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Hippopotamus amphibius Linnaeus 1758 at Ruzizi River and Lake Tanganyika (Territory of Uvira, South Kivu, DR Congo): population census and conservation implications

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ABSTRACT

Description of the subject: The study took place along the Ruzizi River between Kamayola and its mouth in Lake Tanganyika in the coast of Uvira.

Objectives: The aim was to assess abundance and distribution of hippo populations and propose community management to warrant the conservation of the species in these fragmented ecosystems.

Methodology and Results: The methods consisted of sampling on line transects using direct and indirect observations, associated with socio-economic surveys on the cohabitation between the local population and the Hippos. A total of 412 faeces, 123 footprints, 129 tracks and 145 Hippopotamus individuals were observed during two study missions. The average encounter rate per km of signs of hippopotamus activity and the population was higher in the Nyangara & Kahorohoro wetlands. Following the damage caused by the hippopotamuses, two site, Luvungi and Katogota were the most affected, while the human lives lost were more in the city of Uvira.
The socio-economic survey of the local population showed that agriculture was the first economic activity.

*Conclusion and application of results***:** In order to reduce conflict between men and hippopotamus, some strategies were developed and proposed for the long-term conservation of this aquatic pachyderm.

Keywords: Abundance, Spatial distribution, Conservation, habitat management, Hippopotamus.

INTRODUCTION

Counting fauna actively contributes to maintaining the integrity of ecosystems and biodiversity (Poilecot 2009; Poilecot et *al.*, 2013). However, for a better management of species and habitats, it is necessary to have a good understanding of the current situation and/ or changing trends to develop good biodiversity conservation strategies (Hacker et Jank, 1998; Halford et Matthew, 2003). This study focuses on the threats to biodiversity, especially the common hippopotamus (*Hippopotamus amphibius* Linnaeus 1758) faces in two fragmented aquatic environments in a river (the Ruzizi River) and lake (mouth of the Ruzizi River on Lake Tanganyika, west coast near the city of Uvira), eastern Democratic Republic of Congo (DRC). Both sites are characterized by the degradation, loss and reduction of the natural habitat of the hippos because of illegal human activities and more than a decade of armed conflicts (Aruna, 2020; UICN, 2018). Environment in the area has been adversely affected by abusive land use, and is likely to undergo transformations on the hippopotamus species in a near future. As for now, hippopotamuses are wandering around looking for secure habitats (**Figure 1**) and also regularly poached and traded by the soldiers and local communities, due to growing human-animal conflict and increasing contact (Aruna, 2020).

Fig. 1: Hippos foraging in the Ruzizi plain near a village (Photo Witanene Milenge)

A report of the International Union for Conservation of Nature (Chokola et *al.*, 2008) states that the Ruzizi River and Lake Tanganyika are favoured natural habitats for common hippopotamuses in South Kivu Province, eastern DRC. Across the border, in Burundi, is a protected area (Ruzizi Reserve), a RAMSAR site where the species enjoys effective protection (Mushagalusa, 2010). The common hippopotamus is a semi-aquatic mammal species from sub-Saharan Africa, living in rivers, lakes and mangrove swamps (Schwarm et al., 2005); the other existing species being the Dwarf Hippopotamus, found in West Africa. They are all within the family Hippopotamidae (Class of Mammalia and

Chordata Branch, (Boisserie, 2005). The common Hippopotamus can be recognized by its barrel-shaped bust, a mouth which can be opened wide to reveal large canines, a hairless body, a column-like limbs and its large size (Boisserie et *al.*(2005). This study presents data on the abundance and spatial distribution of the hippopotamus population in the Ruzizi River and the coasts of the river mouths, capsizing on Lake Tanganyika in the city of Uvira. It also assessed the poaching pressures in the Ruzizi Plain and give collective and participatory strategies for the sustainable protection of this species.

