Biodiversity and Conservation
https://doi.org/10.1007/s10531-024-02824-x

REVIEW PAPER

Updated review of the conservation status of Nubian giraffe (*Giraffa camelopardalis camelopardalis*) in Kenya

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Received: 26 October 2023 / Revised: 21 February 2024 / Accepted: 4 March 2024

Abstract
Giraffe (*Giraffa* spp.) numbers and their habitat have drastically declined throughout Africa over the last century due to various threats linked to anthropogenic impacts including habitat loss and fragmentation, disease, poaching, and climate change. In Kenya, the Nubian giraffe (*G. camelopardalis camelopardalis*) population decreased significantly up until the late 1980s. As a result of increased conservation efforts, the Nubian giraffe population has rebounded since the early 1990s, however, it remains predominantly extralimital and/or restricted to closed protected areas in central and western Kenya. In this paper, we set out to assess historical and current population numbers and trends of Nubian giraffe in Kenya, and highlight the conservation efforts that are applied to conserve this *Critically Endangered* taxon. We reviewed published manuscripts and grey literature, wildlife authority records and interviewed landowners with Nubian giraffe populations. We also conducted photographic surveys in three national parks and reserves where anecdotal reports suggested that the largest populations of Nubian giraffe occurred. We found that from a low of ~ 130 individuals remaining in the wild and near extinction in the mid-1970s, the Nubian giraffe population has rebounded to ~ 1,042 in 14 populations in Kenya, which represents an increase of more than 700%. This conservation success story is attributed to targeted management efforts, in particular conservation translocations and the increased monitoring of populations. At the same time, various factors including habitat loss and fragmentation, and infrastructure developments, linked with the increasing human population continue to pose a threat to their survival in the country. We place our findings in the broader context of population ecology and present opportunities for conservation research as well as recommendations that inform the management of this critical population of concern.

Keywords *Giraffa* · *Giraffa camelopardalis camelopardalis* · Nubian giraffe · Kenya · Translocation · Population management · Conservation research

Communicated by Nigel Stork.

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Published online: 16 March 2024

Introduction

Wildlife populations have largely declined in the past century throughout their range, especially in Africa (Ogutu et al. 2016; Horváth et al. 2019). These declines are largely attributed to increased anthropogenic impacts linked to human population growth, which in turn result in land-use and cover change, habitat loss, land fragmentation and infrastructural development (Western et al. 2009; Scholte 2011; Said et al. 2016). Additionally, climate change, poor governance, disease, and poaching (illegal hunting) continue to threaten wildlife populations (Scholte 2011; Ferreira et al. 2019). As an example, both species of African elephant (*Loxodonta africana* and *L. cyclotis*) and African rhino (*Diceros bicornis* and *Ceratotherium simum*) have been greatly affected by the illegal trade of their ivory and horns respectively (Ferreira et al. 2015). It is estimated that 2,936 rhinos were killed in Kruger National Park (NP) between 2011 and 2015, and 20.8% of known elephant were killed in Kenya between 2009 and 2012 (Wittemyer et al. 2014; Ferreira et al. 2015). Such steep declines have and can lead to local extinction of species from their natural habitats (Barnes et al. 2016). Crucially, re-establishing populations that have gone extinct from their natural range can be an incredibly challenging and costly endeavour but an equally important conservation tool.

Various wildlife species have been reintroduced to former habitats following their extirpation, as well as established in areas outside their natural ranges (extralimital), to provide safe havens, promote ecosystem health and/or local tourism (Vernesi et al. 2003; Polak and Saltz 2011; Auster et al. 2020). In the last century, giraffe (*Giraffa* spp.) have gone extinct in at least seven sub-Saharan African countries (Burkina Faso, Eritrea, Guinea, Mali, Mauritania, Nigeria, and Senegal) and lost $\sim$ 90% of their historical range during the last 300 years (O'Connor et al. 2019; Brown et al. 2021). Following an estimated decline of $\sim$ 30% in approximately 40 years, the International Union for the Conservation of Nature (IUCN) Giraffe & Okapi Specialist Group uplisted giraffe as a single species from 'Least Concern' to 'Vulnerable' on the Red List of Threatened Species (Muller et al. 2016). Interestingly, these recent declines are not range-wide with major reductions in East and Central Africa, whilst southern Africa shows on average an increasing population trend (Muller et al. 2018a; Brown et al. 2021). Throughout East Africa, Masai (*G. tippelskirchi*) and reticulated (*G. reticulata*) giraffe populations have declined markedly, yet Nubian giraffe (*G. c. camelopardalis*) have increased (Fennessy et al. 2018; Muneza et al. 2018; Bolger et al. 2019). The reasons for the increase of Nubian giraffe are varied but it is assumed that intensive surveys, monitoring and conservation actions, especially in Uganda, contributed significantly (Brown et al. 2019).

As the name indicates, Nubian giraffe ranged in much of the Nubia region in northern Africa (Egypt, South Sudan, and Sudan) as well as parts of Ethiopia, north-western Kenya, and Uganda (Brown et al. 2019). Currently, Nubian giraffe are only found in small populations in Ethiopia, Kenya, South Sudan, and Uganda, and this giraffe subspecies is listed as C*ritically Endangered* on the IUCN Red List (Fennessy et al. 2018). In Kenya, Nubian giraffe have been awarded full protection under the Wildlife Conservation and Management Act of 2013 (WCMA 2013) since their severe decline in the late 1970s (Muller 2019), which almost led to their local extinction within their natural range in Kenya (Kenya Wildlife Service (KWS) 2018). Following targeted conservation translocations, the population has seemingly rebounded, while ongoing threats remain (KWS 2021).

In this study, we detailed the history, population trends and distribution numbers of Nubian giraffe in Kenya by reviewing published manuscripts and grey literature, consulting experts, and conducting field surveys of important populations. Through this approach, we attempted to consolidate information on the historical numbers and current conservation status of Nubian giraffe in Kenya. We also provided recommendations for their management in consideration of the recent conservation actions conducted to enhance their protection.

Methodology

Literature review of historic data

We undertook a detailed search of peer-reviewed scientific papers, grey literature and reports on the history and current Nubian giraffe population status in Kenya using online databases of Google Scholar, JSTOR, ResearchGate, and Web of Science. The search involved combinations of key words that included Nubian giraffe, Rothschild's giraffe, Baringo giraffe, giraffe translocations in Kenya, and names of current and historic geographic ranges of Nubian giraffe in Kenya. We included Nubian, Rothschild's and Baringo giraffe in the search terms as these are names synonymous with the subspecies (Dagg 1971; East 1999). We filtered the results by title, followed by the abstract and full review of the publications, to include only manuscripts and reports that detailed Nubian giraffe numbers, distribution, and threats in Kenya. We did not place any limitations on the year of publication. We rejected results that described the conservation status of Nubian giraffe outside of Kenya and of other giraffe species in Kenya. To complement our results, we visited the KWS library, which serves as the repository for all government documents on wildlife, and searched reports on the history of Nubian giraffe populations as well as their translocation history. In addition, we conducted in-person and email interviews with relevant local experts on the translocation history and conservation status of Kenya's Nubian giraffe. Our intention here was to record first-hand accounts in order to document all current and historical Nubian giraffe numbers and distribution in the country.

