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CAMERA TRAPPING INVENTORY OF UNGULATES IN HUMAN-EXPLOITED CONGOLESE RAINFOREST

Bachelor Thesis

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Environmental Sciences
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Thesis title

Camera trapping inventory of ungulates in human-exploited congolese rainforest

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Objectives of thesis

1) inventory of ungulates in the studied area
2) estimation of the relative abundance of ungulates species

Methodology

The work is based on data from 40 camera traps distributed in a regular network of 2 km and installed for at least two months in the vicinity of human settlements in the tropical rainforest of the Congo. The studied area is close to timber concessions and rivers, which are used to mine gold from river sediments. The obtained data will be filtered to the level of individual ungulates. The taxonomy will be determined based on Wilson, D.E. & Mittermeier, R.A.eds (2011). Handbook of the Mammals of the World. Vol. 2 Hoofed Mammals. Lynx Editions, Barcelona. A contingency table will be used to summarize the data, map data will be processed in the QGIS program, standardized parameters such as relative abundance index or naïve occupancy will be determined.

The proposed extent of the thesis

30 pages

Keywords

duikers, camera traps, inventory, rainforest, Congo

Recommended information sources

CASTELLÓ FORTET, J R. – HUFFMAN, B. – GROVES, C P. *Bovids of the world : antelopes, gazelles, cattle, goats, sheep, and relatives.* Princeton ; Oxford: Princeton University Press, 2016. ISBN 978-0-691-16717-6.

Estes, R. The behavior guide to African Mammals including hoofed mammals, carnivores, primates. London: University of California Press, Ltd., 1992. ISBN 978-0-520-27297-2

WILSON, D E. – MITTERMEIER, R A. – ALTRICHTER, M. – CONSERVATION INTERNATIONAL, – INTERNATIONAL UNION FOR CONSERVATION OF NATURE AND NATURAL RESOURCES. *Handbook of the mammals of the world. 2, Hoofed mammals.* Barcelona: Lynx, 2011. ISBN 978-84-96553-77-4.

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Author’s statement

I hereby declare that I have independently elaborated the bachelor thesis with the topic of: Camera trapping inventory of ungulates in human-exploited congolese rainforest and that I have cited all of the information sources that I used in the thesis as listed at the end of the thesis in the list of used information sources.

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Abstract:

This thesis is focused on the monitoring of tropical ungulates in the broadleaved Congo Basin rainforest. It is the first study conducted in this particular area using camera traps. A total of 37 camera traps were located near the settlement of Megobe in the Republic of Congo on the territory of the TRIDOM complex. The cameras were installed in a grid with a span of 2 km. They were put in representative locations and covered an area of 148 km^2. Simultaneous to the study period, logging and mining took place within the monitoring site. Camera traps recorded biodiversity in the area for approx. 90 days.

The aim of the thesis was an inventory of ungulates occurring in the area. After evaluating the data, we identified an ungulate community of total nine species. The most commonly observed species were Peter's duiker (*Cephalophus callipygus*) and Western blue duiker (*Philantomba congica*), which corresponds to similar studies conducted in other Central African countries.

This work will help to raise awareness of the biodiversity value of the area draw attention to the unsustainable forms of activity that take place in it. The thesis can be used for further study and elaboration in a diploma thesis.

Key words: monitoring, ungulates, exploitation, Republic of Congo

Abstrakt:

Tato práce se zabývá monitoringem kopytníků v listnatém Konžském pralese. Je to první studie provedena na tomto konkrétním území za pomocí fotopastí. Celkem 37 fotopastí bylo rozmístěno nedaleko osady Megobe v Konžské republice na území TRIDOM komplexu. Kamery byly instalovány v pravidelné mřížce s rozestupem 2 km. Byly umístěny na reprezentativních stanovištích a pokrývaly území o celkové výměře 148 km^2. Souběžně s monitoringem na daném území probíhala těžba dřeva a těžba zlata v povodí řek. Fotopasti zaznamenávaly biodiverzitu na daném území po dobu přibližně 90 dnů.

Cílem práce byla inventarizace kopytníků vyskytujících se na daném území.
Po vyhodnocení dat jsme identifikovali společenství devíti druhů kopytníků. Nejčastěji pozorovanými druhy byly chocholatka západní (*Cephalophus callipygus*) a chocholatka modrá (*Philantomba congica*), což koresponduje s podobnými studiemi provedenými v jiných zemích střední Afriky.

Tato práce přispěje ke zvýšení povědomí o důležitosti biologické rozmanitosti dané oblasti, a upozorní na neudržitelné formy činností, které v ní probíhají. Práce může sloužit k dalšímu studiu a rozpracování v diplomové práci.

Klíčová slova: monitorování, kopytníci, exploatace, Konžská republika,

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1. Introduction

Observing the movement of animals in their natural environment is essential to understanding their population dynamics and behaviour (Kays et al. 2009). The anthropogenic influence interferes with animal distribution, abundance and occupancy.

Tropical ungulates play a crucial role in the forest ecosystem. Their function in seed dispersal (Foster et al. 2014), structuring the landscape (Augustine & McNaughton 1998), or as prey to carnivores is unique (Wolf & Ripple 2016). That gives them an irreplaceable position in the ecological niche they inhabit. They can differ in size, abundance and activity patterns. Among the widespread species occurring in the forest are duikers (*Cephalophus spp.*), red river hogs (*Potamochoerus porcus*), sitatungas (*Tragelaphus gratus*) or water chevrotain (*Hyemoschus aquaticus*) (Estes 1992; Groves & Grubb 2011; Castelló 2016). All of these species are hunted either as a necessary source of protein by indigenous peoples or by poachers for profit (Wilkie & Carpenter 1999; Fa et al. 2002). Illegal and commercial hunting is alarming in its growth and leads to unstable ungulate populations (Van Vliet et al. 2012). They are also affected indirectly by anthropogenic activities such as logging, mining, or road development.

Camera traps are the best technology available to monitor certain areas with cryptic mammals like the site in this study. However, it is still a challenge to monitor tropical ungulates in the rainforests of the Congo Basin. This is due to high density of vegetation, low visibility and indistinct coloration of the animals (Van Vliet & Nasi 2008; Van Vliet et al. 2009; Breuer et al. 2010; Breuer & Breuer-Ndoundou Hockemba 2012).

Increased monitoring of the area can improve understanding the connection between animals, habitats and human impact and increase the potential of conservation efforts (Jones 2011). This study will be followed by long-term monitoring of terrestrial mammals between the national parks of Minkébé in Gabon and Odzala-Kokoua in the Republic of Congo mostly along the left bank of Djoua river.

2. Objectives of the thesis

The bachelor's thesis deals with the inventory of ungulates in Congo Basin rainforest at the site which is in the initial stage of human exploitation due to gold mining and logging. Within this work, partial goals were set:

Elaboration of literary research on the studied area and characteristics of ungulates, mainly then living in the rainforest.

As a result of the project data were summarized in contingency table and map data were processed in the QGIS program. Standardized parameters such as Relative Abundance Index or Naïve Occupancy were determined.

3. Literary research

3.1 The Congo Basin rainforest

Tropical rainforests are one of the most important biomes on Earth. Along with coral reefs they are considered an epicentre of biodiversity, and are usually located in the equatorial regions. They cover about 7% of the world's land area and contain over 50% of its species (Primack & Sher 2019).

The Congo Basin rainforest is located in west-central Africa. The largest part of the forest is located in the Democratic Republic of Congo (DRC), with smaller sections in Gabon (GAB), Cameroon (CAM), Equatorial Guinea (EQG), Central African Republic (CAR) and the Republic of Congo (RoC). The Congo river flows through the basin and the forest and floods the forest regularly. The rainforest is second only to the Amazon in geographic area, thus it is a stronghold to many rare and endangered species. The mosaic habitat of the Congo Basin is a refuge for many species. Flooded forests, savannas and swamps are inhabited by chimpanzees, forest elephants, pangolins, duikers and many others (WWF 2021).

The forest also serves as a large carbon sink and is a significant "buffer" against global warming (Primack & Sher 2019; Molua 2019). According to the recent studies, around 145,500 km^2 of the forests in the basin are underlain by peat (Dargie et al. 2017, 2019). This underlaying area is called Cuvette Centrale and it extends through the middle of the Congo River Basin, reaching both RoC and DRC. It is considered to be the largest peatland complex in the tropics and much of it is protected by the Ramsar Convention (Ramsar Convention 2014).

