavango Delta. The gender composition of the total number of people interviewed was: female **56.8%** and males **43.2 %** and interviewees were from all age classes. Figure 6 indicates the number of human attacks by crocodiles in 4 year time intervals for the Panhandle region of the Okavango Delta. The trend of human attacks shows that there has been a higher occurrence of attacks in the last nine years. This could possibly be attributed to a higher population increase, but memory of attacks could dissipate in the earlier years.



**Figure 6:** The number of human attacks by crocodiles in 4 year time intervals for the Panhandle region of the Okavango Delta. Attacks occurring before 1959 were grouped into the 45+ category and attacks that did not have a specific date of attack were grouped into the “can’t recall” category (n = 78).

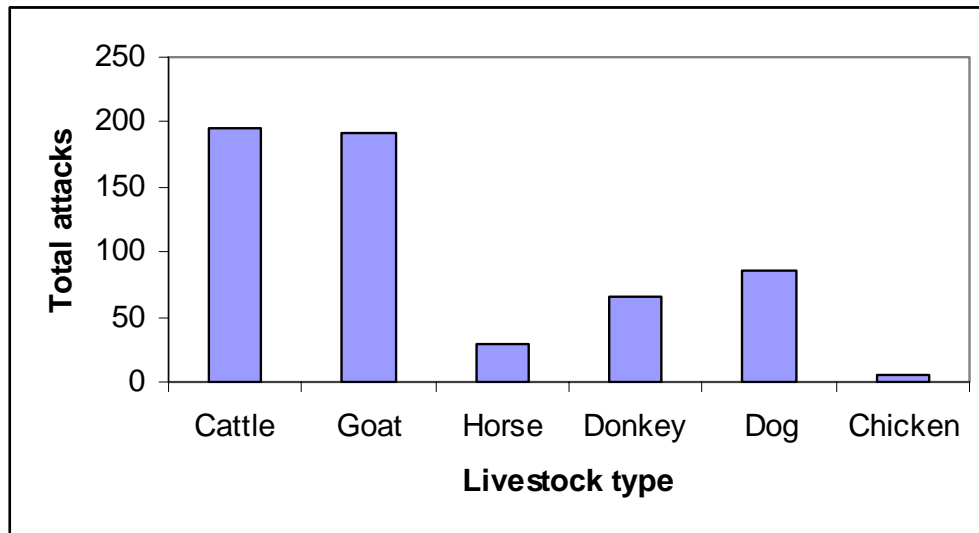
Figure 7 is a pie graph depicting the percentage of people engaged in a specific activity when attacked by a crocodile. It shows that most attacks resulted when people were swimming, collecting water and fishing. Fergusson (2002) reported that most rural land use in developing countries involve the collection of water from man-made and natural water sources. The most common method of water collection is by buckets and containers by women and children. In reference to the natural water sources, this involves standing near to or in knee deep water. Adult crocodiles can be completely submerged at this water level and will be inconspicuous; therefore water collection is seen as a high- risk activity.

Other activities that were described as high- risk in nature are boating, fishing, swimming and playing in or near the water where crocodiles are prevalent and collecting of water lily roots in shallow water.



**Figure 7: Pie diagram showing the percentage of people engaged in a specific activity when attacked by a crocodile.**

Figure 8 below shows the distribution of the total number of attacks by crocodile on the different types of livestock in the study area. The majority of the crocodile attacks were recorded on cattle and goats. This does not imply that crocodiles are specifically selecting their prey, but could relate more to the utilisation of water sources by the different livestock and also to the distribution of livestock ownership within the rural communities of the study site.



**Figure 8: Distribution of the total number of attacks by crocodile on the different types of livestock within the Panhandle region of the Okavango Delta.**

In the full report that will be made available to wildlife officials in March 2005, the management objectives of this study will be proposed in such a way as to provide practical solutions to the immediate problems faced by those who are directly affected by the presence of the Nile crocodile. However, the report will also provide some long-term conflict resolutions in order to reduce general conflict between crocodiles and humans and to ensure the sustained resolution of conflict issues in the future. Various obstacles in conflict resolution will be discussed together with possible solutions to assist in resolving these problems.



**Interviewing Mrs Masai Lenkeme Thebenala in Shakawe**

**H. Build capacity by developing local expertise and by providing a unique opportunity for collaboration between African scientists (Objective 9).**

**1. Education Programme**

The Okavango Crocodile Research team understands the need for a well-established educational programme and as a result the team commenced with a schools programme in February 2002. From 2002 to December 2004, numerous schools were visited, some on more than one occasion. School groups are presented with donated stationary items, books, games, toys and clothing (provided by Earthwatch volunteers). The research team gives a talk about the importance of crocodiles in the Okavango system and a live crocodile is also taken along on each occasion. The school children are given the chance to touch a crocodile and to ask questions. The research team has also helped some school children with projects, providing books, information pamphlets and advice. Some schoolteachers have also visited our base camp on their days off. In October 2004 the Okavango Research team sponsored the annual prize giving awards at Ikoga Primary school. Awards included stationary items, stickers and project T-shirts.