Expert knowledge is used in conservation science and practice to provide reliable data on a particular topic (Martin et al. 2012). As such, we derived updated data on the conservation status of the Nubian giraffe during meetings of the National Nubian Giraffe Range Committee, which was established to support the implementation of the first-ever Recovery and Action Plan for Giraffe in Kenya (2018–2022), as well as in-person interviews with select individuals who have worked with the subspecies. Experts including wildlife veterinarians, park managers and ecologists from parks, reserves and sanctuaries where Nubian giraffe occur, were interviewed. During these meetings, the experts provided updated giraffe data including threats that populations face and priority actions undertaken/proposed to mitigate the identified threats in their specific areas. Additionally, they provided information regarding the translocation history of Nubian giraffe with regards to numbers, source population, destination areas and proposed conservation priority actions.

Photographic surveys

To estimate current numbers and the distribution of Nubian giraffe we conducted photographic surveys in Mwea National Reserve (NR), Ruma NP, and Lake Nakuru NP (Fig. 1). These enclosed government-managed protected areas are home to some of the largest Nubian giraffe population in Kenya (Muller et al. 2018a). The Mwea NR and Ruma NP surveys were carried out over a one-year period between March 2017 and March 2018, while the Lake Nakuru NP surveys were conducted from January to July 2019. Mwea NR covers an area of 48 km^2 in central Kenya and lies between the confluence of the Thiba and Tana Rivers. The landscape is characterised by riverine woodlands and thickets and for the surveys, we divided the Mwea NR road network into three transects, namely the Upper (13.2 km), Lower (13.3 km) and Tana (15.2 km) transects. Ruma NP covers an area of 120 km^2 within Lambwe Valley in western Kenya, and the vegetation is mainly savannah grassland and woodland with extensive bushes. During the survey, we mapped a road network of 66.6 km, which was divided into Kamato (21.9 km), Lambwe (22.3 km) and Wiga (22.2 km) transects. The transects in both Mwea NR and Ruma NP were each surveyed 20 times to ensure all areas of the park were adequately covered. Lake Nakuru NP is located in Nakuru County, and covers an area of $\sim$ 188 km^2. The park is characterised by *Vachellia* and *Euphorbia* woodlands, as well as thick bushes and open grasslands in the sedimentary plains found north and south of the lake. We divided the accessible road network into three transects, namely Lanet (50 km), Nderit (49 km), and Naishi (49 km) transects. Two surveys of three days each were done over two field seasons: dry (January and February 2019)

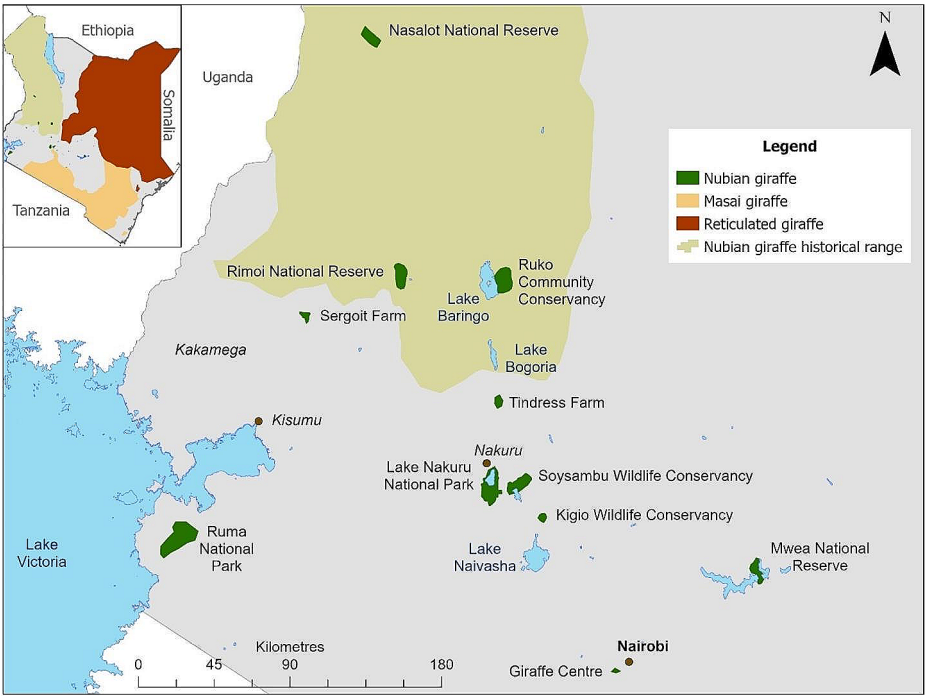

Fig. 1 Current distribution of Nubian giraffe in Kenya. Inset map: Current distribution of all giraffe species in Kenya, including assumed historic range of Nubian giraffe

and wet season (May to July 2019). Additionally, giraffe in Soysambu Wildlife Conservancy (WC) in Nakuru County are regularly monitored and a detailed database of individual giraffe is maintained. We analysed 131 individual identification photos of giraffe to assess whether individuals move between the two conservation areas.

The road-based surveys were conducted through driving along set transects at a speed of $\sim$ 40 km/hr to ensure maximum sightings of giraffe. We took photos of the right-side of every giraffe encountered using a Nikon CoolPix P900 camera for later identification of individuals using Wild-ID (Bolger et al. 2012). When giraffe were encountered, we recorded time of sighting, name of transect, number of individuals in the group, age, sex, signs of disease, and photo number. We sorted the images to remove photos where the right side of the giraffe was not clearly visible either due to blurriness or obstruction of vegetation or other animals. We then cropped suitable images to retain the maximum area of the giraffe coat pattern for Wild-ID analysis to identify individual giraffe. Wild-ID characterised giraffe coat patterns in the images and assigned similarity scores of the images ranging from 0.0001 to 0.9999. We selected the top-ranked image as the matching pair and further inspected each pair visually before confirming the match to avoid false acceptance. We only selected the photograph with the highest ranking that could be visually matched. The results from the photographic analysis yielded encounter histories of giraffe by referring to the GPS coordinates of the corresponding image recorded during our surveys.

Results

From our online search, we found 51 relevant manuscripts, among which 35 were published articles that had information about numbers, habitat, and distribution of Nubian giraffe in Kenya. An additional three focused on giraffe skin disease (GSD), and four described both historic and recent estimates of Nubian giraffe. We also reviewed six reports relating to Nubian giraffe translocations in Kenya from the KWS Vet library.

In early literature, Nubian giraffe were first described as Baringo giraffe as they were recorded in the Lake Baringo District, extending from Mount Elgon (Lydekker 1904) to Turkana (Lipscomb et al. 1931). The first detailed population estimate by the then Kenya Game Department estimated 850 individuals in 1946 with the largest population occurring on Soy Ranch in western Kenya (Leslie-Melville and Leslie-Melville 1977). However, illegal killings by farmers who termed giraffe a menace led to their decline (Nesbit 1970). In 1967, 11 giraffe were translocated from Soy Ranch to Maralal National Sanctuary in the first successful reported translocation as previous attempts to translocate giraffe to Maralal resulted in an early release in the nearby Menengai Crater (Nesbit 1970). However, only three giraffe were sighted in 1968 and by 1970 none survived (Nesbit 1970). By 1974, the number of Nubian giraffe in the country was estimated at 130 individuals (Leslie-Melville and Leslie-Melville 1977). In the same year, Major Rutherford announced the sale of his land, which prompted the then Game Department to begin translocations from the farm (Fig. 2).

