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IUCN-SSC Crocodile Specialist Group
Student Research Assistance Scheme Application

FINAL REPORT: PROJECT 18/19

DEVELOPING ADAPTIVE CONSERVATION STRATEGIES FOR CROCODILE SPECIES UNDER CLIMATE SCENARIOS IN BENIN (WESTERN AFRICA)

Step 1. DISTRIBUTION AND ABUNDANCE OF CROCODILE SPECIES IN THE COMPLEX W-PENDJARI BIOSPHERE RESERVES OF BENIN (WESTERN

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The authors claim no conflicts of interest concerning the results presented in this report.

ABSTRACT

The project submitted aimed to address how far climate change will impact range of suitable habitats for threatened crocodile species (*Mecistops cataphractus, Crocodylus suchus*, and *Osteolaemus tetraspis*) in Bénin (Western Africa). This report is related to the first objective of the project which examined the distribution and abundance of crocodile species in the complex Pendjari Biosphere Reserve (PBR) - W Transboundary Biosphere Reserve (WTBR) of Benin in West Africa from November 2018 to December 2019. The current taxonomic resurrection of the West African crocodile (*Crocodylus suchus*) calls for new assessment of their population in their potential habitat. We aimed to map the current distribution of *C. suchus* in the complex W - Pendjari Biosphere Reserve and to assess their abundance. Data were collected from November 2018 to November 2019. The distribution area of *C. suchus* was mapped with ArcGis 10.5 software using geographical coordinates of presence/absence points. And, we determined population size and structure during day and night counts on foot. *C. suchus* occurred in 54.2 % of water points of the complex (N = 83). A total of 389 crocodiles were recorded across the complex (77.6 % in the Pendjari Reserve and 22.4 % in the W), giving a relative abundance of 10.3±1.13 crocodiles/km in the Pendjari Reserve and 11.4±3.82 crocodiles/km in the W reserve. We used a Getis-Ord Gi* Hot Spot Analysis to show that the two main hot spots of occurence were located in the most secure parts of the Pendjari Reserve (Getis-Ord Gi* Z score = 8.08; Confidence = 99 %) and W National Park (Getis-Ord Gi* Z score = 2.41; Confidence = 95 %). Based on comparison with previous efforts, the crocodile population in the Pendjari reserve is likely to be growing, while the crocodile population in the W reserve is threatened by siltation, illegal fishing and hunting, pollution by pesticides carried from outside the reserve, and illegal access of cattle which call for better management.

Key words: *Crocodylus suchus,* distribution, illegal fishing and hunting, conservation

1. INTRODUCTION

Protected areas are considered as peaceful habitats for the conservation of species where they can easily achieve their high fitness (Xu *et al.*, 2016). Species select protected areas to avoid threats and unsuitable factors of non-protected areas which favored the decrease of their population sizes. In the class of reptiles, crocodilian species can rapidly recover from the decrease of their population when habitat conditions become favorable. Important populations of crocodilian species were recorded in protected areas across the world (Read *et al.*, 2004; Singh & Rao, 2017; Tellez *et al.*, 2017) even though crocodilian are known to also inhabit various waterways and dams outside protected areas (Cedeño-Vázquez, Ross & Calmé, 2006). Unfortunately, even in protected areas, crocodile species face various threats

due to natural predation and climate variability (Delany *et al.,* 2011; Britton, Britton & McMahon*,* 2013) but also due to anthropogenic factors like pollutions, illegal fishing and illegal poaching (Bhatt, Saund & Thapa, 2012; Bouwmann *et al.*, 2014; Yves *et al*., 2018). River and riverside pollutions result in adverse effects on crocodile physiology and health, egg contaminations and various abnormalities (Stocker *et al.,* 2003; Sepulveda *et al.,* 2006; Charruau, Henaut & Alvarez-Legorreta, 2013). Rivers of protected areas exceed generally their borders and easily drain pollutants up to the rivers which threaten aquatic and semi aquatic species like crocodiles. In Benin (Western Africa), pollution threat in protected areas are linked to agricultural practices in the surrounding villages where pesticides can be uncontrollably use in cotton and various cultivations (Kpéra, 2008). Then, even protected areas need continuous surveys of species population and their habitat because, due to the above mentioned threats, species population can drastically decrease (Ferreira & Pienaar, 2011; Britton, Britton & McMahon*,* 2013). Therefore, assessing the species distribution and population sizes is fundamental for early detection of threats and then developing management strategies (Sinclair & Byrom, 2006;

An individual should occupy only habitat in which its evolutionary fitness is maximized which is possible if habitat selection follows an ideal free distribution (IFD). Then, drainage of river section is likely to affect species population of crocodile species in the reserve. Crocodiles play an importance role in their ecosystem and in some countries, the presence of crocodiles has influenced proposals to classify areas as a reserve (FAO, 1982). Bourquin & Leslie, 2011).

