Crocodile ecology, conservation and management in the Ruzizi Burundian and Congolese Plains, Northern End of Lake Tanganyika

by
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1. Abstract

The crocodile ecology, conservation and management in the Ruzizi Burundian and Congolese Plains were investigated from October 2018 to September 2019 with the financial facilitation of the Student Research Assistance Schemes (SRAS) of the Crocodile Specialists Group (CSG) under the conduct of the Centre for Research in Hydrobiology (CRH) of Uvira in the Democratic Republic of Congo (DRC). The research focused on a few ecological elements, conservation strategies and management plans of crocodiles for the protection of their habitats, the wetland areas. Crocodiles are found in rivers, natural ponds and in the shore areas of Lake Tanganyika in Bujumbura-Burundi and at Uvira in the DRC. The research is part of a doctoral thesis to defend at the Doctoral School of the University of Burundi. The study shows that environmental regulations, although partially respected in Burundi, are not enforced in the DRC. The breach leads to the threats of the extinction of crocodiles in the Ruzizi plains and on the shores of Lake Tanganyika in Bujumbura and at Uvira DRC, northern part of Lake Tanganyika. Yet, our diving experience showed that crocodiles catching mostly sick fish and dying fish due to old age, provide sanitation to the lake, ponds and rivers and contribute to their fish productivity. The sustainable conservation strategies suggested by the study concern compliance with environmental regulations in the DRC and in Burundi. These regulations provide for prohibiting all human activities on the 100 m of the Lake Tanganyika shoreline in Bujumbura-Burundi and Uvira in the DRC, on the banks of the Ruzizi river from its falls (Ruzizi III) to the mouths of Great Rusizi River and Small Ruzizi River (about 68km), and along the natural ponds. The strategic management and development plans suggest the establishment of observatories and their access roads with a view to stimulating ecotourism, as source of financial incomes, employment and self-financing for management institutions and governments.

Key words: Ruzizi Congolese Plain; crocodile ecology; crocodile conservation; crocodile management; Small Ruzizi River.

2 Introduction

2.1 Statement of the problem

Crocodiles play an important role in sanitizing lakes, ponds and rivers by predating sick fish, and ready to die by old age. They contribute to the productivity of ecosystems particularly in the Ruzizi plain and the shoreline of Lake Tanganyika where these ecosystems have been overexploited since the wars of 1998 to 2003. The deforestation of the shores of these ecosystems has reached a climax to the point that crocodiles for lack of shelter, safe places of rest and reproduction have been exposed to poaching, lack of food due to ecosystems unproductivity and have gradually decreased in the Ruzizi and the shoreline of Lake Tanganyika in Bujumbura and at Uvira.

The present investigation is a wake-up call for decision-makers to enforce environmental regulations for the protection of the 100m of shoreline along rivers, natural ponds and the shoreline of Lake Tanganyika for the conservation of crocodiles and biodiversity in general.

2.2 Hypothesis

I hypothesized that the decreasing density of crocodiles and biodiversity in general is a strong signal for decision-makers and land users to take the necessary steps to restore wetland vegetation of the Ruzizi plains and of the shores of Lake Tanganyika in Bujumbura Burundi and at Uvira, DRC.

2.3 Objectives

2.3.1 Overall objective

The investigation focused on some ecological elements, conservation and management of crocodiles in the Ruzizi Burundian and Congolese Plains using crocodile density to document strategies for their sustainable conservation and management plans in Burundi and the DRC.

2.3.2 Specific objectives

-Inspect key sites frequented by crocodiles in the Ruzizi plain and the shoreline of Lake Tanganyika in Bujumbura and Uvira, DRC;

-Interview farmers, cow keepers, anglers encountered in the field and security officials on the presence of crocodiles, their number and the damage they cause to the population and their behaviour;

-Interviewer on the customs "for and against" crocodiles;

- Take geographic coordinates of sites using GPS;

-Count crocodiles encountered during the day in the Ruzizi plains;

-Count crocodiles encountered during the day and at night on the littoral of Lake Tanganyika;

-Collect dimensions (length, width and depth) of the places investigated in order to calculate the sampled surface area and if need be the water volume of sites.

3 Overview of Crocodile Literature

The Rusizi Burundian Plain is best known for having hosted one of the largest Nile Crocodiles in the world, known as Gustave (McRae & Michael, 2008, Egide, 2012). He roamed the banks of the Rusizi River and the northern shores of Lake Tanganyika. Gustave, estimated at about 6m (20 ft) long and weighing about 900kg (2,000 lb), would have killed and eaten many people (Egide, 2012).

Flora et al., (2019) studied the importance of bushmeat in household income in relation to the distance of protected areas in the Western Serengeti ecosystem in Tanzania and showed that income was higher according to that households were closer to protected areas. Manolis and Graham 2013 assessed the attacks of the saltwater crocodile (*Crocodylus porosus*) in Australia and their consequences for management. Following this study, the government recognized the need to develop a management plan to provide economic incentives for the sustainable conservation of crocodiles. Manolis and Graham (2014) investigated the impact of sea crocodile (*Crocodylus porosus*) conflicts in the Australia-Oceania region, which have become a key policy issue in Timor Lester and the Solomon Islands and where management programs have not yet been developed. These authors suggest that management programs should reflect the cultural and social characteristics of local stakeholders and leaders.

In the Ruzizi Congolese and Burundian Plains, the management plan for crocodile's conservation must take into account the sociological and cultural characteristics of local populations, as we did awareness campaigns on the reduction of threats to crocodiles and hippopotamuses (Bashonga 2019). Stevenson *et al.* (2014) studied human-crocodile conflict in South Asia and Iran. They showed that culture, poverty and a growing human population

posed problems for wildlife conservation and management in the South Asian region. Although each species is recovering in parts of its range, habitat loss combined with human expansion in previously wild areas leads to increased conflict.