In 1979, three giraffe were translocated from Soy Ranch to Nairobi, with the intention of breeding these individuals for conservation purposes and establishing a nature education centre for students (Sembe 2015). This led to the creation of the Giraffe Centre supported by the African Fund for Endangered Wildlife (AFEW) in 1983. Ever since, the Giraffe Cen-

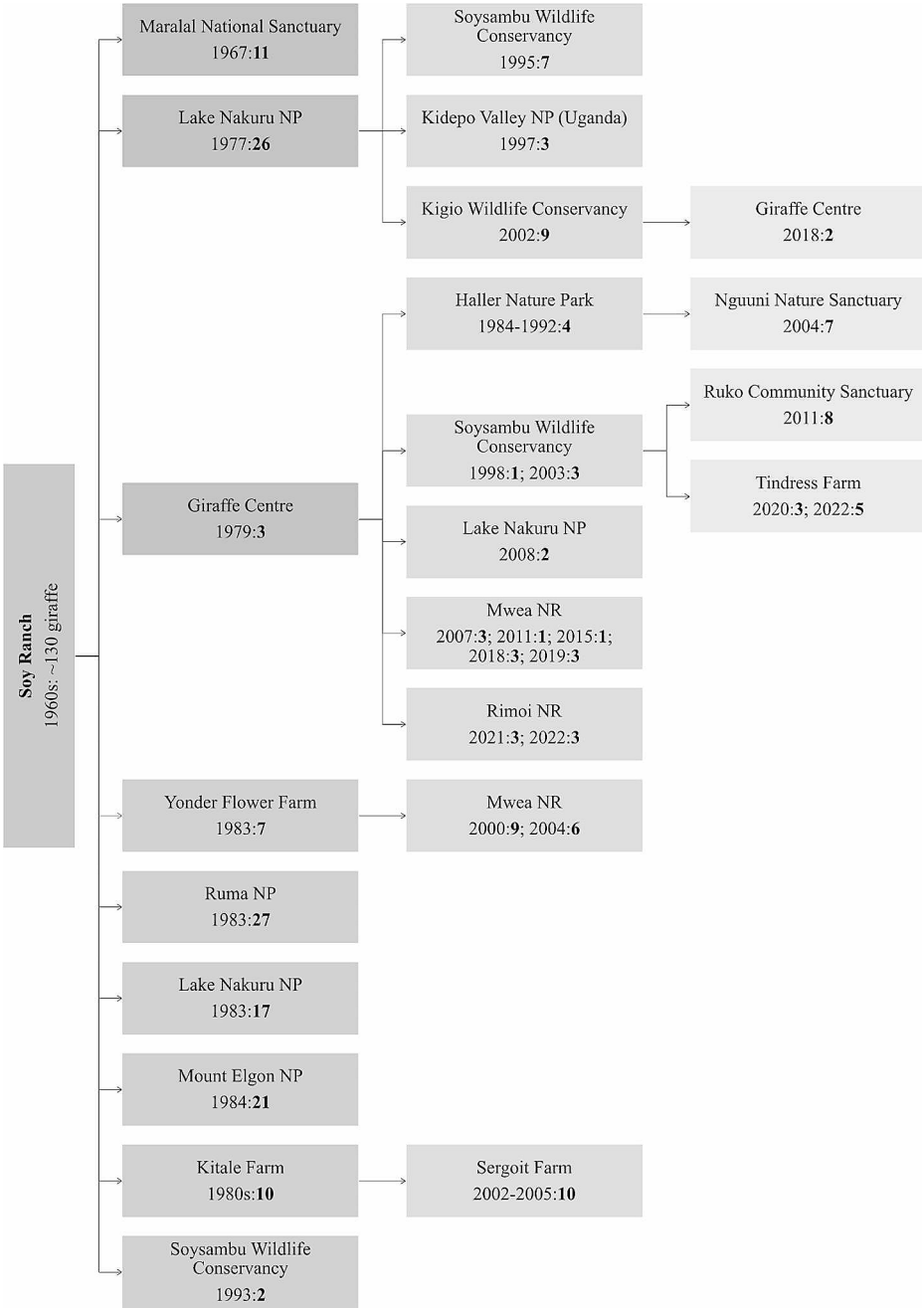

Fig. 2 Major translocations of Nubian giraffe conducted in Kenya from the 1960s to 2022. All major populations were (re-)established from ~ 130 giraffe that were translocated from Soy Ranch between the 1960 and 1980s when it was converted to a human resettlement farm

tre has played a role in conservation education, breeding, (re)populating, and augmenting Nubian giraffe populations throughout the country. To date, 27 giraffe have been translocated from the Giraffe Centre, including 11 to Mwea NR, six to Rimoi NR, four each to Haller Park and Soysambu WC, and two to Lake Nakuru NP (Fig. 2). In 2018, two female giraffe from Kigio WC were brought into the Giraffe Centre to increase the genetic diversity of the population and currently, the Giraffe Centre is home to 11 giraffe, nine females and two males (Table 1).

In 1983, seven giraffe were introduced to Yonder Flower Farm in Mbeere South District in Central Kenya, and by the late 1990s, the population had grown to 24 individuals (Gakuya 2004). Due to concerns of the size of the farm and the desire to expand agricultural activities, translocations from the farm to the nearby Mwea NR in Embu County began in 1985 (Muriuki et al. 2018). Mwea NR was established in 1975 to protect the remaining wildlife species after many large mammals including giraffe, African lion (*Panthera leo*), leopard (*Panthera pardus*), kongoni (*Alcelaphus buselaphus*), black rhino, and lesser kudu (*Tragelaphus imberbis*) were locally extinct due to the increasing human settlements that led to encroachment, poaching, and habitat destruction (Chira 2003). In 2000, an additional nine giraffe were introduced from Soy Ranch, and the last remaining giraffe from Yonder Flower Farm were translocated to Mwea NR in 2004 (Chira 2003). Giraffe numbers slowly increased and in 2007, a further two males and one female were introduced from the Giraffe Centre (Sembe 2015). By 2011, the population had increased to 44 giraffe but an anthrax

Table 1 Current population estimates and trends of Nubian giraffe in Kenya compared to numbers in 2015 when initial IUCN Red List assessment was undertaken