The Pendjari Biosphere Reserve and the W Transboundary Biosphere Reserve are the main protected areas of Benin. A research was carried out in 2002 in the W Transboundary Biosphere Reserve and mentioned anthropogenic threats on crocodiles (Kpéra, 2008). In the Pendjari Biosphere Reserve, no research as done on crocodiles. The current study aimed to assess the distribution and abundance of crocodile species in the two Biosphere Reserves. Especially, the study aims at mapping the current distribution of crocodile species in the complex Biosphere Reserves, assessing the structure and population size of crocodile species and recording the threats of crocodile species. This study also provides data on the important pools for crocodiles' conservation in the reserves.

2. METHODOLOGY

2.1. Study area

The study was held in the Complex Pendjari Biosphere Reserve (PBR) - W Transboundary Biosphere Reserve (WTBR) in Benin (West Africa) located in the Soudanian agro-climatic zone (Western Africa) (Figure 1). The complex of Biosphere Reserve extends over a total

area of 1 313 546 ha of which 495 628 ha for the Pendjari Biosphere Reserve and 817 918 ha for the W Transboundary Biosphere Reserve (WTBR) in Benin.

The following climatic characteristics of Benin were recorded by Tente (2011). The climate is typically dry tropical with one dry season and one wet season. The wet season occurs from May to October. The annual rainfalls in the southern part of the reserves are 1050 mm. $year^{-1}$ in the WTBR and 1329 mm. $year^{-1}$ in the PBR considering respectively the nearest weather station of Kandi and Natitingou Districts. These rainfalls can decrease until 800 mm. $year^{-1}$ in the northern border of the reserves. The dry season is marked by harmattan which is a cool dry wind that blows from the northeast or east in the western Sahara and is strongest occurs from December to January characterized by a fall of temperature till 12°C. Important for crocodile species, the average solar radiation in the study area is 3 068,6 hours.

PBR is bordered and surrounded by Pendjari River the main permanent waterbody. WBR is sprayed by two permanent rivers, Alibori and Mekrou rRvers. The ramifications of those water bodies dry into a series of isolated freshwater pools that persist throughout the dry season.

The study was carried out from November 2018 to December 2019 covering the two seasons of the year (dry season and wet season). Data were collected in the four hunting zones and two National Parks of the PBR and the WTBR. We used data base of Park administrations (list of temporary and permanent pools of Pendjari Biosphere Reserve) to record geographic coordinates of the water points and of the study areas. Additional water points found during data collection were prospected. We prospected 83 river sections and pools (20.5 % rivers and 79.5 % pools) across the complex of Biosphere Reserve of which 68.7 % were located in the Pendjari Biosphere Reserve and 31.3 % in the W Transboundary Biosphere Reserve (Figure 1). Forty-seven (47) % of the water points were permanents and 53 % were temporaries.