The Ruzizi Congolese was seated by an influx of refugees in the years 1998-2003 resulting in an uncontrolled population growth and lack of management plan. The degradation of natural habitats for crocodiles and biodiversity increased and generated human-crocodile conflict up to 2016-2017. Crocodile attacks have dropped around 2016-2017, following the threat of crocodile and their extinction in the region.

Tisen *et al.* 2013 evaluated human-crocodile conflict in the Neyyar Wildlife Sanctuary, India. In order to solve human-crocodile problems, these authors recommended public awareness programs to inform the population about the precautions to take to live safely with crocodiles. Such sensitization on the precautions to live safely with crocodiles is expected on the shores of Lake Tanganyika in Mutambala-Nemba (about 90km south of Uvira), where crocodile attacks on anglers are often reported. Woodward *et al.* (2014) reported the alligator conflict on humans in Florida. The risk of alligator bites can be controlled by selectively eliminating problem alligators and continuing the training of humans that may interact with alligators. They showed that increasing alligator pressure on crops in residential areas and areas with high recreational use was the only way to reduce significantly the risk of alligator bites.

In the world, crocodiles have always played a role in human culture: revered as holy creatures; Hunted for their flesh, skin, food, medical products; Religious decorative objects (CSG, 2019). Caldwell (2017), studying the global trade in crocodilian skins 2013-2015 at the Louisiana Alligator Advisory Council in the United States of America, presented an overview of the trade in classic skins (alligators and real crocodiles) and caimans , as well as a detailed species-by-species analysis of the trade in hides and trade in other products such as live animals and meat. They showed that the rational and sustainable crocodile agriculture could generate a significant source of financial and economic income (CSG, 2019) as the case may be an example for crocodile's management in the Ruzizi Burundian and Congolese plains.

4 Field of study, materials and research methods

4.1 Field of study

The study area is the Ruzizi Rwandan, Burundian and Congolese plains from Kamanyola (Kafunda site) to the mouths of Great Rusizi River and Small Ruzizi River (about 68km). This area includes the Ruzizi Delta between Great Rusizi River in Burundi, and Small Ruzizi River bordering Burundi on east and the DRC on west. The selected sites are those in which at least one crocodile was identified by observation or reported by interview with land users, fishermen, cow keepers, and property security officers (Figure 1).

4.2 Research equipment and materials

The research equipment includes a double cabin Hilux vehicle for transporting researchers and their equipment from Uvira to the Ruzizi plain (65km) and other sites for direct observation during the day. Then a boat Fiberglass for nocturnal investigations on the shoreline of Lake Tanganyika from the Kalimabenge River mouth (Kimanga site) to the mouth of the Small Ruzizi River (about 27km). The research materials included a GPS, binoculars, a telescope, a digital camera, a 50m tape measure, a surveyor's chain (3m), and a luminous equipment equipped with a battery and a projector for searching crocodiles during the night.

4.3 Research methods and techniques

4.3.1 Direct observation

It consists of a meeting with crocodiles and counting them with binoculars, a telescope and a camera.

The different sites are photographed, their geographical coordinates are taken and their dimensions are measured or calculated using the instruments used (GPS, binoculars, telescope).

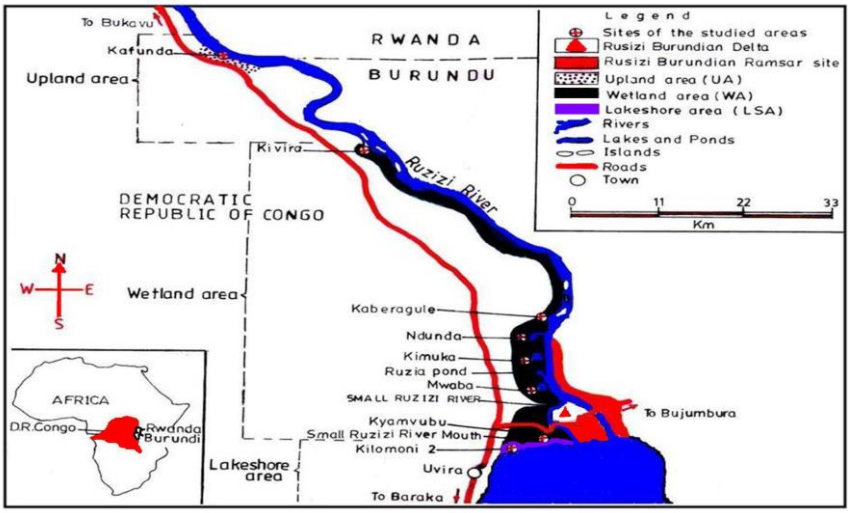


Figure 1 Carte des sites d'investigation des crocodiles dans la plaine de la Ruzizi
Source: Adaptation Felton (2007)

4.3.2 Interviews

The interviews consisted of individual interviews about the presence, number of crocodiles, their attacks on humans and the custom for or against crocodiles in the sites. Then, a systematic questionnaire was submitted in to users, officials, and security guards of property and people in the Ruzizi Congolese Plain and in the Ruzizi Delta.

5 Results

5.1 Ecological elements

5.1.1 Ecological habitats of crocodiles

Figure 1 presents ecological habitats of crocodiles in the Ruzizi Plains. Our respondents reported that crocodiles are found in ponds (55%), in rivers (25%), along the coast of Lake Tanganyika and sometimes on land (5%). The difference between respondent responses on ecological habitats of crocodiles is highly significant (χ=56; df=3; p=0,001).

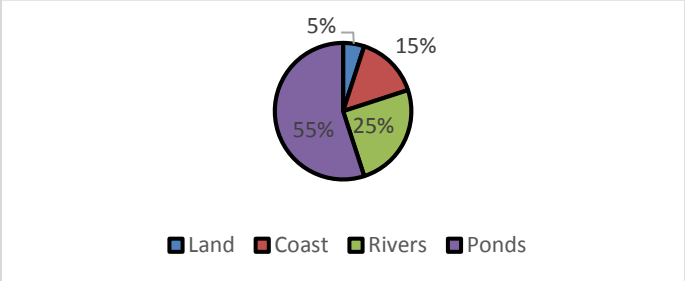


Figure 2 Ecological habitats of crocodiles in the Ruzizi plains
Source: Our interviews of 2018-2019

5.1.2 Reproductive modes of crocodiles

For our respondents, crocodiles reproduce by laying eggs (55%), calve mode (15%) and eggs-calve (30%). The difference between respondent responses on crocodile reproductive modes is significant (χ=24, 5; df=2; p=0,001).