Ecosystem	Size (km^2)	Population estimates				Trend
		2015	Source	Current	Source	
Ruma National Park	120	68	Muller et al. 2016	550	KWS 2021	Increasing
Soysambu Wildlife Conservancy	190	109	Muller et al. 2016	162	This study (pers. comm.)	Increasing
Lake Nakuru National Park	188	81	Muller et al. 2016	109	KWS 2021	Increasing
Mwea National Reserve	42	100	Muller et al. 2016	79	KWS 2021	Increasing
Kigio Wildlife Conservancy	14	37	Muller et al. 2016	46	This study (pers. comm.)	Increasing
Rimoi NR	66	7	Muller et al. 2016	20	This study (pers. comm.)	Stable
Ruko Community Conservancy	17.7	8	Muller et al. 2016	14	This study (pers. comm.)	Increasing
Sergoit Farm	12.1	< 10	Muller et al. 2016	12	This study (pers. comm.)	Stable
Tindress Farm	3.2	5	Muller et al. 2016	12	KWS 2021	Stable
Giraffe Centre	0.6	10	Muller et al. 2016	11	This study (pers. comm.)	Stable
Nguuni Nature Sanctuary	7	-		11	This study (pers. comm.)	Stable
Nasalot NR	92	$\sim$ 10		$\sim$ 10	KWS 2021	Unknown
Haller Nature Park	3	-		6	This study (pers. comm.)	Stable
Mount Elgon	1,279	8	Muller et al. 2016	0	KWS 2021	Extirpated
Total		**$\sim$ 453**		**$\sim$ 1,042**		

outbreak in the reserve led to the death of 11 individuals (Kaitho et al. 2013). Several additional giraffe introductions from the Giraffe Centre were conducted over the subsequent years: one male in 2011, one male in 2015, two females and one male in 2018, and two males and one female giraffe in 2021 (Fig. 2). From our photographic surveys in Mwea NR in 2018, we captured 760 images from 233 sightings of giraffe. After filtering and cropping the images, we were left with 549 images. The average herd size was six giraffe (range 1–23). We identified 56 unique individuals, which included 20 adult males, 21 adult females, five sub-adult males, three sub-adult females and seven calves. Recent numbers from the 2021 National Aerial Census estimated $\sim$ 79 giraffe in Mwea NR based on a total count (KWS 2021), representing an annual population growth rate of 1.4 individuals since 1985. During the photographic surveys, we recorded two giraffe with visible snare wounds on their limbs. One giraffe, which was severely injured and limping, was subsequently treated by a KWS veterinary team. Snares set by poachers targeting small mammals for consumption have long been a threat to the giraffe population in the reserve. This is exacerbated by the loss of habitat caused by invasive plant species and illegal logging, as well as anthrax outbreaks, and climate change (Chira 2003; Gachohi et al. 2019; Jenkins et al. 2021).

Twenty seven giraffe (22 female and 5 male) were reintroduced to Ruma NP in Homa Bay County, western Kenya, from Soy Ranch in 1983 (Awange et al. 2004). The park was assessed as ideal giraffe habitat based on the forage availability (Anyango and Were-Kagogo 2013). By 2002, the population had increased to 69 individuals, with no additional augmentations undertaken (Awange et al. 2004). During our photographic surveys in 2018, we captured 2,392 images from 1,056 sightings of giraffe. After filtering and cropping the images, we were left with 1,268 images that were suitable for Wild-ID analysis. We identified 317 unique giraffe, which included 159 adult females, 83 adult males, 36 sub-adult females, 32 sub-adult males, and seven calves. The average herd size in the park was 21 giraffe (range 1–76). In 2021, the KWS National Wildlife Census conducted via aerial surveys and total counts recorded an estimate of 550 individuals in the park (KWS 2021). The park has the largest population of Nubian giraffe in Kenya and has exhibited an annual population growth of 13 individuals since 1983. In the 2022 Nubian Giraffe Range Committee meeting, frequent fires were highlighted as an emerging threat, as well as the assumed overabundance of giraffe, raising concerns about the carrying capacity of the park (B. Ogwoka pers. comm. 2022). Our surveys recorded one female giraffe with GSD lesions, and no impacts of snares (Muruana and Muneza 2018). However, bovine trypanosomiasis and tick-borne pathogens have been identified as key threats to the health of wildlife in Ruma NP, as well as the livestock of communities living adjacent to the park (Okal et al. 2020; Kalayou et al. 2021).

In Lake Nakuru NP, 26 giraffe were introduced in 1977 from Soy Ranch (Kakuyo 1980). In 2008, two giraffe were introduced from the Giraffe Centre to enrich the population (Muller 2019). Several translocations from this population include: Kidepo Valley NP, Uganda (one male and two female giraffe), Soysambu WC (one male giraffe in 1993 and seven giraffe (three males and four females) in 1995), and Kigio WC (nine giraffe in 2002) (Fennessy and Brenneman 2010). In our 2019 photographic surveys, we captured 917 images from 82 sightings of giraffe, and after filtering and cropping, 368 were suitable for Wild-ID analysis. The average herd size was four giraffe (range 1–27). We identified 113 unique giraffe, including 62 adult females, 25 adult males, 12 subadult females, 10 subadult males, and four calves. Recent KWS aerial surveys in 2021 incorporated total counts and found $\sim$ 109 individuals (KWS 2021). The population numbers have fluctuated over the years as a result

of predation (Brenneman et al. 2009; Muller et al. 2018b), anthrax (Gachohi et al. 2019), habitat loss from rising water levels, and habitat destruction by fire (Herrnegger et al. 2021). Still, the population has maintained an annual population growth of 1.8 individuals since 1977. During our surveys, we encountered giraffe with signs of attempted lion predation and one male giraffe with cranial deformities (Ferguson et al. 2023).

In the neighboring Soysambu WC, the first two giraffe were introduced in 1993 from Soy Ranch (Ramsauer 2016). In two additional translocations from Lake Nakuru NP one male was introduced in 1993 and seven giraffe (three males and four females) in 1995 (Ramsauer 2016). An additional female giraffe in 1998 and three female giraffe in 2003 were introduced from Giraffe Centre (Giraffe Centre pers. comm. 2022). Since 2009, annual surveys have been conducted and the current population is estimated at 162 individuals (B. Limo pers. comm. 2023). The various translocations carried out over the years have enabled the giraffe population to maintain an annual population growth of 5.3 individuals since 1993. Electrocution by powerline has resulted in at least 12 male giraffe deaths over recent years, with the most recent occurring in February 2021 (Matara 2021; Nyaga 2021). Additionally, poisoning through water contaminated by acaricide, and predation by lion have impacted the population (Muller et al. 2018b; B. Limo pers. comm. 2023). In our Wild-ID analysis, we did not detect any giraffe movements between Soysambu WC and Lake Nakuru NP most likely due to the secure fence line between the two properties. In 2018 when the fence was partially damaged, two male giraffe were observed to migrate between the properties (B. Limo pers. comm. 2023). Disease (vitiligo) with loss of coat pigmentation was highlighted as a concern (Muller 2017), although this was likely related to mineral deficiency which has also been reported in cattle on Soysambu WC (Dunlop and Mccallien 1941; McIntosh 1945).

In 2011, KWS reintroduced eight giraffe (seven females, one male) to their historical range in Ruko Community Conservancy, eastern boundary of Lake Baringo, West Pokot County, from Soysambu WC (Oduor and Limo 2011). As a result of continuous rising water levels in the lake since 2015, the giraffe were restricted to Longicharo Island (R. Sebei pers. comm. 2023). Conservancy managers hypothesized that the mortality of all three calves born to these giraffe could be attributed to poor nutrition and/or predation by rock python (*Python sebae*) as the giraffe were trapped on the island (R. Sebei pers. comm. 2023). In 2020–2021, the eight giraffe were translocated from the island to a mainland sanctuary of $\sim$ 17 km^2 in size (Chebet 2021). Since the translocation, the population has increased to 14 individuals (ten females, four males) after the birth of six calves (R. Sebei pers. comm. 2023).

