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Social and spatial behaviour of West African giraffe

DISSERTATION THESIS

Author
Ing. Kateřina Gašparová

Chief supervisor
doc. Ing. Karolína Brandlová, PhD

Consultants
Dr. Julian Fennessy, Dr. Thomas Rabeil

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Declaration

I hereby declare that I have completed this thesis entitled Social and spatial behaviour of West African giraffe independently, except for the jointly authored publications that are included. In the case of such publications, my specific contributions have been clearly stated at the start of the relevant publication chapter. Furthermore, I confirm that proper acknowledgement has been provided within this thesis for any references made to the works of others, I also ensure that this work has not been, nor is it currently submitted, for any other degree, to this or any other university. All information sources have been quoted and acknowledged by means of complete references.

In Date

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Name of the student

Acknowledgement
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Abstract
The West African giraffe (*Giraffa camelopardalis peralta*) was historically common across the Sudano-Sahelian zone. Due to human population growth, habitat lost, habitat degradation, agriculture, poaching and drought population dramatically decreased, and the last population survived in Niger, concentrated in so called “Giraffe Zone”. In 1996, the world's population consisted of only 49 individuals. After several years of intensive government effort, communities, and NGOs, the population has remarkably increased, and nowadays, the population is approximately 600 individuals. This dissertation thesis focuses on conservation approaches such as census monitoring, community engagement, habitat use, and translocation. It also focuses on human-giraffe coexistence, giraffe resting behaviour in the presence of livestock, its movement, and threats. As the giraffe live in human-dominated agro-pastoral landscapes, they, from time to time, damage crops, especially during the night. Although agriculture is primarily the primary source of income, people have a positive attitude towards giraffes and appreciate them as their heritage. Giraffe might be vigilant in close proximity to humans, but they feel comfortable close to livestock enough to rest next to each other. The harsh conditions are probably the main reason for the large home range, which is larger than in other studies. Even though giraffe are not directly threatened, some indirect threats can influence the population, such as human population growth, habitat loss and degradation, climate change, conflict, and unstable political situations.
Keywords: West African giraffe, conservation, human-wildlife coexistence, Niger, resting behaviour

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List of abbreviation

AKDE–Autocorrelated Kernel Density Estimator
ASGN– Association for Saving the Giraffes of Niger
AVEN– Association pour la Valorisation de l´Ecotourisme au Niger
CMR–Capture Mark Recapture
DCR–Democratic Republic of Congo
EU–European Union
GBR–Gadabedji Biosphere Reserve
GCF–Giraffe Conservation Foundation
GPS–Global Positioning System
GZ–Giraffe Zone
HR–Home range
IUCN–International Union for Conservation of Nature
IUCN SSC– International Union for Conservation of Nature Species Survival Commission
KDE–Kernel Density Estimator
MCA–Multiple Correspondance Analysis
MCP–Minimal Convex Polygon
NGO–Non-governmental organization
PURNKO– Projet d'Utilisation des Resources Naturelles de la region de Kouré et Dallol Bosso Nord
PVA–Population Viability Analysis
SCF–Sahara Conservation Fund
UNDP– United Nations Development Programme
UNESCO–united Nations Educational, Scientific and Cultural Organization
WWF–World Wide Fund for Nature

CHAPTER 1

1 Introduction

1.1 General introduction

More than half of Earth´s surface is nowadays changed due to human activities (Barnosky et al., 2012), which negatively affect the ecosystem's function (Foley et al., 2005). The changes are driven by fast human growth and their demand for food, timber, water, etc. (Foley, et al. 2005) not only for humans but also for their livestock (Sakadevan & Nguyen, 2017). Agriculture significantly impacts habitat loss, biodiversity loss, climate change, and others (Duru et al., 2015).

Africa is rich in biodiversity and contains an estimated one-fifth of known species of mammals, birds, and plants (Siegfried, 1989). However, there are many drivers to biodiversity decline, such as habitat loss, overhunting, disease, invasive species, etc. (Di Marco et al. 2014). African large mammals have lost 59% of their population over the four decades (Craigie et al. 2010). Moreover, the threat to biodiversity in West Africa is higher than in other areas of Africa, primarily because of high human population density, hunting, and habitat loss (Sayer et al. 1992). Nevertheless, the Republic of Niger undertaken several conservation projects with the support of NGOs and local population (Rabeil et al. 2014). One of the species which was on brink of extinction is West African giraffe.

The last population of West African giraffe (*Giraffa camelopardalis peralta)* – recently proposed to be a subspecies of the northern giraffe (Fennessy et al. 2016; Winter et al. 2018) is found in the Republic of Niger, in the central region of plateaus and Kouré and North Dallol Bosso, about 60km south-

east of the capital – Niamey, with extension to Doutchi, Loga, Gaya, Fandou and Ouallam areas. Together this area is locally called as the 'Giraffe Zone' (GZ) and forms part of the Parc W Biosphere Reserve covering more than 1,700 km^2. The next closest known population of giraffe is in northern Cameroon and southern Chad and are Kordofan giraffe (*G. c. antiquorum*) (Fennessy et al. 2016; Winter et al. 2018).

This IUCN Red Listed 'Vulnerable' subspecies, most recently down listed from 'Endangered' (Fennessy et al. 2018) yet still few in numbers, is threatened by various factors including agricultural encroachment, change and climate variability, human population growth and natural resource overexploitation. A combination of increasing fuel-wood harvesting, shifting agriculture in search of better soil fertility, and widespread pastoralism, in a country characterized by exponential human demographics and persistent poverty are all exerting substantial pressure on the sparse Sahelian vegetation and forests that constitute the main habitat for these giraffe. These phenomena coupled with dry climate, a climate change have reduced forage and limits access to water points, together resulting in the disappearance of the subspecies that was once represented across several neighbouring African countries e.g. Senegal, Mauritania, Mali, Nigeria (Ciofolo 1995).

In 1996 it was estimated that only 49 giraffe remained in all West Africa, limited to an area of 840 km² of arid Sahelian scrubland north of the Niger River in the Kouré area, Niger (Suraud et al. 2012). The important efforts of the Government of Niger in collaboration with partners (EU, UNDP, etc.) have strongly contributed to the giraffe growth in number. According to the 2015 census, 499 giraffe were estimated, and the most recent census in 2017 estimated ~600 individuals (Zabeirou 2017).

As the population increased, during the second National Strategy workshop in 2014, the translocation was discussed. Translocations are considered among the most powerful tools in biodiversity conservation maintaining or reinvigorating

biodiversity and ecosystem function (IUCN SSC, 2013). The most feasible place was selected Gadabedji Biosphere Reserve (GBR), ~800 km east from 'Giraffe Zone'. In November 2018, the first ever translocation of the West African giraffe was undertaken by GCF in support of the Government of Niger, with assistance from local and international partners. Eight subadult giraffe (five females and three males) were individually immobilized and captured in the 'Giraffe Zone'. After habituating for three weeks in the boma, they were transported to GBR (Gašparová et al., 2018). In 2022, another four giraffe were translocated into GBR. The new established satellite population has expanded with five new-born calves showing early signs of successful translocation (Gašparová et al. 2024). The translocation success depends on pre- and post- translocation monitoring, which has been performed thoroughly in the case of West African giraffe.

The situation where giraffe cohabit with local people in the same place is not unique across Africa. The coexistence did not seem to rise any problems in the past, as it mentioned in Ciofolo (1991) and Ciofolo et al. (2000), giraffe, farmers, pastoralists and domestic herds lived alongside each other in totally peaceful way. Neither the eco-ethological studies on feeding behaviour made any reference to crop damages caused by giraffe (Ciofolo & Le Pendu 2002). However, these studies were focused on diurnal observation. Laboureau (1997) reported complains about damages on cowpea harvest and mangoes caused at night by giraffe. The damage was considered as minimal and easily controlled. The ethological study done by Birck (2001) shows the increase in the conflict between the local people and giraffe. This fact was supported by Laxereau (2004). The conflict situations caused that farmers have rather a negative view of giraffe. Yet, communities expressed a good tolerance degree regarding crop damage (Leroy et al. 2009). The most recent census before publishing Leroy´s result estimated 144 individuals (Saraud & Dovi 2007). Nowadays the

giraffe population increase, and it is estimated on ~600 individuals. The question now is to find out if the tolerance of local people persists and how the higher giraffe population is shaping attitude and behaviour of people towards giraffe conservation.
Giraffe are megaherbivore living in fission-fussion social system and the group size and the composition fluctuate (Gloneková et al., 2021; Carter et al., 2013). Temporal and spatial variation in group is often influenced by environmental and social factors (Muller et al., 2018). Many species living in group spent less time by vigilance and more time with resting. Being in the group is beneficial but brings higher probability of predation (Creel et al., 2014; Beauchamp et al., 2021) competition over resources, risk of disease etc. (Molvar et al., 1994). To reduce vulnerability, megaherbivores often adopt a social resting strategy, gathering in groups with conspecifics or other prey species, which provides protection and conserves energy (Shukla et al., 2021).

The West African giraffe is well adapted to harsh condition, arid climate and sparse vegetation. Giraffe shows seasonal migration to cope with the challenging environment. Their regular seasonal movement is linked with the forage availability (Ciofolo, 1995; Le Pendu & Ciofolo, 1999). In 2018 and 2019, in total, nineteen giraffe were satellite tagged with ossi-units to asses their habitat use and spatial ecology. The spatial ecology of giraffe was studied in the past across the continent (Le Pendu & Ciofolo 1999; Van Der Jeughd & Prins, 2000; Fennessy, 2009; Knüsel et al., 2019; D´haen et al., 2019) and the range of space-use differ according to environment. Larger home range (HR) size is reported in arid environments (Fennessy, 2009; Flanagan et al., 2016). There is also different between methods which are used for analysis (D´haen et al. 2019). The HR estimates calculated by Autocorrelated Kernel Density Estimator AKDE is usually larger in comparison with conventional methods such as Kernel Density Estimator (KDE)

and Minimal Convex Polygon (MCP; Fleming et al., 2015). Living in anthropogenic landscape may lead to alters ecological processes (Newmark, 2008) and understanding of animal movement and their respond to disturbances is key in conservation.

As a part of conservation strategies in 2020, the threat analysis was created for use by Niger authorities and NGOs. The population is increasing but still facing several threats, which are more or less probable. One of it is habitat loss connected to agriculture and pastoralism (Walther, 2016). The woody vegetation in tiger bush is decreasing due to several pressures as fuel wood harvesting or grazing by livestock (Wu et al., 2001). The human population growth in Niger is one of the fastest in the word (Potts et al., 2011) and is not connected only to habitat loss but also to increased infrastructure. Several giraffe were found death after the traffic accident. Last but not least, unstable politic situation and potential conflict may dramatically influence the whole population.

1.2 General aims

This study examines the spatial and social behaviour of West African giraffe living only in the Republic of Niger. As a subspecies of northern giraffe, it was not well studied despite being classified as Vulnerable on The Red List of Endangered Species. This subspecies lives in highly populated areas, and their conservation depends on many factors, including the coexistence with local communities, understanding of seasonal migration, social behaviour and the importance of different threats. In this study, we aimed to achieve these objectives:

- Review all available literature focused on West African giraffe including scientific papers and grey literature
- Summarize past and present conservation activities, and evaluate their impact on the conservation of West African giraffe
- Describe local people's attitudes and perceptions towards giraffe
- Explore if the presence of local people and livestock influence the resting behaviour of giraffe
- Describe the seasonal movement pattern and seasonal home range
- Analyse the threats the West African giraffe is currently facing.

1.3 Chapter overview

This thesis consists of three published peer-reviewed articles, one set of published reports summarizing the spatial behaviour, and the published analysis of threats.

The first article is a review (Chapter 2) where we focus on summarizing all available papers and grey literature about West African giraffe. We divided the literature review into parts focusing on monitoring and annual census, local community engagement, habitat use and translocation, all in the context of conservation activities in Niger.

The second article (Chapter 3) is focused on coexistence of giraffe with local people in Niger. We compared two study sites where giraffe live, Giraffe Zone and Gadabedji Biosphere Reserve. We examined the local people's perception and attitude towards giraffe.

In the third article (Chapter 4) we describe the giraffe diurnal activity and the influence of people and livestock presence on its behaviour. We analysed and compared the distance between giraffe and another giraffe and between giraffe and livestock. We investigated if the resting behaviour is affected by the presence of livestock.

The Chapter 5 focuses on the spatial behaviour of giraffe. This chapter consists of a summary of published periodical reports which were made monthly, quarterly and annually for the Niger authorities. This chapter describe the basic home range size and seasonal movement.

The last Chapter 6 is copy of the Threat analysis, which was prepared for the use of Niger authorities and NGOs. Analysis describes the current threat and their potential influence on population.

Note: The referencing formats and guidelines of all the published articles were maintained according to the respective journal formats in the corresponding chapters.

CHAPTER 2

Review

Saving the Last West African Giraffe Population: A Review of Its Conservation Status and Management

This chapter is a literal copy of the published article.

Adapted from: Gašparová, K.; Fennessy, J.; Moussa Zabeirou, A.R.; Abagana, A.L.; Rabeil, T.; Brandlová, K. Saving the Last West African Giraffe Population: A Review of Its Conservation Status and Management. Animals 2024, 14,702. https://doi.org/10.3390/ani14050702

CRediT- **Kateřina Gašparová**: Writing- original draft. **Karolína Brandlová**: Conceptualization, funding acquisition, project administration, writing-review and editing. **Julian Fennessy**: Conceptualization, funding acquisition, resources, writing-review and editing. **Abdoul Razack Moussa Zabeirou**: Resources, writing-review and editing. **Thomas Rabeil**: Resources, writing-review and editing. **Ali Laouel Abagana:** Resources, writing-review and editing.

2 Saving the Last West African Giraffe Population: A Review of Its Conservation Status and Management

Kateřina Gašparová [1], Julian Fennessy [2,3], Abdoul Razack Moussa Zabeirou [1,2], Ali Laouel Abagana [4,†,] Thomas Rabeil [5] and Karolína Brandlová [1,*]

[1]Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Prague, Czech Republic
[2]Giraffe Conservation Foundation, Windhoek 10009, Namibia;
[3]School of Biology and Environmental Science, University College Dublin, D04 V1W8 Dublin, Ireland
[4]Project Sustainable Management of Biodiversity, Ministry of Environment and Sustainable Development, Niamey 920001, Niger
[5]Wild Africa Conservation, Kouara Kano, BP32, Niamey 920001, Niger
[*]Correspondence: brandlova@ftz.czu.cz
[†]The author has passed away.

Simple Summary: This review focuses on the West African giraffe and summarizes their past and present conservation management activities. It evaluates their impact to advise and prioritize future conservation actions moving forward. This review covers monitoring and annual censuses, local community engagement, habitat use, and translocation. Recommendations for the long-term conservation of the West African giraffe are provided as a summary.

2.1 Abstract

The West African giraffe (*Giraffa camelopardalis peralta*) was historically spread across much of the Sudano-Sahelian zone but is now restricted to Niger. Several factors resulted in their dramatic decline during the late 20th century. In 1996, only 49 individuals remained, concentrated in the 'Giraffe Zone'. Conservation activities implemented by the Government of Niger, supported by local communities and NGOs, facilitated their population numbers to increase. This review summarizes past and present conservation activities and evaluates their impact to advise and prioritize future conservation actions for the West African giraffe. The long-term conservation of the West African giraffe is highly dependent on the local communities who live alongside them, as well as supple- mentary support from local and international partners. Recent conservation initiatives range from community-based monitoring to the fitting of GPS satellite tags to better understand their habitat use, spatial movements to expansion areas, and environmental education to the establishment of the first satellite population of West African giraffe in Gadabedji Biosphere Reserve, the latter serving as a flagship for the future restoration of large mammal populations in West Africa. The integration of modern technologies and methods will hopefully provide better-quality data, improved spatial analyses, and greater understanding of giraffe ecology to inform the long-term management of West African giraffe.

2.2 Keywords

Community engagement; conservation translocation; Giraffa camelopardalis peralta; Niger; human–wildlife conflict; West African giraffe; wildlife survey

2.3 Introduction

The West African savanna and Sahel region, historically hosting diverse and abundant wildlife species, now faces increasing pressure from an escalating human population and insecurity, which may lead to increased habitat loss and degradation, poaching, and other associated impacts [1]. Many large- and medium-sized mammal taxa endemic to the region have dramatically declined in the last century [2], e.g., West African lion (*Panthera leo leo*) [3], Derby eland (*Tragelaphus derbianus*) [4,5], African savanna and forest elephant (*Loxodonta africana* and *L. cyclotis*) [6,7], and cheetah (*Acinonyx jubatus*) [8]. The main drivers of such declines are similar for each species, including the degradation of habitat by fragmentation, illegal hunting (poaching), armed (civil) war, competition with livestock, increasing agricultural land, and climate change [9,10]. The majority of West Africa's megafauna does not persist outside protected areas [1,11]. One of the few exceptions in the region is the West African giraffe (*Giraffa camelopardalis peralta*) [12,13], a subspecies of the northern giraffe (G. camelopardalis) [14–16], which rebounded from the brink of extinction in the mid-1990s [17]. Found almost exclusively outside formally protected areas, the West African giraffe population steadily increased by over 1200% in the past three and a half decades, resulting in its downlisting from Endangered (2008) to Vulnerable (2018) on the IUCN Red List [18].

In the late 19th century, the West African giraffe geographical distribution ranged from Senegal in the west, through Mauritania, Gambia, Mali, and Niger, to western Nigeria [19]. A number of geographical barriers, e.g., Niger River, Upper Guinea Forest, etc., likely prevented their distribution across other West and Central African countries; however, by the beginning of the 20th century, the West African giraffe was extirpated from most of its former range [13,19,20]. In the late 1960s, only a few West African giraffe persisted in Mali, Niger, and Senegal [19].

In Niger, the West African giraffe population was extirpated in the Gadabedji Biosphere Reserve (GBR) in the 1970s because of severe drought, which led to illegal hunting [21]. Similar local extirpations occurred in the Ayorou and Tanout area between Agadez and Zinder in the mid-1980s [22]. The first coordinated effort in Niger to curb illegal hunting was initiated in the early 1980s, yet the demise of the West African giraffe continued [23]. In 1996, the remaining population was estimated at only 49 giraffes, and they were geographically restricted to an area of arid Sahelian scrubland in the Kouré area, commonly referred to as the 'Giraffe Zone'. Occasionally, individuals or small herds seasonally migrated from the core range west towards the Mali border (Ouallam) and east towards Gaya close to the Nigerian border [21,22,24].

In 2008, the first ever national strategy for giraffe conservation was developed together with the population viability assessment (PVA) [25], highlighting the need of establishing additional giraffe populations, understanding the habitat use of the giraffe, working with communities, and preventing habitat loss and conflicts related to the expansion of agriculture in the area. Similar points were raised again in the second West African giraffe strategy in 2016 in line with the IUCN Strategy planning guidelines [26].

Today, the West African giraffe predominantly inhabits the 'Giraffe Zone', north of the Niger River around Kouré, starting ~60 km southeast of the capital, Niamey [20,24], and Gadabedji Biosphere Reserve (GBR), which is located in the Sahelian grasslands of central Niger (Figure 2.1).

In this review, we aimed to summarize past and present conservation management activities for the West African giraffe in Niger and evaluate their impact to advise and prioritize future conservation actions.

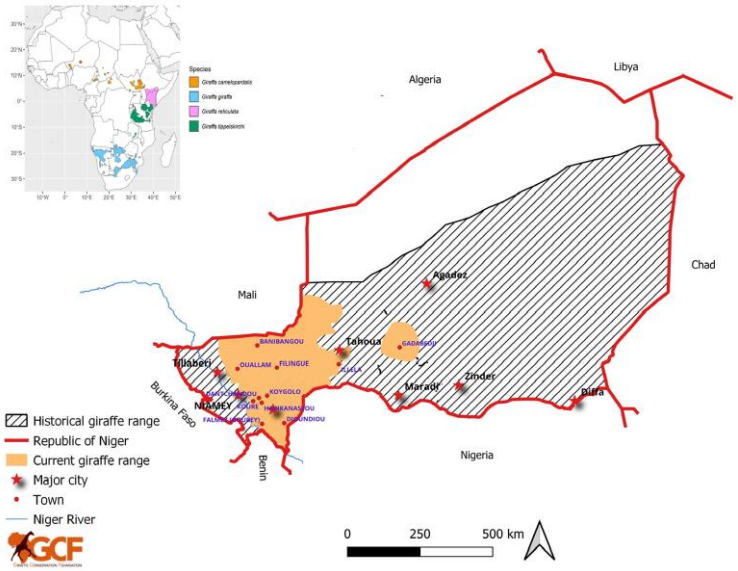

Figure 2.1 Historical and current distribution of West African giraffe in Niger. Inset shows current distribution of all four giraffe species across their range in Africa

2.4 Methods

We undertook an online review of all the relevant scientific publications on Web of Science and Google Scholar, in addition to the available grey literature (project reports, national action plans, conservation strategies, and theses), which highlighted and/or described the ecology and conservation activities of the West African giraffe. During the review, the following keywords were used to ascertain publications related to the West African giraffe: girafe, giraffe, Giraffa camelopardalis peralta, Giraffe Zone, Niger, Girafe d'Afrique de l'Ouest, coexistence. Additionally, we compiled an updated profile of the current activities around the conservation and management of the West African giraffe.

2.5 Results

After the online keyword review of Web of Science and Google Scholar, only 12 scientific papers and 31 grey literature articles referring to the West African giraffe were found. The topics of the papers included conservation activities and census monitoring (16), conservation (13), ecology (5), threats (4), demography (2), human–wildlife coexistence (2), and behavior (1).

2.5.1 Monitoring and Annual Census

Understanding the dynamics of a population is critical for sound conservation planning and management, especially of threatened species [27]. For surveys, regular repeatability and replicability allows for a more accurate assessment of species' demographic parameters [28]. When accompanied with individual attributed population data, e.g., age and sex, one can predict population growth trajectory. Importantly, understanding changes in population size can serve as a proxy for the effectiveness of conservation actions and management practices.

Giraffe's individually unique pelage pattern remains largely unchanged throughout their life and, as such, is a valuable tool for monitoring, e.g., [17,29–32]. The first individual identification census of the West African giraffe in Niger was conducted in 1995 with support from the U.S. Peace Corps, resulting in a population estimate of 49 individuals [33]. Between 1996 and 1999, individual giraffe photographic albums were established through regular surveys under the framework of the "Projet d'Utilisation des Resources Naturelles de la region de Kouré et Dallol Bosso Nord (PURNKO)". No surveys were then undertaken until 2005 when J.P. Suraud, working with the Association for Saving the Giraffes of Niger (ASGN), re-initiated efforts [34,35]. Since then, an annual census in Niger, except for 2001 and 2003, was coordinated by the Government of Niger with support from local community and international NGO

partners [17,21,36–38]. Over the 24 years of surveying, three different methods have been used: (1) ground strip transects (2002), (2) total aerial count (2004), and, predominantly, (3) individual photo identification (1996 to 1998 and 2005 onwards). Both the ground strip transects survey (2002) and the aerial survey (2004) reported more bias than the ground surveys [35]. The ground strip transect method (10 days, 57 transects, 27 km long) led to more biases, such as the small number of observers on motorcycles, lack of individual identification data, double-counting errors, and transect placement [35]. In contrast, the aerial survey was time–cost-effective and covered the whole core 'Giraffe Zone', deploying six people in three ultralight aircrafts undertaking half-day linear transects (1 km apart). However, the results were limited as a standalone assessment, and there was a lack of comparable data, e.g., no individual identification data were recorded, nor age–sex class information, coupled with a large underestimation of the population due to transect widths and limited visibility [22,35]. The long-term vehicle-based surveys provided the most exhaustive and least biased results, despite a level of reduced visibility and accessibility. It proved to be the most reliable method when giraffe numbers were low, and distribution was relatively restricted; hence, the timing of the survey was critical. However, the ground surveys were not comparatively time–cost-effective, especially as more people were involved over an increased time period, and post-survey analysis was time consuming.

The annual survey systematically took place during the rainy season, as giraffes are concentrated on the Kouré and Fandou plateaus. All the giraffes observed were identified, and subsequently they were updated on or added (if new) to the West African giraffe database and initially categorized into one of three age classes: juvenile (6–18 months), subadult (18 months—4 years), and adult (>4 years) [30]. In 2005, a fourth age class (calf—<6 months) was added to further refine the

population structure [35]. Each survey deployed more than 20 people over approximately 45 days, daily searching the area in vehicles until no new giraffes were observed [35,39]. Most recently, the Giraffe Conservation Foundation (GCF) initiated a hot–dry season census to complement the annual survey to assess the most efficient population estimation method for the population [40]. As the population increased, individual identification became more challenging due to their expanded range, and the probability of individual misidentification was multiplying. Unknown, missing, double-counting, and/or deceased animals have likely resulted in higher annual population estimates in recent years. Therefore, to best counter these survey challenges in the future, there is a need to assess and develop relatively time-, cost-effective, and reliable survey and analysis methods to better estimate population numbers [40,41].

Since there was a low number of individuals in 1996, namely 49, the population consistently increased. It reached the highest mean annual growth rate (19%) between 1996 and 1999, immediately following the implementation of the first conservation actions. Until 2005, the survey methods were inconsistent, and it was therefore not possible to accurately evaluate the annual population growth rate. In the following 10 years, the average generation length of a giraffe [42], the mean annual growth rate was 14%, decreasing to 7% between 2016 and 2019 (Figure 2.2). The population growth of the West African giraffe has been truly remarkable, yet the current growth

trend is decreasing, a likely indicator of the population reaching carrying capacity in the ‘Giraffe Zone’.

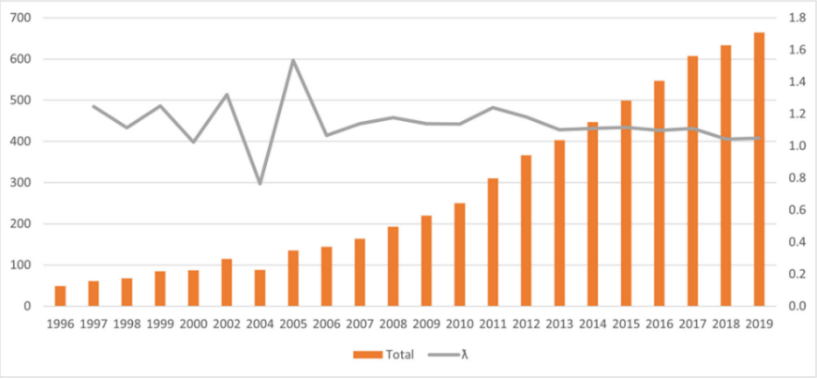

Figure 2.2 The West African giraffe population estimates in Niger from 1996 to 2019. Note: individual photo identification was the most used survey method, except in 2002 when a ground strip transect was used, and in 2004 when an aerial census was conducted. Left Y axis: the total number of individual giraffes counted each year. Right Y axis: ƛ represents the finite rate of growth calculated as (N + 1)/N), where N represents total number of individual giraffes counted in a specific year.

2.5.2 Local Community Engagement

During the mid- to late-1990s, the Government of Niger, alongside local communities with support from WWF, undertook the first targeted efforts to save the last West African giraffe [43]. In September 1996, the PURNKO program, as well as initiating scientific studies and monitoring the giraffe, launched several community projects, which led to the local cessation of poaching. Based on the principles of sustainable natural resources management, PURNKO integrated giraffe conservation within the protection of the “tiger bush” or “brousse tigrée” habitat in the ‘Giraffe Zone’ and the neighboring

ephemeral river system. Among other activities, ecotourism opportunities were initiated alongside various development projects, including soil restoration, forestry, land use management for pastoralist and farming communities, and a microcredit program for women. Following the project end of PURNKO in mid-1999, the future development of those conservation actions was uncertain [34].

As an alternative livelihood opportunity, the Association pour la Valorisation de l´Ecotourisme au Niger (AVEN) was established in 2000 as a local ecotourism initiative to visit the West African giraffe. AVEN and its guides operate in the 'Giraffe Zone' and primarily cooperated with local and international tourist operators to facilitate tourist visits to observe the giraffe, as well as support local education and awareness around giraffes. In the late 2000s, a tourist information center and base for AVEN was established in Kouré with the support of international donor funding. In recent years, regular tourists visited during the peak season; however, tourism totally ceased because of the COVID-19 pandemic and a terrorist attack in August 2020 near Kouré, where six French humanitarians, their driver, and the President of AVEN were killed [44]. Over the past two decades, AVEN has played a critical role in the annual giraffe census and ongoing monitoring of the giraffe in the 'Giraffe Zone', as well as increasing local awareness and education.

In 2001, the L'Association de sauvegarde des girafes du Niger (ASGN) was established with the support of Bioparc de Doué-la-Fontaine and other French zoos and organizations [45]. In the past two decades, the ASGN has helped to protect the West African giraffe through targeted development programs across the 'Giraffe Zone' and neighboring areas. Such support includes improving local peoples' living conditions through access to water, microcredits, education, awareness, monitoring, and more. With an increasing giraffe range, the ASGN more recently expanded their field operations into the Dingazi Region, north of the 'Giraffe Zone'. Importantly, the

positive efforts of the ASGN have been driven from a community-based conservation development approach with a direct link to the long-term management of the West African giraffe.

The positive coexistence of local communities with the West African giraffe has resulted from direct local development and humanitarian assistance. Such support has inevitably been a key factor in curbing giraffe poaching, with relatively few cases reported since 2000 [34,35]. These included five vagrant giraffes from Niger which were poached in Mali in 2000 and two in Nigeria in 2007, as well as a few individual poaching cases in Niger ([17], I. Ciofolo pers. comm.). The coexistence of local people and giraffes is neither unique nor uniform throughout Africa, similarly, occurring in Kenya, Namibia, and Tanzania, for example [13]. However, the relatively harmonious coexistence in the first decade after the establishment of illegal hunting pressure in Niger was a laudable effort spearheaded by the government and NGOs [34,43,46,47].

Over the past few decades, the increasing population numbers and range of both humans and giraffes in Niger has led to growing human–giraffe conflict [47,48]. Daytime crop raiding by giraffes, e.g., cowpeas Vigna unguiculata, has been further exacerbated by the night time raiding of mangoes Mangifera indica [45,47–54]. In retaliation, some local community members have threatened giraffes by chasing them with modified weapons [51], with at least one giraffe being killed [43]. To minimize these conflicts, many local people have fenced their mango trees, but the fields are too large, and giraffes prefer foraging trees which are located within and around them ([33], O. Idrissa, pers. comm.). Despite a high tolerance towards giraffes, conflict will likely increase as both populations grow and competition for resources rises [54]. The carrying capacity of giraffes in the ‘Giraffe Zone’ is hard to assess; however, as the food resources decrease, giraffes are seeking more favorable habitats further away from the core

‘Giraffe Zone’, with greater food availability and fewer human disturbances ([35], A. Zabeirou pers. Comm.). Aside from natural expansion, human–giraffe conflict may likely only be alleviated by augmentation and the creation of new satellite populations of the West African giraffe in their former range across Niger and/or regionally.

2.5.3 Habitat Use

Wildlife population distribution patterns result from individual behavioral processes and are often associated with plant phenology, forage availability, reduction in competition, predator avoidance, and/or avoidance of harsh weather conditions, to name but a few [55–60]. Moreover, and in the context of the West African giraffe, spatial behavior may be influenced by increasing human population and associated disturbances [61].

The remote tracking of large mammals allows for a detailed understanding of individual’s movements, revealing daily and seasonal space-use patterns. The remote tracking of large mammals has become increasingly accessible, with the first giraffe being tracked—an Angolan giraffe *G. giraffa angolensis* in 2002 using a GPS satellite unit in Namibia [31]. The first tracking of the West African giraffe using GPS satellite was subsequently undertaken in 2010 in Niger [35]. Eight collars designed to sit around the base of the giraffe neck were fitted to females and set to send hourly positions. Unfortunately, due to design limitations, they were removed after three months of monitoring because of the irritations and superficial injuries they caused to the giraffes [35]. Importantly, all giraffes recovered well, and all individuals subsequently reproduced (A. Zabeirou pers. comm.).

