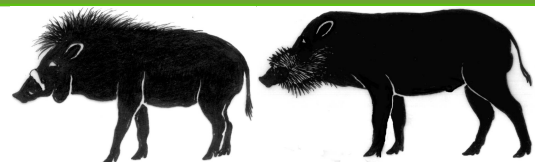


# Ecology and Conservation



## Spatially targeted hippopotamus survey and monitoring in the southern part of the Gamba Complex of Protected Areas, Gabon

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### Abstract

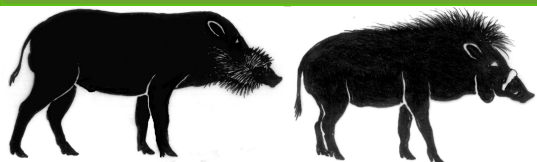
Common hippopotamus (*Hippopotamus amphibius*; hereafter hippo) populations are declining in many African countries, with West African populations most at risk. In Gabon, population numbers are largely unknown, but are believed to be in decline despite national protected status, mainly due to poaching due to poor law enforcement. The Gamba Complex of Protected Areas (GCPA), in south-west Gabon, has been identified as an important area for hippo conservation. However, the last hippo survey in this area was conducted in 2011, making the current status of the hippo population in this area uncertain. Our study aimed therefore to estimate present-day numbers and occurrence of hippos in the southern part of the GCPA and to resample some of the locations of the 2011 survey in order to compare population trends in these selected areas. The results of our spatially targeted hippo survey indicate that hippos are still widely distributed in the southern part of the GCPA, especially along the coast. However, population numbers are rather low, with the exception of the Nyanga region (Nyanga and Mouambi rivers), which revealed stable population numbers (61 individuals) since the last survey in 2011 (56 individuals) and thus remains a key area for hippo conservation in the GCPA.

### Introduction

The common hippopotamus (*Hippopotamus amphibius*; hereafter hippo) is a megaherbivore found in many countries throughout sub-Saharan Africa in suitable wetland habitats. Its conservation status was reviewed by Lewison & Pluháček (2017) and it is classified as vulnerable on the IUCN Red List of Threatened Species. These authors noted that there are clear regional differences in population size and distribution across the range, with Eastern and Southern African countries considered as a conservation stronghold for this species. In contrast, hippos are less widely distributed and typically occur at low densities in West Africa. Recent data suggest that populations in West and Central Africa are at the highest level of risk due to the fragmented nature of their distribution, the high frequency of hippo-human conflicts and unregulated hunting (Lewison & Pluháček, 2017).

In line with reports for West and Central Africa, hippo populations in Gabon are limited in their distribution and occur at low densities (Lewison & Pluháček, 2017). They are reported to reside in the National Parks of Ivindo and Pongara, the hunting reserve Wonga Wongué, and in the Gamba Complex of Protected Areas (GCPA), including Loango and Moukalaba Doudou National Parks (Christy et al., 2008; Eltringham, 1999; Michez, 2006; Rietmann, 2014). The most recent IUCN population estimate for Gabon is 250 individuals (Lewison and Pluháček, 2017). However,