The first reintroduction of giraffe to Rimoi NR in Elgeyo Marakwet County, was undertaken in 2012, and included four female and three male giraffe from Soysambu WC. Later in 2016, the population was augmented with an additional eight giraffe (seven females, one male) from Soysambu WC (KWS 2017). In December 2021, 13 giraffe were sighted providing the best estimate at the time (Z. Omulako pers. comm. 2023). Three female giraffe were translocated to Rimoi NR from the Giraffe Centre in May 2021 and one female and two males in October 2022 to boost the population (Kibor 2022). Post-translocation monitoring is ongoing but challenging as the reserve is characterized by a limited road network, hilly environment, and dense vegetation. Current estimates place the population at $\sim$ 20 individuals following the recent translocations (Z. Omulako pers. comm. 2023).

Nine giraffe were introduced to the extralimital Kigio WC from Lake Nakuru NP in 2002 (Ramsauer 2016). The population is thriving and had increased to 46 individuals (28 females, 18 males) in 2023 (J. Mochoge pers. comm.), with an annual population growth of 1.8 individuals since 2002. In 2012, two giraffe died during preparation for translocation to Tindress Farm (Ramsauer 2016), and low hanging powerlines (electrocution) caused the death of one giraffe in 2019. Other threats and reported fatalities in the conservancy were caused by pitfalls, leopard predation, and fence entanglement (Ramsauer 2016).

Historically, Mount Elgon NP in the Trans-Nzoia County of western Kenya was part of the Nubian giraffe range in Kenya (Lydekker 1904). Giraffe were locally extirpated across much of the range, but there were anecdotal reports of eight giraffe in the early 2000s, following an introduction of 21 individuals from Soy Farm in the mid-1980s (Fennessy et al. 2018). Local experts and conservation area managers indicated that only two giraffe were observed in 2017 (Muruana et al. 2021), but none have been observed since and giraffe are considered locally extinct.

The 92 km^2 Nasalot NR in West Pokot County, western Kenya was among the first major conservation areas to reintroduce Nubian giraffe from Soy Ranch in the 1970-80s (Fennessy et al. 2018). To our knowledge, no giraffe were introduced to Nasalot NR since the first cohort, and the population is currently estimated at fewer than ten individuals (Z. Omulako pers. comm. 2023).

Records from early settlers near Sergoit Hills indicate that giraffe historically roamed the area (Tarus 1994). However, much of the land is occupied by Sergoit Farm (formerly Kruger Farm) in Iten, Eldoret, an extensive commercial ranch that reintroduced ten giraffe from Kitale Farm between 2002 and 2005 (E. Ngumbi pers. comm. 2023). These giraffe were initially introduced to farms in the Kitale-Kapenguria area in the 1960s (Harthoorn 1962). The population increased to 14 individuals in 2017 (KWS 2018) and currently numbers 12 individuals (six females, six males) (I. Kruger pers. comm. 2023). No calves have survived recently, and inbreeding issues have been proposed as a potential threat (I. Kruger pers. comm. 2023), but no assessment has been undertaken.

The $\sim$ 320 ha Tindress Farm (formerly Solai Farm) in Nakuru County, is a mixed land use conservation area that includes floriculture, coffee and dairy farming. Three giraffe were first extralimitally introduced between 2011 and 2012 from Marula Farm, Naivasha (B. Limo pers. comm. 2023), augmented by two more (one female, one male) in 2020, and a further five giraffe (four females, one male) in 2022, the latter two translocations from Soysambu WC (Kaitho 2022). The current population stands at 12 individuals.

Haller Nature Park in Mombasa County was established in the 1970s as part of a rehabilitation of a quarry wast eland with the aim of securing a self-sustaining ecosystem (Siachoono 2010). Between 1984 and 1992, four giraffe were introduced from the Giraffe Centre as the first extralimital population in the area (E. Ngumbi pers. comm. 2023). In 2004, when the population had increased to 15, seven giraffe were translocated to Nguuni Nature Sanctuary from Haller Nature Park to establish a new extralimital population in a rehabilitated *Vachellia* woodland, after which only eight giraffe remained (K. Nyinge pers. comm. 2023). Currently, Haller Nature Park has six giraffe, all female, after two died of old age (K. Nyinge pers. comm. 2023). Nguuni Nature Sanctuary currently has 11 giraffe, comprised of four males, six females, and one calf (Nguuni Nature Sanctuary pers. comm. 2023).

Discussion

While Nubian giraffe were once widely naturally distributed throughout western and north-western Kenya (Fig. 1), their extant populations are now largely limited to a few government-managed protected areas and private conservancies (East 1999; KWS 2018; Muller 2019). Some areas where Nubian giraffe were introduced in Kenya were presumably ranges of different giraffe species at the time, however, they were deemed suitable habitat (Nesbit 1970; Muller et al. 2018a). These concerted efforts to save the Nubian giraffe population has led to their steady increase since the 1970s and presents one of the most remarkable conservation success stories in the country. Despite this success, it is important to note that it is very likely that the current Nubian giraffe populations in Kenya were all established from a single population at Soy Ranch (Fig. 2). Consequently, concerns relating to the genetic fitness of some Nubian giraffe populations in the country have been raised as an intrinsic threat in the Recovery and Action Plan for Giraffe in Kenya 2018–2022 (KWS 2018). Recent studies have shown that while there may be ancestral gene flow in some giraffe populations, the three lineages of giraffe that occur in Kenya have been genetically isolated, thus maintaining genetic distinctiveness (Coimbra et al. 2023). However, to validate this concern, appropriate research is required to determine whether inbreeding is a major threat to Nubian giraffe in Kenya.

Based on current estimates from all available data, Nubian giraffe in Kenya number $\sim$ 1,042 individuals (Table 1). This result is similar to the KWS National Aerial survey that estimated 970 individuals in 2021 (KWS 2021). This represents an increase of more than 700% since the 1970s when Nubian giraffe were almost locally extinct (Fennessy et al. 2018; Muller et al. 2018a). Kenya is now estimated to be home to $\sim$ 25% of the remaining wild population of Nubian giraffe (n=4,083). This marked increase can be attributed to targeted conservation efforts using translocations as the foundation, coupled with heightened security resulting in reduced poaching in government-managed and private protected areas. A similar recovery of Nubian giraffe populations as a result of increased security and a reduction of poaching levels has been recorded in neighbouring Uganda following their previous decline in the 1970s (Brown et al. 2019). However, it is important to note that not all areas in Kenya have exhibited the same growth trends. In Ruma NP for example, the giraffe population has steadily increased from a founder population of 27 individuals which were introduced in 1983 (Awange et al. 2004) to a current estimate of $\sim$ 550 giraffe. Comparatively, the giraffe population in Lake Nakuru NP has stabilised between 95 and 120 individuals based largely on local predation threats as well as forage quality and availability (Brenneman et al. 2009; KWS 2021; Fennessy et al. 2018). The populations in Kenya and Uganda represent $\sim$ 85% of the remaining wild population of Nubian giraffe, with only $\sim$ 170 assumed to be remaining in Ethiopia and $\sim$ 450 in South Sudan (Brown et al. 2021). These two populations exhibited declining trends at the last assessment and the current conservation status remains unknown given that they face severe threats due to illegal hunting and poaching (Brown et al. 2021).