MATERIAL AND METHOD

Study areas*:* The area covered by this study is (*1*) the Ruzizi River in the DRC and (*2*) Lake Tanganyika, near the city of Uvira (**Figure 2**). This river, called Rusizi (i.e. Ruzisi and/or Ruzizi), is the outlet of Lake Kivu, linking it to Lake Tanganyika (Akonkwa, 2006). During its 117 km, it collects water from numerous tributaries, namely Luvungi, Nyakagunda, Nyamagana, Muhira, Kaburantwa, Kagunuzi, Nyarundari, Mpanda and Ruhwa. All these streams originate on the Congo side of the ridges separating the Nile and Congo basins. The Ruzizi River separates Burundi (in the east) and the DRC. Eight kilometers from its mouth, the Rusizi River is divided into two branches. The Little Rusizi to the west carries only a tenth of its waters and runs along the border of the Democratic Republic of Congo. The Grande Rusizi to the east, carrying the remaining waters, is the main tributary of Lake Tanganyika (Mushagalusa, 2010, Akonkwa, 2006). Coulter (1991) and Aruna (2020) indicates that the temperature of Lake Tanganyika in the mouth of the Ruzizi River is above 25°C with an average standard deviation that does not exceed 3°C. A thermal stratification is observed where a warm "epilimnion" superficial layer is superimposed on a colder "hypolimnion" deep layer. Annual rainfall covers almost 8 months of the year with an average of 900 mm. Savannah vegetation has been destroyed along the river and at its mouth.

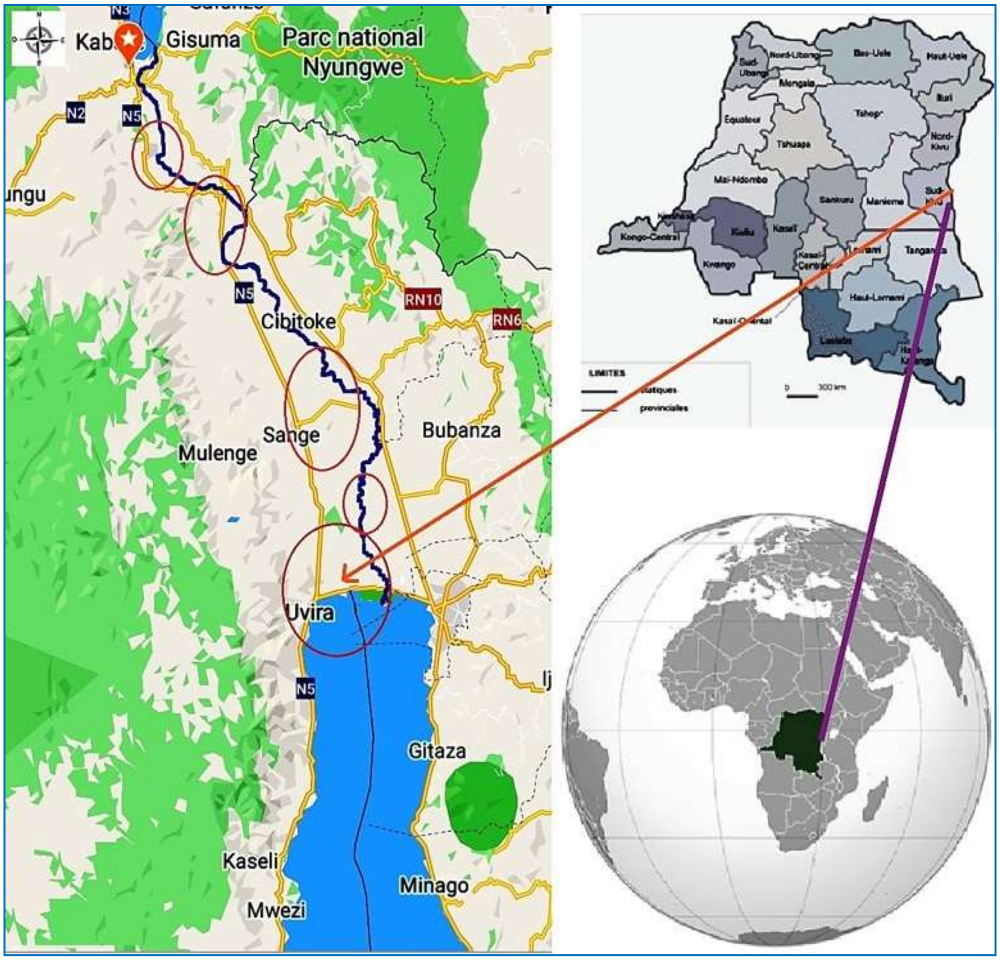

Fig.2: Map of the study area along the river Ruzizi (red circle indicates the sites of investigation).

Methodology

Scalding period: Sampling was undertaken over a period of 5 months, divided into two periods:

- the first 2-month (between 12/04/2020 and 1/06/2020) consisted of prospection in different stations spread along the Ruzizi River and the important tributaries of the catchments located in the Congolese side of the boundary between Burundi and the DRC. Some streams were also prospected and inventoried.

- The second phase, from 26/07/2020 to 26/010/20: investigations were carried out along the beach north of the mouth of Kavinvira and the entire city of Uvira.