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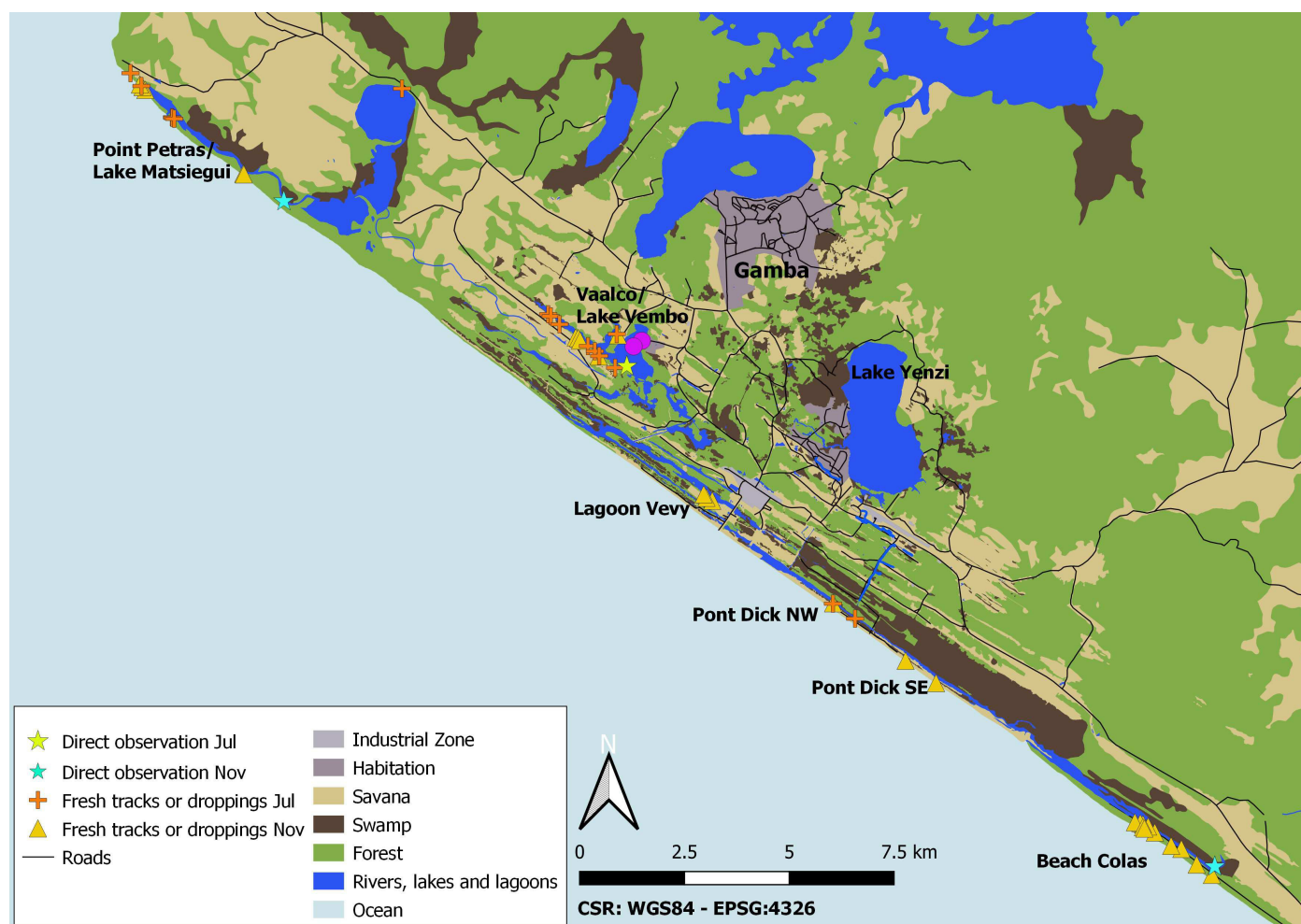
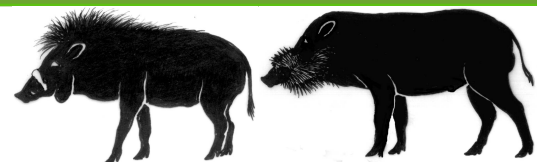


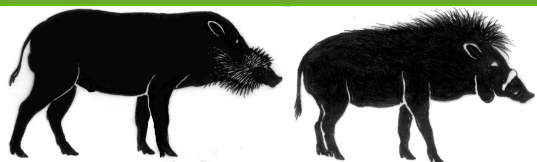
Fig. 1: Direct and indirect hippo presence signs found during the surveys on foot and by boat in July and November 2022 in and around the town of Gamba (Gamba area).

to our knowledge, there has been no systematic assessment of population numbers in Gabon, so this number should be regarded with caution.