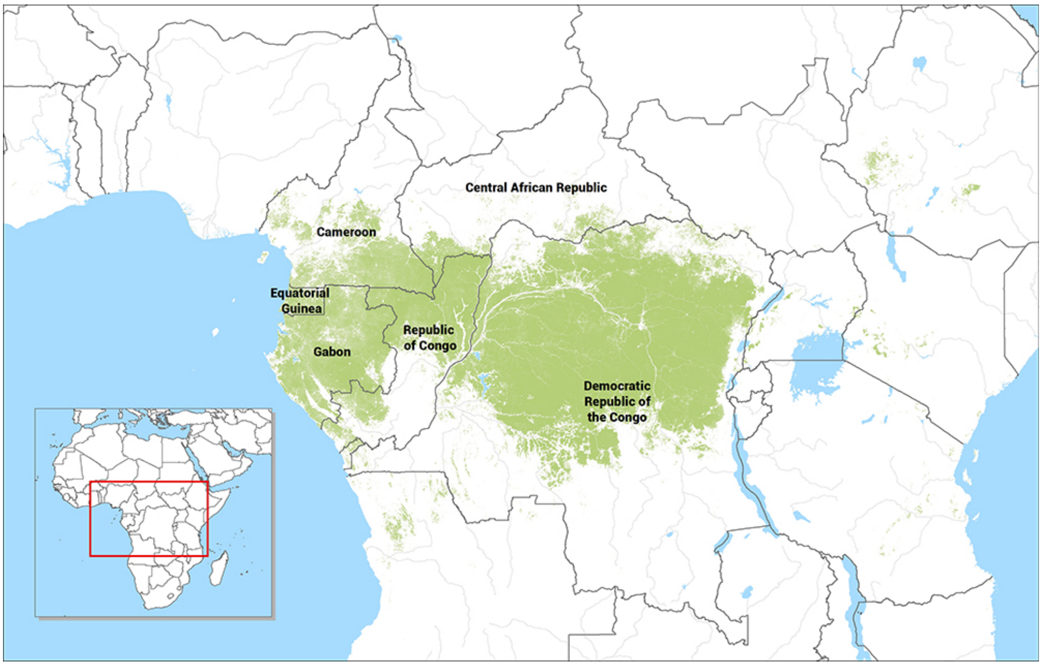


Figure 1: Area of the Congo Basin rainforest in 2010 extending through Gabon, Cameroon, Equatorial Guinea, Central African Republic, Republic of Congo and Democratic Republic of the Congo (source: https://www.globalforestwatch.org/map)

As a huge source of wood, minerals and medicines, the Congo Basin is increasingly exploited by humans. The reasons why the exploitation has not occurred before now, are many. From conflicts between or within the nations, through chronic instability in politics, to poor infrastructure and poor governance and corruption (The Fund for Peace 2020). However, deforestation, mining, poaching, and other human activities have accelerated in recent years. Between years 2015-2020, Africa had the highest deforestation rate (4.41 million ha) of the world continents (Foundation 2020).

About 60 million people, including indigenous groups, are dependent on the Congo Basin rainforest directly for their livelihoods or sustenance, and many are employed in wood industry (Wasseige et al. 2015). Dwellers from rural areas contribute to supply urban areas with bushmeat, which is the main driver of the unsustainable hunting levels in Central Africa (Van Vliet et al. 2012). Also, factors such as increasing demand for bushmeat, biofuels or improving agriculture technologies amplify the pressure on natural forests and are reason for the accelerating pace of deforestation (Megevand et al. 2013). Countries of the Congo Basin have low scores based on the human development index. Fertility and population growth are some of the highest in the world, along with low literacy and short life expectancy (Human Development Report 2016). In addition, poor business conditions, high rates of hunger and other factors cause these countries have alert-level scores on the Fragile State Index (IFPRI et al. 2012; The Fund for Peace 2020).

3.1.1 Agriculture

Deforestation and forest degradation give rise to other destructive human activities in the Congo Basin, and therefore in the rainforest. These threats include agriculture and soil degradation, which are closely linked to logging.

The forest cover in the Congo Basin is not well preserved compared to other rainforests. Studies shows that between years 2001-2019, DRC lost 34% of its total tree cover mostly due to shifting agriculture expansion (World Resources Institute 2019). Deforestation rates have also significantly increased in the RoC since 1990 (Ernst et al. 2012). An estimated 84% of forest disturbance between the years 2000 and 2004 was because of small-scaled, nonmechanized agriculture. Small-scale forest clearing includes clearing for rotational agriculture and conversion into cropland. The average field cleared is about 1.8 ha and except in GAB, these fields are the main direct disturbance driver. Rotational farming is widespread in DRC and CAR. About 90% of forest loss in those countries is because of rotational agriculture on smallholder fields (Tyukavina et al. 2018). Large-scale clearing is comparatively more mechanized and the plots cleared are larger. Deforested areas become palm plantations and industrial pastures, which on average exceed 10 ha. The area with the most of large-scale clearing activity in the Congo Basin is CAM (Curtis et al. 2018; Tyukavina et al. 2018).

The rate of deforestation in the Congo Basin is linked to population density. Agriculture and energy are subsistence activities, which are usually happening at the expense of forest. Farming remains by far the largest employer in the Congo Basin and most of the rural households depend on it (Kissinger 2013).

One method of obtaining land for farming is slash-and-burn method. When forest is burned, the ash enriches the soil, which is then very fertile and suitable for agriculture use. However, due to frequent rains, the soil is a subject to rapid erosion and the nutrients are quickly washed out, so after 2-3 years the obtained area can no longer be used for agriculture. This method is not suitable for supplying large populations, however, studies made by ethnobotanists and anthropologists show that obtaining land by fire is harmless without disturbing effect as long as it is done using methods of the indigenous peoples in forested tropical regions (Rossi 1999; Dounias et al. 2000;

Bérenger et al. 2015). In addition, it is important to realize whether agriculture is carried out in the primary or in the secondary forest. Based on this knowledge we can better estimate forest's carbon storage and biodiversity value (Curtis et al. 2018; Tyukavina et al. 2018).

3.1.2 Road development

Another reason for deforestation is expanding infrastructure such as road construction. With a growing local economy and higher demand for various commodities, the regional market is becoming more accessible for diverse merchants. Road development opens the way for massive logging and mining projects but also poaching. New paths allow poachers to reach vulnerable parts of the forest with easier transport routes to markets. Floods and soil loss in tropics and temperature latitudes as well as landscape fragmentation into small disconnected patches are consequences of road constructions (Forman & Alexander 1998; Wilkie et al. 2000; Megevand et al. 2013; Chomitz & Gray 2017). The transport of timber from the place of logging also requires extensive road networks. Moreover, most of the Congo Basin forest is granted to logging concessions, up to 99 years. Since 2003, the road length in the Congo Basin has increased by 40% to 130.500 km outside logging concessions, and the total length of road networks has increased by 61% to 230.800 km (Kleinschroth et al. 2019). Expanding roads have a negative impact on the most vulnerable areas: dense, slow-growing forests on the border between RoC and CAR, and on the peatland complex of the Cuvette Centrale region. Roads may also act as a physical barrier to migration of animals and thus affect their gene flow or reduce their effective population size (Benítez-López et al. 2010; Laurance 2015). Unpaved logging roads, compared to paved ones, have a great potential in forest regeneration. They become unused and abandoned after few years of usage so the forest can slowly recover. Decommissioning roads after logging, effective road planning and environmental sustainability through transparency has a potential to preserve forest ecosystems for the benefit of people and biodiversity (Wilkie et al. 2000; Kleinschroth et al. 2019).

3.1.3 Logging

Commercial logging contributes to 30-40% of forest losses in Central Africa. It is the most extensive and extractive activity among the tropics (Laporte et al. 2007). GAB is the largest timber producer among Central Africa countries, followed by CAM and RoC (Megevand et al. 2013). Selective industrial logging is usually focused on tree species with high value such as African mahoganies (Laporte et al. 2007). The impact of selective logging affects and modifies forest landscape and structure, but also affects abundance of resources and regional conditions, which can lead to a different species composition (Putz et al. 2001). Logging companies operating in the Congo Basin have resulted in growing deforestation and the emergence of palm oil plantations. One such company is the Atama Plantation SRL in RoC. It belongs to one of the largest logging companies and its work has had a devastating effect on the primary forest and cause a great amount of CO_2 to be released from the soil. However, media coverage of the illegal activities of this corporation slowed down its development to a crawl. Similar cases were observed in other Central African countries. In DRC, illegal logging was done under the pretext of redeveloping the abandoned plantations. To prevent such behaviour of logging companies, it is important to act with transparency and integrity (Earthsight 2018). Nevertheless, a study conducted in the northern part of the RoC made in 2009 proved that commercial logging can cooperate with the conservation estate. According to that study, logged forests may contribute to the conservation of large tropical mammals, but they need to be well managed and monitored (Clark et al. 2009; Poulsen et al. 2011).