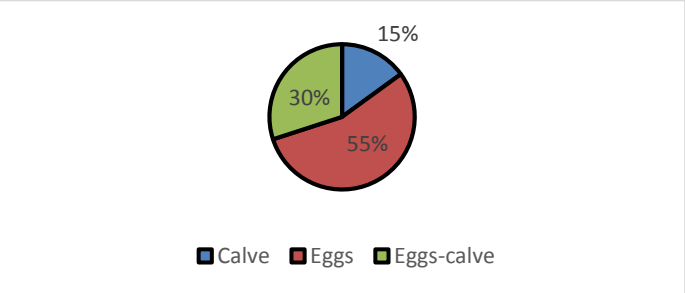


Figure 3 Reproductive modes of crocodiles
Source: Our interviews of 2018-2019

5.1.3 Environments frequented by crocodiles

Figure 3 presents responses of respondents on the environments frequented by crocodiles in the Ruzizi plains. These include ponds with vegetation (40%), ponds without vegetation around (9%), rivers with vegetation along banks (25%), vegetated coasts (15%) and non-vegetated coasts (5%). The difference between responses on environments frequented by crocodiles was highly significant (χ= 55, 52; df=5; p=0,001).

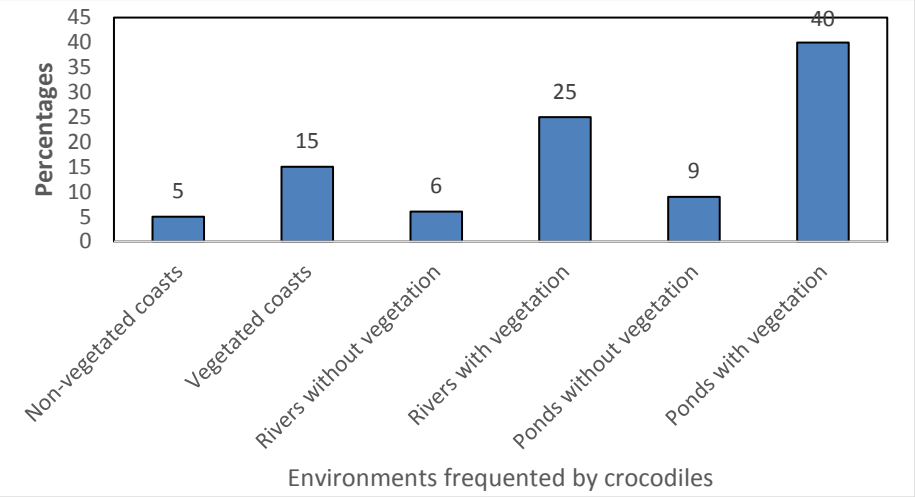


Figure 4 Environments frequented by crocodiles
Source: Our interviews of 2018-2019

5.1.4 Suggested actions to improve crocodile habitats protection

Figure 4 presents suggested actions to improve crocodile habitats protection. They include 100m free of human activity from ponds (39%), 100m free of human activity from rivers (27%), 100m free of human activity from the lake shoreline (16%), dubbing the pond banks (9%), dubbing the riverbanks (5%), and cultivating along the coast (4%). The difference of public opinions between actions to improve crocodile habitats protection is highly significant (χ= 57, 68; df=5; p=0,001).

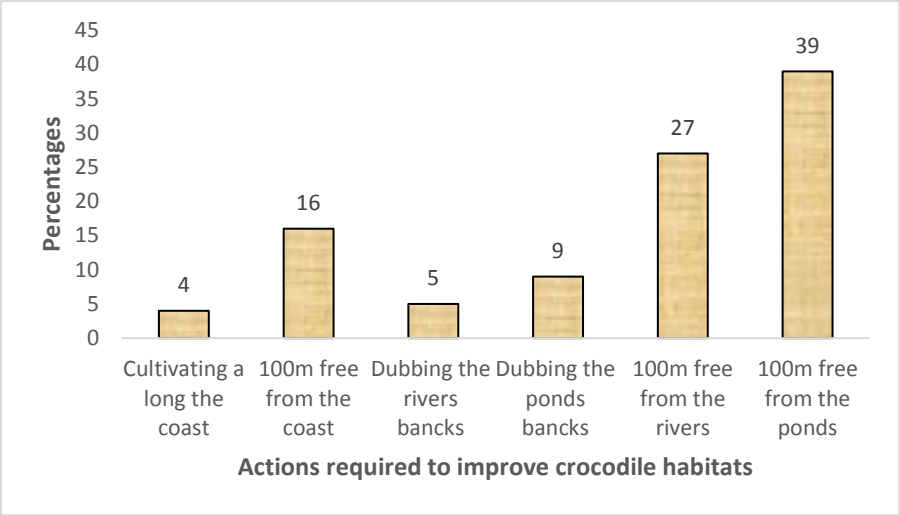


Figure 5 Suggested actions to improve crocodile habitats protection
Source: Our interviews of 2018-2019

5.1.5 Crocodile management measures for natural habitats protection improvement

Figure 5 highlights suggested crocodile management measures improvement by the respondents. These are respect vegetal belt around crocodile habitats (30%), erect observatories for crocodiles, birds and hippopotamuses (25%), reforest demarcations of crocodile's habitats (20%), trace the routes to the observatories (15%), and demarcate crocodile habitats using plant fencings (10%). The difference between suggested measures to improve crocodile management is significant (χ= 12, 5; df=5; p=0,001).