In a predator-free environment, the population distribution of a prey species is expected to be driven mostly by seasonal forage availability, disease, intra-specific competition, and human disturbances. Suraud [35] observed two separately and

seasonally used core home range (HR) areas of the West African giraffe. During the rainy season, almost all (91%) giraffes resided in the Kouré area, where the 'tiger bush' is highly productive. However, during the dry season, 85% of the giraffe population were observed in the north Dallol Bosso area, where the ephemeral riparian environments around Harikanassou and Dallol Bosso are relatively abundant in preferred giraffe forage: *Faidherbia albida*, *Combretum glutinosum, Balanites aegyptiaca*, and *Prosopis africana* [24,30,35]. Transition movements were observed late in the dry season (late April to late May) when the giraffe moved to the Kouré area, coinciding with the leaf flush of the tiger bush before the rains come, and at the end of the rainy season (November), when giraffe moved to the north Dallol Bosso area to take advantage of the abundant reverse phenology of F. albida during the dry season [30,35].

The first HR sizes for the West African giraffe were calculated using both the KernelDensity Estimator (KDE) and Minimum Convex Polygon (MCP), further highlighting the variance between the seasons. The West African giraffe average HR was estimated at 398 km2 (KDE)/47 km2 (MCP) during the rainy season and 507 km2 (KDE)/91 km2 (MCP) during the dry season [24,35]. It was hypothesized that giraffes avoided areas of increased human presence which were higher in north Dallol Bosso because of increased water availability and better-quality soils for agriculture. Despite the short-term data collection achieved by the initial GPS satellite collars, the preliminary results highlighted variances between giraffe diurnal and nocturnal habitat use. Their diurnal selection appears to be shaped by human disturbances, and giraffes moved closer to (and in) the villages at night, especially when a water point was close and the tree density was high [37]. Some giraffes appeared to be non-resident, occasionally migrating west/northwest towards the Mali border (Ouallam district), and others east towards the Nigerian border (Gaya district)

[22,24,60–62]. Seeking new habitats and the long-distance movement towards (and into) Mali and Nigeria associated with this have and will likely continue to present a poaching threat [22,43,60].

In 2018–19, 19 (15 females and 4 males) giraffes were fitted with GPS solar-powered satellite tags as part of the GCF's collaborative Africa-wide Twiga Tracker Initiative to obtain updated knowledge of their habitat utilization and spatial ecology resulting from an increasing population and range extension of the West African giraffe. This activity was a key output in the implementation of the Government of Niger's second National Giraffe Conservation Strategy [26]. The longevity and function of the units varied between individuals ranging from 2 to 28 months, with units fitted to males all stopping transmission prematurely, likely because of damage caused to the units during necking behavior. The data obtained were invaluable in better understanding current giraffe movements and habitat use, confirming previous seasonal migrations reported and highlighting range expansions [61,63–65].

2.5.4 Translocation

Translocations are considered among the most powerful tools in biodiversity conservation, with the aim of maintaining or reinvigorating biodiversity and ecosystem function [66]. Undertaking pre- and post-feasibility analysis to assess such actions and the subsequent success of any translocation is critical, although unfortunately not common.

The establishment of a new 'satellite' population(s) in Niger was assessed and identified as a feasible and desirable measure for the long-term viability of the West African giraffe, and a key objective in both the first and second National Giraffe Conservation Strategy [25,26]. From a conservation perspective, as numbers of populations increase, the demographic and environmental stochasticity risks reduce.

An initial feasibility study to assess giraffe translocation potentials within Niger was presented and discussed during the second National Strategy workshop in 2014 [26]. The methodology for site selection included GIS analysis and the desktop review of West African giraffe historical range and other giraffe translocation successes, combined with detailed discussions with the Nigerian authorities and a participatory survey of 20 experts who prioritized key translocation elements and the most appropriate sites for release. The assessment proposed three potential translocation sites in Niger: (1) GBR in the central areas, (2) Tadrès Total Reserve in the central north, and (3) Park W on the southwestern border. Each of these sites were objectively analyzed using criteria that influenced the distribution and dynamic of the population, e.g., distance to roads, land use, percentage tree cover, human density, distance to river system, vegetation index NDVI, precipitation, and climate change [26]. Park W was selected as the most suitable for translocation but was rejected for political, security, and strategic reasons with the aim of keeping giraffes in the country and not too close to the neighboring Benin and Burkina Faso within the open Park W ecosystem. Additionally, the potential risk of lion predation coupled with the limited evidence of the West African giraffe historical presence south of the Niger River was highlighted. Whilst identified as a potential site, the GBR was not initially selected as the primary location because of the historical poaching in the area and high latitude linked to the risk of long-term climate change. However, following discussions at the second National Strategy workshop, it was subsequently recommended that the first translocation and establishment of a satellite West African giraffe population should be in GBR as local conditions had become more favorable [67–69].

Over more than a year, several meetings, workshops, and field visits were undertaken to assess the feasibility and plan the practicalities of any potential translocation [70,71]. During the

planning, aspects such as the siting of the boma (holding pen) in the ‘Giraffe Zone’ close to a secondary transport route and being easily accessible for the translocation truck were taken into account, and the route from the boma to GBR was checked for road condition, powerlines, and other potential obstacles. In GBR, the team assessed forage availability and abundance, access to water, security, potential release sites, and more, and all agreed that GBR provided a good long-term habitat for giraffes [70]. Once approved by the Government of Niger, the necessary equipment was obtained, a field recovery trailer (chariot) and translocation truck were assembled, and the bomas were built.

In November 2018, the first ever translocation of the West African giraffe was undertaken by GCF in support of the Government of Niger, with assistance from local and international partners. Eight subadult giraffes (five females and three males) were individually immobilized and captured in the ‘Giraffe Zone’. After habituating for three weeks in the boma, they were transported ~800 km east to GBR, approximately 50 years after their local extinction [72]. Following their release, ongoing monitoring of the giraffe’s movements, social behavior, and forage preferences has been undertaken ([72], R. Zabeirou pers. comm.). Local community Tuareg ecoguards were recruited by GCF and trained in Cybertracker and Garmin InReach technology and worked alongside the local GBR rangers to monitor the giraffes as well as raise local awareness among communities. Additionally, in 2022, an additional four giraffes were translocated from the ‘Giraffe Zone’ to the GBR [J. Fennessy pers. comm.]. Since the translocations, all giraffes have successfully coexisted with the local community, including sharing water points with livestock. The population has expanded, with five calves born, showing early signs of success in the first five years after the initial translocation. Occasionally, the giraffes undertake forays out of the reserve, but with the support of the ecoguards, they are guided back to a stress-free

environment. Interestingly, the preferred forages are *Ziziphus mauritania*, *F. albida*, *Vachellia seyal*, and *V. raddiana* [73–75], which are similar forage species to those eaten by giraffes in the 'Giraffe Zone' and across their range throughout Africa [44]. Long-term post-translocation monitoring has and will continue to be crucial to evaluate their translocation success and advise on future translocations to GBR and other potential sites in the country or regionally.

2.6 Discussion

The conservation success of the rebounding West African giraffe population is a direct result of good policy, governance, and community-based conservation activities. However, the valuable community support observed to date may in time become compromised by the increasing numbers of not only giraffes, but also human and livestock populations. This, in turn, may lead to increased human–giraffe conflict. In understanding the increasing giraffe population and their relationships with the available resources, growing human settlements, local infrastructure development, etc., the continued use of GPS satellite technology, combined with targeted ongoing monitoring and adapted surveys, will help to inform better decision making. Additionally, to decrease the risk of stochastic events such as droughts, disease, insecurity, etc., which are currently a risk in the majority 'Giraffe Zone' population, further conservation translocations should be considered to other approved areas in the country and regionally, so that 'all eggs are not in the one basket'.

Long-term annual surveys of the West African giraffe population using ground counts methods have provided the best comparable data for assessing their growth and guiding conservation management [17,32,41]. However, with increasing giraffe numbers, coupled with human population and livestock growth in the 'Giraffe Zone', their range expansion [76] and insecurity in the region will be challenging to implement

population-wide targeted monitoring. The capture–mark–recapture (CMR) methods have been successfully applied to other large giraffe populations across their range to estimate density and abundance, whilst also monitoring age- and sex-specific survival rates and other life history parameters, all valuable for targeted conservation management, e.g., [30,77,78]. Where the range size and/or security situation does not allow for direct observations, data from CMR surveys in the most accessible areas can be used as a proxy for the validation of the effectiveness of other survey techniques (namely aerial surveys) and provide a basis for detection probability calculations [78]. To increase the detectability of an animal in an aerial survey, a camera system is used to simultaneously image the entire strip observed by the rear-seat observers. For instance, an aerial survey by rear-seat observers in Tsavo NP did not detect 60% of giraffe [79]. As the increased time devoted to processing data is considered to be the main disadvantage of the CMR method, the use of machine learning tools for automatic image recognition will become increasingly valuable, e.g., [80].

Knowledge of individual animals is additionally helpful in terms of genetic population management, including minimizing the mean kinship and the long-term effects of genetic diversity [81,82]. Individual identification provides an excellent opportunity for participatory (citizen) science projects to engage guides, tourists, and local communities, which, besides the scientific value, contribute to increased awareness and an enhanced positive approach towards conservation actions [83]. The genetic health of the West African giraffe was first assessed in 2008 and found to be surprisingly healthy, despite the bottleneck experienced during the 1990s [25]. However, these results are consistent with many studies of ungulates which tend to cope relatively well with high levels of inbreeding, including captive populations, which are then able to adapt when released into the wild, such as Przewalski horse (*Equus*

ferus przewalskii) [84], Scimitar-horned oryx (*Oryx dammah*) [85], and Arabian oryx (*Oryx leucoryx*) [86].

An integrated community-based program has and continues to be a crucial part of West African giraffe conservation in Niger. Although concerns were raised regarding long-term human–giraffe coexistence, especially after the closure of PURNKO [32,46], human–giraffe conflicts have remained relatively rare [41,44,45,51]. However, with ever-increasing giraffe, human [87], and livestock [88] populations, competition for space and resources will rise and shape the future conservation attitudes and actions of the local people. Niger's conservation policy is more participatory than fortress-oriented, and the coexistence with giraffe brings both costs and benefits to local communities, e.g., gaining local support, community development benefits, and reducing management costs [89]. Access to conservation-related benefits can positively influence local attitudes [90]. However, local communities adopt participative approaches in different ways, and if benefits are perceived as (increasingly) small in relation to losses, they may not produce the required effect. For example, in Tanzania (Selous Game Reserve), the benefits are seen as minimal when compared with costs [91]. Wildlife can endanger human lives as well as destroy crops, negatively influencing people's attitudes towards conservation. Thus, this can be viewed as a constraint and a burden rather than as a development benefit [91]. In Botswana, rural communities showed negative attitudes towards conservation despite receiving substantial benefits from the licensed hunting of wildlife. This negative perception was individual rather than community-wide, caused by wildlife crop damages, loss of livestock to predators, loss of land to conservation, and lack of control over wildlife resources [92]. In Niger, the positive value of giraffe for local communities was also challenged by some local community members, particularly as they destroyed individual farmer crops. And the vision of them being a national heritage does not seem to be shared by all [93]. Awareness

programs linked to giraffe conservation have aided local communities to value giraffes in terms of the benefits brought through development programs and ecotourism, but what will happen now that tourism is non- existent because of insecurity and the world COVID-19 pandemic? As one of the world's poorest countries, such issues are a real threat to the long-term sustainability of the West African giraffe.

Environmental shifts resulting from habitat loss, degradation and fragmentation, and climate change may in future be exacerbated by increasing human-related disturbances and stochastic events, limiting giraffe seasonal movements and the use of current key forage areas in Niger. Migratory herbivores adapt their behavior to cope with such changes and remain synchronized with the peak of food availability in the landscape whilst minimizing the potentially negative effects on reproductive success [57]. However, the growing human population and the destruction of habitat will likely affect the West African giraffe. As the population increases, we can expect giraffe splitting into sub-populations and broader ranging behavior in search of suitable forage and fewer human disturbances. As such, they will potentially be at greater risk to poaching in neighboring countries which have not had the same level of awareness and benefits [17].

Understanding the movements and habitat use of threatened species is essential to effective conservation planning and management. Wildlife tracking technology has increased our capacity to collect and analyze vast datasets [94]. The knowledge obtained is critical, from the creation/maintenance of corridors for connectivity [95] to the protection of key habitats [96] and managing isolated populations [30]. Such technological advances will bring about more detailed insights into the monitoring of West African giraffe spatial behavior, as well as understanding their ecological needs and guiding effective long-term conservation in this ever-changing human-dominated landscape [30,97–99].

A key step in the long-term conservation of West African giraffe is their reintroduction to GBR. The establishment of new satellite populations will in time lead to the improved viability of the taxon and lower the negative effect of potential stochastic events. Prolonged drought impacted large areas of the Sahel in the 1970s and 1980s [60,100,101]; although, fortunately, the dry conditions have largely been reversed by increased rainfall in the early 2000s, leading to the 'regreening of the Sahel' [102–104]. In the context of climate change, the long-term trends in Niger show an average annual temperature increase of 0.21 ◦C and total rainfall increase by 26.3 mm per decade, despite the rainy days decreasing by 2.1 days/decade between 1979 and 2015 [105]. Since 2013, Niger´s Wildlife Authority, with support from the UNDP Niger Fauna Corridor Project, has worked diligently towards restoring the GBR habitat. From a giraffe perspective, the southern boundary of the reserve touches the northern limit of agricultural land, which may in time result in human– giraffe conflict [67]; although, to date, this has not been observed. In the long-term, re-introductions of the West African giraffe to other sites in Niger (and regionally) will be valuable for their conservation. Although post-release monitoring is recommended [66], it is often not undertaken, and results are rarely published. One of the potential indicators of giraffe translocation success is the establishment of movement patterns and HR in the new location [97]. In Namibia, four out of six translocated Angolan giraffe established HRs, while two exhibited long-distance movements [97]. Ongoing monitoring of the giraffe translocated to GBR continues, and despite an initial long-distance (>100 km) movement undertaken by four individuals, five years post-reintroduction, the initial (and subsequent) giraffes are very much resident in and around the reserve ([72], R. Zabeirou pers. comm.). Moving forward, to best monitor the expanding West African giraffe population, we need to focus on new and/or adapted techniques for surveying and analysis, especially re- garding gaining a higher reliability of

population size estimates and/or trends. In terms of community conservation, increased efforts should be targeted to minimize human–giraffe conflict in both the 'Giraffe Zone' and GBR. Findings from targeted human dimension studies should be applied, and where appropriate, community-based incentives and livelihood opportunities should be further developed and linked to giraffe conservation efforts. The ongoing scientific interrogation of giraffe spatial movements and use will provide additional understanding of the mechanisms to cope with ecological and human-induced constraints. Additionally, the analyzed and modeled results can advise predictions for future reintroduced populations and the designing of (or maintaining) wildlife corridors and connectivity. Finally, the initial success of the GBR translocations serves as a flagship restoration program for large mammal populations across West Africa. In time, it is hoped that similar targeted efforts will be rolled out to secure other wildlife and habitats across the region.

2.7 Conclusions

To ensure the long-term coexistence of West African giraffe and local communities in Niger, the following is recommended: (1) a review of the current survey and monitoring techniques to help better monitor increasing population numbers and range expansion; (2) detailed analysis of human–giraffe conflicts, especially spatial crop-raiding assessment to target community-based incentives (consolation program) in highly populated and expansion areas; (3) development of habitat use and landscape connectivity models to determine key resource use and availability for giraffe and predicting the future expansion of their range; and (4) further translocations to augment current and (re)establish a suitable historical giraffe range.

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2.8 References

1. Brito, J.C.; Durant, S.M.; Pettorelli, N.; Newby, J.; Canney, S.; Algadafi, W.; Rabeil, T.; Pierre-André, C.; Pleguezuelos, J.M.; Wacher, T.; et al. Armed conflicts and wildlife decline: Challenges and recommendations for effective conservation policy in the Sahara-Sahel. Conserv. Lett. 2018, 11, e12446.

2. Weise, F.J.; Vijay, V.; Jacobson, A.P.; Schoonover, R.S.; Groom, R.J.; Horgan, J.; Keeping, D.; Klein, R.; Marnewick, K.; Maude, G.; et al. The distribution and numbers of cheetah (Acinonyx jubatus) in southern Africa. PeerJ 2017, 5, e4096.

3. Henschel, P.; Coad, L.; Burton, C.; Chataigner, B.; Dunn, A.; MacDonald, D.; Saidu, L.; Hunter, L.T. The lion in West Africa is critically endangered. PLoS ONE 2014, 9, e83500. [PubMed]

4. Koláčková, K.; Hejcmanová, P.; Antonínová, M.; Brandl, P. Population management as a tool in the recovery of the critically endangered Western Derby eland *Taurotragus derbianus* in Senegal, Africa. Wildl. Biol. 2011, 17, 299–310. [PubMed]

5. Brandlová, K.; Gloneková, M.; Hejcmanová, P.; Vymyslická, J.P.; Aebischer, T.; Hickisch, R.; Mallon, D. Chinko/Mbari drainage basin represents a conservation hotspot for Eastern Derby eland in Central Africa. Afr. J. Ecol. 2018, 56, 194–201.

6. Gobush, K.S.; Edwards, C.T.T.; Balfour, D.; Wittemyer, G.; Maisels, F.; Taylor, R.D. *Loxodonta africana*. In The IUCN Red List of Threatened Species 2021; IUCN: Gland, Switzerland, 2021; p. E.T181008073A181022663.

7. Gobush, K.S.; Edwards, C.T.T.; Balfour, D.; Wittemyer, G.; Maisels, F.; Taylor, R.D. *Loxodonta cyclotis*. In The IUCN Red List of Threatened Species 2021; IUCN: Gland, Switzerland, 2021; p. E.T181007989A181019888.

8. Brugière, D.; Chardonnet, B.; Scholte, P. Large-scale extinction of large carnivores (lion *Panthera leo*, cheetah *Acinonyx jubatus* and wild dog *Lycaon pictus*) in protected

areas of West and Central Africa. Trop. Conserv. Sci. 2015, 8, 513–527.

9. Beever, E.A.; Ray, C.; Wilkening, J.L.; Brussard, P.F.; Mote, P.W. Contemporary climate change alters the pace and drivers of extinction. Glob. Change Biol. 2011, 17, 2054–2070.

10. Di Marco, M.; Buchanan, G.M.; Szantoi, Z.; Holmgren, M.; Grottolo Marasini, G.; Gross, D.; Tranquillli, S.; Botani, L.; Rondinini, C. Drivers of extinction risk in African mammals: The interplay of distribution state, human pressure, conservation response and species biology. Philos. Trans. R. Soc. B 2014, 369, 20130198.

11. Walther, B.A. A review of recent ecological changes in the Sahel, with particular reference to land-use change, plants, birds and mammals. Afr. J. Ecol. 2016, 54, 268–280.

12. O'Connor, D.; Stacy-Dawes, J.; Muneza, A.; Fennessy, J.; Gobush, K.; Chase, M.J.; Brown, M.B.; Bracis, C.; Elkan, P.; Zaberirou, A.R.M.; et al. Updated geographic range maps for giraffe, Giraffa spp., throughout sub-Saharan Africa, and implications of changing distributions for conservation. Mamm. Rev. 2019, 49, 285–299.

13. Brown, M.B.; Kulkarni, T.; Ferguson, S.; Fennessy, S.; Muneza, A.; Stabach, J.; Fennessy, J. Conservation status of Giraffe: Evaluating contemporary distribution and abundance with evolving taxonomic perspectives. In Imperiled: The Encyclopedia of Conservation; DellaSala, D.A., Goldstein, M.I., Eds.; Elsevier Science Publishing Co. Inc.: Amsterdam, The Netherlands, 2021.

14. Fennessy, J.; Bidon, T.; Reuss, F.; Kumar, V.; Elkan, P.; Nilsson, M.A.; Vamberger, M.; Uwe, F.; Janke, A. Multi-locus Analyses Reveal Four Giraffe Species instead of One. Curr. Biol. 2016, 26, 2543–2549. [PubMed]

15. Winter, S.; Fennessy, J.; Janke, A. Limited introgression supports division of giraffe into four species. Ecol. Evol. 2018, 8, 10156–10165.

16. Coimbra, R.T.F.; Winter, S.; Kumar, V.; Koepfli, K.P.; Gooley, R.M.; Dobrynin, P.; Fennessy, J.; Janke, A. Whole-genome analysis of giraffe supports four distinct species. Curr. Biol. 2021, 31, 2929–2938. [PubMed]

17. Suraud, J.P.; Fennessy, J.; Bonnaud, E.; Issa, A.M.; Fritz, H.; Gaillard, J. Higher than expected growth rate of the Endangered West African giraffe Giraffa camelopardalis peralta: A successful human–wildlife cohabitation. Oryx 2012, 46, 577–583.

18. Fennessy, J.; Marais, A.; Tutchings, A. Giraffa camelopardalis ssp. peralta. In The IUCN Red List of Threatened Species; IUCN: Gland, Switzerland, 2018; p. E.T136913A51140803.

19. Happold, D.C.D. The present distribution and status of the giraffe in West Africa. Mammalia 1969, 33, 516–521.

20. Ciofolo, I. West Africa's last giraffes: The conflict between development and conservation. J. Trop. Ecol. 1995, 11, 577–588.

21. Suraud, J.P.; Dovi, O. Giraffes of Niger—2006 census. Bi-Annu. Newsl. Int. Giraffe Work. Group 2007, 1, 12–13.

22. Boulet, H.; Niandou, E.H.I.; Alou, D.D.; Chardonnet, B. Giraffes (*Giraffa camelopardalis peralta*) of Niger. In IUCN/SSC Antelope Specialist Group Report; IUCN: Gland, Switzerland, 2004.

23. Pfeffer, P. Les dernières girafes occidentales, une action exemplaire du WWF France. Panda 1981, 6, 9–10.

24. Le Pendu, Y.; Ciofolo, I. Seasonal movements of giraffes in Niger. J. Trop. Ecol. 1999, 15, 341–353.

25. Brenneman, R.; Chardonnet, P.; Ciofolo, I.; Desbiez, A.; Fennessy, J.; Leus, K.Y.G.; Paolini, C.; Boubacar, D.S.; Vortex Population Modelling Working Group. Mission D'appui Technique Pour la Définition du PHVA (Population and Habitat Viability Assessment) de la Population de Girafe d'Afrique de l'Ouest (*Giraffa camelopardalis peralta*) en vue de la Formulation d'une Stratégie de Conservation; ECOPAS: Niamey, Niger, 2008.

26. UEMOA. Stratégie de Conservation de la Girafe d'Afrique de l'Ouest; UEMOA: Niamey, Niger, 2016.

27. Guschanski, K.; Vigilant, L.; McNeilage, A.; Gray, M.; Kagoda, E.; Robbins, M.M. Counting elusive animals: Comparing field and genetic census of the entire mountain gorilla population of Bwindi Impenetrable National Park, Uganda. Biol. Conserv. 2009, 142, 290–300.

28. Gaillard, J.M. Contribution à la Dynamique des Populations de Grands Mammifères: L'exemple du Chevreuil (*Capreolus capreolus).* Ph.D. Thesis, Université Claude-Bernard, Villeurbanne, France, 1988.

29. Foster, J.B. The giraffe of Nairobi National Park: Home range, sex ratios, the herd, and food. Afr. J. Ecol. 1966, 4, 139–148.

30. Le Pendu, Y.; Ciofolo, I.; Gosser, A. The social organization of giraffes in Niger. Afr. J. Ecol. 2000, 38, 78–85.

31. Fennessy, J. Ecology of Desert-Dwelling Giraffe, Giraffa camelopardalis Angolensis, in Northwestern Namibia. Ph.D. Thesis, University of Sydney, Sydney, Australia, 2004.

32. D'haen, M.; Fennessy, J.; Stabach, J.A.; Brandlová, K. Population structure and spatial ecology of Kordofan giraffe in Garamba National Park, Democratic Republic of Congo. Ecol. Evol. 2019, 9, 11395–11405.

33. Peterson, P.F. Photograph identification of individual giraffes in the République du Niger. In United States Peace Corps Final Report; United States Peace Corps: Niamey, Niger, 1995; p. 19.

34. Ciofolo, I.; Ambouta, K.; Le Pendu, Y. Les dernières girafes d'Afrique de l'ouest: Sauvegarde assurée ou avenir menacé? Rev. Ecol. 2009, 64, 351–358.

35. Suraud, J.P. Identifying Conservation Constraints for the Last West African Giraffe: Population Dynamics Determining Factors and Spatial Distribution Pattern. Ph.D. Thesis, University of Lyon, Lyon, France, 2011.

36. Suraud, J.P. Giraffes of Niger, 2007 census and perspectives. Bi-Annu. Newsl. Int. Giraffe Work. Group 2008, 2, 4–7.

37. Suraud, J.P. 2008 giraffes in Niger. Bi-Annu. Newsl. Int. Giraffe Work. Group 2009, 3, 32–33.

38. Ministry of Environment and Sustainable Development, Hunting and Protected Areas. Giraffe census in Niger; Ministry of Environment and Sustainable Development, Hunting and Protected Areas: Niamey, Niger, 2016.

39. Zabeirou, A.R.M. National Survey Report of the West African Giraffe, Niger; Giraffe Conservation Foundation: Niamey, Niger, 2017.

40. Zabeirou, A.R.M. Giraffe Conservation in Niger. Hot Season Survey Report; Giraffe Conservation Foundation: Niamey, Niger, 2019.

41. Rabeil, T.; Baouna, A.B.; Garba, H.H.M.; Zabeirou, A.R.M.; Pourchier, C.; Abagana, A. Réunion Technique sur le Suivi des Girafes d'Afrique de l'ouest au Niger; Giraffe Conservation Foundation: Niamey, Niger, 2020.

42. Muller, Z.; Bercovitch, F.; Brand, R.; Brown, D.; Brown, M.; Bolger, D.; Carter, K.; Deacon, F.; Doherty, J.; Fennessy, J.; et al. *Giraffa camelopardalis* (amended version of 2016 assessment). In The IUCN Red List of Threatened Species; IUCN: Gland, Switzerland, 2018; p. e.T9194A136266699.

43. Ciofolo, I.; Le Pendu, Y.; Gosser, A. Les girafes du Niger, dernieres girafes d'Afrique de l'Ouest. Rev. Ecol. 2000, 55, 117–128.

44. Maclean, R. 8 Dead after Attack in Wildlife Reserve in Niger. The New York Times. Available online: https://www.nytimes.com/ 2020/08/09/world/africa/niger-giraffe-reserve-attack.html (accessed on 17 May 2022).

45. Association for Saving the Giraffes of Niger (ASGN). Rapport D'activités 2017-Août; ASGN: Niamey, Niger, 2018.

46. Ciofolo, I.; Le Pendu, Y. The feeding behaviour of giraffe in Niger. Mammalia 2002, 66, 183–194.

47. Ciofolo, I. Faune Sauvage et Potentialités Régionales: La Girafe dans la Région de Kouré-Boboye, L'hippopotame Dans la Région d'Ayorou; Rapport IUCN/DFPP: Niamey, Niger, 1991.

48. Leroy, R.; De Visscher, M.N.; Halidou, O.; Boureima, A. The last African white giraffes live in farmers' fields. Biodivers. Conserv. 2009, 18, 2663–2677.

49. Ministry of Environment and Sustainable Development, Hunting and Protected Areas. Regional Technical Workshop on the Development of the Conservation Strategy and Translocation of the West African Giraffe; Ministry of Environment and Sustainable Development, Hunting and Protected Areas: Niamey, Niger, 2015.

50. Laboureau, C. Ethologie de la girafe: Etude des relations mère-jeune. In Etude des Dégâts Occasionnés par les Girafes aux Cultures; Projet PURNKO: Niamey, Niger, 1997.

51. Birck, C. Implication des Acteurs Locaux Dans le Processus de Conservation de la Girafe au Niger; Mémoire de DEA, Muséum National d'Histoire Naturelle: Paris, France, 2001.

52. Luxereau, A. Des animaux ni sauvages ni domestiques, les «girafes des Blancs» au Niger. Anthopozoologica 2004, 39, 289–300.

53. Rabeil, T.; Zabeirou, A.R.M.; Pourchier, C.; Abbagana, A.L.; Sanoussi, D.F.M.; Sahailou, S.; Madougou, I.; Abdoulaye, A.; Idrissa, S.; Boureima, A.; et al. Technical Workshop National Strategy for the Conservation of the West African Giraffe; Giraffe Conservation Foundation: Niamey, Niger, 2019.

54. Gašparová, K.; Blanco, J.; Glikman, J.A.; Fennessy, J.; Zabeirou, A.R.M.; Mahamadou, A.R.A.; Rabeil, T.; Brandlová, K. Social development and biodiversity conservation synergies for the West African giraffe in a human–wildlife landscape. Environ. Conserv. 2023, 50, 259–266.

55. Mysterud, A.; Langvatn, R.; Yoccoz, N.G.; Chr, N. Plant phenology, migration and geographical variation in body weight of a large herbivore: The effect of a variable topography. J. Anim. Ecol. 2001, 70, 915–923.

56. Du Toit, J.T. Large herbivores and savanna heterogeneity. In The Kruger Experience: Ecology and Management of Savanna Heterogeneity; Du Toit, J.T., Rogers, K.H., Biggs, H.C., Eds.; Island Press: Washington, DC, USA, 2003; pp. 292–309.

57. Fryxell, J.M.; Holt, R.D. Environmental change and the evolution of migration. Ecology 2013, 94, 1274–1279. [PubMed]

58. Middleton, A.D.; Kauffman, M.J.; McWhirter, D.E.; Jimenez, D.M.; Cook, R.C.; Cook, J.G.; White, P.J. Linking anti-predator behaviour to prey demography reveals limited risk effects of an

actively hunting large carnivore. Ecology 2013, 16, 1023–1030. [PubMed]

59. Lendrum, P.E.; Anderson, C.R.; Monteith, K.L.; Jenks, J.A.; Bowyer, R.T. Relating the movement of a rapidly migrating ungulate to spatiotemporal patterns of forage quality. Mamm. Biol. 2014, 79, 369–375.

60. Brown, M.B.; Bolger, D.T. Male-biased partial migration in a giraffe population. Front. Ecol. Evol. 2020, 7, 524.

61. Ordiz, A.; Sæbø, S.; Kindberg, J.; Swenson, J.E.; Støen, O.G. Seasonality and human disturbance alter brown bear activity patterns: Implications for circumpolar carnivore conservation? Anim. Conserv. 2017, 20, 51–60.

62. Gašparová, K.; Fennessy, J.; Rabeil, T.; Zabeirou, A.R.M.; Pourchier, C.; Brown, M.; Brandlová, K. Monthly Report of GPS Satellite Tagged West African Giraffe (*Giraffa camelopardalis peralta*), Republic of Niger, October; Giraffe Conservation Foundation: Niamey, Niger, 2019.

63. Gašparová, K.; Fennessy, J.; Rabeil, T.; Zabeirou, A.R.M.; Pourchier, C.; Brown, M.; Brandlová, K. 1st Quarterly Report of GPS Satellite Tagged West African Giraffe (*Giraffa camelopardalis peralta*), Republic of Niger; Giraffe Conservation Foundation: Niamey, Niger, 2019.

64. Gašparová, K.; Fennessy, J.; Rabeil, T.; Zabeirou, A.R.M.; Pourchier, C.; Brown, M.; Brandlová, K. Annual Report of GPS Satellite Tagged West African Giraffe (*Giraffa camelopardalis peralta*), Republic of Niger; Giraffe Conservation Foundation: Niamey, Niger, 2019.

65. Brown, M.B.; Fennessy, J.T.; Crego, R.D.; Fleming, C.H.; Alves, J.; Brandlová, K.; Fennessy, S.; Ferguson, S.; Hauptfleisch, M.; Hejcmanova, P.; et al. Ranging behaviours across ecological and anthropogenic disturbance gradients: A

pan-African perspective of giraffe (*Giraffa spp*.) space use. Proc. R. Soc. B 2023, 290, 20230912.

66. IUCN SSC. Guidelines for Reintroductions and Other Conservation Translocations; Version 1.0; IUCN Species Survival Commission: Gland, Switzerland, 2013.

