Searching for clues inside the claws

New research is investigating whether the time dimension provided by crocodile claws can indicate if previous food web disturbances caused the 2008 croc mortalities in the Kruger National Park – and unexpected results are already on the cards. Article by Petro Kotzé.

Dr Stephan Woodborne of the CSIR taking a sample from a crocodile claw.

The exact reason for the alarming crocodile mortalities that occurred in the Kruger National Park's (KNP) Olifants Gorge and Lower Letaba River in 2008 continues to be evasive. Post-mortem examinations revealed that the deaths were caused by pansteatitis (hardened fat in the tails and abdomen) but, says Danie Pienaar KNP's Head of Scientific Services Department, even though it is clear that the crocodile deaths were symptomatic of serious environmental problems in the Olifants River system, the exact mechanisms of what took place remain uncertain.

Mortality peak rates of 20 crocodiles per week were reached during the winter months of June and July of 2008 (totalling 170 carcasses recorded by November of that year, although, because carcasses sink and are consumed by other crocodiles, the exact number is likely to be more than

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Top: *While crocodile mortalities have declined each winter in the Kruger National Park since the massive die-offs experienced in 2008, the exact cause of the deaths continue to baffle researchers and managers alike.*

Bottom: *Members of the SANParks staff remove crocodile carcasses from the Olifants River gorge in late 2008.*

that). Even though the mortalities have since decreased every winter, Pienaar cautions that the root problem is still present.

In order to establish a clear cause-effect relationship, a multi-institutional collaborative research programme, known as the Consortium for the Restoration of the Olifants Catchment (CROC) was established. It includes representatives from SANParks, the Department of Water Affairs (DWA), research organisations, universities, independent consultants, NGOs and the Water Research Commission. CROC's research focus is centred on analysis of the water and sediment, fish pathology, water chemistry and algal composition of the river water, the population dynamics of the crocodiles in the Olifants and Letaba river systems, clinical blood parameters of the affected crocodiles in comparison to unaffected crocodiles, invertebrate and fish population dynamics and research into populations of fish-eating birds (for more information, refer to the January/February 2009 edition of the *Water Wheel*).

A unique research project under the CROC umbrella is now experimenting with a novel technique to try and establish what caused the mortalities – by isotopic analysis of crocodile claws. Project leader and CSIR Senior Researcher, Dr Stephan Woodborne says that the study explores the idea that the crocodile deaths might not result from something that can be seen or detected now, but rather something that happened in the past. The foundation for the study was laid during an earlier research programme relating to the crocodile deaths, of which Dr Woodborne formed part.

AN ISOTOPIC FOOD WEB ANALYSIS

A group of CSIR researchers have been commissioned to conduct one of the largest assessments of its kind on the progressive eutrophication and chemical pollution of the Olifants River and the implications for aquatic ecosystems and human health (other parties included the Universities of Pretoria and Stellenbosch, the Mpumalanga Tourism and Parks Agency (MTPA) and the Department of Water Affairs (DWA) – for a full update on this project see elsewhere in this issue). For comparison the group duplicated the study in the pristine Waterberg area. The results obtained from these studies included an isotopic food web analysis that can be used to better understand crocodile ecology.

But what is an isotopic food web analysis? In the simplest terms, carbon and nitrogen isotopes (atoms of a chemical element whose nuclei have the same atomic number, but a different numbers of neutrons giving them different atomic weights) act as markers that can be tracked as they move, for example, through a food web. For instance, grass takes carbon and nitrogen gas from the atmosphere. An impala, in turn, acquire these elements from eating the grass, while a lion, in turn, attains it from eating the impala. Every time the elements are taken up by a different form, it undergoes a slight isotopic change. As these changes are measurable and known to scientists, it can be used as a point of reference to see where in the food web a specific specimen fits in.

A number of results were obtained from the study. First, it was evident that, due to pollution, nitrogen isotope contamination in the Upper Olifants River falls outside of the natural range that was observed in the Waterberg. Furthermore, Dr Woodborne elaborates, the study enabled them to identify the isotopic food web up to the rank of fish. This would later enable them to categorise where crocodiles fit into the food web and, more specifically, what a fish-eating crocodile would look like isotopically.

The researchers now had a bigger picture, showing the isotopic 'image' of both fish-eating crocodiles, and those that occur in heavily polluted areas. However, he says, some of the dead crocodiles matched the profiles, while others didn't. This is because crocodiles don't only eat fish. It was then necessary to determine a number of different options, and researchers continued to map the isotopic differences between crocodiles with aquatic, versus those with terrestrial diets.

ADDING A TIME-DIMENSION

After Dr Woodborne was presented with a crocodile claw, the idea for the unique approach to uncover the root of the crocodile deaths was born. Seeing as claws (like nails) grow with time, researchers theorised that, through isotopic analysis of the claws, they could pick up food chain turbations in the past that might have been responsible for the relatively more recent mortalities.

A crocodile claw forms microscopic layers on its inner side as it grows, almost similar to a series of stacked paper cups. Chemical analysis along the growth of the axis of the claw provides researchers with the opportunity to 'look' into the past at the conditions under which the crocodile grew and where it fitted into the food web. Even more so, by reading the isotopic time series, scientists are able to trace if the reptile changed its diet at any stage of its life. The first sets of exploratory results were received about a year ago, and after these demonstrated the potential of the technique, more claws were received from St Lucia, the University of KwaZulu-Natal and the KNP. The resulting study took place in collaboration between the CSIR, SANParks, Uzemvelo, Prof Colleen Downs from the University of KwaZulu-Natal and several other people, notably, Dr Jan Myburgh from Onderstepoort.