3.1.4 Mining

Mining in the Congo Basin is another human activity carried out there. Important deposits of minerals (e.g. gold, diamond), metals (e.g. cobalt, iron) and nonmetal resources (e.g. precious stones, phosphates, oil) bring mining companies to the area. Mechanized equipment is required to extract the materials from the ground by digging to the ores beneath the surface. In the case of small-scale miners, they use rudimentary technologies or toxic chemicals (Megevand et al. 2013). The indirect impacts of mining to the forest can be, in comparison to the direct impact of deforestation, actually more harmful (WWF 2007). Open-pit and strip-mining operations leave massive disturbance and forest degradation behind. The high value of minerals encourages companies to invest more into developing mineral fields and the necessary supporting infrastructure. Deposits of gold and diamond were found in Sangha Trinational Landscape, which is a conservation complex on the boundaries of CAM, CAR and RoC (UNESCO 2021). Mining here is a significant source of income for artisanal and small-scale miners. However, to lift households out of poverty, the income is still too low. The way to improve the current situation is the proper education of miners on how to avoid income swings and losses, but this is not embedded in current policies, government activities or the private sector in the countries (Schure et al. 2011).

3.1.5 Poaching

Loss of biodiversity is strongly correlated with hunting. About 29% of the Basin rainforest has potentially been opened by logging activity in last decade for poachers and hunters (Laporte et al. 2007). Bushmeat hunting (hunting for wild meat) is an important component of the economy and livelihood of households in rural areas and also a significant source of animal protein for local communities living in the Congo Basin. Between one and five million tonnes of bushmeat is consumed across the Congo Basin every year (Wilkie & Carpenter 1999; Fa et al. 2002; Van Vliet et al. 2012).

Commercial wildlife hunting has been practised in Central Africa for more than two millennia. In the RoC the hunting season is from May to October and is specified by Congolese law to protect endangered species (Poulsen et al. 2011). But ever-evolving trade and demand for forest commodities are becoming a serious threat for Afrotropical rainforest mammals (Breuer et al. 2021). Populations of forest elephant (*Loxodonta cyclotis)* and other species, such as apes have declined dramatically through the years due to hunting (European Union 2016). Hunting is not sustainable and the consequences for both legal and illegal hunting are far-reaching. Unsustainability comes from the trade from rural to urban areas, where people prefer to consume bushmeat for a variety of reasons (e.g. price, taste or preference) (Van Vliet et al. 2012). The most hunted species are mammals, specifically the brush-tailed porcupine *(Atherurus africanus)*, blue duiker *(Philantomba monitcola)* and other duiker species (Vliet et al. 2012). Duikers are the most hunted mammal, both in terms of numbers and biomass. Between years 1973 and 2013 there was a significant decline in duiker populations across Africa (O’Brien et al. 2020). About 63% of bushmeat sold in markets in Central and West Africa is forest ungulates, mainly duikers. Duikers are one of the most hunted animals and on markets they worth up to 3800 CFA each, depending on the size (Wilkie et al. 1992; Noss 1998; Hennessey & Rogers 2008). They are also among the top bushmeat species confiscated at controlled international airports in Europe (Van Vliet & Nasi 2008; O'Brien et al. 2020).

Methods of hunting are evolving and becoming more sophisticated and effective. Snares are one of the most common hunting methods in northern Congo and in forests of central Africa. Congolese law prohibits wire hunting, but authorities have been unable to enforce this (Republique du Congo 2008). Wire hunting is most often used and is able to catch almost every species of mammal (Noss 1998; Hennessey & Rogers 2008). For foot snares, a hole about 15 cm deep and wide is made on an animal trail and covered. Then a loop of cable is placed over the hole. Once the animal steps on into the trap, it's caught by the loop of the cable. In the process of trying to free itself, the animal often gets hurt or die from stress, starvation and exhaustion. Almost 41% of the carcasses found in bushmeat trade in the town of Quesso, Republic of Congo, were caught by snares. This method costs very little and is highly efficient. Cable can be purchased for 300 CFA francs per yard (€ 1 ≈ 653 CFA). With one yard more than 4 two-strand snares or over 10 single-strand snares can be made. Each snare lasts at least 2 years (Wilkie et al. 1992; Noss 1998; Hennessey & Rogers 2008). Another method of hunting is jacklighting, also known as night hunting, which requires a gun. Hunters sight animals by the reflection of the light in their eyes. However, most hunters consider this method too simple and without sport, besides, it is illegal to hunt at night. Unfortunately, daytime hunting is not very popular either. It is more difficult and less successful than the previous methods described here. Therefore, it is the least practiced way of hunting (Hennessey & Rogers 2008).

3.2 Ungulates of the Congo Basin

3.2.1 Characteristics of Afrotropical ungulates

The presence of tropical ungulates is highly important in tropical forests. They have irreplaceable functions and we are still about to discover more details of their ecology and behaviour. Seed dispersal (Foster et al. 2014), structuring landscape and vegetation into a mosaic through herbivory (Augustine & McNaughton 1998), and as prey for carnivores (Wolf & Ripple 2016), they help to keep balance in the ecosystem (Gray 2018).

Ungulates have been evolving since Late Cretaceous (Svršek 1998). The presence of hooves has been considered as a characteristic feature for a long time. According to recent studies of molecular phylogenies the “Ungulata” monophyly have been refuted and animals are now united with other clades. The original division of ungulates into Perissodactyla and Artiodactyla is still relevant, but they are not sister taxa (Janis 2008). The evolution of those mammals was influenced by different factors and we can find their various forms all over the world. Tropical ungulates are a great example of evolutionary adaptation (Geist 1974).

Like any other species, tropical ungulates have specific features which make them special in a biome they live in. Body size is a significant factor affecting tropical ungulates behaviour. It permits anti-predator strategy, migration, visual communication whether the animal is above the vegetation or hidden below it. The body size is highly influenced by fiber content in plant food and density of the forage they exploit. According to Jarman-Bell principle (Müller et al. 2013), the amount of food the small-bodied species have to gain is lower than the amount of food the large-bodied species have to gain. But the quality of the food for small-bodied species has to be much higher than the quality for large-bodied ones. The fast metabolism of small ungulates means they need forage with low fiber and high protein content. Frugivory based on consuming primarily fruit is a common feeding strategy along with browsing and grazing (Bodmer 2016). On the other hand, large ungulates require the opposite – forage with high fiber and low protein content. That is because the requirements for energy and nutrient per unit of body weight are lower. However, the forage that the small ungulates need is dispersed and hard to find. The result of all of these factors is their small body size. There are also studies supporting theories of ungulates supplementing their mainly herbivorous diet with animal matter, especially in ungulate families like Cephalophinae and Tragulidae (Kurt 1963; Walker 1964).

Anti-predator strategy of tropical ungulates is clearly connected with their body size. As small mammals they try to avoid direct contact with predators. The hiding strategy is crucial for them. In an open area the animal can be detected visually before it’s heard while in “unopen” type forests, it is most likely heard first. That means, the forest ungulates minimalize vocal signals so as to not reveal themselves, they are solitary or occasionally travel in pairs to reduce noise levels which they might have in groups. They have perfected the ability to hide in vegetation and remain motionless when detecting danger, relying on their cryptic coloration (Geist 1974).

The Congo Basin is home to a rich community of ungulate species (Wilson 2001), it includes duikers (*Cephalophus spp.*), forest buffalo *(Syncerus c. nanus)*, red river hog *(Potamochoerus porcus)*, gian forest hog *(Hylochoerus meinertzhageni)*, sitatunga *(Tragelaphus gratus)*, water chevrotain (*Hyemoschus aquaticus)*, Bates's pygmy antelope *(Neotragus batesi)*, forest elephant *(Loxodonta cyclotis)* and others (Estes 1992; Groves & Grubb 2011; Castelló 2016). They occur mostly in the Congo rainforest and are under threat of extensive anthropogenic activities.

3.2.2 Duikers

In the Congo Basin, duikers of the family Bovidae, tribus Cephalophinae, are one of the most abundant species in the region. Duikers are species of antelopes appearing primarily in rainforests of Sub-Saharan Africa. The family includes 21 species (O'Brien et al. 2020, Wilson & Mittermeier 2011). Their appearance is adapted to life in forests or savannas. Their distinctive body type is similar but varies in size by species. Typical characteristics that differentiate them from other Bovidae include: a short neck, relatively short limbs, poorly developed jaw muscles, erectile tuft of hair on the crown, and cheek glands that open into a horizontal slit. The glands are present in both sexes. Another trait is small back-slanting horns, which are absent in some species of bush duikers and blue duikers and only the female sex. A slight difference can be seen between males and females in size. Females are often larger than males (Estes 1992; Groves & Grubb 2011). Depending on species the difference between males and females can be from 4 kg up to 80 kg. There are six species that are dominant ruminants within the rainforest and that are sympatric in the same area: *Philantomba congica, Cephalophus callipygus, C. nigrifons, C. leucogaster, C. castaneus, C. silvicultor*. Overlapping so many species have no other antelope genus (Estes 1992). Their movement in forests and bushes is typically inconspicuous, silent, and careful. By lifting their legs high, they avoid unnecessary noise caused by interfering with grass or other vegetation. Primarily they are browsers, feeding on leaves, seeds, fruit or bark (Estes 2018).