67. Chardonnet, P.; Crosmary, W.; Fusari, A. Feasibility Study Translocate Giraffe in Niger; Ministre de l´Hydraulique et de l´Environnement: Paris, France, 2014.

68. Simonet, M. Analyse Diachronique Comparative de la Zone de Répartition des Dernières Girafes de l'Afrique de l'Ouest (*Giraffa camelopardalis peralta*) avec la Réserve Totale de Faune de Gadabédji dans le Cadre du Projet de Translocation d'une Dizaine d'Entre Elles fin 2018. Ph.D. Thesis, Université Paris Diderot, Paris, France, 2018.

69. Ismael, A.M.; Issoufou, B.; Biaou, S.S.H.; Ali, L.A.; Oumani, A.A. Principales menaces et caractéristiques des habitats aux girafes d'Afrique de l'ouest (synthèse bibliographique). Eur. Sci. J. 2020, 16, 107–118.

70. Fennessy, J. Niger Giraffe Translocation Assessment Planning Trip, Operation Sahara Giraffe; Giraffe Conservation Foundation: Windhoek, Namibia, 2017.

71. Sahailou, S.; Madougou, I.; Garba, H.H.; Abagana, A.L.; Fatchima, S.D.; Hamadou, O.; Abdou, A.K.; Boureima, A.; Mamane, A.; Saley, A.; et al. Niger National Giraffe Workshop; Ministry of Environment: Niamey, Niger, 2018.

72. Gašparová, K.; Fennessy, J.; Rabeil, T.; Zabeirou, A.R.M.; Brandlová, K. Operation Sahel Giraffe. Translocation and Post-Translocation Monitoring of West African Giraffe from Kouré to Gadabedji Biosphere Reserve, Niger; Giraffe Conservation Foundation: Niamey, Niger, 2018.

73. Zabeirou, A.R.M. Gadabedji Biosphere Reserve. In Giraffe Post-Translocation Report, January 2020; Giraffe Conservation Foundation: Niamey, Niger, 2020.

74. Zabeirou, A.R.M. Gadabedji Biosphere Reserve. In Giraffe Post-Translocation Report, February 2020; Giraffe Conservation Founda- tion: Niamey, Niger, 2020.

75. Zabeirou, A.R.M. Gadabedji Biosphere Reserve. In Giraffe Post-Translocation Report, April 2020; Giraffe Conservation Foundation: Niamey, Niger, 2020.

76. Hamadou, O.; Amadou Oumani, A.; Morou, B.; Mahamane, A. Détermination Du Régime Alimentaire De La Girafe d'Afrique De l'Ouest (*Giraffa camelopardalis peralta* Linnaeus 1758) En Saison Sèche Dans Les Zones Excentrées De Fandou, Dingazi-Banda Et Simiri Au Niger. Eur. Sci. J. 2021, 17, 120–136.

77. Brown, M.B.; Bolger, D.T.; Fennessy, J. All the eggs in one basket: A countrywide assessment of current and historical giraffe population distribution in Uganda. Glob. Ecol. Conserv. 2019, 19, e00612.

78. Lee, D.E.; Bond, M.L. Precision, accuracy, and costs of survey methods for giraffe *Giraffa camelopardalis*. J. Mammal. 2016, 97, 940–948.

79. Lamprey, R.; Pope, F.; Ngene, S.; Griffiths, N.; Frederick, H.; Okita-Ouma, B.; Douglas-Hamilton, I. Comparing an automated high-definition oblique camera system to rear-seat-observers in a wildlife survey in Tsavo, Kenya: Taking multi-species aerial counts to the next level. Biol. Conserv. 2020, 241, 108243.

80. Bolger, D.T.; Morrison, T.A.; Vance, B.; Lee, D.; Farid, H. A computer-assisted system for photographic mark–recapture analysis. Methods Ecol. Evol. 2012, 3, 813–822.

81. Kubátová, A.; Štochlová, K.; Brandlová, K.; Vymyslická, P.J.; Bolfíková, B.Č. Comparison of divergent breeding management strategies in two species of semi-captive eland in Senegal. Sci. Rep. 2020, 10, 8841. [PubMed]

82. Zemanová, H.; Bolfíková, B.Č.; Brandlová, K.; Hejcmanová, P.; Hulva, P. Conservation genetics of the Western Derby eland (*Taurotragus derbianus derbianus*) in Senegal: Integration of pedigree and microsatellite data. Mamm. Biol. 2015, 80, 328–332.

83. Dagorne, D.; Kantã, A.; Rose, J.B. A citizen science approach to monitoring of the Lion *Panthera leo* (Carnivora: *Felidae*) population in Niokolo-Koba National Park, Senegal. J. Threat. Taxa 2020, 12, 15091–15105.

84. Liu, G.; Shafer, A.B.; Zimmermann, W.; Hu, D.; Wang, W.; Chu, H.; Cao, J.; Zhao, C. Evaluating the reintroduction project of Przewalski's horse in China using genetic and pedigree data. Biol. Conserv. 2014, 171, 288–298.

85. Ogden, R.; Chuven, J.; Gilbert, T.; Hosking, C.; Gharbi, K.; Craig, M.; Al Dhaheri, S.S.; Senn, H. Benefits and pitfalls of captive conservation genetic management: Evaluating diversity in scimitar-horned oryx to support reintroduction planning. Biol. Conserv. 2020, 241, 108244.

86. Marshall, T.C.; Sunnucks, P.; Spalton, J.A.; Greth, A.; Pemberton, J.M. Use of genetic data for conservation management: The case of the Arabian oryx. Anim. Conserv. 1999, 2, 269–278.

87. Worldometers.info Homepage. Available online: http://www.worldometers.info (accessed on 17 March 2022).

88. Food and Agriculture Organization of the United (FAO). FAO Homepage. Available online: https://www.fao.org/home/en (accessed on 13 July 2022).

89. Hulme, D.; Murphree, M. African Wildlife and Livelihoods: The Promise and Performance of Community Conservation; James Currey Publishers: London, UK, 2001.

89. Lewis, D.; Kaweche, G.B.; Mwenya, A. Wildlife conservation outside protected areas-lessons from an experiment in Zambia Conserv. Biol. 1990, 4, 171–180.

90. Haller, T.; Galvin, M.; Meroka, P.; Alca, J.; Alvarez, A. Who gains from community conservation? Intended and unintended costs and benefits of participative approaches in Peru and Tanzania. J. Environ. Dev. 2008, 17, 118–144.

91. Parry, D.; Campbell, B. Attitudes of rural communities to animal wildlife and its utilization in Chobe Enclave and Mababe Depression, Botswana. Environ. Conserv. 1992, 19, 245–252.

92. Boureïma, A. Contribution à L'élaboration d'une Stratégie de Conservation à Long Terme de la Girafe (*Giraffa camelopardalis peralta*) au Niger; ECOPAS: Niamey, Niger, 2006.

93. Noonan, M.J.; Tucker, M.A.; Fleming, C.H.; Akre, T.S.; Alberts, C.S.; Ali, A.H.; Altmann, J.; Antunes, P.C.; Belant, J.L.; Beyer, D.; et al. A comprehensive analysis of autocorrelation and bias in home range estimation. Ecol. Monogr. 2019, 89, e01344.

94. Chetkiewicz, C.L.B.; Boyce, M.S. Use of resource selection functions to identify conservation corridors. J. App. Ecol. 2009, 46, 1036–1047.

95. Simpfendorfer, C.A.; Wiley, T.R.; Yeiser, B.G. Improving conservation planning for an endangered sawfish using data from acoustic telemetry. Biol. Conserv. 2010, 143, 1460–1469.

96. Flanagan, S.E.; Brown, M.B.; Fennessy, J.; Bolger, D.T. Use of home range behaviour to assess establishment in translocated giraffes. Afr. J. Ecol. 2016, 54, 365–374.

97. McQualter, K.N.; Chase, M.J.; Fennessy, J.; McLeod, S.R.; Leggett, K.E. Home ranges, seasonal ranges and daily movements of giraffe (*Giraffa camelopardalis giraffa*) in northern Botswana. Afr. J. Ecol. 2015, 54, 99–102.

98. Hart, E.E.; Fennessy, J.; Hauenstein, S.; Ciuti, S. Intensity of giraffe locomotor activity is shaped by solar and lunar zeitgebers. Behav. Process. 2020, 178, 104178.

99. Ayoub, A.T. Extent, severity and causative factors of land degradation in the Sudan. J. Arid. Environ. 1998, 38, 397–409.

100. Dregne, H.E. Land degradation in the drylands. Arid. Land Res. Manag. 2002, 16, 99–132.

101. Hermann, S.M.; Anyamba, A.; Tucker, C.J. Recent trends in vegetation dynamics in the African Sahel and their relationship to climate. Glob. Environ. Change 2005, 15, 394–404.

102. Derdel, C.; Kergoat, L.; Hiernaux, P.; Mougin, E.; Grippa, M.; Tucker, J.C. Re-greening Sahel: 30 years of remote sensing data and field observations (Mali, Niger). Remote. Sens. Environ. 2014, 140, 350–364.

103. Brandt, M.; Mbow, C.; Diouf, A.A.; Verger, A.; Samimi, C.; Fensholt, R. Ground-and satellite-based evidence of the biophysical mechanisms behind the greening Sahel. Glob. Change Biol. 2015, 21, 1610–1620.

104. African Development Bank. National Climate Change Profile: Niger African Development Bank Group. 2018. Available online: https://www.afdb.org/en/documents/niger-national-climate-change-profile (accessed on 13 July 2021).

CHAPTER 3

Social development and biodiversity conservation synergies for the West African giraffe in a human–wildlife landscape

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3 Social development and biodiversity conservation synergies for the West African giraffe in a human–wildlife landscape

Kateřina Gašparová[1], Julien Blanco[2], Jenny A Glikman[3,4], Julian Fennessy[5,6], Abdoul Razack Moussa Zabeirou[1,7,8], Abdoul Razakou Abdou Mahamadou[9], Fortuné Azihou[9], Thomas Rabeil[10] and Karolína Brandlová[1]

[1]Czech University of Life Sciences Prague, Prague, Czech Republic

[2]SENS, IRD, CIRAD, Paul Valery University Montpellier 3, Montpellier, France

[3]Instituto de Estudios Sociales Avanzados (IESA-CSIC), C´ordoba, Spain

[4]San Diego Zoo Wildlife Alliance, Escondido, CA, USA

[5]Giraffe Conservation Foundation, Windhoek, Namibia

[6]School of Biology and Environmental Science, University College Dublin, Dublin, Ireland

[7]Giraffe Conservation Foundation, Niamey, Niger

[8]Sahara Conservation, Saint-Maur-des-Fossés, France;

[9]University of Abomey-Calavi, Abomey-Calavi, Benin

[10]Wild Africa Conservation, Niamey, Niger

Corresponding author: Karolína Brandlová

3.1 Summary

The West African giraffe is restricted to Niger, but historically it inhabited much of the Sudano- Sahelian zone. The population is concentrated in the 'Giraffe Zone' (GZ), an unprotected area with a high human population density. Since the mid-1990s, the giraffe population has steadily increased mainly due to the collective social and conservation initiatives of the government, non-governmental organizations and the local community. In 2018, the first West African giraffe satellite population was established through the reintroduction of eight individuals into Gadabedji Biosphere Reserve (GBR). In this study, we aimed to describe the current state of human–giraffe coexistence, human attitudes towards giraffe and human habits of natural resources use through a questionnaire survey conducted in the GZ and GBR. Although most of the GZ respondents highlighted crop damage caused by giraffe, we also found overall positive attitudes towards the animals. Most respondents from both sites expressed positive attitudes towards giraffe, highlighting that they do not see poaching as a major current threat. However, the giraffe population continues to be directly threatened by habitat loss through firewood cutting, livestock overgrazing and agriculture expansion. Long-term conservation of the West African giraffe is dependent on better habitat protection and understanding of current human–giraffe coexistence through ensuring that giraffe presence will benefit local communities across their range.

3.2 Keywords

Attitude; crop damage; Giraffa camelopardalis peralta; human–wildlife coexistence; natural resources use; Niger; West African giraffe

3.3 Introduction

Reconciling human development and biodiversity conservation is one of the most urgent and largely unresolved challenges of the Anthropocene (e.g., Tucker et al. 2018, Lindsey et al. 2022). At a global scale, more than 1 million species are effectively threatened, directly and indirectly, by human activities (IPBES 2019), associated with rapid human population growth and demands for resources, agricultural expansion, infrastructural development and more (Tilman et al. 2017). Small-holder agriculture has a relatively large impact on deforestation and biodiversity loss in human-dominated landscapes (Millennium Ecosystem Assessment 2005, Perrings & Halkos 2015), with large mammals being particularly at risk (Cardillo et al. 2005). However, wildlife holds significant cultural heritage value not only for local people, but also for people across the world (Macdonald et al. 2015).

The West African giraffe (*Giraffa camelopardalis peralta*) was historically spread across much of the Sudano-Sahelian zone but is now restricted to Niger (Suraud et al. 2012, Brown et al. 2021). Several threats related to human population growth, including poaching, habitat loss and fragmentation, caused its dramatic decline during the later twentieth century (Fennessy et al. 2018). In 1996, only 49 individuals remained, concentrated in the 'Giraffe Zone' (GZ) – a community area commencing c. 60 km from the capital, Niamey (Ciofolo 1998, Le Pendu & Ciofolo 1999). From the mid-1990s, the giraffe population rebounded from the brink of extinction following targeted conservation efforts (Suraud et al. 2012, Fennessy et al. 2016, 2018).

The Government of Niger, with the support of local communities and local and international non-governmental organizations (NGOs), undertook concerted efforts to establish development-linked livelihoods and awareness programmes throughout the GZ whilst fighting against giraffe poaching. Three targeted initiatives were the Projet d'Utilisation des Ressources

Naturelles de Kouré et du Dallol Bosso nord (PURNKO, 'Use of the Natural Resources of Kouré and Northern Dallol Bosso Project') and two giraffe-centred local associations working directly with communities on a range of activities including micro-financing, water provision, habitat restoration, environmental education and ecotourism: the Association to Safeguard Giraffe of Niger (ASGN) and the Association pour la Valorisation de l'Ecotourisme au Niger (AVEN; 'Association for the Valorisation of Ecotourism in Niger'; Fennessy et al. 2018). Local development and humanitarian assistance have been critical to the positive coexistence of local communities with giraffe. Such coexistence assumes willingness to share the land and natural resources with the animal for the sake of both humans and wildlife (Pooley 2021).

In 2018, the first ever reintroduction of West African giraffe in Niger was undertaken by the Giraffe Conservation Foundation, the Government of Niger and partners supporting the implementation of the country's National Giraffe Conservation Strategy. Eight giraffe were reintroduced from the GZ into their former habitat in Gadabedji Biosphere Reserve (GBR; Gašparová et al. 2018). The first ever International Union for Conservation of Nature (IUCN) Red Listing of the West African giraffe resulted in it being categorised as Endangered (in 2008). Today, the population is estimated at c. 600 individuals (Brown et al. 2021). In 2018, the West African giraffe was downlisted to Vulnerable on the IUCN Red List (Fennessy et al. 2018).

The increasing populations of both humans and giraffe have exacerbated human–giraffe conflict in the GZ (Leroy et al. 2009, Ministry of Environment 2015), fuelled by damage inflicted on subsistence farmers, especially their cowpea crops (Vigna unguiculata) and mango trees (Mangifera indica; Laboureau 1997, Luxereau 2004, ASGN 2018, Rabeil et al. 2019). In response to such damage, some local community members have threatened and/or killed giraffe (ASGN 2018, Rabeil et al. 2019, ARM Zabeirou pers. comm. 2022). Many farmers have

fenced their mango trees, but their fields are too large to protect all of the trees, and giraffe prefer to forage from trees that are located within and around these fields (Suraud 2011). Despite a seemingly high tolerance towards giraffe, such conflict will probably continue to increase as both populations grow and competition for limited resources increases. This may shape the future perceptions and attitudes of the local people towards giraffe conservation efforts (Ruppert et al. 2022). As such, it is crucial to understand the current situation and assess changes over time as to whether the benefits of living with giraffe outweigh the costs of coexistence.

In this study, we aimed to: (1) describe the current situation of the West African giraffe in a human-dominated landscape; (2) assess local people's attitudes and perceptions towards giraffe; and (3) understand local people's habits and practices of natural resource use in the GZ and GBR to inform the development of beneficial human–giraffe relationships in both areas.

3.4 Methods

3.4.1 *Study area*

The GZ lies in a transition area of the W Park Biosphere Reserve; however, it is not officially delimited, nor is it a formally protected area. It is spread across the central plateaus of Kouré and North Dallol Bosso, commencing c. 60 km south-east of the capital, Niamey. The human population of Niger is estimated to be c. 23 million people from several ethnic groups: Hausa (>50%), Zarma (21%), Touareg (11%), Fulani (6.5%) and other minorities (Fuglestad & Diouldé 2021). People from three of these ethnic groups live in the GZ for at least some of the year. In the rainy season (June–September), farmers from the sedentary Zarma ethnic group practise extensive subsistence farming of cereal crops such as millet, sorghum, beans and corn (Ciofolo 1995). Herders from the Fulani and Touareg ethnic

groups live in isolated encampments and move across the plateaus with their livestock (Ciofolo 1995).
As the only formally protected area in the Nigerien Sahelian zone, GBR lies in the Sahelian grasslands of central Niger and has been legally protected as a Forêt classée et reserve de faune (a forest reserve and faunal reserve) since 1965 (Simonet 2018). Since 1992, dry season (October–April) grazing by local communities within GBR has been permitted under the agreement between the Directorate of National Parks and Reserves (DPN/R) and the Chefs de Groupement (regional authorities working in GBR; Wacher 2010). However, camping, grazing at night, cutting of trees to feed livestock and hunting are forbidden, although this is not always strictly complied with (Wacher 2010). The local Touareg and Fulani people living around GBR are nomadic, whilst the south is settled by Hausa, who practise agriculture and livestock husbandry (UNESCO 2020).

3.4.2 *Data collection*

In July 2020, face-to-face questionnaire surveys were undertaken in both the GZ and GBR study sites (Appendix S1). The survey was conducted by one of the co-authors (ARAM), who is local and with whom the respondents felt more confident. Prior to any interview, the research was explained to the authorities of each village, and they were asked for permission to conduct the survey. The questionnaires were prepared in French whilst the questions were asked in a local language (Zarma or Hausa). The answers were recorded in French and later translated into English. The questionnaires were divided into four subcategories, each with a series of questions (ranging from two to six) and answer opportunities (dichotomous, five-point Likert-type scale or open-ended; see Table 3.1 for exact wording and coding).

3.4.3 *Data analysis*

Data were entered into an Excel file and prepared for analysis by classifying and manually coding the responses so they could be processed by R software (R Core Team 2021). We reduced the original dataset as not all variables were relevant for the multivariate analysis. We then analysed response variability among the respondents through a multiple correspondence analysis (MCA) using the FactoMineR package (Lê et al. 2008) that allows qualitative datasets with many categorical variables to be processed and provides robust results when the number of interviewees exceeds 100 (Pagès 2014). A first MCA was computed based on 19 active variables and 8 supplementary variables (see Table S 3.1), which allowed us to identify 14 outliers. Because of the sensitivity of MCAs to outliers, these were removed from the dataset, and we processed a second MCA by using 17 active variables because 2 of the 19 active variables showed no variability after the outliers' removal. For the attitude-related questions, we used Cronbach's α to measure the internal reliability of the responses (Tavakol & Dennick 2011). One of the questions – 'I would be happier if there was no giraffe in the area'– was removed as it lowered the consistency among the variables (see Table S 3.2). Pearson's $\chi 2$ tests were used to analyse the correlations between couples of variables in IBM SPSS Statistics for Windows, version 27 (IBM Corp., Armonk, NY, USA).

Table 3.1 Examples of the questions asked divided into subcategory and answer type.

Subcategory	Question	Answer
1. Natural resources and potential issue with giraffe	a. Do they eat your crops?	Yes/No
	b. What do they eat?	Open ended
	c. Do they trample on your crops?	Yes/No
	d. How do you protect your crops?	Open ended
	e. Do you graze the cattle?	Yes/No
	f. Where do you graze it?	Open ended
2. Benefits and attitudes towards giraffe	a. Is the giraffe presence beneficial?	Yes/No
	b. Do they allow you to get extra money?	Yes/No
	c. Do you have job in giraffe conservation or tourism?	Yes/No
	d. Do you enjoy seeing giraffe?	Likert scale (Strongly disagree (Strongly agree)
3. Threats to giraffe	a. What can cause death nowadays?	Open ended
	b. Are giraffe poached?	Yes/No
4. Socio-demographic	a. Age	Open ended
	b. Ethnicity	Open ended
	c. Main family income	Open ended
	d. Gender	Male/Female

3.5 Results

3.5.1 Respondents' socio-demographic profiles

Of the 297 respondents (208 in the GZ and 89 in GBR), the majority were male (75.4%; Table 2). Most respondents were middle-aged (54.9%), followed by older adults (33.7%) and young adults (11.4%; Table 2). Three ethnicities were represented: (1) Zarma (64.3%), (2) Touareg (17.1%) and (3) Fulani (17.1%). Most respondents were farmers (68%), 29.3% were herders and other occupations were minor (2.7%). Family income mainly came from agriculture (41.1%) and pastoralism (23.6%), followed by trade (15.2%), income from families living in urban zones (7.7%) and other incomes including undeclared incomes (12.5%). The majority (92.3%) of respondents did not have any education, 4.7% had only primary school education and <3.0% had attended tertiary education (Table 3.2).

3.5.2 People's use of natural resources

Respondents' gathering and use of natural resources were focused on subsistence crop farming (100% in the GZ and 7.9% in GBR), cattle grazing (63.5% in the GZ and 100% in GBR) and fuelwood harvesting (86.5% in the GZ and 91.0% in GBR). In GBR, 96.6% of respondents claimed that they grazed cattle in the Reserve and only during the determined period (dry season; 98.8%). A minority grazed cattle outside of the Reserve (3.4%) or they did not know whether they grazed them inside of the Reserve (1.2%). Most respondents from the GZ (87%) harvested fuelwood in the area where they lived; 6.1% of them did this very often, 92.8% did this sometimes and 1.1% did this rarely. Most respondents from GBR (92.1%) harvested fuelwood, and all of them did this in the morning. Moreover,

28.0% stated that they harvested fuelwood inside the Reserve, and 60.9% did this throughout the year.

Table 3.2 Summary of the socio-demographic parameters of the respondents in the surveys from both study sites, including total count and percentages.

		GZ (%)	GBR (%)
Gender	Male	149 (71.6)	75 (84.3)
	Female	59 (28.4)	14 (15.7)
Age	Young (25-35)	15 (7.2)	19 (21.3)
	Middle age (35-55)	117 (56.3)	46 (51.7)
	Old (>56)	76 (36.5)	24 (27)
Ethnicity	Zarma	191 (87)	0
	Touareg	14 (6.7)	39 (43.8)
	Fulani	3 (1.4)	50 (56.2)
Occupation	Farmer	202 (97.1)	0
	Herder	0	87 (97.8)
	Other	6 (2.9)	2 (2.2)
Education	No education	191 (91.8)	83 (93.3)
	Primary	10 (4.8)	4 (4.5)
	Secondary	0	2 (2.2)
	College	6 (2.9)	0
	Lyceum	1 (0.5)	0

3.5.3 The benefits and detriments of human–giraffe coexistence

The majority (82.7%) of respondents in the GZ complained about crop damage caused by giraffe, while none complained of such an issue in GBR. All GZ respondents who reported an issue with giraffe (57.9%) highlighted crop damage ($\chi 2 = 303$; $p < 0.001$) as the key threat, and this included the eating of crops (100%) and trampling (65.5%). The saliency of crop damage depended on the site ($\chi 2 = 180$; $p < 0.001$), people's occupation ($\chi 2 = 173$; $p < 0.001$) and ethnicity ($\chi 2 = 204$; $p < 0.001$). Farmers in the GZ, who have Zarma ethnicity, responded as being the most vulnerable to damage, especially

as farming was their main occupation. The most damaged crops were cowpeas (*V. unguiculata*; 83.3%) and mangos (*M. indica*; 51.1%); others were sorghum (*Sorghum bicolor*), moringa (*Moringa oleifera*), peanuts (*Arachis hypogaea*) and baobab fruit (Adansonia sp.; Figure 3.1). Almost all damage incidents (97.7%) occurred at night. People's responses to damaged fields were to protect their crops, either in the field or in granaries; the crop damage and protection were correlated with each other ($\chi 2 = 182$; $p < 0.001$). The main types of protection were bringing the harvested crops home (54.8%), putting them into storage (21.0%) and building a moat as a barrier (20.4%), especially around mango trees (93.8%). Some 61.0% of farmers indicated that when they observed giraffe close to their fields or granaries they would chase them away.

With respect to benefits associated with giraffe conservation, micro-credits (32.2%), and the construction of water points (27.1%) were the most reported in the GZ. A few additional benefits included the provision of wire mesh to protect fields (7.1%), the construction of latrines (7.1%), healthcare (6.2%), baobab nurseries (3.8%) and rehabilitation of habitat (1.4%). In GBR, no one interviewed indicated any benefits. Overall, respondents claimed that the presence of giraffe did not directly benefit most residents financially (86.1% GZ; 97.8% GBR). However, the possibility of receiving extra money depended on study site ($\chi 2 = 9.12$; $p = 0.003$), with the possibility of receiving extra money being higher in the GZ. In addition, the respondents from the GZ had more opportunities to be involved

in ecotourism and giraffe conservation than those in GBR $\chi 2 = 41.6$; $p = 0.00$

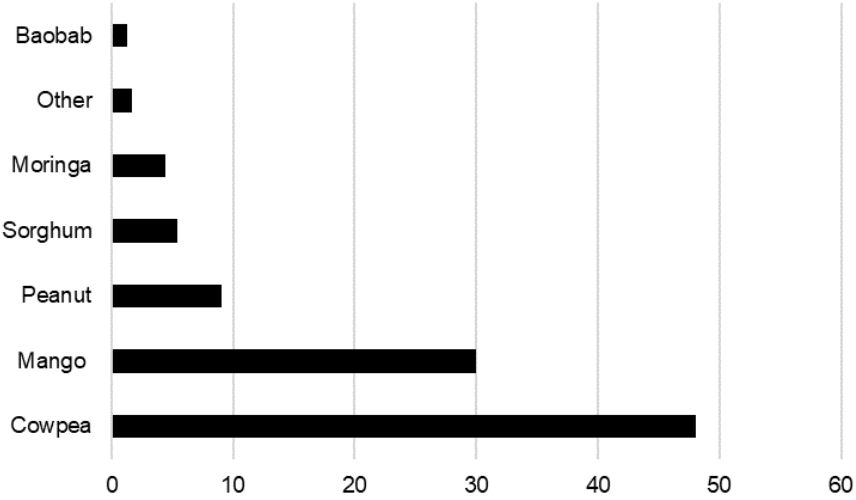

Figure 3.1 Percentage representation of respondents' answers according to the crops that were eaten by the giraffe in the 'Giraffe Zone'. The category 'other' includes aubergine, manioc and fruit of the African fan palm (*Borassus aethiopum*).

3.5.4 Attitudes towards giraffe

The first MCA highlighted a clear separation along the first dimension between respondents in GBR and respondents in the GZ (Fig. 2a); this was mostly explained by respondents in GBR declaring there to be no issues and no crop raiding caused by giraffe in contrast to respondents in the GZ (Figure 3.2b). Interestingly, despite the issues that they reported, respondents in the GZ also declared that they derived benefits from giraffe. The second dimension of the MCA was mainly structured by

a few outliers who harboured a relatively negative attitude towards giraffe, as they disagreed with statements such as 'I enjoy viewing giraffe' or 'I would be sadder without giraffe', or they considered that they would be happier without giraffe (Figure 3.2b).

A second MCA without the 14 outliers confirmed the separation between respondents from the GZ and those from GBR (Figure 3.3a). The first dimension of the MCA tended to separate respondents who reported issues related to giraffe, in particular crop raiding, from those who reported no such issues (Figure 3.3b). The second dimension was linked to respondents' positive attitudes towards giraffe.

Thus, the second MCA highlighted that vulnerability to crop damage did not influence people's attitudes. This was further supported by the fact that 93.6% of respondents considered that the giraffe population should increase in the next 3 years, and 97.0% of them preferred to have giraffe nearby rather than none. A strong positive attitude towards giraffe was also apparent from the answers to the questions about their happiness and enjoyment of nearby giraffe, even though their presence was not always seen as beneficial (66.3%). There was a high consistency among answers related to attitude (Cronbach's $\alpha = 0.856$). The positive feelings and attitudes (48.1%) were further supported by those indicating that they did not poach giraffe because they liked to see them. Most respondents (77.4% in the GZ and 64.0% in GBR) indicated that giraffe deaths are today predominantly due to natural causes, whereas the historical threats were more variable, with poaching being the second most common cause (Table 3.3).

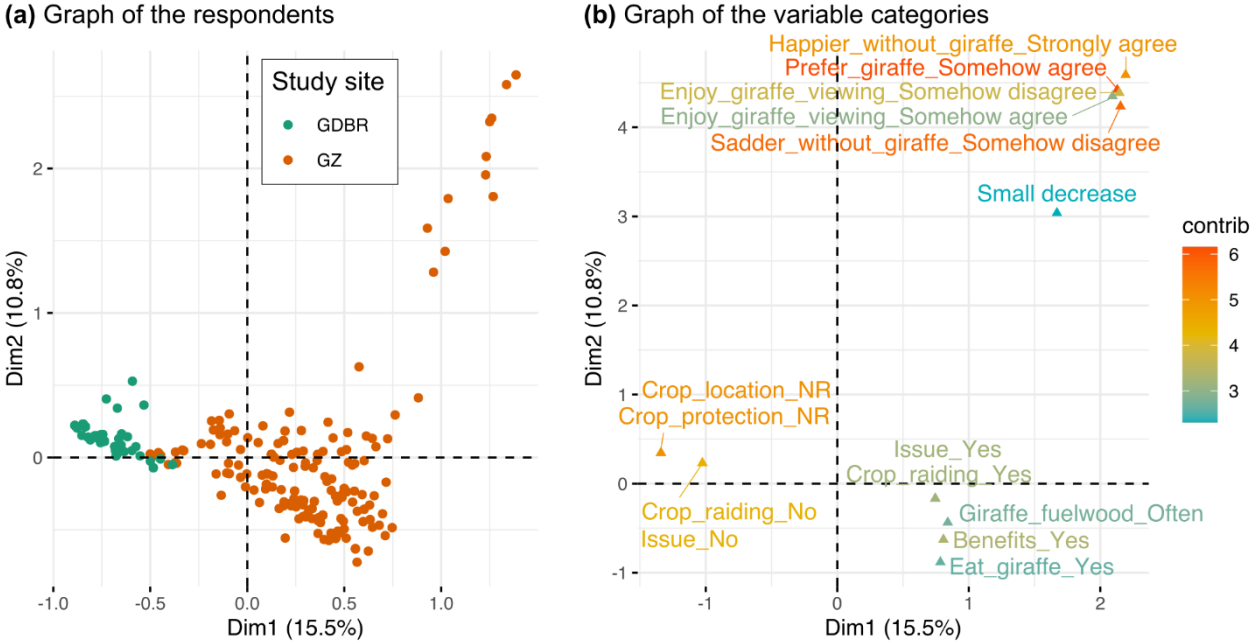

Figure 3.2 Results of the first multiple correspondence analysis (MCA) computed on the basis of all 297 respondents. (a) Plot of the respondents in the two first MCA dimensions, coloured according to study site (Gadabedji Biosphere Reserve (GBR) in green, 'Giraffe Zone' (GZ) in orange). (b) Plot of the active variables coloured according to their contributions to the MCA's first two axes. For the sake of readability, only the 15 most contributing categories are shown.