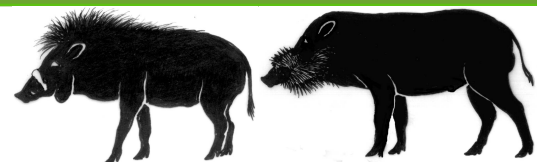
In Gabon, the GCPA is thought to hold a significant portion of Gabon's hippo population (Lee et al., 2006; Rietmann, 2014). However, in the last 16 years there have been only two surveys in the GCPA, one in the southern part of the Loango National Park, along the river Mouena Mouélé in 2006 (Michez, 2006) and more recently a more extensive survey in spatially selected areas within the GCPA in 2010 and 2011 (Rietmann, 2014). The latter study recorded the sighting of 75 and 111 individuals in the GCPA in 2010 and 2011, respectively.

Hippopotamuses have been legally protected in Gabon since 1982, but the level of law enforcement is considered to be poor. Population numbers are thought to be declining due to poaching for meat and tusks (Christy et al., 2008; Rietmann, 2014). Hippo poaching is an ongoing reality in the GCPA and was observed in Pont Dick near the town of Gamba (Fig. 1), where poachers were arrested with a fresh hippo carcass (M. Navarro, pers. comm.). Older signs of poaching (hippo bones) were also found at the same site (G. Moussavou, pers. obs.). To our knowledge the development of the hippo population in the GCPA has not been investigated since the 2010/11 survey. However, up-to-date information on the population and distribution is needed to inform





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hippo conservation. Furthermore, some suitable habitats along the coast close to the town of Gamba, which are part of the southern concessions of Assala Gabon, were not included in the last hippo survey within the GCPA. Accordingly, our study aimed to 1) estimate current numbers and occurrence of hippo populations along the coast and in lakes and lagoons near Gamba and 2) resample some of the locations of the 2010/11 survey that lie outside the Loango National Park, in order to compare population trends in these selected areas.

## Material and Methods

### Study area

The GCPA is situated in southwestern Gabon at latitude 1°50'- 3°10'S and longitude 9°15'- 10°50'E (Lee et al., 2006). The Gamba Complex is an 11,320 km<sup>2</sup> protected area on the southwest coast of Gabon that supports significant habitat and species diversity, as well as the country's largest onshore oil reserves (Dallmeier et al., 2006; Lee et al., 2006). The GCPA includes two of the 13 national parks of Gabon, Moukalaba-Doudou and Loango which are separated by an industrial corridor in which oil and logging concessions are found. Assala Gabon holds several onshore oil concessions in the industrial corridor which include Gamba and the surrounding area, including the coast. The GCPA contains a diverse mosaic of terrestrial and aquatic habitats, including mangrove forests, littoral forest, savannas, wetlands, lagoons, rivers and the Atlantic Ocean (Lee et al., 2006). The hydrologic landscapes in which hippos occur are formed by three main watersheds and a complex network of minor rivers, streams and lagoons (Lee et al., 2006; Rietmann, 2014).

Focusing on areas in and around Gamba (Gamba area), six sites were surveyed in the southern concessions of Assala Gabon that were considered suitable hippo habitat and where hippos have already been seen or reported in the past. These sites are Lake Vembo/Vaalco, Lagoon Vevy, the beach around Pont Dick north-west, Pont Dick south-east, Beach Colas and Point Petras/Lake Matsiegui (Fig. 1). Among the surveyed sites in the Gamba area, Point Petras represents the most distant site in the northwest and Beach Colas the most distant site in the southeast. These

Tab. 1: Number of direct and indirect hippo presence signs and survey effort and means per site in the dry and wet season.