Data collection: Data were collected on the hippopotamus populations as well as anthropogenic activities and environmental factors. Fieldwork consisted of two series of investigations: firstly, direct observation (counting observed animals) and other signs of the evidence of their presence (faeces abundance indices, vocalizations or calls, tracks, fresh footprints.) to assess their abundance and the second consisted of socio-economic surveys to guide conservation strategies (Poilecot et *al.*, 2010). A codification of indices, human activities and environmental factors was made to facilitate data collection. Transect data collection in general has followed the principles of distance sampling (Buckland al.1993; Buckland et *al.*, 2001). The data collection sheet and the CyberTracker database also recorded general information about the site and transects and the collection team. For each observation, the data recorded included: time of observation, distance on the transect along the river, code of the index seen, location code, GPS coordinates, point number and altitude. A description of the habitat or environment (type of vegetation, slope, and weather conditions) was also recorded.

Hippopotamus abundance: The data collected on Hippopotamuses consisted mainly of dung piles, tracks, mud beside marshes and tree scrapings, feeding tracks, mud bathing sites, observation of individuals, vocalizations/ calls and footprints (Viljoens, 1997; Bouchée, 2008). For each observation, the age and the number were recorded as well as the frequency of use for the tracks.

For dung piles, the age class was described and the perpendicular distance from the transect was measured as suggested by Edwards and White (2001). All the coordinates were recorded using a GPS, brand Geko 201. The distances between the stations or from the source were estimated using a curvimeter software (Xander Curvimetre v2). *Socio-economy and raising awareness:* In order to try to find out the needs of households, the damage from Hippopotamuses and the threats on the hippos, the field work consisted of investigating and mapping the flow of damage attributed to Hippopotamuses. A questionnaire on a sample of households affected by the Hippopotamus was used in the villages along the Ruzizi River (**figure 3**).

Figure 3. A Collecting data in the field using the dugout canoe and B. raising awareness among the local population (Photos: Witanene Milenge).

Data analysis: The data were entered into an Excel sheet for various analyses. Using the Excel software, pivot tables and groupings were used to synthesize indices of the species recorded. On this basis, encounter rates (Kilometric Abundance Indices) were calculated (Scotcher et *al*, 1978; Delvingt, 1978; Eltringham, 1993). Graphs and tables were produced using Excel. In order to compare encounter rates at the different sites for the types of observation made, histograms associated with confidence intervals were drawn using the software STATISTICA 7. The encounter rates on transects made it possible to draw the spatial distribution maps using ArcGIS 10.2. The logistic regression model was used to estimate the rate of habitat degradation using R for Windows and Excel. This model made it possible to plot the survival curves of the indices and to determine the decay rate corresponding to a probability of survival (P) of 0.5.

$$\mathbf{P}\left(\mathbf{Y}=\frac{\mathbf{1}}{\mathbf{Xi}}\right)=+\frac{\mathbf{e}^{\mathbf{2\alpha+\beta X+\alpha i}}}{\mathbf{e}^{\mathbf{2\alpha+\beta X+\alpha i}}}.\ (1)$$

Where α (constant) and β (time coefficient) are coefficients determined using the Software R; X represents the time (Weiler et *al*., 1994).
In order to estimate the density and abundance of hippopotamuses, the software Distance 6.2 was used, taking into account the conversion parameters estimated. In order to obtain a better fit of the data, data truncations and interval readjustments were done to achieve good detection curves. Stratification by site was necessary to obtain estimates for different sites in the study area. To determine the sample size, we used Bouchard (2010) table according to which, for an infinite population of up to 1,000,000 individuals, a sample of 96 subjects is matched with a 10% margin of error (Bouchard, 2010):

$$N=\frac{n\ x\ N}{n+N}=\frac{96\ x\ 59268}{96+59268}=95,5 \text{ i.e. 96 persons } (2).$$

N = the size of the parent population, n = the sample size for an infinite population or sample size for the finite universe.

According to Bouchard (2010) formula, a margin of error of 100% must be assumed each time we want to determine the sample; in this case, 106 households. Given that five sites were chosen to investigate socioeconomic activities of the local populations, a total of 530 households were interviewed (106 per site). To test the influence some factors on the density and distribution of hippos in order to test the correlation, the distance to the river bank was recorded, vegetation type, number of villages within 10 km of transects, and evidence of poaching or human activities. To achieve it, Canonical Redundancy Analyses (CRA) was performed using the software CANOCO for Windows, version 4.5 (ter Braak et Verdonschot, 2002).