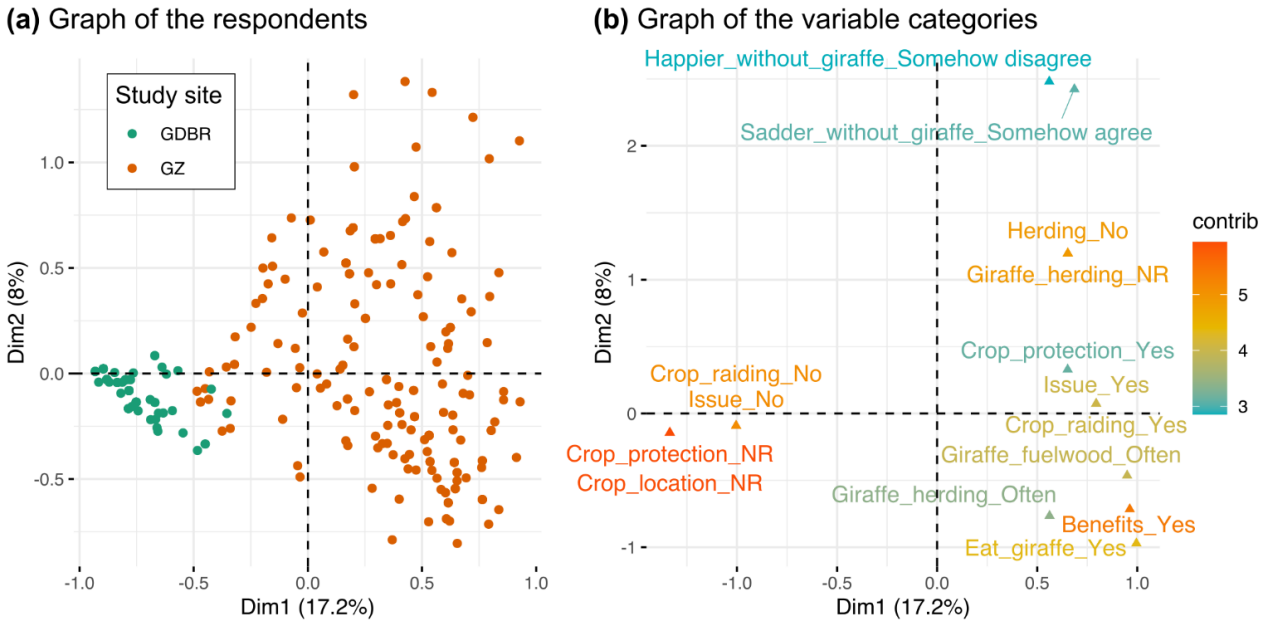

Figure 3.3 Results of a second multiple correspondence analysis (MCA) computed on the basis of 283 respondents (14 outliers removed). (a) Plot of the respondents in the two first MCA dimensions, coloured according to study site (Gadabedji Biosphere Reserve (GBR) in in green, 'Giraffe Zone' (GZ) in orange). (b) Plot of the active variables coloured according to their contributions to the MCA's first two axes. For the sake of readability, only the 15 most contributing variables are shown.

Table 3.3 Historical and current threat responses regarding giraffe in the study areas. Note that the question was open-ended and multiple answers were

Answer	According to you, what is the major threat which could cause the death of a giraffe in the past? (%)	According to you, what can cause the death of a giraffe now? (%)
Natural death	0	220 (75.1)
I do not know	87 (29.3)	48 (16.2)
Poaching	74 (25.6)	0
Accident on road	28 (9.4)	0
Drought	27 (9.1)	1 (0.3)
Illness	18 (6.1)	26 (8.8)
Deforestation	17 (5.7)	1 (0.3)
Fall into hole	16 (5.4)	1 (0.3)
Fighting (necking)	13 (4.4)	0
Stuck in mud	12 (4)	0
Parturition	11 (3.7)	0
Bushfires	6 (2.4)	0
Population explosion	4 (1.3)	0
Snake bite	3 (1)	1 (0.3)
Starvation	0	1 (0.3)

3.6 Discussion

We found that the GZ and GBR residents held overall positive attitudes towards living with giraffe and considered them part of their heritage, despite the increasing reports (ARM Zabeirou pers. comm. 2022) of damage caused to crops and the general lack of direct benefits from giraffe presence.

Conflict with wildlife is not a new or unique phenomenon in Niger (Woodroffe et al. 2005, Watve et al. 2016), and across Africa

herbivores such as hogs/pigs (*Potamochoerus sp.*), African savannah elephant (*Loxodonta africana*) and hippopotamus (*Hippopotamus amphibius*) cause varying degrees of loss and damage to agricultural fields, leading to clashes as to how to manage wildlife (Woodroffe et al. 2005, Gross et al. 2018, Adeola et al. 2022). Moreover, damage to physical property and even severe injuries or deaths amongst humans, although not caused by giraffe, continue to occur (Compaore et al. 2020, Marowa et al. 2021). However, the impact of crop damage caused by the West African giraffe in Niger is possibly unique in Africa (Leroy 2009). Whilst this scenario is less dangerous for human safety, the potential impact on individual livelihoods may in future result in increased retaliation, thus negatively impacting human–giraffe coexistence (Leroy 2009, Ruppert et al. 2022). Whilst negative attitudes towards wildlife stemming from human–wildlife conflict have been observed (Gross et al. 2018), people are often positively biased towards some animals more than others due to aesthetic appreciation. This can influence their conservation decision-making (Stokes 2007, Marešová & Frynta 2008, de Pinho et al. 2014). In general, the attitudes of people living with giraffe across Africa are mostly positive (Hamutenya et al. 2022, Ruppert et al. 2022), and the animals are viewed as 'attractive' enough for them to be considered worth protecting (de Pinho et al. 2014).

We observed a significant difference in terms of resource use and management in the two areas that giraffe inhabit in Niger. This was a result of both the significantly larger population in the GZ (c. 600 individuals; Zabeirou 2018) versus GBR (8 individuals; Gašparová et al. 2018) and the subsistence nature of people relying on agriculture; for example, crop production was the main form of subsistence farming in the GZ,

whereas pastoralism was predominant in GBR. Despite GBR being a formally protected area, it allows grazing of cattle during the dry season, and although firewood cutting and collection are prohibited, this is not strictly enforced (Wacher 2010). In contrast, the GZ is an unprotected area, and the preferred vegetation type of the giraffe – tiger bush – is seemingly facing ongoing pressure from cattle grazing and firewood cutting for the local and capital city markets (Morou et al. 2011, Ismael et al. 2020). Such pressure has led to increased habitat degradation, resulting in reduced giraffe forage available andincreased bare soil (Wu et al. 2000), which directly and indirectly threaten the long-term conservation of the giraffe.

In the GZ, giraffe preferred foraging for cowpeas and mangos, predominantly during the night, despite them not being the most planted crops (Leroy 2009). In the last few decades, local people have increased efforts to protect their crops from giraffe, such as by digging moats around mango trees and storing harvested crops in granaries as soon as possible rather than leaving them in the field (Leroy 2009, Sogbohossou et al. 2013). In some landscapes, protected areas have positive economic, social and environmental impacts on local people, both directly and indirectly (Andam et al. 2010). In the GZ, the main perceived benefits reported were monetary, despite direct financial benefits not being received. However, many respondents were receiving support indirectly through a local micro-credit scheme (ASGN 2018). Since 2001, this scheme has provided support to women living in the GZ by helping them to develop their own income- generating activities (ASGN 2018). This support was directly linked to local giraffe conservation development issues, enabling these women to offset losses caused by giraffe. Since 2000, some community

members have worked as local giraffe guides and educators for AVEN in the GZ, thus allowing them to benefit from tourism and international NGO support (ARM Zabeirou pers. comm. 2022); however, tourism worldwide was negatively impacted by the COVID-19 pandemic, and related conservation efforts have also suffered (van der Merwe et al. 2021).

While ecosystem services were not highlighted as a benefit, respondents generally indicated that giraffe were important to the area in terms of value to the environment and local heritage. Such attitudes were a testament to the benefits that the giraffe bring to the community, led by the government and NGO partners. Overall, local communities held positive attitudes towards giraffe in the GZ and GBR despite negative livelihood impacts, as reported elsewhere (Sekhar 1998, Granados & Wladji 2012, Megaze et al. 2017, Allendorf 2022). Unsurprisingly, the community in the GZ was concerned about crop damage while simultaneously appreciating the monetary and non-monetary benefits of giraffe. Whether or not the costs were considered to outweigh the benefits depended on the individual.

Currently, the main threats facing the giraffe in Niger are both natural deaths and road accidents (Zabeirou 2018, 2019). However, poaching does occur, and data on poaching are not easy to obtain where it occurs at the periphery of the GZ. The last major incident occurred in 2017, when five giraffe were killed by armed bandits close to the border with Mali (Zabeirou 2018). In the same year, eight more individuals died, one as a result of a road accident (Zabeirou 2018). In 2018, eight giraffe died, three from natural causes, four from traffic accidents and one from falling into a well (Zabeirou 2019). Since 2019, 22 individuals have been found dead, some of them because of

road accidents, but some probably died of injuries caused by people defending their crops (ARM Zabeirou pers. comm. 2022).

The Nigerien populations of the West African giraffe, people and livestock are growing, as are the pressures on natural resources. Currently, and over the past few decades, human–giraffe conflict has resulted in crop losses. Local communities, in particular women, have benefitted from living with giraffe through micro- credit schemes, the benefits of which to date have overweighed any costs incurred. In the long term, it will be important to provide ongoing support to those living alongside giraffe and link benefits with conservation development activities to sustain human–giraffe coexistence into the future.

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Ethical standards: None.

3.7 References

Adeola AJ, Sulyman A, Babatunde KO, Onihunwa JO, Mohammed HL, Joshua DA, Adeniji OA (2022) Human–hippo relationship in selected communities around Kainji Dam in New-Bussa, Niger State, Nigeria. Journal of Applied Sciences and Environmental Management 26: 769–774.

Allendorf TD (2022) A global summary of local residents' perceptions of benefits and problems of protected areas. Biodiversity and Conservation 31: 379–396.

Andam KS, Ferraro PJ, Sims KRE, Healy A, Holland MB (2010) Protected areas reduced poverty in Costa Rica and Thailand. Proceedings of the National Academy of Sciences of the United States of America 107: 9996–10001.

ASGN (2018) Rapport d'activités 2017-août. Niamey, Niger: Association to Safeguard Giraffes of Niger.

Brown MB, Kulkarni T, Ferguson S, Fennessy S, Muneza A, Stabach J, Fennessy J (2021) Conservation status of giraffe: evaluating contemporary distribution and abundance with evolving taxonomic perspectives. In: DA DellaSala, MI Goldstein (eds), Imperiled: The Encyclopedia of Conservation (pp. 471–487). Amsterdam, The Netherlands: Elsevier.

Cardillo M, Mace GM, Jones KE, Bielby J, Bininda-Emonds ORP, Sechrest W, et al. (2005) Multiple causes of high extinction risk in large mammal species. Science 309: 1239–1241

Ciofolo I (1995) West Africa's last giraffes: the conflict between development and conservation. Journal of Tropical Ecology 11: 577–588.

Ciofolo I (1998) Rapport final de mission du Projet d´Utilisation des Ressources Naturelles de Kouré et du Dallol Bosso Nord. PURNKO Report. Niamey, Niger: Projet d'Utilisation des Ressources Naturelles de Kouré et du Dallol Bosso nord.

Compaore A, Sirima D, Hema EM, Doamba B, Ajong SN, Di Vittorio M, Luiselli L (2020) Correlation between increased human–elephant conflict and poaching of elephants in Burkina Faso (West Africa). European Journal of Wildlife Research 66: 1–9.

de Pinho JR, Grilo C, Boone RB, Galvin KA, Snodgrass JG (2014) Influence of aesthetic appreciation of wildlife species on attitudes towards their conservation in Kenyan agropastoralist communities. PLoS ONE 9, e88842.

Fennessy J, Bidon T, Reuss F, Kumar V, Elkan P, Nilsson MA, et al. (2016) Multi-locus analyses reveal four giraffe species instead of one. Current Biology 26: 2543–2549.

Fennessy J, Marais A, Tutchings A (2018) Giraffa camelopardalis ssp. peralta. The IUCN Red List of Threatened Species 2018: e.T136913A51140803 [www document]. URL https://www.iucnredlist.org/species/136913/51140803.

Fuglestad F, Diouldé L (2021) Niger. Encyclopaedia Britannica [www document]. URL https://www.britannica.com/place/Niger.

Gašparová K, Fennessy J, Rabeil T, Zabeirou ARM, Brandlová K (2018)

Operation Sahel Giraffe. Translocation and post-translocation monitoring of West African giraffe from Kouré to Gadabedji Biosphere Reserve, Niger [www document]. URL https://giraffeconservation.org/wp-content/uploads/2019/06/Operation-Sahel-Giraffe-Report.pdf.

Granados A, Weladji RB (2012) Human–elephant conflict around Bénoué National Park, Cameroon: influence on local attitudes and implications for conservation. Human Dimensions of Wildlife 17: 77–90.

Gross EM, Lahkar BP, Subedi N, Nyirenda VR, Lichtenfeld LL, Jakoby O (2018) Seasonality, crop type and crop phenology influence crop damage by wildlife herbivores in Africa and Asia. Biodiversity and Conservation 27: 2029–2050.

Hamutenya J, Hauptfleisch M, De Cauwer V, Fennessy J, Fennessy S, Nzuma T (2022) Understanding community attitudes toward the Angolan giraffe (*Giraffa giraffa angolensis*) and its potential reintroduction into Iona National Park. Namibian Journal of Environment 6: A–56.

IPBES (2019) Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (ES Brondizio, J Settele, S Díaz, HT Ngo, eds). Bonn, Germany: IPBES Secretariat.

Ismael AM, Issoufou B, Biaou SSH, Ali LA, Oumani AA (2020) Principales menaces et caractéristiques des habitats aux

girafes d'Afrique de l'ouest (synthèse bibliographique). European Scientific Journal 16: 107.

Laboureau C (1997) I. Ethologie de la girafe: étude des relations mère-jeune. II. Etude sur les dégâts occasionnés par les girafes aux cultures. Niamey, Niger: Projet d'Utilisation des Ressources Naturelles de Kouré et du Dallol Bosso nord.

Lê S, Josse J, Husson F (2008) FactoMineR: an R package for multivariate analysis. Journal of Statistical Software 25: 1–18.

Le Pendu Y, Ciofolo I (1999) Seasonal movements of giraffes in Niger. Journal of Tropical Ecology 15: 341–353.

Leroy R, De Visscher MN, Halidou O, Boureima A (2009) The last African white giraffes live in farmers' fields. Biodiversity and Conservation 18: 2663–2677.

Lindsey PA, Anderson SH, Dickman A, Gandiwa P, Harper S, Morakinyo AB, et al. (2022) Shepherding Sub-Saharan Africa's Wildlife through peak anthropogenic pressure toward a green Anthropocene. Annual Review of Environment and Resources 47: 91–121. Luxereau A (2004) Des animaux ni sauvages ni domestiques, les 'girafes des Blancs' au Niger. Anthropozoologica 39: 289–300.

Macdonald EA, Burnham D, Hinks AE, Dickman AJ, Malhi Y, Macdonald DW (2015) Conservation inequality and the charismatic cat: *Felis felicis*. Global Ecology and Conservation 3: 851–866.

Marešová J, Frynta D (2008) Noah's Ark is full of common species attractive to humans: the case of boid snakes in zoos. Ecological Economics 64: 554–558. Marowa I,

Matanzima J, Nhiwatiwa T (2021) Interactions between humans, crocodiles, and hippos at Lake Kariba, Zimbabwe. Human–Wildlife Interactions 15: 212–227.

Megaze A, Balakrishnan M, Belay G (2017) Human–wildlife conflict and attitude of local people towards conservation of wildlife in Chebera Churchura National Park, Ethiopia. African Zoology 52: 1–8.

Millennium Ecosystem Assessment (2005) Ecosystems and Human Well-Being (Vol. 5). Washington, DC, USA: Island press.

Morou B, Ambouta JMK, Karim S, Mahamane A, Saadou M, Mainassara ZA, Sinsin B (2011) État de dégradation de l'habitat de la girafe (Giraffa camelopardalis peralta Linnaeus, 1758) au Niger. Science et changements planétaires/Sécheresse 22: 57–64.

Pagès J (2014) Multiple Factor Analysis by Example Using R, 1st edition. Boac Raton, FL, USA: Chapman and Hall/CRC.

Perrings C, Halkos G (2015) Agriculture and the threat to biodiversity in Sub-Saharan Africa. Environmental Research Letters 10: 095015

Pooley S (2021) Coexistence for whom? Frontiers in Conservation Science 2: 72699.

R Core Team (2021) R: A Language and Environment for Statistical Computing. Vienna, Austria: R Foundation for Statistical Computing.

Rabeil T, Zabeirou ARM, Pourchier C, Abbagana AL, Sanoussi DFM, Sahailou S, et al. (2019) Technical Workshop National Strategy for the Conservation of the West African Giraffe.

Niamey, Niger: Giraffe Conservation Foundation. Ruppert KA, Sponarski CC, Masiaine S, Larpei L, Lekushan J, Lenaipa D, et al. (2022) Perceptions, attitudes, and beliefs toward giraffes in northern Kenya. Human Dimensions of Wildlife 27: 97–115.

Sekhar NU (1998) Crop and livestock depredation caused by wild animals in protected areas: the case of Sariska Tiger Reserve, Rajasthan, India. Environmental Conservation 25: 160–171.

Simonet M (2018) Analyse diachronique comparative de la zone de répartition des dernières girafes de l'Afrique de l'Ouest (*Giraffa camelopardalis peralta*) avec la Réserve Totale de Faune de Gadabédji dans le cadre du projet de translocation d'une dizaine d'entre elles fin 2018. Dissertation. Paris, France: Université Paris Diderot.

Sogbohossou EA, Kassa BD, Aboibacar Z, Mahamane A (2013) Les conflits homme-girafe dans l'aire centrale de répartition de la girafe (*Giraffa Camelopardalis peralta* Linnaeus 1758) au Niger. Annales des Sciences Agronomiques 17: 107–119.

Stokes DL (2007) Things we like: human preferences among similar organisms and implications for conservation. Human Ecology 35: 361–369.

Suraud JP (2011) Identifying Conservation Constraints for the Last West African Giraffe: Population Dynamics Determining Factors and Spatial Distribution Pattern. Dissertation. Lyon, France: University of Lyon.

Suraud JP, Fennessy J, Bonnaud E, Issa AM, Fritz H, Gaillard J (2012) Higher than expected growth rate of the

Endangered West African giraffe Giraffa camelopardalis peralta: a successful human–wildlife cohabitation. Oryx 46: 577–583.

Tavakol M, Dennick R (2011) Making sense of Cronbach's alpha. International Journal of Medical Education 2: 53–55.

Tilman D, Clark M, Williams DR, Kimmel K, Polasky S, Packer C (2017) Future threats to biodiversity and pathways to their prevention. Nature 546: 73–81. Tucker MA, Böhning-Gaese K, Fagan WF, Fryxell JM, Van Moorter B, Alberts SC, et al. (2018) Moving in the Anthropocene: global reductions in terrestrial mammalian movements. Science 359: 466–469.

UNESCO (2020) Gadabedji Biosphere Reserve, Niger [www document]. URL https://en.unesco.org/africa/gadabedji.

van der Merwe P, Saayman A, Jacobs C (2021) Assessing the economic impact of COVID-19 on the private wildlife industry of South Africa. Global ecology and Conservation 28: e01633.

Wacher T (2010) Wildlife and Land Use Survey of Gadabedji Faunal Reserve, Niger. Niamey, Niger: Sahara Conservation Fund; London, UK: Zoological Society of London.

Watve M, Patel K, Bayani A, Patil P (2016) A theoretical model of community operated compensation scheme for crop damage by wild herbivores. Global Ecology and Conservation 5: 58–70.

Woodroffe R, Thirgood S, Rabinowitz A (eds) (2005) People and Wildlife, Conflict or Co-existence? (Vol. 9). Cambridge, UK: Cambridge University Press.

Wu XB, Thurow TL, Whisenant SG (2000) Fragmentation and changes in hydrologic function of tiger bush landscapes, south-west Niger. Journal of Ecology 88: 790–800.

Zabeirou ARM (2018) Projet de Conservation de la Girafe au Niger Rapport du dénombrement Annuel. Niamey, Niger: Giraffe Conservation Foundation.

Zabeirou ARM (2019) Projet de Conservation de la Girafe au Niger Rapport du dénombrement Annuel. Niamey, Niger: Giraffe Conservation Foundation.

3.8 Supplementary materials

3.8.1 The questionnaires used for the survey

The questionnaire used for Giraffe Zone

Village……..Number……
Date…… Start time…….
Interviewer Name……

1. What do people think about giraffe presence
1.1. Do you have any issues or concerns of having giraffe live nearby?
1.2. Do they eat your crops? If yes, then for each crop…
What do they eat? Quantity Day time (DAY/NIGHT) Season (hot dry/cold dry/rainy)
1.3. Where do you grow your crops? Inside of the area where I live, outside of the area, in different area- what area? _____
1.4. Do they trample on your crops? YES/NO
1.5. If yes, how often does it happen? Never, Rarely, Sometimes, Very often, Always
1.6. How do you protect your fields/granaries?
1.7. What do you do if you see giraffe close to your field or granaries?
1.8. Do you own and/or graze cattle? YES/NO
1.8.1 Where do you or someone in your behalf graze your cattle? Inside of the area where I live, outside of the area, in different area- what area? _____
1.8.2. How often do you meet giraffe while you graze your cattle? Never, Rarely, Sometimes, Very often, Always
1.8.3. Have you had some problem with giraffe during this activity? YES/NO
1.8.4. What do you do when you meet giraffe?
1.9. Do you harvest fuelwood and/or timber? YES/NO
1.9.1. Where do you harvest fuelwood/timber? Inside of the area where I live, outside of the area, in different area- what area?
1.9.2. How often do you harvest fuelwood/timber? Never, Rarely, Sometimes, Very often, Always
1.9.3. How often do you meet giraffe when you harvest fuelwood/timber? Never, Rarely, Sometimes, Very often, Always

1.9.4. Have you had any problem with giraffe when you were harvesting fuelwood/timber? YES/NO

1.9.5. What do you do when giraffe is close to you?

1.10. Do they pose any other problems, according to you? If so, can you elaborate on each problem?

1.11. Do you think of any benefits of having giraffe´s living nearby? For each benefit, could you elaborate and explain?

1.12. Do they allow you to get extra money?

1.13. Do you feel happy to have them nearby?

Overall, do you agree with the following statements:

- I would be happier if there was no giraffe in the area. Fully agree/Somehow agree/ Somehow disagree/Fully disagree
- You would be less happy if there was no giraffe in the area. Fully agree/Somehow agree/ Somehow disagree/Fully disagree
- I prefer having giraffes nearby rather than having no giraffe at all. Fully agree/Somehow agree/ Somehow disagree/Fully disagree

1.14. Have you received any gift from tourists coming to see giraffe? YES/NO/DO NOT WANT TO ANSWER

1.14.1. What kind of gift? Do you have any idea about the value of the gift?

1.15. Do you have a job in tourism that is related to the presence of giraffe? YES/NO/DO NOT WANT TO ANSWER

1.16. Do you have a job in giraffe conservation? YES/NO/DO NOT WANT TO ANSWER

1.17. Do you enjoy seeing giraffes? Fully agree/Somehow agree/ Somehow disagree/Fully disagree

1.18. Do you eat giraffe's meat? Never/Once a year or less/Several times a year/Every month or more

1.19. Do you use any other parts of giraffe. YES/NO (if yes, which parts and in what purpose?)

1.20. Do you think giraffes help you with the working of the savannah. YES/NO (if yes, can you explain?)

1.21. How many giraffe do you think currently live in this area?

1.22. Is this number of giraffe for you in this area: Far Too Little, Too Little, About Right,
Too Many, Far Too Many

1.23. Do you think the number of giraffe in this area in the next 3 years should: Decrease a lot, decrease a little, stay the same, increase a little, Increase a lot

2. How do people know about giraffe?

2.1. Have you already seen a giraffe in the wild with your own eyes? YES/NO

2.1.1. If yes, how many times?

A) Less than once a year
B) Once a year
C) Once a month
D) Once a week
E) More
F) Never
G) Other_____

2.2. When is the last time you saw giraffe in the wild with your own eyes?

A) Less than year ago
B) Year ago
C) Month ago
D) Week ago
E) Less than week ago
F) Other_____

2.3. Have you heard people from your family, village or friends talking about wild giraffes? YES/NO

2.3.1. If yes, how many times?

A) Less than once a year
B) Once a year
C) Once a month
D) Once a week
E) More
F) Never
G) Other_____

2.3.2. Have you heard about giraffe from the TV? YES/NO If yes, how many times?

A) Less than once a year
B) Once a year
C) Once a month
D) Once a week
E) More

F) Never
G) Other_____

3. Threats
3.1. According to you, what is the major threat which could cause the death of a giraffe in the past?
3.2. Do you think this cause could make giraffe disappear from this place?
3.3. According to you, what can cause the death of a giraffe now?
3.4. Are the giraffe poached? If not…
3.4.1. Why don't you (and people of the area) poach them?
3.4.2. If yes, what are the reasons why people poach them?
4. Personal questions
4.1. Gender
4.2. Age
4.3. Role in household
4.4. How long have you lived in this community?
4.5. Ethnicity
4.6. The main occupation? Livestock herder/pastoralist, Livestock broker – buys and sells, Crop farmer, Tourism worker, Business (except livestock), wildlife related, Other
4.7. Does most of your family's income come from: Livestock sales, Subsistence from livestock, Tourism, Wildlife-related, Business
4.8. What is your highest level of completed education? None, primary, secondary, university, post-grad
4.9. Total number of adults living in the household
Total number of children living in the household

The questionnaire used for Gadabedji Biosphere Reserve

Village……..Number……
Date…… Start time…….
Interviewer Name……

5. What do people think about giraffe presence
5.1. Do you have any issues or concerns of having giraffe live nearby?
5.2. Do you grow crops? YES/NO
5.3. If yes- Do giraffe eat your crops? If yes, then for each crop…
What do they eat? Quantity Day time (DAY/NIGHT) Season (hot dry/cold dry/rainy)
5.4. Where do you grow your crops? Inside of the reserve, outside of the reserve? _____
5.5. Do giraffe trample on your crops? YES/NO
5.6. If yes, how often does it happen? Never, Rarely, Sometimes, Very often, Always
5.7. How do you protect your fields/granaries?
5.8. What do you do if you see giraffe close to your field or granaries?
5.9. Do you own and/or graze cattle? YES/NO
5.9.1. Where do you or someone in your behalf graze your cattle? Inside of the reserve, outside of the reserve? _____
5.9.2. At what time during the day do you usually do this activity?
5.9.3. Do you also do this activity during the night?
5.9.4. Do you do this activity all year long, or during specific period?
5.9.5. If yes, in which period during the year?
5.9.6. How often do you meet giraffe while you graze your cattle? Never, Rarely, Sometimes, Very often, Always
5.9.7. Have you had some problem with giraffe during this activity? YES/NO
5.9.8. What do you do when you meet giraffe?
5.10. Do you harvest fuelwood and/or timber? YES/NO
5.10.1. Where do you harvest fuelwood/timber? Inside of the reserve, outside of the reserve? _____
5.10.2. At what time during the day do you usually do this activity?
5.10.3. Do you also do this activity during the night?
5.10.4. Do you do this activity all year long, or during specific period?
5.10.5. If yes, in which period during the year?
5.10.6. How often do you meet giraffe when you harvest fuelwood/timber? Never, Rarely, Sometimes, Very often, Always
5.10.7. Have you had any problem with giraffe when you were harvesting fuelwood/timber? YES/NO

5.10.8. What do you do when giraffe is close to you?
5.11. Do they pose any other problems, according to you? If so, can you elaborate on each problem?
5.12. Do you think of any benefits of having giraffe´s living nearby? For each benefit, could you elaborate and explain?
5.13. Do they allow you to get extra money?
5.14. Do you feel happy to have the giraffe back in the reserve?
Overall, do you agree with the following statements:
- I would be happier if there was no giraffe in the area. Fully disagree/Somehow disagree/ Somehow agree/Fully agree
- You would be less happy if there was no giraffe in the area. Fully disagree/Somehow disagree/ Somehow agree/Fully agree
- I prefer having giraffes nearby rather than having no giraffe at all. Fully disagree/Somehow disagree/ Somehow agree/Fully agree

5.15. Have you been informed about the giraffe translocation before the translocation? YES/NO/DO NOT WANT TO ANSWER

5.16. Have you received any gift from tourists coming to see giraffe? YES/NO/DO NOT WANT TO ANSWER

5.16.1. What kind of gift? Do you have any idea about the value of the gift?

5.17. Do you have a job in tourism that is related to the presence of giraffe? YES/NO/DO NOT WANT TO ANSWER

5.18. Do you have a job in giraffe conservation? YES/NO/DO NOT WANT TO ANSWER

5.19. Do you enjoy seeing giraffes? Fully disagree/Somehow disagree/ Somehow agree/Fully agree
5.20. Do you eat giraffe's meat? Never/Once a year or less/Several times a year/Every month or more

5.21. Do you use any other parts of giraffe. YES/NO (if yes, which parts and in what purpose?)

5.22. How many giraffe do you think currently live in this area?

5.23. Is this number of giraffe for you in this area: Far Too Little, Too Little, About Right, Too Many, Far Too Many

5.24. Do you think the number of giraffe in this area in the next 3 years should: Decrease a lot, decrease a little, stay the same, increase a little, Increase a lot

6. How do people know about giraffe?

6.1. How many times you have seen a giraffe in the wild with your own eyes? YES/NO

H) Less than once a year
I) Once a year
J) Once a month
K) Once a week
L) More
M) Never
N) Other_____

6.2. When is the last time you saw giraffe in the wild with your own eyes?

G) Less than year ago
H) Year ago
I) Month ago
J) Week ago
K) Less than week ago
L) Other_____

6.3. Have you heard people from your family, village or friends talking about wild giraffes? YES/NO

6.3.1. If yes, how many times?

H) Less than once a year
I) Once a year
J) Once a month
K) Once a week
L) More
M) Never
N) Other_____

6.3.2. Have you heard about giraffe from the TV? YES/NO If yes, how many times?

H) Less than once a year
I) Once a year
J) Once a month
K) Once a week
L) More
M) Never
N) Other_____

7. Threats

7.1. According to you, what is the major threat which could cause the death of a giraffe in the past?

7.2. Do you think this cause could make giraffe disappear from this place?

7.3. According to you, what can cause the death of a giraffe now?

7.4. Are the giraffe poached? If not…

7.4.1. Why don't you (and people of the area) poach them?

7.4.2. If yes, what are the reasons why people poach them?

8. Personal questions

8.1. Gender

8.2. Age

8.3. Role in household

8.4. How long have you lived in this community?

8.5. Ethnicity

8.6. The main occupation? Livestock herder/pastoralist, Livestock broker – buys and sells, Crop farmer, Tourism worker, Business (except livestock), wildlife related, Other

8.7. Does most of your family's income come from: Livestock sales, Subsistence from livestock, Tourism, Wildlife-related, Business

8.8. What is your highest level of completed education? None, primary, secondary, university, post-grad

8.9. Total number of adults living in the household

Total number of children living in the household

Table S 3.1 showing the variables used for the first Multiple Correspondence Analysis

Active variables	Do you have any issues or concerns of having giraffe nearby?
	Do they eat your crops?
	Where do you grow your crops?
	Do you protect your crops?
	Do you own/or graze cattle?
	How often do you meet giraffe while you graze your cattle?
	Do you harvest fuelwood?
	How often do you meet giraffe when harvest the fuelwood?
	Do you think of any benefits of having giraffe´s living nearby?
	Do they allow you to get extra money?
	I would be happier if there was no giraffe in the area
	You would be less happy if there was no giraffe in the area
	I prefer having giraffe nearby rather than having no giraffe at all
	Do you have job in giraffe conservation/tourism?
	Do you enjoy seeing giraffe?
	Do you eat giraffe meat?
	Do you use any parts of giraffe for medical purpose?
	Is this number of giraffe in this area
	Do you think the number of giraffe in this area in the next 3 years should
Supplementary variables	Study site
	Gender
	Age
	Role in household
	Ethnicity
	The main occupation
	Does most of your family's income come from
	What is your highest level of completed education?

