

Nile crocodile (*Crocodylus niloticus*) genetic diversity and population structure in the Kunene and Kavango River systems in Northern Namibia

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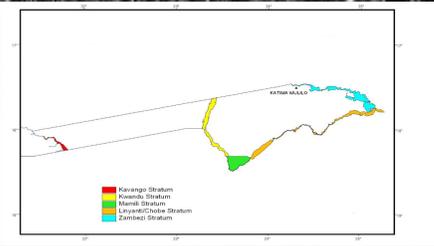
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INTRODUCTION

Crocodiles play an important role within the ecosystem, use in tourism and trophy hunting. The Nile crocodile is the only crocodile in Namibia and little is known about its genetics and abundance. The Nile crocodile population has gone through a number of reduction events since 1957 and today the numbers of crocodiles is much reduced, but recovering. Small *C. niloticus* populations are under increased extinction pressure, because the genetic diversity of such populations can be low. A genetic diversity study has been performed on *C. niloticus* from the Okavango Delta in Botswana by Bishop and colleagues (2009). They found that the effective population ratio of this population was lower than expected while neutral genetic variation is still at moderate levels. The aim of our study is to determine whether the two populations in the river systems diverged due to geographical or other physical barriers to form distinct genetic populations with no recent gene flow expected.



Map of North Eastern Namibia river systems



Small crocodile captured with animal noose

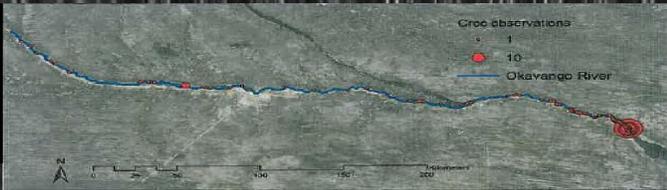
KAVANGO RIVER SYSTEM

- An aerial survey was conducted in 2013 to provide a true population estimate, making use of a recently developed *N*-mixture model for estimation of abundance and spatial variation
- Study area for aerial survey covered 480 km from the Angola boundary (1100 meters above sea level) to the Botswana boundary (998 meters above sea level)
- The Okavango river was split into two sections due to several km being protected areas (inhabited and Mahango Core Area)
- Average density of animals was calculated at 4.06 (Sd = 1.057) (456 km) crocodiles per 8km on the inhabited river portion and 52.72 (SD = 15.696) (24 km) crocodiles per 8 km segment on the Mahango core area.

	Mean	SD	Bayesian Credibility Interval 95%	
			Low	High
# of crocodiles [1-2m]	59.15	15.395	40	96
# of crocodiles [2-3m]	80.37	20.918	54	131
# of crocodiles [3-4m]	67.98	17.692	46	110
# of crocodiles [4+]	24.04	6.256	16	39
Total # of crocodiles	231.54	60.261	156	376

Total population size and number of crocodiles in each class in the Okavango river, inhabited area

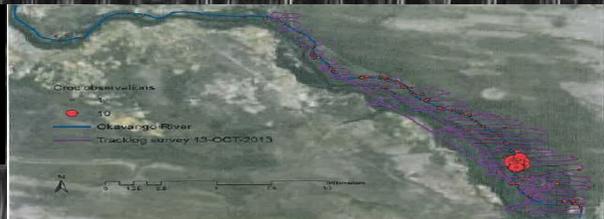
Observation of crocodile size in the inhabitant area of the Okavango river. Red dots indicate crocodile observation and circle size is proportional to the number of individuals observed.



	Mean	SD	Bayesian Credibility Interval 95%	
			Low	High
# of crocodiles [1-2m]	40.4	12.03	30.15	70.51
# of crocodiles [2-3m]	54.9	16.345	40.96	95.81
# of crocodiles [3-4m]	46.43	13.825	34.64	81.03
# of crocodiles [4+]	16.42	4.888	12.25	28.65
Total # of crocodiles	158.15	47.089	118	276

Total population size and number of crocodiles in each class in the Okavango river, Mahango core area

Observation of crocodile size in the Mahango core area of the Okavango river. Red dots indicate crocodile observation and circle size is proportional to the number of individuals observed. Purple lines indicate helicopter track log.