RESULTS

Sampling efforts

Sampling effort and hippopotamus behaviour*:* Of the 30 km of transect planned, 26 km were covered; a completion rate of 86.7%. Some transects could not be surveyed because of accessibility on one hand, and the fact that most of them overlapped and were subject to flooding, water erosion, landslides and sedimentation of rivers and the lake. According to the study field observations, these animals are herbivorous and have a more diversified diet. On site, territorial males defend a portion of the territory of a group of 5 to 12 females and/ or 3 to 8 individuals, with the juveniles. In the field, we also found that during the day, they prefer cool environments by staying in the water or mud, and they feed on grass near the river banks (**Fig.4, A&B**).

Figure 4: On the left, the population of Amphibious Hippopotamus in its natural habitat in the Nyangara wetland and on the right, population towards the delta at the mouth of the Ruzizi River (Photos: Witanene Milenge and Mangambu).

Relative abundance of hippopotamuses

Density and absolute abundance of hippopotamuses: A total of 412 faeces, 123 footprints, 129 tracks and 145 hippopotamus individuals were observed during the two study missions. The average density of hippopotamuses observed was 0.135 [0.06 - 0.15] individuals/km2, i.e. an estimated population of 96 [54-137] individuals. This population is highest in the Nyangara & Kahorohoro wetlands (56 [28-83] individuals), followed by the Katokota site (50 [22-78] individuals) and the northern part of the plain at Kamanyola (23 [18-28] individuals, table 1).

Table 1: Density and number of hippos in the different macro-sites

Parameters		*Uvira*	*Nyangara Kahorohoro wetlands*	*Katokota*	*Luvungi*	*Kamanyola*
Density (Number/km²)	Average	0,465	0,08	0,078	0,34	0,18
	Coefficient of variation	26,14	12,61	26,12	24,12	22,45
	Confidence intervals	0,003-0,005	0,03-0,09	0,024 -0,086	0,005 - 0,02	0,02-0,031
Total Number of individuals	Average Confidence interval	4 3 - 5	56 28 - 83	50 22 - 78	12 5 - 18	23 18 - 28

Relative abundance of hippos: The average encounter rate per km of signs of hippopotamus activity in the Nyangara and Kahorohoro wetlands was 13.8 ± 5.81 of which 2.9 ± 1.11 are for direct observation and 3.1 ± 1.11 are for droppings. The Footprints have an encounter rate of 2.81±1.07 indexes/km and the track rate (3.88 ± 1.01) in Kamanyola. Vocalizations are highest in Kamanyola (2.11 ± 0.99) followed by Luvungi: 2.09±0.91 (Table 2). Values are lower at Uvira.

Table 2: Encounter rate (n/km) of hippopotamus signs in different macro-zones.

Types of signs	***Uvira***	***Nyangara Kahorohoro wetlands***	***Katokota***	***Luvungi***	***Kamanyola***
Food	0,08±0,04	2,09±1,02	1,07±0,87	0,45±0,082	0,97±0,12
Mud on grasses and shrubs	0±0	1,05±0,76	0,04±0,016	1,32±0,94	0,012±0,0012
Dungs	0,04±0,02	3,1±1,41	2,2±1,19	0,86±0,12	1,06±0,65
Footprint	0±0	0,75±0,07	1,63±0,261	1,13±0,32	2,81±1,07
Direct observation	0,53±0,1	5,9±3,11	5,2±1,71	2,32± 1,005	3,14± 1,11
Track	0,3±0,07	2,88±1,18	3,09±1,01	1,02±0,82	3,91±1,09
Vocalization	0±0	0,01±0,01	1,01±0,86	1,09±0,71	2,11±0,99
Global	0,95±0,23	15,78±7,56	14,24± 6,717	8,19±3,997	14,012±5,042

Spatial distribution of hippopotamuses and effects of some factors on species density

Spatial distribution of hippopotamuses: The spatial interpolation of hippopotamus distribution (IKA) according to direct and indirect observations is shown in Figure 5.