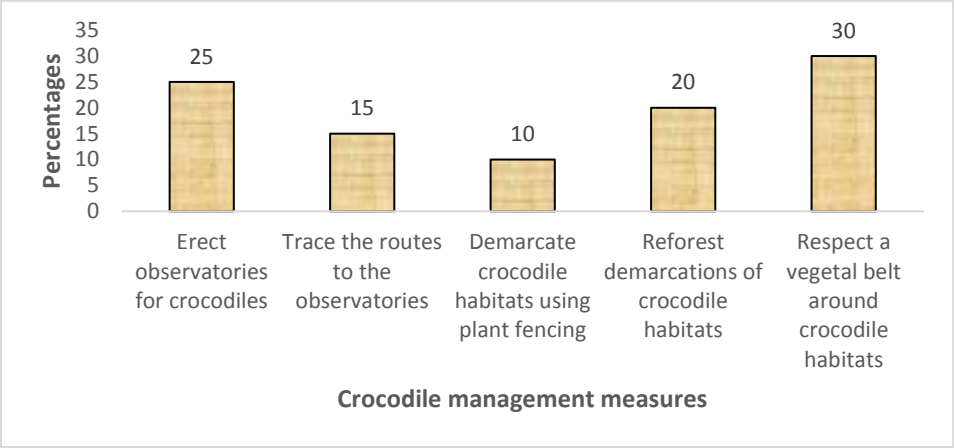


Figure 6 Suggested crocodile management measures improvement
Source: Our interviews of 2018-2019

5.2 Density of the crocodiles of the Ruzizi plains

5.2.1 Density of the Nile Crocodile in the Ruzizi Congolese Plain

Figure 2 shows the density of the Nile Crocodile (*Crocodylus niloticus*) in the Ruzizi Congolese Plain by sampling site. The Kivira site, locally called Tangaro, is the entrance of the Ruhwa River into the Ruzizi River. It is as well the area of contact of Rwanda, Burundi and DRC. The site has the highest density (4.9 crocs / km^2), followed by the Ruzia site (1.7 crocs / km2), the sites of Mwaba and the mouth of small Ruzizi River (1.3 crocs / km2), Kilomoni 2 (1 croc / km2), the Kimuka and Ndunda sites (0.9 croc / km2), and finally, the Kimanga site (0.3 croc / km2).

The difference in Nile crocodile densities by sampling site is highly significant (χ = 464.22, df = 9, p <0.001).

The sites of Kaberagule and Kyamvubu frequented by the Slender-snouted Crocodile (*Mecistops cataphractus*), are not inhabited by the Nile Crocodile probably because of their topograghic homogeneity.

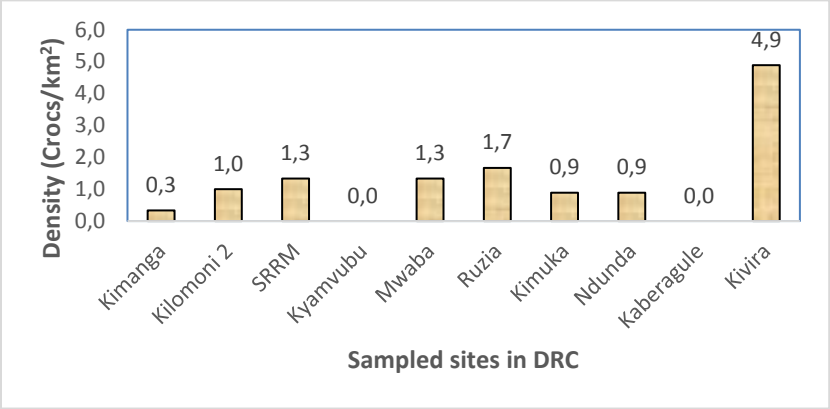


Figure 7 The density (crocs/km²) of Nile Crocodile in DRC
SRRM: Small Ruzizi River in DRC. **Source**: Our fieldwork of 2018-2019

5.2.2 Density of the Nile Crocodile in the Rusizi Burundian Plain

Figure 3 shows the density of the Nile Crocodile in the Rusizi Burundian Plain. The densest sites are Vugizo and the mouth of the Great Rusizi River (8.0 crocs / km2). The following sites are Mpanda site (4.4 crocs / km2) and the Grande Rusizi River Bridge (2.2 crocs / km2). The difference between Nile Crocodile densities per sampling site is significant (χ = 66.49, df = 4, p <0.001). The Nile crocodile does not inhabit the site of Kagunuzi with less extent of wetlands. The Slender-snouted Crocodile yet frequent it.

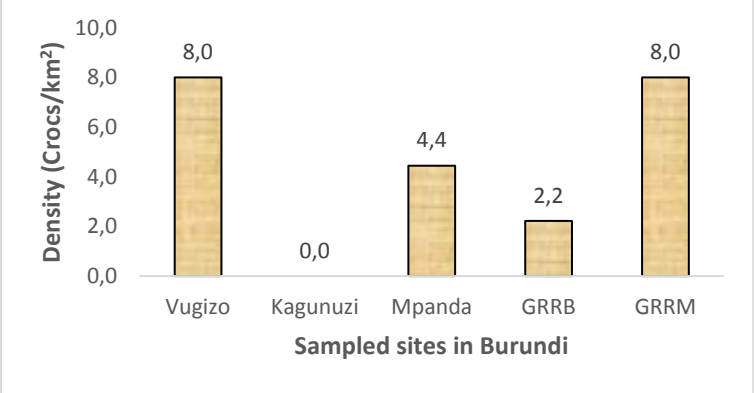


Figure 8 The density of Nile Crocodile in the Rusizi Burundian Plain
GRRB: Great Rusizi River Bridge; **GRRM:** Great Rusizi River Mouth.
Source: Our fieldwork of 2018-2019

5.2.3 Density of the Slender-snouted Crocodile in the Ruzizi Congolese Plain

Figure 4 shows the density of the Slender-snouted Crocodile (*Mecistops cataphractus*) in the Ruzizi Congolese Plain by sampling site. The site of Kaberagule (4,9crocs / km^2) is the densest. It is followed by the Kilomoni 2 site (2.7 crocs / km^2), then the Ndunda site (2.0 crocs / km^2), Kyamvubu (1.8 crocs / km^2), the Mwaba, Kimuka and Ruzia sites. (1.3 crocs / km^2).