Social behaviour varies from species to species, but duikers tend to be solitary. Known for all duikers is that they are territorial and sedentary. Some live in monogamous pairs and associate more closely than others, such as blue or Maxwell's duiker (*Philantomba maxwellii*). The bay duiker is considered as the least sociable. Differences can be found in communication, mutual grooming, play and more. In general, nocturnal duikers or those living in a dense cover tend to be less social (Estes 1992).

3.2.3 Water chevrotain

A world rarity among tropical ungulates can be found in the Congo Basin rainforest. Water chevrotain (*Hyemoschus aquaticus*) is one of the small species of ungulates, belonging to the family Tragulidae, tribus Hyemoschus. Typical features of this species are protruding canine teeth and the absence of upper incisors, not to mention their small size. They are the only group of ungulates tied exclusively to warm tropical forests along the equator with stable conditions and can be literally described as "opponents of seasonality" (Pluháček 2014). All other species of chevrotains can be found in tropical Asia.

Both sexes are territorial, while in the territory of the male there are usually two territories of females. Chevrotains feed mainly on plant food, especially fruits, seeds, stems or mushroom, but they do not despise carrion either. Water chevrotain is attached to water, so it actively catches fish, small mammals and crabs. Water also serves as an escape route from predators.

The main threat to water chevrotain is overharvesting and the destruction of their suitable environment (Pluháček 2014; Curtin 2021).

3.2.4 Hogs

Hogs are other inhabitants of the Congo Basin rainforest. They are mainly nocturnal species from the family Suidae. Two representatives of this family occur in the Congo Basin rainforest. The red river hog (*Potamochoerus porcus*) and the giant forest hog (*Hylochoerus meinertzhageni*). Our camera traps captured only *Potamochoerus* porcus, therefore it is the main subject of the paragraph. The natural habitat of the red river hog is Western and Central Africa. It can inhabit lowland to montane forests, but also marshes and swamps if they provide food (Estes 1992). Due to its coloration, it is easily recognized. Its bright orange colour with white dorsal line and black face-mask makes it distinctive from any other species from family Suidae (Groves & Grubb 2011). They live in herds of up to 60 individuals and are nonterritorial (Oliver 1993; Leus & Vercammen 2013). Although a red river hog is omnivorous its importance for seed dispersal could have significant effect on plant communities. Anthropogenic activities, especially hunting in the DRC where the red river hog is a target species, may adversely affect their populations (Wilkie & Carpenter 1999; Muller-Landau 2007; Vanthomme et al. 2010).

3.3 Monitoring of forest ungulates

3.3.1 General insight

To prevent biodiversity loss and understand the cycle of substances and metabolism in forest, monitoring is highly important action to take. Its aim is to gather data about the condition of the forest related in its current state, but also to understand long-term changes. The regularity and longevity of monitoring is a key factor to understand the cause-and-effect relationship. Consequences of deforestation, forest cover, biodiversity or precipitation during the year are examples of reasons for monitoring.

Forest monitoring methods vary according to the data they seek to achieve. Among relatively new widely applied methods, there is “drone” aerial photography. It is used in various fields for collecting data about environmental anomalies, vegetation and soil disturbances (Brilis et al. 2000, 2001; Eisenbeiss et al. 2005; Verhoeven 2009). A similar method, but with a much larger scale, is remote sensing from space, which can be used to measure deforestation at national level or document coastal landscapes (Warrick et al. 2016). For more detailed data on a small scale, another method must be used, namely ground-based monitoring systems. These can serve to measure base height or stem density that cannot be captured from the air (Marco Ferretti 2013; Bucht et al. 2014).

For wildlife monitoring, various methods are used according to the objective of the observation or according to the species. It is essential for conservation biology and it helps to assess changes in populations such as abundance or distribution (Viquerat et al. 2012). Tropical ungulates, one of the most hunted species, are the key to stability in the forest ecosystem, and their monitoring is crucial for sustainable bushmeat harvesting and to reveal the impact of resource extraction on them (Breuer et al. 2010).

Duikers, as shy and inconspicuous animals, require different monitoring methods also due to the habitat they occur in. High forest density, general cryptic life-style, avoidance to people, poor light conditions, alternating dry seasons and rainy seasons make observation difficult. In the following paragraph, the monitoring methods, that are commonly used for the Afrotropical ungulates, will be described in detail (Van Vliet & Nasi 2008; Van Vliet et al. 2009; Breuer et al. 2010; Breuer & Breuer-Ndoundou Hockemba 2012).

3.3.2 Line-transect surveys

Line transect is a straight line through the forest on which observers walk to count animals on both sides of the line and their perpendicular distance from the transect line. The line is marked through the habitat and is visible at all times. It is important to ensure that transects are situated at random with relation to the distribution of animals. If the transects are deliberately situated along water holes or salt lakes, the survey could overestimate the population size. Surveys can be conducted by volunteers or wildlife staff after proper training. Factors as dense vegetation are later taken into consideration in the scientific calculations (Karanth & Nichols 2017).

3.3.3 Dung line-transect surveys

This method is based on the same principle as line-transect survey. The observers are walking through the forest and counting dung piles instead of living animals. For good estimation it is necessary to know how often duikers defecate and how fast the pile decays. Errors caused by not counting the overlooked faeces are later taken into account in the modelling software. Incorrect measurements can occur when the same species of duiker differs in a size and so their faeces. Therefore, the research result is erroneous. DNA analysis is required for proper distinguish of a species (Bowkett et al. 2009; Ntie et al. 2010).

3.3.4 Call counts

The essence of this method is to imitate sounds of distress to lure duikers. Call counts have potential, but it has not been used for duikers to date, because it is not certain how large is the area affected by calls (Buckland et al. 2006; Van Vliet et al. 2009; O’Brien et al. 2020).

3.3.5 Camera trapping

Camera trapping has proven that they are an effective sampling method, though researchers have to count with high initial costs in purchasing the equipment. It is one of the newest tools for ethologists, conservation biologists, and wildlife managers. The ability to place camera systems in otherwise inaccessible areas such as bear dens, bird's nests, or dense rainforest, is a significant step forward in understanding animal behaviour and activity patterns. In comparison to dung-based surveys, observers have fewer problems recognizing duiker species from photos, which is an important improvement. Moreover, camera traps allow researchers to collect data about distribution trends over time, abundance and to learn about specifics of species (O'Connell et al. 2011; O'Brien et al. 2020).

Camera traps can be divided into two broad groups, depending on their trigger mechanism. Non-triggered cameras are suitable for open space or locations with high visiting rates, or when continuous data are required (e.g. feeding behaviour, seal activity, bird nests). Time intervals can also be set (Swann et al. 2011; Expedition Field Techniques 2014). Triggered cameras are appropriate for infrequent events, where the importance is to capture presence of the animals rather than its absence (Swann et al. 2011). Two types of triggered camera traps are used. A mechanical one, activated either by applying pressure on a pressure pad (Griffiths & Schaik 1993; Mudappa 1998; Fedriani et al. 2000; York et al. 2001; Moruzzi et al. 2002) or stepping on bait lines. Bait line is a line connecting trigger of camera trap and the bait or decoy (Picman & Schriml 1994; Cresswell et al. 2003; Glen & Dickman 2003; González-Esteban et al. 2004). Mechanical camera traps are less common due to technological improvements, but are still used in nest predation studies (Swann et al. 2011). Another activating system for triggered camera traps is infrared sensor, which can be active or passive (Expedition Field Techniques 2014). Passive infrared sensor (PIR-sensor) reads background temperature signature and when an animal passes by, it is triggered because it detects two different temperatures (Swann et al. 2004). The major disadvantage of PIR-sensors is their sensitivity to temperature change due to environmental conditions such as sunlight movement or precipitation. These mystifying triggers are called false triggers (Swann et al. 2011; Expedition Field Techniques 2014). Active infrared sensor (AIR-sensor) is based on transmitting a single infrared beam from the emitter to a receiver. It captures the moment when animal disrupts the beam. In contrast to PIR-sensors, temperature changes do not affect detection, but growing vegetation, rain or snow can cause a false trigger (Kawanishi 2002; Henschel & Ray 2015). Camera traps using infrared sensor are broadly used in wildlife population studies or studies of rare animals (Swann et al. 2011; Expedition Field Techniques 2014).