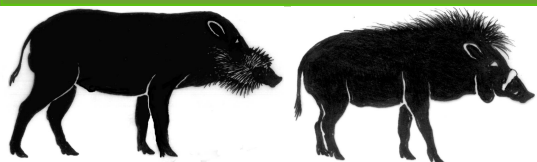
Sites	Direct observation		Droppings				Tracks				Survey effort (km)		Survey means	
	dry	wet	dry		wet		dry		wet		dry	wet	dry	wet
			fresh	old	fresh	old	fresh	old	fresh	old				
Vaalco, Lake Vembo	1	0	4	12	2	7	4	1	3	0	4.8	4	foot	foot
Pont Dick NW	0	0	0	6	0	1	2	1	1	2	3.6	3.3	foot	foot
Pont Dick SE	0	0	0	8	0	1	0	0	2	0	2.9	4.6	foot	foot
Lagoon Vevy	0	0	0	5	1	0	0	0	3	0	3	2.8	foot	foot
Colas Beach	0	4	0	3	2	0	0	0	9	0	4.3	2.8	foot	foot
Point Petras, Lake Matsiegui	0	1	3	11	0	1	3	1	3	0	5	7.9 (1.5 + 6.4)	foot	foot + boat
Nyanga	47	23									55.7	43.6	boat	boat
Mbissi	0	0									8.9	NA	boat	boat
Mouambi	14	4									27.3	27.4	boat	boat
Lake Yenzi <sup>x</sup>	0	3									NA	NA	camera trap	camera trap
Vaalco, Lake Vembo <sup>y</sup>	NA	6									NA	NA	NA	camera trap
<b>Total</b>	<b>62</b>	<b>41</b>	<b>7</b>	<b>45</b>	<b>5</b>	<b>10</b>	<b>9</b>	<b>3</b>	<b>21</b>	<b>2</b>	<b>115.5</b>	<b>96.4</b>		

NW = north-west, SE = south-east

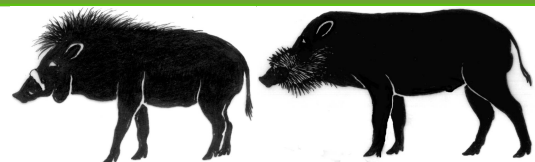
<sup>x</sup> camera trap data from July (dry) and November (wet)

<sup>y</sup> camera trap data from December (wet) 2022





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two locations are 33 km apart. With the exception of Lake Vembo, which was part of the 2010/11 survey, none of these sites has ever been systematically surveyed for hippos to our knowledge. Additionally, we included surveys in the Nyanga, Mbissi and Mouambi rivers close to the Moukalaba Doudou National Park, which were also part of the 2010/11 survey. Three other regions in the GCPA that were surveyed in 2010/11, such as the lagoons Ngove and Ndougou (both in and near Loango National Park) and the Moukalaba river (eastern part of Moukalaba Doudou National Park), were not included in our surveys.

Another site with suitable hippo habitat is Lake Zenzi (Fig. 1). However, Lake Zenzi was not included in the Gamba area surveys on foot and by boat because we have been monitoring the hippos at Lake Zenzi with camera traps (Reconyx PC800 Hyperfire) since 2020, so already know the number of hippos there. In November 2022, following the wet season survey results, we installed additional camera traps at two sites (Vaalco and Lagoon Vevy) to identify the number of hippos. The results of the camera trap records at these sites are reported along with the results of the surveys on foot and by boat to provide a more complete report on the total number of hippos in the greater Gamba area in 2022. At the other sites, we rely on surveys on foot and by boat, as installing cameras is too risky due to the risk of theft and disturbance from human activities, as well as logistical constraints.

## Data collection

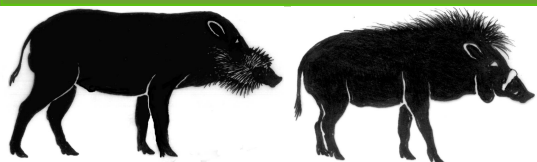
Hippos are expected to be more widely distributed in the wet season than in the dry season due to changing water levels (Fritsch et al., 2022; Karstad & Hudson, 1986; Stommel et al., 2016). Therefore, surveys were conducted in both the dry (July) and wet (November) season in 2022. For sites in the Gamba area, surveys were mainly conducted on foot. On one occasion in the wet season, the survey at Point Petras/Lac Matsiegui was conducted on foot and by motorized boat (aluminum boat, length = 4 m). For areas not accessible on foot, such as the rivers Nyanga, Mbissi and Mouambi, we conducted hippo count surveys by motorized boat (fiberglass boat, length = 7.5 m) exclusively, which was also the main survey method used by Rietmann (2014). All sites were surveyed once in the dry and once in the wet season.