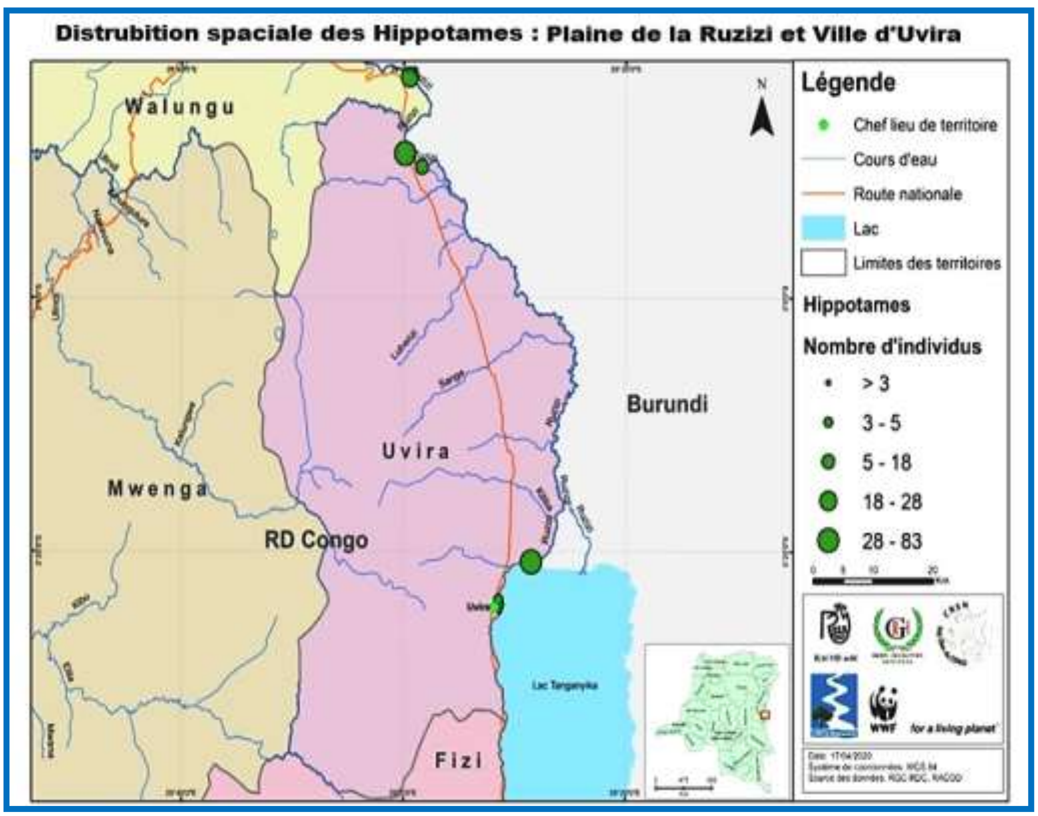

Figure 5: Map showing the distribution and numbers of populations and individuals of Hippopotamus along the Ruzizi River, its mouth and the coasts of the city of Uvira.

We observed four distinct hippopotamus populations since there is no sign of a migration corridor according to the data collected:
- On the Ruzizi River whose range straddles between Luvungi and Katogota;
- The largest population of hippopotamuses is found in the two swamps of Nyangara and Kahorohoro almost at the mouth of the Ruzizi River;
- Another population is at Kamanyola, which is the second largest, and the animals range between Ruzizi River and Rhuwa River at the border between Burundi and Rwanda.
- The smallest, very offensive population on the shores of Lake Tanganyika, in the city of Uvira.

Factors affecting species densities*:* Figure 6 shows the effects of some factors on hippopotamus diversity, abundance and density. The explanation of the relationships between different parameters in the redundancy analyses takes into account the angle between the arrows representing the eigenvectors defined by each variable. The more acute the angle is (≥ 0° and < 90°) between the vectors of two variables, the more positive the correlation between the two variables. A right angle (90°) denotes a null relationship, while an angle between 90° and 180° shows a negative correlation. The correlation is stronger and more significant when the angle tends towards 180°.

