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Market survey and population characteristics of three species of pangolins (Pholidota) in the Republic of the Congo

MASTER'S THESIS

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Declaration

I hereby declare that I have done this thesis entitled Market survey and population characteristics of three species of pangolins (Pholidota) in the Republic of the Congo independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In Prague, 26.4. 2019

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Markéta Swiacká

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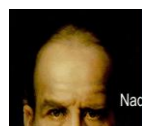
Lastly, I thank all brave people I have met in my life.

Abstract

Market survey and population characteristics of three species of pangolins (Pholidota) in the Republic of the Congo

Nowadays, pangolins are considered to be the most heavily trafficked mammals in the world. Their populations are depleting because of their scales and other parts of the bodies which are used in Asian, as well as African, traditional medicines, and additionally, the consumption of pangolins is widely favored. The Republic of the Congo is perceived to be an origin-destination in the intercontinental trade with pangolins, but overall, a minor fraction of the information has been detected up to now. Therefore, we conducted the first pilot study focused on three species of pangolins (*Phataginus tricuspis*, *Phataginus tetradactyla*, *Smutsia gigantea*) which are found in the Congo. The aim of this thesis was to determine baseline information about pangolins regarding their hunting pressure, trade dynamics, the attitude of the local people towards pangolins and the major threats for their survival in our study area, Odzala-Kokoua National Park. For this purpose, a questionnaire survey was run with the village dwellers, hunters and market sellers in the places situated in close proximity to the park. In total, data were collected from 387 respondents in the villages and from 50 sellers in the local markets within the two data collection periods, May-June 2018 and January-March 2019. Moreover, we directly observed 17 pangolins and gathered the samples originating from 108 individuals, which will be used for future genetic analysis, and now the mentioned techniques were particularly used to assess the local detectability of pangolins. The presence of all three pangolin species was confirmed by all the methods used, only *Smutsia gigantea* was not directly observed. Our findings show that the hunting pressure on pangolins persists substantially, implying pangolins are largely consumed for bushmeat and they are also perceived to be an important source of income and traditional medicine. Even though the respondents were greatly aware of the current status of pangolins, illegal activities continue across the study area. Further research is urgently required with regards to awareness education programmes, development of alternative protein sources and strengthening law enforcement across the whole study region.

Key words: *Phataginus tricuspis*, *Phataginus tetradactyla*, *Smutsia gigantea*, bushmeat, wildlife trade, community survey, traditional knowledge

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List of the abbreviations used in the thesis

CITES   Convention on International Trade in Endangered Species of Wild Fauna and Flora

CULS   Czech University of Life Sciences

EAGLE   Eco Activists for Governance and Law Enforcement

GPS   Global Positioning System

IUCN   International Union for Conservation of Nature

OKNP   Odzala-Kokoua National Park

PALF   Project for the Application of Law for Fauna

SPSS   Statistical Package for Social Science

WHO   World Health Organization

XAF   Central African CFA franc

ZIMS   Zoological Information Management System

1. Introduction

Human populations have persisted in harvesting wildlife for thousands of years and it continues to be one of the major threats causing species declines and extinctions, both local protein consumptions as well as commercial exploitations included (Mambeya et al. 2018; Ingram et al. 2019). Pangolins (Pholidota, Manidae) are highly specialized; foraging just on ants and termites; cryptic in the wild, nocturnal, and therefore complicated to monitor. Globally, there are eight extant species of pangolins, four Asian species and four African ones (Kingdon & Hoffmann 2013; Kingdon 2015). They are easily distinguished from all other mammals by protective keratinous scales that covering their skin. Unfortunately, their scales; as well as other derivates of their bodies namely blood, bones, claws and even fetuses; are believed to be utilized for a wide range of different treatments in the traditional African as well Asian medicines (Bräutigam et al. 1994; Katuwal et al. 2013; Boakye et al. 2014; Soewu & Ayodele 2009; Soewu & Adekanola 2011). Additionally, pangolin meat is an essential source of protein consumed by local people in their native areas, and in general, they are considered to be a delicacy and a symbol of status (Bräutigam et al. 1994; Challender et al. 2015; Soewu & Sodeinde 2015; Shairp et al. 2016). Therefore, based on the enormous number of seizures in the recent years, currently, pangolins are identified as the most trafficked mammals worldwide with an estimate of over one million of pangolins being illegally traded (Challender 2011; Challender & Hywood 2012; Heinrich et al. 2016). In response to this, all pangolin species were upgraded by CITES to Appendix I., conferring it the highest level of protection (Challender & Waterman 2017). However, exploiting of pangolin populations persists as seemingly a market shift to the African species is seen now (Challender & Hywood 2012; Heinrich et al. 2016); recently a record number of pangolin scales have been seized in Singapore, nearly 26 tons (Aljazeera 2019).

Even though the Republic of the Congo typifies the place of origin in the international trafficking routes with pangolins (Heinrich et al. 2017), presumably, only a fraction of these illicit activities has been revealed so far in the Congo (Ingram et al. 2019), and a huge amount of information about pangolins is lacking. Hereby, this thesis is expected to highly contribute to such a knowledge gap.

2. Literature review

2.1. Order Pholidota

2.1.1. Description and overview

Pangolins are unique scale-covered mammals that belong to the order Pholidota (Weber 1904) with a single family Manidae (Gray 1821). There are eight extant species of pangolins included in that family (Wilson & Reeder 2005; Gaubert 2011; Kingdon & Hoffmann 2013; Kingdon 2015); four of which inhabit Asian: the Indian pangolin (*Manis crassicaudata*), Chinese pangolin (*Manis pentadactyla*), Sunda pangolin (*Manis javanica*), Philippine pangolin (*Manis culionensis*); and four species occur in Africa: the white-bellied pangolin (*Phataginus tricuspis*), black-bellied pangolin (*Phataginus tetradactyla*), giant ground pangolin (*Smutsia gigantea*) and Temminck´s ground pangolin (*Smutsia temminckii*). Regarding the nomenclature of pangolins, there are still various statements in terms of the number of genera (du Toit et al. 2017). This diploma thesis uses the taxonomy classification based on the current phylogenetic studies (Gaudin et al. 2009; du Toit et al. 2017), which implies that pangolins are categorized into three monophyletic genera, *Manis* for the Asian species, *Phataginus* for the African arboreal species and *Smutsia* for the African ground-dwelling pangolins as the IUCN Red List follows as well. Despite their similarities to the order Xenarthra, pangolins diverged around 60 million years ago possibly in Europe from the closest related group of animals to them, the order Carnivora (Murphy et al. 2007; Choo et al. 2016).

All species prey almost exclusively on ants and termites which makes them an essential element in the control of insects in natural ecosystems. They are described as selective feeders focused just on a few ant and termite species and it is estimated that one pangolin may consumes even 70 million insects each year (Swart et al. 1999; Hua et al. 2015). The most important adaptations, which enable them to burrow and disturb termite mounds or anthills, are an extremely long stick tongue reaches up to one-third of their body, powerful front claws and a highly developed olfactory system (Challender et al. 2014a; Vallianos 2016). There are further adaptations like thick skin, small eyes and the ability to close their ears. Due to their adaptation to this specialized diet, they

lack teeth, and therefore insects are mechanically crushed in their stomach by means of small pebbles (Nowak 1991).

Pangolins are morphologically distinct from all other animals since they are the only group of mammals on the planet that is covered by keratinous scales. Scales and skin make up about 25% of their body weight, and the number of scales remains steady as they grow. When pangolins are threatened, they curl up into a tight ball and this defence strategy serves together with their scales as great protection against predators. Originally the name "pangolin" is descended from the Malay word "pengguling", loosely translating into "something that rolls up" (Nowak 1991; Wang et al. 2016). Apart from the fact that each species differs in size, colour or habitat preferences, the Asian species are easily distinguished from the African pangolins thanks to the presence of bristles occurring between their scales (Cota-Larson 2017).

2.1.2. Distribution range

Pangolins are solitary and particularly nocturnal animals with only the exception of the black-bellied pangolin which has been recorded to remain active also during the daytime. Due to all these reasons and their shy character, pangolins are only rarely encountered by people (Willcox et al. 2019). They live in a variety of different habitats on the grounds of their preferences and living strategies; encompassing subtropical and tropical forests, savannah grasslands, mixed forest, cultivated areas and others (Challender et al. 2014a). In general, pangolins tend to be close to water sources and places where ants and termites are found in large quantities (Gaubert 2011). The black-bellied pangolin (*Phataginus tetradactyla*) is almost exclusively arboreal species using its prehensile tail for climbing and residing in hollow trees, whereas others, including *S. gigantea*, *S. temminckii* and *M. pentadactyla*, are strictly ground species living in burrows dug by themselves or by other animals. The other Asian species together with *P. tricuspis* are rather opportunistic animals used to foraging insects in trees as well on the ground (Bräutigam et al. 1994; Willcox et al. 2019).

The distribution range of all pangolin species is presented in Figure 1. In total, pangolins are spread across 51 countries, including 19 Asian states and 32 African ones (Vallianos 2016). The Asian species are dispersed from the Indian sub-continent through

China to Southeast Asia with a similar expanse of the three species (*M. pentadactyla*, *M. crassicaudata*, *M. javanica*) and the fourth one, *M. culionensis,* is endemic only to the Philippines (Baillie et al. 2014; Challender et al. 2014b; Challender et al. 2014c; Lagrada et al. 2014). Regarding the African pangolins, the three species (*P. tricuspis*, *P. tetradactyla*, *S. gigantea*) occur solely in Central and Western regions of the continent with an obvious overlapping range. Of them, the white-bellied pangolin inhabits the most extensive area and is often found even in artificial and secondary types of forest. On the other hand, Temminck´s ground pangolin is the only species living predominantly in arid regions of Eastern and Southern Africa with a preference for woodland savannah and light sandy soil (Bräutigam et al. 1994; Heath & Coulson 1997; Pietersen et al. 2014a).
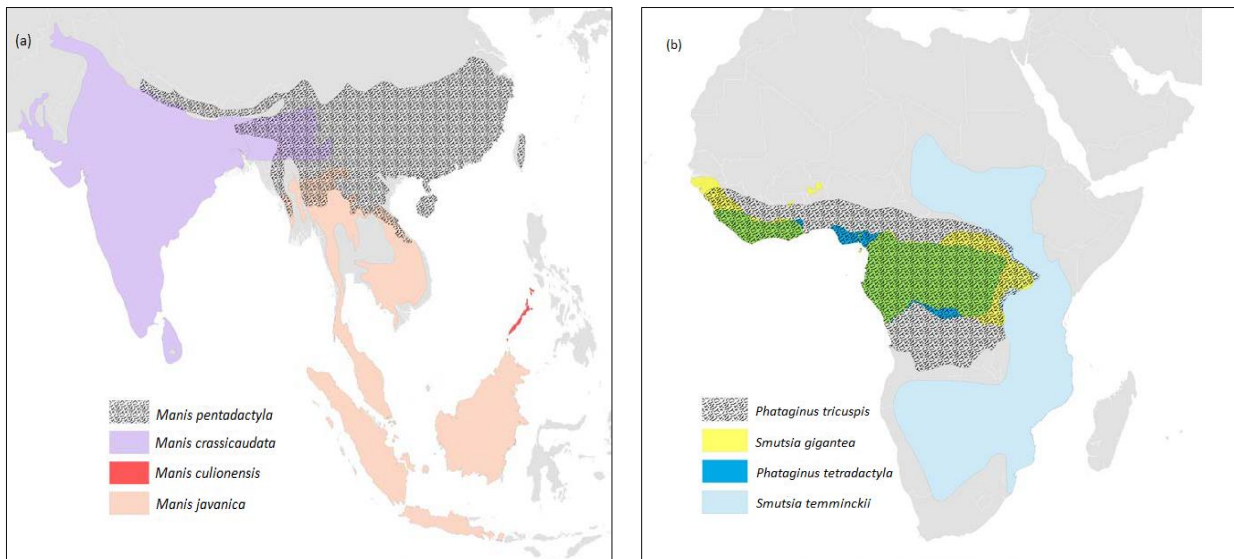
Figure 1. The extension area of living species of the Asian pangolins (a) and the African pangolins (b) (source: Heinrich et al. 2017)

2.1.3. Conservation status

Only limited information is known about the status and population size of pangolins. However, all pangolin species are threatened due to habitat loss, fragmentation and unsustainable exploitation. Their scales and other parts of their bodies are widely used for traditional African as well as Asian medicine, and their meat is considered a delicacy (Challender & Hywood 2012). Despite their protected status, all species are listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) which means international commercial trade is

totally banned with them globally (CITES 2016), a huge illegal trade is largely driven by demand for pangolin products predominantly in China and Vietnam. Domestic law concerning the protection level of pangolins differs greatly by country and species, although hunting and killing pangolins is commonly prohibited in the majority of these countries where pangolins naturally occur (Vallianos 2016). In addition, agricultural intensification related to various types of trapping or poisoning, and usage of electric fencing have importantly contributed to the population decline of pangolins, particularly the African ones (Bräutigam et al. 1994; Challender et al. 2014a; Pietersen et al. 2014b). In spite of the fact that some species have already adapted to modified habitats and palm oil plantations, deforestation and land conversion still remain one of the most important threats for pangolins (Pietersen et al. 2014b; Vallianos 2016).

For all these reasons, pangolins are listed on the International Union for Conservation of Nature (IUCN) Red List of the Threatened species, meaning they are classified as threatened with extinction. The African species are categorized as Vulnerable (Pietersen et al. 2014a; Waterman et al. 2014a; Waterman et al. 2014b; Waterman et al. 2014c), the two Asian species as Endangered (Baillie et al. 2014; Lagrada et al. 2014) and the remaining two Asian species are identified as Critically endangered (Challender et al. 2014b; Challender et al. 2014c) which is summarized in Table 1. Hence for all species concerned, wild populations are believed to be in decline due to increasing local and international exploitation trends, in the case of *M. pentadactyla* the decline has been greater than 90% in China since the 1960s (Challender & MacMillan 2014).

Table 1. Conservation status and population trends of all pangolin species proposed by the IUCN Red List (source: IUCN 2014)

Continent	Species	IUCN Red List status	Population trend
Asia	*Manis pentadactyla*	Critically endangered	Decreasing
	Manis crassicaudata	Endangered	Decreasing
	Manis culionensis	Endangered	Decreasing
	Manis javanica	Critically endangered	Decreasing
Africa	*Phataginus tricuspis*	Vulnerable	Decreasing
	Smutsia gigantea	Vulnerable	Decreasing
	Phataginus tetradactyla	Vulnerable	Decreasing
	Smutsia temminckii	Vulnerable	Decreasing

2.1.4. Challenges and breeding in captivity

Regardless of a relatively wide distribution of pangolins and great market demand for them, there is a lack of fundamental knowledge about their population levels, ecology and biology. They live only in low densities and have also slow reproductive rates, with females giving usually one offspring per year. It is estimated the pangolin´s generation length is between seven to nine years based on uncertain data (Vallianos 2016). Moreover, pangolins are not known to do obvious vocalization sounds and individuals are hardly identified from each other based on their markings. By all means, their elusive natural character makes them to be difficult to monitor, and therefore are a relatively unstudied group of animals (Hua et al. 2015; Bruce et al. 2018; Willcox et al. 2019).

Historically, although over 100 different facilities have tried to sustain pangolins, they reached only a little success (Yang et al. 2007). In fact, pangolins are very sensitive to stress induced by capture, and besides considered their diet requirements, it is a complicated issue to keep them in captivity. Even though it is recorded that pangolins lived even for over 23 years in captivity (Van Thai et al. 2014), according to the data from these institutions, the mortality rate of pangolins reaches up to 70% during the first year of being kept in captivity. The longevity of wild pangolins is still unknown. The most common ailments, which typically occur in the pangolin breeding facilities, are digestive problems, skin diseases, pneumonia and ailments caused by parasites (Hua et al. 2015; Lin et al. 2015). In December 2018, 80 pangolins mostly of the Asian species were kept in captivity in the 17 different zoological institutions throughout three continents (ZIMS 2018). However, a new population of *P. tricuspis* was also established from Togo in 2016 in the five North American Zoos (Challender & Waterman 2017; Lombardi 2018). The species *M. crassicaudata*, *M. pentadactyla*, *M. javanica* and *S. gigantea* are bred in the Asian facilities as well as in Leipzig ZOO, the only European facility (ZIMS 2018). A few rescue centres in Asia and Africa maintain pangolins too (Heinrich et al. 2016; Challender & Waterman 2017).

2.2. Trade and usage

2.2.1. Traditional medicine and beliefs

The most serious threats for the loss of biodiversity mostly take habitat destruction, pollution and human consumption into consideration. Nevertheless, when the species occurs already at such low densities, and simultaneously having a slow reproductive rate, their proneness to extinction is highly increased with the harvesting of pangolins for traditional medicine (Whiting et al. 2011) and for some of them, it is the most severe challenge for their survival (Gaski & Johnson 1994). Since ancient times, different parts of animal bodies and products have held an imperative position in human health care within a broad geographical range. According to the World Health Organization (WHO) as many as around 60%-80% of world´s human population use animals and plants as the main source of medical care (WHO et al. 1993; Alves & Rosa 2005; Boakye et al. 2014); only in Chinese traditional medicine, with a history of more than 4,000 years, it has been recorded that about 1,574 animal species are involved in medical practices (Gaski & Johnson 1994; Liu et al. 2016), and in particular people living in the developing countries rely completely on oriental traditional medicine. In Africa, up to 80% of the local population depends on traditional medicine as the main tool for health care (WHO 2008).

As a matter of fact, the current population decline of Asian pangolin species is highly affected by the demand for pangolins in the Asian traditional medicine. Throughout Asia, pangolin scales have been typically utilized for diverse medicinal functions even though no scientific proof exists to support the suggested healing properties. From the point of view of traditional Chinese medicine, pangolins are considered to be "salty" and "cool" medicine, typically used to promote lactation and blood circulation, reduce swelling, promote the discharge of pus and for pain relief (Gaski & Johnson 1994; Challender 2011; Challender et al. 2015). Therefore, scales are mostly used for treating rheumatic pain, toxicosis, inflammation, asthma, skin diseases, scabies and cancer, among other maladies (Bräutigam et al. 1994). Scales are firstly dried and cooked before grinding into a powder which is frequently inhaled, mixed with other medicines or prepared as a paste (Vallianos 2016). Surveys carried out in China during

October 2015 revealed that the majority of respondents (70%) believed in the medicinal value of pangolins (Vallianos 2016).

Pangolins are also widely distributed in the traditional African bush medicines which is locally known as "muti", "juju" and others (Bräutigam et al. 1994; Challender & Hywood 2012; Boakye et al. 2014; Challender et al. 2014a; Pietersen et al. 2014b). For treating different human ailments, the scales are used in abundance, but nearly all parts of the animal are utilized in some significant way (Pietersen et al. 2014b; Baiyewu et al. 2018; Boakye 2018). For example, it has been recently discovered that as many as 13 pangolin body parts are utilized for the treatment of 35 different ailments in Ghana (Boakye et al. 2015). The highest prevalence was identified as the use of their scales and bones for healing rheumatism, convulsions and financial troubles, as well as enhancing spiritual connection. The same goes for Benin (Akpona et al. 2008) where organs of pangolins are used as a medication for asthma and cardiovascular or dermatological problems. In Nigeria, there is an even broader usage range of pangolins in local medicine. Pangolins are prominently used in healing 47 various conditions by the local traditional Yorubic medical practitioners (Soewu & Ayodele 2009; Soewu & Adekanola 2011). Aside from common human ailments, scales and other parts of their bodies are also utilized for spiritual values; such as having good luck, financial prosperity or generally for protection against many diverse factors. Just as for the previous examples, a total of 22 various pangolin body parts are used for the treatment of 59 diseases in Sierra Leone (Boakye et al. 2014) with the most commonly used bring the scales, head, meat and tail. Bräutigam et al. (1994) reported the importance of the pangolin´s magical properties for people living in Africa. It is believed scales are used as a talisman or for protection against malaria. Other explanations state that the smoke emitted from the burning of pangolin scales can have a positive impact on the health of livestock and repel lions. In conclusion, throughout their distribution range pangolins are appreciated for a lot of medical as well as magical powers that are attributed to them by local populations, despite the lack of scientific evidence to back up these claims (Challender 2011; Pietersen et al. 2014b).

2.2.2. Meat and other products

Besides the use of pangolin scales and parts of their bodies in traditional medicine, they are also harvested for their meat, skins and as souvenirs substantially (Akpona et al. 2008; Pantel & Chin 2009; Soewu & Sodeinde 2015). Historically, large volumes of pangolin skins and leather have been traded internationally for commercial purposes, mainly the Asian species like *M. javanica* and *M. pentadactyla*, and this leather manufacturing continued to taking place in high numbers throughout the 1980 and 1990s with the final destination being the United States, Japan and Mexico in the most cases (Challender et al. 2015), continuing even now (Nijman et al. 2016; Heinrich et al. 2016; Shepherd et al. 2016). The leather is used for making shoes, wallets, belts and handbags; and their scales and claws are utilized in a wide variety for the production of ornaments and musical instruments (Challender 2011; Katuwal et al. 2013; Soewu & Sodeinde 2015; Akrim et al. 2017; Akeredolu et al. 2017).

Pangolin meat has been always an essential part of the human diet throughout the African continent, moreover, one of the most requested ones (Bräutigam et al. 1994; Boakye et al. 2016; Ingram et al. 2017). It is a source of income as well as protein for a large economic spectrum (Baker 2014); and is of great importance among other bushmeat types, considered to be a delicacy and highly ranked for its tastiness in comparison to other animal species accordingly (Soewu & Sodeinde 2015; Ordaz-Németh et al. 2017; Boakye 2018). Chaber et al. (2010) reported that pangolin meat even supplies the lucrative European bushmeat trade based on the smuggling animals at Paris Charles de Gaulle airport arriving from sub-Saharan Africa.

Nowadays in China, the consumption of pangolin meat is a symbol of hospitality and of high-ranking positions in the social system (Xu et al. 2016). Compared to the past when their meat had a primary function as a protein source, the majority of today´s demand is driven by the wealthy who consider the meat to be a delicacy (Vallianos 2016). Furthermore, some Chinese regions are well-known for their beliefs in the nourishing effects of pangolin meat for the kidneys (Pantel & Chin 2009; Aisher 2016). A semi-structured interview survey carried out in Vietnamese luxury restaurants revealed that pangolins belong to the most expensive meats that are consumed mostly by business elites or civil servants (Challender et al. 2015). It has been reported that alive

pangolins are sometimes offered to guests in Asian restaurants to ensure their freshness, even cases have been reported of the blood can being drained and drunk. The foetuses of pangolins are also consumed in local soups as they are believed to have healing properties as well (Aisher 2016; Vallianos 2016). The increasing trend of the price for pangolin meat in China during the period between 1991 and 2012 is displayed in Figure 2. Consumption of pangolin meat is widespread also in other parts of Asia (Baker 2014; Mohapatra et al. 2015; D´Cruze et al. 2018).
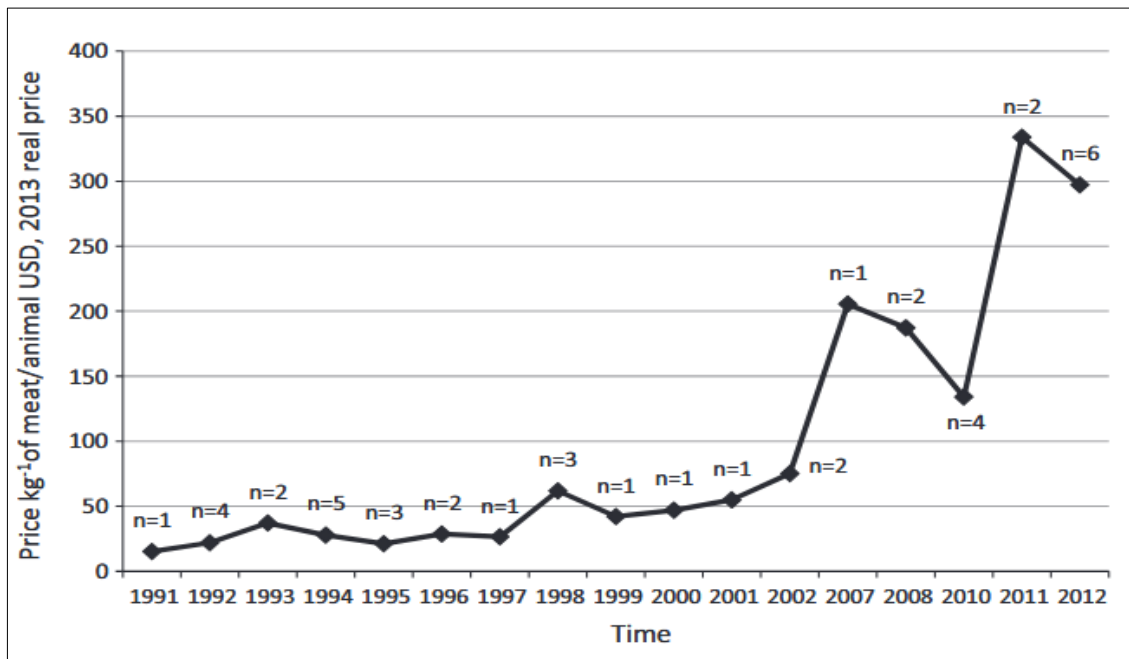
Figure 2. The average retail price of pangolin meat in China (source: Challender et al. 2015)

2.2.3. International trade

2.2.3.1. CITES

CITES is the international agreement among governments presently of the 183 countries (known as Parties) which was enforced in 1975 in conformity with the aim to regulate international trade with plants and animals to avoid an unsustainable situation leading to their extinction. Based on the species status and protection they need, the species covered by CITES are listed in three Appendices. In Appendix I and II there are only species threatened or nearly threatened with extinction included, whose trade must be controlled with strict attention. Appendix III comprises the species protected at least in one state that needs help of the CITES to keep the species trade under control.

At present, approximately 30,000 species of plants and 5,800 species of animals are classified into one of the three Appendices (CITES 2019a). The Czech Republic joined the agreement in 1993 (Klouček 2017).

Since the beginning of the CITES activities, all Asian species of pangolin were included in Appendix II and the Temminck´s ground pangolin in Appendix I. The rest of African species were put into Appendix III in 1976. In 1998 the status of pangolins was up-listed again, which means all species were included in Appendix II. In addition, for the wild-gained Asian pangolins, a zero-export quota was imposed in 2000 to control commercial purposes. However, the quota did not apply to the African species (Challender & Hywood 2012; Heinrich et al. 2016; Challender & Waterman 2017). Hence, a dramatic shift of the trade has been recorded from Asian species to the African since 2001 (Pietersen et al. 2014b; Heinrich et al. 2016). According to Challender & Hywood (2012), an inter-continental trade of African pangolins to Asia happens frequently based on a number of seizures discovered in Asia which is only just a small fraction of the actual numbers being trafficked. In 2016, taking into account this severe illegal trade, the Parties decided to renew the status of the African pangolin species, attaching them to Appendix I which means the commercial trade of these pangolins is completely forbidden since January 2017. There are only a few exceptions when pangolins are legally traded, like in case of scientific purposes, with the given export permission and import permissions that are necessary to obtain (Challender & Waterman 2017; CITES 2019a). Before 2016, when the commercial trade was not entirely prohibited, the largest African exporters of pangolins and their products were Cameroon, Togo and South Africa who were regularly supplying the intercontinental markets (Heinrich et al. 2016).

2.2.3.2. Illegal trade

Illegal wildlife trafficking is a serious criminal activity that has become, alongside illegal trading of drugs, weapons and humans, one of the largest and the most profitable (Wyatt 2013). Due to the uniqueness of their scales and the tastiness of their meat, the populations of pangolins have been exploited in their native countries for centuries. However, today´s demand that is the strongest in East Asia, particularly in China and Vietnam (Pantel & Anak 2010), is unsustainable and hunting to meet the illicit

international trade is the main threat for their survival at the moment. Lately, it has been estimated that more than one million pangolins have been hunted between 2000 and 2013, which may still reflect only a fraction of the actual global illegal trade, and thanks to this they are presently considered to be the most heavily trafficked mammals on the planet (Challender et al. 2014a; Xu et al. 2016; Heinrich et al. 2017).

Nowadays, the pangolin trade involves mainly the living animals, their meat and their scales; all of them are trafficked by the ton, most commonly together with elephant ivory. China has always had a dominant role in the global pangolin traffic concerning the illegal trade as well as the CITES one (Heinrich et al. 2016; Cheng et al. 2016; Heinrich et al. 2017), particularly receiving shipments with pangolin scales and whole animals. Based on the report made by Cheng et al. (2016), 206 seizure incidents were recorded in the period from 2008 to 2016 in China. As a result, it is estimated that 65,849 pangolins have been illegally hunted during this time in China. In total, Heinrich et al. (2017) recently investigated a total of 1,270 seizures between 2010 and 2015 in which 67 countries have taken place across six continents. Except for China and Vietnam, other destinations that have been mainly attached to pangolin trafficking were Malaysia, Hong Kong, Thailand, Laos, Indonesia, the United States, Germany and Nigeria.