Table S 3.2 showing the lowering consistency represented be Cronbach´s alpha

	Cronbach´s alpha if item deleted
I would be happier if there was no giraffe in the area	0.856
You would be less happy if there was no giraffe in the area	-1.000
I prefer having giraffe nearby rather than having no giraffe at all	-0.645
Do you enjoy seeing giraffe?	-0.823

CHAPTER 4

Diurnal activity and resting time allocation of West African giraffe in an agropastoral human-dominated landscape

This chapter is literal copy of the published article

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4 Diurnal activity and resting time allocation of West African giraffe in an agropastoral human-dominated landscape

Pavla Hejcmanová[1], Kateřina Gašparová[1], Tamara Fedorova[1], Mara Vukelić[1], Julian Fennessy[2,3], Abdoul Razack Moussa Zabeirou[1, 2, 4], Thomas Rabeil[5], Karolína Brandlová[1] *

[1] Department of Animal Science and Food Processing, Czech University of Life Sciences Prague, Kamýcká 129, Prague – Suchdol, Czechia

[2] Giraffe Conservation Foundation, Windhoek, Namibia

[3] School of Biology and Environmental Science, University College Dublin, Ireland

[4] Sahara Conservation, Saint-Maur-des-Fossés, France

[5] Wild Africa Conservation, Niamey, Niger

*Correspondence: Karolína Brandlová brandlova@ftz.czu.cz

4.1 Abstract

Resting is an integral component of animal behavior, contributing to one's fitness through careful optimization strategies. In large herbivores, resting periods are driven by availability of food, presence of predators, and thermoregulation. A combination of these drivers leads to high variability in resting behaviors and their time allocation throughout the day. However, these drivers are rarely evaluated in the wild. Megaherbivores, including giraffe (*Giraffa spp*.), adopt social resting strategies which enable them to optimize the cost-benefit ratio, with rest and vigilance varying with group size and composition. We investigated resting behavior of the West African giraffe (*G. camelopardalis peralta*) living in a human populated landscape dominated by agropastoralism activities in Niger. Through direct observation we evaluated the influence of group size and composition, and presence of livestock and humans on giraffe resting behavior. We concluded that giraffe increased their resting time with shorter distance to other giraffe and livestock. Livestock did not negatively impact giraffe behavior; rather, they provided a kind of "safe environment". Human presence resulted in only minor changes in vigilance of giraffe and did not significantly affect their resting time. Our findings highlight a positive instance of human-giraffe coexistence in a human dominated landscape, attributed to the long-term benefits of conservation efforts.

4.2 Keywords

Giraffa camelopardalis peralta, wildlife - livestock interaction, anthropogenic disturbance, resting behaviour, human - wildlife coexistence, human-dominated landscape, Niger

4.3 Introduction

Resting is an integral and vital part of an animal behavioral state and rhythm (Siegel, 2008). Resting behaviors vary, from inactivity to sleeping, each having multiple essential functions reflecting an animal's actual ecological and physiological demands (Dallaire, 1986; Craig et al., 2016; Rattenborg et al., 2017). Ultimately, the primary purpose of resting is to manage and strategically allocate energy to enhance reproductive success (Schmidt, 2014). The impact of resting or not resting on an individual's fitness is varied, making the allocation of resting time a critical decision with that involves both benefits and risks. Such decisions require careful optimization strategies, accounting for timing, location with actual environmental, i.e. ecological and human-related context, and duration (Shukla et al., 2021).

The allocation of time between active and resting behaviors is driven by trade-offs between three major needs, i.e. satisfying nutritional requirements through securing food, evading predators, and coping with heat load (Owen-Smith and Goodall, 2014; Mole et al., 2016; Vermeulen et al., 2024). This balance is shaped by the individual's site- and time- specific context. For example, the search for food and the time spent foraging fluctuate with seasonal variation in forage abundance, quality, and environmental heterogeneity. However, the behavioral activity cycles of large herbivores, particularly ruminants, are constrained by the digestive passage rates which force animals into periods of physical inactivity to process the food (Hirakawa, 1997; Jeschke and Tollrian, 2005). Animals therefore exhibit more significant plasticity in time allocation for antipredator behavior, enabling them to switch between foraging, active vigilance, and inactivity, depending on the level of perceived risk, as proposed by risk allocation hypothesis (Lima and Bednekoff, 1999; Luttbeg, 2017). Whilst resting behavior and sleep of large mammals varies considerably (e.g. Duggan et al., 2016, Burger et al., 2020b), studies in the wild are limited (e.g.

Siegel, 2008; Burger et al., 2020a). The presence, abundance and behavior of predators strongly influence these patterns. For instance, in regions with nocturnal predators, prey species remain active, avoiding predator-frequented habitats, and rest during the daylight hours (e.g. Beekman and Prins, 1989; Fischhoff et al., 2007; Owen-Smith and Goodall, 2014; Owen-Smith and Traill, 2017). To reduce vulnerability, megaherbivores often adopt a social resting strategy, gathering in groups with conspecifics or other prey species, which provides protection and conserves energy (Shukla et al. 2021). Giraffe (Giraffa spp.) are megaherbivores with a social resting strategy (Shukla et al., 2021), living in multilevel fission-fusion social systems with fluctuating group size modulated by social preferences (Gloneková et al., 2021; Carter et al., 2013; Burger et al., 2020b). Many herbivore species allocate less time to vigilance and more to resting with increasing group size and higher risk of predation (Creel et al., 2014, Beauchamp et al., 2021). A giraffe's group size may not primarily be driven by predation avoidance, but also other factors such as habitat and presence of calves (Muller et al., 2018). For instance, giraffe allocation of time to vigilance is reported to be greater in woodland environments (Marealle et al., 2020). Additionally, Marealle et al. (2020) observed that both presence of calves and predation risk increased proportion of vigilant individuals, and that proportion of vigilant individuals decreased with an increase in group size. Moreover, the presence of a big bull giraffe influenced vigilance significantly with male vigilance decreasing as they invested more in mating, while females remained vigilant. The vigilance in giraffe therefore seems to also be influenced by presence of specific herd members (Cameron and du Toit, 2005).

Fear from predators is one of the strongest determinants of resting and vigilant behaviors with direct impacts on social structure, and ultimately fitness. With regards to wildlife, humans are "super predators" across the globe, hence their

presence can incite more fear than other predators and may have stronger effects on behavior and vigilance (Ciuti et al., 2012; Zbyryt et al., 2018; Zanette et al., 2023). Intensive human presence in a landscape can be of conservation concern as it can lead to disturbances in wildlife activity patterns, and increased levels of stress and energy expenditures (e.g. Jayakody et al., 2008; Gaynor et al., 2018; Ripari et al., 2022; Tucker et al., 2023), leading to reduced animal fitness and altered population dynamics. Wildlife often responds to anthropogenic disturbance by changing space use patterns (Chen and Koprowski, 2015), allocating more time to vigilance (Scheijen et al., 2021), or shifting specific activities to the night. Specifically, intensifying land use through livestock grazing in wildlife habitats forces them to change their ecological niche and shift their spatiotemporal use of the ecosystem by e.g. contraction of home ranges, decreasing animal movement or becoming more nocturnal (Loft et al., 1991; Scholte et al., 2022; Stabach et al., 2022; Brown et al., 2023). However, wildlife-livestock interactions seem to be predominantly indirect, with direct interactions requiring increasing investigation.

The West African giraffe (*G. camelopardalis peralta*), historically native throughout the Sudano-Sahelian belt in West Africa, now almost exclusively persist in an open, human-inhabited landscape in Niger, called the “Giraffe Zone”, and in a small, recently established population in the Gadabedji Biosphere Reserve, eastern Niger (Gašparová et al., 2024). Although poaching, habitat loss, degradation, and fragmentation were historically the main causes of their decline, the situation has changed significantly in recent decades. Today, despite the close human-giraffe coexistence, human-giraffe conflict is minimal thanks to the long-term conservation efforts of the Nigerian government, local communities and NGOs (Gašparová et al., 2023). The effect of such co-existence in the “Giraffe Zone” has only peripherally been evaluated. Besides the potential risks of pathogen transmissions (Gašparová et al.,

2020), livestock may present an indirect disturbance for the giraffe. Accompanied by pastoralists and inhabiting areas near human settlements, giraffe may experience reduce forage due to wood cutting and limited crop production by local communities (Bond et al., 2021). However, the presence of livestock may also benefit the giraffe as there is no natural predators present, aside from humans (Bond et al., 2019). Mixed species groups of herbivores are common across taxa and habitats, allowing prey species to benefit from the presence of other animals by decreasing individual vigilance and increasing foraging time in areas with predators (Stensland et al., 2003). The West African giraffe therefore represents an ideal model to investigate the influence of livestock, human and other disturbances on resting behavior of megaherbivores in a densely inhabited rural area.

Our study aimed to disentangle the patterns of West African giraffe resting within diurnal (daylight) activities in a human-dominated landscape and to explore whether the presence of livestock and people modulate the time they allocate to active or resting behaviors. Specifically, we hypothesized that presence of another giraffe or livestock does not affect, or can even increase, the resting behavior of an individual giraffe by creating a 'group effect' (as suggested by Muller et al., 2018) which acts as a 'detection and dilution effect' against potential predators (Stensland et al. 2003, Makenbach et al., 2013). In contrast, human presence may have disturbing and fear-inducing effects on an individual. We first identified the group size and composition of each giraffe herd and observed their activity time budgets, i.e. the total allocation and behavior durations according to time of day, and social category, i.e. sex and age. For activity patterns, we particularly focused on resting behaviors, i.e. laying, calm standing, and ruminating. Furthermore, we tested whether the active and resting behavior of an individual giraffe was impacted with the presence of conspecifics, livestock, and people. Finally, we tested the effect

of group size and distance of conspecifics, livestock, and people on giraffe activity and resting time.

4.4 Material and methods

4.4.1 Study site

The “Giraffe Zone” is an unofficial protected area situated across the central plateaus of Kouré and North Dallol Bosso, c. 60 km south-east of the capital Niamey (Figure 4.1). The area is densely populated with people (49/km2), and habitat overlaps with pastoralists and their primarily subsistence agriculture activities and livestock (goat, sheep, and cattle) (Brown et al., 2023).

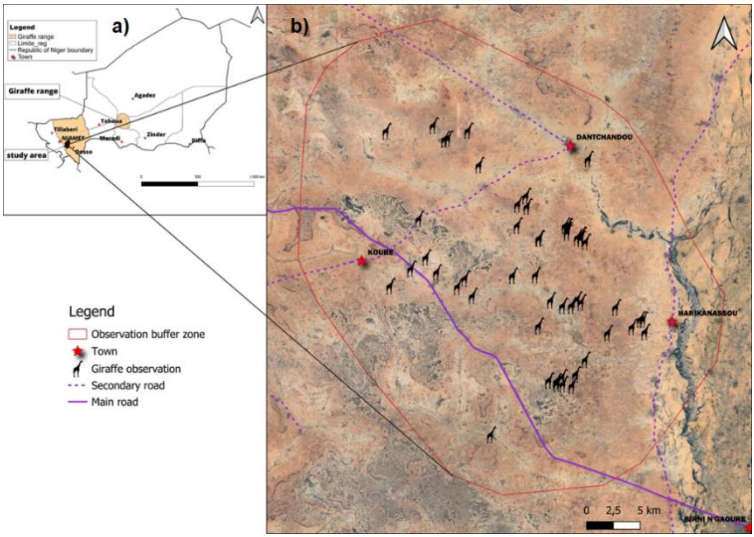

Figure 4.1 Map of the study site: a) illustrative location of the ‘Giraffe Zone’ in Niger, and b) positions of West African giraffe observations within the ‘Giraffe Zone’.

4.4.2 Data collection

To assess West African giraffe activity and their response to people and livestock presence, we observed them over a two-month period in the dry season (January to March 2020). In this period the average diurnal temperature was 31.2 °C (January), 34.7 °C (February), and 38.9 °C (March, WorldData.info, 2024). Direct observations of giraffe were conducted using binoculars during daylight hours from 08:00 to 18:00 using CyberTracker®. Further, we divided each day into three periods: morning (8:00 to 11:00), midday (11:01 to 15:00), and evening (15:01 to 18:00).

Upon spotting a giraffe herd, data collection was initiated. The observer (KG) recorded her own GPS position, number of giraffe in the herd, and their individual sex and age class. Distance and absolute angle of observer to each individual giraffe in the group, livestock, people, and house, if any, was then measured using a Rangefinder laser device (Nikon Monarch 3000 Stabilized). One giraffe within the herd was then assigned as a focal animal, and the distances were measured from that focal individual to herd members, livestock, people, and houses. The distance between focal giraffe to other giraffe, livestock, people, and house was then calculated with the help of basic trigonometric function. After that, the focal individual was observed for 20 min and all activities and their durations were recorded. When the focal sampling was finished, we repeated measuring the distance and angle between the focal individual and all other giraffe, livestock, people, and houses. Following this, another giraffe in the herd was selected for focal sampling. The recorded activities included feeding, walking, vigilance, and social interactions as active behaviors, while resting behavior included standing still and laying on ground,

both with and without ruminating. According to the definition of Suscke et al. (2021) “vigilance” was recorded when individuals were performing an activity but constantly turning their heads around to monitor conspecifics, observers, or their surroundings.

In total, more than 300 giraffe in 54 groups (1-21 individuals) were recorded. For the data analyses, giraffe were classified into three categories: adult-size male, adult-size female, and calf/juvenile of any sex. We undertook 143 focal samplings and measured 521 distances between giraffe and other giraffe, livestock, people, and houses, with a total time of almost 48 hours during 27 days (1-9 per day). The extent of the study was considerably smaller than originally planned due to safety and security restrictions imposed after a terrorist attack in the “Giraffe Zone” in May 2020 and subsequently by the Covid19 pandemic.

4.4.3 Data analysis

For analyses, detailed activity categories were divided into active and resting behavior. First, we calculated proportion of behaviors from data pooled across the data set and visualized them according to daytime and sex-age categories. Then, to assess the length of behavior bouts, we tested differences of activity duration among sex-age categories and across the daytime (separately) using Kruskal-Wallis test followed by pairwise comparisons of Wilcoxon rank sum test with Bonferroni correction.

To test the effects of group size and composition, and distance from another giraffe, livestock (cattle, sheep/goat), people, and houses on the activity of the focal giraffe (active versus resting coded as 1 and 0, respectively), we applied logistic regression

approach with logit link function, assessing models by AIC criterion, Tjur's R squared coefficient of discrimination, and level of significance 0.05. All the analyses were performed in R 4.3.3 version using R base, tidyverse, lme4, MASS, tidy models, sjplot, and cowplot packages (R Core Team, 2024).

4.5 Results

4.5.1 Giraffe group size and composition

We observed a total of 54 independent events. Giraffe were mostly in herds (n = 45; 83.3%) ranging from 2-21 animals, with two (3.7%) and seven (13%) observations of a single adult male and female, respectively. The overall median herd size was four individuals. Males were present in 22 (48.8%) giraffe herds. Herds with males were larger (median size = 8) compared to herds without males (median size = 4). Calves were present in 28 (51.9%) giraffe herds with median herd size of six, compared to herds without calf with median size of three. Mixed herds consisting of females, males, and calves had a median size of ten.

4.5.2 Giraffe diurnal activity

Giraffe were mostly active during the day, spending 75% (n = 333) of their time in active behaviors compared to 25% (n = 97) of time resting (Figure 4.2). The proportion of active and resting behaviors was similar across sex and age categories, with slightly prolonged active behaviors in the evening (Figure 4.3).

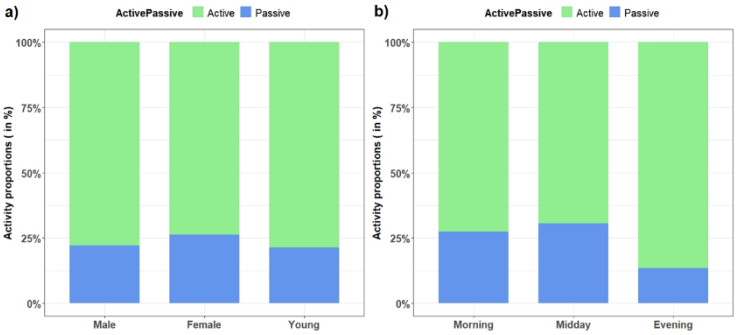

Figure 4.3 Proportions of active and resting behaviors of West African giraffe in the 'Giraffe Zone', Niger divided by a) sex and age categories, and b) time of day.

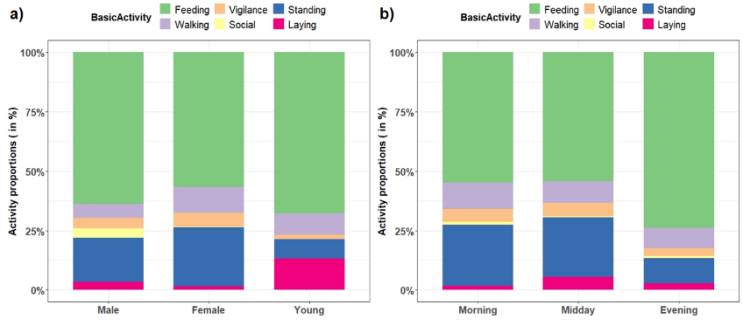

Figure 4.2 Proportions of basic activities of West African giraffe in the 'Giraffe Zone', Niger divided by a) sex and age categories, and b) time of day.

Giraffe allocated most of the daylight time to feeding (59.7%), followed by standing (21.3%), walking (9.6%), vigilance (5%), laying (3.5%), and social interactions (0.9%) (see Figure 2 for proportions of total time allocated to activities across sex and age categories and time of day). On average, laying was infrequent but observed for 13.3 min, and feeding for 7.7 min. Vigilance and walking during the focal bouts were significantly

shorter than other activities (Kruskal-Wallis test, chi-sq= 79, df=5, $p < 0.001$) (see Table 4.1 for mean duration of activities). The mean duration of activities was similar for sex and age categories (all $p > 0.05$, Kruskal-Wallis tests) and for time of day, except for feeding which was greater in the evening compared to the morning (Kruskal-Wallis test, chi-sq= 10, df=2, $p = 0.006$) (Figure 4.4).

Table 4.1. Number (N) and duration (Mean duration and Median duration) of basic diurnal activities (in minutes) of West African giraffe in the 'Giraffe Zone', Niger.

Activity	N	Mean duration	Median duration	Std.Dev.
Feeding	204	7.7	6	5.7
Standing	90	6.2	5	5.3
Laying	7	13.3	16	7.8
Walking	82	3.1	2	3.0
Vigilance	41	3.2	2	4.1
Social	6	4.0	3	3.8

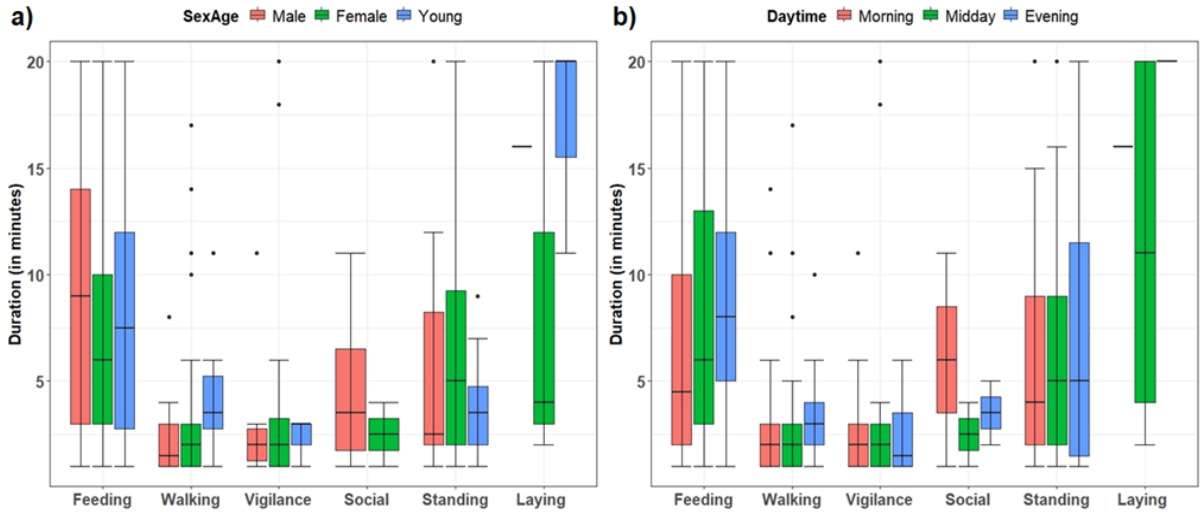

Figure 4.4 Duration of behavioral activity bouts (in minutes) behaviors of West African giraffe in the 'Giraffe Zone', Niger divided by a) sex and age categories, and b) time of day. Line in the box indicates median and error bars are minimum (Q1-1.5*IQR) and maximum (Q3+1.5*IQR).

4.5.3 Giraffe response to animals and people

Giraffe were seen in the presence of other giraffe only (i.e. no livestock, nor people) in 42% of observations at an average distance to the other giraffe of 57.7 m (SE ± 2.9 m, range 1-259 m). In 23% of observations, giraffe were observed in the presence of sheep/goat at an average distance of 82.3 m (SE ± 4.8 m, range 20 - 251 m), and in 15% of cases in the presence of cattle at an average distance of 109.8 m (SE ± 11.2 m, range 11-360 m). Giraffe were observed also in presence of people (14%) and their houses (9%) at an average distance of 95.2 m (SE ± 7.4 m) and 220 m (SE ± 12.4 m), respectively.

Giraffe only spent a small portion of daytime resting. We observed a tendency for them to rest more when in the presence of other herbivores, whether these were other giraffe or livestock. In contrast, their activity increased as the distance from these animals grew. Specifically, the probability of a giraffe being active significantly increased with the distance from another giraffe ($p = 0.03$), and similar tendency ($p < 0.1$) was recorded for the distance to cattle and sheep/goat (Table 4.2, Figure 5a, b). The giraffe herd size had no effect on the time spent being active or resting.

Predictors	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*	*Odds Ratios*	*CI*	*p*
(Intercept)	2.49	1.73 – 3.61	**<0.001**	1.61	0.53 – 4.88	0.392	0.88	0.16 – 3.89	0.873	1.36	0.50 – 3.54	0.54	5.05	1.40 – 19.53	**0.014**	11.12	0.57 – 208.17	0.094
Giraffe	1.01	1.00 – 1.01	**0.03**				1.01	0.99 – 1.04	0.317									
Cattle				1.01	1.00 – 1.02	0.091	1.01	1.00 – 1.02	0.084									
Sheep										1.01	1.00 – 1.02	0.074						
People													1	0.99 – 1.01	0.735			
House																1	0.99 – 1.02	0.993
Observations	345			60			59			104			57			49		
R^2 Tjur	0.015			0.073			0.088			0.031			0.002			0		
AIC	367.541			60.065			60.261			114.844			59.808			31.708		

Table 4.2 Regression models showing the effects of distance of another giraffe, domesticated animals (cattle, sheep/goat), people (pastoralists, women and kids walking outside of village), and human structures on West African giraffe activity in the 'Giraffe Zone', Niger.

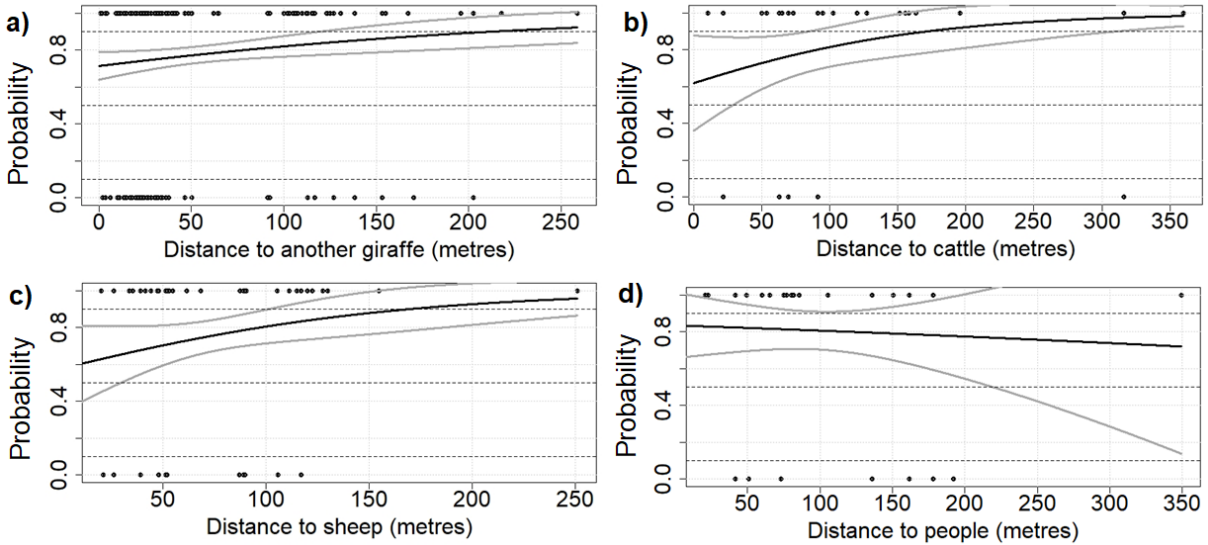

Figure 4.5 Probability of active (1) and resting (0) behavior of West African giraffe in the 'Giraffe Zone', Niger in response to distance to another animals: a) giraffe, b) cattle, c) sheep/goat), and d) people.

There was no effect of giraffe distance to people and their houses ($p > 0.05$, Table 2, Figure 5c, d). There were, however, interesting anecdotal observations. On the rare occasion we observed that giraffe became more vigilant in the presence of people, especially if they carried a wooden stick which is common among the herders. On one occasion we observed giraffe were vigilant towards women with post-harvest remnants of millet which looked like a wooden stick. Regarding interactions between giraffe and livestock, we observed one instance of a giraffe approaching a tree with a donkey tied to it. The donkey appeared afraid and tried to escape. When the giraffe saw that the donkey was not moving away, it changed direction and moved off to another tree. Lastly, we recorded giraffe on one occasion feeding together with sheep on branches cut by people and pods of *Faidherbia albida* on the ground.

4.6 Discussion

We investigated the diurnal activity and resting behaviors of West African giraffe in an agropastoral human-dominated landscape. Our findings suggest that giraffe were not disturbed by the presence of livestock and, in fact, preferred the presence of other animals – whether conspecifics or domestic animals – when resting. They remained highly active during the day and they exhibited increased resting behaviors in proximity to livestock or other giraffe.

The social behavior and population structure of giraffe have increasingly been studied since the early 2000s (Muller and Harris, 2021). Whilst we did not primarily focus on their social structure, herd size was considered an important aspect in assessing their resting behavior. We predominantly observed smaller herds, similar to that of Kordofan giraffe

(G. c. antiquorum) in the DRC (D'haen et al., 2019) and in contrast to larger Nubian giraffe (G. c. camelopardalis) herds in Kenya (n = 5-8) (Muller et al., 2018); largely attributed to habitat type. Herds sizes of the West African giraffe vary seasonally, notably smaller during the dry season (mean = 6, median = 4 individuals) compared to the rainy season (mean = 9; Le Pendu et al., 2000). The low number of lone males' contrasts to almost all other studies e.g. in Kenya lone Nubian giraffe represented 17% of observations of which males were 85% (Muller et al., 2018). Such low observations of males might also be attributed to the female-dominated sex-ratio, similarly to D'haen et al. (2019).

The West African giraffe inhabiting the "Giraffe Zone" were active most of the day, engaging at times in all activities, from feeding to walking, and vigilant scanning to social interactions. As large-bodied ruminant browser, giraffe inherently invest the majority of time in active searching for food and browsing to meet their metabolic demand (Demment and Van Soest, 1985; du Toit and Yetman, 2005). Yet, searching for food implies frequent, short-distance walking which forms typical fine spatiotemporal scale movements of browsing animals between discrete patches of resources (Gordon and Prins 2008), i.e. scattered clumps of trees (e.g. *Combretum spp*., F. albida). In the "Giraffe Zone", those patches are interspersed by pastoral areas and crop fields (Ciofolo, 1995; Leroy et al., 2009; Gašparová et al., 2023), creating a mosaic agropastoral landscape. Consequently, West African giraffe move greater distances daily and maintain larger home ranges than giraffe elsewhere to meet their demands (Brown et al., 2023).

The allocated day time browsing time of the West African giraffe during our study was high (59%) in comparison to previous

findings in the same landscape i.e. dry (46%) and rainy (22.8%) season (Ciofolo and Le Pendu, 2002). As the study was conducted during the dry season, a higher forage time allocation was anticipated (Ciofolo and Le Pendu, 2002). Allocation of time for browsing depends on site-specific resource availability and environmental heterogeneity, varying across giraffe species and populations. For instance, Masai giraffe (*G. tippelskirchi*) in the Masai Mara National Reserve, Kenya spent 36% (females) and 39% (males) of time browsing (Adolfsson, 2009) compared to Masai giraffe in Serengeti National Park (NP), Tanzania, 53.2% (females) and 43.2% (males) (Pellew, 1984). High variability in allocation of time spent feeding occurs in browsers across species regardless of body size: 31.7% in black rhino (*Diceros bicornis*) (Kiwia, 1986), 36% in giant eland (*Tragelaphus derbianus derbianus*; Hejcmanova et al., 2013), 34.3% in greater kudu (*T. strepsiceros*; du Toit and Yetman, 2005), and 45% in African savannah elephant (*Loxodonta africana*; Shannon, 2005). Time allocation also depends on a variety of other non-metabolic factors such as higher stress from anthropogenic disturbances or increased population density which, in fact, is the case of the West African giraffe (Gašparová et al., 2024).

The West African giraffe dedicated 25% of their day to resting, a behavior consistent across age and sex classes and time of day, although marginally increased during midday. Giraffe were mostly standing when resting, including relaxed standing and ruminating. There were, however, several occasions when giraffe laid down, always when together with calves, and sometimes in the presence of sheep/goat, but never with cattle. Resting time was lower compared to Nubian giraffe, which also displayed variance in resting times across the day and seasons,

with higher resting time observed in calves compared to adults (Gitau et al., 2024). However, midday resting was similar to Angolan giraffe (*G. giraffa angolensis*) (Hart et al., 2020) and other African ruminants e.g. buffalo (*Syncerus caffer*) (Owen-Smith and Goodall, 2014; Megaze et al., 2018), blue wildebeest (*Connochaetes taurinus*) (Owen-Smith and Traill, 2017), and sable antelope (*Hippotragus niger*), especially during the dry season. The difference in resting patterns is likely environmental as the study of Nubian giraffe was conducted in a protected area with more diverse habitats and wildlife, including predators and without human and livestock presence (Gitau et al., 2024). From our findings, West African giraffe in the human-dominated landscape decreased resting time during the day, possibly shifting their resting to night when people are less active and there are no other predators.

Proportion of vigilance in the West African giraffe was on average low (5%) with calves being the least vigilant in comparison with adult males and females. Due to the absence of predators in the “Giraffe Zone”, our findings differed from those elsewhere e.g. Paulse et al. (2023) recorded vigilance from 7 - 11% of daylight activity in adult giraffe and up 47% in juveniles.

Inhabiting an agropastoral landscape with human settlements and co-occurrence with domestic animals naturally modulate the West African giraffe activity patterns. Importantly, they did not compete with the livestock for food resources because of their height and preferences. As with other browsers (Fritz et al., 1996), giraffe are little disturbed by livestock, and even associate with them as we observed. Kinga et al. (2018) described large browsers are attracted to livestock at short distances (up to 500 m) in pastoral grazing lands with free

ranging livestock herds accompanied by herders. For approximately 40% of their time, West African giraffe associated with livestock at short distances and within visibility that the Sahelian tiger bush savanna allowed, similar to time they spent with other giraffe (42%). As such, they preferred to 'be in group' regardless of 'a specific group' or species (Muller et al., 2018), but notably often not the same giraffe in a herd. This finding corresponds to their social resting strategy, further supported by the tendency of giraffe to relax and rest in proximity of another animals, even if our data confirmed significant effect only for distance to another giraffe. They were often observed browsing close to sheep/goat yet appeared less relaxed in the presence of cattle. This disturbance may in fact be a result of cattle herds increasing dust and giraffe seeking to avoid it (Tawey, pers. comm., AVEN), or because cattle are often accompanied by herders.