In June 2002, the Okavango Crocodile Project sponsored the 12 prize winners of the "Every River has its People" project run by the Kalahari Conservation Society. The 12 lucky prize winners got to spend a weekend with the research team. Accommodation was provided by Shakawe Fishing Lodge and food etc. provided by the project. Seven teachers also joined the programme. The 12 kids were divided into two teams and taken out on the boat at night to catch crocodiles. Every kid got to touch a crocodile and went home with a polaroid photo of themselves with a crocodile. A prize giving ceremony was held and certificates were handed out. The children also watched videos about the delta and got to play football in-between other activities. A very memorable weekend was had by all. The total value of the sponsorship exceeded P5000.00.



**A school visit and food web demonstration**

## **2. Community Participation**

In November 2003 and 2004 the research team presented some of their preliminary results to a group of American ITC students who visited the crocodile research base camp. This will continue in 2005.

In July 2004 the research team requested a Kgotla meeting in the village of Samochima. The aim of the meeting was to introduce the project to the community. Ms Shone was the translator at the meeting. The response towards the project was very positive and the chief and other delegates appreciated the effort made by the research team to communicate their intentions.



**Okavango Crocodile Research team staff members at a Kgotla meeting**

In October 2004, the research team invited the Chief from the Ikoga Community to our research camp, to meet all staff members and to enjoy a meal and a boat trip. The Secretary to the Chief and the Town Planner for Ikoga Village were also invited. A wonderful day was had by all. The research team have the full support of the Chief of Ikoga Village and he regularly visits the research base camp.

### **3. Training Workshop**

In late August 2004, a workshop in Maun was organised and convened by the research team. The purpose was to provide both theoretical and practical training in crocodile biology and handling techniques to wildlife students and Department of Wildlife and National Parks (DWNP) staff. It also provided an opportunity to report back to wildlife officials on project progress and recent findings of the Okavango Crocodile Project. Financial support for this workshop was provided by a Vodafone Group Foundation grant for Communications technology and conservation, administered by Earthwatch Institute (Europe).

**Represented organisations:** Conservation International, Kalahari Conservation Society, Department of Wildlife and National Parks (DWNP), IUCN Okavango Management Plan, DWNP Wildlife Training Centre, Wild Dog research project and DARUDEC (International Consultants)

After morning tea, the workshop was officially opened by Dr Alison Leslie who gave an overview of the entire research programme, introducing all project members and emphasising the objectives and significance of the research project. This was followed by talks from three of the project members. There was a 20 minute question and answer session before a mid-morning tea break. After tea the delegates were divided into four groups for the practical aspects of the workshop. Project staff members demonstrated the use of various pieces of research equipment and techniques used. The practical sessions included: a demonstration of the various capture techniques; the principals and use of radio-tracking equipment; the processing of captured animals, such as blood and urine sampling, measuring, sexing, weighing, stomach flushing and tagging of crocodiles; and a laboratory session demonstrating the processing of blood samples and stomach contents. The practical session was followed by a video presentation - a 30 minute documentary produced in January 2004 entitled "Okavango's Croc Team". A highlight for the research team was the interest and enthusiasm for the project as expressed by the delegates. The team was inundated with very useful questions during the question and answer session. At the end of the workshop a senior member of the Department of Wildlife and National Parks thanked the research team for their continued effort and excellent contribution towards the conservation and management of the Okavango Delta. The majority of the delegates remarked positively on the workshop programme which incorporated both a theoretical and practical section and a fun "live" action video. We feel that the DWNP staff and students in particular, gained a better understanding as to what we do, why we do it and how we do it. The "hands-on" aspect of the workshop undoubtedly increased the delegates understanding of scientific research in general and this is vital as they are the future managers of the ecosystem.

#### **Significance/Benefits of Research**

a) What is/are the significance/benefits of your research at the following levels?