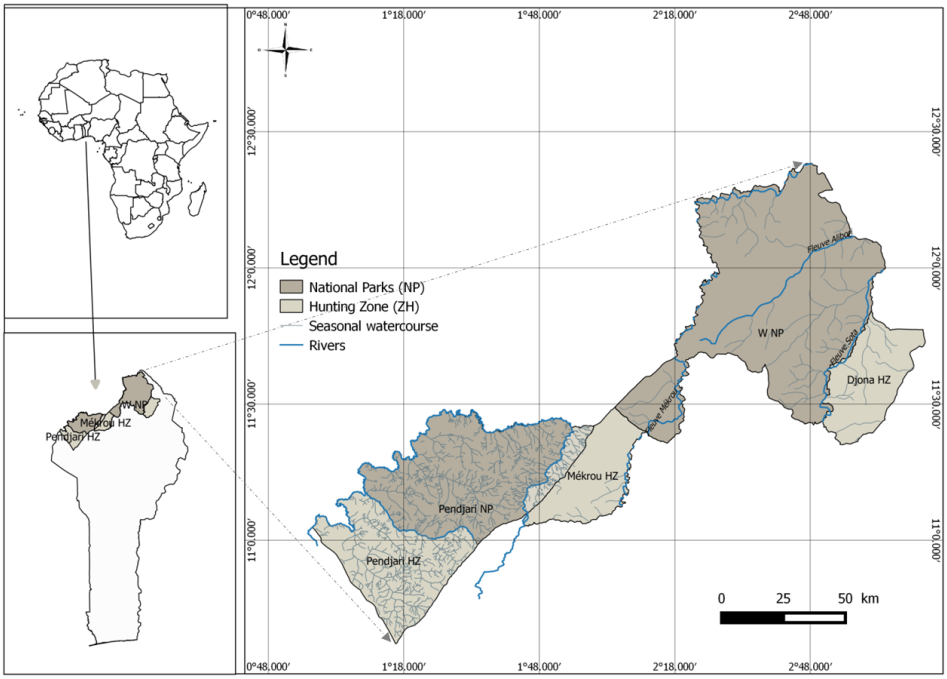


Figure 1. Complex Pendjari Biosphere Reserve and W Transboundary Biosphere Reserve (Source: Bio Ouré, December, 2019)

2.2. Data collection

2.2.1. Distribution and abundance of crocodile species

Data collection occurred from 7 am to 7 pm during the day and from 10 pm to 3 am during the night (Kpéra, 2008). During the day, we firstly searched for crocodile species in their habitat by visualizing the water points and the banks from elevated points using binoculars. We recorded for crocodile presence marks by their faecal pellets, burrows, nest, eggshells, ventral scale tracks, tail marks, footprints, death crocodiles, shouting of juvenile during the day (Campos *et al.,* 2016; Sai *et al*., 2016; Prasad *et al.,* 2018). We recorded geographic coordinates of presence and absence points using global positioning system (GPS). We recorded the locations if there was at least less than 4 m accuracy on the GPS receiver. The presence points indicate pools and river sections where crocodiles were recorded instead of the presence points of each crocodile seen. Then, in one presence point mentioned, more than one crocodile can be recorded. Each age class was counted daily using the following size classes of *Crocodylus niloticus*, total length (TL) < 1 m as juveniles, 1.1 m to 2 m as sub-adults, and > 2 m as adults (Sai *et al.,* 2016).

We realized night spotlight counts of crocodile's species (Da Silveira, Magnusson & Thorbjarnarson, 2008) on foot because whether water level in the river sections didn't allow the use of boat or in high water level, hippopotamus were presents. Then, foot surveys were used in all the water points to avoid survey methods bias. We identified crocodiles by the reflection of their eyes as a result of the presence of a reflective optic layer known as the tapetum lucidum (Leslie, 1997; Espinal & Escobedo-Galva, 2011). River lengths and pool areas were measured with GPS. Size classes were also recorded during the night but we

have just made the difference between juveniles and the other classes (sub adults and adults).

2.2.2. Habitat characteristics

Habitats characteristics of crocodiles were deeply analyzed in the Pendjari Biosphere Reserve (BRP) by recording determinants of habitat selection, characteristics of crocodile burrows and the characteristics of crocodile nesting sites. Eight potential factors were recorded namely the type of water point (Pool or river), aquatic vegetation (Behler *et al.*, 2018), shoreline vegetation (presence or absence) (Lyet *et al.,* 2016; Adugna *et al*., 2017), accessibility to the bank, seasonality of the water point (temporary or permanent), presence of hippopotamus, siltation (high or low), type of bank (Adugna *et al.*, 2017). Burrows were characterized by recording the width and height using a measuring tape, the distance burrow-water points with a penta-decameter and the position (Under tree, under rock, free).

2.3. Data analysis

The distribution of crocodile species was mapped using ArcGis10.5 software. Daytime counts were used to determine the structure of crocodile population. We performed a Chi-square ($\chi 2$) test of independence of variables to determine difference in population structure between the two Reserves (Sai *et al.*, 2016). We considered $P < 0.05$ to be biologically significant (Espinal & Escobedo-Galva, 2011). We determined the linear density and the density per water surface prospected with night counts data. Linear density (number of crocodiles per kilometer) is the encounter rate of crocodile species per distance prospected (Adugna *et al*., 2017; Choudhary, Choudhury & Gopi, 2018). The density of crocodiles per water surface or area prospected is expressed in number of crocodiles per hectare (Crocodile/ha) (Riley & Huchzermeyer, 1999; Brazaitis *et al.*, 2009; Calverley & Downs, 2014; Marques *et al.*, 2016) or kilometer square (Prasad *et al*., 2018). Welch Two Sample t-test was used to determine difference in crocodile encounter rates and densities between the two Reserves.