Interestingly, the West African giraffe did not alter their activity or resting patterns in response to human presence. Our observations of giraffe in alert when people appeared within sight or earshot (e.g. kids shouting) were anecdotal. Giraffe were also alert when herders with visible sticks accompanied larger cattle herds. These sticks are commonly used by locals to protect their crops and mango trees from giraffe approaching villages in search for food, by making threatening gestures (Suraud, 2011; Gašparová et al., 2023). Positively, people living in the "Giraffe Zone" generally hold favorable attitudes toward giraffe, are aware of their threatened status, and rarely harm them (Leroy et al., 2009; Suraud, 2011; Gašparová et al., 2023). In recent decades, the West African giraffe in Niger have always lived in a human-dominated landscape. Therefore, they most likely evolved a certain level of habituation and tolerance

towards people (e.g. Blumstein, 2016; Scheijen et al., 2021), with limited disruption to their behavioral patterns while keeping vigilance under specific circumstances. Living in proximity to human settlements is not unique to the West African giraffe, although not always in similar ways. For example, Masai giraffe living in proximity to people in Tanzania showed social disruptions and/or looser social associations within larger giraffe herds (Bond et al., 2021).

Our findings on the activity and resting behavior patterns of West African giraffe and their response to livestock and people is positive for their conservation with the population adapted to the anthropogenic landscape which they inhabit. We demonstrated that long-term awareness campaigns and conservation measures by NGOs and government at local level are beneficial for their co-existence.

4.7 Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

4.8 Author Contributions

PH: Conceptualization (lead), data curation, formal analysis, methodology, writing – original draft, writing – review & editing; KG: Data curation, funding acquisition, investigation, writing – original draft; TF: writing – original draft, writing – review & editing; MV: Data curation, writing – review & editing; JF: Funding acquisition, writing – review & editing; ARMZ: Resources, writing – review & editing; TR: Resources, writing – review & editing; KB: Funding acquisition, methodology, project administration, supervision, writing – review & editing

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4.11 Data Availability Statement

Data available on request

4.12 References

Adolfsson, U. G. (2009). Diurnal behaviour and utilization of shade in Masai giraffes (*Giraffa camelopardalis tippelskirchi*). [Degree project]. [Swedish University of Agricultural Sciences].

Beauchamp, G., Li, Z., Yu, C., Bednekoff, P. A., & Blumstein, D. T. (2021). A meta-analysis of the group-size effect on vigilance in mammals. Behav. Ecol. 32(5), 919-925. https://doi.org/10.1093/beheco/arab048

Beekman, J. H., Prins, H. H. T. (1989). Feeding strategies of sedentary large herbivores in East Africa, with emphasis on the African buffalo, *Syncerus coffer*. Afr. J. Ecol. 27(2), 129-147. https://doi.org/10.1111/j.1365-2028.1989.tb00937.x

Blumstein, D. T. (2016). Habituation and sensitization: new thoughts about old ideas. Anim. behav. 120, 255-262. https://doi.org/10.1016/j.anbehav.2016.05.012

Bond, M. L., König, B., Lee, D. E., Ozgul, A., Farine, D. R. (2021). Proximity to humans affects local social structure in a giraffe metapopulation. J J. Anim. Ecol. 90(1), 212 221. https://doi.org/10.1111/1365-2656.13247

Bond, M. L., Lee, D. E., Ozgul, A., König, B. (2019). Fission-fusion dynamics of a megaherbivore are driven by ecological, anthropogenic, temporal, and social factors. Oecologia, 19, 335–347. https://doi.org/10.1007/s00442-019-04485-y

Brown, M. B., Fennessy, J. T., Crego, R. D., Fleming, C. H., Alves, J., Brandlová, K., et al. (2023). Ranging behaviours across ecological and anthropogenic disturbance gradients: a pan-African perspective of giraffe (*Giraffa spp*.) space use.

Proc. Biol. Sci. 290(2001), 20230912. https://doi.org/10.1098/rspb.2023.0912

Burger, A. L., Fennessy, J., Fennessy, S., Dierkes, P. W. (2020b). Nightly selection of resting sites and group behavior reveal antipredator strategies in giraffe. Nat. Ecol. Evol. 10(6), 2917-2927. https://doi.org/10.1002/ece3.6106

Burger, A. L., Hartig, J., Dierkes, P. W. (2020a). Shedding light into the dark: Age and light shape nocturnal activity and sleep behaviour of giraffe. Appl. Anim. Behav. Sci. 229, 105012. https://doi.org/10.1016/j.applanim.2020.105012

Cameron, E. Z., du Toit, J. T. (2005). Social influences on vigilance behaviour in giraffes, *Giraffa camelopardalis*. Anim. Behav. 69(6), 1337-1344. https://doi.org/10.1016/j.anbehav.2004.08.015

Carter, K.D., Brand, R., Carter, J.K., Shorrocks, B., Goldizen, A.W. (2013) Social networks, long-term associations and age-related sociability of wild giraffes. Anim. Behav. 86: 901–910. https://doi.org/10.1016/j.anbehav.2013.08.002

Ciofolo, I., Le Pendu, Y. (2002). The feeding behaviour of giraffe in Niger. Mammalia. 66: 183-194. https://doi.org/10.1515/mamm.2002.66.2.183

Ciofolo, I. (1995). West Africa's last giraffes: the conflict between development and conservation. J. Trop. Ecol. 11(4), 577-588. https://doi.org/10.1017/S0266467400009159

Ciuti, S., Northrup, J. M., Muhly, T. B., Simi, S., Musiani, M., Pitt J.A., et al. (2012). Effects of humans on behaviour of wildlife exceed those of natural predators in a landscape of fear. PloS One d7, e50611. doi: 10.1371/journal.pone.0050611

Craig, M., Dewar, M., Harris, M. A., Della Sala, S., Wolbers, T. (2016). Wakeful rest promotes the integration of spatial memories into accurate cognitive maps. Hippocampus 26(2), 185-193. https://doi.org/10.1002/hipo.22502

Creel, S., Schuette, P., Christianson, D. (2014). Effects of predation risk on group size, vigilance, and foraging behavior in an African ungulate community. Behav. Ecol. 25(4), 773-784. https://doi.org/10.1093/beheco/aru050

Dallaire, A. (1986). Rest behavior. Vet. Clin. N. Am. 2(3), 591-607. https://doi.org/10.1016/S0749-0739(17)30708-3

Demment, M. W., Van Soest, P. J. (1985). A nutritional explanation for body-size patterns of ruminant and nonruminant herbivores. Am. Nat. 125(5), 641-672. https://doi.org/10.1086/284369

D'haen, M., Fennessy, J., Stabach, J. A., Brandlová, K. (2019). Population structure and spatial ecology of Kordofan giraffe in Garamba National Park, Democratic Republic of Congo. Nat. Ecol. Evol. 9(19), 11395-11405. https://doi.org/10.1002/ece3.5640

du Toit, J. T., Yetman, C. A. (2005). Effects of body size on the diurnal activity budgets of African browsing ruminants. Oecologia. 143, 317-325. https://doi.org/10.1007/s00442-004-1789-7

Duggan, G., Burn, C. C., Clauss, M. (2016). Nocturnal behavior in captive giraffe (*Giraffa camelopardalis*)—A pilot study. Zoo. Biol. 35, 14-18. https://doi.org/10.1002/zoo.21248

Fischhoff, I. R., Sundaresan, S. R., Cordingley, J., Rubenstein, D. I. (2007). Habitat use and movements of plains zebra (*Equus*

burchelli) in response to predation danger from lions. Behav. Ecol. 18(4), 725-729. https://doi.org/10.1093/beheco/arm036

Fritz, H., De Garine-Wichatitsky, M., and Letessier, G. (1996). Habitat use by sympatric wild and domestic herbivores in an African savanna woodland: the influence of cattle spatial behaviour. J. Appl. Ecol. 33, 589–598. doi: 10.2307/2404987

Gašparová K., Fennessy J., Rabeil T. Brandlová K. (2020). Threat analysis: West African giraffe (*Giraffa camelopardalis peralta*) in Republic of Niger. Niamey, Niger 18pp. https://giraffeconservation.org/wp-content/uploads/2020/05/Threat-analysis-West-African-giraffe-in-Niger_April-2020.pdf

Gašparová, K., Blanco, J., Glikman, J. A., Fennessy, J., Zabeirou, A. R. M., Mahamadou, A. R. A., et al. (2023). Social development and biodiversity conservation synergies for the West African giraffe in a human–wildlife landscape. Environ. Conserv. 50(4), 259-266. https://doi.org/10.1017/S0376892923000243

Gašparová, K., Fennessy, J., Moussa Zabeirou, A. R., Abagana, A. L., Rabeil, T., Brandlová, K. (2024). Saving the Last West African Giraffe Population: A Review of Its Conservation Status and Management. Animals, 14(5), 702. https://doi.org/10.3390/ani14050702

Gaynor, K. M., Hojnowski, C. E., Carter, N. H., Brashares, J. S. (2018). The influence of human disturbance on wildlife nocturnality. Science. 360(6394), 1232-1235. https://doi.org/10.1126/science.aar7121

Gitau, C. G., Mbau, J. S., Ngugi, R. K., Ngumbi, E.,Muneza, A. B. (2024). Activity budget and foraging patterns of Nubian giraffe (*Giraffa camelopardalis camelopardalis*) in Lake Nakuru National Park, Kenya. Ecol. Evol. 14(6), e11463. https://doi.org/10.1002/ece3.11463

Gloneková, M., Brandlová, K., Pluháček, J. (2021). Further behavioural parameters support reciprocity and milk theft as explanations for giraffe allonursing. Sci. Rep. 11(1), 7024. https://doi.org/10.1038/s41598-021-86499-2

Gordon, I. J., Prins, H. H. (2008). The ecology of browsing and grazing (No. 195). Berlin: Springer.

Hart, E. E., Fennessy, J., Hauenstein, S., Ciuti, S. (2020). Intensity of giraffe locomotor activity is shaped by solar and lunar eitgebers. Behav. processes.178, 104178. https://doi.org/10.1016/j.beproc.2020.104178

Hejcmanová, P., Vymyslická, P., Žáčková, M., Hejcman, M. (2013). Does supplemental feeding affect behaviour and foraging of critically endangered western giant eland in an ex situ conservation site? Afr. Zool. 48(2), 250-258. https://doi.org/10.1080/15627020.2013.11407590

Hirakawa, H. (1997). Digestion-constrained optimal foraging in generalist mammalian herbivores. Oikos 78, 37–47. doi: 10.2307/3545798

Chen, H. L., Koprowski, J. L. (2015). Animal occurrence and space use change in the landscape of anthropogenic noise. Biol. Conserv. 192, 315-322. https://doi.org/10.1016/j.biocon.2015.10.003

Jayakody, S., Sibbald, A. M., Gordon, I. J., Lambin, X. (2008). Red deer *Cervus elephus* vigilance behaviour differs with habitat and type of human disturbance. Wildl. Biol. 14(1), 81-91. https://doi.org/10.2981/0909-6396(2008)14[81:RDCEVB]2.0.CO;2

Jeschke, J. M., Tollrian, R. (2005). Predicting herbivore feeding times. Ethol.111(2), 187-206. https://doi.org/10.1111/j.1439-0310.2004.01052.x

Kinga, G. W., Mironga, J., Odadi, W. O. (2018). Analysis of the spatial relationship between cattle and wild ungulates across different land-use systems in a tropical Savanna landscape. Int.J eccol. 2018(1), 2072617. https://doi.org/10.1155/2018/2072617

Kiwia, H. Y. D. (1986). Diurnal activity pattern of the black rhinoceros. *Diceros bicornis* (L.) in Ngorongoro Crater, Tanzania. Afr. J. of Ecol. 24(2), 89-96. https://doi.org/10.1111/j.1365-2028.1986.tb00347.x

Le Pendu, Y., Ciofolo, I., Gosser, A. (2000). The social organization of giraffes in Niger. African J. Ecol. 38(1), 78-85. https://doi.org/10.1046/j.1365-2028.2000.00214.x

Leroy, R., De Visscher, M. N., Halidou, O., Boureima, A. (2009). The last African white giraffes live in farmers' fields. Biodivers. Conserv. 18, 2663-2677. https://doi.org/10.1007/s10531-009-9628-0

Lima, S. L., Bednekoff, P. A. (1999). Temporal variation in danger drives antipredator behavior: the predation risk allocation hypothesis. Am. Nat. 153(6), 649-659. https://doi.org/10.1086/303202

Loft, E. R., Menke, J. W., and Kie, J. G. (1991). Habitat shifts by mule deer: the influence of cattle grazing. J. Wildl. Manage. 55, 16–26. doi: 10.2307/3809236

Luttbeg, B. (2017). Re-examining the causes and meaning of the risk allocation hypothesis. Am. Nat.189(6), 644-656. https://doi.org/10.1086/691470

Makenbach, S. A., Waterman, J. M., Roth, J. D. (2013). Predator detection and dilution as benefits of associations between yellow mongooses and Cape ground squirrels. Behav. Ecol. Sociobiol. 67, 1187-1194. https://doi.org/10.1007/s00265-013-1544-3

Marealle, W. N., Holmern, T., Røskaft, E. (2020). Factors Affecting Group Size and Vigilance Behaviour of Maasai Giraffe (*Giraffa camelopardalis tippelskirchi*) on the Serengeti-Ngorongoro Ecosystem, Tanzania. EANSO. 2(1), 14-23. https://doi.org/10.37284/eajenr.2.1.133

Megaze, A., Balakrishnan, M., Belay, G. (2018). Diurnal activity budget of African buffalo (*Syncerus caffer* Sparrman, 1779) in Chebera Churchura National Park, Ethiopia. Afr. J. Ecol. 56(3), 436-444. https://doi.org/10.1111/aje.12359

Mole, M. A., Rodrigues DÁraujo, S., Van Aarde, R. J., Mitchell, D., Fuller, A. (2016). Coping with heat: behavioural and physiological responses of savanna elephants in their natural habitat. Conserv. Physiol. 4(1), cow044. https://doi.org/10.1093/conphys/cow044

Muller, Z., Harris, S. (2021). A review of the social behaviour of the giraffe *Giraffa camelopardalis*: a misunderstood but socially

complex species. Mammal Revi. 52(1), 1-15. https://doi.org/10.1111/mam.12268

Muller, Z., Cuthill, I. C., Harris, S. (2018). Group sizes of giraffes in Kenya: the influence of habitat, predation and the age and sex of individuals. J. Zoo. 306(2), 77-87. https://doi.org/10.1111/jzo.12571

Owen-Smith, N., Goodall, V. (2014). Coping with savanna seasonality: comparative daily activity patterns of African ungulates as revealed by GPS telemetry. J. Zool. 293(3), 181-191. https://doi.org/10.1111/jzo.12132

Owen-Smith, N., Traill, L. W. (2017). Space use patterns of a large mammalian herbivore distinguished by activity state: fear versus food? J. Zool. 303(4), 281-290. https://doi.org/10.1111/jzo.12490

Paulse, J., Couldridge, V., Cupido, C., Deacon, F. (2023). The diurnal activity budgets of extralimital giraffe (*Giraffa camelopardalis giraffa*) in the Western Cape Province, South Africa. Afr. J. Ecol. 61(3), 746-751. https://doi.org/10.1111/aje.13135

Pellew, R.A. (1984). The feeding ecology of selective browser, the giraffe (*Giraffa camelopardalis tippelskirchi*). J. ZooL. 202: 57-81. https://doi.org/10.1111/j.1469-7998.1984.tb04288.x

R Core Team (2024). R: A Language and Environment for Statistical Computing_. R Foundation for Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.

Rattenborg, N. C., de la Iglesia, H. O., Kempenaers, B., Lesku, J. A., Meerlo, P., Scriba, M. F. (2017). Sleep research goes wild: new methods and approaches to investigate the ecology,

evolution and functions of sleep. Philos. Trans. R. Soc. Lond. B Biol. Sci. 372(1734), 20160251. https://doi.org/10.1098/rstb.2016.0251

Ripari, L., Premier, J., Belotti, E., Bluhm, H., Breitenmoser-Würsten, C., Bufka, L. et al. (2022). Human disturbance is the most limiting factor driving habitat selection of a large carnivore throughout Continental Europe. Biol. Conserv. 266, 109446. https://doi.org/10.1093/jmammal/gyz044

Scheijen, C. P., Van der Merwe, S., Ganswindt, A., Deacon, F. (2021). Anthropogenic influences on distance traveled and vigilance behavior and stress-related endocrine correlates in free-roaming giraffes. Animals. 11(5), 1239. https://doi.org/10.3390/ani11051239

Schmidt, M. H. (2014). The energy allocation function of sleep: a unifying theory of sleep, torpor, and continuous wakefulness. Neurosci. Biobehav.Rev. 47, 122-153. https://doi.org/10.1016/j.neubiorev.2014.08.001

Scholte, P., Pays, O., Adam, S., Chardonnet, B., Fritz, H., Mamang, J. B. et al. (2022). Conservation overstretch and long-term decline of wildlife and tourism in the Central African savannas. Conserv. Biol., 36(2), e13860. https://doi.org/10.1111/cobi.13860

Shannon, G. (2005). The effects of sexual dimorphism on the movements and foraging ecology of the African elephant [dissertation thesis]. [University of KwaZulu-Natal].

Shukla, I., Kilpatrick, A. M., Beltran, R. S. (2021). Variation in resting strategies across trophic levels and habitats in

mammals. Ecol. Evol. 11(21), 14405-14415. https://doi.org/10.1002/ece3.8073

Siegel, J. M. (2008). Do all animals sleep? TINS. 31(4), 208-213. https://doi.org/10.1016/j.tins.2008.02.001

Stabach, J. A., Hughey, L. F., Crego, R. D., Fleming, C. H., Hopcraft, J. G. C., Leimgruber, P. (2022). Increasing anthropogenic disturbance restricts wildebeest movement across East African grazing systems. Front. Ecol. Evol. 10:846171. https://doi.org/10.3389/fevo.2022.846171

Stensland, E. V. A., Angerbjörn, A., Berggren, P. E. R. (2003). Mixed species groups in mammals. Mamm. Rev. 33(3-4), 205-223. https://doi.org/10.1046/j.1365-2907.2003.00022.x

Suraud, J.P. (2011): Identifying conservation constraints for the last West African giraffe: population dynamics, determining factors and spatial distribution pattern. PhD thesis, University of Lyon, France.

Suscke, P., Presotto, A., Izar, P. (2021). The role of hunting on Sapajus xanthosternos' landscape of fear in the Atlantic Forest, Brazil. Am. J. Primatol. 83(5), e23243. https://doi.org/10.1002/ajp.23243

Tucker, M. A., Schipper, A. M., Adams, T. S., Attias, N., Avgar, T., Babic, N. L. et al. (2023). Behavioral responses of terrestrial mammals to COVID-19 lockdowns. Science, 380(6649), 1059-1064. https://doi.org/10.1126/science.abo6499

Vermeulen, M. M., Fritz, H., Strauss, W. M., Hetem, R. S., Venter, J. A. (2024). Seasonal activity patterns of a Kalahari mammal community: Trade-offs between environmental heat

load and predation pressure. Ecol. Evol. 14(4), e11304. https://doi.org/10.1002/ece3.11304

Worlddata.info. (2024). The climate in Niger. https://www.worlddata.info/africa/niger/climate.php [Accessed September 14, 2024]

Zanette, L. Y., Frizzelle, N. R., Clinchy, M., Peel, M. J., Keller, C. B., Huebner, S. E. et al. (2023). Fear of the human “super predator” pervades the South African savanna. Curr. Biol. 33(21), 4689-4696. https://doi.org/10.1016/j.cub.2023.08.089

Zbyryt, A., Bubnicki, J. W., Kuijper, D. P., Dehnhard, M., Churski, M., Schmidt, K. (2018). Do wild ungulates experience higher stress with humans than with large carnivores? Behav. Ecol. 29(1), 19-30. https://doi.org/10.1093/beheco/arx142

CHAPTER 5

The spatial behaviour of West African giraffe

This chapter summarizes the regular report

5 The spatial behaviour of West African giraffe

5.1 Introduction

Nowadays organisms are facing to a changing climate and the rapid conversion of natural habitats in human-dominated landscapes, their future depend on their ability to adapt to these new circumstances. Adaptation may involve behavioural changes or alternation (Sol et al., 2005), the changes in geographical ranges (Laidre et al., 2018) or how a species moves through its existing range (Tucker et al., 2018) and may allow to cope with novel environmental conditions or pressures. The decision of animal to shift range and relocate from one site to another have often been predicted by using of simple decision models (Bastille-Rousseau et al., 2018). These movements are mainly guided by suitable climatic conditions and by sufficient availability of food and water, but also by other factors. Understanding the ecology of spatio-temporal movement patterns is critical for conservation of free ranging terrestrial species and the ecosystems on which they occur (Graham et al., 2009). The predicted shifts can be integrated into conservation and management strategies for species of interest, but they are unlikely to be accurate because of full range of factors influencing movement which should be taken into account (Boult, 2018).

Movement is often in response to short-term goals such as reproduction, maintenance, including feeding, and survival, including escaping threats. It may also be shaped by longer-term fitness implications, such as avoidance of inbreeding and population extinction (Dingle, 1996).

Many ungulates migrate along traditional routes between seasonal ranges, often associated with plant phenology or weather and perform the seasonal movements (Owen-Smith et al., 2010; Brikett et al., 2012). There are several reasons how to explain why herbivores migrate, these hypotheses include differences in forage quality and availability, changes in climate,

reduction of competition, and escape from predation (Nicholson et al., 1997). Moreover, the increasing human population and associated disturbances may also influence spatial behaviour. Such environmental alterations such as climate change, changing plant phenology, habitat loss, and increasing disturbance may reduce benefits which were achieved by seasonal migration (Tucker et al., 2018). Migratory herbivores may make behavioural changes to cope with such changes and remain synchronized with peak of food availability in the landscape and minimize the potentially negative effects on reproductive success. (Lendrum et al., 2014).

As a Sahelian subspecies, West African giraffe is an animal well adapted to arid climates and sparse vegetation. In such a challenging environment, giraffe shows seasonal movement and occasionally out-migrate from their core range to the vicinity of the Mali border (Ouallam), and Nigeria border (Gaya; Ciofolo, 1995; Le Pendu & Ciofolo, 1999). The regular seasonal movement between the tiger bush of Kouré and the area of Harikanassou is clearly linked to the vegetation availability. In the rainy season from June to October giraffe occur in Kouré, where the tiger bush is highly productive. In November they return to the area of Harikanassou (Le Pendu & Ciofolo, 1999).

One of the basic questions in animal ecology is the home range size. Home range (HR) is an area used by an animal during its normal activities of foraging, mating and caring young (Burt, 1943). Any animal can make an “unusual” movement outside the HR resulting in outlier points which are not considered as part it is normal activity area unless observed regularly (Burt, 1943). Undoubtedly, the home range size is influenced by numerous environmental and anthropogenic factors with smaller home range on average observed in populations with higher rainfall resulting in greater productivity and access to critical resources (Fennessy, 2009; Knüsel, 2019). Giraffe living in arid ecosystems have larger HR on average as the productivity is lower and giraffe have to roam further to reach

resources and find mates (Le Pendu & Ciofolo, 1999; Fennessy, 2009). Knüsel (2019) indicated significant differences in HR size between Masai giraffe in Tanzania living in close proximity of towns and those living far from human settlements. The farther from developed human areas, the smaller the giraffe HR size was observed (Knüsel, 2019). Giraffe as non-territorial megaherbivore plays a major role in shaping the vegetation of savannah ecosystems (Strauss et al., 2015). Quantifying spatial ecology and habitat use by giraffes is critical for effective conservation (Deacon & Smit, 2017). The giraffe´s home range size is more expansive than the HR of smaller ungulates in the same environment due to their large body mass and high bioenergetic requirements (Fennessy, 2009). There are several studies reporting the giraffe home range size, but the estimates varied substantially (Knüsel et al., 2019). The results are influenced by the used estimator, when the older, routinely used methods underestimate the HR enormously (Fleming et al., 2015, Fleming & Calabrese, 2017). Historically, the home range analyses were limited to direct field observation (Fennessy, 2009). Since that time the animal tracking technology has increased the capacity of collecting data, and so too the methods analysing them (Noonan, 2018). The method which takes this into account is Autocorrelated Kernel Density Estimator (AKDE). The HR estimates calculated by AKDE is usually larger in comparison with conventional methods such as Kernel Density Estimator and Minimal Convex Polygon. It is because of fact that AKDE contain substantial areas where the focal individual was not directly observed (Fleming et al., 2015). The new and modern method of collecting and analysing data will bring more accurate insight into West African giraffe spatial behaviour.

We aimed to describe the movement of West African giraffe based on GPS data and estimate the home range size.

5.2 Methods

Giraffe Conservation Foundation (GCF), Sahara Conservation Fund (SCF) and the Government of Niger fitted nineteen West African giraffe (*Giraffa camelopardalis peralta*) with solar powered GPS satellite units (ossi-units) to help assess their habitat use and spatial ecology over time. During the first mission in November 2018 three giraffe were tagged (1 male, 2 females). During the second one in August 2019, sixteen giraffe were tagged (3 males, 13 females). All units fitted to males do not work, all likely due to damage incurred during necking behaviour. As the position data are collected with short intervals (daily, hourly), they become dependent and highly autocorrelated (Noonan 2018).

For assessing the preliminary West African giraffe´s HR size in Niger, the R package continuous-time movement modelling (ctmm) version 0.5.7 was used (Calabrese and Fleming 2016). The ctmm package is based on Autocorrelated KDE (AKDE). After running 95% and 50% AKDE in R studio the resulting shapefile was opened in QGIS 2.18.12 and the area calculated using the $area function. The mean, range, and standard deviation of 95% AKDE and 50% AKDE was calculated by Microsoft Excel (Microsoft Office 365 ProPlus). For statistical analyses, Statistica (TIBCO Software Inc 2018) was used. For comparison, the 50% AKDE and 95% AKDE between dry and rainy season the Mann-Whitney U test was run. The dry season HR was estimated for the 14 giraffe for the period from December 2019 to April 2020. Unit 3241 was excluded because of a very unusual movement pattern and as such considered to be non-resident during the whole year. The female giraffe did not create a ‘normal’ HR and AKDE applied on this movement pattern resulted in 95% HR exceeding 62,000 km2 during the

dry season and 35,000 km2 during the rainy season. The HR during the rainy season (June-October) HR was estimated for 5 giraffe. The dataset was divided into two parts which cover the rainy season period, the first from June to July 2020 and the second from August to October 2019. The values of each individual from both parts of the rainy season were averaged and a new column in Table 5.1 was created. The averaged values were used for statistical comparison between dry and rainy seasons November and May were not included as they were transition months (Le Pendu and Ciofolo 1999).

5.3 Results

The average dry season HR was 2,301.7 km^2 ± 3,327.8 ranging from 312.6 to 12,902.9 (n=14). The dry season core area was 355.5 km^2 ± 403.1 ranging from 62.9 to 1,518.8 (n= 14). The average rainy season HR was 2,413.2 km^2 ± 1,944.7 ranging from 766 to 5,711.9 (n=5). The rainy season core area was 526.6 km^2 ± 391.5 ranging from 140.7 to 1,139.1 (n=5). The difference between the dry and rainy season HR is not significant ($p>0.05$, $U=27$), nor the core areas used ($p>0.05$, $U=24$).

Table 5.1 represent the HR estimates for dry season, rainy season for June and July, rainy season from August to October and averaged values for rainy season. Values and unit marked by * are not included into any analysis. Giraffe 3241 did not created “normal“ HR and the other values are from stationary units.

	Dry season Dec 2019 – Apr 2020			Rainy season Jun-Jul 2020			Rainy season Aug-Oct 2019			Rainy season (mean)	
ID	**Number of records**	**50% AKDE (km^2)**	**95% AKDE (km^2)**	**Number of records**	**50% AKDE (km^2)**	**95% AKDE (km^2)**	**Number of records**	**50% AKDE (km^2)**	**95% AKDE (km^2)**	**50% AKDE (km^2)**	**95% AKDE (km^2)**
3037	2.217	70.4	315.9								
3038	801	204.7	973.6	190	113.7	522.7	54	167.6	668.1	140.7	595.4
3224	3.376	62.9	312.6	1.283	515.4	2.195.2	2.022	1.762.7	9.228.7	1.139.1	5.711.9
3226	3.238	317.2	12.902.9								
3236	3495	371	1.610.4	682	*3.5	*16.1	2.023	*506	*1.955.4		
3237	501	1.518.8	6.020.4								
3238	3.493	69.2	270.5	1.057	286.7	1.356.4	2.023	38.9	175.6	162.8	766
3241*	3.493	14.195.4	62.534.6	2.006	*3.652.7	*15.339.1	2.023	*13.650.1	*56.439.2		
3243	3.349	93.5	359.3	264	*0.02	*0.09	2.021	*641.5	*2.507.1		
3244	9.809	242.6	1.063.3	605	*25.6	*136.2	2.023	*181.8	*851.8		
3245	3.484	274.1	1183	202	*0	*0.01	2.023	*27	*125.9		
3247	2.486	318.9	1.349.3								
3248	3.646	92.2	567.3	855	808.1	3.802.1	2.023	831.2	3.188.4	819.7	3.495.3
3249	3.646	289.7	1.260.1	1.462	120.2	424.5	2.023	621.5	2570	370.9	1.497.3
3250	1.384	1.051.8	4.034.5								
Mean		**355.5**	**2.301.7**		**368.8**	**1.736.1**		**684.4**	**3.166.2**	**526.6**	**2.413.2**
Standard deviation		**403.1**	**3.327.8**		**291.4**	**1.296.4**		**614.0**	**3.267.1**	**391.5**	**1.944.7**

5.4 Discussion

In comparison with other studies published on giraffe´s HR, the preliminary results of the West African giraffe HR size is relatively large. The same result provides study of Brown et al. (2023), which summarise giraffe movement data across Africa. Our result can be attributed to several factors. Firstly, the methods used traditionally for HR estimating are KDE and MCP, both proven to underestimate results (Fleming et al., 2015, Fleming & Calabrese, 2017). Our preliminary findings were calculated using AKDE and KDE, as per similar methods for giraffe published (D´haen et al., 2019). Undoubtedly, the HR size is influenced by numerous environmental and anthropogenic factors with smaller HR on average observed in populations with higher rainfall resulting in greater productivity and access to critical resources (Fennessy, 2009; Knüsel, 2019). Giraffe living in arid ecosystems with less woody environment have larger HR on average as the productivity is lower and they roam further for resources and finding mates (Le Pendu & Ciofolo 1999; Fennessy, 2009; Brown et al., 2023) On the other hand it is reported that anthropogenic landscape reduces the movement of wildlife (Tucker et al., 2018) it might be caused mainly by hard boundaries such as fence (Hering et al., 2022). As the West African giraffe live in the human dominated, fragmented and agricultural landscape of the Sahelian zone with an annual rainfall of ~400 mm, it is more likely that aridity, fragmentation and proximity to people are the main drivers of their increased HR.

5.5 Conclusion

West African giraffe live in fragmented and arid conditions. Due to these conditions show large home range. The resulted size is larger than in other studies and it might be explained by different methods which was used or by the fragmentation of the landscape, which is shared with people and livestock. As mentioned, these results are preliminary and more complex analysis are needed. Understanding of the movement behaviour is critical for the conservation of the species.