Judging by the current evidence, pangolin populations occurring in China seem to be commercially extinct and for that reason the local demand increasingly seeks pangolins in other parts of Asia or in alarming rates also in Africa (Pantel & Anak 2010; Challender & Hywood 2012; Challender et al. 2014a; Gomez & Leupen 2016; Challender & Waterman 2017; Mambeya et al. 2018). Ingram et al. (2017) suggest that between 0.42 and 2.71 million pangolins were killed annually in West and Central Africa in the sampled period 1975-2014 that signifies the increase of hunted pangolins over time in markets. Nevertheless, the causes of this situation are hardly discernible and the growth in prices was detected just in urban areas. In fact, the first known records of trafficked pangolins from Africa to Asia were detected after 2008 (Challender & Hywood 2012), and since then, many shipments have been recorded (Challender 2016; Heinrich et al. 2016). Prior to 2012, a single pangolin seizure did not exceed more than 200 kg of scales, whereas more present seizures commonly range from 250 kg to 2,000 kg (Challender & Hywood 2012; Gomez & Leupen 2016; Shepherd et al. 2016). In extreme cases, four tons

of pangolin scales have been recently seized in Hong Kong sourced from Cameroon (Andersen 2016) and another 5.4 tons of pangolins were seized in 2017 that represent at least 5,000 animals hunted in the wild (Heinrich et al. 2016; Challender & Waterman 2017). Indeed, between 2012 and 2018, 33 seizures with altogether more than 55 tons of pangolin scales have been recently identified by Ingram et al. (2019) originated from the countries of the Central and Western Africa. Pangolin scales are predominantly traded from Africa; namely from Nigeria, Cameroon, Kenya, Uganda or Sierra Leone in most cases whose function is being a source or transit country in this inter-continental pangolin trade chain (Gomez & Leupen 2016; Heinrich et al. 2017). The mean retail price of pangolin scales reaches up 800 dollars per kilogram in the Chinese market (Challender et al. 2015).

2.2.3.2. Traffic routes

Pangolins are illegally trafficked by air, land, sea; and the trade is carried out by the several principal smuggling routes which are displayed in Figure 3. Before shipping, the animals are often slaughtered and frozen in large numbers and declared as fish, while their scales are transported separately (Pantel & Chin 2009). Firstly, intra-continental trade is released from Southeast Asia to China or Vietnam by shipping containers, where pangolins are often descaled, or by land involving mostly living animals or their scales carried in huge grain bags. The second well-known traffic route, particularly with pangolin scales, originates from India or Nepal from which pangolins continue to be transported through Myanmar to China. On the other hand, trade of African pangolins to Asia is led frequently via Hong Kong by shipping containers, largely consisting of scales or frozen animals (Pantel & Chin 2009; Pantel & Anak 2010; Vallianos 2016). If pangolins are brought to China or Vietnam by sea, these cases involve an enormous quantity of dead specimens. Based on the current seizures, the three greatest source countries have been discovered to be Vietnam and Myanmar in Asia; and Nigeria and Cameroon in Africa (Xu et al. 2016; Ingram et al. 2019). However, many trade routes exist in international pangolin trafficking and during the period 2010-2015, on the whole of 159 routes were recorded (Heinrich et al. 2017).

All these illicit activities are extremely well-organized by capable groups of criminals (Pantel & Chin 2009), they are difficult to detect and there is a need for the involvement of as many cooperative subunits and organizations as possible to have at least a small chance of succeeding in the investigation processes. In addition, thanks to a growing economic link between Asia and Africa, the increasing traffic of African pangolins to Asia is assumed to be a serious threat to their survival (Challender & Hywood 2012; Baker 2014; Gomez & Leupen 2016). However, it remains unclear how broad the scale of pangolin trade is from Africa to Asia and how many pangolins supply the domestic market (Challender & Hywood 2012; Challender & Waterman 2017).
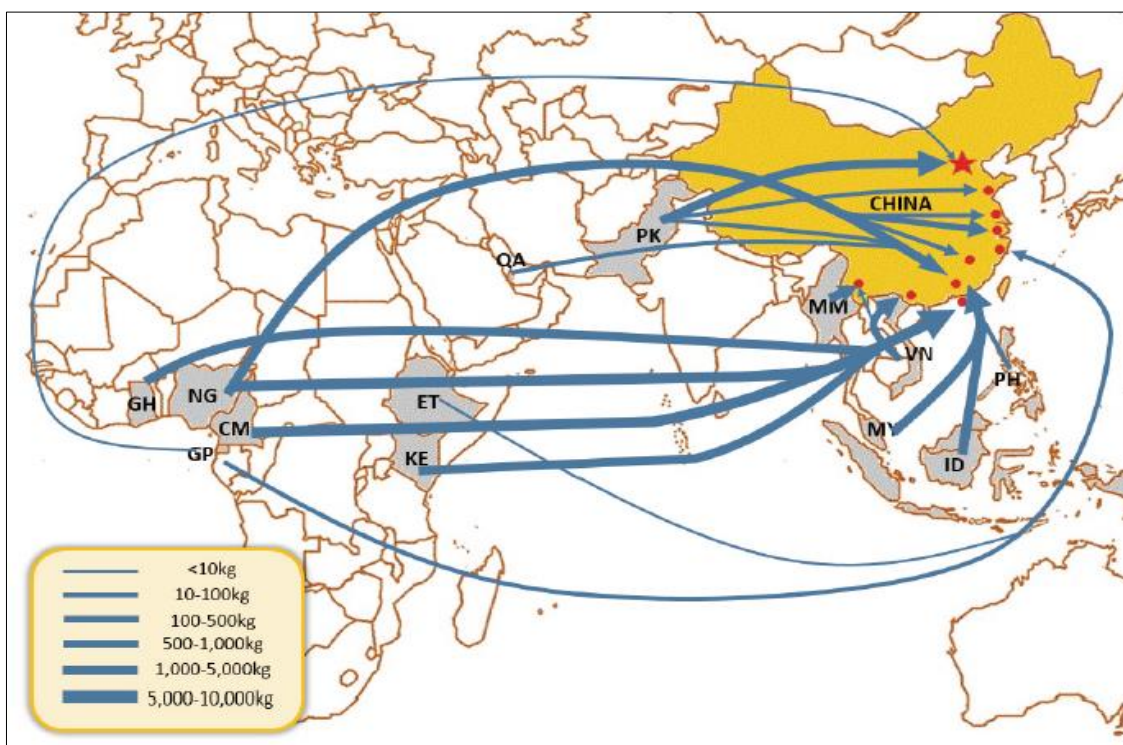
Figure 3. Key traffic routes for pangolin scales based on seizures between 2007 and 2016 (source: Xu et al. 2016)

2.3. Bushmeat consumption

2.3.1. Bushmeat crisis in Central and Western Africa

Bushmeat is a term referring to meat that is derived from all wild animals, mostly used in context with Africa (Bennett et al. 2007; van Vliet et al. 2012). Central and Western parts of the African continent there are some of the most remote forest spots on the planet, many different species are consumed for bushmeat including primarily

pigs, primates, rodents and ungulates (Wilkie & Carpenter 1999; Nasi et al. 2011; Abernethy et al. 2013). In fact, more than two-thirds of the catches in these forest areas are rodents, such as brush-tailed porcupine (*Atherurus africanus*), and ungulates like blue duiker (*Cephalophus monticola*) (van Vliet et al. 2012). Protected species like apes or elephants are involved rather in the total offtake at a smaller scale (Nasi et al. 2011). However, in compliance with the review of Taylor (2012) almost 178 species are presently hunted in Central Africa which also consists of some reptile and bird meat (Fa et al. 2003). It has been recently proven by Fa et al. (2016) that non-Pygmy settlements hunt a wider range of animal species in larger quantities in comparison with Pygmies whose hunting range is distinctly less extensive across the Congo Basin. In terms of primarily rural areas, bushmeat has always been a main source of animal proteins for village dweller in this part of Africa where meat derived from domestic animals is lacking and often more expensive (Fa et al. 2003; Nasi et al. 2011; van Vliet et al. 2012; Abernethy et al. 2013); irrespective of infectious diseases with which the consumption of bushmeat is associated (van Vliet et al. 2012) as well as illegal wildlife trade (Rosen & Smith 2010). Even though human populations are used to hunting in local forests for thousands of years, the present hunting pressure is not sustainable in most cases, which is explained by following reasons (van Vliet et al. 2012).

Firstly, increased demand for bushmeat caused by a growing population, and scarcity of alternative protein sources and better access even to previously remote places are the main generators of unsustainability in bushmeat offtake (van Vliet et al. 2012). Further unsustainable activities such as mining, and logging industries are highly involved in destroying biodiversity in Africa. In addition, newly built roads facilitate access to formerly untouched forest and allow hunters to exploit the forest deeper (Wilkie & Carpenter 1999; Wilkie et al. 2000; Laurence et al. 2006; van Vliet et al. 2012). Thibault and Blaney (2003) also described that the oil industry contributes to the bushmeat crisis as well as logging. Moreover, the profit from hunting of wildlife has increased rapidly in recent years as it started to be a crime of capital importance. Due to it, the commercial wildlife hunting has grown exponentially (Abernethy et al. 2013) and is considered to be the principal reason of the bushmeat demand in Central Africa (Nasi et al. 2011; van Vliet et al. 2012). It means, apart from selling bushmeat as a

popular type of meat for urban areas (Nasi et al. 2011), hunters secure wildlife derivates like the well-known ivory of elephants, skins of various species and others to supply a highly organized illegal trade chain. This current hunting pressure means hunters are becoming greatly specialized, using heavier weapons and in general modern techniques which have an even bigger impact on nature in comparison to the past. This harmful impact of hunting is particularly related to Central and Western Africa that is sometimes termed as the "bushmeat crisis", meaning an enormous decline especially in the large-bodied wildlife and the increasing trend to meet this rapidly evolving demand for bushmeat (Bennett et al. 2007; Baker 2014; Wilkie et al. 2016). Wilkie & Carpenter (1999) estimated that bushmeat consumption across the Congo Basin countries is around one million tons and Fa et al. (2002) calculated an even higher proportion of hunted bushmeat annually, proportionate to five million tons. The current bushmeat crisis is detrimental not only for local wildlife but also for the people living in that area too. Since forest-dwelling people rely on well-valued nutrients from bushmeat whose deficiency can inflict serious health consequences; and the lack of income from wildlife harvesting is of a big concern too (Wilkie & Carpenter 1999; Fa et al. 2003; Bennett et al. 2007; Nasi et al. 2011). Furthermore, if the growing human population continues, insufficient amounts of wild meat will be available by 2050 since wildlife will be quickly depleted. This is why maintaining alternative sources of protein must be pursued which will aid in finding new ways of creating revenue for rural areas (Fa et al. 2003; van Vliet et al. 2012; Wilkie et al. 2016).

2.3.2. The Republic of the Congo

One of the last intact lowland rainforests lies in the Congo Basin of Central Africa, also within the confines of the Republic of the Congo located in the central-western part of sub-Saharan Africa and divided into 12 departments (Blake 1993; Koukouikila-Koussounda & Ntoumi 2016) as it is displayed in Figure 4. The total area of the Congo is 342,000 km^2 that is inhabited by around 5.26 million people. The majority of population is concentrated in the south, the capital city Brazzaville and the second largest city Pointe-Noire, and therefore being one of the most urbanized African countries (U.S. Fish & Wildlife Service 2014; Koukouikila-Koussounda & Ntoumi 2016;

World Bank 2017). In total, there are around 22.5 million hectares of forest composing around 60% of the country from which of more than 11% of the national territory makes up protected areas in the Congo (Wilkie et al. 2000; UICN/PACO 2012; Mavah et al. 2018). Nevertheless, all unprotected forest areas, as well as the protected ones hold a crucial role in terms of local livelihoods, wildlife and ecosystem services (UICN/PACO 2012).
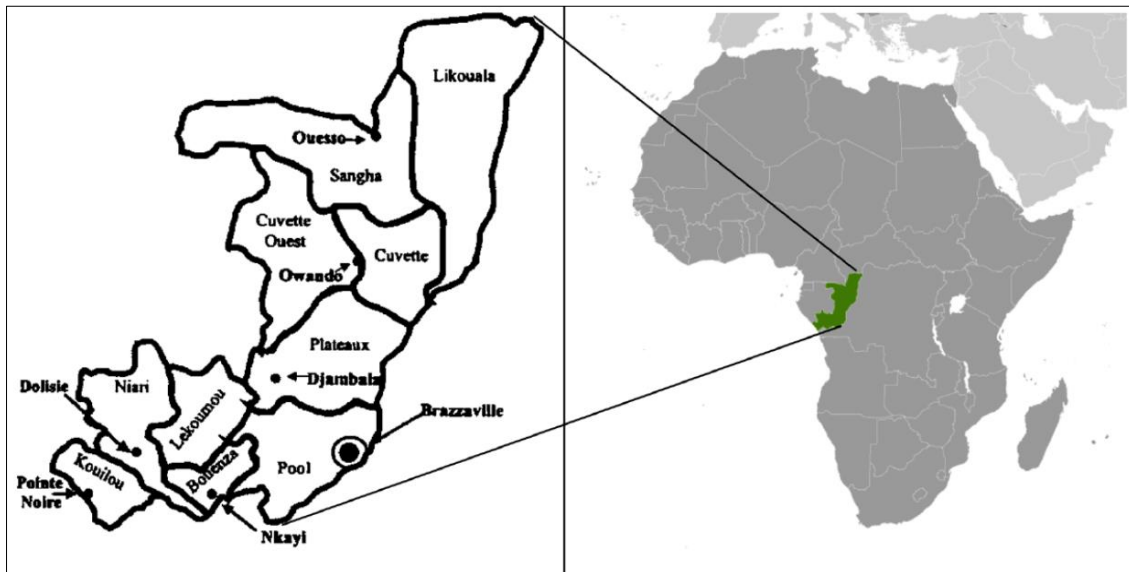
Figure 4. Location of the Republic of the Congo in Africa and its administrative departments distribution (source: Koukouikila-Koussounda & Ntoumi 2016)

Bushmeat consumption is commonly practiced across the country; contributing to the Congolese livelihoods in even higher rates in comparison to other neighbouring countries (Wilkie & Carpenter 1999). Bushmeat is the most important source of protein especially for people living in the vicinity of the forest, but it conduces to urban sites largely as well (Fa et al. 2003; Poulsen et al. 2009; Mbete et al. 2011; Chausson et al. 2019). Even though higher prices of bushmeat have been reported recently in Brazzaville, a long tradition of consumption and preference for the flavour of bushmeat are the main driving factors (Mbete et al. 2011; Chausson et al. 2019). Duikers and primates belong to the most consumed animal species in the Congo; alternatively, rodents or pigs are also consumed (Blake 1993; Wilkie & Carpenter 1999; Hennessey & Rogers 2008; Poulsen et al. 2009; Mbete et al. 2010; Mbete et al. 2011; Nasi et al. 2011). Bushmeat consumption is even higher in northern Congo as local communities restrict their protein intake almost exclusively just to bushmeat or fish. Ouesso with about

30,000 inhabitants is the main city in the northern part of the Congo where the accumulation of bushmeat from other adjacent villages occurs in large quantities. Due to the paucity of wildlife in surrounding forests, the Ouesso population depends on the external bushmeat supply as the demand even surpasses the distribution of forest meat (Hennessey & Rogers 2008; Latour & Stiles 2011; Wilkie et al. 2016; Mavah et al. 2018). Hennessey & Rogers (2008) monitored that an average of 5,700 kg of meat is sold in the local market each week. Bushmeat sourced from the north of the country is imported not only to closely situated markets but to Brazzaville as well. Thanks this, in larger cities, bushmeat is often sold at much higher prices as a significant source of cash (Fa et al. 2003; Mavah et al. 2018).

2.4. Pangolins in the Republic of the Congo

2.4.1. Species

Three pangolin species occur in the Republic of the Congo, namely the white-bellied pangolin (*Phataginus tricuspis*), black-bellied pangolin (*Phataginus tetradactyla*) and the giant ground pangolin (*Smutsia gigantea*) (Kingdon & Hoffmann 2013; Kingdon 2015). However, there is a shortage of official data about pangolins in the Congo and the only existing information sources refer to bushmeat markets or pangolin seizures.

In the review of hunted pangolins in sub-Saharan Africa created by Ingram et al. (2016), it was summarized that the median percentage of the total number of individual hunted pangolins was 0.18 based on the studies between 1972 and 2014 and 0.28 for pangolins offered at local markets by virtue of the studies conducted between 1970 and 2013, involving all species of pangolin. Other articles reported the hunting of seven pangolins within the logging concession of Kabo area (Mockrin et al. 2011), of two pangolins (*Phataginus tricuspis*, *Smutsia gigantea*) in the Odzala-Kokoua National Park (Mbete et al. 2010), of one pangolin in Botala village (Blake 1993), of one individual of *Smutsia gigantea* and of 21 individuals of *Phataginus tetradactyla* at Ouesso markets (Hennessey & Rogers 2008). The occurrence of pangolins at 21 markets in Brazzaville that have been mapped by Mbete (2012) during October of 2008 consisted of the following: 26 specimens of *Phataginus tetradactyla*, 20 specimens of *Phataginus*

tricuspis and 38 specimens of *Smutsia gigantea*. Concerning the trade, the Congo is credited for being the original territory in the international trafficking routes of pangolins (Heinrich et al. 2016; Heinrich et al. 2017; Ingram et al. 2019). In 2015, a shipment of 150 kg of pangolins scales was confiscated in Brazzaville (Shepherd et al. 2016). Between January 2014 and February 2018, PALF (Project for the Application of Law for Fauna), a member of the EAGLE Network since 2008, revealed four seizures of pangolins which is displayed in Table 2 (Ingram et al. 2019). In general, Heinrich et al. (2017) published that during the period from 2010 to 2015, a total number between 7-20 of pangolin seizures was discovered which is demonstrated in Figure 5.

Table 2. Pangolin seizures discovered by PALF between 2014 and 2018 in the Congo (source: Ingram et al. 2019)

Year	Location	Genus	Type	Quantity
2015	Yengo, Sangha Department	-	scales	3 bags
2015	Pointe Noire	*Phataginus*	bodies	1
2015	-	*Smutsia*	bodies	1
2018	Sibiti, Lekoumou Department	*Smutsia*	scales	1 bag (6.5 kg)

2.4.2. Insight into wildlife legislation

In the Congo, the present wildlife legislation (Decree No. 6075 agreed on the 9th of April 2011) distinguishes three protection levels of all locally living animals; classes A, B and C. Class A incorporates only species that are fully protected by the Congolese law. Partially protected species are designated Class B; following the gain of the hunting permission to hunt, capture or kill the animal; and all other animals are put in Class C without any special protection status. Only two species of pangolins are completely protected in the Congo. *Phataginus tricuspis*, the most commonly observed species, together with *Smutsia gigantea* are listed in Class A. On the contrary, *Phataginus tetradactyla* has not been classified in any protected category regardless of the fact that the species is the least widespread of them all (Ministere du developpement durable, de l'economie forestiere et de l'environnement 2011; Kingdon 2015). The import, detention and transport of the species that are totally protected by the national law is forbidden (Article 27) and the only exception is a subject of scientific research or

reproduction intentions. Pursuant to the Act No. 37-2008 on Wildlife and Protected Areas agreed on the 28th of November 2011, more than 20 different wildlife offences are outlined. The scale of fines extends from 10,000 to 5,000,000 XAF, while imprisoning for committing wildlife-related crimes is from one month up to five years in the most serious incidents (Pyhala et al. 2016; Batchy et al. 2018). Even though two pangolin species are fully protected, judicial proceedings are rarely enforced. Based on the recent findings published by Batchy et al. (2018), focus on law enforcement is not equally distributed among species having the same status of legal protection. Between 2008 and 2016, around 70% of the court procedures directed against wildlife crime were aimed at elephant poaching; only 2% of them were dedicated to pangolins (Batchy et al. 2018). The usage of wire snares for hunting is forbidden by the law, despite that fact it is still the most popular method of hunting. Only traditional weapons and shotguns are allowed to be used with a restricted period for shotgun hunting from May to October (Republique du Congo 2008; Hennessey & Rogers 2008; Mockrin et al. 2011).
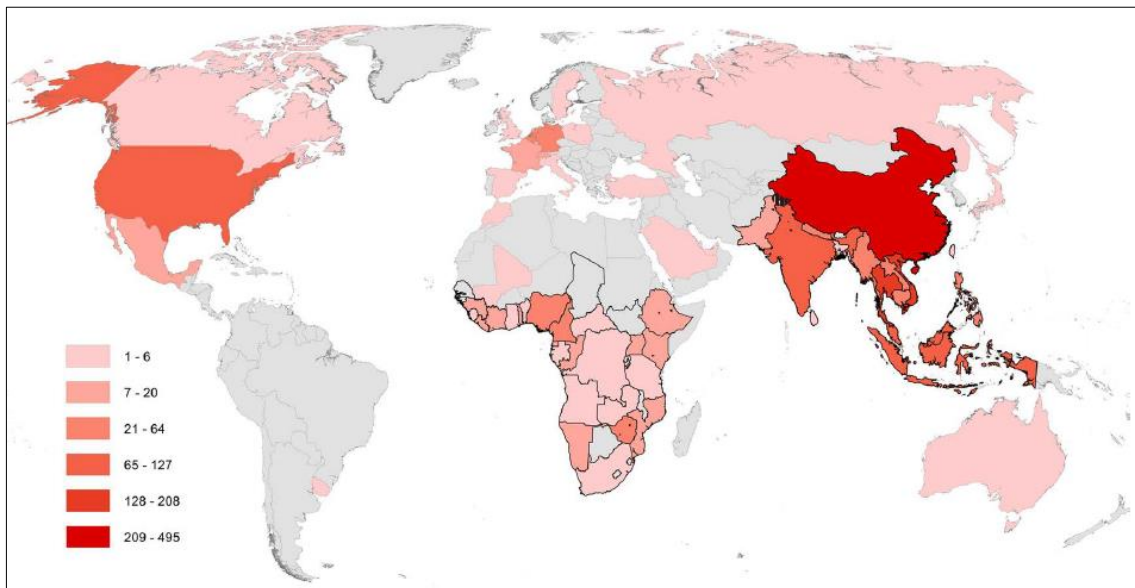
Figure 5. The number of pangolin trafficking incidents (2010-2015) related to each country (source: Heinrich et al. 2017)

The Republic of the Congo became a Party of the CITES agreement in 1983, and therefore the prohibition of commercial trade of pangolins is fully implemented in the country´s legislation. International trade of pangolin derivates, which has been reported by CITES up to the present time, is shown in Table 3 (CITES 2019b).

Table 3. Pangolin legal exports from the Congo between 1975 and 2018 recorded in the CITES trade database (source: CITES 2019b)

Year	App.	Species	Importer	Type	Quantity
1985	I	*Smutsia temminckii*	France	bodies	1
1987	III	*Phataginus tricuspis*	France	bodies	1
1988	III	*Phataginus tricuspis*	France	bodies	1
1988	III	*Phataginus tricuspis*	Italy	bodies	1
1988	III	*Phataginus tricuspis*	Sweden	bodies	1
1989	III	*Phataginus tricuspis*	Sweden	bodies	1
1990	III	*Phataginus tetradactyla*	France	bodies	1
2011	II	*Phataginus tricuspis*	USA	skins	1
2015	II	*Phataginus tricuspis*	USA	scales	1,000 (kg)
2016	II	*Phataginus tricuspis*	China	scales	500 (kg)

2.4.3. Population characteristics of pangolins

2.4.3.1. Questionnaire surveys

Pangolins are cryptic animals, living in low densities with specific ecological requirements. That is why standard field methods have little success in their monitoring and a substantial knowledge gap exists concerning baseline data on their status and population size. Thus, the scarcity of accurate ecological techniques in the detection of pangolins has led to a change in focus to find alternative methods (Newton et al. 2008; Nash et al. 2016; Willcox et al. 2019). Consequently, more and more studies concentrate on utilising the knowledge of local people as a meaningful source of information for the protection of pangolins. Several substantive surveys have been conducted about pangolins occurring mainly through the Asian range. Thanks to the community surveys, the presence of these hard to detect animals is confirmed as in the same way the hunting pressure on pangolins was detected (Newton et al. 2008; Pantel & Anak 2010; Thapa et al. 2014; Nash et al. 2016; Trageser et al. 2017; Zhang et al. 2017; D´Cruze et al. 2018). Moreover, Newton et al. (2008) and Nash et al. (2016) highlight the importance of hunter´s experiences for developing superior methodology protocols and for conservation practices in general. In Africa, similar studies have been carried out; mostly determining the traditional beliefs and medical purposes of pangolins (Soewu &

Adekanola 2011; Setlalekgomo 2014; Boakye et al. 2015), or the hunter´s perception of pangolins and their hunting frequencies (Sodeinde & Adedipe 1994; Boakye et al. 2016; Akeredolu et al. 2017; Mambeya et al. 2018). All these findings assist us in understanding the present scale of illicit trade and the drivers of consumer demand for pangolins (Thapa et al. 2014; Katuwal et al. 2015; Zhang et al. 2017; D´Cruze et al. 2018; Mambeya et al. 2018). Nevertheless, results of such community interviews must be discussed properly due to potential respondent dishonesty and reluctance to confess the illicit activities; including inaccurate interpretations as well (Willcox et al. 2019).

2.4.3.2. Biological variables

Three species of pangolins living in the Congo are easily distinguished by several characteristics. Firstly, they differ significantly in their body size and in the number of their scale rows. A body of the white-bellied pangolin (*P. tricuspis*) is covered by 19-22 rows of three-cusped scales. On the other hand, the scales of the black-bellied pangolin (*P. tetradactyla*) are larger, darker and less numerous with approximately 10-13 rows on their body; and in general, the species is of slightly bigger proportions. The ground-dwelling species referring to the giant pangolin (*S. gigantea*) is typically characterized by a stout body with shorter hindlimbs and tail in comparison to the previous species. In fact, it is the largest species of all eight pangolins having weight around 30-35 kg with the enormous overlapping scales of around 17 rows on their body. Moreover, the belly hairs of *P. tricuspis* are white in contrast to *P. tetradactyla* whose hairs as well as skin are black. All of them occupy particularly tropical moist and swampy forest and depend on water availability. However, while *S. gigantea* also inhabits savannas situated near forests, the two remaining arboreal species prefer more closed areas such as dense woodlands. It is believed that *P. tricuspis* is the most widespread species of them all, whereas *P. tetradactyla* is the most elusive (Bräutigam et al. 1994; Kingdon & Hoffmann 2013; Kingdon 2015; Cota-Larson 2017). In contrast to the Asian species, which are well-known for breeding even two or three young at a time, females of the African pangolins usually have a single offspring in the litter (Hua et al. 2015; Mahmood et al. 2015). Pangolins are categorized commonly into three different age classes: juveniles, sub-adults and adults; depending on the species and sex of the individual taking into account

the fact that females are generally smaller (Akpona et al. 2008; Irshad et al. 2015). External genitals are an additional feature in the identification of males and females. Even though both genders possess the cranial part of the nipples, males are distinguished thanks to a tiny penis, while females have a distinct vulva (Van Thai et al. 2014). Concerning sex ratio of pangolins, little information is known (Zhang et al. 2016). However, these exact relations between males and females, alternatively among different age groups, may be an essential predictor of the current population pyramid and decline of pangolins in the wild.

2.4.3.3. Genetic methods

As with the substantial increase of biodiversity loss lately, usage of new molecular techniques has started to be of great importance in the conservation of threatened species. Hence, the quickly evolving field of the conservation genetics has arisen to reduce the extinction risk in endangered species. Conservation genetics has many applications; including topics like genetic diversity of small populations, stochastic events, taxonomy specification, population fragmentation, extension risks and others; to preserve biological variation. Additionally, it contributes to the detection of illegal hunting and trade enormously in terms of understanding of species biology and in forensics as well. Application of wildlife forensics enables the identification of species, individuals, parents and the origin of seized samples that helps to fight against wildlife crime and facilitates the determination of population characteristics (Landweber & Dobson 1999; Frankham et al. 2002; Frankham et al. 2004; Allendorf & Luikart 2009). Just as the example of pangolins, the most heavily poached mammals in the world, genetic identifications play an imperative role in combating illegal trade. The techniques that have been successfully utilized so far include DNA barcoding for species identification (Kumar et al. 2016; Luczon et al. 2016; Zhang et al. 2015) which has since proven the illegal trafficking of African pangolins to Asia (Mwale et al. 2017). Also, Gaubert et al. (2016) has suggested the necessary contribution of mitochondrial DNA to trace the origin of African pangolins in the illegal trade chain and forensic methods for the detection of the exact geographical origin of pangolin in seizures have to be applied persistently in the future (Heinrich et al. 2017).

3. Aims of the thesis

Even though nowadays, pangolins are the most trafficked mammals on the planet, there is an alarming lack of information regarding the three species of pangolin in the Republic of the Congo. Therefore, the assessment of the current regional status of pangolins is essential. In addition, only a limited number of studies have been conducted on the morphological evaluation of pangolins worldwide, most of which are primarily focused on the Asian species. Thus, the contribution of such information is of great importance for understanding differences within local populations of pangolins, as well as among the different species found in Africa. The same goes for evaluating population genetic diversity of pangolins. On top of that, direct observations of pangolins, as well as collection of genetic samples, may highly contribute to the overall point of view of the accessibility of pangolins in the study region.

With respect to above, the fundamental goal of this research was to find out baseline population information about pangolins in the northern part of the Congo; specifically focused on the area around the Odzala-Kokoua National Park. We aimed to characterize the presence of pangolins in the local markets and villages thanks to the direct observations, gathering genetic samples and gaining an understanding of the perceptions of local people in relation to pangolins by a questionnaire survey. Within the community survey, the research was particularly aimed to answer the following key questions:

1. To what extent are locally living people informed about pangolins and what is their attitude towards pangolins?
2. What are the principal characteristics of hunters, their motivations to hunt pangolins and hunting practices in the study area?
3. What do trade dynamics and illegal activities look like in the study area?
4. What are currently the main conservation threats to pangolins in the study area?

The results were compared and discussed in the greater context of different independent factors and already published studies regarding the given topic, moreover, linked to practical outcomes to highlight the conservation significance of the study.