While increased monitoring and surveys have contributed to a better understanding of the Nubian giraffe distribution and abundance trends in Kenya, more intensive efforts are required. The first national review of their distribution and abundance was conducted between 2011 and 2013 as part of the development of the Recovery and Action Plan for Giraffe in Kenya 2018–2022 (KWS 2018). Following the initial review, it was estimated

that there were ~ 479 Nubian giraffe in Kenya (Fennessy et al. 2018). However, site-specific surveys have since provided more insights. We observed more than double the assumed giraffe numbers through targeted individual giraffe photographic surveys in Lake Nakuru NP, Mwea NR, and Ruma NP. Photographic identification of species with individual unique features that present externally has long been used to acquire biodiversity data to learn about population structure and dynamics, and inform management decisions (Hillman et al. 2005; Bolger et al. 2012; Brown et al. 2019; Kays et al. 2022). Of relevance to managing the Nubian giraffe population in Kenya, our findings include individual attributes such as sex and age that can be used in decision making for future translocations and management. This is particularly salient for translocations involving areas such as Sergoit Farm and Mwea NR where the male:female ratio is 1:1, and in areas such as Ruma NP where the population has increased markedly. Additionally, the countrywide aerial survey of large mammals conducted in mid-2021 found that there were more giraffe in Mwea NR and Ruma NP compared to the photographic surveys (Muruana and Muneza 2018; KWS 2021). This was notable given that aerial surveys tend to under count giraffe (Lamprey et al. 2020). Given that, these variances can be attributed to the different survey methods, there is a need for regular standardised individual photographic surveys to update the numbers and reliably inform management decisions. Photographic surveys are more cost effective and thus allow for long-term monitoring and more precise recording of individual attributes of giraffe populations (Lee and Bond 2016).

In the Lake Nakuru NP, Mwea NR, and Ruma NP surveys, we observed that snaring and GSD appeared uncommon, e.g. only one female giraffe exhibited signs of GSD in Lake Nakuru NP. Severe forms of GSD and snares were reported to impact the movements of individual giraffe in other populations (Muneza et al. 2017; Mudumba et al. 2020; Bernstein-Kurtycz et al. 2023) but these effects are potentially minimal in the ranges where Nubian giraffe occur in Kenya. Additionally, disease does not appear to be a major threat for Nubian giraffe in Kenya. However, anthrax has previously impacted giraffe in Mwea NR and Lake Nakuru NP, with the latter considered a hotspot for the disease in Kenya (Kaitho et al. 2013; Gachohi et al. 2019). We also observed one case of congenital deformity in giraffe in Lake Nakuru NP and Ruma NP, respectively. Despite these deformities, the two giraffe did not exhibit poor body condition and appeared to feed normally (Ferguson et al. 2023). The KWS mobile veterinary units respond to wildlife health and disease interventions in the major conservation areas, and it is hoped that regular monitoring will increase our understanding of diseases that might impact Nubian giraffe in the country.

Based on a combination of photographic surveys, expert knowledge, and aerial surveys there are currently > 1,000 Nubian giraffe in Kenya. With the increasing population size and distribution, we recommend that regular surveys should be conducted, particularly in the key areas of Ruma NP, Soysambu WC, Lake Nakuru NP, Mwea NR, and Kigio WC which collectively account for more than 90% of the Nubian giraffe population in the country. Regular, robust surveys and data analysis could provide detailed demographic parameters to inform future management decisions (MacKenzie 2005; Sandercock 2006; Pitman et al. 2017). It would be prudent to update conservation status of Nubian giraffe in the Wildlife and Conservation Management Act of 2013 considering their marked growth in numbers and range since the 1970s. Additionally, we propose that Nubian giraffe in Kenya should be listed as *Vulnerable* (D1) as part of a National Red List assessment using the IUCN criteria based on their low number of less than 1,000 mature individuals in the coun-

try (IUCN 2022). Such a listing would better reflect and highlight the conservation success in the country rather than current *Critically Endangered* IUCN listing.

To further support Nubian giraffe conservation in Kenya, we propose to undertake a population viability analysis (PVA) of the population in Kenya. Considering that Nubian giraffe largely occur in enclosed areas, with very little to no movement between populations, a PVA would help to assess the potential or likelihood of the metapopulation going locally extinct due to a wide range of threats, and inform future management and decision-making (Keedwell 2019). While further work would be valuable, it is important to acknowledge that the Nubian giraffe population in Kenya has considerably increased due to various conservation actions and that this increase should be considered a true conservation success story for one of the most imperilled giraffe species.

Acknowledgements We thank the Kenya Wildlife Service (KWS), Wildlife Research and Training Institute (WRTI), Giraffe Conservation Foundation (GCF) and African Fund for Endangered Wildlife for their technical and logistical support. We also appreciate the KWS park ecologists and wardens, farm and conservancy managers, sanctuary managers, and researchers who attended the Nubian Giraffe Range Committee meetings and provided insightful information on Nubian giraffe. Lastly, we thank GCF for their financial support for this study and for ongoing Nubian giraffe conservation efforts in Kenya.

Author contributions A.B.M., S.F., and J.F. were the project leaders for this manuscript and wrote the main text. A.B.M., J.S.K., M.W.M., T.I., A.B., and E.N. collected and sorted the data in Lake Nakuru National Park, Mwea National Reserve, and Ruma National Park. J.S.K., M.W.M. and A.K.K. conducted the literature review. A.B.M. prepared the figures and tables. All authors contributed to the write-up and review of the main text of the manuscript and agree with the content.

Declarations

Competing interests The authors declare no competing interests.

References

Anyango DC, Were-Kagogo PJA (2013) Dietary preference of the Rothschild's giraffes (Giraffa camelopardalis rothschildi) translocated to Ruma National Park, Kenya. Jaramogi Oginga Odinga University of Science and Technology, Kisumu, Kenya

Auster RE, Barr SW, Brazier RE (2020) Wildlife tourism in reintroduction projects: exploring social and economic benefits of beaver in local settings. J Nat Conserv 58:125920. https://doi.org/10.1016/j.jnc.2020.125920

Awange JL, Aseto O, Ong'ang'a O (2004) A case study on the impact of giraffes in Ruma National Park in Kenya. J Wildl Rehabil 27:16–21

Barnes MD, Craigie ID, Harrison LB et al (2016) Wildlife population trends in protected areas predicted by national socio-economic metrics and body size. Nat Commun 7:1–9. https://doi.org/10.1038/ncomms12747

Bernstein-Kurtycz LM, Dunham NT, Evenhuis J et al (2023) Evaluating the effects of Giraffe skin disease and wire snare wounds on the gait of free-ranging nubian giraffe (*Giraffa camelopardalis camelopardalis*) in Murchison Falls National Park, Uganda. Sci Rep 13:1959. https://doi.org/10.1038/s41598-023-28677-y