5.6 References

Bastille-Rousseau, G., Douglas-Hamilton, I., Blake, S., Northrup, J. M., & Wittemyer, G. (2018). Applying network theory to animal movements to identify properties of landscape space use. Ecological Applications, 28(3), 854-864. https://doi.org/10.1002/eap.1697

Boult, V. L., Sibly, R. M., Quaife, T., Fishlock, V., Moss, C., & Lee, P. C. (2019). Modelling large herbivore movement decisions: Beyond food availability as a predictor of ranging patterns. African Journal of Ecology, 57(1), 10-19. https://doi.org/10.1111/aje.12553

Brown, M. B., Fennessy, J. T., Crego, R. D., Fleming, C. H., Alves, J., Brandlová, K., ... & Stabach, J. (2023). Ranging behaviours across ecological and anthropogenic disturbance gradients: a pan-African perspective of giraffe (Giraffa spp.) space use. *Proceedings of the Royal Society B*, 290(2001), 20230912. https://doi.org/10.1098/rspb.2023.0912

Burt, W. H. (1943). Territoriality and home range concepts as applied to mammals. Journal of mammalogy, 24(3), 346-352. https://doi.org/10.2307/1374834

Ciofolo, I. (1995). West Africa's last giraffes: the conflict between development and conservation. Journal of Tropical Ecology, 11(4), 577-588. https://doi.org/10.1017/S0266467400009159

D'haen, M., Fennessy, J., Stabach, J. A., & Brandlová, K. (2019). Population structure and spatial ecology of Kordofan giraffe in Garamba National Park, Democratic Republic of

Congo. Ecology and Evolution, 9(19), 11395-11405. https://doi.org/10.1002/ece3.5640

Deacon, F., & Smit, N. (2017). Spatial ecology and habitat use of giraffe (Giraffa camelopardalis) in South Africa. Basic and Applied Ecology, 21, 55-65. https://doi.org/10.1016/j.baae.2017.04.003

Dingle, H. (2014). Migration: the biology of life on the move. Oxford University Press, USA.

Fennessy, J. (2009). Home range and seasonal movements of Giraffa camelopardalis angolensis in the northern Namib Desert. African Journal of Ecology, 47(3), 318-327. https://doi.org/10.1111/j.1365-2028.2008.00963.x

Fleming, C. H., Fagan, W. F., Mueller, T., Olson, K. A., Leimgruber, P., & Calabrese, J. M. (2015). Rigorous home range estimation with movement data: a new autocorrelated kernel density estimator. Ecology, 96(5), 1182-1188. https://doi.org/10.1890/14-2010.1

Fleming, C. H., & Calabrese, J. M. (2017). A new kernel density estimator for accurate home-range and species-range area estimation. Methods Ecol Evol 8: 571–579. https://doi.org/10.1111/2041-210X.12673

Hering, R., Hauptfleisch, M., Jago, M., Smith, T., Kramer-Schadt, S., Stiegler, J., & Blaum, N. (2022). Don't stop me now: Managed fence gaps could allow migratory ungulates to track dynamic resources and reduce fence related energy loss. *Frontiers in Ecology and Evolution*, *10*, 907079. https://doi.org/10.3389/fevo.2022.907079

Knüsel, M. A., Lee, D. E., König, B., & Bond, M. L. (2019). Correlates of home range sizes of giraffes, Giraffa camelopardalis. Animal Behaviour, 149, 143-151. https://doi.org/10.1016/j.anbehav.2019.01.017

Laidre, K. L., Born, E. W., Atkinson, S. N., Wiig, Ø., Andersen, L. W., Lunn, N. J., ... & Heagerty, P. (2018). Range contraction and increasing isolation of a polar bear subpopulation in an era of sea-ice loss. Ecology and Evolution, 8(4), 2062-207 5. https://doi.org/10.1002/ece3.3809

Le Pendu, Y., & Ciofolo, I. (1999). Seasonal movements of giraffes in Niger. Journal of Tropical Ecology, 15(3), 341-353. https://doi.org/10.1017/S0266467499000863

Lendrum, P. E., Anderson Jr, C. R., Monteith, K. L., Jenks, J. A., & Bowyer, R. T. (2014). Relating the movement of a rapidly migrating ungulate to spatiotemporal patterns of forage quality. Mammalian Biology, 79(6), 369-375. https://doi.org/10.1016/j.mambio.2014.05.005

Microsoft Office365 ProPlus, version 1908.

Noonan, M. J., Tucker, M. A., Fleming, C. H., Akre, T. S., Alberts, S. C., Ali, A. H., ... & Calabrese, J. M. (2019). A comprehensive analysis of autocorrelation and bias in home range estimation. Ecological Monographs, 89(2), e01344. https://doi.org/10.1002/ecm.1344

Sol, D., Duncan, R. P., Blackburn, T. M., Cassey, P., & Lefebvre, L. (2005). Big brains, enhanced cognition, and response of birds to novel environments. Proceedings of the National Academy of Sciences, 102(15), 5460-5465. https://doi.org/10.1073/pnas.0408145102

Strauss, M. K. L., Kilewo, M., Rentsch, D., & Packer, C. (2015). Food supply and poaching limit giraffe abundance in the Serengeti. Population Ecology, 57, 505-516. https://doi.org/10.1007/s10144-015-0499-9

TIBCO Software Inc. 2018. Statistica (data analysis software system), version 13. http://tibco.com.

Tucker, M. A., Böhning-Gaese, K., Fagan, W. F., Fryxell, J. M., Van Moorter, B., Alberts, S. C., ... & Mueller, T. (2018). Moving in the Anthropocene: Global reductions in terrestrial mammalian movements. Science, 359(6374), 466-469. https://doi.org/10.1126/science.aam9712

CHAPTER 6

Threat analysis: West African giraffe (Giraffa camelopardalis peralta) in Republic of Niger

This chapter is literal copy of the study done for GCF purpose

Kateřina Gašparová, Julian Fennessy, Thomas Rabeil, Karolína Brandlová

Adapted from the original https://giraffeconservation.org/wp-content/uploads/2020/05/Threat-analysis-West-African-giraffe-in-Niger_April-2020.pdf

6 Threat analysis: West African giraffe (*Giraffa camelopardalis peralta*) in Republic of Niger

April 2020

Kateřina Gašparová[1], Julian Fennessy[2], Thomas Rabeil[3] & Karolína Brandlová[1]

[1]Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague, Kamýcká 129, 165 00 Praha Suchdol, Czech Republic

[2]Giraffe Conservation Foundation, Windhoek, Namibia

[3]Wild Africa Conservation, Niamey, Niger

6.1 Overview

The Sudanian savannah currently suffers increasing pressure connected with growing human population in sub-Saharan Africa. Human settlements and agricultural lands have negatively influenced the availability of resources for wild ungulates, especially with increased competition from growing numbers of livestock and local human exploitation. Subsequently, and in context of giraffe (*Giraffa spp*.), this has led to a significant decrease in population numbers and range across the region. Remaining giraffe populations are predominantly conserved in formal protected areas, many of which are still in the process of being restored and conservation management improving. The last population of West African giraffe (*G. camelopardalis peralta*), a subspecies of the Northern giraffe (*G. camelopardalis*) is only found in the Republic of Niger, predominantly in the central region of plateaus and Kouré and North Dallol Bosso, about 60 km south east of the capital – Niamey, extending into Doutchi, Loga, Gaya, Fandou and Ouallam areas (see Figure 6.1). Together this area is locally known as the "Giraffe Zone" and forms part of the Parc W Biosphere Reserve covering more than 1,700 km2. In addition, towards the end of 2018 eight giraffe were successfully translocated to the Gadabedji Biosphere Reserve

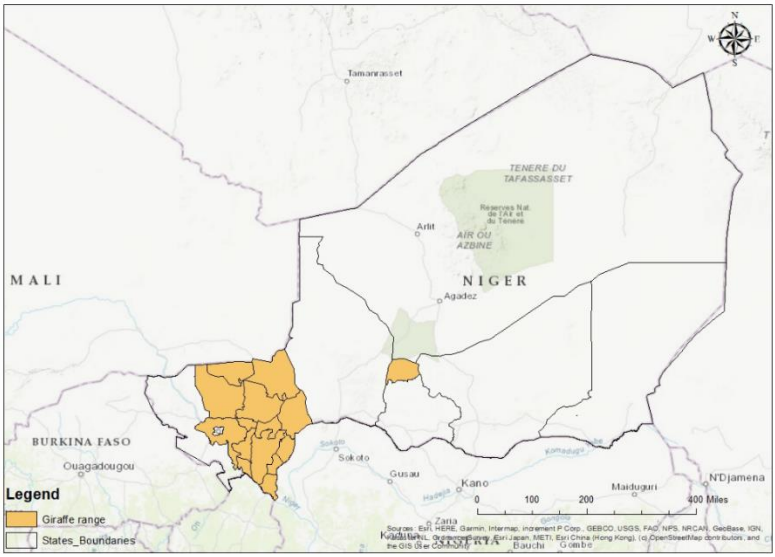

Figure 6.1 Current West African giraffe distribution in Niger (Map courtesy of GCF 2020).

in eastern Niger (see Figure 6.1). The establishment of the first-ever satellite population back into their natural range was a key step for the long-term conservation.

To better understand the current conservation status of the West African giraffe and provide a baseline to the planned future review of the National Giraffe Conservation Strategy and Action Plan in Niger, this threat assessment was developed and focuses on the original population in “Giraffe Zone”. The specific purpose of threat analysis is to: (1) describe threats (historic and current) to facilitate conservation planning decisions; (2) provide tools that will allow conservation managers to prioritise actions; and (3) provide data to support comprehensive review of threats.

The direct threats were included into the table in Annex 1 Threat types were hierarchically categorized according to IUCN Classification Scheme (version 3.2) with references in the text. These categories are standardized and used for IUCN Red List. Follow the globally recognized system helps to better orientation and understanding.

6.2 Habitat loss

A key habitat of the West African giraffe in the 'Giraffe Zone' is 'tiger bush' (brousse tigrée), and predominantly used during the rainy season (Suraud 2008, 2011; Le Pendu & Ciofolo 1999). It is a unique habitat covering about 22,000 km2, approximately one third of Sahelian Niger (Galle et al. 1999) and is characterised by regularly alternating bare-soil stripes with dense linear thickets. The dominant woody species are *Combretum micranthum*, *C. nigricans* and Acacia (*Senegalia*) *macrostachya*; whilst the dominant herbaceous species are *Ctenium elegans* and *Pennisetum pedicellatum* (Manu et al. 1994). Unfortunately, the 'tiger bush' faces many pressures, in particular over-exploitation from local use and supplying the capital Niamey with a fuel source (Annex 1; 5.3.2). Importantly, this habitat is of considerable economic interest since it is the main source of livestock forage year-round for local farmers as well as for the wood for domestic energy. Such intensive browsing pressure has resulted in excessive overgrazing and deforestation, respectively (Annex 1; 2.3.1). Over the last few decades, the woody vegetation on the Kouré plateau has decreased from 53% in 1960 to 14% in 1992, while bare soil increasing from 14% to 72% (Wu et al. 2000). Fiorillo et al. (2017) analysed the land clearing and degradation activities on the 'tiger bush' to the south-west of Niamey (Annex 1; 11.1). He

identified the spatial and temporal dynamic changes through remote sensing digital images (MODIS NDVI and LANDSAT) and observed the percentage of bare soil pixels increased from 29.52 in 1986 to 64.57 in 2012. Therefore, it appears that that degradation processes has accelerated and correlates with previous studies findings.

Figure 6.2 Illegal harvesting of 'tiger bush' habitat in the 'Giraffe Zone' (photo courtesy of A.R. Zabeirou, GCF-SCF).

A study by Morou (2011) investigated the land use changes in the "Giraffe Zone" comparing satellite images from 1986 and 2003. In 1986 the 'tiger bush' covered ~26% of the surveyed area, and by 2003 had decreased to 10.9% (see Figure 6.3; Morou 2011). The land use changes are a result of harvesting for fuelwood production, especially in areas adjacent to densely populated centres (Fiorillo et al. 2017; Morou 2011).

It is hypothesised that such vegetation loss and fragmentation has further reduced the amount of water retained leading to further indirect degradation of downslope vegetation bands (Wu et al. 2000). Some area of the plateau are completely bare, and the vegetation can no longer be restored naturally (see Figure 6.4). In some areas, re-forestation/vegetation programmes have been initiated with terraces dug in the shape of half-moon. These structures can retain water locally which hopefully leads to improvement in soil quality and thus promote the vegetation growth (Simonet 2018). Several NGOs together with government have been and/or are involved in such projects over the last decade e.g. AWF, GIZ, NIGERMAZADA (A.R. Zabeirou pers. comm.), however little analysis has been undertaken about the long-term success of these initiatives.

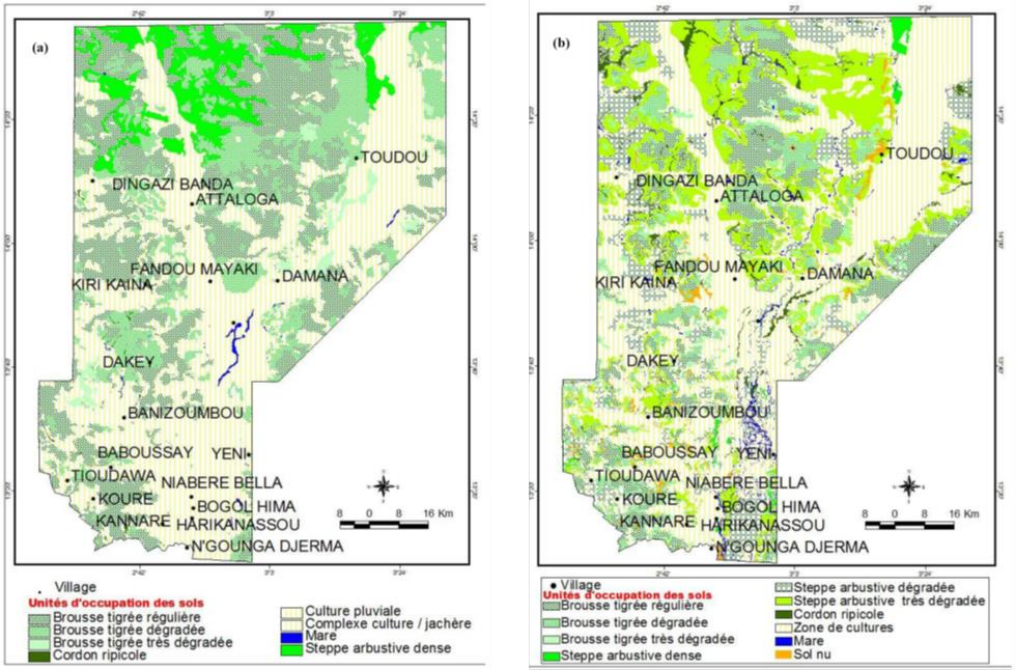

Figure 6.3 and use changes observed in Niger, including the 'Giraffe Zone' between (a) 1968 and (b) 2003 (Morou 2011).

Figure 6.4. Deforested and overgrazed habitat in the 'Giraffe Zone' (photo courtesy of A.R. Zabeirou, GCF-SCF).

6.3 Human population growth and associated conflict

Due to the population growth and the expansion of agriculture to meet the associated needs, the Kouré area and Dallol Bosso Nord of the 'Giraffe Zone' is heavily subject to over-exploitation, predominantly from cultivation of millet, deforestation and livestock overgrazing (see Figure 6.5; Annex 1; 2.1.2). The Niger human population has significantly increased over the last ten years alone from 16 to 24 million individuals, at a population growth rate of ~3.9% (Worldometers.info 2020; Annex 1; 1.1). The increase in human population goes in parallel with increasing livestock population in the country (see Table 6.1). Additional to the resource competition between livestock and giraffe, livestock can directly threaten giraffe through disease transmission (Sahailou et al. 2018; Annex 1; 8.2).

Table 6.1 Comparative number of livestock in Niger from 2010 and 2018 (FAO 2020).

Species	2010	2018	Variance (%)
Camel	1,633,569	1,811,395	110.9
Cattle	9,011,897	14,363,595	159.4
Goat	12,722,529	17,411,659	136.9
Sheep	9,680,058	12,746,788	131.7
Total	**33,048,053**	**46,333,437**	**140.2**

It is assumed that giraffe have been less affected by rinderpest when compared to other ruminants (MacClintock 1973); nevertheless, rinderpest has been cited as a major contributing factor to local loss of giraffe across the continent in the last couple of hundred years (Skinner & Chimimba 2005). Giraffe are also susceptible to outbreaks of anthrax, bacterial disease and epidemics of gastroenteritis – albeit to a lesser degree than many species (MacClintock 1973).

During the 2018 Niger giraffe translocation activities, giraffe were sampled to run various diagnostic tests, and one giraffe from tested positive for the Peste des petit ruminants (PPR) virus (also known as 'goat plague') (P. Chardonnet pers. comm.). PPR is an infectious and highly contagious viral disease of wild and domesticated small ruminants (Jones et al. 1993). PPR occurs in sub-Saharan Africa, the Middle East and Indian subcontinent (Farougou et al. 2013). In 2016 an outbreak of PPR among domesticated sheep and goats in Mongolia caused uncontrolled transmission on several Mongolian wild species (Mongolian saiga, Siberian ibex and goitered gazelle). The most affected was Mongolian saiga resulting in a population declined of ~80% (Pruvot et al. 2020). In Niger, a study conducted by Farougou et al. (2013) tested 253 and 266 unvaccinated sheep and goat respectively in three areas (Tahoua, Tillabéri and Niamey). In Niamey, there was recorded 24.6% of infected animals while in Tillabéri and Tahoua there is 46.1% and 49.3% positive cases respectively. Taking all the above into account, it is important to ongoing assess the impact

of transmission and impact of PPR in the current 'Giraffe Zone' and for any future translocations to limit spread of such virus.
The close cohabitation of giraffe with local communities in Niger has resulted in other issues from time to time. It has been

Figure 6.5 Increasing conflict between giraffe and local communities in the 'Giraffe Zone' (photo courtesy of A.R. Zabeirou, GCF-SCF).

reported that some local communities have threatened giraffe with modified weapons while chasing them away from fields or mango trees where giraffe trample and/or feed on flowers and fruits (Rabeil et al. 2019). However, these conflict situations are decreasing as the majority of mango trees are now fenced (O. Idrissa, AVEN; pers. comm.). In the 'Giraffe Zone', almost a third of the area has been converted to cultivation zones between 1986 and 2003. In 1986 the cultivation zone covered 48.7% in 2003 the surface cover by crops increased to 70.6% (Morou et al. 2011). The increase in development activities at

a local level will likely correlate with increasing threats to giraffe – direct and indirect. Expansion of market gardening using human-made “basins” (mini well) has not only reduced the amount of area but also increased the danger to giraffe with one fatality reported in the last year when a giraffe fell down into one of the wells (A.R. Zabeirou pers. comm.).

With the increasing human population in Niger, the infrastructure required also increases (Annex 1; 4.1). The ‘Giraffe Zone’ is divided by the main national road from Niamey to Dosso which runs through the core area with busy traffic dominated by heavy trucks. Additionally, a relatively dense ‘road’ network also exists within the “Giraffe Zone” which itself exacerbates movement of people and increasing potential threats. Several giraffe road deaths have been reported over the last few years (see Table 3). Such road accidents, as observed for other wildlife elsewhere, are often caused by high speed and increased frequency of vehicles on roads (Forman et al. 2003; Fahrig and Rytwinski 2009; Carvalho and Mira 2011). Despite lower traffic frequency at night, generally nocturnal animals are usually more often killed on road in comparison with diurnal animals, a result of reduced visibility (Bullock et al. 2011). The roads in “Giraffe Zone” are on some places surrounded by bush and the visibility is low, very often the speed limit is exceeded by drivers (Rabeil et al 2019). This threat does not have potential to impact to whole population, but it is fatal for individual (see Table 6.2).

Table 6.2 Comparative table of road accidents in the 'Giraffe Zone' from 2015-19 (A.R. Zabeirou. pers. comm.).

Year	No. giraffe	Sex/age	Vehicle
2015	1	Adult female	Bus
2017	1	Adult female	Bus
2018	1	Young male	Truck
2019	1	Adult female	Car

Another threat connected with human development is the relatively new railway which was built in Niger a few years ago (see Figure 6.6, Annex 1; 4.1). The railway that runs from Niger-Benin also dissects the 'Giraffe Zone' and despite its current lack of service – it is believed Niger does not own any trains; it can be an insurmountable obstacle for giraffe in some areas. In some sections the railroad is above or under the ground level and it is impossible for giraffe to cross it (Ministry of Environment 2015). The railway may however represent much serious threat if ever it will get operational in the future.

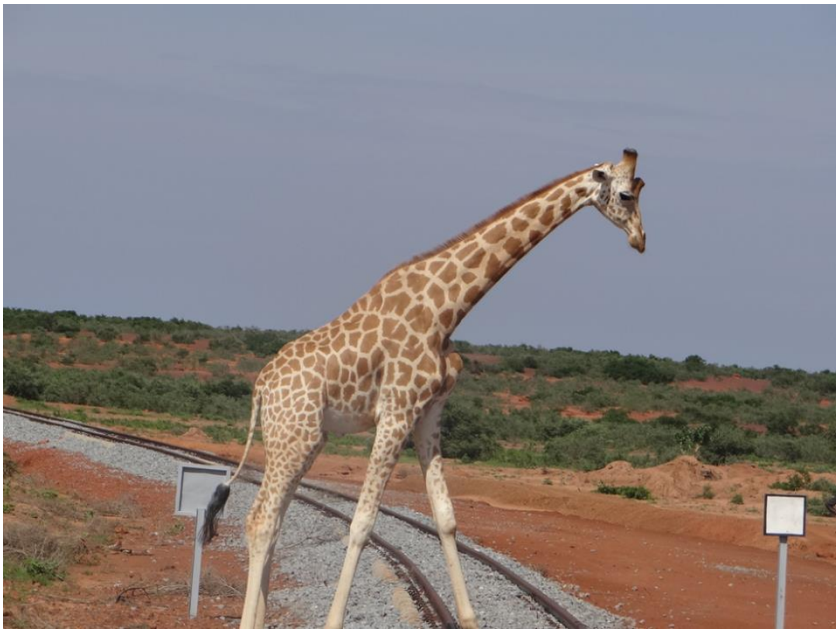

Figure 6.6 Giraffe crossing railway in 'Giraffe Zone' (photo courtesy of A.R. Zabeirou, GCF-SCF).

6.4 Climate Change

The 'Giraffe Zone' lies in a semi-arid region where the mean annual total rainfall is ~350mm/year and the daily mean temperature average is 29°C (National Climate Change Profile: Niger 2018). Rainfall decreases and interannual variability of rainfall increases from south to north. The majority of Niger experiences moderately high rainfall variability on an inter-annual basis. On decadal time scale, Niger also experiences clear variability with some periods being relatively drier or wetter than others. Long-term trends show consistent upward trends of increasing temperature over the period 1979-2015, on

average 0.21°C annually. The total rainfall increased by 26.3mm per decade, but the rainy days decreased by 2.1 days/decade (National Climate Change Profile: Niger 2018, Annex 1; 11.2).

Projection of future climate based on (Couple Model Inter-comparison Project) CMIP5 GCM simulations under the RCP 8.5 pathway predict increase of temperature by 2.5°C by 2050s with changes evident in the next decades. The total annual rainfall trend is estimated to be normal to increasing, ranging anything up to an additional 50% by 2050 and even stronger by the end of the century (National Climate Change Profile: Niger 2018).

After a dry period with prolonged droughts in the 1970s and 1980s (see Figure 6.7), many scientists worried that large areas of the Sahel were irreversibly degraded (Ayoub 1998, Dregne 2002). However, recent scientific results suggest that the decades of abnormally dry conditions in the Sahel have been reversed by positive rainfall anomalies in the early 2000s (Hermann et al. 2005, Brandt et al. 2015). Various remote sensing studies observed a positive trend in vegetation greenness over the last two decades – the 're-greening of the Sahel'. However, this trend is not uniform throughout the Sahel

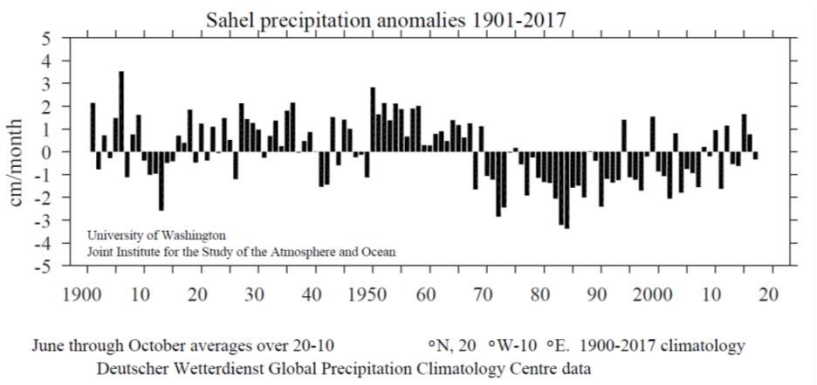

Figure 6.7 Sahel precipitation anomalies since 1900 (source: JISAO)

when looked at on a finer scale (Fiorillo et al. 2017). The greening and degradation are heterogenous and caused by combination of both climate and anthropogenic factors such as historical increase in cropped areas, changes in land use, shortening of the fallow duration, an increase in the grazing pressure intensity during the rainy season and the decline of soil fertility (Derdel et al. 2014).

Droughts can cause serious problems, with that of the early 1970s supposedly one of the last issues that led to the local extirpation of giraffe from the current day Gadabedji Biosphere Reserve (Suraud et al. 2008). Additionally, large herds were also reported to be in the Tanout area, between Agadez and Zinder, however they also likely disappeared because of drought. In 1984, the giraffe in the Ayorou area was reported to also became locally extinct in 1984. Whilst the droughts in all of these areas likely played a role, one can also presume that such harsh conditions led to illegal hunting by local communities in each of these areas – a combination of direct and indirect threats (Boulet et al. 2004).

6.5 Illegal hunting (poaching)

In the early 20th century the West African giraffe occurred across the Sudano-Sahelian zone. One of the main drivers of their disappearance was illegal hunting (poaching; Ciofolo 1998). In Niger, efforts to curb illegal hunting was initiated in the early 1980s (Pfeffer 1981), yet the decline continued. In 1996 only 49 West African giraffe remained in the wild and were concentred in the ‘Giraffe Zone’ close to capital Niamey (Ciofolo 1998; Le Pendu & Ciofolo 1999). The Government of Niger with support from local and international partners increased their effort to enforce legislation preventing the illegal killing of the last West African giraffe. Dedicated community education and awareness campaigns coordinated by PURNKO (Projet d´Utilisation des Resources Naturelles de Kouré), ASGN (Association for Saving the Giraffes of Niger) and AVEN

(Association pour la Valorisation de l´Ecoturisme au Niger) were established with international support to help save the last West African giraffe before it was too late (Fennessy et al. 2018). However, they are more vulnerable to illegal hunting in neighbouring Mali or Nigeria with the long-distance movements sometimes occurring north-west to Mali and east to Gaya (Nigeria border) (Le Pendu & Ciofolo 1999). The same was recorded by (Boulet et al. 2004). (Suraud et al 2008) observed two giraffe in Nigeria in 2007, at least one was immediately poached. The most recent long-distance movement was observed in October 2019, when one of GPS satellite tagged giraffe approached Nigeria, ~30 km from the border (Gašparová et al. 2019). As the West African giraffe population grows and expansion of range increases, we will likely these dispersals more often and can be a future threat that needs monitoring and awareness creation in the local community.

Since 2015, Niger has been waging an open war against Boko Haram, a jihadist insurrection founded in north-eastern Nigeria that has spread to neighbouring countries (Annex 1; 6.2). The Government of Niger declared a State of Emergency (SoE) in 2017 across the country including Diffa Region, Ouallam, Ayrorou, Bankilare, Abala and Banibongou (Tillabéri Region), and Tassara and Tillia (Tahoua Region). This SoE was in response to an escalation in terrorist attacks, especially in the Tillabéri Region. In the last year alone there have been several terror attacks particularly in the Diffa and Tillabéri Regions (www.gov.uk):

- 9 January 2020: terrorists killed 89 Nigerien soldiers at their base in Chinegodrar, Tillabéri
- 10 December 2019: terrorists killed 71 Nigerien soldiers at their base in Inates
- 1 July 2019: terrorists killed at least 18 Nigerien soldiers at an army base in Tillabéri
- 19 June 2019: gunmen killed 2 police officers at the north Niamey Gates

- 16 May 2019: terrorists killed 28 Nigerien soldiers in Tillabéri
- 27 March 2019: suicide bombers and gunmen killed 12 people in Diffa

Additional to Boko Haram, there are number of other terrorist groups active in the region. These include Jamaat Nusrat al-Islam wal Muslimeen (JNIM), Islamic State West Africa (ISWA), Islamic State Greater Sahara (ISGS), Al Qaeda in the Islamic Maghreb (AQIM), Al Murabitoun and Ansar Dine (www.gov.uk). These terrorist groups make work and travel difficult in the majority of Niger, in particular around key border areas of Burkina Faso, Mali and Nigeria (see Figure 6.8).

Figure 6.8 British travel advice for Niger highlighting areas of concern for travellers – essentially all the country is advised against travel although the 'Giraffe Zone' and Gadabedji Biosphere Reserve are in the orange areas (www.gov.uk).

During civil or regional conflicts, it is not surprising that militant and terrorist groups are sometimes involved in illegal hunting of wildlife and potentially trade, to either feed soldiers and/or generate funding. Historically, and likely still ongoing, groups such as the Lord´s Resistance Army (LRA´s) have illegally hunted elephant across parts of East and Central Africa; the Janjaweed Arab militia of Sudan has been accused of killing thousands of elephant in Cameroon, Chad and the Central African Republic (Christy 2015); and, Resistência Nacional Moçambicana (RENAMO) traded in rhino horn and ivory during Mozambique´s civil war (Naylor 1999). In 1970-80s militant groups such as UNITA (União Nacional para a Independência Total de Angola) in Angola as well as the military of numerous African governments illegally killed thousands of elephants for bushmeat and ivory (Benz & Benz-Schwarzburg 2011). Bushmeat from illegal hunting is often a valuable a source of food for militants and civilians during conflicts, and as such can have dire impacts on wildlife populations. Insecurity and violent conflicts are and may continue to be a serious potential threat for the West African giraffe if terrorists turn to illegally hunting them for food, resulting in a decrease in the population size or possibly leading to extinction (Annex 1; 5.1.1).

In addition to insecurity through civil unrest, community members own insecurity may lead to illegal activities. The current corona virus pandemic may be one such threat. The disruption of the global tourism, restricting movements, grounding daily activities and shutting down of unessential businesses may lead to unpredictable economic and social consequences. The indirect impacts of such a threat and associated 'lockdown' measures may result in trouble for wildlife. Not only does the lack of tourism reduce one of the main sources of revenues for local communities, private business and government, but also anti-poaching activities and other conservation work is also restricted – leading to areas possibly being poorly protected during such vulnerable times. If local (or

neighbouring) communities do not have any other alternatives for income (or access to food), it is predicted that illegal hunting may result for local consumption and/or trade (Deliso 2020). And interlinked with this and other threats highlighted above, the lack of resources may also drive local communities towards the cooperation with illegal terrorist organisations.