4. Methods and material

The Methodical Manual for the Writing of Master´s Thesis of the Faculty of Tropical AgriSciences prepared by Brandlová et al. (2018) was used for conducting a structure of the thesis as well as all references were cited according to Citation Rules of the Faculty of Tropical AgriSciences, CULS Prague created by Fedorova (2017).

4.1. Study area

The research was placed at the villages and markets situated in the immediate vicinity of the Odzala-Kokoua National Park (OKNP) in the north of the Republic of the Congo (0°09'-1°35'N, 14°18'-15°21'E). The OKNP is the largest protected site in the Congo located in the regions Sangha and Cuvette-Ouest with a total area covers 13,600 km^2. As the park was established in 1935, it belongs among the oldest national parks in Africa (Hecketsweiler et al. 1991; Latour & Stiles 2011; UICN/PACO 2012; Henschel et al. 2014; Mavah et al. 2018) and since 2010 it has been managed by a non-profit organization African Parks Network (UICN/PACO 2012; Pyhala et al. 2016) that operates within several protected areas across the continent, and takes the responsibility for their long-term management in cooperation with local governments and communities.

The OKNP is composed of a variety of different habitats with a high diversity of plants and species, well-known as a stronghold for one of the last populations of African forest elephant (*Loxodonta cyclotis*), the critically endangered western lowland gorillas (*Gorilla gorilla gorilla*) and a significant group of primate species remaining in Central Africa (Fay & Agnagna 1992; Batchy et al. 2018). Above all, the park is of great importance because of the presence of many carnivores and large-bodied herbivore mammals as well (Henschel et al. 2014; Bohm & Hofer 2018). There are several vegetation types in the park; while in the northern part a denser tropical moist forest is sited, in the south of the park, an extensive forest-savannah mosaic occurs. The dominant characteristic vegetation is represented by the Marantaceae family. The area is full of swamps, watercourses and rivers with a wide occurrence of clearings called "bais" that attracts many animal species for a high volume of minerals. In respect of species richness and greatness of the location, the park faces the highest hunting pressure in the Congo, particularly commonly known as a focal point for ivory poaching.

Average annual temperatures are 23-25 °C and humidity of around 80% all year-long in the park (Latour & Stiles 2011; Henschel et al. 2014; Mavah et al. 2018).

The populations of the sampled places are particularly made up a few Bantu and indigenous hunter-gather ethnic groups (Baka, Bakola) that live in settlements on roads and rivers alongside the borders of the park. The Indigenous people were formerly called Pygmies, however, now it is prohibited to entitle them by this term in the Congo. A low population density predominated in the study area. In total, the population of Cuvette-Ouest was registered at 72,999 in 2010 (Latour & Stiles 2011) and the estimated size of the population was about 109,000 in 2010 in the Sangha department (FCPF 2014). The most common sources of livelihood are farming, fishing and hunting. Indeed, the majority of the forest dwellers depend on protein or cash income originated from bushmeat or fisheries (Marrocoli et al. 2018; Mavah et al. 2018). Moreover, in the northern sector, there is a tradition of cocoa production that is exported particularly to neighbouring Cameroon (Latour & Stiles 2011).

The study area for the village survey was divided into three parts based on the position of the visited places in the park: west, east and north (Figure 6). The western boundary of the park runs between Oloba and Ebana villages, followed by the eastern periphery placed on the Mambili-Liouesso axe where the national road (N2) from Brazzaville connects the largest town of the region, Ouesso. Finally, the last section of the sampled places consisted mainly of area between Ouesso and Souanké, the northern periphery of the OKNP, which is linked by the well-built main road facilitating the access to the park. Overall, we gathered data from 67 different places around the park. In this way, we collected information from the villages situated around the boundaries of the entire park and we also monitored the largest bushmeat markets in the area; namely Etoumbi, Makoua, Ouesso, Sembé, and Souanké. In addition, we also covered six bushmeat markets in the capital city Brazzaville to record the potential differences in comparison to the north of the Congo (Latour & Stiles 2011; Mavah et al. 2018).
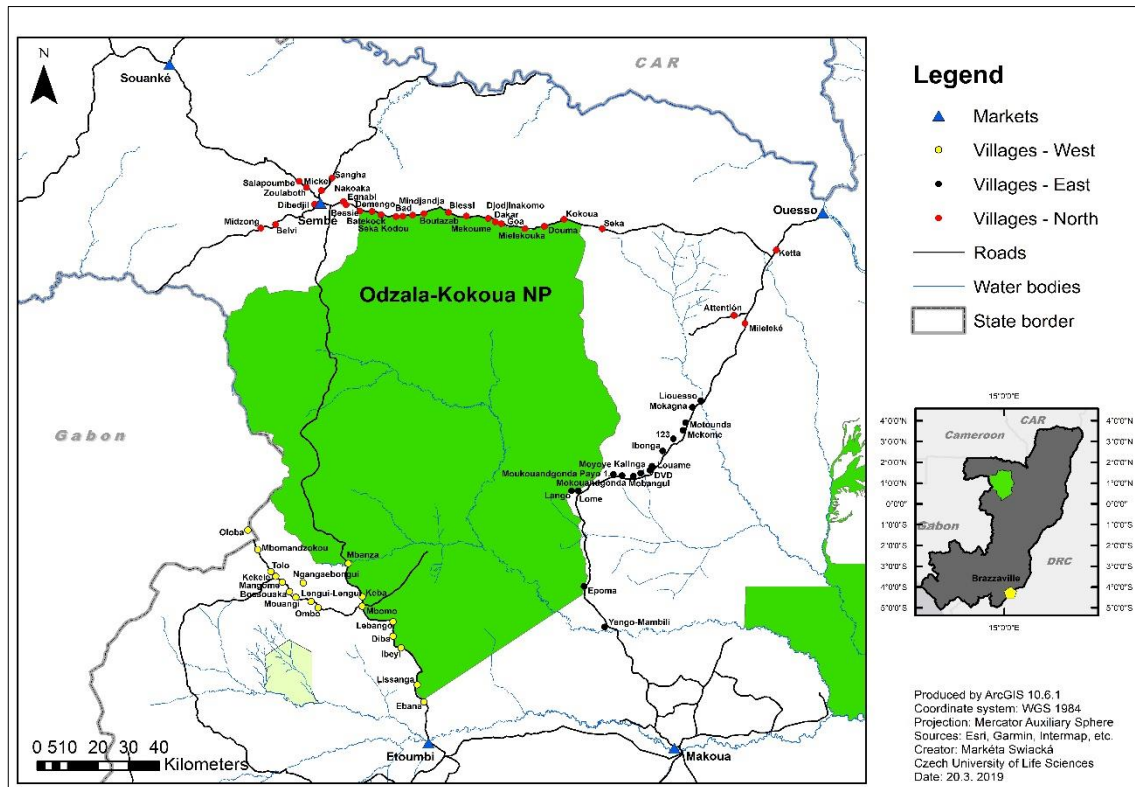
Figure 6. Location of the sampled villages and markets around the Odzala-Kokoua National Park in the Republic of the Congo

4.2. Data collection

4.2.1. Questionnaires

4.2.1.1. Village survey

The village survey took place over a period of nine weeks (May and June 2018) and a total of 387 questionnaires were carried out with village dwellers in 65 villages. The data were collected during open hunting period occurring in the Congo from May to the end of October, which encompassed the end of the short rainy season and the start of the long dry season. However, restrictions are rarely respected by local hunters and moreover, use of snares, hunting by torches at night, hunting of protected species and without license occur frequently as well (Mockrin et al. 2011; Marrocoli et al. 2018). We conducted semi-structured questionnaires as a principal tool for collecting data. It was used a random sampling with the occasional usage of the snowball technique. Nevertheless, a very important feature for the selection of the respondents was availability and willingness to participate in the research. Due to the limited time spent

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in each village, we conducted the questionnaires during various daytime. A target number of six respondents per village was performed. Only twice the goal was not realized because of the low number of people in the village at the time of our visit. Firstly, in the villages, we always approached a chief of the village to inform them about our intentions and to get permission for our activities. The chiefs of the villages often introduced us to other village dwellers and helped us to find well-experienced hunters. Only people above 18 years old were interviewed, both men and women included. Questionnaires were conducted mostly in the company of all the people present at that moment as we found out it was a better technique than to force people to make it individually one by one.

A questionnaire was divided into three parts and comprised of open-ended as well as structured questions (see Appendix 1) to allow ease of capturing the various responses. The first part was devoted to the characterization of the respondents. We documented information about gender, age, ethnic group, education, occupation and duration of living in the sampled villages of all interviewees. Regarding the education system, there are three levels in the country: primary, secondary and tertiary. However, secondary education is divided into two parts altogether taking seven years, of which the first four years refer to college and the final three years are spent at lycée. In the second part, we asked the respondents about the knowledge of pangolins and their perception of them. We monitored data regarding local names of pangolins, the frequency of potential observations, species determination, their price, medical value, meat preferences and status determination to analyse the socio-economic and cultural role of the species there. The final series of the questions was attributed only to hunters and their personal experiences with the hunting of pangolins. The colour pictures of pangolins were shown to interviewees in case of uncertainty about pangolins which originated from the IUCN Pangolin Specialist Group website (www.pangolinsg.org). Questionnaires lasted between 2 and 33 minutes and the mean time of each one was 9 minutes. We always recorded GPS coordinates of the location where the questionnaire was carried out, and the name of the village itself as shown in Figure 6.

Participation in the research was voluntary and questionnaires were anonymous to avoid the risk of harm to respondents. Moreover, all participants interviewed were always assured that they can finish the questionnaire at any time since we obtained verbal consent before the beginning of the questionnaires. The semi-structured questionnaire was prepared in French. Nevertheless, in some cases, it needed to be translated to Lingala, the most local spoken language in the north of the Congo, by a local field assistant Darcy Bikindou and it was subsequently translated into English. To facilitate the process of filling out forms, data were recorded by questioners. Due to the sensitive information we asked the respondents about, a voice recorder was not possible to use. Above all else, we were trying to promote conservation awareness of pangolins in each place visited; by spreading informative leaflets, pangolin stickers and by holding discussions with village dwellers to emphasize the value of pangolins for the ecosystem after conducting the questionnaires (Figure 7).

Figure 7. Increasing awareness about pangolins in Moukouandgonda Payo 1. (a) and in Batekock (b)

4.2.1.2. Market survey

The market survey was carried out from January to March 2019 for seven weeks, within 13 bushmeat markets in the six different Congolese towns (six in Brazzaville, one in Etoumbi, two in Makoua, two in Ouesso, one in Sembé and one in Souanké); and altogether a total of 50 market sellers were interviewed (Figure 6). A short dry season was occurring during that time. The data were collected with the assistance of a local student, Vitel Loubassou, during closed hunting season starting in the Congo from

November to the end of April (Mockrin et al. 2011). We conducted semi-structured questionnaires as a principal tool for collecting the data. Random sampling was utilized, with the occasional usage of the snowball technique. In comparison to the previous questionnaires carried out in the villages, people offering bushmeat were hardly approachable, reserved concerning the sharing of their knowledge and the majority of them did not want to spend their time answering questions without any visible benefit. Since the willingness to participate in the interview was the most essential condition. In most of the cases, we had to provide the sellers with a bottle of beverage to convince them to share the information with us. A target number of six respondents per town was determined; this was dependent on the time we spend in the given place and availability of the people to participate in the research. We sometimes had to firstly contact the chief of the market to get oral permission for carrying out the questionnaires. Only people above 18 years old were interviewed, both men and women included.

A questionnaire was separated into two parts containing open-ended as well as structured questions (see Appendix 2). We asked market sellers about their gender, age, ethnic group, education and how long they have been doing this job. In the second part, we gathered the data about their experiences with pangolins, a frequency of selling and prices for them. As it was during the interviews in the villages, we always documented GPS coordinates of the market, date and time of the questionnaire. Questionnaires were anonymous and prepared in French. Nevertheless, Lingala was sometimes useful to facilitate the survey collection process. The majority of the interviews were carried out individually without an audience, dependent on the exact situation. Questionnaires lasted between 3 and 23 minutes with a mean time of each at almost 11 minutes.

4.2.2. Population variables

In the course of the two data collections in the Congo (May-June 2018 and January-March 2019), we were monitoring the presence of pangolins by direct observation in the markets and villages. Overall, 17 pangolins were monitored; 16 specimens of the white-bellied pangolin (*Phataginus tricuspis*) and one black-bellied pangolin (*Phataginus tetradactyla*). In a case of the encounter of a pangolin, firstly, we

recorded date and time of observation, place and the exact GPS coordinates, sex, and species. Moreover, weight and basic physical measurements (length of head, tail, and body) were taken during the observations. The weight of the pangolins was measured by a digital hanging scale in grams (g), and measuring tape was used for taking the rest of the parameters. All of the length measurements were recorded in centimetres (cm). Total body length was measured from the tip of the tail to the tip of the snout. Tail length was recorded from its tip to the base of the tail located around the anus area. Head length was measured from the tip of the head to the base of the neck area. After that, body length was determined which is the total body length counted without head and tail measurements. If we observed a living pangolin, firstly, it was necessary to unroll the pangolin to get reliable data.

Further, gender determination based on external genitals had to be carried out in case of direct pangolin encounters. In general, it was possible to easily recognize male pangolins thanks to a small clearly visible penis located in the anus area as displayed in Figure 8. On the other hand, female pangolins had an obvious vulva similarly located around their anus (Van Thai et al. 2014). For handling pangolins, dead ones as well as living ones, nitrile gloves were always utilized to avoid any potential disease transmission. Photos of each individual and their genitals were always taken.
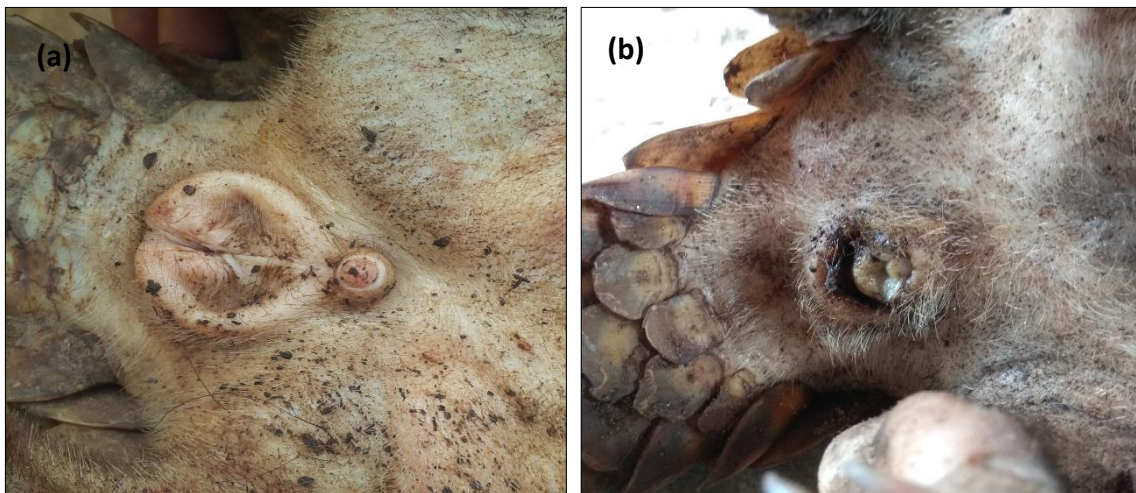
Figure 8. Sex examination of white-bellied pangolins (*Phataginus tricuspis*) during the fieldwork activities; the male recorded in the Ouesso´s bushmeat market (a) and the female monitored in Liouesso (b)

4.2.3. Genetic samples

Genetic samples were gathered during the two data collections in the Congo, the first one (May-June 2018) and the second one (January-March 2019). However, due to reasons beyond our control, we did not sample the western periphery of the park (Oloba-Ebana) during the second fieldwork. Therefore, collecting the samples was not conducted at that time and the samples originated only from the east and north. Three types of pangolin samples were obtained: tissues, buccal swabs and scales. Samples originated directly from pangolins that were observed in the markets and villages, or all scale samples were given to us from people living there. Moreover, we always collected data regarding hour and date of sampling, exact GPS coordinates, pangolin species, number of samples and any other relevant supplementary information. Handling of pangolins, the collection of DNA samples as well as all other research activities were undertaken thanks to obtaining the research permission from Ministere de la recherche scientifique et de l´innovation technologique in the Republic of the Congo that we had to apply for several months before the start of the study.

For each encounter with a pangolin, genetic sampling was carried out. Except for one living white-bellied pangolin (*Phataginus tricuspis*) where saliva had to be acquired, all other samples were obtained from the dead carcasses of pangolins. The tissues, as well as saliva, were stored in 96% ethanol in the collection tubes and labelled by date, place and ID of samples. Only a small piece of tissue was taken (0.5 cm^3) with the preference given to the tongue. A total number of 16 tissue samples and two buccal swabs were collected across the study region. Within the pangolin sampling, nitrile gloves were always utilized to avoid any potential disease transmission or DNA contamination as shown in Figure 9; and all used instruments were sterilized (scissors, forceps, scalpel handle) after sampling.

On the other hand, the scale samples were retrieved from people living in the villages or bushmeat markets. Giving scales to us was always a voluntary decision for the people, and therefore we have never paid for any of these genetic samples. It was indeed for us an ethical restriction in terms of getting the sample. Thanks to this strategy, gathering of the scales will have no impact on market demand. We were always able to distinguish concrete species of pangolins since scales of all three species were

undoubtedly easily recognized (Figure 10). In total, the scales from 91 individuals of different species of pangolins were obtained. The samples of scales were stored in lockable plastic bags together with silica gel and labelled by date, place and ID of samples.

Figure 9. Taking the tissue samples from white-bellied pangolins (*Phataginus tricuspis*) encountered in Belvi (a) and in Sangha (b)

4.3. Data analyses

The data from the questionnaires were recorded in English during the fieldwork and then re-written in an Excel sheet in July 2018, and March 2019 in case of the second data collection. The results of the questionnaires were presented with averages, frequencies, percentages and statistically completed with the IBM SPSS 25 Statistics (Statistical Package for Social Science). Some of the questions, predominantly opened ones, had to be sorted and classified into specific categories before the statistical analysis. Then, all these variables collected in the questionnaires were categorical or were categorized during the data processing phase, and thus not normal distributed. Therefore, a chi-square test (χ^2 test) was used to find out the associations between independent and dependent factors of all questions asked and were significant at α=0.05. Additionally, all answers "I do not know" where excluded from the statistics. The results of the descriptive statistics were expressed by the percentage calculated from all respondents, while the results of the chi-square tests were demonstrated by the percentage of people who only answered the given question.

In terms of the population variables; comprising the gender of pangolins, weight, total body length, body length, head length and tail length; the data were recorded in the Excel sheet and afterward statistically analysed in the SPSS software. For calculations significance level α=0.05 was established. Three individuals were excluded from the statistical assessment because two pangolins were already heat treated (smoked, cooked) and the third one was a different species (*Phataginus tetradactyla*) from all others. Overall, 14 individuals of the white-bellied pangolin (*Phataginus tricuspis*) were included in the statistical analyses. First of all, the normal distribution test was applied, and except for a gender variable that is an independent factor, in fact, all the data were normally distributed (Shapiro-Wilk). Hence, independent t-test (p≤0.05) was used to statistically compare the potential difference between males and females.

Figure 10. Obtained scale samples of three species of pangolins in the Republic of the Congo; scales of all of them (a), specifically *Phataginus tricuspis* (1.), *Phataginus tetradactyla* (2.), *Smutsia gigantea* (3.); and already stored pangolin scales in the plastic bags together with silica gel (b)

The information related to the genetic sampling was recorded in the Excel sheet. Nevertheless, related to the fact that the laboratory assessment of the genetic samples was not the purpose of this thesis, collected samples were presented only as the summary review to give evidence of hunting pressure on pangolins.

5. Results

5.1. Questionnaires

5.1.1. Descriptive statistics

5.1.1.1. Village survey

The respondent description

We gathered data from total of 387 village dwellers living in the surveyed area. The majority interviews were conducted in the northern periphery of the park (n=182, 47%), then from the west (n=111, 28.7%) and east (n=94, 24.3%). The majority of the respondents were men (n=338, 87.3%), only 49 women (12.7%) were interviewed. Most of the respondents (n=129, 33.3%) were between 18 and 30 years old as shown in Table 4. The dominated ethnic groups were formed by people of the Kwele (n=137, 35.4 %), Mboko (n=70, 18.1%), Kota (n=51, 13.2%), Indigenous ethnic group of people (n=42, 10.9%), formerly commonly called as Pygmies, Mbeti (n=11, 2.8%) and Makoua (n=10, 2.6%). The remaining ethnic communities comprised of less than 10 people (<2.5%).

Table 4. Age distribution of the interviewed villagers

Age group	Frequency (n)	Men (n)	Women (n)	Percentage (%)
18-30	129	110	19	33.3
31-40	107	94	13	27.6
41-50	82	74	8	21.2
51-60	46	40	6	11.9
61+	23	20	3	5.9
Total	**387**	**338**	**49**	**100**

The most common education level was a secondary level, namely college (n=148, 38.2%). All results are listed in Table 5. Occupation of the interviewed people was mainly characterized as a mixture of several different activities. The majority of the respondents described themselves to be occupied mainly by farming (n=236) and hunting (n=133). We also interviewed 22 chiefs of the villages and 15 unemployed people. Other reported activities included fishing (n=14), driving (n=13), studying (n=8) and selling (n=8) and the rest of the job activities were represented by less than eight people. In total, 245 of the respondents (63.3%) were hunters and 142 of the respondents (36.7%) had never had

any hunting experience. More than half of the interviewed people had lived their entire life in the same village (n=211, 54.5%) where the questionnaire was carried out, then 103 respondents (26.6%) lived two or more years in the village and 41 respondents (10.6%) less than two years. A few respondents (n=32, 8.3%) lived in a different place from where the questionnaire was performed.

Table 5. Education level of the interviewed villagers

Education level	Frequency (n)	Men (n)	Women (n)	Percentage (%)
None	83	64	19	21.4
Primary	105	94	11	27.1
College	148	133	15	38.2
Lycée	41	37	4	10.6
University	10	10	0	2.6
Total	**387**	**338**	**49**	**100**

The attitude of the respondents to pangolins

Almost all interviewed people (n=380, 98.2%) were able to identify pangolins and provide their local names. They mostly distinguished two types of pangolins based on their size as "the small pangolin" (*Phataginus tricuspis*, *Phataginus tetradactyla*) and "the large pangolin" (*Smutsia gigantea*). The Kwele ethnicity used to call the small pangolin "zele" and the bigger one "guime". The Indigenous people reported using "kokolo" for the smaller species and "kelepa" for the giant pangolin. The rest of the ethnic groups named mostly the smaller species as "kaka", "lekara", "lekaka" or "okara" and the standard name for the giant pangolin was "pige". Most respondents (n=376, 97.2%) also noted that they had observed a pangolin at least once in their life while 11 village dwellers (2.8%) had never seen the pangolin. Regarding the last observed pangolin by the interviewed villagers, the majority (n=103, 26.6%) reported sighting pangolins a long time ago, nonetheless, some of them still observed a pangolin the day of the interview (n=13, 3.4%) or the day before (n=17, 4.4%) as displayed in Figure 11. The last reported place of sighting of a pangolin mentioned by the respondents was particularly the forest surrounding the village (n=156, 40.3%), then in the village itself (n=137, 35.4%) where the questionnaire was conducted; or in other spots like markets, fields, roads or different villages (n=83, 21.4%). Additionally, 213 respondents (55%) stated that the pangolin was still living.
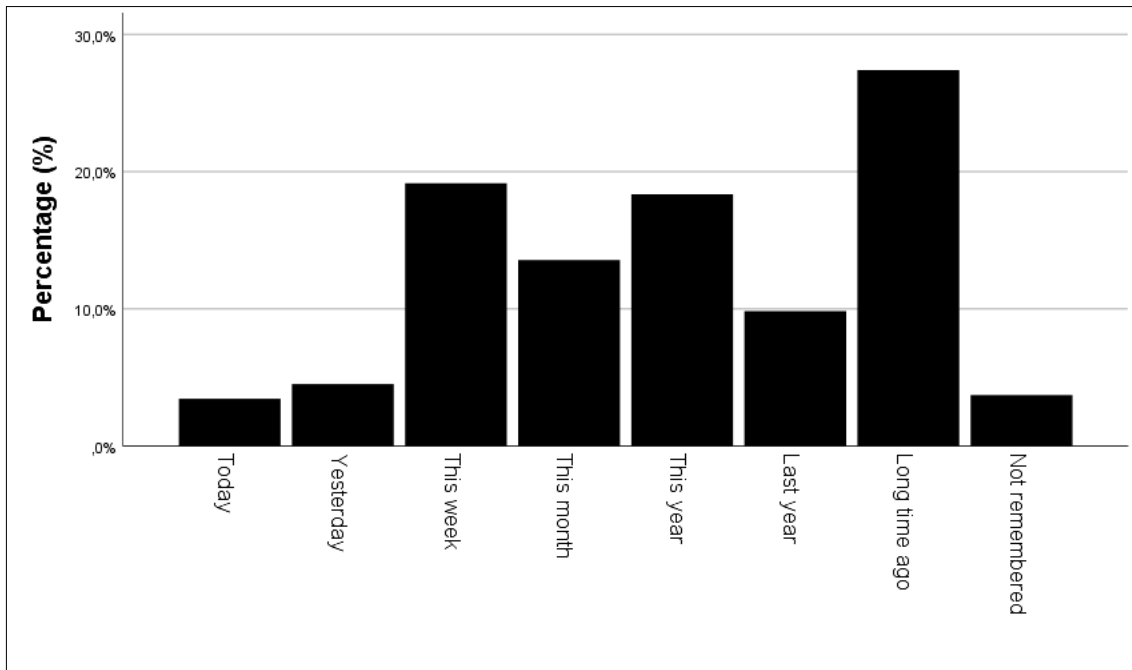
Figure 11. Reported last time when respondents sighted a pangolin

Most respondents (n=325, 84%) were able to provide us additional information about pangolins primarily related to their food preferences and ecological or morphological description. Besides, 350 respondents (90.4%) identified various species of the pangolins. However, 315 of them (81.4%) were familiar with two species of pangolins (*Phataginus tricuspis*, *Smutsia gigantea*) and only 30 respondents were aware of the black-bellied pangolin. This species was described as a very elusive animal having a black colour that lives high in the crowns of trees and was the only diurnal species among all the three pangolin species. Five respondents also believed there to be four species of pangolin (two smaller and two larger). In conclusion, 329 respondents (85%) answered observing predominantly the white-bellied pangolin, nine of them (2.3%) only the giant pangolin and 12 villagers (3.1%) reported both species of pangolins equally.

The majority of the respondents (n=221, 57.1%) were informed about the price of pangolins, of which 104 respondents (26.9%) believed to have seen an increased price for pangolins in the last five years, 39 of them (10.1%) considered the price as "stable", 27 of them (7%) as "decreased" and the rest of the respondents (n=51, 13.2%) did not know the answer. For the whole body of the smaller species, the most frequent response (n=116, 30%) was between 2,000 and 5,000 XAF, then 83 respondents (21.4%) reported

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the price less than 2,000 XAF; of which seven villagers (1.8%) mentioned only 500 XAF for a part of the pangolin body; and a few respondents (n=10, 2.6%) noted that the price was higher than 5,000 XAF. In general, fewer respondents (n=147, 38%) were aware of the price for the giant pangolin. Most interviewed villagers (n=88, 22.7%) identified the price between 10,000 and 40,000 XAF, followed by the prices less than 10,000 XAF (n=41, 10.6%) and 18 respondents (4.7%) suggested the price higher than 40,000 XAF; of which two respondents mentioned 100,000 XAF and 200,000 XAF. Concerning the price of pangolin scales, there was even wider disparity in the answers. In total, only 72 respondents (18.6%) were aware of the price for pangolin scales. The price depended on the pangolin species and the quantity of the scales. Nevertheless, the majority of the respondents (n=27) reported the price between 5,000 and 15,000 XAF for one kilogram of scales from the giant pangolin.

As the respondents were being asked for the medical or cultural value of pangolins, 73 interviewed respondents (18.9%) reported it. The healing properties were exclusively attributed to pangolin scales with only several exceptions when the meat (n=6) or their tail were noted as well. The majority (n=34, 8.8%) believed in attracting women by men thanks to the powder of scales mostly mixed with plants and palm oil and used during some traditional rituals. Five of them also mentioned using the tails of pangolins for this purpose. The other villagers reported ailments like wounds (n=12), skin diseases (n=11), haemorrhoids (n=9), constipation (n=7), mycosis (n=3), potency (n=2), ear infection (n=1), body pain (n=1), asthmas (n=1) and scabies (n=1) as being healed by pangolin scales . A relatively high number of the respondents (n=11) believed that pangolin scales could have given you strength, protect you against snake venom (n=3) and bullets (n=3). Three respondents described using the powder of scales as prevention against bad luck for pregnant women. If a pregnant woman eats a slice of pangolin meat, then she must burn scales and use it as an ointment for her belly to avoid any of the wicked impacts. One respondent also noted a belief in prolongation of life thanks to consumption of the powder of scales. Moreover, pangolin scales were referred to as having a cultural role for several respondents. A few of them knew about the usage of scales for artificial nails (n=5) and playing a guitar (n=2), to keeping good luck (n=5),

as protection for fields against animals (n=4), protection against witchcraft (n=2) and totem (n=1) for which both scales, as well as meat of pangolins, were attributed.