We performed a Kernel density of ArcGIS Spatial Analysis tools to highlight crocodile distribution in the complex of Biosphere Reserves. As non-parametric tool, Kernel density doesn't identify statistically significant hotspots, we then combined it with a Hot Spot Analysis (Getis-Ord Gi*) of ArcGIS Spatial Statistics tools.

3. RESULTS

3.1. Distribution of crocodile species

The West African crocodile (*Crocodylus suchus*) was the only crocodile species recorded in the complex of Biosphere Reserves. The species is present both in the hunting zones and the National Parks, in river and pool, and in temporary and permanent water points.

Crocodiles were recorded in 54.2 % water points prospected (n = 83) in the complex Biosphere Reserves (Figure 2). The crocodile's water points were composed by 64 % pools and 36 % rivers. Those water points had both permanent (69 %) and temporary (31 %) flows. However, in five temporary river sections in the Pendjari Biosphere Reserve, a part from the presence marks, only hatchlings were recorded.

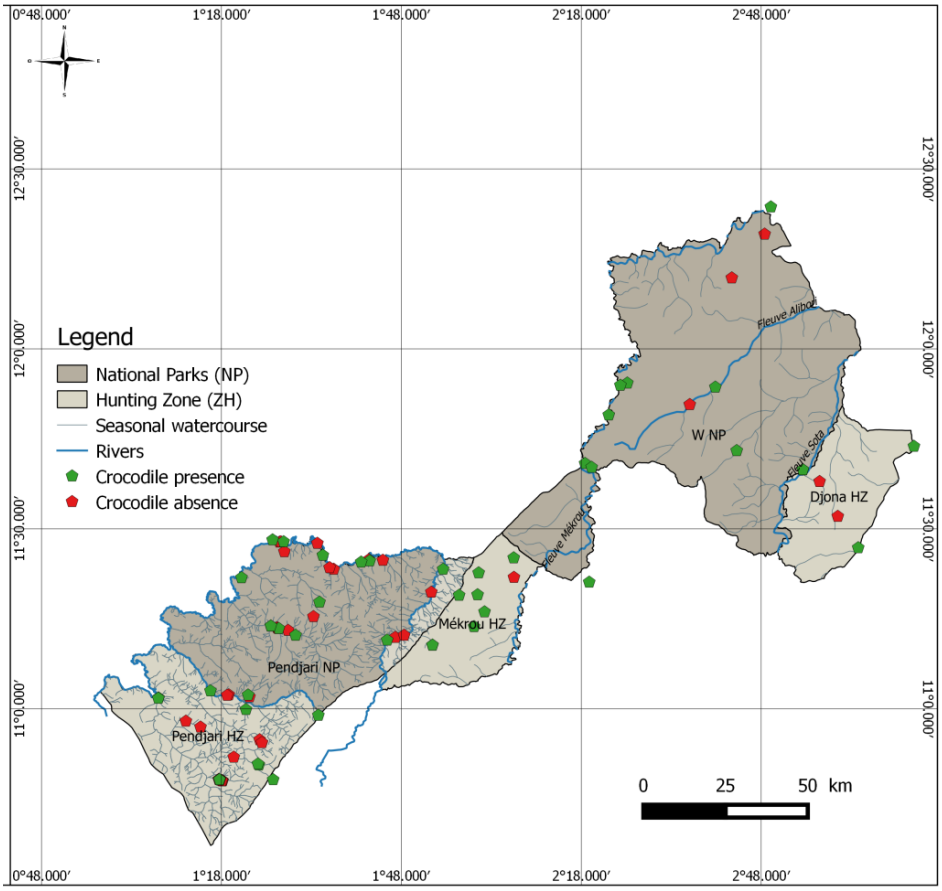


Figure 2. Distribution of West Africa Crocodile (*Crocodylus suchus*)

3.2. Abundance of crocodile species in the complex PBR-WTBR

3.2.1. Structure of crocodile population in the complex PBR-WTBR

Hundred thirty (130) C*rocodylus suchus* were counted during day surveys in the complex PBR (88.5 %) and WTBR (11.5 %). Juveniles were the less recorded class (Figure 3). However, during night survey in PBR, the proportion of juveniles was more than the half (54.55 %).