Once again this past year, our projects ever expanding educational programme benefited many school children (and adults) in the area. They not only received numerous books stationary, etc., from Earthwatch volunteers on the project, but they were also exposed to a research team in action and exposed to a live crocodile, gaining a better understanding as to the importance of these creatures in the Okavango system. On a national scale we are realizing the extent of the problems related to crocodiles in Botswana, and received a good response from the Dept Wildlife and National Parks with regards to the importance of crocodiles and crocodile conservation. In 2004 the

crocodile research team relocated two problem crocodiles from the Moremi Game Reserve area. This was a service provided by the research team and all expenses, from drugs through transport, were covered by the team. These relocations were carried out in collaboration with the Department of Wildlife and National Parks in Botswana. Research team members also assisted the Botswana Police Force with regards to more recent crocodile attacks in the region. After a fatal crocodile attack in 2004, team members together with the police visited the site of the attack and also the deceased's family to offer our condolences. Thereafter a local school was also visited in order to remind the children as to the dangers of swimming in the Okavango River. As a research team we are continually expanding upon our collaborative efforts, both nationally and internationally.

b) How do your findings contribute to issues of sustainability?

Our project has a great deal to contribute to sustainability, in particular to conflict resolution and natural resource management. In 2004, we commenced with the establishment of a crocodile farm and research centre. The Pabalelo Research Trust, as it is known, is a joint initiative by community development specialists, universities and conservationists in the far northern section of the Okavango Panhandle.

The Trust originates from the collaboration between five groups, including the University of the Free State Zoology Department, the **University of Stellenbosch Crocodile Research team** and the Harry Oppenheimer Okavango Research Centre of the University of Botswana, as well as Tuudoro, a non-profit company of community development specialists. All four above groups have extensive experience in their fields and have actively been working in the Panhandle area of the Delta. The fifth partner, the Samochima Crocodile and Aquaculture Farm is a commercial crocodile and fish farm that provides the land, security and management of facilities, as well as on-site research opportunities with fish as well as crocodiles. The farm will provide the opportunity for research results to be tested and applied in practice.

The aims and objectives of the Pabalelo Research Trust are to combine research with community development and education on conservation, linked to the development of a commercial crocodile and aquaculture production unit.

The crocodile farm opened in July 2004 and the principal investigator of the Okavango Crocodile Research project acts as a scientific advisor on the board of trustees. A scientifically determined quota of crocodile eggs will be collected from the wild on an annual basis. The eggs will be incubated at the farm and the hatchlings raised for 24 months for meat and leather production. Five percent of the 1.5 year olds will be returned to the wild. This method of sustainable harvesting has been very successfully practised in many parts of the world and has contributed to the conservation of many wild species of crocodilians.

### **Dissemination of Results**

a) Have you provided details of results from your research to or within:

- Scientific papers (indicate status; e.g., peer reviewed or in progress/press)  
A number of scientific papers are in progress.
- Management plans and reports (in progress or completed)  
Project progress report to Department of Wildlife and National Parks, Botswana. Submitted June 2004.

Project progress report to Department of Wildlife and National Parks, Botswana. Submitted Dec 2004.  
Two crocodile relocation reports submitted to the Department of Wildlife and National Parks, Botswana

- Presentations (given or planned)

**A.J. Leslie.** 2004. The Okavango Story. Somerset-West Wildlife Society, Western Cape, South Africa.

**S. Bourquin and A.J. Leslie.** 2004. Population Ecology of the Nile crocodile in the Okavango Delta, Botswana. 7<sup>th</sup> HAA Symposium (Herpetological Association of Southern Africa), Port Elizabeth, South Africa.

**G. Thomas and A.J. Leslie.** 2004. Crocodile/human conflict in the Okavango Delta, Botswana: a preliminary investigation. 7<sup>th</sup> HAA Symposium (Herpetological Association of Southern Africa), Port Elizabeth, South Africa.

**A.J. Leslie.** 2004. Okavango's Crocodiles. Workshop presentation for the Department of Wildlife and National Parks, Maun, Botswana.

N.J. Smit, **A.J. Leslie** and A.J. Davies. 2004. Protozoan blood parasites of the Nile crocodile, *Crocodylus niloticus*, from the Okavango Delta, Botswana. Poster presentation. 33<sup>rd</sup> Annual Conference of PARSA (Parasitological Association of Southern Africa), 12 – 15 September, Manyane, Pilanesberg National Park, North West Province, South Africa. Won bester poster award.

- **Popular articles or films (in progress or completed)**

**2004 ONLY**

Gedeon Programmes, Paris, France. "The Monster of Tanganyika". A crocodile special. Premiered January 2004.

Strings Productions. "Okavango Crocodiles" for 50/50. Premiered March 2004.

Teirzight Production, Germany. Premiered July 2004.

Strings Production for German television. Premiered October 2004.

EarthBound 3. Filmed September 2004. Premiers January 2006

Crocodile Specialist Group Newsletter, Vol 23 No. 4. 2004. Project update.