The absolute majority (n=354, 91.5%) had tried pangolin meat at least once in their life. In fact, 268 interviewed people (69.3%) considered it a delicacy, 82 respondents (21.2%) identified the meat to be good and only four people (1%) described it as not to be good (Figure 12). Furthermore, 259 respondents (66.9%) admitted their preferences to eat pangolins instead of other animals; actually, 32 of them highlighted clearly that it was the tastiest meat of all bushmeat for them.
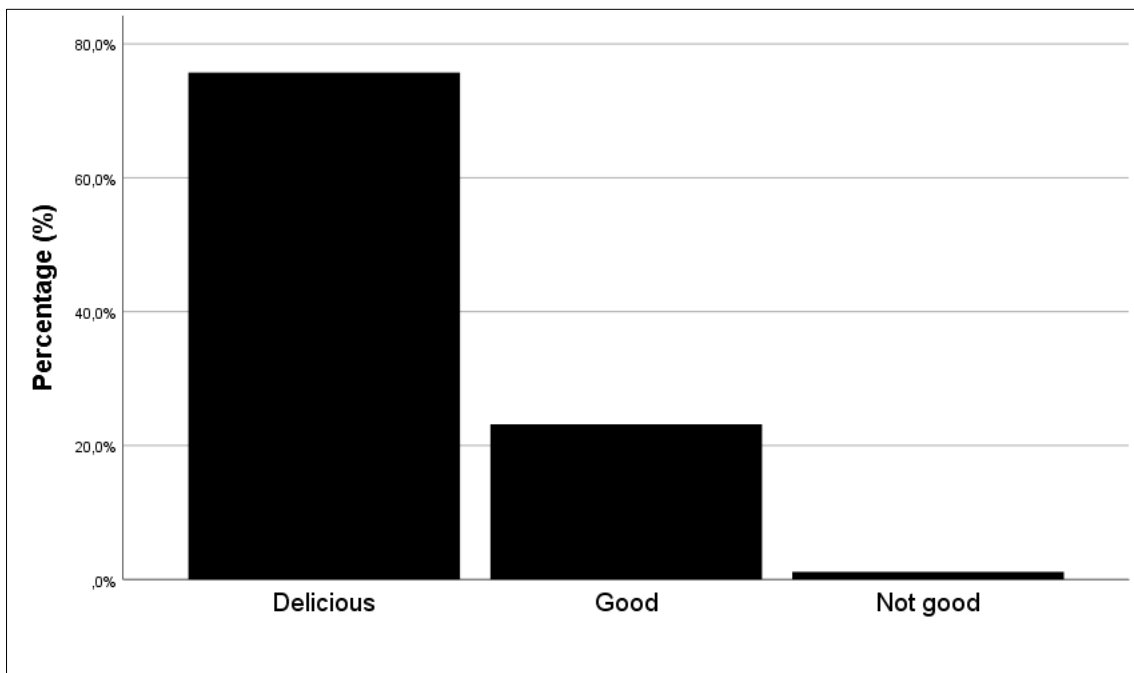
Figure 12. Respondent´s description of pangolin meat

One of the questions was made to address to the present status of the pangolin population in nature. The villagers had to choose from a scale "increased", "stable", "decreased" or they could have answered that they did not know it. In fact, 211 respondents (54.5%) were thinking that the population of pangolins was increasing. A relatively wide range of explanations was provided by respondents to specify their statements. Most of them stated (n=106) that they were observing or hunting pangolins; particularly in the forest (n=55) or in the village (n=7). The other ideas were that the respondents (n=37) detected a lot of tracks of pangolins in the forest, or they were not hunting pangolins (n=25) so according to them, pangolins had to remain in the forest. Some of them mentioned that pangolins had the ability to reproduce all the time (n=7)

or they were afraid of killing pangolins due to eco-guards (n=4). For the other interviewed villagers (n=21), the animals simply had to be in the forest. However, 47 respondents mentioned that, even though the population was increased according to them, pangolins were very rare to encounter. Additionally, a significant number of the respondents (n=27, 7%) reported that only the populations of the smaller pangolin species were increasing and contrarily, the population of the giant pangolin was decreasing. On the other hand, 70 respondents (18.1%) believed the current status of the pangolin population was decreasing and an overwhelming part of them (n=51) considered pangolins to be very rare and heavily detected. The other respondents reported that they observed more pangolins in the past compared to this day (n=11), hunting pressure was high (n=6), pangolins had slow reproduction (n=6) or did not occur in the studied area anymore (n=5). Furthermore, four respondents (1%) considered the pangolin population as stable and 64 respondents (16.5%) were not able to precise their status. The last question of the questionnaire was dedicated to information about the protected status of pangolins. The absolute majority (n=364, 94.1%) knew pangolins were protected, only three of them considered pangolins to be not protected and 20 respondents did not know what to answer.

The experiences of hunters with pangolins

The last section of the questionnaire was addressed just to the hunters (n=245, 63.3%) and their experiences with the hunting of pangolins. The hunting frequency of the respondents is expressed in Figure 13. Of all hunters, 64 of them were interviewed in the west, 47 in the east and 134 in the northern periphery of the OKNP.

In fact, 226 hunters (58.4%) admitted that they had been hunting pangolins at least once in their life. Most of them (n=156, 40.3%) reported they hunted pangolins many times, meaning more than ten times, while the rest of them (n=69, 17.8%) answered that they hunted pangolins less than ten times, between once and five times (n=60, 15.5%) and between six and ten times (n=10, 2.6%). Further, 62 respondents (16%) reported that they hunted a pangolin for the last time just one week ago and less, 82 hunters (21.2%) one year ago and less and 79 respondents (20.4%) more than one year ago. The majority (n=171, 44.2%) noted that a pangolin was captured for the last

time in the forest close to the home village, directly in that village (n=24, 6.2%) and in other locations (n=31, 8%), for example in the field, road or garden. On the grounds of the hunter´s responses, the best time for hunting pangolins was just evening (n=94, 24.3%), all night (n=74, 19.1%), around midnight (n=31, 8%) and 27 hunters believed there was no opportune moment for hunting of pangolins, even daytime was convenient. On the basis of 19 respondents (4.9%), they had never hunted any pangolin because of the rarity of the species (n=11), protected status (n=6) or other reasons (n=2).
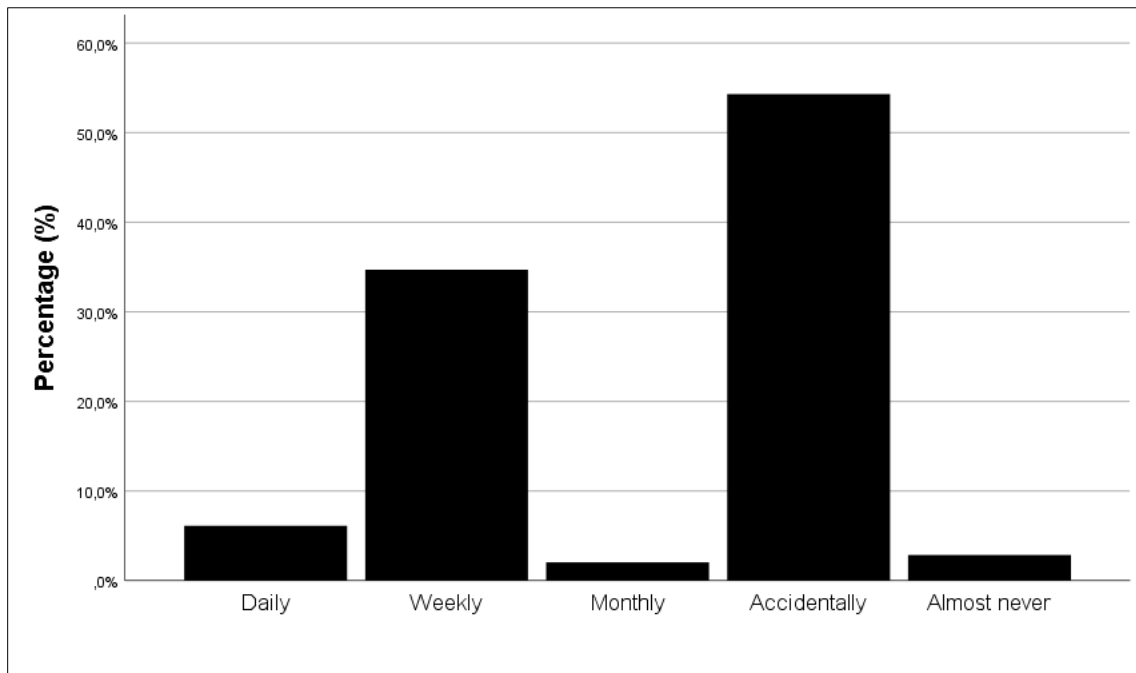
Figure 13. Reported hunting frequency of the interviewed hunters

Overall, 102 hunters (26.4%) stated that they were hunting pangolins for other reasons than just for meat (n=225), like income (n=100) and medicine properties (n=5). Indeed, the hunters mostly had experiences with the selling of the whole body (n=91, 23.5%), thereafter scales (n=31, 8%) and parts of the body (n=12, 3.1%). The majority of the hunters (n=85, 22%) mentioned trading pangolins predominantly to local people in the villages. Further, 33 respondents (8.5%) noted selling pangolins to people passing the main road. In addition, 21 respondents (5.4%) specified doing pangolin traffic particularly with foreigners, of which 12 hunters to people from Cameroon and five hunters to Chinese. All hunters were trading pangolins in dead form, one respondent mentioned also selling a living animal.

Traditional hunting methods of pangolins include collecting them with their bare hands (n=205), followed by the usage of shotguns (n=67), machetes (n=52), snares (n=45), torchlights (n=17), fire (n=1), dogs (n=1) and digging of burrows (n=1). Additionally, some hunters (n=23) used to hunt the smaller species just by hand; and regarding the giant pangolin, 23 people utilized shotguns and 17 of them machetes to catch them.

In total, 120 respondents (31%) claimed that there was a difference in availability of pangolins during the year. Most of them (n=106, 17.4%) reported a higher occurrence of pangolins in the rainy season because they sighted them more frequently (n=55, 14.2%), related to the fact that many insects, termites and ants appeared during the rainy season (n=51, 13.2%). Fourteen respondents (3.6%) reviewed that there were more pangolins during the dry season, referring pangolins used to like cold or it was easier to detect sounds of pangolins as the hunters stated.

Almost all interviewed hunters (n=217, 56.1%) admitted hunting predominantly the smaller species. From the point of view of five respondents (1.3%), they were hunting mainly the giant pangolin, and four hunters (1%) mentioned hunting mostly very small pangolins. As we asked the hunters about their observation experiences of other people hunting pangolins, from the scale "often", "sometimes", "rarely", "never" and "I do not know", the majority of the respondents (n=87, 22.5%) answered often to detect other hunters capturing pangolins, 54 of them (14%) mentioned rarely, 34 of them (8.8%) just sometimes and two people (0.5%) had never observed it. Moreover, some respondents (n=49, 12.7%) noted that they did not care about activities of the other village dwellers, and therefore they were not able to respond to us. The absolute majority of the hunters (n=220) were informed about the protected status of pangolins, meaning the respondents knew it was illegal to poach pangolins. Only six respondents (1.6%) were not sure about it.

5.1.1.2. Market survey

The respondent description

Overall, we conducted 50 questionnaires with market sellers in six different locations; 12 interviews (24%) in Brazzaville, 16 of them in Ouesso (32%), 12 of them

(24%) in the southern periphery of the park (Etoumbi, Makoua) and 10 interviews (20%) in the northern periphery of the park (Sembé, Souanké). The majority of the respondents were women (n=41, 82%), and nine men (18%) were interviewed as well. Age categories are displayed in Table 6. Indeed, most of the sellers (n=18, 36%) were between 31 and 40 years old. The Kwele (n=14, 28%) was the dominant ethnic group participating in the survey, followed by Makoua (n=7, 14%) and Lari (n=5, 10%). The remaining ethnicities made up less than five people (<10%).

Table 6. Age distribution of the interviewed market sellers

Age group	Frequency (n)	Men (n)	Women (n)	Percentage (%)
18-30	14	2	12	28
31-40	18	3	15	36
41-50	10	3	7	20
51-60	6	1	5	12
61+	2	0	2	4
Total	**50**	**9**	**41**	**100**

Most of the respondents (n=28, 56%) had secondary education, college namely, as shown in Table 7. Almost all respondents (n=44, 88%) were bushmeat sellers and six of them (12%) were sellers in the traditional medicine stalls. Based on the answers, the majority of the respondents (n=23, 46%) were working as sellers for more than 11 years. Further, 15 respondents (30%) were selling bushmeat or traditional medicines for between one and five years, nine of them (18%) between six and ten years and the rest of them (n=3, 6%) were sellers for less than one year.

Table 7. Education level of the interviewed market sellers

Education level	Frequency (n)	Men (n)	Women (n)	Percentage (%)
None	2	0	2	4
Primary	10	0	10	20
College	28	3	25	56
Lycée	7	5	2	14
University	3	1	2	6
Total	**50**	**9**	**41**	**100**

The experiences of market sellers with pangolins

All of the market sellers (n=50, 100%) were aware of pangolins and, similarly as the results from the village survey, the Kwele ethnicity used to name the smaller pangolins "zele", or "guime" referring to the giant pangolin. The smaller species of

pangolins also were largely called "lukaka" or "kaka" by people living in Brazzaville, "okaga" in Makoua, "lekara" in Etoumbi. Moreover, the Djem ethnicity named the smaller species "nzele" and the giant pangolin "djumo".

Overall, 44 sellers (88%) admitted that they had been selling pangolins at least once in their life and six market sellers (12%) had never had such experience. Of the respondents selling pangolins, the majority (n=40, 80%) expressed it like the "occasional" event, three of them (6%) were selling pangolins "almost never" and for one seller (2%) it was the "weekly" trade. Most respondents (n=37, 74%) reported selling predominantly the smaller species, three of them (6%) the giant pangolin and four of them (8%) described trading both species of pangolins equally. All respondents (100%) were mostly trading dead pangolins, fresh ones (n=26) or smoked (n=7). Additionally, five sellers had experience in selling a living pangolin as well.

The majority of the respondents (n=22, 44%) reported trading the smaller pangolins for between 2,000 and 5,000 XAF. For some sellers (n=5, 10%), the price ranged less than 2,000 XAF and for the rest of them (n=8, 16%), the normal price was more than 5,000 XAF for one small pangolin. In terms of the giant pangolin, six sellers (12%) mentioned the normal price for one individual as between 20,000 and 50,000 XAF, six of them (12%) suggested the price less than 20,000 XAF and the rest of them stated the price more than 50,000 XAF (n=5, 10%). In total, more sellers (n=35, 70%) were informed about the prices for the smaller species in comparison to the giant pangolins (n=17, 34%). As stated by some of the respondents (n=19, 38%), the price has decreased during the last five years. Furthermore, 15 sellers (30%) identified the price as increased, five of them (10%) were thinking that the price of pangolins was stable and five of them (10%) did not want to give us an answer. Moreover, six medicine sellers (12%) were exclusively selling pangolin scales and in total of 11 people (22%) had sold the pangolin scales at least once in their life. Contrarily, 33 respondents (66%) were trading only pangolin meat. The majority of the market sellers (n=33, 66%) reported that they were selling pangolins particularly to local people, nine of them (18%) were trading pangolins to local people and foreigners equally, and three sellers (6%) were doing the trade with pangolins primarily with foreigners. Moreover, some of these sellers (n=11, 20%) identified the foreigners as Chinese, alternatively as Cameroonians (n=2, 4%).

Nevertheless, only 16 sellers (32%) stated that customers had been asking frequently to buy pangolins and on the contrary, most of them (n=28, 56%) reported that people had not been often coming to demand them. Therefore, almost all sellers (n=42, 84%) summarized that they did not prefer selling pangolins over other animals. For some of them (n=25, 50%), as justification, pangolins were rarely sold as a protected species, and thus risky to be involved in the trade of them. Whereas, 17 sellers (34%) expressed the concern that pangolins were less profitable to sell in comparison to other animal species like antelopes or primates. To conclude, only two sellers (4%) preferred to trade with pangolins than with other species.

In fact, the majority of the sellers (n=20, 40%) were unaware of the actual status of pangolins. On the grounds of it, they just expressed "I do not know". A further 12 respondents (24%) believed that the population of pangolins was decreasing, nine of them (18%) suggested that the population of pangolins was increasing and only three respondents (6%) identified it as "stable". With one exception (2%), all market sellers (n=43, 86%) were informed about the conservation status of pangolins.

5.1.2. Discussing independent factors influencing the results of the questionnaire

5.1.2.1. Village survey – all respondents

LOCATION

It was found that within three different locations of the park (west, east, north), overall, 28.2% of the people reported observing a pangolin for the last time in the past week or less (χ^2=79.508, df=4, p<0.001), but this percentage was significantly greater in the north where 45.5% of the people did it. In the north, there also was a significantly lower percentage of the people (18%) than was expected (38.7%), who actually reported seeing a pangolin more than the year ago. Again, it may be explained by the greater readiness of the respondents to share their information with us and their noticeable skills to detect pangolins, or otherwise, pangolins truly may be found in higher numbers in the northern periphery of the park. In the north, the surveyed villages are located just in immediate proximity to the protected land of the OKNP, and thus, the local availability

of prey may be greater unlike the other parts of the park where the villages are positioned further from the park borders (Fa et al. 2006; Boakye at al. 2016; Mavah et al. 2018). Moreover, overall, 93.1% of the people were able to recognize two pangolin species (large and small), but only 8.6% of the people were familiar with three species of pangolins (χ^2=29.722, df=4, p<0.001). Contrary to other parts, this percentage was significantly greater in the north (16%) where people were more informed about the black-bellied pangolin. As it has been discovered, in the east, there was a significantly lower percentage of the people (26.9%) than expected, who reported observing a pangolin in the forest for the last time (χ^2=14.992, df=4, p=0.005). On the other hand, 32.3% of the people in the east reported most recently sighting a pangolin in other places which was significantly greater than expected. It may show that pangolins are already difficult to observe in the forest of the eastern periphery of the park, and people detect them mostly in other villages or on the main road connecting Ouesso and Brazzaville where illegal traffic may occur (Wilkie et al. 2000; Akpona et al. 2008). For example, in the Congo, Latour & Stiles (2011) already mentioned that all the villages located on this road are potentially collecting places for bushmeat.

Regarding the pangolin trade, in the north, 76.5% of the people were familiar with the prices for pangolins (χ^2=47.594, df=2, p<0.001) which were significantly greater than expected from the overall interviewed population (58.5%). In the east, even though there was no significant difference (χ^2=8.786, df=4, p=0.067) among the surveyed locations, the perception of the price to be 2,000 XAF or lower for the smaller pangolins was lower than expected (25%), but higher than expected concerning the price of more than 5,000 XAF (11.1%). This may be explained by the fact that people living in the east are actually just on the main road connecting the capital city Brazzaville and the main regional town Ouesso, meaning they can easily sell their products to people who are heading to the larger markets and are willing to pay for more (Wilkie et al. 2000; Latour & Stiles 2011; Boakye et al. 2016; Mavah et al. 2018), as this was already reported by Akpona et al. (2008) in Benin. Similarly, it is related to the giant pangolin (Figure 14), the perception of the price was lower than expected in the west (up to 10,000 XAF), average in the north (10,000-40,000 XAF) and higher in the east where a significant percentage of the people (30%) reported the price for the giant pangolin to be more than 40,000

XAF (χ^2=12.373, df=4, p=0.015). Furthermore, 19% of the respondents were informed about the price of scales (χ^2=28.028, df=2, p<0.001), but this percentage was significantly lower in the west (4.7%), average in the east (15.1%) and higher than expected in the north (29.6%). Additionally, in the west, only 20% of the respondents believed in attracting women by use of scales (χ^2=7.831, df=2, p=0.020) which was significantly lower than expected (46.6%). This may show that in the west, people do not perceive the value of scales as strongly as people in other parts do, including traditional medicine as well as the pangolin trade.
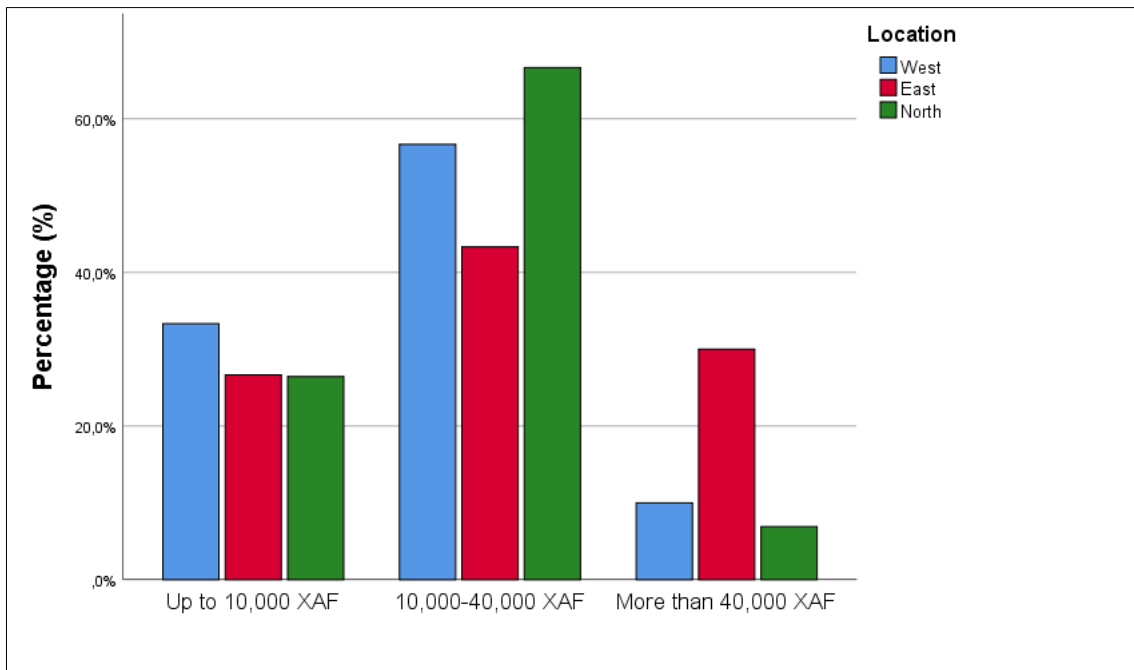
Figure 14. Respondent´s perception of the prices for the giant pangolin with regards to the different study area of the Odzala-Kokoua National Park

In the north, 96.6% of the people had eaten pangolin meat at least once in their life which was significantly greater than expected (χ^2=7.112, df=2, p=0.029). On the opposite side, in the west, 88.7% of the respondents had tried pangolin meat which was significantly lower than expected. Then, for a total of 75.7% of the people, pangolin meat was a delicacy (χ^2=20.170, df=4, p<0.001), which was significantly greater than expected in the west (81.9%) and in the north (79.8%), while lower than expected in the east (60.9%). Actually, in the east, 39.1% of the respondents reported pangolin meat to be just "good" which was significantly higher than expected. It is connected to the result that, in the east, only 56.3% of the respondents considered pangolins to be better meat in comparison to other animals (χ^2=16.664, df=2, p<0.001) which was significantly lower

than expected (73.2%). This result is also related to the hunting frequency of pangolins which is significantly lower in the east than in other parts of the park, as it will be explained in the following chapters.

Regarding the perception of the current status of pangolins (χ^2=15.416, df=6, p=0.017), overall, 67.6% of the people were thinking the population of pangolins was increasing, but this percentage was significantly greater than expected in the west (84.3%). On the contrary, a lower percentage of the respondents (10.8%) than expected considered the population "decreased" in the west. This may be related to our finding that overall, 56.6% of the respondents observed a living pangolin recently (χ^2=41.506, df=2, p<0.001), but this percentage was only significantly greater than expected in the west (81.9%).

GENDER

Some results were detected to be statistically different between women and men. In general, women reported observing a pangolin for the last time significantly longer time ago in comparison to men (χ^2=8.406, df=2, p=0.015). Only seven women (15.6%) observed a pangolin one week ago and less which was significantly lower than expected (28.2%). On the other hand, 57.8% of the women reported seeing a pangolin more than the year ago for the last time which was significantly greater than expected (38.7%). Further, a significantly lower percentage of the women (10.6%) observed pangolins most recently in the forest (χ^2=21.064, df=2, p<0.001) compared to men (45.9%). On the contrary, a significantly higher percentage of the women (55.3%) reported sighting pangolins in the villages than men (33.7%) which is shown in Figure 15. Moreover, the latest recorded pangolin was a living one for 36.2% of the women (χ^2=9.173, df=1, p=0.002), while this percentage was significantly greater than expected for men (59.6%). The women (53.2%) also provided us with significantly less additional information about pangolins (χ^2=50.636, df=1, p<0.001) than men (91.2%). On top of that, only 76.6% of the women described different species of pangolins (χ^2=22.690, df=1, p<0.001), which was significantly lower than expected (93.1%), and no women were aware of the black-bellied pangolin.

It follows that women seem to not have had similar experiences with pangolins as men have, or pangolins are simply less detectable for women. This is based on the

fact that hunting roles belong solely to men in local cultures, so women do not hunt animals, and therefore rarely have the opportunity to enter the forest (Lindsey et al. 2013). That is why women reported sightings of pangolins frequently in the villages where subsequently after the capture of animals by hunters they take care of meal preparations. It is also related to the fact that women recorded seeing fewer living pangolins than men and in general, they were less informed about pangolins, just as Nash et al. (2016) described. This suggests that women are less attentive to animal ecology and other supplementary knowledge. It was sometimes even problematic for us to engage women in the questionnaire survey because their demonstrated interest was low or rather their attitude to us was quite aloof which may be connected with the overall shyness of character of the village women. Even though women are not traditionally hunters, they may strongly encourage men in hunting as such type of behaviour was monitored by Lowassa et al. (2012).
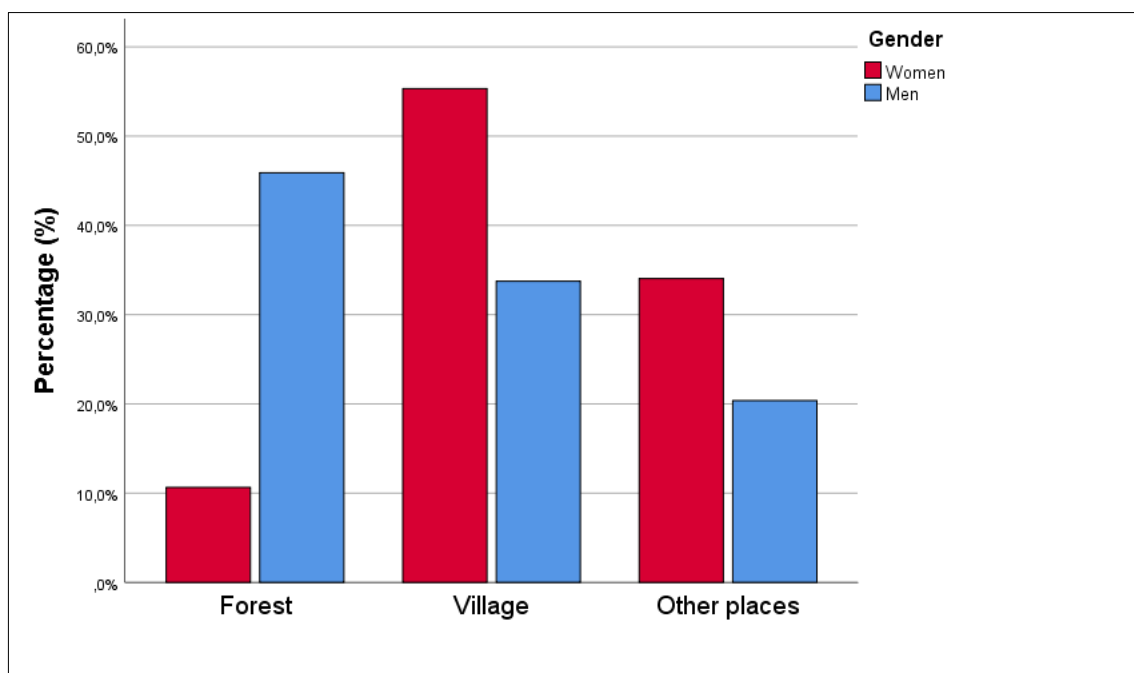
Figure 15. The place of the most recently seen pangolin reported by the interviewed respondents with regards to their gender

AGE

The age of the respondents also significantly influenced some of the following results. Older people, meaning the group aged 61+, observed pangolins a significantly longer time ago than other age categories (χ^2=16.653, df=8, p=0.034). Overall, 4.5% of

the oldest respondents detected pangolins for the last time one week ago and less which was significantly lower than expected (28.2%). On the other hand, the majority of the old men (72.7%) reported seeing the last pangolin more than the year ago which was significantly greater than expected (38.7%). This may be related to the fact that older people more likely remain in their houses, not exploring neighbourhoods, due to their current health state. Thus, they do not have the opportunities to encounter pangolins as the younger people have.