On every survey day, a minimum of two observers walked around the aquatic habitat to search for the presence of and signs of hippos, from morning to afternoon (09h00 - 15h00). We recorded direct observations of hippos as well as indirect presence signs, such as droppings, tracks, feeding lawns and frequently-used paths. Droppings and tracks were marked as fresh (one to three days) or old (four days and more). When hippos were spotted, we waited, if possible, for 15-20 minutes at a safe distance (minimum 30 m) to see if there were others nearby. During direct observations we counted all visible individuals and if possible, recorded age classes (adult, subadult or juvenile). At a sighting, all observers counted independently and then discussed the numbers until agreement was reached on numbers and corresponding age and sex classes. We recorded the GPS coordinates of all indirect and direct presence signs and tracked the survey efforts using a Garmin GPSmap 62s. Maps were created using QGIS software (Version 3.22.2).

## Results

Eight sites were surveyed for direct and indirect signs of hippo presence once in July (dry season) and once in November (wet season), resulting in a total survey length of 211.9 km over 16 days





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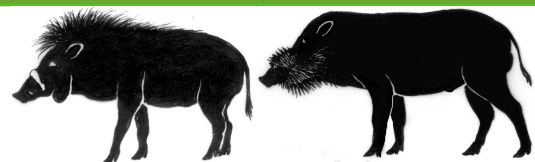


Fig. 2: A group of hippos encountered in the Mouambi river in July 2022.

(Tab. 1). At the non-river survey sites, where surveys were mainly on foot, one adult hippo was counted in the dry and five hippos in the wet season (a single adult and a group of three adults and one juvenile). During surveys on rivers conducted by boat, we encountered nine groups with a median size of 4.5 individuals (range 2 – 15) and one single individual in the dry season in the Nyanga river, and two groups with two and ten individuals and twice single individuals in the Mouambi river (Fig. 2). This resulted in a count of 47 and 14 hippos in the Nyanga and Mouambi rivers, respectively (Tab. 1). In the wet season, 23 hippos of four groups with a median size of 2.5 individuals (range 2-16) were counted in the Nyanga river (Fig. 3), and four hippos, a group of three individuals and a single individual, were counted in the Mouambi river (Tab. 1).

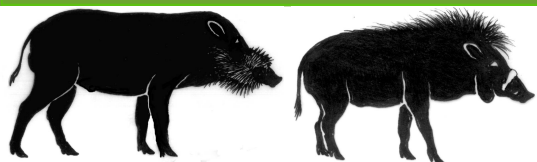


Fig. 3: Hippo feeding on the Nyanga riverbank at noon. The hippo immediately jumped into the water when it noticed the boat passing by.

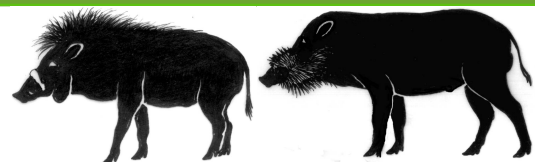
We identified three hippos (adult male, adult female and subadult male) in November 2022 at Lake Yenzi from camera trap data (three camera traps, 93 trap-days); none were recorded in July 2022 (three camera traps, 86 trap-days). At Vaalco/Lake Vembo in December 2022 (two camera traps, 62 trap-days) six hippos (adult male, two adult females with juveniles and a subadult) and one adult at lagoon Vevy (one camera, 31 trap-days) were recorded. Overall, we counted 62 hippos in the dry and 44 in the wet season.

The results of the surveys in the dry season, but not in the rainy season, on





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Tab. 2: Comparison of the number of hippos counted in 2010/11 by Rietmann (2014) with counts in July and November 2022 at the same locations.