Camera traps can be classified by whether they use an incandescent flash or infrared flash. Both are used to illuminate the scene when it is too dark. Infrared flash is best to use for nocturnal species, because there is no visible white flash. If there is enough light during the day, they produce images in color. Incandescent flash can be either visible or white. The camera trap is equiped with xenon lamp or white LED flash, which produces light resembling the sun at noon. Photographs with a white LED flash or xenon lamp are in higher quality than the ones produced by camera traps using infrared flash. However, a xenon lamp flash can startle animals by the sound it makes (Expedition Field Techniques 2014; LaFleur & Pebsworth 2017; Ehlers Smith et al. 2018).

With advancing technology, camera systems are also improving. They are able to record videos and thus provide new scientific opportunities. Increasing storage capacity, higher durability and resilience reduces the number of visits by researchers who would otherwise have to replace cameras. This new method has great potential in observing wildlife behaviour and scientists may prefer to use it with multiple techniques simultaneously to achieve the most accurate results (O'Connell et al. 2011; O'Brien et al. 2020).

4. Methodology

4.1 Study area

The research was performed primarily in broadleaved tropical rainforest in northwest headland of the RoC, in the Tri-National Dja-Odzala Minkébé transborder territory (TRIDOM). TRIDOM is spread over three countries – CAM, RoC and GAB (WWF 2006), and was created in 2005. Inside the complex there are 10 differently distributed protected areas. The area covers 7.5% of the Congo Basin rainforest and is a stronghold for large and medium-sized mammals such as buffaloes and gorillas. It also serves as an important corridor for migratory birds and elephants (Buxton et al. 2000; Ngouhouo Poufoun et al. 2016; Lindsay et al. 2017). Additionally, it is a home to an indigenous BaAka population of around 10,000 people (WWF 2020).

Specifically, our study area was placed in the Megobe locality (1°31'N, 13°11'E), which is a settlement with around 200-300 inhabitants (WWF 2006). The settlement is on the left bank of Ivindo river, which flows on the border with Gabon. The highest point of the monitored area is a secluded Mount Badondo with an altitude of around 930 m, and the lowest is on the river Ivindo around 480 m. The location of the camera traps within the study area is shown in Figure 2. In close proximity to Megobe settlement is a secondary forest and plantations of cassava, sugar cane and bananas. Logging by Karagoua concession took place at the same time as the research and also gold mining on the tributaries of the Ivindo river (World Resources Institute 2021).

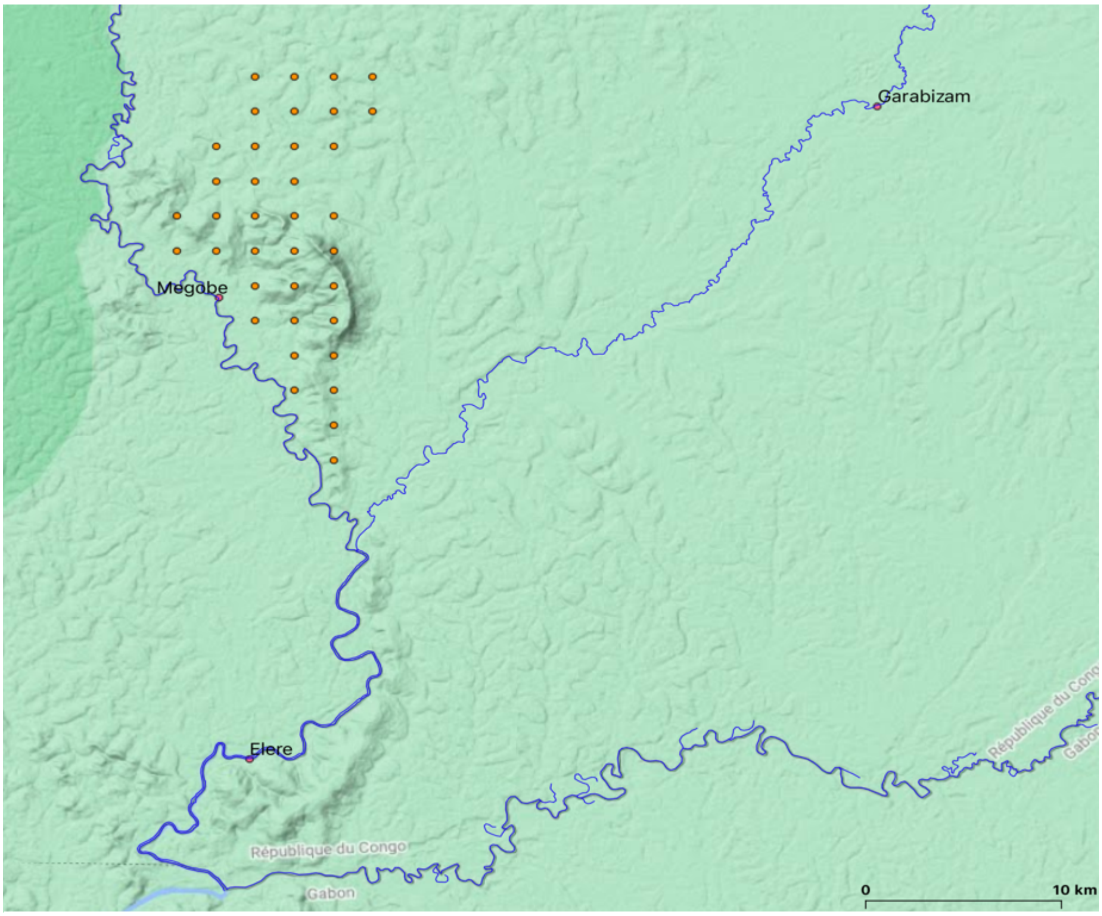


Figure 2: Detailed map of monitored area, next to the Megobe settlement from one side and secluded hill from the other. Orange points on the map represent the location of each camera trap. (source: QGIS)

Climate data recorded for the year 2020 for the nearest dwelling Eghui (1°75'N, 13°65'E) shows annual average temperature around 26.2°C and precipitation of 287.7 mm with a 412.3 mm peak in May 2020. Near the equator alternates dry and wet season. A short dry season from December to February, then a short wet season March to May, long dry season from June to August and a long wet season from September to November (Creese et al. 2019). The short dry season from December 2019 to February 2020 had average rainfall 45.4 mm per month and average temperature was 28.7°C. Following short wet season had average rainfall 342.3 mm with average temperature 26°C. Average number of rainy days from June 2019 to July 2020 was 25. A more detailed overview is shown in Figure 3 and Figure 4.

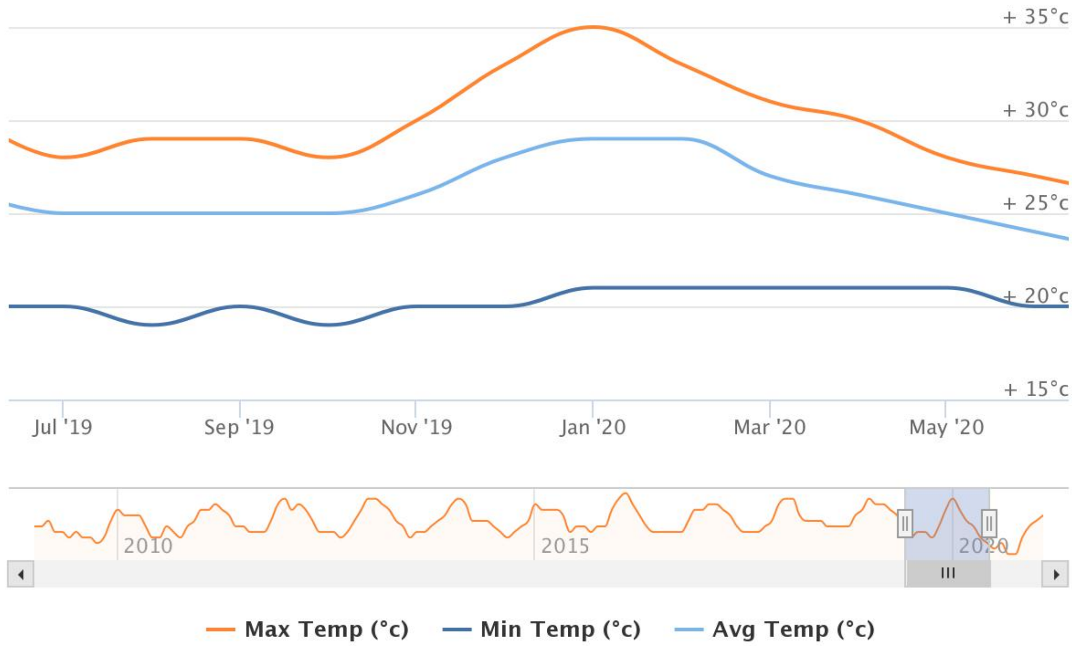


Figure 3: Annual average temperature in Eghui from July 2019 to June 2020 (source: https://www.worldweatheronline.com)