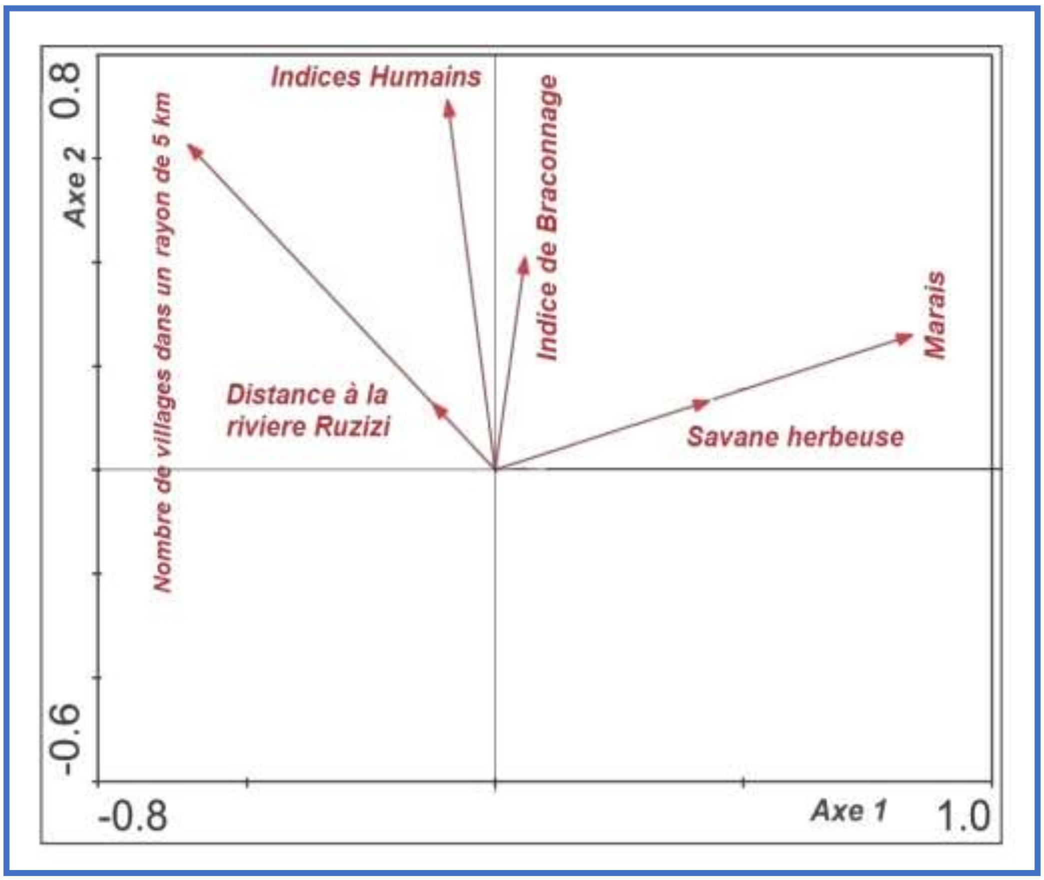

Fig.6: Effects of selected factors on the diversity, abundance and density of Hippopotamuses**.**

The cumulative percentages of the explained variance vary between 83.9% and 98.8%; the smallest explained variance is 70%. In fact, due to the negative impact of human pressures (marked by the number of villages within a radius of 5 km, the encounter rate of all human indices, the encounter rate of poaching activities), the hippopotamus prefers marshland and grassy savannah environments, where it finds much of its food; this shows the particularity of these areas and their importance in the conservation of hippopotamuses.

Strategies of conservation

Damage caused by Hippopotamuses*:* The consequences of the proximity of hippos with villages are damaging for both hippopotamuses and humans: reduction of crop harvests in agricultural lands; insecurity in the areas where hippopotamuses live; decimation of the hippopotamus population and the loss of human lives. We used surveys to categorize the populations according to the different types of damage identified. The results Table 3 show that hippos have caused more damages at Luvungi, followed by Katogota. However, the killings and insecurity are high in the city of Uvira. The situation seems to be stable in the Nyangara & Kahorohoro swamp.

Table 3: Hippopotamus damage in the study area. No = numbers; % = percentage.

Variable per camp	**Uvira**		**Nyangara & Kahorohoro wetlands**		**Katokota**		**Luvungi**		**Kamanyola**	
	No	%	No	%	No	%	No	%	No	%
Destruction of crop fields	0	0	11	68,7	38	41,3	33	37,9	24	72,8
Destruction of pastures	0	0	5	31,3	16	17,4	12	13,8	6	18,1
Insecurity and killing	44	74,7	0	0	26	28,3	39	44,8	2	6,1
Destruction of house	15	25,3	0	0	12	13,	3	3,5	1	3
Total	59	100	16	100	92	100	99	100	33	100

Socio-economic aspect of the local population*:* To achieve the strategies of natural resource management policies, maintain sustainability of hippopotamus habitats, and avoid their overexploitation, we investigated the main activities of the local populations.

Table 4: Main activities of island populations

Business of the population	Numbers	Percentage
Agriculture	130	24,5
Breeder	115	21,7
Small business	110	20,8
Fishermen	100	18.8
Crafts	75	14,2
Total	530	100

The results in Table 4 show that agriculture is the higher rated economic activities for local populations, followed respectively by animal husbandry and small-scale business. Other activities, such as fishing and handicrafts, which are considered secondary activities, have a significant contribution to the economy.

Community management of Hippopotamus habitats: State agencies are often characterised by lack of efficiency and most of the time, inability to determine and control people's environmental practices. For a significant contribution, we carried out the following activities:

Installation of signs*:* We installed signposts (**Figure 7 A, B & C**) for the delimitation of areas with a high concentration of hippos, divided into 3 categories: passage areas or site for crossing, maternity and resting sites following a participatory delimitation on site with the local community. Key message on the signposts is "Protect, Participate, Innovate...” for the protection and safeguard of the hippopotamus.