Bolger DT, Morrison TA, Vance B et al (2012) A computer-assisted system for photographic mark-recapture analysis. Methods Ecol Evol 3:813–822. https://doi.org/10.1111/j.2041-210X.2012.00212.x

Bolger DT, Ogutu JO, Strauss M et al (2019) *Giraffa camelopardalis* ssp. *tippelskirchi* The IUCN Red List of Threatened Species 2019: e.T88421036A88421121

Brenneman RA, Bagine RK, Brown DM et al (2009) Implications of closed ecosystem conservation management: the decline of Rothschild's giraffe (Giraffa camelopardalis rothschildi) in Lake Nakuru National Park, Kenya. Afr J Ecol 47:711–719. https://doi.org/10.1111/j.1365-2028.2008.01029.x

Brown MB, Bolger DT, Fennessy J (2019) All the eggs in one basket: a countrywide assessment of current and historical giraffe population distribution in Uganda. Glob Ecol Conserv 19:e00612. https://doi.org/10.1016/j.gecco.2019.e00612
Brown MB, Kulkarni T, Ferguson S et al (2021) Conservation status of Giraffe: evaluating contemporary distribution and abundance with evolving taxonomic perspectives. Imperiled Encycl Conserv. 1–17
Chebet C (2021) Inside delicate Baringo giraffe translocation. In: Stand. https://www.standardmedia.co.ke/entertainment/news/article/2001414289/inside-delicate-baringo-giraffe-translocation. Accessed 24 Jun 2023
Chira RM (2003) Changes in Wildlife Habitat and numbers in Embu and Mbeere districts, Eastern Province, Kenya. Nairobi, Kenya
Coimbra RTF, Winter S, Muneza AB et al (2023) Genomic analysis reveals limited hybridisation among three giraffe species in Kenya. BMC Biol 21:215. https://doi.org/10.1186/s12915-023-01722-y
Dagg AI (1971) Giraffa camelopardalis. Mamm Species 1. https://doi.org/10.2307/3503830
Dunlop G, Mccallien WJ (1941) Influence of geology on the health of grazing animals. Nature 147:615–617. https://doi.org/10.1038/147615a0
East R (1999) African antelope database 1998. IUCN/SSC Antelope Specialist Group, Gland
Fennessy J, Brenneman RA (2010) Giraffa camelopardalis ssp. rothschildi. The IUCN Red List of Threatened Species 2010
Fennessy J, Wube T, Muller Z et al (2018) Giraffa camelopardalis ssp. rothschildi. IUCN Red List Threat Species 2018 8235:e.T174469A51140829
Ferguson S, Kaitho T, Lekolool I et al (2023) Congenital and neoplastic deformities observed in wild giraffe (*Giraffa* spp). J Wildl Dis 59:472–478
Ferreira SM, Greaver C, Knight GA et al (2015) Disruption of rhino demography by poachers may lead to population declines in Kruger National Park, South Africa. PLoS ONE 10:1–18. https://doi.org/10.1371/journal.pone.0127783
Ferreira SM, le Roex N, Greaver C (2019) Species-specific drought impacts on black and white rhinoceroses. PLoS ONE 14:1–11. https://doi.org/10.1371/journal.pone.0209678
Gachohi JM, Gakuya F, Lekolool I et al (2019) Temporal and spatial distribution of anthrax outbreaks among Kenyan wildlife, 1999–2017. Epidemiol Infect 147:e249. https://doi.org/10.1017/S0950268819001304
Gakuya F (2004) Report of capture and translocation of 7 Rothschild's giraffe (Giraffa camelopardalis rothschildi) from Yonder Farm, Embu to Mwea National Reserve. Nairobi, Kenya
Harthoorn AM (1962) Translocation as a means of preserving wild animals. Oryx 6:215–227. https://doi.org/10.1038/187518a0
Herrnegger M, Stecher G, Schwatke C, Olang L (2021) Hydroclimatic analysis of rising water levels in the Great Rift Valley Lakes of Kenya. J Hydrol Reg Stud 36:100857. https://doi.org/10.1016/j.ejrh.2021.100857
Hillman GR, Würsig B, Gailey GA et al (2005) Computer-assisted photo-identification of individual marine vertebrates: a multi-species system. Aquat Mamm 29:117–123. https://doi.org/10.1578/016754203101023960
Horváth Z, Ptacnik R, Vad CF, Chase JM (2019) Habitat loss over six decades accelerates regional and local biodiversity loss via changing landscape connectance. Ecol Lett 22:1019–1027. https://doi.org/10.1111/ele.13260
IUCN (2022) Guidelines for Using the IUCN Red List Categories and Criteria. Version 15.1
Jenkins RLM, Warren RF, Price JT (2021) Addressing risks to biodiversity arising from a changing climate: the need for ecosystem restoration in the Tana River Basin, Kenya. PLoS ONE 16:e0254879. https://doi.org/10.1371/journal.pone.0254879
Kaitho T (2022) SWT/KWS Rift Valley Mobile Veterinary Report. Nairobi, Kenya
Kaitho T, Ndeereh D, Ngoru B (2013) An outbreak of anthrax in endangered Rothschild's giraffes in Mwea National Reserve, Kenya. Vet Med Res Rep 4:45–48
Kakuyo K (1980) The effect of translocation on the Rothschild's giraffes (*Giraffa camelopardalis rothschildi*) from Lewa Downs Farm. to Lake Nakuru National Park. University of Nairobi
Kalayou S, Okal MN, anga, Odhiambo PO et al (2021) Prevalence of trypanosome species in Cattle near Ruma National Park, Lambwe Valley, Kenya: an Update from the historical focus for African trypanosomosis. Front Vet Sci 8:750169. https://doi.org/10.3389/fvets.2021.750169
Kays R, Lasky M, Allen ML et al (2022) Which mammals can be identified from camera traps and crowdsourced photographs? J Mammal 103:767–775. https://doi.org/10.1093/jmammal/gyac021
Keedwell RJ (2019) Use of population viability analysis in conservation management in New Zealand. Sci Conserv 2019-Decem:
Kenya Wildlife Service (2018) National Recovery and Action Plan for Giraffe (Giraffa camelopardalis) in Kenya (2018–2022). Kenya Wildlife Service, Nairobi, Kenya