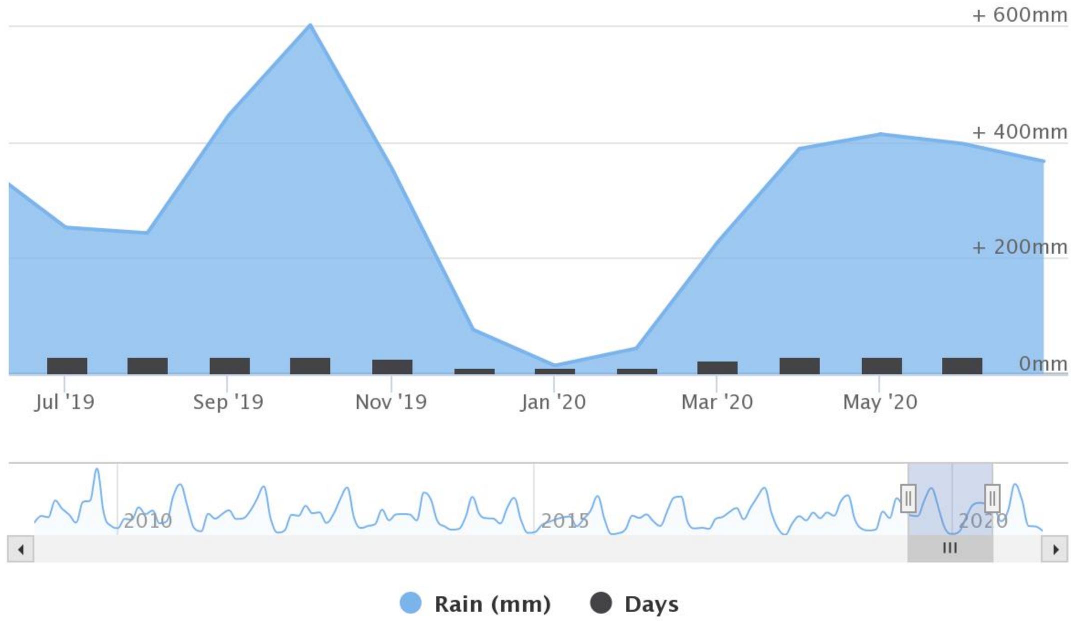


Figure 4: Annual average rainfall and rainy days in Eghui from July 2019 to June 2020 (source: https://www.worldweatheronline.com)

4.2 Data collection

Ungulate inventory data were collected by 37 camera traps installed in a grid with a span of 2 km, one camera trap per one trapping station. When reaching the pre-defined point the camera trap was installed within a radius of 50 m from the selected point on visibly used animal path. Camera traps were installed on February 29, 2020 and collected on May 28, 2020. Several camera traps were placed a few days later or collected earlier, and some were not in operation throughout the placement. The research last 90 days (from the starting date of the first installed camera to the last one collected). Each camera trap virtually covered an area of 4 km^2, which makes a total of 148 km^2 of monitored area. Camera traps were located on all habitats present in the area (on a slope, on a hill, by a river, etc.). A map network was made in Geographical Information System (GIS) and uploaded to Global Positioning System (GPS). Camera traps were installed approx. 1 m above the ground and approx. 5 m from the path, in places with the highest probability of the occurrence of animals. Once a camera started shooting, it made 3 photographs in a row in one capture. Between captures, there was a gap lasting 1 second. All cameras were turned on 24 hours a day and were in operation mainly during the rainy season. From the whole number of cameras, it was not possible to obtain data from six, therefore the total number of cameras from which data were successfully collected, is 31. Three different brands of cameras were used – Browning (model Spec Ops Advantage, 12 pcs), Bushnell (model Trophy Cam HD, 9 pcs) and UOVision (model UV595HD, 4 pcs). Survey name was Djoua corridor – Megobe, therefore the name of stations had abbreviation Mg. All the research was designed, prepared and carried out in close cooperation with WWF.

4.3 Data analysis

All images obtained from memory cards of the camera traps were manually sorted and only those photographs containing the animal or part of it were included in the analysis. Further analysis was processed in the software Camelot (version 1.6.9, GitHub Inc.). Objects of all images were visually identified to species or family (in case of Muridea family) using the nomenclature from the Handbook of the Mammals of the World (Wilson & Mittermeier 2011). Only such records were included in the analysis at which consensus in identification between WWF and CZU researchers was achieved. When processing photographs in the Camelot program, the number of animals visually depicted in the image was taken into account for each species. One hour was used to separate two consecutive animal capture events to ensure the independence of such records as Independent Observations for further calculation of the Relative Abundance Index (RAI) (Rovero et al. 2014). The RAI was calculated as the number of independent species events divided by the total number of trapnights and multiplied by 100. Another calculation was to determine naïve occupancy which was calculated as a number of camera traps recording certain species divided by the total number of camera traps and multiplied by 100 (Rovero et al. 2014). The number of night elapsed is the sum of the number of days during which all 31 camera traps were in operation. The spatial design of the monitoring and maps was prepared, processed and visualized in QGIS (version 3.10., QGIS Development Team 2020) software.

5. Results

Data were obtained from 31 camera trap stations and processed in Camelot program and exported as CSV. files. The total number of species the camera traps recorded, was 30 (including *Homo sapiens)*. The overall trapping success, including 6 failed camera traps, is 74% and we elapsed 2430 trap nights in total. The following Table 1 shows 9 species of tropical ungulates recorded by camera traps and more details about their observations. Detailed information about each camera trap are figured in Table 2.

Genus	Species	Naïve occupancy	Number of Trap Stations	Number of Photos	Independent Observations	Nocturnal (%)	Abundance Index
Cephalophus	callipygus	77,42	24	7512	451	18,4	18,56
Philantomba	congica	48,39	15	3192	329	15,8	13,54
Cephalophus	castaneus	38,71	12	717	104	92,3	4,28
Cephalophus	silvicultor	54,84	17	1220	71	76,1	2,92
Cephalophus	leucogaster	22,58	7	208	25	24,0	1,03
Potamochoerus	porcus	25,81	8	328	21	57,1	0,86
Tragelaphus	gratus	3,23	1	96	7	100,0	0,29
Hyemoschus	aquaticus	3,23	1	21	6	100,0	0,25
Cephalophus	nigrifrons	3,23	1	8	1	0,0	0,04

Table 1: Tropical ungulates observed near the settlement Megobe

Peter's duiker (*Cephalophus callipygus*) is the species that was captured most frequently from all the recorded species and has highest naïve occupancy when this species was captured 77.42% trap stations. The second most frequent was the blue duiker (*Philantomba congica*) and the third was bay duiker (*Cephalophus castaneus*). The least frequent ungulate was *Cephalophus nigrifrons*, as recorded only once. Also, *Tragelaphus gratus* and *Hyemoschus aquaticus* were recorded only at one trap station, water chevrotain typically close to the Ivindo river. Only other ungulate species than *C. callipygus* which occurred in more than half of the stations (54.84%) was yellow-backed duiker (*Cephalophus silvicultor*), biggest of the local duiker species.

The Relative Abundance Index indicates relative abundance of one species to another. For example, *Potamochoerus porcus* was recorded more than twenty times fewer than *C. callipygus*.

In terms of activity patterns sitatunga (*Tragelaphus gratus*), water chevrotain (*Hyemoschus aquaticus*), bay duiker (*C. castaneus*), yellow-backed duiker (*C.

silvicultor) occurred as a nocturnal species given that they were captured during the night in more than 75% case of Independent Observations.

We have found pattern of sympatry among ungulate species, out of 31 camera traps 3 of them detected 6 species, 3 camera traps detected 5 species, 9 camera traps captured 4 ungulate species, 2 camera traps recorded 3 species, 3 camera traps recorded 2 species, and 4 camera traps detected 1 ungulate species. Unsuccessful camera traps, which did not capture any ungulate species, was 7. The overall success rate of camera traps, that recorded at least 1 ungulate species is 77%.

Every single camera trap recorded at least 1 animal species from total 30 species (including human) recorded during the study. The highest number of species, 16, was recorded on the Eastern slope of Mount Badodo, hence opposite to the Megobe village (Figure 5.).