Figure 7. Sign posts indicating the activities of common hippopotamuses. A: resting site, B: crossing route and C: maternity. (Photos: Witanene Milenge).

This message embodies the work of raising public awareness at Uvira and the Ruzizi plain, explaining why protect, why participate and why innovate in this sector.

- The word protect includes the protection of the population itself which will have to define the community mechanisms to live with animals as it happens in Burundi where the Hippopotamus never constitutes a problem and the protection of the species in accordance with the law on the conservation of biodiversity in the DRC ;
- Participate: it is a principle of involvement of all stakeholders in the definition of strategies for the conservation of the species but also the diversification of the livelihoods of communities to reduce poaching;
- Innovate: This is the principle according to which each stakeholder in the area will be able to make an innovative contribution to enhance the protection and conservation of the species and positively change the perception of people living along the Ruzizi River and Lake Tanganyika on hippos in order to use them for economic, cultural and tourist opportunities.

Income-generating activities (IGAs) by local population: Income-generating activities increase the purchasing power and strengthen the livelihoods of households highly dependent on the market for food. In this project, IGA benefits, some agreed to become involved in the management and protection of the habitat of the species Hippopotamus at the mouth of the Ruzizi River on Lake Tanganyika. An identification of the project beneficiaries, of which One hundred and twenty seven (127) households were identified, represented by 84 women and 43 men in Kahorohoro, Kilomoni and Kilubula near the mouth of the Ruzizi River at Lake Tanganyika (figure 8 A &B).

Fig.8. A, Handing over of seeds to the local population and B, handing over of breeding rabbits to the population in the study area (Photos: Witanene Milenge).

The beneficiaries received 267.5 kg kits of maize seed and 40 households also benefited from 80 rabbits - a male and a female for each household. Out of a Baseline of 104 households planned for the first phase of the project, the present outcome of the seed beneficiaries is 127 households as shown in Table 5.

Table 5: Distribution of kits to income-generating activities (IGAs) carried out among the local population.

Distributed kits	Number of beneficiaries per household	Kits received per household	Grand total
Maize seeds	107	2,5 kg	**267.5 kg**
Princess amaranth seeds	107	50 g	**53.5 kg**
Rabbits' progenitors	40	2 Rabbits (1 male + 1 female)	80 individuals

DISCUSSION

Favourable habitats and abundance of hippopotamuses: The Ruzizi River and Lake Tanganyika are the privileged habitats of hippopotamus in South Kivu Province, Eastern Democratic Republic of Congo (DRC). We found a total of 145 Hippos observed during the two survey missions with an average density of 0.135 [0.06 - 0.15] individuals per km^2; an estimate of à 96 [54-137] individuals. This population is higher in the Nyangara & Kahorohoro marshes (56 [28-83] individuals). The importance of this site was confirmed by Cikwanine et *al* (2008) who characterized the abiotic and biotic environments of fishing activity in the wetland of Nyangara. They found that the Nyangara & Kahorohoro wetlands play an important role in this ecosystem. The Hippopotamus dungs bring a large quantity of silicon to the water. This chemical is vital for the microalgae that feed the fauna and flora of these sites. Chokola et *al* (2008) found that the Nyangara wetland is a maternity site for hippopotamus in their study based on the socio-economic aspects of fishing at Lake Tanganyika and the Nyangara wetland, near the city of Uvira.

According to Mushagalusa [8], the city of Uvira is currently under demographic pressure with a population concentrated on various activities such as agriculture, livestock farming and commerce other tertiary activities; fishing is an important activity along the coasts of Uvira on several beaches. It noteworthy to show that our study area is cross-border with Burundi. This area has been experiencing internal conflicts for more than two decades. These phenomena have caused significant population movements and led to strong demographic growth in the town of Uvira. While on the other side of the border, in Burundi, there is a protected area (Ruzizi Reserve), a RAMSAR wetland site where species benefit from effective protection, in DRC hippopotamus habitats are occupied and degraded by different human activities.

Hippopotamuses looking for secure habitats are regularly poached and traded by the soldiers and local communities because of growing human-animal conflict and frequent contact (**Figure 9**). This is confirmed in our analyses; one of the signs of the negative impact of humans is the number of villages within a 5 km radius of the hippopotamus' natural habitat. On the other hand, they prefer marshland and grassy savannah environments in which they find much of their food, highlighting their importance in the conservation of hippopotamuses.