However, the older respondents seemed to have a better overview of traditional ecological knowledge of pangolins than younger respondents (χ^2=20.535, df=4, p<0.001). In accordance with the results, 86.4% of the respondents identified more details about pangolins. Nevertheless, this percentage was significantly lower than expected in the youngest respondents (75%), meaning the age group 18-30, which was significantly different from the other age categories, and the trend of higher knowledge increased with aging (Figure 16).
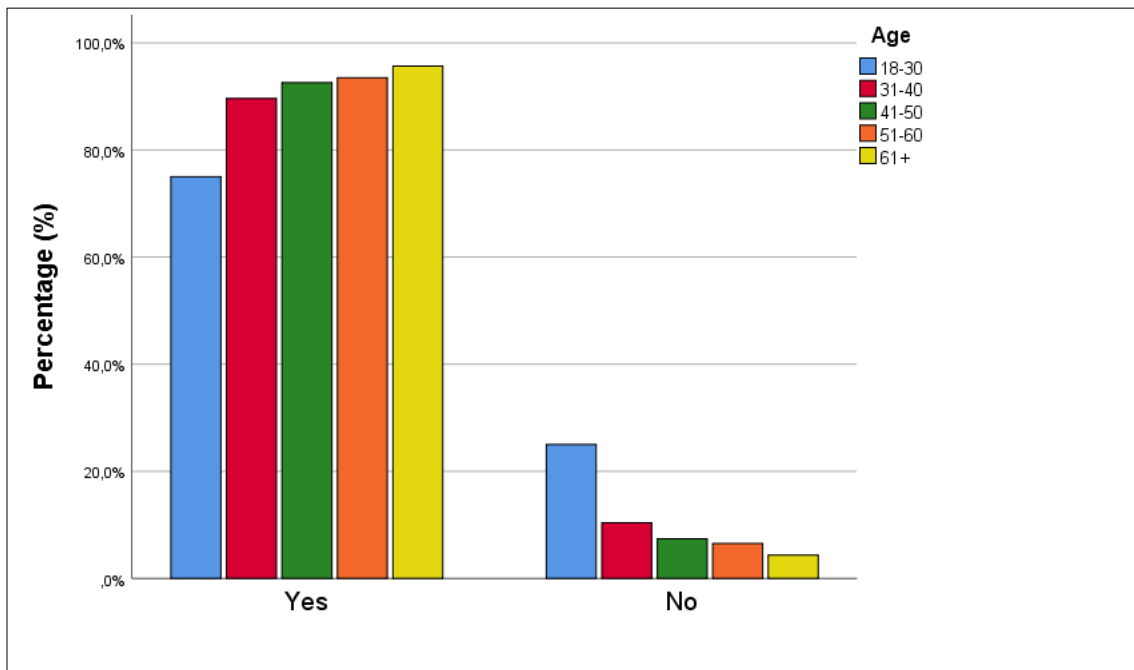
Figure 16. Respondent´s ability to provide additional information about pangolins with regards to the different age categories

Besides, the youngest respondents (85.8%) were also significantly less familiar with different species of pangolins (χ^2=15.550, df=4, p=0.004) which was lower than expected (93.1%). It is apparent from our study that the older the people are, the higher

the ecological knowledge they have based on their experiences they have gained throughout the years. In total, 58.5% of the respondents were aware of the market prices of pangolins (χ^2=17.564, df=4, p=0.002), which was significantly lower than expected of the youngest (47.5%) and of the oldest respondents (34.8%). Seemingly, these two groups were distinguished from other age categories again, suggesting they may be the least involved in pangolin trade. Furthermore, even though there was not find a significant difference (χ^2=8.609, df=4, p=0.072) in the knowledge of the price for pangolin scales among age groups, none of the oldest respondents were aware of it. It may imply that older people appear to participate less likely in illegal traffic activities with pangolin scales in comparison to younger respondents. Regarding the medicinal value of pangolins (χ^2=10.479, df=4, p=0.033), overall, 19.3% of the respondents believed in it, but this percentage was only significantly greater than expected in the middle-aged people (41-50) where 28.4% of the respondents agreed on it.

ETHNICITY

Based on the wide spectrum of ethnic groups that participated in the study, they were categorized into five prominent groups: Kwele, Mboko, Kota, Indigenous people and the remaining groups were determined as "others" (Figure 17). Regarding the result of the most recent observation of pangolins by respondents, there were more likely many differences among the groups (χ^2=69.368, df=8, p<0.001). To summarize, 44.8% of the Kwele and 40.5% of the Indigenous people reported sighting pangolins for the last time in the past week and less, which was significantly greater than expected, while this percentage was significantly lower than expected with the Mboko people (4.7%). Simultaneously, 65.6% of the Mboko group declared to have seen pangolins more than a year ago. Our findings are interconnected with the locations of the survey; the Kwele ethnicity together with the Indigenous people were the dominant ethnic groups in the north, while the Mboko ethnicity was based in the west. This may reflect the fact that there are more pangolins surviving in the north, while in the west the overall population decline may be substantial, or pangolins are concentrated deeper in the forest which will be more elaborate in the following chapters.

Furthermore, a significantly lower percentage of the Kwele (32.4%) and the Indigenous people (25.6%) observed pangolins most recently in the village (χ^2=28.004,

df=8, p= p<0.001), but more in the forest and other places, and additionally, the Kwele (14%) was the major ethnic group detecting the black-bellied pangolin (χ^2=16.844, df=8, p=0.032) which was significantly higher than expected (8.6%). The head office of the OKNP is based in Mbomo, which is situated in the west, where local villagers are frequently in touch with employees of the park. Therefore, referring also to our experience, the respondents could have not been willing to reveal the truth due to their fear to admit the illegality. Nevertheless, 39% of the Kwele reported seeing most recently a living pangolin (χ^2=34.951, df=4, p<0.001) which was significantly lower than expected, on the contrary, a greater percentage of the Mboko (76.9%) did the same. It may reveal the fact that the interviewed Kwele ethnicity only observed a pangolin for the last time while the Mboko were hunting pangolins themselves.
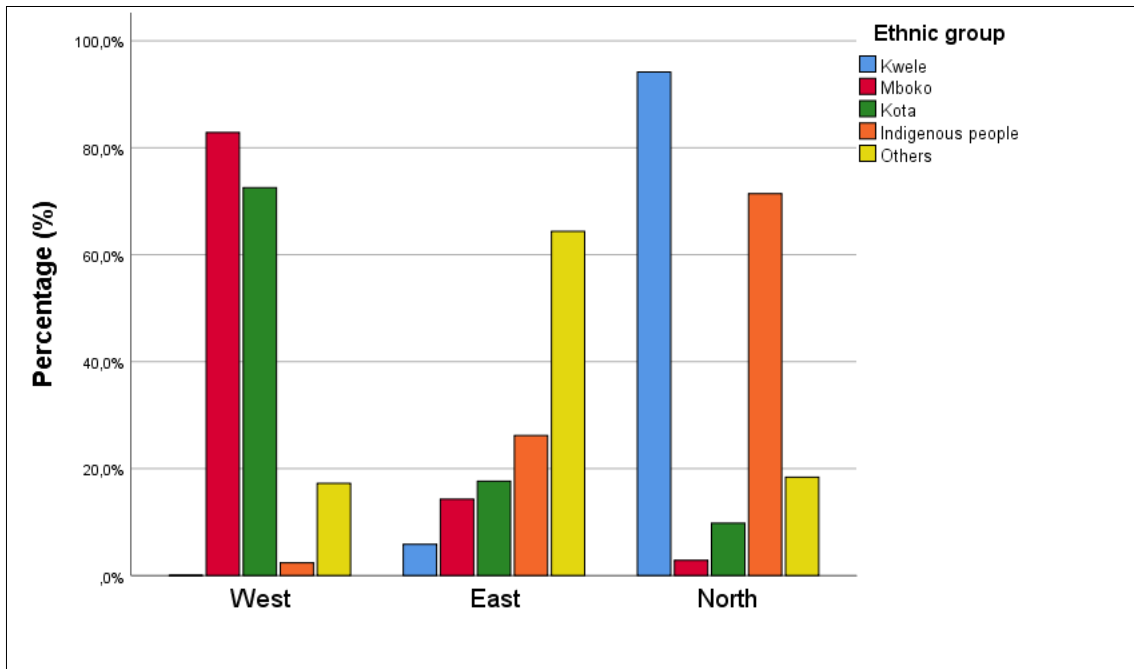
Figure 17. Distribution of the interviewed respondents among locations of the Odzala-Kokoua National Park with regards to their ethnic group

Furthermore, 74.5% of the Kwele, the dominant ethnicity of the north, were aware of the price for pangolins, which was significantly greater than expected (χ^2=32.303, df=4, p<0.001), while this percentage was significantly lower than expected for the Mboko ethnic group (33.3%). The perception of the price for the smaller pangolins (χ^2=22.115, df=8, p=0.005) was lower than expected in the Indigenous people (up to 2,000 XAF) and significantly greater than expected in the Mboko ethnicity where

20% of the respondents estimated a price higher than 5,000 XAF. Indigenous people are a well-experienced predominantly forest-dwelling ethnic group inhabiting remote areas (Pyhala et al. 2016). This may affect sale prices for animals regarding to Fa et al. (2016) who described that the "Pygmy" settlements did commercialize less hunted prey contrary to the "non-pygmy" settlements. Moreover, Indigenous people are more likely to be living on the edge of the local society and thus, they must be modest in terms of asking for higher prices (Pyhala et al. 2016). On the other hand, if the Mboko ethnicity is less informed about the prices, it may identify their lower engagement to the traffic with pangolins. All these findings are also related to the fact that 33.6% of the Kwele reported their knowledge of the price for pangolin scales (χ^2=36.390, df=4, p<0.001), which was greater than expected, while this percentage was significantly lower than expected for the Kota ethnic group (2%). On the grounds of it, this may indicate that people in the north, the Kwele ethnicity, are involved in the illegal pangolin trade more than in other parts referring pangolin carcasses as well as their scales

In total, 93.7% of the people had eaten pangolins at least once in their life (χ^2=12.092, df=4, p=0.017), but this percentage was significantly greater than expected in the Kwele ethnicity (97.8%) and Indigenous people (97.4%). Additionally, 93.6% of the Kota preferred eating pangolins than other animals (χ^2=19.233, df=4, p=0.001), which was significantly greater than expected in comparison to the other ethnic groups, and this percentage was significantly lower than expected with the Mboko group (57.9%). Even though there were no significant differences (χ^2=9.679, df=8 p=0.288) among ethnicities, 85.1% of the Kota people certainly considered pangolin meat a delicacy which was greater than expected (75.7%). The belief in the medicinal value of pangolins was also higher for the Kota (28%) than expected despite the fact that the differences among ethnic groups were not significant (χ^2=8.291, df=4, p=0.081). Contrarily, only 10.3% of the Indigenous people considered that pangolin scales may be used for traditional medicine. This may imply that the Kota, the dominant ethnicity occupying the west, prefers to keep pangolins for meat or traditional medicine than to sell them; which may also be a crucial sign of illegal traffic activities of other ethnicities in the eastern and northern periphery of the park.

EDUCATION

In total, 33.1% of the people reported seeing pangolins for the last time within the past year or less, but a significantly lower percentage of the people with no education (14.5%) noted the same (χ^2=19.784, df=8, p=0.011). On the contrary, 50% of the people with no education reported observing pangolins more than a year ago which was significantly greater than expected. Furthermore, non-educated people (41.3%) together with people who had obtained primary education (52.5%) observed a pangolin most recently in the forest (χ^2=26.781, df=8, p=0.001) which was significantly greater than other age categories. Oppositely, people with higher education levels, lycée (36.6%) and university (70%), reported to have most recently seen a pangolin in other places like markets or different villages which was greater than expected (22.1%). This may indicate that less educated people spend more time in the forest, for hunt or doing other activities, while well-educated people are occupied by different jobs, and therefore having a chance to see pangolins is more like for them in the markets or other towns. Just as the fact that even though 86.4% of the people provided us with additional information about pangolins (χ^2=12.144, df=4, p=0.016), this percentage was significantly lower for the people with no formal education (77.5%) and with university level (70%); and significantly greater for the respondents with primary education (92.1%). Similarly, regarding the ability to recognize the different species of pangolin based on their education level (χ^2=18.190, df=4, p=0.001), a normal Gaussian distribution was reflected. People with no education (83.8%) or university education (80%) identified the species significantly lower than expected, an average result was seen the people with primary (95%) and lycée (95.1%) and higher than expected for the people with college level education (97.2%).

The higher the education level, the more people believed in the uses of pangolin scales for traditional medicine (Figure 18). In total, 19.3% of the people suggested the healing properties of pangolin scales (χ^2=13.686, df=4, p=0.008), this percentage was significantly lower for the people with no education (8.8%), average for people with college level education (21.4%) and greater than expected for the people with university level (50%) or lycée level education (26.8%). This is apparently an essential finding as education and conservation programmes may not be so successful if traditional

perception of animals plays a strong role in the community. Therefore, behaviour change programmes are necessary to apply for. Finally, the results were not significantly different (χ^2=8.502, df=4, p=0.075), but generally, it seems that people with a higher education level were aware of the prices for scales more than people with a lower education level, meaning they may be more likely involved in the traffic of pangolin scales.
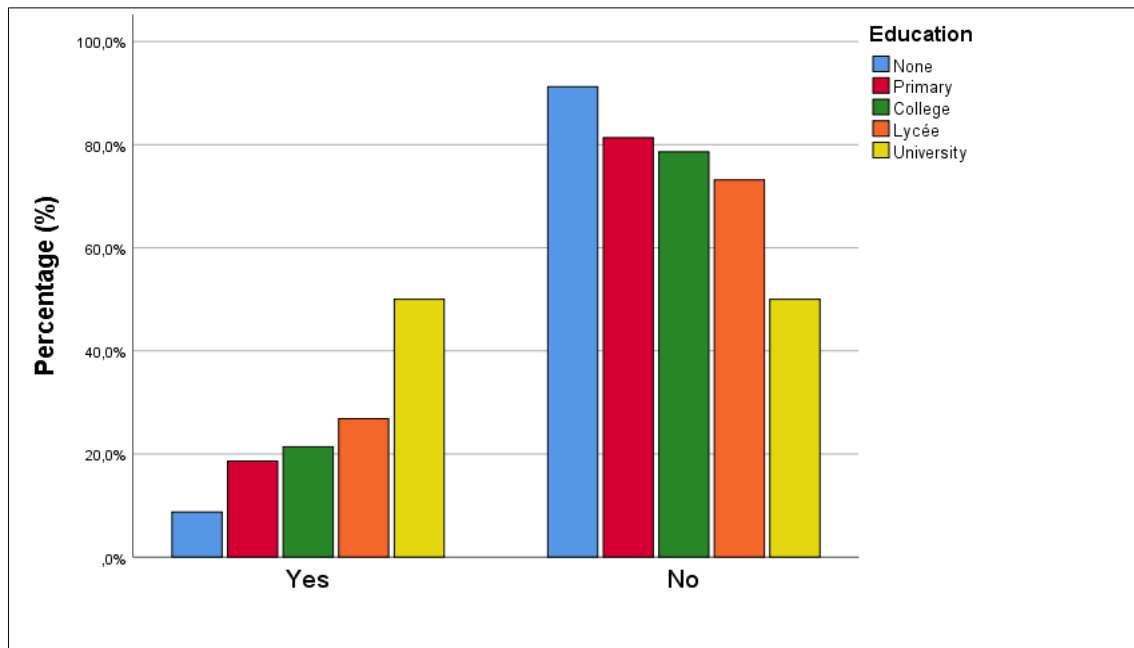
Figure 18. Respondent´s belief in the medical value of pangolin scales with regards to their education level

HUNTING

In terms of awareness about pangolins, there was a significant difference between hunters and non-hunters, as some of the other interviewed respondents had never had any hunting experience (χ^2=12.300, df=1, p<0.001). As such, all interviewed hunters (100%) were aware of pangolins, while this percentage was significantly lower for the non-hunters (95.1%). Further, 97.1% of the hunters characterized pangolins in detail (χ^2=68.757, df=1, p<0.001), including information on the pangolin diet and ecology, while this percentage was significantly lower than expected for the non-hunters (66.4%). Other analysis showed that 98.4% of the hunters significantly recognized different pangolin species (χ^2=30.483, df=1, p<0.001) which was greater than the non-hunters (83.2%). With regards to the fact that 11.6% of the hunters were able to identify the black-bellied pangolin, which was significantly higher than expected (χ^2=11.815,

df=2, p=0.003), while only 1.8% of the non-hunters did as well. Moreover, 35.1% of the hunters reported seeing a pangolin for the last time within the past week and less (χ^2=35.578, df=2, p<0.001) which was significantly greater than expected. Similarly, only 28% of the hunters admitted to seeing pangolins more than a year ago which was actually significantly lower than in the case of the non-hunters (59.3%). Further, in a total of 41.5% of the respondents observed pangolins in the forest for the last time (χ^2=58.472, df=2, p<0.001) which was significantly higher than expected for the hunters (55.1%) and lower than expected for the non-hunters (16%). The non-hunters more likely detected pangolins in the villages or other spots, particularly seeing dead pangolins (54.2%) which was significantly higher (χ^2=9.633, df=1, p=0.002) compared to the hunters (37.6%).

At the same time, a significantly greater percentage of the hunters (66.1%) knew about the prices for pangolins (χ^2=16.811, df=1, p=0.009) in comparison to 44.4% of the non-hunters. By all means, there were also differences in awareness of the scale prices (χ^2=8.033, df=1, p=0.005), meaning that 23.3% of the hunters were familiar with prices for scales, which was significantly greater than 11.3% of the non-hunters who knew the same.

Overall, 93.7% of the people had eaten a pangolin at least once in their life (χ^2=35.849, df=1, p<0.001), but this percentage was significantly lower than expected for the non-hunters (83.5%) and greater than expected for the hunters (99.2%) where only two hunters denied having eaten one. Similarly, for a significantly higher percentage of the hunters (79.4%), the pangolin meat was delicious (χ^2=6.378, df=2, p=0.041) on the contrary to the non-hunters (67.6%). To conclude, 78.6% of the hunters preferred eating pangolins than other animals (χ^2=11.668, df=1, p=0.001) which was significantly greater than expected (Figure 19), while this percentage was significantly lower than expected for the non-hunters (61.3%).

In accordance with the results, hunters are obviously well-experienced, informed about pangolins and they are attentive to different species. With regards to their knowledge, hunters are used to having a huge source of traditional knowledge that may be useful for methodological support of the field pangolin studies (Newton et al. 2008; Trageser et al. 2017), but as well as that, hunters are also a driving force responsible for

the exploitation of pangolins. Apart from their trading activities, they also referred to their higher preferences for pangolin meat in comparison to other respondents. Indeed, some of the hunters considered the meat to be so special that after the successful capture of a pangolin, they prefer to eat a pangolin silently with just their family and not give a sign to anybody from the village. In light of the fact that all hunters were well-informed that pangolins are a protected species and it is illegal to kill them, they may be even a greater threat for the population of pangolins.
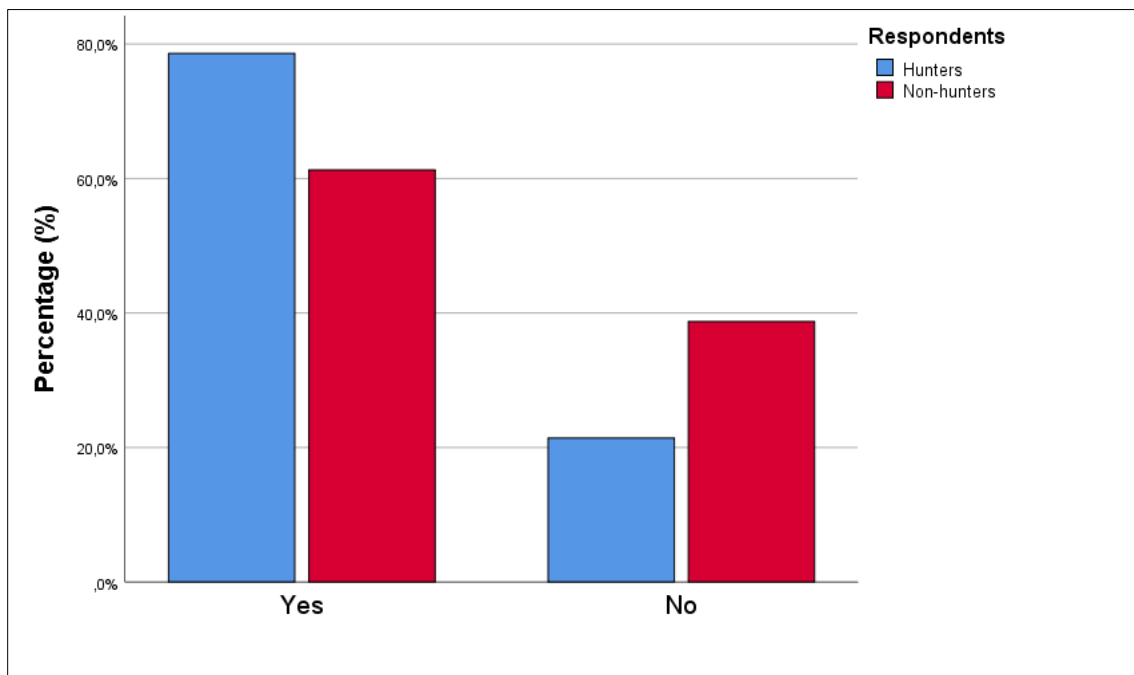
Figure 19. Demonstrated preference by the respondents to eat pangolins than other animals with regards to their hunting status

DO YOU LIVE IN THIS VILLAGE?

In fact, 25.8% of the people, that were living in the village where the questionnaire was carried out, reported observing a pangolin for the last time within the past week and less which was significantly lower than expected (χ^2=11.353, df=2, p=0.003). On the other hand, this percentage was significantly higher for the people who were not living in the village (55.2%). It may be explained by the fact that non-villagers travel through different places, and thanks to this, they may have more opportunities to detect pangolins. Moreover, village dwellers (43.6%) reported seeing pangolins in the forest for the last time (χ^2=32.399, df=2, p<0.001) which was higher than expected, while this percentage was significantly lower for the non-villagers (16.7%). Non-villagers

(63.3%) sighted more pangolins in the other places that support the previous statement about higher possibilities of encountering them. Moreover, a significantly higher percentage of the village dwellers (58.7%) observed a living pangolin for the last time (χ^2=7.217, df=1, p=0.007) contrary to the non-villagers (33.3%).

Nevertheless, in the villages, there was a lower percentage of the people who actually knew the price for pangolins (χ^2=6.841, df=1, p=0.017) than expected (56.5%), while this percentage was significantly greater than expected for the people who were not living in the village (80.6%) as displayed in Figure 20. The same goes for the price of scales, even though there was no significant difference (χ^2=3.822, df=1, p=0.051), 17.9% of the village dwellers were aware of the price for scales, but this percentage was greater for the non-villagers (32.3%). This may show that the non-villagers have the higher chance to encounter different localities, gain more information and thus, they may be potentially involved in the pangolin trade to a larger extent than villagers who are primarily used to being settled in the same place.

A significantly greater percentage of the village dwellers (94.5%) than expected had tried pangolin meat at least once in their life (χ^2=5.432, df=1, p=0.020), while this percentage was lower than expected for the non-villagers (83.9%) who may not have frequent possibilities to eat pangolin meat as the villagers have.
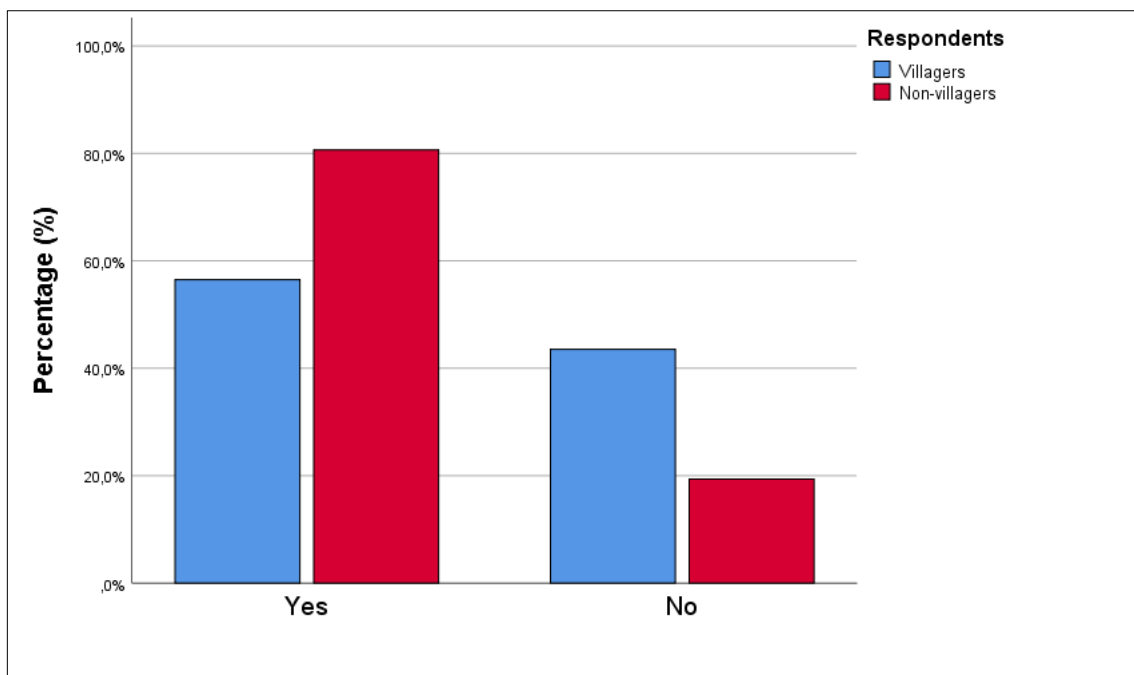
Figure 20. Demonstrated percentage of the people informed about prices of pangolins between the village dwellers and non-villagers

IF YES, HOW LONG?

A significantly lower percentage of the people living in the village for less than two years (10%) observed a pangolin in the forest for the last time (χ^2=51.688, df=4, p<0.001), the percentage was average for the people living in the village for two years or more (35.6%) and higher than expected for the people living in the village for their whole lives (54.1%). Contrarily, 47.5% of the people living in the village for less than two years reported sighting a pangolin for the last time in different places than the forest or village which was significantly greater than expected. This may be related to the persisting opportunities for these people to travel around. However, 72.5% of the people living in the village for a shorter period of time (less than two years) knew significantly less about pangolins (χ^2=7.943, df=2, p=0.019) than expected (86.7%).

5.1.2.2. Village survey – hunters

LOCATION

A total of 245 hunters participated in the questionnaire survey within three study areas of the park; west, east and north; but a significantly higher percentage of the hunters than expected (73.6%) were interviewed in the northern periphery of the OKNP (χ^2=17.034, df=2, p<0.001). Even though the result was not significantly different (χ^2=12.105, df=8, p=0.147) among the locations, hunting frequency of the respondents was different in the east where fewer hunters identified to hunt "weekly" (21.3%) but more "accidentally" (74.5%) than expected.

Overall, 92.2% of the hunters had hunted a pangolin at least once in their life (χ^2=9.624, df=2, p=0.008), but this percentage was significantly lower in the west (87.5%) and in the east (85.1%) and higher than expected in the north where 97% of the hunters reported it. Moreover, in the north, 36.2% of the hunters detected a pangolin for the last time within the past week or less (χ^2=17.816, df=4, p=0.001) which was significantly greater than expected. On the other hand, in the east, 59.5% of the hunters observed a pangolin more than a year ago which was significantly greater than expected (35.4%). Similar results were demonstrated in the previous chapter where all of the 387 respondents were involved. Even though it seems that pangolins are possibly found more extensively in the north, or the local hunters could be reluctant to tell us more

than people in other parts, it is also necessary to take into consideration a higher number of the interviewed hunters in the north (n=134) than in the east (n=47). This could have influenced the results greatly as well. Additionally, in the east, people may tend to do different kind of jobs, for example jobs that are related to this strategically suitable place for doing trade. These results are also related to the following; in the north, 66.7% of the respondents stated to have observing other hunters capturing pangolins like it was an event that happened "often" (χ^2=40.736, df=6, p<0.001) which was significantly greater than expected (Figure 21). Contrarily, in the east, respondents perceived the hunting frequency of pangolins as "rarely" (60.6%) and "sometimes" (33.3%) which was significantly greater than expected than other locations.

In terms of the best presented time for the hunting of pangolins (χ^2=76.527, df=6, p<0.001), the results differed greatly. In the north, 60.8% of the hunters considered "evening" as the proper day period to hunt pangolins which was significantly greater than expected. Contrarily, in the east, 42.5% of the hunters reported the most suitable moment "around midnight" and in the west, 48.2% of the hunters noted "all night". Only 11.9% of the hunters were thinking that pangolins might have been captured in any night period as well as during a day, but this percentage was significantly lower than expected in the north (5.4%).