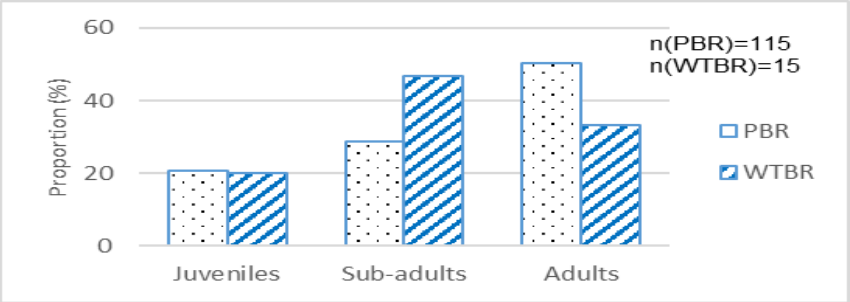


Figure 3. Size classes of crocodile in PBR and WTBR

We found a non-significant difference in population structure of crocodile species between the Pendjari Biosphere Reserve (PBR) and the W Transboundary Biosphere Reserve (WTBR) (*Chi-Sq = 1.198; DF = 2; P-Value = 0.333*).

3.2.2. Abundance of crocodile population in the complex PBR-WTBR

A total of 389 *C. suchus* were counted during night spotlight surveys in dry season in the PBR (77.6 %) and WTBR (22.4 %).

The Getis Ord Gi* statistics indicated two significant Hotspots (Getis Ord Gi* *Z* score of > 2) in the Pendjari Biosphere Reserve (Getis Ord Gi* *Z* score = 8.08; Confidence = 99 %) and the WTBR (Getis Ord Gi* *Z* score = 2.41; Confidence = 95 %) for crocodiles. The two hotspots were located in the National Parks.