Kibor F (2022) KWS begins restocking of Rimoi Wildlife Reserve in Elgeyo Marakwet. In: Dly. Nation. https://nation.africa/kenya/counties/elgeyo-marakwet/kws-begins-restocking-of-rimoi-wildlife-reserve-in-elgeyo-marakwet-3992288. Accessed 5 May 2023
KWS (2017) The National Wildlife Conservation Status Report (2015–2017). Nairobi, Kenya
KWS (2021) National Wildlife Census 2021 report
Lamprey R, Pope F, Ngene S et al (2020) 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 241:108243. https://doi.org/10.1016/j.biocon.2019.108243
Lee DE, Bond ML (2016) Precision, accuracy, and costs of survey methods for giraffe *Giraffa camelopardalis*. J Mammal 97:940–948. https://doi.org/10.1093/jmammal/gyw025
Leslie-Melville B, Leslie-Melville J (1977) Raising Daisy Rothschild. Warner Books, New York City, NY. USA
Lipscomb J et al (1931) Gooeh. CEDA, Esq. HDH, Game Department Annual report
Lydekker R (1904) On the subspecies of giraffa camleopardalis. Proc Zool Soc Lond 1:202–227
MacKenzie DI (2005) What are the Issues with Presence–absence data for Wildlife managers? J Wildl Manage 69:849–860. https://doi.org/10.2193/0022-541x(2005)069[0849:watiwp]2.0.co;2
Martin TG, Burgman MA, Fidler F et al (2012) Eliciting Expert Knowledge in Conservation Science. Conserv Biol 26:29–38. https://doi.org/10.1111/j.1523-1739.2011.01806.x
Matara E (2021) Alarm after 3 more giraffes electrocuted at Soysambu Conservancy. In: Dly. Nation. https://nation.africa/kenya/news/alarm-after-3-more-giraffes-electrocuted-at-soysambu-conservancy-3299290. Accessed 23 Jun 2023
McIntosh RA (1945) Cobalt Deficiency. Can J Comp Med 9:179–182
Mudumba T, Jingo S, Heit D, Montgomery RA (2020) The landscape configuration and lethality of snare poaching of sympatric guilds of large carnivores and ungulates. Afr J Ecol 1–12. https://doi.org/10.1111/aje.12781
Muller Z (2017) White giraffes: the first record of vitiligo in a wild adult giraffe. Afr J Ecol 55:118–123. https://doi.org/10.1111/aje.12323
Muller Z (2019) Rothschild's giraffe Giraffa camelopardalis rothschildi (Linnaeus, 1758) in East Africa: a review of population trends, taxonomy and conservation status. Afr J Ecol 57:20–30. https://doi.org/10.1111/aje.12578
Muller Z, Bercovitch F, Fennessy J et al (2016) Giraffa camelopardalis. The IUCN Red List of Threatened Species 2016
Muller Z, Bercovitch F, Brand R et al (2018a) Giraffa camelopardalis (amended version of 2016 assessment)
Muller Z, Cuthill IC, Harris S (2018b) Group sizes of giraffes in Kenya: the influence of habitat, predation and the age and sex of individuals. J Zool 306:77–87. https://doi.org/10.1111/jzo.12571
Muneza AB, Linden DW, Montgomery RA et al (2017) Examining disease prevalence for species of conservation concern using non-invasive spatial capture–recapture techniques. J Appl Ecol 54:709–717. https://doi.org/10.1111/1365-2664.12796
Muneza AB, Doherty JB, Hussein AA et al (2018) *Giraffa camelopardalis ssp. reticulata* The IUCN Red List of Threatened Species 2018: e.T88421020A88421024
Muriuki MLM, Munene SM, Murithi JAM et al (2018) Report of the Committee on Trade, Tourism, Investment and Industrialization on Status of Mwea National Game Reserve and Mount Kenya South Eastern Tourism Route. Embu, Kenya
Muruana M, Muneza A (2018) Nubian Giraffe Conservation Assessment in Mwea National Reserve and Ruma National Park, Kenya. Windhoek
Muruana M, Muneza AB, Ferguson S, Fennessy J (2021) Country Profile: a rapid assessment of the giraffe conservation status in Kenya. Windhoek, Namibia
Nesbit EM (1970) The reaction of a Group of Rothschild's Giraffe to a New Environment. Afr J Ecol 8:53–62. https://doi.org/10.1111/j.1365-2028.1970.tb00830.x
Nyaga J (2021) Three Giraffes Electrocuted in Kenya's Soysambu. In: Swara. https://swara.co.ke/three-giraffes-electrocuted-in-kenyas-soysambu-conservancy/. Accessed 23 Jun 2023
O'Connor D, Stacy-Dawes J, Muneza A et al (2019) Updated geographic range maps for giraffe, Giraffa spp., throughout sub-saharan Africa, and implications of changing distributions for conservation. Mamm Rev 49:285–299. https://doi.org/10.1111/mam.12165
Oduor D, Limo B Rothschild's giraffe translocation from Soysambu. In: Soysambu Conserv., Blog (2011) https://soysambuconservancy.org/blog/rothschild-giraffe-translocation-from-soysambu/. Accessed 23 Jun 2023
Ogutu JO, Piepho HP, Said MY et al (2016) Extreme wildlife declines and concurrent increase in livestock numbers in Kenya: what are the causes? PLoS ONE 11:1–46. https://doi.org/10.1371/journal.pone.0163249

Okal MN, Odhiambo BK, Otieno P et al (2020) Anaplasma and Theileria pathogens in cattle of lambwe valley, Kenya: a case for pro-active surveillance in the wildlife–livestock interface. Microorganisms 8:1830. https://doi.org/10.3390/microorganisms8111830

Pitman RT, Fattebert J, Williams ST et al (2017) Cats, connectivity and conservation: incorporating data sets and integrating scales for wildlife management. J Appl Ecol 54:1687–1698. https://doi.org/10.1111/1365-2664.12851

Polak T, Saltz D (2011) Reintroduction as an ecosystem restoration technique. Conserv Biol 25:424. https://doi.org/10.1111/j.1523-1739.2011.01669.x

Ramsauer J (2016) Conservation of the Rothschild ' s Giraffe (Giraffa camelopardalis rothschildi) and a case study on the local acceptance in Kigio Wildlife Conservancy

Said MY, Ogutu JO, Kifugo SC et al (2016) Effects of extreme land fragmentation on wildlife and livestock population abundance and distribution. J Nat Conserv 34:151–164. https://doi.org/10.1016/j.jnc.2016.10.005

Sandercock BK (2006) Estimation of demographic parameters from live-Encounter Data: a Summary Review. J Wildl Manage 70:1504–1520. https://doi.org/10.2193/0022-541x(2006)70[1504:eodpfl]2.0.co;2

Scholte P (2011) Towards understanding large mammal population declines in Africa's protected areas: a West-Central African perspective. Trop Conserv Sci 4:4–11. https://doi.org/10.1177/194008291100400102

Sembe JK (2015) Effects of the rothschild giraffe on the biophysical and socio- economic environment: a case of giraffe center sanctuary in Nairobi county

Siachoono SM (2010) Land reclamation efforts in Haller Park. Mombasa 2:19–25

Tarus I (1994) The Keiyo of Kenya during the early colonial period, 1902–1939. University of Nairobi, Nairobi, Kenya

Vernesi C, Crestanello B, Pecchioli E et al (2003) The genetic impact of demographic decline and reintroduction in the wild boar (Sus scrofa): a microsatellite analysis. Mol Ecol 12:585–595. https://doi.org/10.1046/j.1365-294X.2003.01763.x

Western D, Russell S, Cuthil I (2009) The status of wildlife in protected areas compared to non-protected areas of Kenya. PLoS ONE 4:e6140. https://doi.org/10.1371/journal.pone.0006140

Wittemyer G, Northrup JM, Blanc J et al (2014) Illegal killing for ivory drives global decline in African elephants. Proc Natl Acad Sci U S A 111:13117–13121. https://doi.org/10.1073/pnas.1403984111

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