Concerning the pangolin trade, in total, 45.1% of the people expressed to be hunting also for income rather than just for meat (χ^2=16.494, df=2, p<0.001), but this percentage was significantly different among the locations. For example, in the north and in the east, hunters reported a higher number of such activities, while in the west, only 23.2% of the hunters reported hunting for other reasons (income, medicine) which was significantly lower than expected. To compare different trade strategies, in the north, 95.8% of the hunters were predominantly selling the whole body of pangolins (χ^2=8.090, df=2, p=0.018) which was significantly greater than expected, while in the west, 45.5% of the hunters preferred to sell just parts of the pangolin body (χ^2=13.402, df=2, p=0.001) which was significantly higher than in other locations. With regards to pangolin scales, 31% of the people confessed doing trade with pangolin scales for income (χ^2=11.208, df=2, p=0.004), but this percentage was significantly greater than

expected in the east (58.8%), average in the north (29.2%) and lower in the west where no hunters did it (0%).
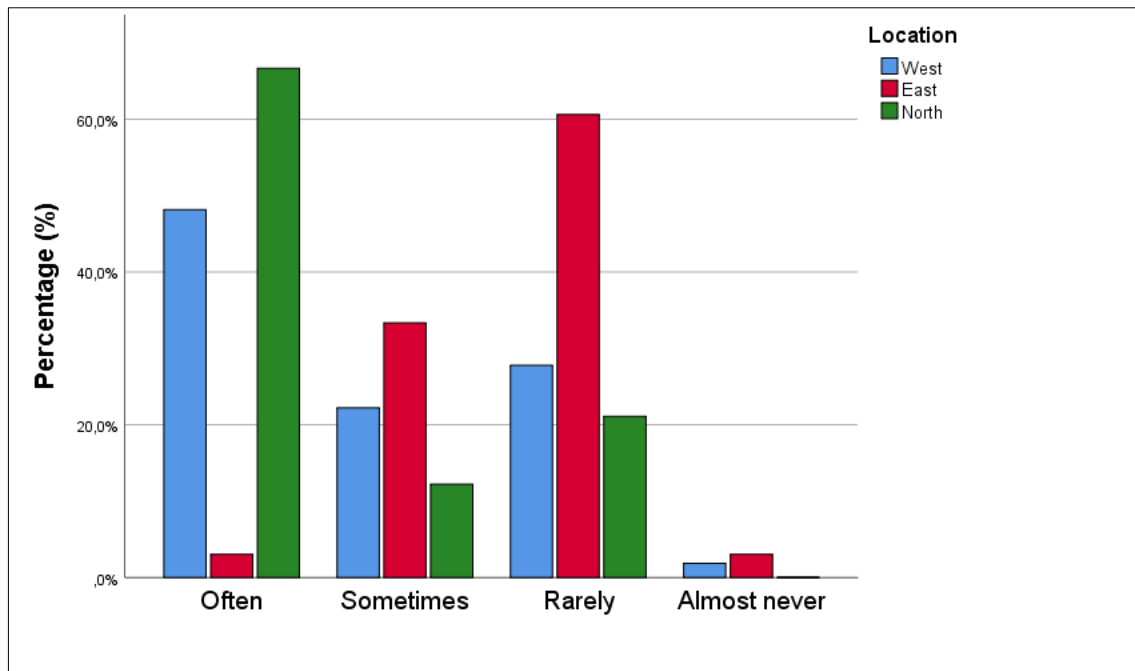
Figure 21. The interviewed hunters reported hunting frequency of pangolins which were captured by the other people with regards to the different study locations

Further, 33% of the hunters mentioned selling pangolins just to people passing the main road (χ^2=9.676, df=2, p=0.008), but this percentage was significantly greater in the north (41.7%), average in the east (17.6%) and lower in the west where no hunters admitted it (0%). In comparison to other parts of the park, the western periphery is quite isolated since the major road crossing the area is not asphalted (Latour & Stiles 2011). In addition, to cross the Likouala river, which is connecting Etoumbi with the rest of the western periphery, the cable ferry is necessary to use. Hence, this may identify the fact that local people do not have the same trade possibilities with pangolins and their derivates as the people in the east and north have (Mavah et al. 2018). In general, due to these lower trade opportunities, people are used to cutting pangolin meat into slices which is economically more acceptable for local communities to buy with regards to its lower price. Contrarily, in the east and north, the village dwellers have the access to the main road and thus, they likely offer proportionally a greater percentage of their prey to the surrounding markets, suggested also by Wilkie et al. (2000).

Even though there was no significant difference (χ^2=4.780, df=2, p=0.092) among locations, in the west, all hunters (100%) reported selling pangolins only to local people. On the contrary, this percentage was lower in the east (70.6%) and in the north (86.1%) where hunters stated doing pangolin trade also with foreigners. Besides, in the north, a significantly higher percentage of the hunters (26.9%) reported using snares for hunting of pangolins (χ^2=10.338, df=2, p=0.006) compared to the other parts.

Overall, 53.1% of the hunters were thinking that the availability of pangolins in the forest during the year was influenced by different seasons (χ^2=12.243, df=2, p=0.002). However, this percentage was significantly greater in the north (63.1%), of which 48.8% of the hunters considered the rainy season to be the most fitting period for hunting pangolins since pangolins search for food after the rain.

AGE

The age of the hunters clearly influenced some of the following results since the highest number of hunters were in the age group of 41-50 years old (75.6%) which was significantly greater than expected (χ^2=11.150, df=4, p=0.025), lower than expected in the age group 18-30 (53.5%) and average in the rest of the age categories. In accordance with the results, 35.5% of the hunters in the age group 18-30 hunted a pangolin for the last time within the past week or less (χ^2=20.790, df=8, p=0.008) which was significantly greater than expected. Contrarily, the oldest group of the respondents captured a pangolin for the last time a significantly longer time ago which is displayed in Figure 22. Clearly, it implies the general insight to the age differences, meaning that older hunters do not hunt as often as the younger hunters do (Mavah et al. 2018) and thus, they may have less opportunity to observe pangolins; on the contrary to the research conducted by Nash et al. (2016) in China who reported the younger people less likely realized hunting of pangolins in that study area.

Although no significantly obvious result was found in this question (χ^2=9.304, df=4, p=0.054), overall, 45.1% of the respondents hunted pangolins for income, but this percentage was lower than expected for the oldest hunters (8.3%). In fact, predominantly younger hunters were significantly more likely to be selling pangolin scales than elders (χ^2=11.598, df=3, p=0.009), including the group 31-40 (50%) and the group 18-30 (32%). None of the oldest hunters (61+) were aware of the scale prices.

Apparently, this may be also related to the fact that the younger hunters were selling pangolins to foreigners the most (χ^2=9.229, df=3, p=0.026). A total of 21% of the hunters admitted to trading with foreigners, but this percentage was significantly greater than expected for the group 31-40 (37.5%). Younger respondents obviously look for other income opportunities while the elders prefer to settle in one place (Mavah et al. 2018). Thus, traffickers may target predominantly the younger hunters who seem to be more reluctant to cooperate and able to provide the essential information as well as the pangolins themselves (Katuwal et al. 2013; Baiyewu et al. 2018).
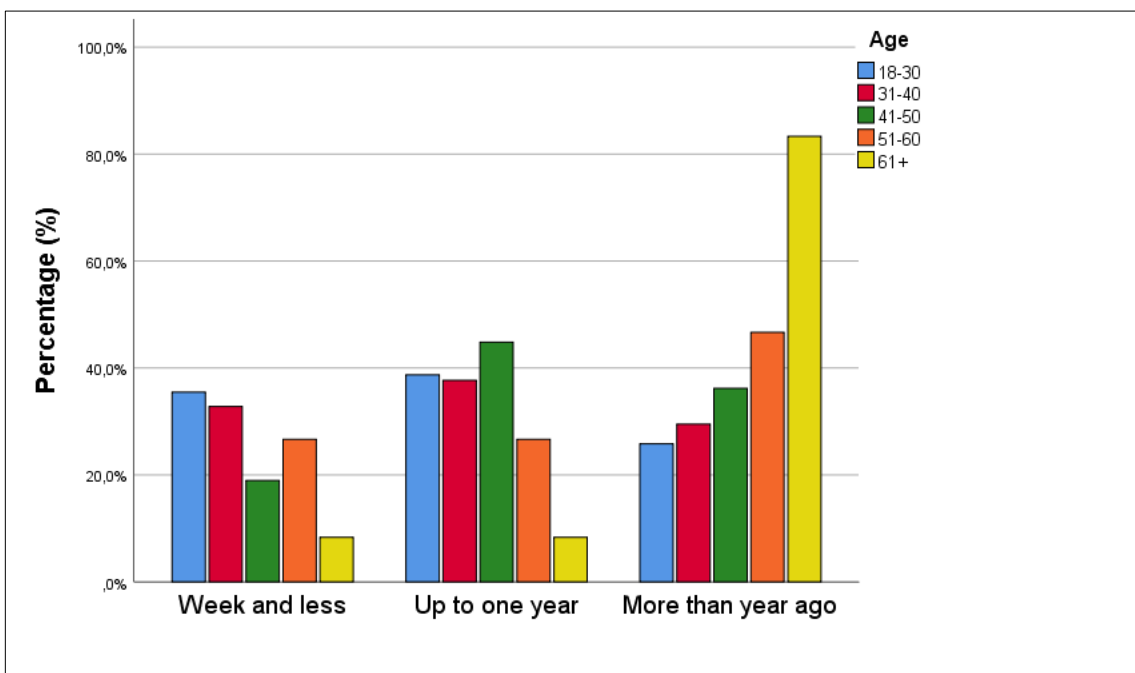
Figure 22. Time of the last captured pangolin by the interviewed hunters with regards to their age

ETHNICITY

Regarding the different ethnic groups, a significantly higher percentage of the Kwele (76.6%), Indigenous people (73.8%) and Kota (72.5%) were hunters than expected (χ^2=35.021, df=4, p<0.001). At the same time, 50% of the Mboko people, prevalently inhabiting the western periphery of the park, mentioned that they had hunted no more than 10 pangolins in their life (χ^2=10.913, df=4, p=0.028) which was significantly greater than expected while all other groups reported to have captured more than 10 pangolins (Figure 23). Significantly, 57.1% of the Mboko ethnic group also sighted a pangolin for the last time more than a year ago (χ^2=21.759, df=8, p=0.005) and contrarily, 3.6% of

them within the last week which was different from all other parts. A significantly greater percentage than expected of the Kwele (80.4%) and Indigenous people (81.5%) hunted pangolins for the last time in the forest (χ^2=18.028, df=8, p=0.021), but this percentage was lower than expected for the Mboko group (60.7%). On the other hand, 26.5% of the Kota hunted pangolins in the village which was significantly greater than expected. The Kwele (52.9%) and Indigenous people (70.4%) indicated "evening" as the best time for hunting pangolins (χ^2=51.131, df=12, p<0.001) which was significantly greater than expected. According to other ethnic groups (31.4%), times "around midnight" were stated, and 47.1% of the Kota pointed out "all night" as being sufficient. The ethnic groups participated in our study were not distributed equally in each part of the park. That is why our findings are highly influenced by the area of the questionnaire and prevalently related to the results of the previous independent factor "location". Hence, it looks like that the western ethnic groups namely Mboko and Kota have the least experiences with pangolins, which may be influenced by decreased presence of pangolins, respondent´s dishonesty or their fewer hunting experiences.

Further, a significantly lower percentage of the Mboko (14.3%) hunted pangolins for income (χ^2=14.721, df=4, p=0.005) compared to the overall expectations (45.1%). Additionally, only 50% of the Mboko reported selling the whole body which was significantly lower than expected (χ^2=11.563, df=4, p=0.021). Contrarily, all Indigenous people (100%) were selling the whole body of pangolins. Further, there was no significant difference (χ^2=7.823, df=4, p=0.098) in selling pangolin scales among different ethnic groups. Nevertheless, in total, 31% of the people were focusing on the pangolin trade as well, but this percentage was lower than expected in the Kota (7%) and Mboko (0%). Oppositely, a significantly greater percentage of the other ethnic groups (50%) frequently reported the same. None of the Indigenous people specifically mentioned that foreigners attended to buy pangolins from them, likely resulting in different hunting impact between the Indigenous people and the other ethnic groups which was also suggested by Fa et al. (2016). However, simultaneously, they reported doing pangolin trade generally with people passing the main road (χ^2=11.024, df=4, p=0.026) which was significantly higher than expected. Again, all findings strongly reflect the location of the conducted questionnaire.

The majority of the Indigenous people (74.1%) also predominantly believed in the various presence rates of pangolins in the forest over a year (χ^2=16.941, df=4, p=0.002) which was significantly greater than expected as well. According to them, most pangolins were possible to detect during the rainy season (100%) than in the dry one (0%). Contrarily, only 26.5% of the interviewed Kota perceived the differing numbers of pangolins in the forest during the year which was significantly lower than expected. Indigenous people have some of the best expertise in forestry worldwide, combined with priceless hunting skills (Mockrin et al. 2011; Fa et al. 2016; Pyhala et al. 2016). Concerning especially the village life, men are predominantly well-experienced hunters, depending on such activity from the point of view of meat as well as income. Hence, their traditional knowledge of the forest is more likely significant and the fact that they highlighted the rainy season as the best period for the occurrence of pangolins needs to be taken into consideration.

Most hunters of the Kwele (67.1%) reported frequently observing other people hunting pangolins (χ^2=35.443, df=12, p= p<0.001) which was significantly greater than expected. On the other hand, the Kota and Mboko ethnicities perceived the frequency rather as "rarely" or "sometimes", which is again strongly linked with the area where the survey was carried out.
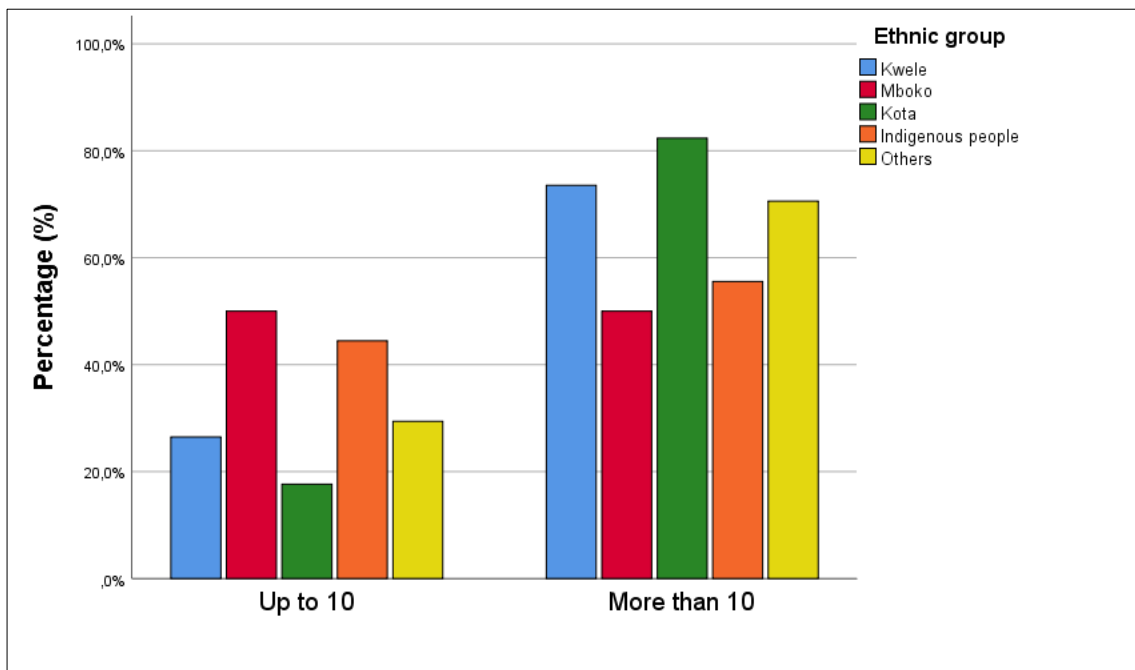
Figure 23. Reported number of captured pangolins by the respondents in context of their ethnicity

EDUCATION

The demonstrated level of literacy was different for the interviewed hunters (χ^2=22.231, df=4, p<0.001); a significantly higher percentage of the hunters than expected was in the group with a primary education (69.5%) and college (69.6%), average in the group with no education (59%) and lycée (46.3%) and lower than expected in group of the people with university level (10%). In other aspects, education level did not influence the results of the survey significantly.

DO YOU LIVE IN THIS VILLAGE?

People living in the village during the time of the survey hunted pangolins a long time ago (χ^2=15.290, df=2, p<0.001). Overall, 27.8% of the people killed a pangolin for the last time within the past week or less, but this percentage was significantly greater in the non-villagers (68.8%) and lower than expected for the village dwellers (24.6%). Contrarily, 6.3% of the non-villagers hunted a pangolin for the last time within the past year or less which was significantly lower compared to the village dwellers (39.1%). Moreover, 37.5% of the non-villagers hunted a pangolin for the last time in different places than forest or village (χ^2=8.268, df=2, p=0.016) which was significantly greater in comparison to the village dwellers (11.9%).

Even though there was no significant difference (χ^2=2.788, df=1, p=0.095) in this question between the villagers and non-villagers, while overall, 31% of the people admitted to selling pangolin scales, this percentage was greater for the non-villagers (55.6%) in comparison to the village dwellers (28.6%). Similarly, there was no significant difference (χ^2=3.277, df=1, p=0.070), but more non-villagers (44.4%) were trading pangolins to foreigners than village dwellers (18.7%). On the grounds of our findings, in total, 29.6% of the people were using shotguns for hunting pangolins (χ^2=8.911, df=1, p=0.003), but this percentage was significantly higher for the non-villagers (62.5%). Further, 87.5% of the non-villagers claimed seeing other hunters capturing pangolins as an event that occurred "often" (χ^2=10.392, df=3, p=0.016) which was significantly greater than expected. Indeed, this may imply that hunters who were not living in the surveyed village at the time of the questionnaire have thanks to their travel activities more opportunities to hunt or sell pangolins, and therefore they are a potentially dangerous group of the people in terms of illegal traffic activities. Based on Latour &

Stiles (2011), there are considered to exist two groups of hunters in the given area: "commercial" ones, hunting for cash, and "subsistence" ones, hunting wildlife particularly for consumption which may be related to our findings as well. In Nepal, Katuwal et al. (2015) even found that poachers of pangolins originated from different places usually attend the villages in the survey location to look for the unemployed youth to export pangolins across the borders.

IF YES, HOW LONG?

The results showed that the longer people lived in the village, the more ended up becoming hunters (Figure 24). As a matter of the fact, overall, 64.5% of the respondents were hunters (χ^2=30.460, df=2, p<0.001), but this percentage was significantly lower for the people living in the village for less than two years (29.3%), average for the people living in the village more than two years (60.2%) and greater than expected for the people living in the village for their whole life (73.5%).
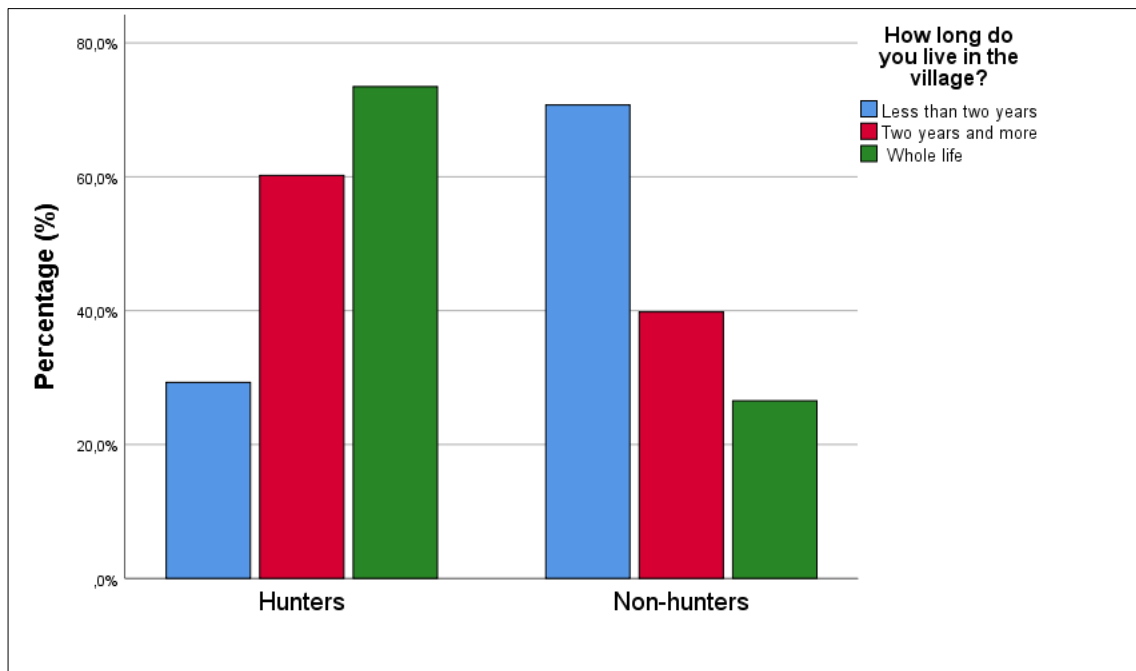
Figure 24. Spent time in the village which was reported by the respondents with regards to their hunting status

Additionally, a total of 77.1% of the people hunted a pangolin most recently in the forest (χ^2=14.881, df=4, p=0.005), but this percentage was significantly lower than expected for the people living in the village for less than two years (40%). On the other hand, a significantly greater percentage of the people living in the village for less than

two years hunted a pangolin in other places (40%) in comparison to the rest of the categories. Obviously, hunters living in the village for a shorter time do not have such experiences from the forest around the village and they more likely hunt pangolins during different occasions.

5.1.2.3. Market survey - sellers

LOCATION

Locations of the visited markets were grouped in four categories to get more accurate statistical results: Brazzaville, south (Etoumbi, Makoua), Ouesso and north (Sembé, Souanké). In Ouesso, the main regional trade centre in the north of the Congo, there was a greater percentage of the sellers (100%) actually selling pangolins than expected (χ^2=9.912, df=3, p=0.019), while this percentage was significantly lower than expected in the north (60%). Similar results were obtained in the south and Brazzaville. Additionally, even though there was no significant difference in frequency of selling pangolins among locations (χ^2=11.644, df=6, p=0.070), in the north, a higher percentage of the people (33.3%) were selling pangolins "almost never" than expected. Seemingly, in the north, sellers offer fewer pangolins in comparison to other monitored markets, but in the same way, this may indicate that sellers purposely did not share all the information with us. As a matter of fact, the forest situated around the Sembé and Souanké markets is one of the most abundant in the country (Latour & Stiles 2011). Besides, Hennessey & Rogers (2008) explains how the population of Ouesso depends on external sources of meat. Based on our experiences, indeed, the local markets were supplying pangolins, alongside other bushmeat, substantially coming from this area. Then, as restrictions and protected status of pangolins are not respected in the study area and the pangolin trade continues, it is rather unexpected that some of the local bushmeat sellers would not have a chance to sell pangolins, including the fact that people in the north of the Congo consume bushmeat in large quantities (Hennessey & Rogers 2008). Additionally, local forest eco-guards, who are supposed to control illicit activities in the markets, were sometimes observed taking bribes and ignoring the law, which only facilitates the selling of pangolins. In fact, some of the interviewed sellers

mentioned to us that the eco-guards only control the giant pangolin trade, but the smaller pangolin species can be freely offered in the markets.

The perception of the price of the small pangolin was lower (χ^2=31.117, df=6, p<0.001) than expected in the local markets (north and south, especially in the south), average in the regional market Ouesso (2,000-5,000 XAF) and higher in Brazzaville where all the sellers estimated the price to be greater than 5,000 XAF. No sellers suggested the price to be greater than 5,000 XAF in north or south (Figure 25). Clearly, markets placed in larger towns retain more customers and the quantity of pangolins supplied is probably less than the quantity demanded (Brazzaville, Ouesso), thus, their prices are higher on the contrary to the local markets like in Sembé or Souanké (Mavah et al. 2018). According to our experiences, firstly, bushmeat is purchased from hunters in the villages by middlemen who transport the carcasses afterwards mostly just to the surrounding markets. Nevertheless, some of the middlemen are focused on transporting bushmeat even to distant places, thus pangolins hunted in the forest around Sembé or Souanké may be imported even to Ouesso´s markets, which was indeed confirmed by some of the interviewed sellers (n=8) in Ouesso. Moreover, most of the Brazzaville´s sellers (n=9) stated that pangolins or their scales frequently originated from the north of the Congo, meaning the Sangha region. This may indicate that pangolins are largely also captured in the Odzala-Kokoua National Park (OKNP), the main regional source of animals in the north, and transported hundreds of kilometres to the capital city of the Congo. In general, people selling in the bushmeat markets need to make their profit when they purchase carcasses from middlemen who transport it to the towns, sometimes located apparently very far away (Mavah et al. 2018). Therefore, this may be another explanation of the higher prices for pangolins in Ouesso or Brazzaville which corresponds with the research of Hennessey & Rogers (2008).

However, the sellers in Brazzaville (75%) and in the south (63.6%) significantly perceived a decrease in the price during the last five years (χ^2=14.616, df=6, p=0.023) while sellers in the north (100%) and Ouesso (46.7%) significantly reported an increase in the price. This may be related to the fact that while overall, 36.4% of the sellers reported an active search by buyers of pangolin products (χ^2= 7.595, df=3, p=0.055), this percentage was greater in Ouesso (50%) and north (66.7%), while this percentage was

lower than expected in Brazzaville (27.3%) and south (9.1%). Moreover, although there was no significant difference (χ^2=4.456, df=3, p=0.216) among locations, overall, 40.5% of the sellers considered pangolins to not be profitable, and this percentage was greater than expected in Brazzaville (66.7%).
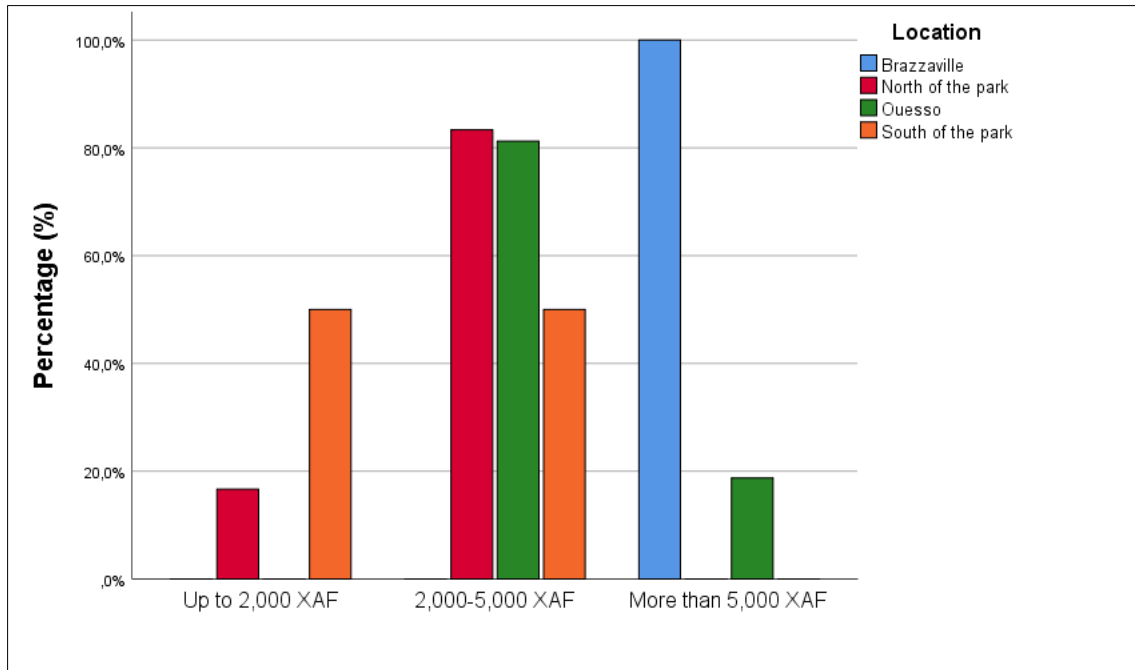
Figure 25. Reported prices for the smaller pangolins (*Phataginus tricuspis, Phataginus tetradactyla*) by the interviewed market sellers with regards to the different locations

Overall, 25% of the sellers were trading scales, but this percentage was only significantly greater than expected in Brazzaville (χ^2=13.788, df=3, p=0.003) where 63.6% of the sellers did it, or in the south (27.3%). On the other hand, no sellers admitted to selling scales in the north (0%) and only 6.3% of them in Ouesso which was significantly lower than expected. Similarly, in total, 27.3% of the sellers reported that they were selling scales or pangolins to foreigners (χ^2=17.799, df=3, p<0.001), but this percentage was significantly increased in Brazzaville (72.7%). On the contrary, this percentage was significantly lower in Ouesso (0%), where no sellers reported selling pangolins to foreigners, and in the north (16.7%). In Brazzaville, the higher percentage of people trading scales, not only carcasses, is evidently due to the interviewed traditional medicine sellers (n=6), who are usually engaged only in business with animal derivates. Nonetheless, this may also show that potential buyers of scales are likely used to attending the markets in the capital city for scales. On the other hand, in the north

and Ouesso, interested buyers may prefer to directly contact the people living in the villages to avoid exposing themselves in the markets. The same goes for selling pangolins to foreigners. From our experience, outsiders, commonly represented by Chinese and Cameroonians in the north of the Congo, often ask for pangolin scales directly from the people in the villages; they even keep their contacts to do regular trade with them. Therefore, it is not usually possible to observe solely scales in the markets, more likely only whole fresh carcasses of pangolins are observed. Regarding the attendance frequency of foreigners in Brazzaville´s markets, as more sellers were offering scales of pangolins, more foreign buyers seem to be attracted by it.

Although there was no significant difference (χ^2=12.250, df=6, p=0.057) among locations, overall, 50% of the sellers considered that the population of pangolins was decreasing, and this percentage was greater (85.7%) in Brazzaville. Contrarily, overall, 37.5% of the sellers claimed that the population of pangolins was increasing, but this percentage was higher in the north (66.7%) and Ouesso (62.5%). This may be related to the fact that all sellers who perceived the pangolin population as decreased in Brazzaville were men, and besides, the supply of markets may be more affected by the shortage of pangolins. It is the opposite of the situation in the north of the Congo, where local markets are placed close to the forest, and the population decline of pangolins may not be as obvious for the people living there.

GENDER

The following differences between genders which influenced the results were found. Firstly, a significantly greater percentage of men (62.5%) reported selling scales (χ^2=7.333, df=1, p=0.007) in comparison to women (16.7%). This may reflect that the traditional medicine sellers who were selling scales in Brazzaville were mostly men (n=4). Women keep the strong traditional role in the bushmeat markets, where they offer a wide range of animal species. Contrarily, men are not commonly observed selling bushmeat in the markets and they are rather used to actively searching for different, often more profitable, income possibilities. Overall, 22.9% of the sellers reported to believe that the price for the small pangolins was as greater than 5,000 XAF, however, this perception was significantly higher than expected for men (75%). Additionally, no men (0%) considered the price to be up to 2,000 XAF. Indeed, women perceived

significantly lower prices for the smaller pangolins (χ^2=7.047, df=2, p=0.029). Further, 75% of the men admitted to selling pangolins or their scales to foreigners (χ^2=11.229, df=1, p=0.001) which was significantly higher in comparison to women (16.7%). It may be related to the fact that most of the interviewed men were based in Brazzaville (n=8) where people perceived higher prices for pangolins than in the local markets located in the north of the Congo.