River/Lake	2010	2011	Jul 2022	Nov 2022
	Rietmann	Rietmann	GBP	GBP
Mbissi/Lake Cachimba	6	8	0	NA
Nyanga	33	45	47	23
Mouambi	NA	11	14	4
Lake Vembo	2	3	1	0 (6*)
<b>Total</b>	<b>41</b>	<b>67</b>	<b>62</b>	<b>27 (33)</b>

GBP = Gabon Biodiversity Program

\*counted from camera trap data obtained in December 2022

the Nyanga and Mouambi rivers, revealed a comparable number of hippos to the numbers counted by Rietmann (2014) in 2011. As the 2010 and 2011 surveys were conducted in the dry season only, a comparison of numbers in the dry season is most relevant. Both dry season surveys in 2011 and 2022 counted the most hippos in the Nyanga River: 45 animals in 2011 and 47 in 2022 (Tab. 2).

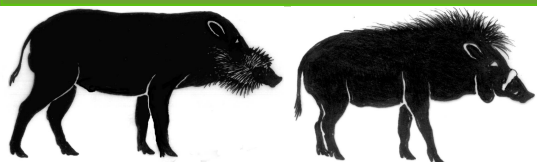
We were not able consistently to record age classes during boat surveys, due to hippos reacting strongly to the boat presence by hiding in and under water and moving away quickly, which made it difficult to compare sizes among the group members (the only means we had to distinguish between adults and subadults). However, we detected four and two juvenile hippos in the Nyanga river in the dry and wet season, respectively and two juveniles during the dry season survey in the Mouambi river.

Indirect signs of hippo presence were only collected during surveys on foot. At all sites prospected, indirect signs were found. During the dry season, we found fresh signs of hippo presence at three of the six survey sites, while during the wet season we found fresh signs at all six sites (Fig. 1, Tab. 1). The number of fresh droppings found was relatively low and comparable for dry and wet season surveys, while we found more fresh tracks during the wet (21) than the dry season (nine). The number of signs found that were older than three days (old) was generally higher in the dry season than in the wet season, likely due to the fact that rain in the wet season washes away droppings and tracks relatively quickly. We found fresh tracks of individuals of different sizes walking together at two beach survey sites, which allowed us to estimate a minimum number of hippos at these sites. At Point Petras we found single tracks and twice tracks of two individuals (adult + subadult and adult + juvenile) indicating a minimum number of four hippos (two adults, one subadult, one juvenile). At Colas Beach we found tracks of single individuals and twice tracks of two individuals (adult + subadult and adult + juvenile) indicating a minimum number of four hippos (two adults, one subadult and one juvenile). We found single tracks only at the other beach sites at Pont Dick and at the non-beach sites Lagoon Vevy and at Vaalco/Lake Vembo.

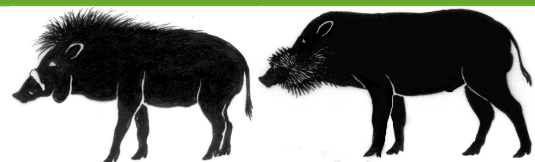
## Discussion

The results of our spatially targeted hippo survey in the Gamba area and within the Assala Gabon concessions indicate that hippos are still widely distributed in this part of the GCPA, especially along the coast. However, our data suggest that population numbers in the Gamba area are low. Within the southern part of the GCPA, our survey results confirm that the Nyanga region remains an important area for hippo conservation, as the largest population of hippos was found there.