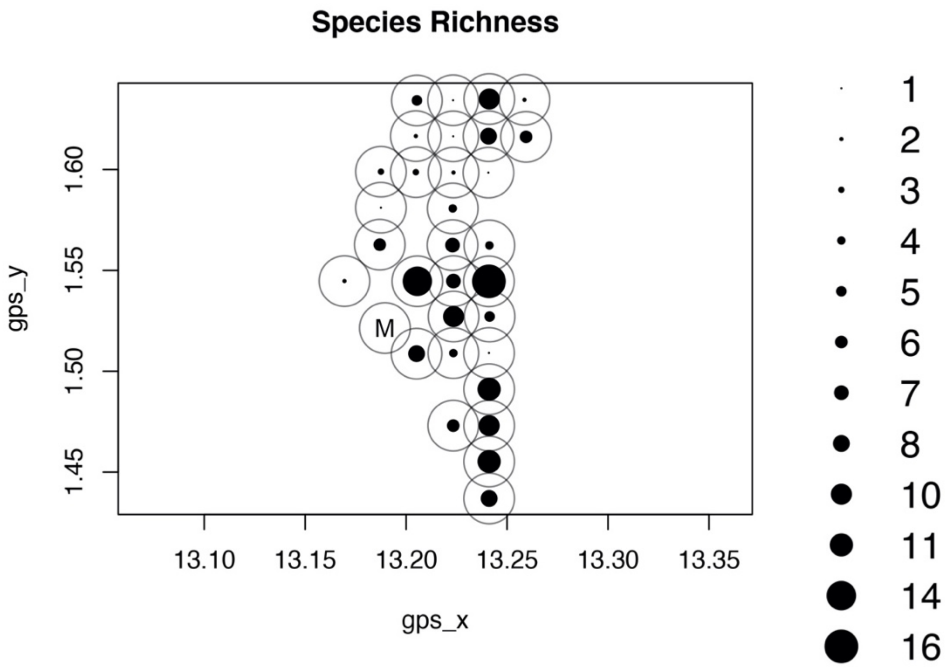
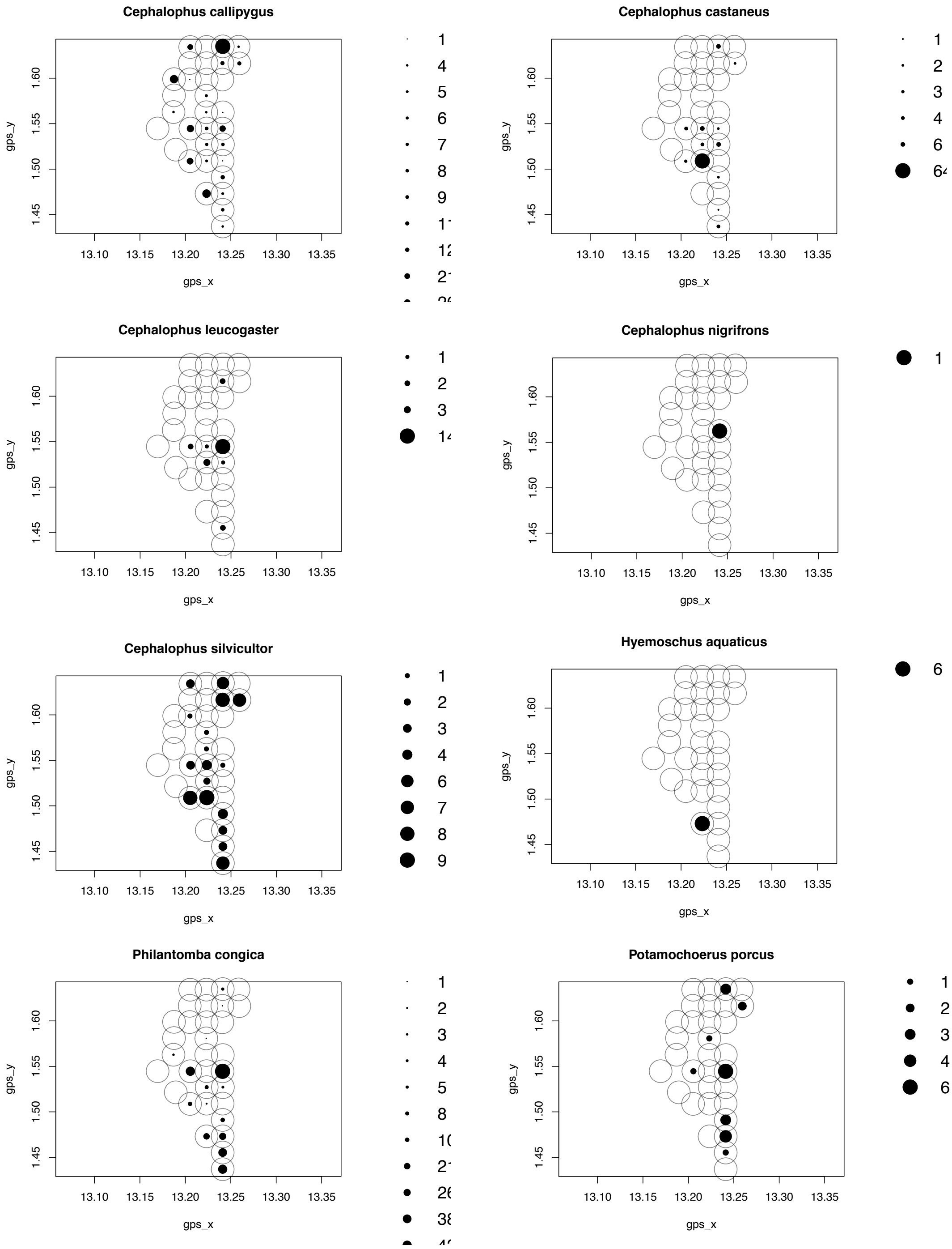


Figure 5: Distribution of all recorded species accross the study site, size of the points represents number of independent observations

Figure 6 shows the distribution of all recorded species accross the study site, size of the point represent number of independent observations.



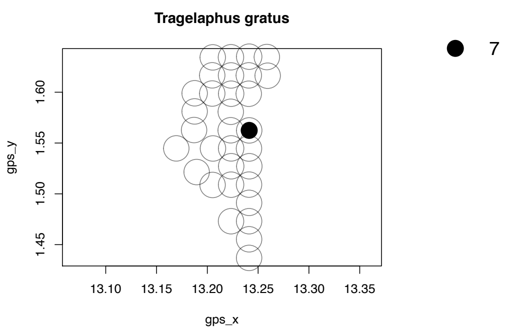


Figure 6: Spatial location of camera traps showing the occurence of individual species of tropical ungulates, size of the points represents number of independent observations

6. Discussion

In this thesis, the focus of attention is on the abundance of tropical ungulates living in the TRIDOM complex in the northwest headland of RoC in broadleaved tropical rainforest.

Our study shows a relatively rich species community of forest dwelling mammals, particularly ungulates, in the monitored area. Ungulate species in general were not observed close to the large river of Ivindo, which can be explained by the wet season at the time, but also by dominantly territorial and frugivorous behaviour of duikers.

The species composition is affected by microhabitat, season and human activity. Vegetation type also plays an important role (Akomo-Okoue et al. 2015; Diarrassouba et al. 2019; Breuer et al. 2021). This aspect was not part of my thesis but our data of surveyed habitat allow for further analysis of species preferencies.

The camera trap closest to the Megobe settlement did not detect any ungulate species. However, the second closest installed camera trap captured four of them - *C. callipygus, Philantomba congica, C. castaneus* and *C. silvicultor*, which might indicate that residents of Megobe tend to obtain animal proteins out of fish from Ivindo river rather that from bushmeat.

As already described (Kamgaing et al. 2018), we recorded high rate of sympatry especially among duiker species. *C. callipygus* and *C. silvicultor* are the ones, who met each other and among other ungulates the most. A similar area of co-occurrence has been observed in species *C. castaneus, C. leucogaster* and *Philantomba congica*. The same and only camera trap, placed behind the Mount Badodo, captured *Tragelaphus gratus* and *C. nigrifrons*. Likewise, *Hyemoschus aquaticus* was recorded by a single camera trap near Ivindo river which indicate different vegetation type on periodically inunded banks of the river. Together with almost all duiker species (except *C. nigrifrons)*, *Potamochoerus porcus* has been detected by the same camera traps.

As this was the first systematic monitoring of tropical ungulates in this specific area, we are missing data from previous years to draw comparisons. However, similar studies were conducted in various Central African countries.

Firstly, a study in the TRIDOM complex in CAM where the results do not differ concerning the most abundant species. Mostly observed were blue duikers (*Philantomba congica)* and red duikers (*Cephalophus callipygus, C. dorsalis, C.*

leucogaster, C. nigrifrons) (Djekda et al. 2020). Another study conducted in Nouabalé-Ndoki National Parc in northern Congo confirmed that the most abundant duiker species were again C. *callipygus* and *Philantomba congica* (Breuer et al. 2021). Both studies are consistent with our obtained results.