The difference between the densities of the Slender-snouted Crocodile per sampling site is highly significant (χ = 342.03, df = 9, p <0.001). The site of Tangaro / Kivira does not contain any Slender-snouted Crocodile but the Nile Crocodile strongly frequent it.

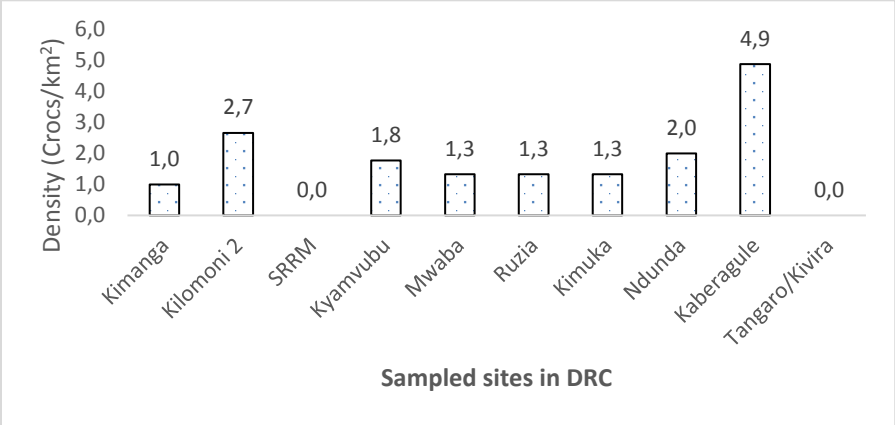


Figure 9 The density of Slender-snouted Crocodile in the Ruzizi Congolese Plain
SRRM: Small Ruzizi River Mouth**; Source:** Our fieldwork of 2018-2019

5.2.4 Density of the Slender-snouted Crocodile in the Rusizi Burundian Plain

Figure 5 shows the density of the Slender-snouted Crocodile, in the Rusizi Burundian Plain by sampling site. The Vugizo site (13.8 crocs / km^2) has the highest density. It is followed by the Great Rusizi River Mouth (12.0 crocs / km^2), then the Mpanda (4.9 crocs / km^2) and Kagunuzi (4.4 crocs / km^2) sites. The difference between the densities of the Slender-snouted Crocodile per sampling site is significant (χ = 92.752, df = 4, p <0.001). The topographically homogeneous site of the Great Rusizi Bridge, mainly inhabited by the Nile crocodile, does not contain the Slender-snouted Crocodile.

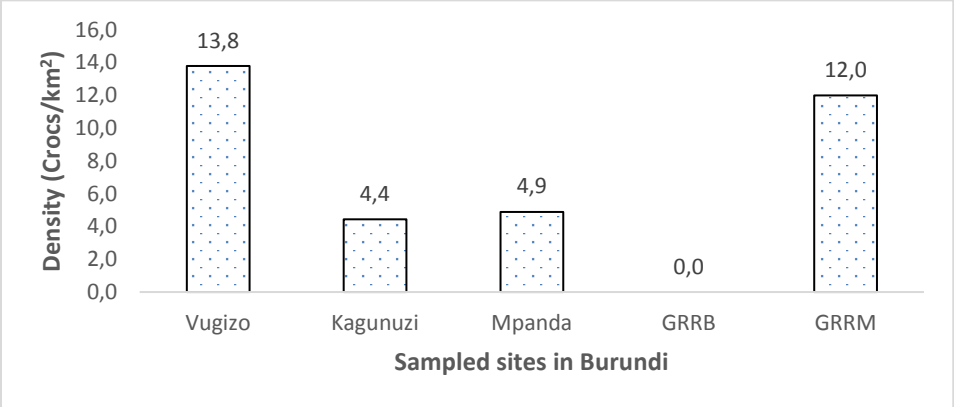


Figure 10 The density of the Slender-snouted Crocodile in the Rusizi Burundian Plain
GRRB: Great Rusizi River Bridge; **GRRM**: Great Rusizi River Mouth.
Source: Our fieldwork of 2018-2019

5.2.5 Density of the Nile Crocodile in the DRC and Burundi

Figure 6 shows the density of the Nile Crocodile in the DRC and Burundi. The density is higher in Burundi (22.6 crocodiles / km2) than in the DRC (12.3 crocodiles / km2). The difference between the densities of the Nile Crocodile in Burundi and DRC is highly significant (χ = 3518,079, df = 14, p <0.001)

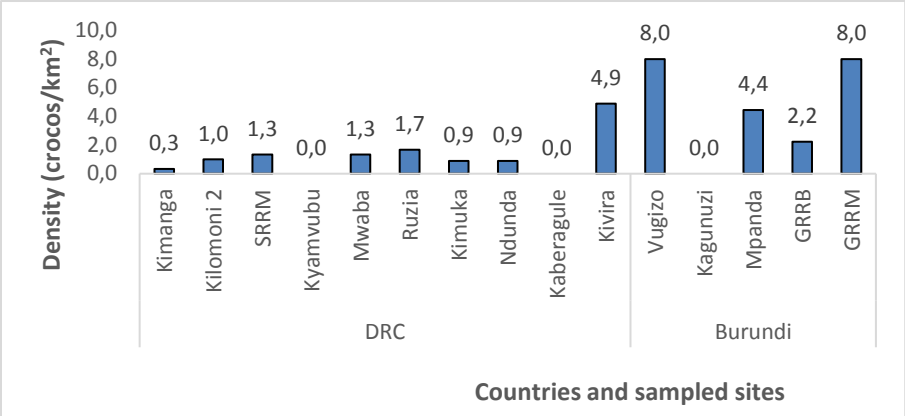


Figure 11 The density of Nile Crocodiles in the Rusizi Plains

SRRM: Small Ruzizi River Mouth; **GRRB**: Great Rusizi River Bridge; **GRRM**: Great Rusizi River Mouth. **Source**: Our fieldwork of 2018-2019

5.2.6 Density of the Slender-snouted Crocodile in the Rusizi Plains

Figure 7 shows the densities of the Slender-snouted Crocodile in the Rusizi Burundian Plain and in the Ruzizi Congolese Plain.