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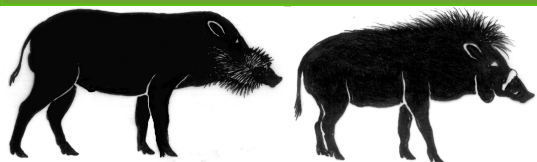
We found hippo signs at all six sites prospected in the Gamba area, but the number of signs found per site was quite low, often indicating the presence of one or two individuals only. Vaalco/Lake Vembo was the only site where signs indicated a relatively larger number of hippos (more than two individuals), which we later confirmed using camera traps (recording six different hippos). The fact that we had only observed one hippo in the dry season and none in the rainy season at this location during the surveys demonstrates the difficulty to make direct observations of hippos in the Gamba area. The overall low number of hippos encountered on foot during the surveys is most likely a result of the elusive nature of the hippos in the Gamba area due to their low numbers, but also to the inaccessibility of potential wetland areas. For the surveys planned in 2023, we will try to use the boat to reach more aquatic habitats and thus increase the probability of encountering hippos during the surveys in the Gamba area.

In contrast to the surveys in the Gamba area, surveys by boat on the Nyanga and Mouambi rivers revealed many encounters with hippos. With the dry season counts in the Nyanga and Mouambi rivers it can be confirmed that this area can still be considered as key for hippo conservation in the GCPA, eleven years after the last survey in 2010/11 by Rietmann (2014). The 2010/11 surveys included the Mbissi river, which was difficult for us to access in the dry season due to low water levels. We were not able to include it in the wet season due to time constraints. The current number of hippos in the Mbissi river and Lake Cachimba has therefore yet to be determined. Overall, our results indicate that the hippo population in the Nyanga and Mouambi region seems to be stable since the last published survey in 2011.

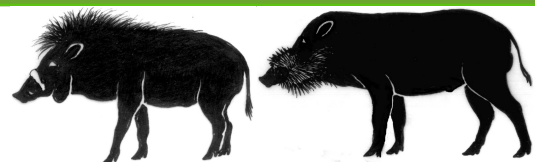
The large difference in numbers of individuals counted between the dry and wet seasons during the river surveys is most likely due to the much higher water levels in the rivers, which increases the inundated areas around the two rivers. This allows the hippos to disperse more widely, thus reducing the likelihood of encountering them in the river (Fritsch et al., 2022; Karstad & Hudson, 1986; Stommel et al., 2016). The smaller group sizes found in the wet season compared to the dry season also support this assumption (Fritsch et al., 2022; Stommel et al., 2016). Thus, dry season surveys by boat in the Nyanga region are preferable over wet season surveys, since they lead to more realistic population size estimates.

Almost all the hippos we encountered by boat or on foot were disturbed by our presence and reacted promptly by retreating to deeper waters, if possible, or moving away from us quickly. Similar behavioral observations were reported for hippos in the Nyanga region but not in the Ngove and Ndougou region in 2010/11 (Rietmann, 2014). Various animal species have been reported to alter their behavioral responses to threats when exposed to human disturbances such as hunting (e. g. Croes et al., 2007). The shy behavior of the hippos towards boats and humans in the study areas probably indicates that poaching or disturbance is a constant threat to the hippos in the southern part of the GCPA. This assumption is supported by recent poaching incidents of hippos in the region (M. Navarro, pers. comm.; G. Moussavou, pers. obs). Hippos are fully protected in Gabon, but law enforcement is low. Therefore, assessing the current size and distribution of the hippo population and monitoring population trends is important to inform and raise awareness among local authorities in order to increase hippo conservation and law enforcement efforts. We will therefore plan to continue spatially targeted surveys to contribute to a





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better understanding and protection of the current hippo population in the southern part of the GCPA and within the southern concessions of Assala Gabon. Knowing more about the hippo population in the concessions will also be useful in evaluating the oil company's biodiversity conservation efforts.

## Acknowledgements

This work was carried out under research permit (No. AR031/22/MESRSTTCA/CENAREST/CG/CST/CSAR). We would like to thank Assala Gabon for support. Thanks to Elie Tobi and Gabriel Koumba (GBP) for helping with survey organization and to Cedric Paga (local NGO KUSSU) for providing useful information and participating in the hippo surveys on the Nyanga and Mouambi rivers. Alonso Alfonso provided helpful comments on the manuscript. This is contribution # 207 of the Gabon Biodiversity Program.

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