As a study in northeast GAB shows, hunting can affect same duiker species differently in different sites. According to results, *C. nigrifrons* and *C. leucogaster* were naturally least abundant. Most abundant were *Philantomba congica, C. callipygus* and *C. dorsalis* (Feer 1988)*.* The same study was performed twenty years later. *Philantomba congica* remained as the most abundant species, but *C. dorsalis* was reduced due to hunting. *C. callipygus* successfully resisted the hunting pressure (Vliet et al. 2007). That could explain why these species (*C. callipygus* and *Philantomba congica*) are the most abundant in our study.

Results from a similar study in southeast CAM showed, that only *Philantomba congica, C. callipygus* and *C. dorsalis* still appeared among duiker catches (*C. leucogaster* and *C. nigrifrons* were not appearing) (Duda et al. 2017). That can lead to the conclusion that *C. leucogaster* and *C. nigrifrons* were overexploited or changed habitat due to hunting pressure. When the hunting of medium-sized species (e.g. *Potamochoerus porcus*, *C. silvicultor*) decreases, the hunting of smaller species (e.g. *Philantomba congica*) increases (Nasi et al. 2008; Fa & Brown 2009; Koerner et al. 2017).

In our study, *C. nigrifrons* was observed only once. A low level of observation occurred also in the species *Tragelaphus gratus*. The reason for that might be that their natural habitats (e.g. swamps) differ from our monitored area, which was mainly broadleaved forest (Weber et al. 2001; Wilson 2001; Magliocca et al. 2002). The occurrence of *C. silvilcultor* had a lower number in independent observations (71), which can be explained by larger territories (Newing 2001) and its tendency to retire to the most conserved forests due to anthropogenic pressure mainly manifested by illegal hunting (Diarrassouba et al. 2019). But on the contrary, this species (*C. silvicultor*) has the second highest value in naïve occupancy (after *C. callipygus)*. The value of naïve occupancy shows what percentage of all camera traps recorded the species. It indicates a wide movement through the studied area and can possibly mean low hunting pressure.

C. nigrifrons and *Tragelaphus gratus* were captured by same camera trap behind the secluded hill, away from the Megobe settlement, behind the Mount Badodo. We can conclude that they react more sensitively to the presence of human and therefore they choose less frequented routes.

Despite the confirmed occurrence of the African forest buffalo (*Syncerus caffer nanus)* (Rutten 2015), giant forest hog (*Hylochoerus meinertzhageni)* (Sutherland-Smith 2015) and forest sitatunga (*Tragelaphus gradus)* (Manguette et al. 2017), only sitatunga was observed in this study.

Due to hunting pressure and poaching, the occurrence of duikers and tropical ungulates is lower in recent years (Poulsen et al. 2009). The tightening of hunting rules could negatively affect local human population for whom bushmeat is a main source of protein and income. However, people and duikers are not the only ones who are negatively affected by higher hunting pressure. Felid predators and carnivores are losing their natural prey and that can lead to significant decline in their population (Henschel et al. 2011).

The presence of humans and their activities which took place near the studied area could affect the species abundance as well. Logging and mining activities are connected with road development that opens vulnerable parts of the forest to hunters and poachers, which can lead to an unsustainable level of hunting (Yasuoka 2006). A hunting camp of logging workers was located near the Northern section of studied area and should be a subject for another research in future. The data that has been collected could therefore be negatively affected by these activities and result in lower species abundance. As an indicator of increasing wire hunting we could use the loss of *Philantomba congica* (Dethier 1995; Jeanmart 1998; Yasuoka et al. 2015).

Using camera traps for monitoring has shown to be very efficient and accurate in estimating relative abundance and inventorying of tropical ungulates compared to surveys from dung decays, which can disappear due to dung beetles (Van Vliet et al. 2009; Breuer et al. 2021). Many authors have considered dung method relevant but resulting in inaccurate numbers of ungulates occurring in an area. However, it is a cost-effective method. Call counts as another available method doesn't require any special skills of the observer but depends on changes in conditions or habitat openness. Camera traps are more reliable in this regard. Line transects surveys might be the best option in terms of price and accuracy for estimating the abundance of tropical ungulates (Entanga Elenga et al. 2019). However, several studies agree that the relative abundance of duikers is best determined by using camera traps or applying more monitoring methods together especially for recognition of red duikers (O'Connell et al. 2011; Akomo-Okoue et al. 2015; O'Brien et al. 2020). The "exact" relative abundance for each species might differ from the one obtained due to data from lost camera traps.

7. Conclusion

This study has shown that the Congo Basin rainforest is a stronghold to many animal species and endemics. Growing deforestation threatens the biodiversity, but also the ecological balance and stability of the forest ecosystem. Loss of tree cover in Central Africa is influenced by direct and indirect drivers caused by humans. Agricultural expansion is extending in the countries of the Congo Basin (RoC, DRC, GAB, EQG, CAR, CAM), and is likely to continue. With increasing populations, more agricultural land will be needed. Shifting cultivation and demand for cash crops might become a serious problem and cause deforestation blast which opens rainforest to poachers.

Our study shows rich ungulate community in the forest adjacent to the remote village of Megobe. Relatively high numbers of records close to the village indicate a chance that human pressure on Congo Basin forest can be sustainable. Nevertheless, to support such idea, we need to repeat the same monitoring design and conduct further analysis, because recent incoming exploitation of wood and minerals brings new workers who are both hunters and consumers of bushmeat.

From analysed data we can say that camera traps are efficient and effective monitoring method. Estimating relative abundance and naïve occupancy of the tropical ungulates was due to that more accurate. As we have shown, mainly duiker species tend to occur at same sites in several species, differing in a day time activity. This represents higher risk of non-selective snare wire trapping for more species. If some of these species becomes endangered, this way of hunting, no matter if intended for the most abundant Peters' duiker, will contribute to the decline of the rarest species, including carnivores or apes. Therefore, ban of snare wire hunting should be imposed and enforced.

This study is an initial part of intended long-term monitoring system which will map terrestrial mammals between the national parks of Minkébé in GAB and Odzala-Koukoua in the RoC mostly along the left bank of Djoua river. We need to repeat the same initial study in following year to uncover changes in wildlife community.

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! Záložka není definována.

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Station	Camera	gps_y	gps_x	Setup_date	Retrieval_date
Mg-01	1	1.634290	13.205330	29.02.2020	24.05.2020
Mg-02	4	1.634400	13.223260	29.02.2020	25.05.2020
Mg-03	5	1.634990	13.241180	01.03.2020	26.05.2020
Mg-04	6	1.634610	13.258590	01.03.2020	26.05.2020
Mg-05	34	1.616620	13.204810	02.03.2020	27.05.2020
Mg-06	8	1.616500	13.223320	02.03.2020	27.05.2020
Mg-07	9	1.616570	13.240810	01.03.2020	26.05.2020
Mg-08	10	1.616250	13.259390	01.03.2020	26.05.2020
Mg-09	11	1.598960	13.187520	03.03.2020	27.05.2020
Mg-10	12	1.598710	13.204830	03.03.2020	27.05.2020
Mg-11	13	1.598540	13.223450	03.03.2020	28.05.2020
Mg-12	14	1.598500	13.240750	03.03.2020	28.05.2020
Mg-13	35	1.581111	13.187500	29.02.2020	25.05.2020
Mg-15	15	1.580750	13.223070	03.03.2020	25.05.2020
Mg-17	16	1.562556	13.222985	29.02.2020	26.05.2020
Mg-18	17	1.562419	13.241219	29.02.2020	26.05.2020
Mg-19	18	1.544724	13.223417	03.03.2020	27.05.2020
Mg-20	29	1.544587	13.240995	01.03.2020	27.05.2020
Mg-22	19	1.562778	13.186944	29.02.2020	26.05.2020
Mg-23	36	1.544722	13.169444	29.02.2020	26.05.2020
Mg-25	30	1.544652	13.205552	03.03.2020	11.04.2020
Mg-27	31	1.527149	13.223491	03.03.2020	13.03.2020
Mg-28	20	1.527151	13.241325	01.03.2020	28.05.2020
Mg-29	21	1.508732	13.205174	02.03.2020	28.05.2020
Mg-30	32	1.509019	13.223382	02.03.2020	28.05.2020
Mg-31	33	1.509081	13.241043	01.03.2020	04.03.2020
Mg-32	22	1.491111	13.241111	03.03.2020	27.05.2020
Mg-34	23	1.473056	13.223333	01.03.2020	27.05.2020
Mg-35	24	1.473056	13.241111	02.03.2020	24.04.2020
Mg-36	25	1.455278	13.241111	02.03.2020	27.05.2020
Mg-37	26	1.436944	13.241111	01.03.2020	27.05.2020

Table 3: Information about individual camera traps, their GPS coordinates, day of installation and day of collection