The density is higher in Burundi (35.1 crocs / km^2) than in the DRC (16.3 crocs / km^2). The difference between the densities of the Slender-snouted Crocodile between Burundi and the DRC is highly significant (χ = 4655.43, df = 14, p <0.001)

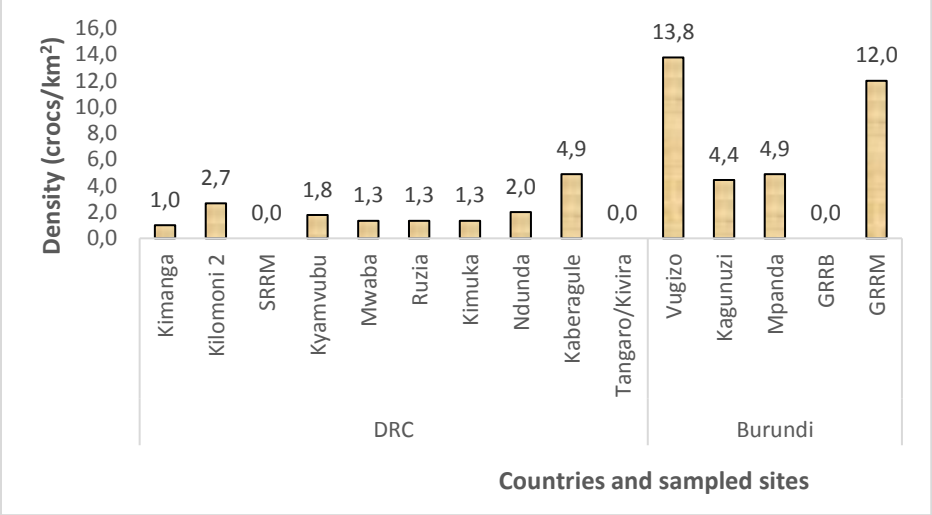


Figure 12 The density of Slender-snouted Crocodile in the Rusizi Plains

SRRM: Small Ruzizi River Mouth; **GRRB**: Great Rusizi River Bridge; **GRRM**: Great Rusizi River Mouth. **Source**: Our fieldwork of 2018-2019

5.2.7 Compared densities of the two recorded crocodile species

Figure 8 shows the comparative densities of the two crocodile species recorded in the Rusizi Burundian Plain and in the Ruzizi Congolese Plain. The Global density is 101.44 crocs / km^2 of which 42.50 crocs/km2 for the Nile Crocodile (*Crocodylus niloticus*) the real crocodile, and 58.94 crocs/km2 for the Slender-snouted Crocodile (*Mecistops cataphractus*) or caiman. The difference between the densities of the two crocodile species is highly significant (χ = 101.44, df = 14, p <0.001).

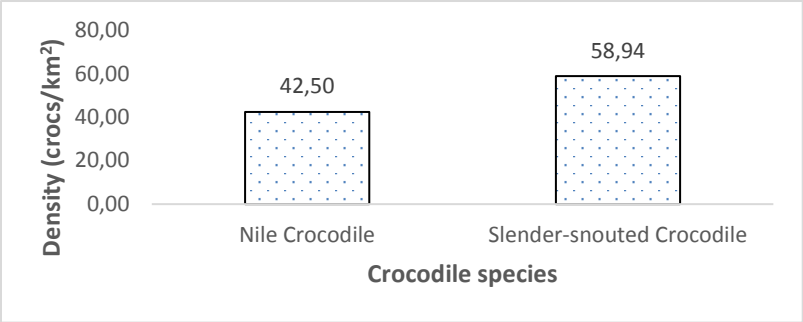


Figure 13 The densities of the two species of crocodiles in the Ruzizi Plains
Source: Our fieldwork of 2018-2019

6 Discussion

Crocodiles reproduce by laying eggs and means of calve process (Ziegler & Olbort, 2018). Some of our respondents looted crocodile habitats and built residential, commercial, cow-breeding and fishing houses there. Others use wetlands as their fields and practice traditional practicing agriculture on burns. This explains some unusual positions, but the majority of the population, recognizes the need to protect the banks (100m) of rivers, ponds, the shore of the lake up to 100m for crocodiles, birds and hippos and biodiversity in general (CPR 2002). Two crocodile species are recorded in the Ruzizi Congolese and Burundian Plains, the real crocodile, the Nile Crocodile (*Crocodylus niloticus*) and the false crocodile, Slender-snouted Crocodile (*Mecistops cataphractus*) or Caiman. These two crocodile species are endangered in the Ruzizi plains, and on the littoral of the northern end of Lake Tanganyika. The threshold being 50 individuals/km^2, only the caiman, Slender-snouted Crocodile (*Mecistops cataphractus*) hardly exceeds the threshold with 58.94 crocs/km^2, while the Nile Crocodile falls below the threshold with 42.50 crocs/km^2. The reasons for this threat of extinction are the degradation of natural ecosystems and poaching. Crocodile sexing based on external morphological features alone is rather difficult particularly in juvenile and mature specimens. In general, males possess relatively thicker tail bases, are stronger built and grow larger than females (Ziegler & Olbort, 2018)

According to the Egide (2012), the Rusizi River Mouth was once home to various species of crocodiles. The density of crocodiles in this river offered him the particularity of the most populated Crocodile River in the entire Great Lakes region of Africa. Twenty years ago, it was easy for tourists to observe crocodiles from the top of the Great Rusizi River Bridge. Thus crocodiles had trouble feeding themselves as the fish in the river dwindled more and more, leading some of them to roam the beaches of Lake Tanganyika in search of food. This caused almost regular crocodile attacks on lake swimmers. Seven years after this author's observation, things have completely changed. There are almost no crocodiles under the Grande Rusizi River Bridge, also known as the Barundi Unity Bridge. Our surveys nevertheless recorded 2.2 crocs / km^2, only the Nile Crocodile (*Crocodylus niloticus*). The Nile Crocodile is really endangered in the Ruzizi plains as reported by this author. Although the crocodiles had diminished to the point where they disappeared, the fish did not increase as the author had said. Contrary to the argument of this author, we argue that the presence of the crocodiles in rational proportions following a rational harvest, would favour the density of the fish because the crocodile plays the role of sanitation of the ecosystems by catching the sick fish and ready to die due to their old age.