Results from the St Lucia crocodile claws suggest that lake levels and probably the corresponding changes in salinity have a strong influence on the nutrient supply, but that trophic level relationships (the position that an organism occupies in the food chain) do not change. A substantial turbation that took place in the Lake St Lucia food web system is evident, and is believed to be the result of the 2007 breaching of the estuary mouth after five years of closure. This caused a significant water level rise and temporary drop in salinity.

In KNP the isotopic time series from crocodiles in the Olifants Gorge were compared with crocodiles from other river systems. "When we plotted the isotopes we could pick up the differences between those crocodiles with an aquatic, and those with a terrestrial diet," says Dr Woodborne. In addition some of the claws contained regular nitrogen isotope pulses that may relate to seasonal biology of the animals, and can therefore be used as a time marker. With the calibration of the time dimension the results showed that during times of extreme droughts, the diets of two crocodiles from the Olifants Gorge (from three analysed) changed from those living in a riverine habitat to those frequenting dams. The isotopic analysis indicated that they converted back to riverine diets at a later stage.

According to Dr Woodborne, the results indicate that the two crocodiles in question were living in the Olifants Gorge, moved to a dam environment (which could include large pools, which can 'act' as dams) during drought, and then returned to the gorge under more favourable circumstances. SANParks has some data that suggest that, under conditions of drought, crocodiles will probably move upstream. Even though the Massingir Dam (downstream) is large enough, the variability in habitat preferred by crocodiles (for example nesting opportunities and shelter for their young) are not present. The closest dam upstream from the gorge is the Engelhard Dam in the Letaba River where, says Dr Sam Ferreira (SANParks Large Mammal Ecologist), crocodiles were noticed that had earlier been marked in the gorge.

Notably, Dr Woodborne's study shows that from the three crocodiles sampled, the two crocodiles that displayed these possible movement patterns were the ones that developed pansteatitis.

Stephan Woodborne

Left: *This picture is of a croc claw that has been sampled along the growth axis starting at the base (left) which is the most recent growth, and ending at the tip (right) which grew sometime in the past. The largest claws that have been analysed seem to record about 12 years of growth.*

Below: *A close-up of the crocodile claw sampling process.*

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THE WAY FORWARD

Dr Woodborne emphasises that "the interpretation of the time dimension of a crocodile's position in the food web as an indication of mobility and changing river ecology is a hypothesis at the moment." Pienaar also adds that the technique is very new, and much work is still needed in order to fine-tune it and get the desired results.

Among others, possible future research will aim to characterise the isotopic profiles of apparently healthy crocodiles from different environments (like fresh water lakes and rivers) in order determine if food web turbations are responsible for the crocodile deaths.

In general, there are three aspects that should be explored in further research. Space (testing the hypothesis on more crocodile claws), time (asking if pansteatitis is caused by something that happened in the past, and developed gradually, or not) and an unexpected third aspect, age.

To date, says Pienaar, it has been difficult to gauge crocodiles' exact age as an older crocodile exposed to a specific diet might be smaller than a younger one exposed to other dietary elements. Dr Woodborne's method could, however, dispel this problem by providing a more specific method. When analysing the claw, scientists can pick up an annual pattern, when a crocodile's metabolism slows down during winter months (metabolism is temperature-dependent). This knowledge can be applied to estimate a crocodile's age.

In order to take the concept further, Dr Woodborne is calling for more scientists to become involved and develop both a strategy and set of approaches that can exclude certain hypotheses. Continuing research is, however, dependent on funding, for which proposals have been submitted. It is hoped that such research might provide the answers to the evasive crocodile mortality questions by simply unlocking the past. ❑

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Left: SANParks staff removes crocodile carcasses from the Olifants River gorge in late 2008.

Below: While crocodile mortalities have declined each winter in the Kruger National Park since the massive die-offs experienced in 2008, the exact cause of the deaths continue to baffle researchers and managers alike.

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LAST BOW OF THE LOSKOP DAM NILE CROCODILE POPULATION

Recent counts revealed that the Loskop Dam population of crocodiles have all but died out as the mere two reptiles that were located during recent surveys are too small to breed. These finding were presented at the 9th Annual Savanna Science Network Meeting that took place at the Kruger National Park in March (at the time of the presentation, a total of four crocodiles were observed in the Loskop Dam). Presenter MTPA herpetologist, Dr Hannes Botha, reported back on a study that aimed to determine the distribution, status, vulnerability and general health of Nile Crocodiles in the Olifants River, also part of the CROC umbrella of collaborative research projects.

The count, the most comprehensive done since the massive crocodile mortalities in 2008, was a combined effort by the Centre for Wildlife Management (University of Pretoria), The DWA, the University of Florida and the MTPA. It included the Blyde River Poort, Loskop and Flag Boshielo Dams as well as the Olifants River Gorge in the KNP.

An average 1 140 crocodiles were counted during two aerial surveys. The Olifants River gorge in the KNP, the Flag Boshielo Dam, the area between the Blyde River and the Western boundary of the KNP and the area between the Loskop Dam and the Flag Boshielo Dam were found to be preferred habitat areas and critically important to their nesting success. The Elands River was confirmed as an important refuge area. Unfortunately, their preferred habitat in the river inflow zone, especially in the Loskop Dam, exposes them to a wide array of concentrated contaminants.