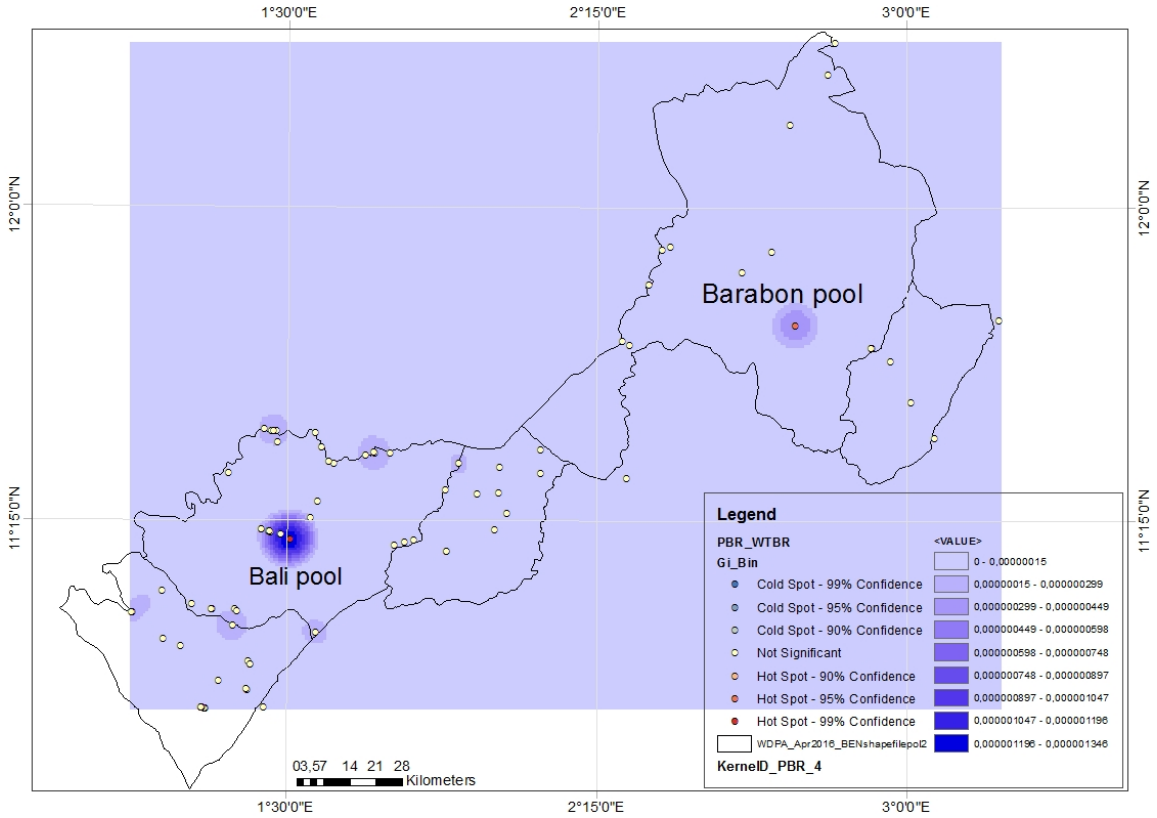


Figure 4 : Results of Kernel density analysis combined with Getis Ord Gi* Hotspot for West Africa crocodile (*Crocodylus suchus*) in the complex PBR-WTBR

- Linear densities

A total of 34.96 km of bank were prospected in the PBR (72.86 %) and WTBR (27.14 %) during night surveys. In the PBR, the high encounter rate was recorded in the Pendjari National Park and the average encounter rate for all the Pendjari Biosphere Reserve was 10.3 (± 1.13) crocodiles/km. However, in the WTBR, the high encounter rate was recorded in the Hunting Zone of Mékrou and the average density per kilometer for all the WTBR was 11.4 (± 3.82) crocodiles/km (Table 1).

Table 1. Crocodile encounter rate in PBR and WTBR (Croc./km)

	Hunting Zone 1		National Parks		Hunting Zone 1		Entire Reserves	
	PHZ	MHZ	PNP	WNP	KHZ	DHZ	PBR	WTBR
Number (Distance prospected)	78 (8.89)	19 (1.07)	196 (15.7)	59 (4.98)	25 (2.62)	9 (1.98)	299 (26.93)	87 (8.03)
Density per km	8.8	17.8	12.5	11.8	9.5	4.6	10.3 (± 1.13)	11.4 (± 3.82)

PHZ : Pendjari Hunting Zone KHZ: Konkombri Hunting Zone PNP : Pendjari National Park
MHZ : Mekrou Hunting Zone DHZ: Djona Hunting Zone WNP: W National Park

Welch Two Sample t-test for crocodile linear densities (Croc. /km) revealed no relevant difference between the PBR and WTBR (t = -0.28469, df = 2.351, *p-value* = 0.799) and between the hunting zones (Konkombri, Pendjari, Djona and Mekrou) and National parks (Pendjari and W) (t = -0.7093, df = 3.0947, *p-value* = 0.5279). During wet season, crocodiles scattered from the permanent water points to the temporary and in the WTBR, the encounter rate was 1.12 crocodiles/km (3 crocodiles for 2.67 km prospected on night) in a temporary river randomly selected in wet season (tatabouba River).

The average density of the PBR was 2.1±0,623 crocodiles/ha versus 10.1 ± 2,10 crocodiles/ha in the WTBR and the National Parks have the high densities.

Table 2. Crocodile density per area in the Complex PBR-WTBR

	Hunting zone 1		National Parks		Hunting zone 2		Reserves	
	PHZ	MHZ	PNP	WNP	KHZ	DHZ	PBR	WTBR
Number (Area Ha)	20 (12.77)	19 (2.79)	185 (53.81)	49 (3.49)	28 (21.06)	7 (0.73)	233 (87,64)	75 (7,01)
Density per ha	1,6	6,8	3,3	14,0	1,3	9,6	2,1 (±0,623)	10,1 (± 2,10)

PHZ : Pendjari Hunting Zone KHZ: Konkombri Hunting Zone PNP : Pendjari National Park
MHZ : Mekrou Hunting Zone DHZ: Djona Hunting Zone WNP: W National Park

Welch Two Sample t-test for crocodile densities per area of pool prospected in the PBR and the WTBR revealed no significant difference (t = -3.69, df = 2.3505, *p-value* = 0.0515). The results were not significant between the hunting zones and the National Parks using the same test (t = -0.668, df = 1.3002, *p-value* = 0.6026).

3.2.3. Burrows

A total of 107 burrows were counted in the PBR (82.24 %) and the WTBR (17.76 %). In the PBR, 55.68 % burrows recorded were measured (table 6). The last (44.32 % burrows) were not considered because of their positions, their modified sizes by other animal species (baboons, warthog and elephants) or because there are rocky cavities. A burrow damage by elephant foot showed a living room and 3 secondary rooms.