Nevertheless, all of the men (100%) perceived a significant decrease in the price of pangolins during the last five years (χ^2=8.980, df=2, p=0.011) in comparison to women (37.5%). In fact, 46.9% of the women claimed that the price was increasing which was significantly greater than expected (Figure 26). Additionally, all the interviewed men (100%) suggested that the population of pangolins was decreasing (χ^2=8.000, df=2, p=0.018) which was a significantly greater percentage in comparison to women (33.3%). This finding may reflect the location where the interview was carried out as it has been already discussed in the previous paragraphs. Meanwhile, it has been shown that 18 women were not able to precise the population of pangolins and answered "I do not know", while only two men responded the same. In general, women were more reserved than men in sharing the information with us, only devoted to selling bushmeat and not paying attention to other issues happening around them.
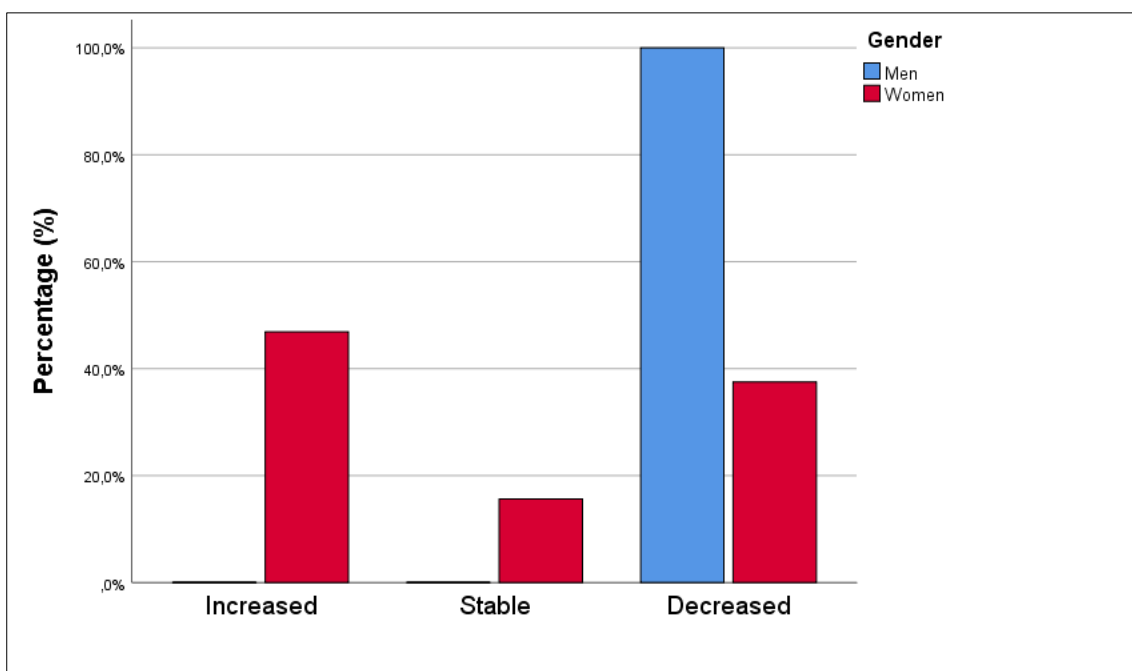
Figure 26. Reported perception of the price of pangolins during the last five years between men and women

AGE

Regarding the various age categories, there were no statistically significant differences among the market sellers which means that the age of the respondents did not have an influence on the results.

ETHNICITY

To acquire reliable results, the ethnic groups needed to be categorized into two groups: the Kwele ethnicity (n=14), and other ethnicities (n=36), as there was a large diversity of the reported ethnic groups. Overall, 88% of the sellers claimed to have traded pangolins (χ^2=5.057, df=1, p=0.025), while this percentage was significantly lower for the Kwele ethnic group (71.4%) than for other ethnicities (94.4%). Actually, the Kwele ethnic group occupies the north of the park where people were sometimes more distant in their responses which was previously described.

Although there was no significant difference (χ^2=5.946, df=2, p=0.051) in that question, 75 % of the Kwele perceived an increase in the price during the last five years, which was a higher percentage compared with other ethnic groups (29%). On the contrary, no Kwele people (0%) reported selling scales (χ^2=4.314, df=1, p=0.038) which was significantly lower than expected (25%). Similarly, 35.3% of the sellers of the other ethnic groups claimed to have traded scales to foreigners (χ^2=4.853, df=1, p=0.028) which was significantly higher than expected in comparison to the Kwele (0%).

Indeed, 40.5% of the sellers preferred to sell other animals than pangolins because it was more profitable for them (χ^2=5.060, df=1, p=0.024), but this percentage was significantly lower than expected for the Kwele (10%). Nine percent of the Kwele, which was significantly higher than expected, suggested selling other species because for them pangolins are a protected group of animals and are difficult to obtain from middlemen. However, it does not reflect our observations of pangolins in Ouesso and Sembé where most of the monitored pangolins were directly encountered. Most of our interviewed sellers belonging to the Kwele were indeed from the Ouesso´s markets. Thus, sellers are greatly aware of the pangolin vulnerability, but they still continue the trade with them.

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EDUCATION

Even though no significant difference (χ^2=8.911, df=8, p=0.350) in this question was found, more educated sellers, meaning with the lycée level (66.7%) or university education (66.7%), claimed to sell the smaller pangolins for a price of higher than 5,000 XAF, which was greater than expected (22.9%). Similar results were received concerning the prices for the giant pangolin. Seemingly, the higher the education level a person has, the higher the asking price of pangolins. It supports another finding that 80% of the sellers with lycée education preferred to sell other animals because of better profit, which was greater than expected (40.5%), indicating a self-oriented attitude to get the highest intake as possible.

On top of that, a significant percentage of the sellers with lycée education (83.3%) reported selling scales (χ^2=14.466, df=4, p=0.006) in comparison to the overall percentage of the sellers (25%). The same percentage of the sellers with lycée education (83.3%) admitted to selling pangolins or their scales to foreigners (χ^2=14.188, df=4, p=0.007) which was significantly more than expected. On the contrary, only 10% of the sellers with primary education reported to be selling scales, and none of them (0%) claimed to sell pangolins or their scales to foreigners (Figure 27). It may be explained by the fact that sellers who conduct the trade of scales were living in larger towns where access to higher education is more available. On the other hand, it may also indicate that the well-educated people are more aware of the pangolin trade value and they actively search to use this opportunity. Further, all six people who denied selling pangolins had obtained secondary education level (college, lycée). This may be related to the fact that these sellers were also well-informed about the current demand for pangolins and they did not want to reveal the truth in front of us.

OCCUPATION

Indeed, 100% of the medicine sellers reported selling pangolin scales (χ^2=20.842, df=1, p<0.001) which was a significantly greater percentage in comparison to the bushmeat sellers (13.2%). This was an obvious result. Moreover, a significantly greater percentage of the medicine sellers (83.3%) had the experience of selling pangolins or their scales to foreigners (χ^2=11.008, df=1, p=0.001), while the percentage of the bushmeat sellers (18.4%) was significantly lower than expected. It may reflect that

foreigners, like Chinese or Cameroonians in our case, search specifically for the pangolin scales, and therefore they target the traditional medicine stalls instead of bushmeat markets.

In addition, overall, 33.3% of the medicine sellers stated that they preferred to sell the derivates from pangolins than from other animals (χ^2=13.270, df=1, p<0.001) which was significantly greater than expected. All bushmeat sellers (100%) preferred to sell other animals due to the pangolin´s protection level and rarity (65.8%) which was significantly decreased (χ^2=6.502, df=1, p=0.011) in the case of the medicine sellers (0%). In addition, all medicine sellers (100%) claimed that the pangolin population was decreasing (χ^2=6.316, df=2, p=0.043), while this percentage was significantly lower than expected of the bushmeat sellers (36.8%). Once more, it may be related to the location where the questionnaire was conducted or the gender of the sellers as it was explained in the previous statements.

The results were not affected by the time length that the people had worked as sellers in the markets, and therefore it was found there was no statistically significant difference among the respondents in all the questions we asked.
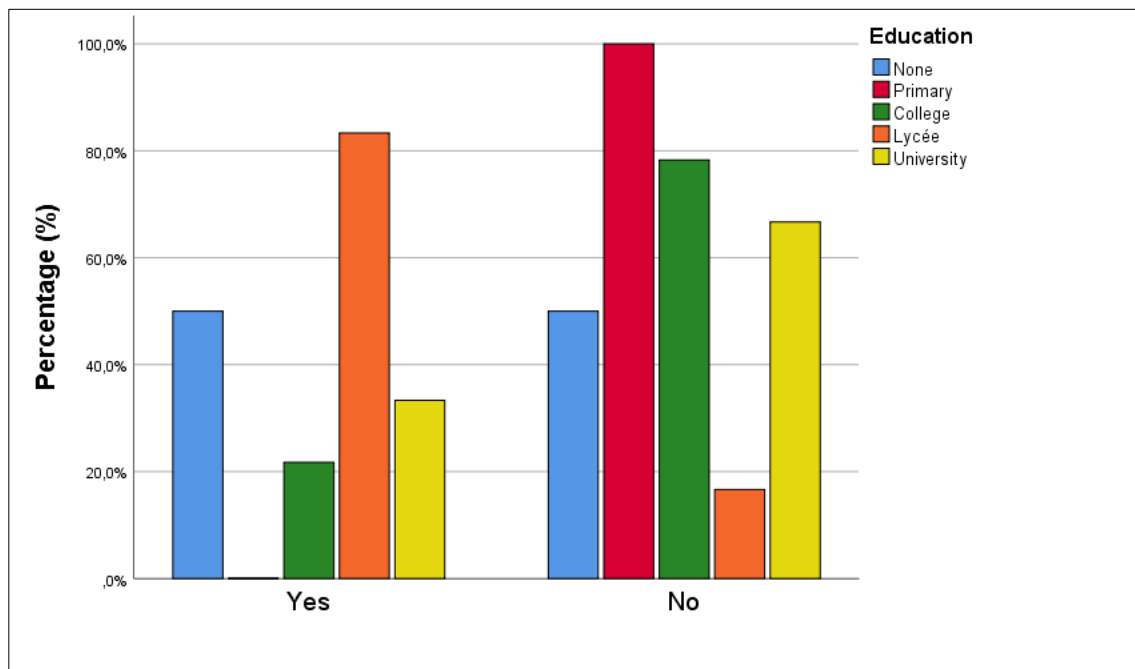
Figure 27. The interviewed market sellers reported the trade with pangolins and their derivates to foreigners regards to their education level

5.2. Population variables

In total, 17 pangolins were recorded during the two research periods, comprising eight pangolins in 2018 and nine pangolins in 2019. Three individuals had to be excluded from the statistics, as it was already explained in the methodology chapter, that means 14 individuals were included in the analysis. Two of the observed pangolins are shown in Figure 28.

All statistical parameters in the context of the gender of the pangolins are summarized in Table 8. Overall, seven males and seven females were sampled, so the sex ratio was determined at 1:1. Then, a two-tailed t-test was applied with the critical value 2.1788. As the results showed (Table 8), all measurements were not statistically different (p≥0.05) between males and females.

Table 8. Summary of the basic statistical parameters of the measured variables together with the results of the t-test

Parameters	Weight	Total length	Body length	Tail length	Head length
Males					
Mean	2293.6	85.7	33.0	46.1	6.5
Std. deviation	289.6	8.5	2.4	7.9	0.7
Minimum	1895.0	71.0	29.0	30.0	5.6
Maximum	2780.0	95.0	35.8	53.0	7.2
N	7	7	7	7	7
Females					
Mean	1994.0	84.9	32.1	46.1	6.6
Std. deviation	231.3	3.8	2.8	2.5	0.8
Minimum	1685.0	80.0	27.0	43.0	5.5
Maximum	2440.0	91.0	35.5	49.0	8.0
N	7	7	7	7	7
Total					
T-test	2.139	0.244	0.651	0.000	-0.140
Significance	0.054	0.811	0.527	1.000	0.891

* Weight is displayed in grams (g)

* Measurements are expressed in centimetres (cm)
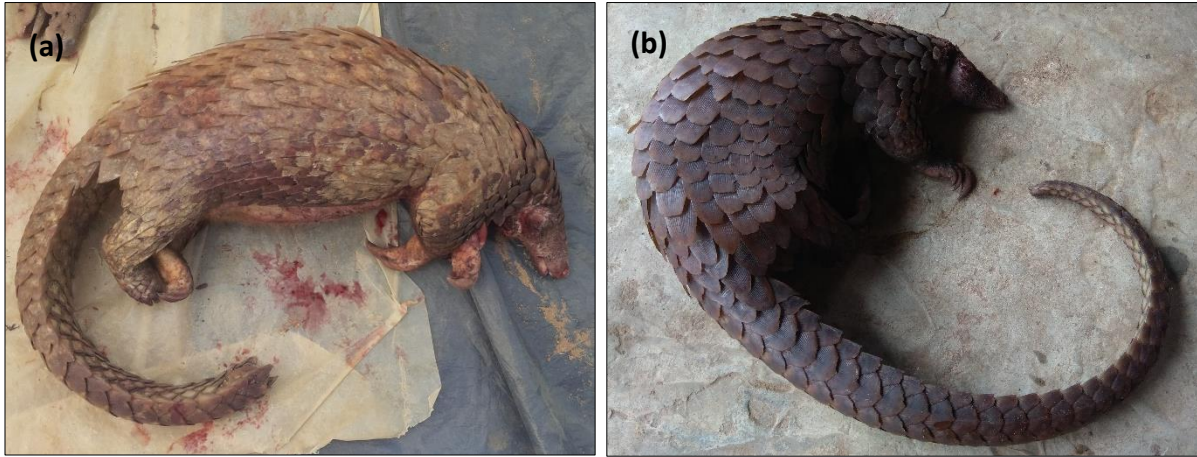
Figure 28. Some of the observed white-bellied pangolins (*Phataginus tricuspis*) during the fieldwork activities; the male was recorded in the Ouesso´s bushmeat market (a) and the female observed in Liouesso (b)

5.3. Genetic samples

In terms of the genetic samples, during the two data collections, we gathered the scales from 91 pangolin individuals of different species, further the tissues were from 16 white-bellied pangolins and two buccal swabs of the white-bellied pangolin were obtained as well (Table 9). On these grounds, it is assumed that the samples originated from 108 different pangolins since one buccal swab and tissue sample were obtained from the same pangolin. Genetic analysis of the given samples will be the aim of another study.

Table 9. Summary of all the samples acquired during the two data collections in the Republic of the Congo

Species	Scales	Tissues	Buccal swabs
First fieldwork			
Phataginus tricuspis	33	7	2
Phataginus tetradactyla	0	0	0
Smutsia gigantea	16	0	0
Total	49	7	2
Second fieldwork			
Phataginus tricuspis	35	9	0
Phataginus tetradactyla	4	0	0
Smutsia gigantea	3	0	0
Total	42	9	0

6. Discussion

This study represents the pilot research activities concentrating on three species of pangolin in the Congo, since up to the present moment, only data from bushmeat evaluation articles are known. The following discussion focuses on the comparison of our obtained results to similar studies that have already been published. Due to the extensive scope of our findings, the discussion is comprised primarily of the aims that were set up at the beginning of the study. For a better understanding of the results, all activities of the research are summarized in Table 10, showing overall insight into our survey of pangolins in the study area.

Table 10. Displayed research activities together with obtained results during the two data collections in the Odzala-Kokoua National Park, Congo

Time period	Activities	Results	Study area
1. Data collection (open hunting season)			
May-June 2018	Village survey	387 questionnaires	65 villages
May-June 2018	Direct observations	Eight pangolins	All parts of the park (west, east, north)
May-June 2018	Genetic sampling	58 samples	All parts of the park (west, east, north)
May-June 2018	Education programme	-	All parts of the park (west, east, north)
2. Data collection (closed hunting season)			
January-March 2019	Market survey	50 questionnaires	Six towns
January-March 2019	Direct observations	Nine pangolins	Two parts of the park (east, north)
January-March 2019	Genetic sampling	51 samples	Two parts of the park (east, north)
January-March 2019	Education programme	-	Two parts of the park (east, north)

6.1. Questionnaires

6.1.1. Survey technique used

Our findings indicate that community-based interviews can be a truly effective way of monitoring pangolin presence, helpful in the identification of hunting and market dynamics (Jones et al. 2008; Newton et al. 2008; Meijaard et al. 2011; Thapa et al. 2014; Katuwal et al. 2015; Turvey et al. 2015; Nash et al. 2016; Ichu et al. 2017; Trageser et al. 2017), and supposed to be the first step to prove the occurrence of pangolins in the study area before using other research techniques (Willcox et al. 2019); as pangolins are a group of animals which are challenging to monitor in the wild. However, with regards to the sensibility of the topic and sympatric species distribution, usage of combined

methods needs to be taken into account which is also suggested by Willcox et al. (2019). Besides the questionnaire survey, direct observations and collecting of pangolin samples supported the statements in our research. Further, these methods cannot be taken unless a solid questionnaire strategy is designed which is also attributed to understanding all essential restrictions and factors included (Jones et al. 2008). In this study, closed as well as open questions have been used and thanks to that combination, the results have been comprehensively analysed, the other ones bringing vital understandings of perceptions and motivations of the respondents towards pangolins (White et al. 2005; Bird 2009).

The preliminary surveys are predominantly carried out to identify potential defects of the questionnaire and mitigate the risks (White et al. 2005; Meijaard et al. 2011). Nevertheless, different strategies are sometimes applied to conduct the questionnaires within the communities. For example, Baker (2014) discussed deeply her questionnaire focused on pangolins only with the help of the local fieldwork assistants without the need to use it on actual respondents. Moreover, the assistants were taken under training before the start of data collection. In our case, similarly, the preliminary survey was not possible to conduct prior to the fieldwork due to financial and time requirements of such an activity. Hence, our questionnaire design was inspired by existing research which has been already published, mainly Nash et al. (2016) who greatly recommended conducting questionnaire surveys across natural occurrence regions of pangolins as a relatively effective and inexpressive method for assessing their current status. However; with regards to potential biases, inaccuracy and dishonesty of the respondents; precisely selected methods must always be used (Meijaard et al. 2011; Nuno et al. 2013; Nash et al. 2016), such as an indirect questioning technique. In this study, surprisingly, respondents only rarely were unwilling to participate in the survey despite the fact that they were asked about participating in illicit and sensitive activities. Therefore, the direct questioning method was applied since the village respondents were always ensured their anonymity. Additionally, the high response rate was guaranteed by well-trained Congolese assistants whose function were interpreting the locally employed languages. However, the situation was differently perceived by some of the interviewed market sellers compared to the village survey due to the general

reluctance to share the information with us. In reality, it was mostly not caused by the fear of the respondents to answer the sensitive questions, but more likely the market sellers were not open to any kind of the questioning. In accordance with their behaviour, we had to support their reluctance to participate in the research by the purchase of a bottled beverage to give them.

Participation of the "white foreigner" in the interview sessions could have had a detrimental impact on the resulting data as well. Based on it, respondents may feel fear of replying to sensitive issues, or on the other hand, they intend to please the interviewer by positive answers which can cause biases in the results too (Nsonsi et al. 2017). Newton (2008) and D´Cruze et al. (2018) suggested caution in interpreting data particularly those which are derived from hunters and may be underestimated. In this study, the majority of the interviewed hunters openly admitted to hunting pangolins (226/245), similarly, most market sellers were willing to talk with us about illegal trading of pangolins (44/50). That may indicate credible information since the respondents were aware of their illegal behaviour and potential consequences resulting from it, there is no reasonable explanation to deny it. In fact, it is more likely to expect that the level of illicit activities would be even higher than reported.

Nonetheless, the differences among study areas regarding the interviewed respondents should be taken into consideration everywhere, while in some localities people are rather informed about the enormously valued pangolin trade (Nash et al. 2016; Willcox et al. 2019) and they may be dishonest in their statements, in other places, the character of people may be dissimilar. On the grounds of our experiences in the Congo, appropriate research strategy and approach to the respondents were of great significance which may be sometimes a crucial factor for success (Jones et al. 2008). Moreover, the remoteness of the sampled villages means that people are not used to be in frequent contact with "white foreigners" and thence, people were more likely open-minded and surprisingly, welcoming to our intentions there. On top of that, the research team composed of a local person together with a foreigner was the right combination which worked advantageously in the local conditions, and a substantial portion of time assumed to be dedicated to establishing the trust with respondents, that is in agreement with the proposed ideas of Willcox et al. (2019).

6.1.2. Awareness of local communities towards pangolins

The respondents who participated in the research were well-informed about pangolins. In fact, more than 97% of the interviewed respondents in the villages were aware of pangolins, provided us their local names and had detected a pangolin at least once in their life directly; in case of the market sellers, all of them (100%) were able to identify the species. Regarding the ecological knowledge of the respondents, Akeredolu et al. (2017) described that 42% of the respondents in Nigeria knew additional information about the biology of pangolins which is a lower percentage in contrast to this study, suggesting that it might be affected by the different composition of the respondents. Within this survey, the dominant proportion of the respondents comprises hunters and then village dwellers living in daily contact with the forest environment, whereas Akeredolu et al. (2017) interviewed predominantly sellers and customers of the bushmeat markets in Lagos. It is important to consider also the community surveys conducted in Asia where similar results were obtained as in our case (Katuwal et al. 2013; Katuwal et al. 2015; Nash et al. 2016).

The majority of the respondents were able to recognize two pangolin species, but the most predominantly sighted species was the white-bellied pangolin (n=330) in comparison to the giant pangolin (n=9), and only 30 respondents were aware of the black-bellied pangolin. These results are similar to other studies, for example in Cameroon, Ichu et al. (2017) also found that the respondents were the least informed about the black-bellied pangolin. Nevertheless, Willcox et al. (2019) mentioned that interview surveys should be careful in presenting incorrect data particularly from the areas where similar pangolin species occur. In this study, only men recognized the black-bellied pangolin during the questionnaire, moreover, almost all of them were hunters (28/30). This may signify that hunters are more attentive to different species, or more likely they have simply a higher probability of encountering the black-bellied pangolin because of their activities in the forest. Additionally, hunters determined the species to be tree-dwelling and diurnal which was confirmed also by Kingdon & Hoffmann (2013), Kingdon (2015) and Ichu et al. (2017). Based on the shared experiences by Rod Cassidy from the Central Africa Republic (Ichu et al. 2017; Willcox et al. 2019), this species resides mainly high in the crowns of trees and rarely go down to the ground, which was

equally stated by our interviewed respondents, which makes this species poorly detectable. With regards to the fact that after each questionnaire session the photos of the black-bellied were shown to the respondents and most of the respondents still validated their previous statements, suggesting rather correctly the interpretation of the data. Simultaneously, Baker (2014) mentioned the least occurrence of the black-bellied pangolin in her research as well. All of this may indicate the population vulnerability of the black-bellied pangolin in the given study areas, but the inaccuracy of the data needs to be taken into account regarding the difficulties in the species recognition of the arboreal pangolins (*P. tricuspis, P. tetradactyla*), and the application of other monitoring techniques are highly recommended.

Interestingly, the absolute majority of the respondents mentioned observing mainly the white-bellied pangolin, but a few people also considered the giant pangolin to be sighted the most. In fact, in the western periphery of the park, five respondents (5/9) noted it, and six of them (6/12) reported to have seen the both species equally. This part of the park consists more likely of forest-savannah mosaic, whereas northern area of the park is a dense tropical forest (Henschel et al. 2014; Bohm & Hofer 2018). Hence, giant pangolins may occur preferably in the south-western part of the park where there is a more suitable habitat for them (Kingdon & Hoffmann 2013; Ichu et al. 2017; Bruce et al. 2018).

As an important result, the village survey, as well as the market one, showed that people are greatly aware of the protected status of pangolins in the research location and thus, it is illegal to capture, kill or trade them. Similarly, all respondents were informed about the illegality of the pangolin trade reported by Zhang et al. (2017) in Myanmar, but Katuwal et al. (2015) stated that 64% of the respondents knew the legal status of pangolins in Nepal which was a lower percentage compared to this study. In Nigeria, Akeredolu et al. (2017) described that only 31% of the respondents were aware of the illegality of pangolin trade, and according to Soewu & Ayodele (2009), even more than 95% of the respondents did not have any information about the conservation status of pangolins in the study area. On the other hand, our results refer to a high level of awareness of the local people about the present conservation status of pangolins, which may be credited to active patrolling of the eco-guards in the study area and

related education programmes of the African Parks and other organizations occurring there. Nevertheless, illicit activities continue despite the informed level of the local people, and other alternative reduction methods of hunting pressure on pangolins will be discussed in the following chapters.

6.1.3. Hunting practises

As the Odzala-Kokoua National Park is the largest protected area in the country and the occurrence of wildlife is higher than in other parts (Latour & Stiles 2011; Boakye et al. 2016), it is known that there is a heavy hunting pressure on animal species, but up to now, attention was particularly focused on the poaching of elephants (Latour & Stiles 2011). However, in accordance with our results, the hunting of pangolins is widespread in the study area as well (Mambeya et al. 2018). In fact, most of the hunters admitted to hunting pangolins more than ten times in their life, predominantly they reported the last time they captured a pangolin as being one year ago and less, and moreover, many of them mentioned detecting other people often carrying out the hunting of pangolins. Further, just as described in the previous texts, independent factors, such as the locality of the interviewed person, age of the hunters, their ethnic group and place of their residence noticeably influenced the results of the research. On the other hand, surprisingly, the education level of the hunters did not have any significant impact on this survey.

Nevertheless, we did not register any specific hunting activities which would be targeted only at pangolins which were similarly noted by Ichu et al. (2017) in Cameroon. Indeed, within the local communities, bushmeat hunting is prevalently non-selective with wire snaring holding an important role. Use of this method is of great threat for wildlife in general as snares do not consider species, gender, age or protected status of hunted animals. In this research, surely, seven out of a total of seventeen pangolins were observed to be hunted by snares on the basis of the fact that their throats were slashed, and they did not have any other injuries (Hennessey & Rogers 2008; Mbete et al. 2010). Additionally, 45 hunters reported capturing pangolins thanks to snares, primarily involving hunters interviewed in the northern periphery of the park, since Ichu et al. (2017) claimed that an even larger quantity of snares are involved in the hunting of

pangolins in Cameroon. Therefore, reduction of snares should have a positive effect not only for the pangolin populations but more likely for all wildlife including that which other authors of the similar studies suggested as well (Hennessey & Rogers 2008; Baker 2014; Boakye et al. 2016; Ingram et al. 2017). Besides, other commonly used methods in the hunting of pangolins included shotguns (Mbete et al. 2010; Mockrin et al. 2011), machetes used for mainly killing the giant pangolin, torchlights, and almost all hunters were used to capturing pangolins just with their bare hands; differing between the arboreal species and the giant ground-dwelling pangolin. Equally, similar hunting methods of pangolins were employed in Africa (Akeredolu et al. 2017; Ichu et al. 2017), as Boakye et al. (2016) reported that snares and shotguns are widely preferred hunting techniques used on pangolins in Ghana. In Asia, seemingly, hunters were more utilizing trained dogs for hunting, or alternatively they were digging pangolins out of their burrows (Thapa et al. 2014; Nash et al. 2016). This may be a sign of a more specialized type of hunting, whereas, within our interviews, the hunters were rather opportunistically finding pangolins in the forest, villages, fields or the pangolins were captured by snares.

Regarding the most frequently noted time to capture pangolins, in Nigeria, overnight was predominantly mentioned by hunters with respect to one person who captured the black-bellied pangolin also during the daytime (Sodeinde & Adedipe 1994). Our findings demonstrate similarities since most of the hunters reported "all night" to be suitable for the hunting of pangolins. Nevertheless, 27 hunters did not find any difference between night and daytime for capturing these animals, and interestingly, 18 out of 30 people who knew the black-bellied pangolin perceived "evening" as the best moment for capturing pangolins. This may indicate a connection with their knowledge of this species which is active during the daytime. However, unlike the study of Sodeinde & Adedipe (1994) in Nigeria where all hunters agreed on the greater availability of pangolins during the dry season, in this thesis, the hunters likely believed in a higher occurrence of pangolins during the rainy season. Newton et al. (2008) reported a similar experience in Vietnam; all hunters stated the rainy season to be the easiest time of year to catch pangolins, and D´Cruze et al. (2018) highlighted the importance of the field signs to track pangolins. By all means, pangolins may have distinctive activity during the rainy

season, or their tracks are simply more visible, which is not clear even from the previous studies and further research is of great need.

Comparably to our study, a similar proportion of the hunters claimed to sell pangolin meat and sell it frequently to the local communities in India (D´Cruze et al. 2018), and as Latour & Stiles (2011) described, only specific hunters may be focused on the commercialization of bushmeat around the OKNP (van Vliet et al. 2012). In this study, nonetheless, apart from one person, all hunters admitted to targeting pangolins mostly for their meat. In fact, a lot of them noted that they prefer to sell other bushmeat than pangolins because of the specific structure and taste of pangolin meat, which was also significantly different from the non-hunters as proved, and it will be further discussed in the upcoming chapters. In addition, the absolute majority of the interviewed hunters (217/226) reported hunting most likely the white-bellied pangolins which correspond with our previously mentioned results.