McNeish (2014) who visited Burundian works to prevent crocodiles from putting on the stove informed that crocodiles had disappeared from the shores of Lake Tanganyika in Burundi because of poaching and hunger. This alarm should as well be done on the other side of the Ruzizi River in Uvira DRC. A widely publicized man-eating crocodile had roamed the banks of the Ruzizi River and the northern shores of Lake Tanganyika. Crocodile Gustave, estimated at about 6 meters long and weighing about 900 kilograms, would have killed and eaten many people (MCRae & Michael 2008). Currently it is believed that due to the degradation of natural conditions and to escape poaching, Crocodile Gustave has dug southward into Zambia, Nsumbu National Park (McNeish, 2014) where ecological conditions are favorable.

Crocodiles are necessary for the ecosystem productivity because they feed on fish and other aquatic vertebrates that are sick and ready to die by old age. They play the role of sanitation of aquatic environments. Crocodiles are important in the income of households close to crocodile parks (Flora et al., 2019) and their growing populations can help mitigate human-crocodile conflict by alleviating poverty and hunger (Fukuda *et al.,* 2014). Crocodile's skin is highly sought after by the footwear industry, belts and other uses such as travel bags. It generates economical supplies when crocodiles are properly managed (Tisen *et al., 2013*; Stevenson *et al.,* 2014; Woodward *et al.,* 2014).

Both Burundi and the DRC receive refugees and internal displacement people sometimes, creating man-crocodile conflicts, apparent or not apparent. An adequate management plan for crocodiles would contribute to the resolution of human-wildlife conflicts through job creation, the alleviation of poverty, hunger and the underpinnings for international trade (Tisen *et al., 2013*; Stevenson *et al.,* 2014; Woodward *et al.,* 2014). Crocodiles would also contribute to valuing peoples' cultures as customary or religious decorative objects and international trade if they were well developed and rationally managed (Caldwell, 2017, CSG, 2019) in the Ruzizi plains. Land users along the Ruzizi River in the DRC and Burundi would understand that by protecting the banks of rivers and ponds, their households will be the most beneficiaries of the gains of protection compared to more distant households (Flora et al., 2019).

Fukuda et al. (2014) studied the management of human-crocodile conflict in Northern Territory Australia. They examined crocodile attacks and elimination of problem crocodiles and concluded that crocodilian populations in one location are causing a recrudescence of human-crocodile conflict, and that the focus of changes in conservation management at mitigation should be take into account possible man-crocodile conflicts. In the Ruzizi Plain, the farmers, the anglers and the guards of cows at the beginning, did not want to see or hear about crocodiles. For them crocodiles are dangerous, malevolent and evil animals. At the end of our public sensitization, they understood that crocodiles play the role of sanitation of lakes, rivers and ponds by the predation of sick fishes, fishes weakened and ready to die by old age (Bashonga 2019). Manolis and Graham 2013 assessed the attacks of the saltwater crocodile (*Crocodylus porosus*) in Australia and their consequences for management. Following this study, the government recognized the need to develop a management plan to provide economic incentives for the sustainable conservation of crocodiles. In Uvira DRC, attacks of crocodile were not reported during the 2017-2019 years, indicating that crocodilians are disappearing on the coast of the northern end of Lake Tanganyika.

This is a significant signal that if actions to protect their natural habitats by respecting 100m of riverbanks free of any human activity in the bays and mouths of major rivers in accordance with the environmental protection regulations relayed by ministerial and provincial decisions in the DRC, crocodiles will completely disappear from the north coast of Lake Tanganyika.

7. Conclusion

The density of the Nile Crocodiles is below the minimum threshold in the Burundian and Congolese plains of Ruzizi. Similarly, the density of the Slender-snouted Crocodile has dramatically dropped compared to previous years. These two species are endangered in these environments if necessary actions to protect their natural habitats are not made effective.

8. Recommendations

At the national level, pursue the national development plan for the creation of new protected areas for the conservation of biodiversity, particularly 100m from the banks and mouths of the Ruzizi Rivers, natural ponds and the shoreline of Lake Tanganyika at Uvira DRC. At the provincial level, we recommend the continuation of provincial actions to protect the 100m of Ruzizi River bank, natural ponds and the shoreline of Lake Tanganyika in Uvira. At the territorial level and Uvira Town Hall, to raise awareness of the need for wetlands for hippos, crocodiles, birds and biodiversity in general for the productivity of rivers, ponds and Lake Tanganyika. In Burundi we recommend support for the protection actions of the Rusizi National Park for the conservation of hippopotamus, crocodiles, birds and biodiversity in general, a source of fisheries, economic, financial and cultural productivity. For local people, we recommend respect the 100m of riverbanks and lakeshore for hippopotamus, crocodiles, birds and biodiversity conservation.

Biodiversity conservation is very important for the fish productivity essential for people nutritional, economic, financial and cultural wellbeing and for fight against climate change.

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References

Bashonga B. Alexis (2019). Sensibilisation du public sur la réduction des menaces qui pèsent sur les crocodiles et les hippopotames de la plaine de la Ruzizi et du littoral du lac Tanganyika à Uvira RDC, extrémité nord du lac Tanganyika. CEBioS, http://cebios.naturalsciencess.be 4 pages 27/08/2019.