Table 3. Descriptive statistics of PBR burrows recorded

	Burrow width (cm)	Height (cm)	Distance burrows-water points (m)
Numbers	49	49	20
Means	66.51	42.85	3.82
± Standard Error	± 3.7	± 2.4	± 0.6
Minimum - Maximum	18 - 112	20 - 92	0 - 10.15

The distances from burrows to water points were measured during dry season. The level achieved by water during wet season perceived through water marks on shoreline trees indicated that all the burrows used to be covered by water during wet season.

Table 4. Locations of burrows recorded in the complex

Burrows location	Under trees	Free	In water	Rock cavities
PBR (n = 88)	55 (62.5 %)	12 (13.64 %)	11 (12.5 %)	10 (11.36 %)
WTBR (n = 19)	14 (73.7 %)	3 (15.8 %)	1 (5.3 %)	1 (5.3 %)
All the complex (N = 107)	69 (64.5 %)	15 (14 %)	12 (11.2 %)	11 (10.3 %)

3.3. Threats

Natural threat0s and anthropogenic threats were recorded in the complex of Biosphere Reserves. In the PBR, the natural threats recorded were a nest predated by monitor lizards, a burrow destruction by elephant feet and siltation of some pools. We didn't record any anthropogenic threats for crocodiles in the PBR.

In the WTBR, the natural threats were mainly the siltation of all the pools prospected. The anthropogenic threats recorded were illegal fishing a presence of boat at Koudou River, three presence of fishing nets and the presence of cattle's in the reserve.



Figure 5: Fishing net, Torom pool, PNW *(December, 2018)*



Figure: Cattles in the WNP near Barabon pool (*February 2019*)

4. DISCUSSION

4.1. Species richness and distribution

Crocodylus suchus is the only one species recorded in the two reserves. The slender-snouted crocodile (*Mecistops cataphractus*) and the African dwarf crocodile (*Osteolaemus tetraspis*) were not recorded both during wet and dry season. Although, absence of

occurrence is not occurrence of absence (Somaweera et al., 2019), it is likely that the two species were not present in the complex of reserves. *Mecistops cataphractus* prefers densely vegetated water points (Shirley, 2010) and northern Bénin with an average six months of dry season is not therefore a suitable habitat for the species. The presence of *O. tetraspis* was established in southern Bénin as the species prefers lagoon, small streams and swamps in forest habitat (Shirley, Oduro & Yaokokore Beibro, 2009). In a study realized within Nazinga Game Ranch (Burkina Faso) only *Crocodylus suchus* were recorded. Any Dwarf crocodile and African slender snouted crocodile were not recorded and local extinction was among the reason mentioned (Ouedraogo et al., 2016).

4.2. Structure

Both in the Pendjari Biosphere Reserve (PBR) and the W Transboundary Biosphere Reserve (WTBR), size class structures base on diurnal counts revealed that juveniles (less than 1meter) have the least proportion. This could inform that the population of West Africa crocodile is declining in the study area (Botha, 2005). However, the high proportion of juveniles recorded during the night in the PBR showed that juvenile crocodiles were not very active during the day. They do not venture as far into open water even on night and therefore are less conspicuous (Platt & Thorbjarnarson, 2000; Prasad *et al.*, 2018). Low size crocodiles rapidly learn to avoid various threats (Somaweera *et al*., 2010) and may stay hide to avoid threats such as predation and cannibalism which occur even on crocodile up to 1.5 m of total length (Tellez *et al*., 2017). Cannibalism has a significant influence on survivorship of juvenile crocodile and regulate crocodile population (Delany *et al*., 2011). Then, day surveys are inappropriate for juvenile crocodile counts. In the WTBR, even during night surveys, the proportion of juveniles remained low and suggests either low survivorship or fearful juvenile population which calls for analyzing the nesting behavior of crocodile species in future study. However, crocodile population in the study area is growing in the Pendjari Biosphere Reserve.