6.1.4. Trade dynamics

In fact, several characteristic features of the pangolin trade, with regards to various independent factors, have already been highlighted in the previous text. Thus, the following discussion will be focused primarily on the overall insight to the pangolin trade; as the hunting pressure on pangolins at the village level is assumed to be high based on our findings, only insignificant numbers of publications detected pangolin bushmeat records in the Congo (Blake 1993; Hennessey & Rogers 2008; Mbete et al. 2010; Mbete et al. 2011; Mockrin et al. 2011). In accordance with Fa et al. (2006) and Boakye et al. (2016), there are many factors potentially influencing such deficiency of information, for example, level of law enforcement or distance to markets needs to be considered. Nevertheless, in this study, only 50 market sellers were interviewed, and therefore further research should be implemented to enlarge the scale of data, and to be sure in our assumed statements.

Summarised, most of the interviewed village dwellers were well-informed about the price of pangolins which may point toward the frequent trade occurrence. However, they perceived an increase in the price of pangolins during the last five years (Newton et al. 2008; D´Cruze et al. 2018; Ingram et al. 2019), just as it has been recently reported

by Mambeya et al. (2018) in Gabon, whereas most of the market sellers stated a decreasing trend of the price. This may be caused by the different time of conducting each survey, referring to the more than six months' time gap between the village and market survey, and pointing out the potential economic crisis in the Congo at the moment. But more likely, the market sellers from Brazzaville, who were involved in the analysis, should be taken into account too; meaning the different point of view of absolutely dissimilar categories of people, suggesting their location of residence, occupation, education level, gender and motivations to sell pangolins, or simply to answer us. Contrarily, Ingram et al. (2017) reported the increased prices for pangolins in the urban markets through West and Central Africa, but not in the rural ones.

With regards to the price of pangolins reported from the village survey, these results are similar to those obtained from the market sellers. The most commonly stated price for the whole body of the white-bellied pangolin was between 2,000 and 5,000 XAF, just as similarly Mambeya et al. (2018) stated in Gabon and Akpona et al. (2008) in Benin, and in both groups of the respondents, people were less aware of the price for the giant pangolin, of which the price differed more between the respondents, but mostly ranged between 20,000 and 50,000 XAF, which corresponds with the results found by Mambeya et al. (2018) in Gabon. Apparently, the giant pangolin is only rarely captured in the forest by hunters, and therefore only occasionally offered to the local bushmeat markets to sell. However, this may also be a clue to the secretive trade of this species.

In general, only less than half of the hunters claimed to be doing trade with pangolins which is differing from the published studies in Vietnam (Newton et al. 2008) and in India (D´Cruze et al. 2018) where pangolins are primarily targeting for cash, not for income. In this study, it was found that the hunters were selling predominantly pangolin meat as the same goes for the bushmeat market sellers. If hunters sell pangolins to middlemen or directly to markets sellers, they predominantly offer the whole body of pangolin (Heinrich et al. 2016), while just parts of the body are offered more likely only to other village dwellers. Indeed, most of the hunters mentioned selling pangolins to local people, then some of them to people passing the road and 17 out of 21 respondents, who were selling pangolins to foreigners, pangolin scales were a trade

article for them. From a general point of view, it is not a common practice for market sellers to be selling scales, which may signify that scales are smuggled secretly and not offered openly in the markets. In other words, market sellers offer mainly only whole pangolin carcasses and do not separate it, just as it was confirmed by our direct observations. On the other hand, the majority of the village dwellers, who knew the price for pangolin scales (n=72), highlighted the price of scales just from the giant pangolin whose scales seem to be more valuable in the local conditions compared to the arboreal pangolin species; which was described in Gabon as well (Mambeya et al. 2018; Ingram et al. 2019). Similarly, we did not observe any giant pangolins during our bushmeat market investigations, and simultaneously, the market sellers provided us less information about this species. All of that may imply that giant pangolins are traded secretively outside of the bushmeat markets, their meat eaten, and scales potentially trafficked out of the Congo.

In the same way, the population decline of the giant pangolin may be apparent, and most importantly, law enforcement is implemented more in this species contrary to the arboreal pangolins. Considering it, some of the interviewed hunters confirmed that they are scared of selling the giant pangolin because of the potential of imprisonment, while they frequently sell the smaller species of pangolins, concerning mainly the northern periphery of the park. Similarly, Ouesso´s market sellers even admitted to giving bribes to the forestry eco-guards, who are supposed to supervise illegal trade with protected species, to keep the market being open for the smaller species of pangolins. Therefore, almost all surveyed market sellers preferred to do business with other animals than with pangolins because of their perceived low profit or conservation status. Contrary to the study performed by Akeredolu et al. (2017) who found that most of the interviewed sellers believed in the trade with pangolins to be lucrative in Lagos since pangolins were ranked among the most expensive type of bushmeat in the markets which is likely associated with the surveyed location. Lagos is a Nigerian metropole and one of the most populated cities in Africa, there is a well-recognized large-scale trafficking of pangolins and their derivates (Gomez & Leupen 2016; Heinrich et al. 2017; Ingram et al. 2019), and thus the demand for pangolins as well as their prices are high. Nevertheless, a deeper analysis of the trade dynamics with pangolins especially in the

largest main cities, Brazzaville and Pointe Noire (Mambeya et al. 2018), needs to be conducted in the Congo. In our case, direct questioning of the bushmeat sellers in Brazzaville, except for the traditional medicine sellers, did not work well compared to the survey in the northern part of the Congo. The behavior of the local sellers was reluctant and not cooperative and due to the lack of time, we were not able to gain their trust. Hence, a long-term secretive investigation of the local markets, traditional medicine stalls and restaurants, is recommended to be carried out there (Mambeya et al. 2018).

6.1.5. The main conservation threats

One of the imperative goals of the questionnaire was to reveal the perception of the local communities of the population trend of pangolins, as according to IUCN, all pangolin species are vulnerable and moreover, they are believed to be decreasing in all the populations due to their current unsustainable persecution. In light of this background, surprisingly, the majority of the village dwellers (n=211) noted that the population of pangolins was increasing as well as similar results were obtained from the market sellers; which is more likely on the contrary with other studies conducted in Africa (Soewu & Adekanola 2011; Akeredolu et al. 2017; Ichu et al. 2017). However, the justifications of their statements are of concern. In many cases, the respondents simply answered that "pangolins are animals and thus, they must be in the forest", "pangolins are animals and thus, they reproduce all the time", "we sometimes encounter pangolins" or "we do not hunt pangolins, why would they not be in the forest". And even though they reported that nowadays it is a very rare situation to detect pangolins anywhere, they still perceived that the pangolin population was increasing. Hence, educational and explanatory, not only informative, programmes are necessary to carry out in the study area just as an overall increase in the education level of local communities may be a crucial point for the success of any conservation strategy.

Practise of traditional medicine including herbalists, spiritualists, and practitioners with animal products is highly valued in the Republic of the Congo, considering dissimilarities between rural and urban areas (WHO 2001). Nevertheless, as of this moment, no official information about the medical utilization of pangolins in the

local conditions has been published, and therefore the impact of traditional medicine on the population of pangolins is largely unknown in the Congo. In this respect, our study revealed 22 different ways of the utilization of pangolins, meaning that in total 73 interviewed respondents had knowledge of the cultural or medicinal uses of the species. And on the contrary to the previous published studies (Bräutigam et al. 1994; Akpona et al. 2008; Soewu & Ayodele 2009; Soewu & Adekanola 2011; Boakye et al. 2014; Boakye et al. 2015; Baiyewu et al. 2018; Boakye 2018), only the scales of pangolins (n=73), their meat (n=6) and tail (n=5) were mentioned to be useful for the stated properties. The most frequently utilized part of the pangolin body was the scales which corresponds also with findings provided by Boakye et al. (2014, 2015) and Baiyewu et al. (2018). Interestingly, of all independent factors, only age and education level of the respondents had a small but significant influence on the belief in healing uses of pangolins, as it was discussed in the previous chapters. For example, Boakye (2018) described the associated ethnicity of the respondents with their preference for different pangolin body parts used in the traditional medicine, but it was not confirmed in our results. In this study, we found a predominant amount of people who stated their use of pangolin scales (n=34) for men to attract women, that have not been reported frequently in previous studies, and in addition, only some of the beliefs were similar to the healing purposes in other African countries (Bräutigam et al. 1994; Akpona et al. 2008; Soewu & Ayodele 2009; Soewu & Adekanola 2011; Boakye et al. 2014; Boakye et al. 2015; Baiyewu et al. 2018; Boakye 2018). This may be related to the character of the interviewed people and their ailment requirements in the study area more than anything else regarding the very diverse utilization of pangolins. Nevertheless, none of the suggested healing properties of pangolins have been scientifically proven up to the present moment (Soewu & Ayodele 2009; Boakye et al. 2015; Baiyewu et al. 2018). Traditional medicine is sometimes perceived to be the only source of medical care for the village dwellers living in close proximity to the OKNP and thus, the discovered uses of pangolins cannot be underestimated as the potential threat for their wild populations. However, we did not determine any targeted hunting on pangolins just because of the traditional medicine, more likely it is understood to be the value added to pangolin meat or cash, and we identified that all pangolin species were similarly perceived. Additionally, in pursuance

of the market questionnaire survey, we visited the largest market called "Marché Total" in Brazzaville (Latour & Stiles 2011) and six traditional medicine stalls were documented to be offering pangolin scales; scales of all three pangolin species were detected at that time. Hence, there is a need to undertake a further examination of these places to assess in detail the impact of harvesting pressure on pangolin populations for cultural and medicinal purposes and to better understand the customer´s demand.

The high cultural and social importance of pangolin meat in this research was similar to those found in the previous studies (Bräutigam et al. 1994; Akpona et al. 2008; Friant et al. 2015; Soewu & Sodeinde 2015; Baiyewu et al. 2018; Boakye 2018). In actual fact, Akpona et al. (2008) reported that more than 78% of the respondents highly valued pangolin meat in Benin, Soewu & Sodeinde (2015) determined pangolin meat as being a symbol of status in Nigerian society and Boakye (2018) mentioned that pangolins are commonly perceived as "meat for chiefs" in Ghana. Moreover, there was even not any change in the preference for pangolin meat during the Ebola crisis in West Africa (Ordaz-Németh et al. 2017), and people openly admitting favourable consumption of pangolins despite their protected status was recorded in the Congo as well (Chausson et al. 2019). In our rural region, pangolin meat was represented to us as a highly appreciated source of proteins by the respondents regardless of their gender, age or education level. This result is different from those found by Luiselli et al. (2019) in other West African countries, where the dissimilarities among respondent´s age, gender, residence locality with respect to rural and urban areas significantly influenced the overall bushmeat consumption. In this study, according to our findings, almost all village dwellers (n=354) had eaten pangolin meat at least once in their life and 268 of them perceived the meat to be a delicacy, of which, the majority preferred consuming pangolins than other animals. Partially, this might also be related to the reduced occurrence of pangolins offered in the bushmeat markets resulting from our market survey. Thus, not only population decline, the rarity of the species and potential secretive traffic with pangolins beyond the bushmeat markets may be the reasons of this situation, but similarly, the decision of the hunters to keep the meat instead of offering it to the markets must be considered. Based on our experience, some of the encountered hunters reported even eating pangolins in private, which is not standard practice for such a traditionally family-

based community. Truly, for some hunters, the motivation to sell pangolins was minor compare to preserving it as a desired source of meat. By all means, this may indicate that pangolins are locally valued predominantly for bushmeat and not for income or traditional medicine, which refer to the village dwellers as well as bushmeat sellers. Seemingly, this overwhelming consumption preference for pangolins poses a considerable threat to their survival. However, just as Boakye (2018) suggested, even culturally preferred bushmeat may be replaced by alternative species if it is available. Hence, a clear understanding of the consumer´s preferences is essential before any decision is taken, and subsequently, the substitute protein alternatives may be applied, which is seemingly a problematic issue concerning the rural areas (Schenck et al. 2006; Luiselli et al. 2019).

Nevertheless, 21 out of 226 hunters declared to have done the trade with pangolins or their derivates predominantly with "foreigners", since 11 hunters described them to be like Cameroonians in the northern periphery of the park, and five of them described them to be Chinese people. To the best of our knowledge, the number of illegal trade activities with Chinese, Cameroonians or another West Africans is even most likely higher. During our informal talks with the village dwellers beyond the questioning, in the larger villagers of the northern periphery of the park, many of the villagers admitted to doing regular trade mainly with Cameroonians. There are a lot of Cameroonians, or alternatively, other West Africans, in the north of the Congo since the area is near to the borders, and they look for job opportunities there. Due to this, it seems that likely not all scales for sale in these seizures are of domestic origin in Cameroon. For example, Latour & Stiles (2011) pointed out that traffickers are used to smuggling even ivory out of the Congo to Cameroon because one of the reasons are better infrastructure appropriate for the export to other parts of Africa, like Nigeria, or directly to Asia, and already developed trafficking routes (Ingram et al. 2019). Indeed, based on our findings in the study region, a similar pattern may correspond in trafficking of pangolins regarding the fact that Cameroon and Nigeria were determined to be the most common international transit places for trafficking of pangolins (Soewu & Sodeinde 2015; Gomez & Leupen 2016; Xu et al. 2016; Heinrich et al. 2017; Ingram et al. 2019). In light of the report published by EAGLE (2016), one Nigerian trafficker has been

even already identified to be doing regular trade with pangolins in the Congo directing them to Chinese clients. In our surveyed region of the Congo, the trade with Chinese occurs specifically in the places where Chinese companies undertake their business (Hennessey & Rogers 2008); like workers of the Chinese logging or road construction companies were used to ask surrounding villagers living in the given area for pangolins and their derivates. However, concerning mainly the western part of the park, some of the respondents were still not aware of the value of pangolins elsewhere, and therefore we were not revealing it to them of course. Regarding the market sellers, most of the declared trade with foreigners was realized in Brazzaville, which has been already discussed in the previous chapters, and which may not be the group potentially targeted by the international traffickers. With respect to the previously published seizures of pangolin scales, only a minor amount of the pangolin derivates has been revealed up to now in the Congo (Ingram et al. 2019), or the small-scale seizures of pangolins are not being published openly by all the conservation organizations operating in the country. Thus, more in-depth research and investigations are necessary to conduct, as the prevalent part of the illegal traffic with pangolins is very likely undetected.

6.2. Measurements and samples of pangolins

Direct observation method of pangolins and collecting their genetic samples were used to verify information provided by respondents in the community questionnaire survey. The presence of all three pangolin species (*Phataginus tricuspis*, *Phataginus tetradactyla*, *Smutsia gigantea)* was confirmed by the collected scale samples in the study area, and moreover, the presence of the arboreal pangolins (*Phataginus tricuspis*, *Phataginus tetradactyla*) was also proved by the direct observation of pangolins in the bushmeat markets or villages.

Like the results of the questionnaire survey, we gathered the highest number of samples from the white-bellied pangolin, then from the giant pangolin and scales from only four black-bellied pangolins were obtained. The most frequently seen species was the white-bellied pangolin in the study area, just as Sodeinde & Adedipe (1994) and Soewu & Ayodele (2009) detected in Nigeria during their market surveys, and as well as all other already published data claims (Kingdon & Hoffmann 2013; Kingdon 2015). In

terms of the giant pangolin, we did not directly sight any of them, but we gathered together scales from potentially 19 different individuals, which must also be confirmed by genetic analysis. However, the majority of these samples were obtained from the village dwellers in the western periphery of the park during the first fieldwork in the Congo. Within the second data collection in the Congo, we were not able to sample this area due to reasons beyond our control, and at that time, only scales from three giant pangolins were gained. This is perfectly related to discussed results from the questionnaire survey. The western periphery of the park is more isolated due to the road quality in comparison to the other parts. Except for the concern of location, additionally, there is a base of the park management, and therefore illegal activities may be under greater control. Further, some of the respondents did not know the value of pangolin scales on the market yet and normally, they used to throw away scales of pangolins, or alternatively, utilize them for the traditional medicine. Finally, even based on the questionnaire results, none of the hunters reported selling scales of pangolins. To summarize other locations, the fact that we did not obtain such a quantity of the scales of the giant pangolins in the east and north could be affected by the following explanations. Firstly, a population decline of this species should be considered with respect to the habitat variance, but probably, the pressure of the illegal traffic with their scales is more severe in these parts and hence, people do not normally keep their scales, or did not want to expose them. Importantly, the availability of pangolins and their scales did not differ between open and closed hunting seasons, which implies that hunting restrictions are widely not respected by local people in the study region.

Monitoring of pangolin harvest in the markets was not the purpose of this research, however, it may be largely meaningful for the overall point of view. Hereby, to evaluate the volume of traded pangolins in the study area, the trade needs to be more detailed and regularly investigated. Especially, Ouesso´s markets should be monitored for a longer period, with respect to the fact that eight out of all 17 pangolins were found just in the local bushmeat markets during our occasional visits in a relatively short time. The rest of the reported pangolins were founded in the villages. Further surveys should also be focused on middlemen who regularly supply these markets with animal carcasses and may be a key link to a comprehensive understanding of traffic routes with

pangolins and all other trade dynamics. In fact, Boakye et al. (2016) and Mambeya et al. (2018) suggested that the prevalent part of the pangolin offtake may be even found completely outside of the major bushmeat markets, just as it was reported in Ghana, and accurate investigative methods supposed should be applied to enable better assessment of the given topic.

Our results of the population variables could not be accurately evaluated due to being based on the limited number of the individuals that were encountered. By all means, of the white-bellied pangolins included in statistical analysis, none of the morphological measurements were significantly different between males and females. In general, categorization of pangolins based on their age is a very tricky concern, and therefore not easy to discuss. Regarding this topic, no guidance manual has been produced yet to manage the age classification of pangolins, and even information resulting from already published scientific articles are not clear. Asian as well as African species of pangolins are mostly grouped into three age categories; juveniles, sub-adults and adults; but in fact, only some of these categories were clarified on what matter of data they have been defined (Akpona et al. 2008; Pantel & Anak 2010; Irshad et al. 2015; Ingram et al. 2017; Sulaiman et al. 2017; Ingram et al. 2019), suggesting more likely that all of our sampled white-bellied pangolins were adults with respect to their weight (≥1.6 kg) (Kingdon 2015). On the basis of the stated reasons and a small number of the sampled pangolins, the author of the thesis does not want to present any inaccurate conclusions. Hence, further research is recommended to conduct on morphological differences among pangolin species, sex of pangolins and with a specific focus on age categorization is a meaningful issue. Such scientific activities are not time-consuming or expensive and involvement of more data sets through the African species may be essential in the understanding of overall current population dynamics of pangolins.

6.3. Enforcement implementations

Our results of the village survey, as well as the market one, showed that the people living around the Odzala-Kokoua National Park greatly ignore and do not respect the protected status of pangolins, the law enforcers are corrupted and overall, the law is not correctly being enforced in the study area. The fact that utilization of wire snares

is a broadly favored method of hunting in the study region, despite the forbidden legal status of it, is of great concern. Pangolins are easily captured by snares (Boakye et al. 2016; Akeredolu et al. 2017; Ichu et al. 2017), which has been confirmed also thanks to our research, and the tolerance of the given hunting technique cannot be accepted. Thus, local law enforcers should concentrate on the reduction of wire snaring; just as hunting during the closed season because we did not detect any significant difference of the pressure on pangolins during different seasons. Besides, Batchy et al. (2018) summarized that judicial proceedings are only rarely enforced apart from elephants in the Congo, even though the same level of protection is attributed to pangolins as is with elephants. In fact, only 2% of all offenses were dedicated to pangolins between 2008 and 2016. By all means, increasing awareness programmes may be of help to not only deter people from becoming involved in the illegality of the killing and trading pangolins but to press them on abiding the laws and correct penalization as well. In light of the concern that ignorance of the enforcement officials to implement the law supports the people in continuing their illicit activities. Except for a negligible amount of detected trafficked pangolins, which has already been reported in the country, the majority of the illegal trade with pangolins is being unrecorded with respect to our findings and in-depth further investigations must be set up (Shepherd et al. 2016).

The black-bellied pangolin is assumed to be the rarest species of all three studied pangolins (Kingdon & Hoffmann 2013; Kingdon 2015; Ichu et al. 2017), which also was verified by this study. Paradoxically, this species has not been classified in any protected category established by the Congolese law yet unlike the two other species of pangolins (*Phataginus tricuspis, Smutsia gigantea*) found in the Congo (Ministere du developpement durable, de l'economie forestiere et de l'environnement 2011). Forsooth, this may seem that the species has been more likely neglected in the process of law-making than purposely not included. Therefore, the urgent revision of the species formal status is a fundamental step for maintaining their survival in the Congo.

The lack of monitoring of pangolin populations limits the further analysis of their threats and in general, finding cost-effective and sufficient methods to detect pangolins in the wild is heavily difficult to process worldwide (Heath & Coulson 1997; Boakye et al. 2016; Ichu et al. 2017; Bruce et al. 2018; Willcox et al. 2019). However, thanks to the

application of primary ecological monitoring methods, differences among the study locations and the pangolin species may be substantially understood. As such, it is recommended to initiate similar studies as those which have already been conducted in other countries (Willcox et al. 2019). Moreover, monitoring of the availability of pangolins in the markets should be imposed to get overall insight into their local offtake, not only in our study area but all over the country.

Nevertheless, according to the thesis author´s point of view, the provision of alternative protein sources and likelihoods is the first imperative goal to target in the study region which is essential to find out for the mitigation of one the biggest present threat to pangolins in the Congo, that is the bushmeat consumption. However, this cannot be undertaken without a prior clear understanding of the consumers and their requirements (van Vliet et al. 2012; Boakye et al. 2016; Wilkie et al. 2016; Chausson et al. 2019). And the continually performed education sessions are of crucial need in all conservation programmes. This may be important for local communities to comprehend the value of pangolins for the ecosystem, and for development of the appropriate conservation management strategies as well.

7. Conclusions

This study has compiled the first data focused on the three species of pangolins in the Republic of the Congo. We have demonstrated that questionnaire surveys can extensively contribute to the assessment of populations of pangolins and powerfully inform about the regional trends of hunting and trading the species. Thanks to interviewing local communities, the presence of all pangolin species was proven together with direct observation and collection of the genetic samples, and alongside this, the attitude of local people towards pangolins was discussed in detail. The value of pangolin meat was high for the local communities. In general, bushmeat was very much consumed by people living around the Odzala-Kokoua National Park for protein as well as to generate cash. Moreover, pangolins also remained to be an important social and cultural tradition for a lot of the interviewed respondents. We also have discovered crucial baseline information on illicit activities targeted pangolins. We provided evidence that the current hunting of pangolins was frequently occurring in the study region, and even though there is a possibility the hunters and traders may have not been reluctant in their statements, more likely our results are still underestimations of the reality.

Our results are meaningful in the development of the conservation management policy for this endangered group of mammals in the Congo; specifically, the established different impacts of the independent factors on the harvest of pangolins should be considered. To mitigate the current quantity of pangolins that are consumed, acceptable alternative sources of proteins are essential to discover. However, this may be less successful to realize in the rural areas if the taste preference is a major driver of bushmeat consumption, just as it has been determined in this study. All of this will not be possible to undertake without an efficient collaboration network between the locally operating conservation organizations, and the international ones. Therefore, we recommend conducting long-term studies of this character and to also establish novel monitoring techniques of pangolins in the wild. However, the survival of pangolins will not be possible to maintain without solid education activities, improvement of law enforcement and traceability of the local illegal trade with pangolins which will very likely increasingly continue in the north of the Congo where the Chinese companies operate, and West Africans demand the pangolin scales.

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Appendices

Appendix 1

Enquête dans les villages (French version)

Fiche de collecte de données

Date:	Village/marché:	Numéro du répondant:
Temps:	Région:	GPS:

Section A: Informations à propos du répondant

1. **Etes-vous intéressés à participer à cette recherche?**   Oui   Non
2. **Genre:**   Homme   Femme
3. **Age:**   18-30   31-40   41-50   51-60   61+
4. **Groupe ethnique:**   Kota   Mboko   Mbochi   Téké   Peuple autochtone   Autre: _____
5. **Education:**   Aucun   Primaire   Collège   Lycée   Université
6. **Occupation:** _____
7. **Vivez-vous dans ce village?**   Oui   Non

   Si oui, depuis quand: _____

   Si non, où vivez-vous: _____

Section B: Opinions et connaissances générales

8. **Connaissez-vous cet animal (présenter la photo du pangolin)?**   Oui   Non

   Si oui, quel est le nom de cet animal: _____

9. **Voyez-vous parfois cet animal?**   Oui   Non

   Si oui, la dernière fois que vous l´avez vu: _____ le lieu:_____

   l'animal était: Vivant   Mort

   Si non, alors que savez vous de cet animal: _____

10. **Savez-vous quelque chose (taille, nourriture, apparence, etc.) de plus à leur sujet?** Oui   Non

    Si oui, qu'est-ce que c'est:_____

11. **Pouvez-vous distinguer plusieurs espèces de pangolins?**   Oui   Non

    Si oui, combien: _____ la différence: _____

    les espèces les plus fréquemment vues: _____

12. **Connaissez-vous le prix de l'animal (du kilogramme)?**   Oui   Non   Montant: _____

    Si oui, comment le prix a changé au cours des 5 dernières années: Augmenté Stable Diminué Je ne sais pas

13. **Savez-vous le prix d´un kilogramme de leurs écailles?**   Oui   Non   Montant: _____

14. **Savez-vous que les pangolins ont une valeur médicale ou culturelle?**   Oui   Non

    Si oui, quelle partie du corps: _____ et pourquoi: _____

15. **Avez-vous déjà essayé de manger le pangolin?**   Oui   Non

Si oui, comment était-il: Délicieux   Bon   Pas bon

Si oui, préférez-vous manger les pangolins plus que d'autres animaux: Oui   Non

16. Pensez-vous que la population de cet animal est? Augmenté   Stable   Diminué   Je ne sais pas

Pourquoi:_____

17. Savez-vous que ces animaux sont protégés? Oui, ils sont   Non, ils ne sont pas   Je ne sais pas

Section C: Informations sur la chasse

18. Chassez-vous?   Oui   Non

19. A quelle fréquence chassez-vous? Journalière   Hebdomadaire   Mensuelle   Accidentelle
Presque jamais

20. Avez-vous déjà chassé le pangolin?   Oui   Non
Si oui, combien de fois: _____ la dernière fois chassé: _____
et le lieu: _____
Si non, pourquoi: _____

21. Où et quand est le meilleur moment pour trouver des pangolins?
_____

22. Pourquoi vous avez les chassés? Revenu   Viande   Culture   Médecine   Autre: _____
Si vous les vendez, specifiez quelle partie du corps: _____
à qui vous les vendez: _____ à quel prix: _____   sont-ils: Vivants   Morts

23. Qu'utilisez-vous pour la chasse? Fusil Piège Chien   Utilisation de la lumière   Collecte à la main
Autre: _____

24. Quels pangolins chassez-vous surtout?   Très petits   Petits   Taille moyenne   Grands

25. Y a t-il une différence dans la disponibilité des pangolins au cours d'une année dans la forêt?
Oui   Non
Si oui, quelle est la différence: _____

26. Avez-vous déjà vu d'autres personnes chassant les pangolins?   Souvent   Parfois   Rarement
Jamais   Je ne sais pas

27. Est-il légal de chasser les pangolins?   Oui, c'est légal   Non, c'est illégal   Je ne sais pas

Appendix 2

Enquête dans les marchés (French version)

Fiche de collecte de données

Date:	Numéro du répondant:	Marché:
Temps:	Région:	GPS:

Section A: Informations à propos du répondant

1. **Etes-vous intéressés à participer à cette recherche?**   Oui   Non

2. **Genre:** Homme   Femme

3. **Age:**   18-30   31-40   41-50   51-60   61+

4. **Groupe ethnique:** Kota Mboko Mbochi Téké Peuple autochtone   Autre: _____

5. **Education:**   Aucun   Primaire   Collège   Lycée   Université

6. **Combien de temps êtes-vous vendeur au marché?** Moins d'un an   1-5   6-10   11+

Section B: Informations d'enquêtes de marchés

7. **Connaissez-vous cet animal (présenter la photo du pangolin)?**   Oui   Non

   Si oui, quel est le nom de cet animal: _____

8. **Vendez-vous parfois des pangolins?**   Oui   Non

   Si oui, à quelle fréquence: Journalière Hebdomadaire Mensuelle Occasionnelle Presque jamais

   Si oui, d´où viennent les pangolins: _____

   Si oui, sont-ils: Vivant   Mort   Préciser: _____

   Si non, pourquoi: _____

9. **Quelles pangolins vendez-vous le plus souvent?**   Petits   Grands   Autre: _____

10. **A quel prix vendez-vous des pangolins normalement?** _____

11. **Comment le prix a changé au cours des 5 dernières années?** Augmenté Stable Diminué   Je ne sais pas

12. **Vendez – vous leurs écailles ou l´autres parties de leurs corps?**   Oui   Non

    Si oui, que-ce que c´est: _____ et pour combien: _____

13. **A qui vendez-vous surtout les pangolins?**   Locaux   Etrangers   Préciser: _____

14. **Est-ce que les gens demandent souvent des pangolins?** Oui   Non   Préciser: _____

15. **Préférez-vous vendre les pangolins plus que d'autres animaux?** Oui   Non

    Porquoi: _____

16. **Pensez-vous que la population de cet animal est?** Augmenté   Stable   Diminué Je ne sais pas

    Pourquoi:_____

17. **Est-il légal de vendre les pangolins?**   Oui, c´est légal   Non, c´est illégal   Je ne sais pas