Caldwell J. (2017). *World trade in crocodilian skins 2013-2015. The Louisiana Alligator Advisory Council, Louisiana, United States of America*. UN Environment World Conservation Monitoring Centre (UNEP-WCMC), Cambridge, 32 pages. www.unep-wcmc.org 29/08/2019

CSG (2019). Farming and the Crocodile Industry. *Crocodile Specialists Group.* http://www.iucncsg.org/pages/Farming-and-the-Crocodile-Industry.html 29/08/2019, 5pp.

CPR (Cabinet du Président de la République), 2002. *LOI N°011/2002 DU 29 AOUT PORTANT CODE FORESTIER.* Journal Officiel, 43ème Année Numéro Spécial 6 novembre, 102 pages.

Egide Alex B. (2012) Le crocodile de la Rusizi, une espèce en voie de disparition. *Club Karibu*, Bujumbura, Burundi. http://www.guidetouristique-clubkaribu.over-blog.com 20/06/2016

Felton, Anna A.; Russell, James M.; Cohen, Andrew S.; Baker, Mark E.; Chesley, John T.; Lezzar, Kiram E.; McGlue, Michael M.; Pigati, Jeffrey S. et al. (2007). Paleolimnological Evidence for the Onset and Termination of Glacial Aridity from Lake Tanganyika, Tropical East Africa .*Palaeogeography Palaeoclimatology Palaeoecology* **252** (3–4): 405. doi:10.1016/j.palaeo.2007.04.003

Flora Felix Manyama, Martin Reinhardt Nielsen, Eivin Røskaft, & Julius William Nyahongo (2019). The Importance of Bushmeat in Household Income as a Function of Distance from Protected Areas in the Western Serengeti Ecosystem, Tanzania. Environment and Natural Resources Research; Vol. 9, No. 3; ISSN 1927-0488 E-ISSN 1927-0496. Canadian Centre of Science and Education 49, 14 pages. URL: https://doi.org/10.5539/enrr.v9n3p49 28/08/2019

Fukuda, Y., Manolis, C. and Appel, K. (2014). Management of human-crocodile conflict in the Northern Territory, Australia: review of crocodile attacks and removal of problem crocodiles. Pp. 256-278 *in* Crocodiles. Proceedings of the 23rd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland. 23 pages
http://www.iucncsg.org/pages/Human%252dCrocodile-Conflict.html 28/08/2019

Hannah McNeish, 2014. Burundian Works to Keep Crocs Out of the Cooking Pot (VOA). https://www.voanews.com/africa/burundian-works-keep-crocs-out-cooking-pot 3/09/2019

McRae, Michael, 2008. *"Gustave the Croc Surfaces to Strike Again"*. National Geographic. Retrieved 14 January 2013. 7 pages
https://en.wikipedia.org/wiki/Ruzizi_River

Manolis, S.C. and Graham J.W. (2013). Assessment of Saltwater Crocodile (*Crocodylus porosus*) attacks in Australia (1971-2013): implications for management. Pp. 97-104 *in* Crocodiles. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.
http://www.iucncsg.org/pages/Human%252dCrocodile-Conflict.html 8 pages 29/08/2019

Manolis, S.C. and Graham J.W. (2014). Human-crocodile conflict in the Australia and Oceania region. Pp. 200-208 *in* Crocodiles. Proceedings of the 23rd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland.
http://www.iucncsg.org/pages/Human%252dCrocodile-Conflict.html 29/08/2019, 9pages

Stevenson, C., De Silva, A., Vyas, R., Nair, T., Mobaraki, A. and Chaudhry, A.A. (2014). Human-crocodile conflict in South Asia and Iran. Pp. 209-226 *in* Crocodiles. Proceedings of the 23rd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland..
http://www.iucncsg.org/pages/Human%252dCrocodile-Conflict.html 29/08/2019 18 pp

Tisen, O.B., Gombek, F., Ahmad, R. and Kri, C. (2013). An assessment of human-crocodile conflicts in Neyyar Wildlife Sanctuary, India. Human-crocodile issues: Sarawak report. Pp. 115 *in* Crocodiles. Proceedings of the 22nd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland. One page
http://www.iucncsg.org/pages/Human%252dCrocodile-Conflict.html 29/08/2019

Woodward, A.R., Leone, E.H., Dutton, H.J., Hord, L. and Waller, J.E. (2014). Human alligator conflict in Florida, USA. Pp. 182-199 *in* Crocodiles. Proceedings of the 23rd Working Meeting of the IUCN-SSC Crocodile Specialist Group. IUCN: Gland, Switzerland. 18 page.
http://www.iucncsg.org/pages/Human%252dCrocodile-Conflict.html 29/08/2019

Ziegler T. and Olbort S., 2018. Genital structures and sex identification in crocodiles. https://www.iucncsg.org/365_docs/attachments/protarea/Geni-4343c282.pdf

Appendices

Appendix 1. Questionnaire on crocodile's ecology, conservation and management plans

1 Where do crocodiles live (on land, on the coast of the lake, in rivers or in ponds?
2 How do crocodiles reproduce (calve, lay eggs or both at the same time)?
3 Crocodiles frequent which environments (non-vegetated coasts, vegetated coasts, rivers without vegetation, vegetated rivers, ponds without vegetation or ponds with vegetation)?
4 What should we do to improve crocodile habitats protection (cultivating along the coasts, let 100m free shore, dubbing the rivers and Ponds, leave free 100m from the rivers and the ponds)?



Figure 14 Young Slender-snouted Crocodile (*Mecistops cataphractus*)



Figure 15 Sampling crocodiles at Tangaro (Kivira) site in November 2018



Figure 16 Sampling crocodiles and hippos in Rubenga (Luvungi) site November 2018



Figure 17 Sampling crocodiles in Ruzia Site in November 2018



Figure 18 Loss of teeth by crocodiles in captivity from 2016 to 2019



Figure 19 Sampling crocodiles in Kyamvubu site in October 2018



Figure 20 Sampling crocodiles at Small Ruzizi River Mouth October 2018



Figure 21 Sampling crocodiles at Great Rusizi River Mouth October 2018

22 September 2019