Factors increasing human-wildlife conflicts : According to Aruna (2020), in 2019 alone, there were four cases of human life loss and seven cases of poaching on hippos. In addition to the direct poaching pressure, habitat fragmentation is one of the threat. An important factor in our study area is human demography (Akonkwa, 2006); habitat evolution, the distribution and behaviour of wildlife have significantly contributed to increasing human-wildlife conflicts as highlighted by Aruna (2020).

Figure 9: A and B, A hippopotamus shot by soldiers at Kiliba, eastern DRC (Photo Aruna***)***

However, in other sites such as Uvira, hippopotamuses go through a life of wandering looking not only secure habitat, but also food because their habitat has been destroyed and disturbed by human activities. According to Amoussou et *al.* (2006), the influence of habitat, anthropisation and neighbourhood effects are the factors contributing to the emergence and persistence of hippopotamus-human conflicts Aruna et *al.* (2020). The consequences are damaging for both hippopotamuses and humans: reduction in agricultural yields, insecurity in the areas where hippopotamuses live, decimation of the hippopotamus population, loss of human lives (Olivier et Laurie, 1974). This is particularly true in Africa, where human population almost tripled in four decades from 1960 onwards and where, as a result, agricultural encroachment has colonised the most marginal lands, encroaching on wildlife habitats (Noirard, 2008). Under these conditions, conflicts between wildlife and local communities are bound to develop. In Niger, it is estimated that about 95% of the hippopotamuses counted are outside the national park near the only protected area where a few individuals live. Access to water is basic need to all living organisms (Grey et *al*., 2020). Permanent crop protection fences are usually erected close to a water source when there are intense wildlife activities that can cause crop raiding (Charmes, 2005).

Mechanism to reduce human-amphibious hippopotamus conflicts: Although crop damage is less widespread, human deaths and/or injuries are the most serious form of human-wildlife conflict. It is still generally believed that the Hippos are responsible for more deaths than any of Africa's wildlife species once destabilised in its habitat, (Weiler et *al*., 1994; Boisserie et *al*., 2005b). In the surrounding villages and city districts close to the site, three meetings were held in this hinterland in the city of Uvira (Kilomi, Kilubula and Kahorohoro) for awareness-raising sessions on the ecological importance of amphibious hippopotamus conservation in our area and the definition of community mechanisms. That is why; we contributed to some income generating activities among the local population. According to Vwima (2014), rabbits are the most widely distributed animals in the fight against food insecurity in the Kivu region. The rabbit herd is probably the most important because of its rapid reproduction rate that is because of the presence almost everywhere of its food, which favours its rapid growth and production of substances that allow rapid fertility. The resolutions for the conservation of the species and habitat management by the local community are:

- Request the creation of a reserve dedicated to the conservation of the Hippopotamus and other animals and their habitat along Ruzizi and in Lake Tanganyika;
- Initiate a project to plant reeds and bamboos and other edible species for Hippopotamus on the beaches of the Kilibula and Kalundu neighbourhoods, around the Nyangara wetland and along the Ruzizi River;
- Avoid building in the shores of Lake Tanganyika and the Kalimabenge River and initiate a ban for communities to crop or fish in some areas of high hippo concentration;
- Use community participatory demarcation of the area to limit the area for human's activities with the habitats of the hippos;
- Use solar panel fences with electric shock to limit crop fields and village from hippo grazing sites;
- Initiate regular meetings on human - wildlife conflicts, and think of a system of alerts on cases of poaching and attacks by hippos to the local communities.

CONCLUSION AND APPLICATION OF RESULTS

This study focused on the abundance, distribution and community management of the Hippo populations in fragmented ecosystems: the case of the Ruzizi River and Lake Tanganyika (Uvira, DR Congo). This study results showed an uneven distribution of hippopotamus in the study area. Numbers are high in places far from human dwelling; however, sites close to human activities, the density and abundance is low and the cohabitation between local population and the hippos leads to conflicts. On the one hand, humans occupy and unsustainably hippos grazing areas, while the hippos increase in number, causing damage to farming, fishing or on livestock.

Conflicts range from the repeated crop raiding to direct attack on animals resulting in human deaths. Local populations need awareness on ecosystem services rendered by animals. To mitigate negative impacts, we recommend:
- Protection of the hippos and their habitat from human activities;
- Promote the hippos through raising awareness to the public and the rural population for a better integration of the hippos in the local culture;
- Raise awareness in the sustainable use and management of natural resources.

ACKNOWLEDGEMENTS

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