DISCUSSION

By estimating the total count of the Namibian crocodile population from the Kunene and Kavango river along with genetic diversity and population structure, we are able to effectively implement the National crocodile species management plan. However, the effectiveness of the plan will also require the implementation of current on going studies and updated aerial surveys of the Kwando, Linyanti, Chobe and Zambezi river systems. Current on going studies involve the assessment of dietary habits, along with nesting ecology, locating nesting sites.



Crocodile identification via cattle tags and scute cuts. The colour of the tag identifies the sex and the scute cut assists with the individual identification and monitoring of crocodiles in the Kunene and Kavango River systems.



Crocodile captured in a five meter cage trap



Crocodile captured in a pitman noose trap

MATERIALS AND METHODS

Aerial Survey:

The Kunene river area surveyed in 2012, was separated into an east and west section and the Okavango river was surveyed as a whole in 2013. The rivers were split into portions and each portion was covered on a different day, with each portion flown over two or three times. Recording of crocodile sizes were as follow Class 1 = 1-2m, Class 2 = 2-3m, Class 3 = 3-4m and Class 4 = <4m.

Sampling and DNA Isolation:

Sampling will be performed in the Kunene and Okavango rivers during field trips by taking blood and scutes, under veterinary supervision along with tagging the captured crocodile. DNA will be extracted using the CTAB method of Saghai-Marroof et al. (1984).

Microsatellite Analyses:

Twelve microsatellites have been chosen from the FitzSimmons et al. (2000) and Miles et al. (2009) papers for cross species amplification in total (*C391*, *CUD68*, *Cj18*, *Cj119*, *Cj 35*, *CpP 1409*, *CpP 2504*, *CpP 305*, *CpP 307*, *CpP 309*, *CpP 4311* and *CpP 218*). Data will be generated using fluorescently labelled primers and automated sequencers (e.g.: 3730XL Genome Analyzer). Data generated will be tested for genetic diversity, population differentiation and structure.



Collection of cloaca fecal tissue samples with distilled water.



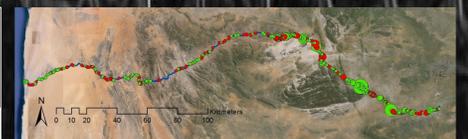
Map of North Western Namibia, depicting the Kunene river

KUNENE RIVER SYSTEM

- An aerial survey was conducted in 2012 to provide a true population estimate, making use of a recently developed *N*-mixture model for estimation of abundance and spatial variation
- Study area for aerial survey covered 352 km from the mouth (km 0, altitude 0 meter above sea level) to Ruacana falls (km 352, altitude 775 meters above sea level)
- Average density of animals was calculated at 2.29 crocodiles per km across the Kunene River system.

	Mean	SD	Bayesian Credibility Interval 95%	
			Low	High
# of crocodiles [1-2m]	238.98	35.12	189	320
# of crocodiles [2-3m]	340.26	50.00	268	455
# of crocodiles [3-4m]	149.01	12.65	131	180
# of crocodiles >= 4 m	78.12	6.63	68	94
Total # of crocodiles	806.36	91.03	674	1015

Total population size and number of crocodiles in each class in the Kunene River from its mouth to Ruacana dam, 352 kilometers.



Green dots indicate animals between 1 and 3 meters in length, red dots indicate animals greater than 3 meters. The size of the circle is proportional to the number of individuals observed at the location.



FLTR: Pierre du Preez, Hans Swartbooi, Karoba, Basco Budget, Jonathan, Ita Matthews, William Versfeld and Piet Beytell. Photo by: Chris Eyre

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