4.3. Population sizes and densities

Comparisons of both linear density and density per ha revealed non-significant difference between the two Biosphere Reserves ($p > 0.05$). However, the Getis Org G* statistic results suggest a greater population of crocodiles in the Pendjari Biosphere Reserve (PBR). The population size of crocodile recorded in the PBR (302 crocodiles) during the night was almost 3.5 times more than the population size in the WTBR (87 crocodiles). The difference in population sizes is likely due to lower number and lower sizes of permanent pools in the WTBR. There was significant difference between permanent pool areas of WTBR and PBR (*T-Value* = - 3.35; *p -Value* = 0.003; df = 20). Therefore, some crocodiles can migrate

(Campbell *et al*., 2013) due to the low host capacity of the WTBR water points in other permanent rivers even outside the border of the Reserve to avoid competition for territories and agonistic interactions (Brien *et al.,* 2013). Crocodiles also have estivation capacities and can spend more than three months in their burrows waiting for wet season (Christian, Green & Kennett, 1996). *C. suchus* in the WTBR may have developed this adaptive behavior to face the change in their habitat. Indeed, all this hypothesis need to be deeply studied, estivation can be an option for crocodile species to support the dry season as burrows were recorded also in temporary water points. Fergusson (2010) in Mozambique suggested that differences in river length, width and availability of suitable habitats between rivers could likely influence the population of crocodile. In fact, water fragmentation, siltation and illegal poaching/ fishing are likely to contribute to the reduction in habitat suitability in WTBR which in turn negatively impacted crocodile abundance and population size (Sai *et al.,* 2016). Then, the close statistical densities obtained for the two reserves is due to siltation threat in the WTBR which favored the reduction of water size and length during dry season. Crocodile aggregation in small size areas have contributed to high density even though the population sizes were not too high. Too high water level has significant and negative effect on the number of crocodile species seen (Da Silveira, Magnusson & Thorbjarnarson, 2008). *C. suchus* had lived the permanent water during wet season to temporary water point. The density (2.6 croc. /ha) recorded for the broad-snouted caiman (*Caiman latirostris*) is close to the one of the PBR (Marques *et al., 2016*). The encounter rate of both reserves are close to the encounter rate of *Caiman latirostris* (11.3 croc. / km) (Marques *et al.,* 2016). But in other species studied, low encounter rate were recorded for *C. morelettii* (3.6 croc./ km) (Tellez et al., 2017) and *C. niloticus* (2.29 croc./ km) (Lyet *et al.,* 2016).

The hotspots or high concentrations of West Africa crocodiles (*C. suchus*) were located in the Pendjari National Park (Bali pool) and the W National Park (Barabon pool). This indicated that *C. suchus* were liable to select the most protected areas (National Parks). In the most protected areas, the other species which are paramount the crocodile potential preys are also protected. Then the high concentration of crocodile species in the National Parks may be due to prey availability. The locations of the hotspots, almost far from the reserve borders, is interesting as crocodiles were then far from the riparian local communities. In the context where human-crocodile coexistence is usually conflicting, crocodile populations of the complex were well-protected. The results were also in adequacy with the threats recorded in the WTBR. Although, one of the hotspot is located in the WTBR, this was less (95 % Confidence) than the hotspot of the PBR (99 % Confidence).

4.4. Burrows

Crocodile species use burrows to estivate or nest. Hatchlings of *C. suchus* have been recorded in burrows and it's unclear whether female crocodiles have nested in the burrows or

they took their hatchlings at the burrows after hatching. However, burrows were used to secure the hatchlings.

Table 5. Burrows dimensions

	Mugger crocodile (*Crocodylus palustris*) (total body length up to 5 m) (Mobaraki, 2015)	*Crocodylus suchus* (total body length up to 5 m)
Width of entrance	27 cm to 60 cm	18 cm to 112 m
Height of entrance	15 cm to 40 cm	20 cm to 92 cm

The maximum burrow sizes of *C. suchus* is an average 2 times of the one of *C. palustrus* although the two species have close body length. Simpson *et al.* (2006) recorded that up to five individuals of *C. siamensis* can utilize a single burrow at one time.

5. IMPLICATION FOR MANAGEMENT

Dry season is a crucial period for aquatic species. The study revealed that in each of the reserves there is at least a pool which play a major role for crocodile species during dry season. More than 40 % of crocodile population of the complex recorded during the survey were hosted in Barabon pool (WTBR) and Bali pool (PBR). However, they are silting up and the problem occur in all the pools of the WTBR. The urgent action mainly in the WTBR where all the pools are seriously silted, is to dig the pools by removing the silt. This action must be profitable indeed for crocodile species but also all the aquatic species and the animal species in general. The direct impact for Park administration will be to maintain animal species in the area and then create more attraction for tourism purpose.

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