6.6 Population viability – risk of small population

Small populations are in real danger of going extinct, predominantly due to: (1) genetic issues resulting from loss of genetic variability; (2) demographic fluctuations; and, (3) stochastic events. Genetic variability is important in enabling a population to adapt to a changing environment. In a small population there is a significant probability of losing the variability in each generation due to chance (Primack 2000). Once a population size is small, the mechanism to prevent inbreeding can fail, potentially resulting in inbreeding depression (Ralls et al. 1988). Loss of genetic variability in a small population may limit the ability of the population to respond to long-term changes in environment, for example the new diseases or climate change (Ellstrand 1992; Figure 6.9).
Another problem which can arise in a small population is that of a “bottle neck effect” or “founder effect”. When the population is greatly reduced in size, rare alleles may be lost if individuals do not survive and reproduce, hence unable to pass them along. The “founder effect” may happen when few individuals leave large populations to establish a new one. The new population has potentially less genetical variability and lower probability of persisting (Bryant et al. 1998). When the population become small the demographical and environmental stochasticity becomes crucial factors, the population has higher probability of extinction due to chance alone (Lacy & Lindenmayer 1995). Small populations are also more threatened by random unpredictable catastrophes such are the natural factors

(drought, storm, flood, disease, etc.) (Young 1994). As well as by political and social conflicts, which may significantly affect the wildlife and their habitat (Kanyamibwa 1998). Despite the fact that West African giraffe population rapidly dropped to 49 individuals in 1996 (Ciofolo 1998) the population has high level of genetic diversity (heterozygosity) in comparison with other giraffe population. However, some level of inbreeding is likely to be present in the population. According to molecular genetic research, it is evident that the population went through a bottleneck (Suraud et al. 2008). Management of threatened population should take into account the possible existence and effect of inbreeding depression (Frankham & Ralls 1998). Therefore, efforts such as conservation translocations and establishment of satellite populations are important measures

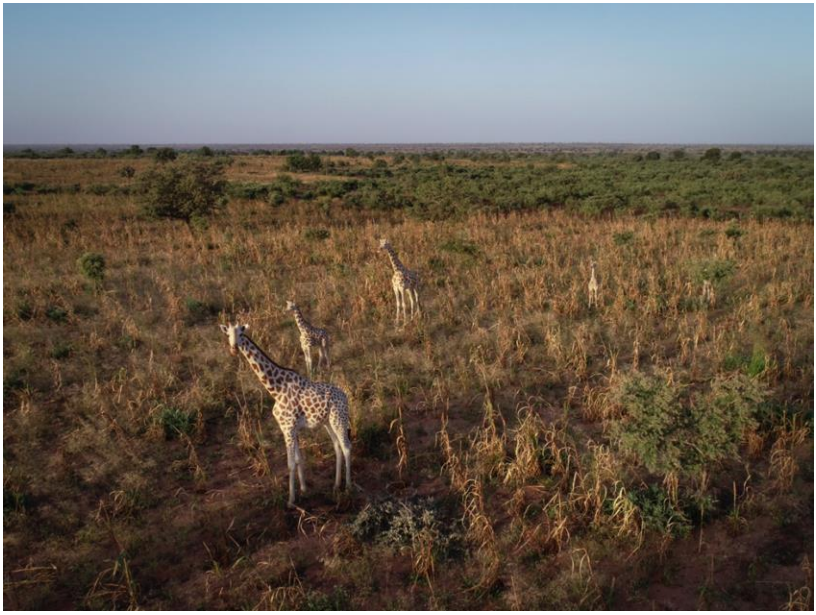

Figure 6.9 Small population size of West African giraffe has rebounded however the long-term monitoring of their genetics is key to their future management (photo courtesy of S. Viljoen).

to help improve long-term viability of the West African giraffe with critical monitoring, including genetic, a tool to help assess its success and ongoing management.

6.7 Conclusion

The most serious threat currently facing the West African giraffe, as for the majority of Sahelian wildlife species, is habitat loss. With the ever-increasing human population in Niger, the space for wildlife is becoming greatly reduced. Much of the original 'tiger bush' habitat, tiger bush on the plateaus has been converted to fields or pastures. Deforested, overgrazed and degraded land continues to rapidly occur throughout the 'Giraffe Zone' and the current conservation agriculture projects are unable to turn the tide. A looming threat is that of current and increasing infrastructural development programmes including roads and railway, and associated traffic. These threats may not affect the entire population; however, the impacts are fatal.

An ongoing threat to the West African giraffe population, especially with their expanding range, is that of illegal hunting. If the country continues to faces unpredictable natural catastrophes (drought, disease, etc.) or political unrest (civil war, terrorism, etc.), illegal hunting may become a direct threat if giraffe is seen as an alternative source of food and/or income. With the current coronavirus disease (COVID-19) resulting in an international pandemic, social, economic and political instability may fuel local civil unrest and terrorism activities, leading to illegal activities involving wildlife. As always, climate change combined with all the other threats will continue to have an impact on giraffe and their habitat – this is something that may not be able to managed but monitored and appropriate actions undertaken.

Fortunately, over the last two and a half decades targeted activities supporting the long-term conservation of the West African giraffe in Niger have enabled the population to bounce back from a critical threshold.

6.8 References

Ayoub, A.T. 1998. Extent, severity and causative factors of land degradation in the Sudan. Journal of Arid Environment 38: 397-409.

Benz, S. & Benz-Schwarzburg, J. 2011. Great Apes and New Wars. Civil Wars 12: 395-430.

Brandt, M., Mbow, C., Diouf, A.A., Verger, A., Samimi, C. & Fensholt, R. 2015. Ground-and satellite-based evidence of the biophysical mechanisms behind the greening Sahel. Global Change Biology 21: 1610-1620.

Bryant, D., Burke, L., McManus, J. & Spalding, M. 1998. Reefs at Risk: A Map-Based Indicator of Threats to the World´s Coral Reefs. World Resources Institute, Washington, D.C.

Boulet, H., Niandou, E.H.I., Alou, D.D. & Chardonnet, B. 2009. Giraffes (Giraffa camelopardalis peralta) of Niger. IUCN/SSC Antelope Specialist Group Report. 81pp

Bullock, K.L., Malan, G. & Pretorius, M.D. 2011. Mammal and bird road mortalities on the Upington to Twee Rivieren main road in the southern Kalahari, South Africa. African Zoology 46: 60-71.

Carvalho, F. & Mira, A., 2011. Comparing annual vertebrate road kills over two time periods, 9 years apart: a case study in Mediterranean farmland. European Journal of Wildlife Research 57: 157-174.

Coelho, I.P., Kindel, A. & Coelho, A.V.P. 2008. Roadkills of vertebrate species on two highwaysthrough the Atlantic Forest Biosphere Reserve, southern Brazil. European Journal of Wildlife Research 54: 689-699

Ciofolo I. 1998 Rapport final de mission du Projet d´Utilisation des Ressources Naturelles de Kouré et du Dallol Bosso Nord. PURNKO Report, Niamey, Niger.

Derdel, C., Kergoat, L., Hiernaux, P., Mougin, E., Grippa, M. & Tucker, C.J. 2014. Re-greening Sahel: 30 years of remote sensing data and field observation (Mali, Niger). Remote Sensing of Environment 140: 350-364.

Deliso, M. 2020. Conservationists fear African animal poaching will increase during COVID-19 pandemic. abcNEWS. https://abcnews.go.com

Dregne, H.E. 2002. Land degradation in the drylands. Arid Land Research and Management 16: 99-132.

Ellstrand, N.C. 1992. Gene flow by pollen: implication for plant conservation genetics. Oikos 63: 77-86.

Galle, S., Ehrmann, M. & Peugeot, C. 1999. Water balance in a banded vegetation pattern – a case study of tiger bush in western Niger. Catena 37: 197-216.

Gašparová, K., Fennessy, J., Rabeil, T., Pourchier, C., Brown, M.M., Zabeirou, A.R.M. & Brandlová, K. 2019. Monthly report of GPS satellite tagged West African giraffe October 2019. Giraffe Conservation Foundation, Namibia. 7pp.

GOV.UK. https://www.gov.uk/foreign-travel-advice/niger/terrorism

Fahrig, L. & Rytwinski, T. 2009. Effects of roads on animal abundance: an empirical review and synthesis. Ecology and Society 14: 1-21.

Farougou, S., Gagara, M. & Mensah, G.A. 2013. Prevalence of peste des petits ruminants in the arid zone in the Republic of Niger. Onderstepoort Journal of Veterinary Research 80: 1-6.

Fennessy, J., Marais A. & Tutchings, A. Giraffa camelopardalis ssp. peralta. In IUCN Red List of Threatened Species 2018: e.T136913A51140803.

Fiorillo, E., Maselli, F., Tarchiani, V. & Vignaroli, P. 2017. Analysis of land degradation processes on tiger bush plateau in

South West Niger using MODIS and LANDSAT TM/ETM+ data. Int J Appl Earth Obs Geoinformation 62: 56-68.

Forman, R.T., Sperling, D., Bissonette, J.A., Clevenger, A.P., Cutshall, C.D., Dale, V.H., Fahrig, L., France, R.L., Goldman, C.R., Heanue, K., Jones, J.,Swanson, F., Turrentine, T. & Winter, T.C. 2003. Road Ecology: Science and Solutions. Island Press, Washington, DC.

Frankham, R. & Ralls, K. 1998. Inbreeding leads to extinction. Nature 392: 441-442.

Hermann, S.M., Anyamba, A. & Tucker, C.J. 2005. Recent trends in vegetation dynamics in the African Sahel and their relationship to climate. Global Environmental Change 15: 394-404.

Christy, B. 2015. How Killing Elephants Finances Terror in Africa. National Geographic. https://www.nationalgeographic.com/tracking-ivory/article.htm

JISAO. http://research.jisao.washington.edu/data_sets/sahel/

Jones, L., Giavedoni, L., Saliki, J.T., Brown, C., Mebus, C. & Yilma T. 1993. Protection of goats against peste des petits ruminants with a vaccinial virus double recombinant expressing the F and H genes of rinderpest virus. Vaccine 11: 961-964.

Kanyamibwa, S. 1998. Impact of war on conservation: Rwanda environment and wildlife in agony. Biodiversity and Conservation 7: 1399-1406.

Lacy, R.C. & Lindenmayer, D.B. 1995. A simulation study of the impact of population subdivision on the mountain brushtail possum Trichosurus caninus Ogilby (Phalangeridae: Marsupalia), in south-eastern Australia: Loss of genetic variation within and between subpopulation. Biological Conservation 73: 131-142.

Le Pendu, Y. & Ciofolo, I. 1999. Seasonal movements of giraffes in Niger. Journal of Tropical Ecology 15: 341-353.

MacClintock, D. 1973. A Natural History of Giraffes. Charles Scribner's Sons, New York. 131pp.

Manu, A., Thurow, T.L., Juo, A.S.R., Sanguina, I., Gandah, M. & Mahamane, I. 1994. Sustainable land management in the Sahel: a case study of an agricultural watershed at Hamdallaye, Niger. TropSoils. Bulletin 94-01.

Ministry of Environment. 2015. Regional Technical Workshop on the Development of the Conservation Strategy and Translocation of the West African Giraffe. Niamey, Niger. 9pp.

Morou, B. 2011. État de dégradation de l'habitat de la girafe (Giraffa camelopardalis peralta Linnaeus, 1758) au Niger. Université Abdou Moumouni de Niamey, Niger. 198pp.

National Climate Change Profile: Niger. 2018. African Development Bank Group. https://www.afdb.org/en/documents/niger-national-climate-change-profile

Naylor, R.B. 1999. Economic Warfare, Sanctions, Embargo Busting and Their Human Cost. McGill-Queen´s University Press, Montreal.

Pfeffer, P. 1981. Les dernières girafes occidentales, une action exemplaire du WWF. Panda 6: 9-10.

Pruvot, M., Fine, A.E., Hollinger, C., Strindberg, S., Damdinjav, B., Buuveibaatar, B., Chimeddorj, B., Bayandonoi, G., Khishgee, B., Sandag, B. & Narmandakh, J. 2020. Outbreak of Peste des Petits Ruminants among Critically Endangered Mongolian Saiga and Other Wild Ungulates, Mongolia, 2016–2017. Emerging Infectious Diseases 26: 51-62.

Primack, R.B. 2000. A primer of Conservation Biology. Second Edition. Sinauer Associates, USA.

Rabeil, T., Zabeirou, A.R.M., Pourchier, C., Abbagana, A.L., Sanoussi, D.F.M., Sahailou, S., Madougou, I., Abdoulaye, A., Idrissa, S., Boureima, A., Garga, H.H.M., Abdou, K. & Idrissa, O. 2019. Technical Workshop National Strategy for the Conservation of the West African giraffe. Niamey, Niger. 9pp.

Ralls, K., Ballou, J.D. & Tampleton. 1998. Estimates of lethal equivalents and the cost of inbreeding in mammals. Conservation Biology 2: 185-193.

Sahailou, S., Madougou, I., Garba, H.H., Abagana, A.L., Fatchima, S.D., Hamadou, O., Abdou, A.K., Boureima, A., Mamane, A., Saley, A., Zabeirou, A.R.M. & Rabeil, T. 2018. Niger National Giraffe Workshop. Niamey, Niger. 9pp.

Simonet, M. 2018. Analyse diachronique comparative de la zone de répartition des dernières girafes de l'Afrique de l'Ouest (Giraffa camelopardalis peralta) avec la Réserve Totale de Faune de Gadabédji dans le cadre du projet de translocation d'une dizaine d'entre elles fin 2018. Thesis. Université Paris Diderot. 177pp.

Skinner, J.D. & Chimimba, C.T. 2005. The mammals of the Southern African subregion. Cambridge University Press, Cambridge. 814pp

Suraud, J-P., Chardonnet, P., Ciofolo, I., Fennessy, J., Brenneman, R., Paolin, C. & Boubacar, D.S. 2008. Vortex Population Modelling Working Group. Mission d'appui technique pour la définition du PHVA (Population and Habitat Viability Assessment) de la population de Girafe d'Afrique de l'Ouest (*Giraffa camelopardalis peralta*) en vue de la formulation d'une stratégie de conservation. 187pp.

Suraud, J-P. 2011. Identifying conservation constraints for the last West African giraffe: population dynamics determining factors and spatial distribution pattern. PhD thesis, University of Lyon.

Worldometers.info. 2020. Dover, Delaware, USA. www.worldometers.info

Wu, X.B., Thurow, T.L. & Whisenant, S.G. 2000. Fragmentation and changes in hydrologic function of tiger bush landscapes, south-west Niger. Journal of Ecology 88: 790-800.

Young, T.P. 1994. Natural die-off of large mammals: Implication for conservation. Conservation Biology 8: 410-418.

Annex 1

Threats			Current level	Potential Future level	Impact on Population
1. Residential & Commercial Development	1.1 Housing & Urban Areas		High	High	Medium
2. Agriculture & Aquaculture	2.1 Annual & perennial non-timber crops	2.1.2 Small-holder Farming	High	High	High
	2.3 Livestock Farming & Ranching	2.3.1 Nomadic Grazing	High	High	High
4. Transportation & Service Corridors	4.1 Roads & Railroads		Medium	Medium	Medium
5. Biological Resource Use	5.1 Hunting & Collecting Terrestrial Animals	5.1.1 Intentional Use (species being assessed is the target	Low	High	High
	5.3 Logging & Wood harvesting	5.3.2 Intentional Use: large scale (species being assessed is the target) [clear cutting of hardwoods, fuel wood collection]	Medium	High	Medium
6. Human Intrusions & Disturbances	6.2 War, Civil Unrest & Military Exercises		Low	High	High
8. Invasive & Other Problematic Species, Genes & Diseases	8.2 Problematic Native Species/Diseases		Low	Medium	High
11. Climate Change & Severe Weather	11.1 Habitat Shifting & Alternation [desertification]		Medium	High	High
	11.2. Droughts		Medium	High	High

7 General Discussion

Our results highlight the challenges related to conservation of a large charismatic mammal in human dominated landscape and demonstrate a positive example of joint governmental, community and NGOs conservation effort.

The West African giraffe was, in the past, spread across most of the Sahelian zone. In the late 20th century, they appeared on the brink of extinction. In 1996 only 49 individuals remained concentrated in “Giraffe Zone”. Thanks to conservation actions and local´s people initiatives, West African giraffe´s population remarkable increased. Being only one concentrated population brings risk of stochasticity, and thus new satellite population was established. In 2018 and 2022 in total 12 giraffe were reintroduced into Gadabedji Biosphere reserve. Although the West African giraffe was downlisted from “Endangered” to “Vulnerable” by IUCN Red List, the positive population growth may rapidly change. Conflict and social insecurity are known to accelerate biodiversity decrease globally and escalate the poaching of wildlife (Gaynor et al., 2016). In southern Niger, northern Cameroon, west-central Chad, and northern Nigeria, Boko-Haram performed over 800 attacks between 2009 and 2013 (Akinola, 2015; OECD-SWAC, 2014). In 2020 six humanitarians, driver and guide were killed by terrorists in “Giraffe Zone” (Maclean, 2020). The security situation is unpredictable especially after the coup in 2023 (Lebovich, 2024). According to Threat analysis, which was prepared in 2020, war, civil unrest and military exercise had medium level of probability but the high negative impact on population.

Although the poaching was evaluated improbable, most local people are convinced that there is no threat to giraffe except natural death (Gašparová et al., 2023). Giraffe cause damage to crops (Gašparová et al., 2023, Leroy et al., 2009, Luxereau, 2004) and agriculture in one of the most important incomes, especially for people in “Giraffe Zone (Gašparová et al., 2023). The human population is increasing, and Niger is still one of the poorest nations in the word (USAID, 2021), moreover the politician situation is not stable (Lebovich, 2024). It is known that armed conflict has negative effect on wildlife and poaching for bushmeat, ivory, fur, etc. is common (Dudley et al. 2002). On the other hand, giraffe means heritage and touristic object for Nigerian local people, and they appreciate their increasing population (Gašparová, et al. 2023).

In anthropogenic landscape, which is highly fragmented a disturbed, changes in spatial pattern occur (Tucker et al. 2018). According to the GPS satellite units, we can see the exact movement of West African giraffe. Our unpublished findings show more extensive HR than these shown in other publications. It may be due to several reasons, the most probable is use of different analysing tool. In the past MCP and KDE was used for measuring the HR. The techniques for collecting the movement data are more modern and exact, and thus, the analysis methods are. We used AKDE for our data, result of this method shows bigger HR size than the formerly used ones. Another reason for larger HR size might be the fragmentation and habitat destruction (Tigas et al. 2002; Lenz et al. 2011), as “Giraffe Zone” is highly populated and fragmented due to villages, roads and railway.

Despite the anthropological influences, giraffe are able to coexist in agro-pastoral human-dominated landscape with

locals and their livestock. After a several decades of living next to human settlements they likely evolved certain level of habituation and tolerance towards people and livestock. They did not compete with livestock for food resources because of the height (Fritz et al., 1996) In fact, they associate with them and also preferred the presence of other animals - weather conspecifics or domestic animals - while resting.

8 General conclusion

This work is focused on the West African giraffe, its conservation, threats, coexistence with humans and livestock, and movement. General conclusions come out of the main chapters of this work:

a. The population of West African giraffe remarkably increased thank to Nigerian government, NGOs and local people's initiatives.
b. Giraffe cause damages on field crops and granaries and despite that farmers appreciate their presence.
c. Poaching of giraffe was in the past threat to giraffe Nowadays, it is improbable, and most people are convinced that giraffe die naturally.
d. Giraffe are habituated and tolerant towards human and their livestock. They prefer company of another animals-whether conspecific or livestock, while resting.
e. West African giraffe show larger home range size than was analysed in the past. It might be due to different analysing technique or due to habitat changes.
f. Despite the human-giraffe coexistence in Niger, giraffe are facing several potential threats such as habitat lost, human population growth, increasing of infrastructure, climate change and armed conflicts.

9 General References

Akinola, O. (2015). Boko Haram insurgency in Nigeria: Between Islamic fundamentalism, politics, and poverty. African Security, 8(1), 1-29. https://doi.org/10.1080/19392206.2015.998539

Barnosky, A. D., Hadly, E. A., Bascompte, J., Berlow, E. L., Brown, J. H., Fortelius, M., ... & Smith, A. B. (2012). Approaching a state shift in Earth's biosphere. Nature, 486(7401), 52-58. https://doi.org/10.1038/nature11018

Beauchamp, G., Li, Z., Yu, C., Bednekoff, P. A., & Blumstein, D. T. (2021). A meta-analysis of the group-size effect on vigilance in mammals. Behavioral Ecology, 32(5), 919-925. https://doi.org/10.1093/beheco/arab048

Burt, W. H. (1943). Territoriality and home range concepts as applied to mammals. *Journal of mammalogy*, 24(3), 346-352. https://doi.org/10.2307/1374834

Carter, K.D., Brand, R., Carter, J.K., Shorrocks, B., & Goldizen, A.W. (2013) Social networks, long-term associations and age-related sociability of wild giraffes. Animal Behaviour 86: 901–910. https://doi.org/10.1016/j.anbehav.2013.08.002

Ciofolo, I. (1991). Faune sauvage et potentialités régionales: la girafe dans la région de Kouré-Boboye, l'hippopotame dans la région d'Ayorou. Rapport IUCN/DFPP, Niamey.

Ciofolo, I. (1995). West Africa's last giraffes: the conflict between development and conservation. Journal of

Tropical Ecology, 11(4), 577-588. https://doi.org/10.1017/S0266467400009159

Ciofolo, I., & Le Pendu, Y. (2002). The feeding behaviour of giraffe in Niger. Mammalia, 2, 183-194. https://doi.org/10.1515/mamm.2002.66.2.183

Ciofolo, I., Le Pendu, Y., & Gosser, A. (2000). Les girafes du Niger, dernières girafes d'Afrique de l'Ouest. Revue d'écologie, 55(2), 117-128.

Craigie, I. D., Baillie, J. E., Balmford, A., Carbone, C., Collen, B., Green, R. E., & Hutton, J. M. (2010). Large mammal population declines in Africa's protected areas. Biological conservation, 143(9), 2221-2228. https://doi.org/10.1016/j.biocon.2010.06.007

Creel, S., Schuette, P., & Christianson, D. (2014). Effects of predation risk on group size, vigilance, and foraging behavior in an African ungulate community. Behavioral Ecology, 25(4), 773-784. https://doi.org/10.1093/beheco/aru050

D'haen, M., Fennessy, J., Stabach, J. A., & Brandlová, K. (2019). Population structure and spatial ecology of Kordofan giraffe in Garamba National Park, Democratic Republic of Congo. *Ecology and Evolution*, 9(19), 11395-11405. https://doi.org/10.1002/ece3.5640

Di Marco, M., Buchanan, G. M., Szantoi, Z., Holmgren, M., Grottolo Marasini, G., Gross, D., ... & Rondinini, C. (2014). Drivers of extinction risk in African mammals: the interplay of distribution state, human pressure, conservation response and species biology. Philosophical Transactions of the Royal Society B: Biological Sciences, 369(1643), 20130198. https://doi.org/10.1098/rstb.2013.0198

Dudley, J. P., Ginsberg, J. R., Plumptre, A. J., Hart, J. A., & Campos, L. C. (2002). Effects of war and civil strife on wildlife and wildlife habitats. Conservation Biology, 16(2), 319-329. https://doi.org/10.1046/j.1523-1739.2002.00306.x

Duru, M., Therond, O., Martin, G., Martin-Clouaire, R., Magne, M. A., Justes, E., ... & Sarthou, J. P. (2015). How to implement biodiversity-based agriculture to enhance ecosystem services: a review. Agronomy for sustainable development, 35, 1259-1281. https://doi.org/10.1007/s13593-015-0306-1

Fennessy, J. (2009). Home range and seasonal movements of Giraffa camelopardalis angolensis in the northern Namib Desert. African Journal of Ecology, 47(3), 318-327. https://doi.org/10.1111/j.1365-2028.2008.00963.x

Fennessy, J., Bidon, T., Reuss, F., Kumar, V., Elkan, P., Nilsson, M. A., ... & Janke, A. (2016). Multi-locus analyses reveal four giraffe species instead of one. Current Biology, 26(18), 2543-2549. https://doi.org/10.1016/j.cub.2016.07.036

Fennessy, J., Marais, A. & Tutchings, A. 2018. Giraffa camelopardalis ssp. peralta. The IUCN Red List of Threatened Species 2018: e.T136913A51140803. https://dx.doi.org/10.2305/IUCN.UK.2018-2.RLTS.T136913A51140803.en. Accessed on 01 October 2024.

Flanagan, S. E., Brown, M. B., Fennessy, J., & Bolger, D. T. (2016). Use of home range behaviour to assess establishment in translocated giraffes. *African Journal of Ecology*, 54(3), 365-374. https://doi.org/10.1111/aje.12299

Fleming, C. H., Fagan, W. F., Mueller, T., Olson, K. A., Leimgruber, P., & Calabrese, J. M. (2015). Rigorous home range estimation with movement data: a new autocorrelated kernel density estimator. Ecology, 96(5), 1182-1188. https://doi.org/10.1890/14-2010.1

Foley, J. A., DeFries, R., Asner, G. P., Barford, C., Bonan, G., Carpenter, S. R., ... & Snyder, P. K. (2005). Global consequences of land use. Science, 309(5734), 570-574. https://doi.org/10.1126/science.1111772

Fritz, H., De Garine-Wichatitsky, M., & Letessier, G. (1996). Habitat use by sympatric wild and domestic herbivores in an African savanna woodland: the influence of cattle spatial behaviour. Journal of Applied Ecology, 589-598.https://doi.org/10.2307/2404987

Gašparová, K., Fennessy, J., Rabeil, T., Zabeirou, A.R.M., Brandlová, K. (2018). *Operation Sahel Giraffe. Translocation and Post-Translocation Monitoring of West African Giraffe from Kouré to Gadabedji Biosphere Reserve, Niger*. Giraffe Conservation Foundation: Niamey, Niger.

Gašparová, K., Blanco, J., Glikman, J. A., Fennessy, J., Zabeirou, A. R. M., Mahamadou, A. R. A., ... & Brandlová, K. (2023). Social development and biodiversity conservation synergies for the West African giraffe in a human–wildlife landscape. Environmental Conservation, 50(4), 259-266. https://doi.org/10.1017/S0376892923000243

Gašparová, K., Fennessy, J., Moussa Zabeirou, A.R., Abagana, A.L., Rabeil, T., Brandlová, K. (2024). Saving the Last West African Giraffe Population: A Review of Its Conservation Status and Management. *Animals*. 14, 702. https://doi.org/10.3390/ ani14050702

Gaynor, K. M., Fiorella, K. J., Gregory, G. H., Kurz, D. J., Seto, K. L., Withey, L. S., & Brashares, J. S. (2016). War and wildlife: linking armed conflict to conservation. Frontiers in Ecology and the Environment, 14(10), 533-542. https://doi.org/10.1002/fee.1433

Gloneková, M., Brandlová, K., & Pluháček, J. (2021). Further behavioural parameters support reciprocity and milk theft as explanations for giraffe allonursing. Scientific Reports, 11(1), 7024. https://doi.org/10.1038/s41598-021-86499-2

Graham, M. D., Douglas-Hamilton, I., Adams, W. M., & Lee, P. C. (2009). The movement of African elephants in a human-dominated land-use mosaic. *Animal conservation*, 12(5), 445-455. https://doi.org/10.1111/j.1469-1795.2009.00272.x

IUCN SSC. (2013). *Guidelines for Reintroductions and Other Conservation Translocations; Version 1.0*. IUCN Species Survival Commission: Gland, Switzerland.

Knüsel, M. A., Lee, D. E., König, B., & Bond, M. L. (2019). Correlates of home range sizes of giraffes, Giraffa camelopardalis. Animal Behaviour, 149, 143-151. https://doi.org/10.1016/j.anbehav.2019.01.017

Laboureau, C. (1997). Ethologie de la girafe: Etude des relations mere-jeune. Etude des dégâts occasionnés par les girafes aux cultures. Projet PURNKO, SNV, Niamey, Niger.

Lebovich, A. (2024) Security in Sahel. Danish Institute for International Studies. https://www.diis.dk/en/research/security-in-the-sahel

Lenz, J., Fiedler, W., Caprano, T., Friedrichs, W., Gaese, B. H., Wikelski, M., & Böhning-Gaese, K. (2011). Seed-dispersal distributions by trumpeter hornbills in

fragmented landscapes. Proceedings of the Royal Society B: Biological Sciences, 278(1716), 2257-2264. https://doi.org/10.1098/rspb.2010.2383

Leroy, R., De Visscher, M. N., Halidou, O., & Boureima, A. (2009). The last African white giraffes live in farmers' fields. Biodiversity and conservation, 18, 2663-2677. https://doi.org/10.1007/s10531-009-9628-0

Luxereau, A. (2004). Des animaux ni sauvages ni domestiques, les «girafes des Blancs» au Niger. Anthopozoologica, 39(1), 1-12.

Maclean, R. (2020). 8 Dead after Attack in Wildlife Reserve in Niger. The New York Times. https://www.nytimes.com/2020/08/09/world/africa/niger-giraffe-reserve-attack.html

Molvar, E. M., & Bowyer, R. T. (1994). Costs and benefits of group living in a recently social ungulate: the Alaskan moose. *Journal of mammalogy*, 75(3), 621-630. https://doi.org/10.2307/1382509

Muller, Z., Cuthill, I. C., & Harris, S. (2018). Group sizes of giraffes in Kenya: the influence of habitat, predation and the age and sex of individuals. Journal of Zoology, 306(2), 77-87. https://doi.org/10.1111/jzo.12571

Newmark, W. D. (2008). Isolation of African protected areas. *Frontiers in Ecology and the Environment*, 6(6), 321-328. https://doi.org/10.1890/070003

OECD-SWAC (2014). An Atlas of the Sahara-Sahel. Geography, Economics and Security. OECD Publishing. Retrieved from https://doi.org/10.1787/9789264222359-en

Potts, M., Gidi, V., Campbell, M., & Zureick, S. (2011). Niger: Too Little, Too Late. *International Perspectives on*

Sexual and Reproductive Health, 37(2), 95–101. https://www.jstor.org/stable/41229000

Rabeil, T., Newby, J., & Harouna, A. (2014). Innovation, traditional knowledge and awareness lead to good practices for avoiding biodiversity loss in the Sahara. Biodiversity, 15(2-3), 185-191. https://doi.org/10.1080/14888386.2014.936038

Sakadevan, K., & Nguyen, M. L. (2017). Livestock production and its impact on nutrient pollution and greenhouse gas emissions. Advances in agronomy, 141, 147-184. https://doi.org/10.1016/bs.agron.2016.10.002

Sayer, J. (Ed.). (1992). The conservation atlas of tropical forests: Africa. Springer.

Siegfried, W. R. (1989). Preservation of species in southern African nature reserves. *Biotic diversity in southern Africa: Concepts and conservation*, 186-201.

Shukla, I., Kilpatrick, A. M., & Beltran, R. S. (2021). Variation in resting strategies across trophic levels and habitats in mammals. Ecology and evolution, 11(21), 14405-14415. https://doi.org/10.1002/ece3.8073

Suraud, J. P., & Dovi, O. (2007). Giraffes of Niger—2006 census. Bi-Annual Newsletter of the International Giraffe Working Group, 1(2), 12-13.

Suraud, J.P., Fennessy, J., Bonnaud, E., Issa, A.M., Fritz, H., & Gaillard, J. (2012). Higher than expected growth rate of the Endangered West African giraffe *Giraffa camelopardalis peralta*: A successful human–wildlife cohabitation. *Oryx*, 46, 577–583. https://doi.org/10.1017/S0030605311000639

Tigas, L. A., Van Vuren, D. H., & Sauvajot, R. M. (2002). Behavioral responses of bobcats and coyotes to habitat

fragmentation and corridors in an urban environment. Biological Conservation, 108(3), 299-306. https://doi.org/10.1016/S0006-3207(02)00120-9

Tucker, M. A., Böhning-Gaese, K., Fagan, W. F., Fryxell, J. M., Van Moorter, B., Alberts, S. C., ... & Mueller, T. (2018). Moving in the Anthropocene: Global reductions in terrestrial mammalian movements. Science, 359(6374), 466-469. https://doi.org/10.1126/science.aam9712

USAID. (2021). Niger: Nutrition Profile. https://www.usaid.gov/document/niger-nutrition-profile

Van Der Jeugd, H. P., & Prins, H. H. (2000). Movements and group structure of giraffe (*Giraffa camelopardalis*) in Lake Manyara National Park, Tanzania. *Journal of Zoology*, 251(1), 15-21. https://doi.org/10.1017/S0952836900005033

Walther, B. A. (2016). A review of recent ecological changes in the Sahel, with particular reference to land-use change, plants, birds and mammals. *African Journal of Ecology*, 54(3), 268-280. https://doi.org/10.1111/aje.12350

Winter, S., Fennessy, J., & Janke, A. (2018). Limited introgression supports division of giraffe into four species. Ecology and Evolution, 8(20), 10156-10165. https://doi.org/10.1002/ece3.4490

Wu, X. B., Thurow, T. L., & Whisenant, S. G. (2000). Fragmentation and changes in hydrologic function of tiger bush landscapes, south-west Niger. *Journal of Ecology*, 88(5), 790-800. https://doi.org/10.1046/j.1365-2745.2000.00491.x

Zabeirou, A.R.M. (2017). National Survey Report of West African Giraffe, Niger. 9pp.