REVIEW ARTICLE

The evolution of tracking technology for wild giraffe (*Giraffa* spp.)

Courtney J. Marneweck[1*] (iD)[§], **Michael B. Brown**[1] (iD), **Stephanie Fennessy**[1] (iD), **Sara Ferguson**[1] (iD), **Rigardt Hoffman**[1,2], **Arthur B. Muneza**[1] (iD) & **Julian Fennessy**[1,3] (iD)

[1]*Giraffe Conservation Foundation, Windhoek, Namibia*
[2]*School of Biology and Environmental Sciences, University of Mpumalanga, Mbombela, South Africa*
[3]*School of Biology and Environmental Science, University College Dublin, Ireland*

Received 28 September 2023. To authors for revision 14 November 2023. Accepted 4 March 2024

The use of telemetry for animal tracking studies has been a key component of wildlife research and monitoring for decades. The unique anatomy of giraffe, however, has presented special challenges for developing functional animal-borne tracking devices for these species. Since the first reported collaring of a giraffe in 1970, several modifications (from neck collars to ear tags, and head harnesses to tail units) and technological developments (Very High Frequency [VHF] to Ultra High Frequency [UHF], Global System for Mobile communication [GSM], and Low Range [LoRa] to Global Positioning System [GPS] satellite) have taken place. Here, we describe the evolution of tracking units used on giraffe and, where available, report their performance diagnostics, highlighting the applicability of such units for modern-day tracking studies with both improved data quality and improved animal welfare. Based on the data gathered, we make recommendations about which modern-day units to use regarding research and management goals.

Keywords: collar, GPS, megaherbivore, tag, telemetry, VHF.

INTRODUCTION

Animal tracking studies are critical to ecological research and conservation management. As such, wildlife veterinarians, scientists and managers have deployed animal-borne tracking devices for decades, with more recent advances in technology making the practice widely accessible and the information collected highly valuable. These high-resolution spatiotemporal data enable monitoring of individuals and entire populations, as well as answering a wide range of questions relating to movement ecology, for example, how species interact, make foraging decisions, and where and when they migrate (Owen-Smith, 2014; Seidel, Dougherty, Carlson & Getz, 2018; Broekhuis, Madsen, Keiwua & Macdonald, 2019; Dickie, McNay, Sutherland, Cody & Avgar, 2020; Davies *et al.*, 2021; Ranc, Moorcroft, Ossi & Cagnacci, 2021). These data are also increasingly valuable for addressing specific conservation management issues related to the rapid processing of real-time locational data (Kays, Crofoot, Jetz & Wikelski, 2015; Katzner & Arlettaz, 2020).

Among the large African mammals, giraffe (*Giraffa* spp.) are notably understudied despite recent reports of declining populations (Muller *et al.*, 2018; Brown *et al.*, 2021). Populations of several (sub)species are extremely fragmented, and four taxa are listed as either Endangered (Masai giraffe, *G. tippelskirchi tippelskirchi* (Bolger *et al.*, 2019); Reticulated giraffe, *G. reticulata* (Muneza *et al.*, 2018)) or Critically Endangered (Nubian giraffe, *G. camelopardalis camelopardalis* (Wube, Doherty, Fennessy & Marais, 2018); Kordofan giraffe, *G. c. antiquorum* (Fennessy & Marais, 2018)) on the IUCN Red List. Amongst their greatest threats are habitat loss and fragmentation, therefore understanding the spatial ecology of giraffe is crucial to their long-term conservation and management.

The first animal-borne tracking units for mammals were deployed in the early 1960s (reviewed by Adams, 1965), mostly as neck collars or harnesses, which have since become the conventional attachment method. However, the unique anatomy of giraffe, with their long necks, presents chal-

*To whom correspondence should be addressed.
E-mail: courtney@giraffeconservation.org

ISSN 2410-8200 [Online only] — DOI: https://doi.org/10.3957/056.054.0046

lenges for affixing these traditional designs. The first recorded neck collaring of a giraffe was in 1970 (Foster & Dagg, 1972) and the design was subsequently adapted several times before it was determined that giraffe anatomy did not lend itself to this method of attachment (Fennessy, 2004; Hart, Fennessy, Rasmussen, *et al.*, 2020). Yet, other aspects of giraffe morphology have allowed for innovative trials. While their large body size enables them to carry large Global Positioning System (GPS) units with heavier batteries, technology advances and solar-powered options have facilitated more compact and lightweight solutions.

Today, high-resolution spatiotemporal data from tracking units can be paired with environmental variables for robust and high-impact analyses (*e.g.* Kays *et al.*, 2015; Brown *et al.*, 2023). Here we describe the evolution of telemetry techniques used in monitoring giraffe populations over time. These advances in radiotelemetry and GPS satellite tracking technology have allowed researchers to document and understand the interactions of giraffe with their environments, which is crucial to their conservation and management in a constantly changing landscape. The desire for reliable and functional tracking units that are also small and lightweight with minimal impact on animal welfare remains a priority, and we hope that this review will contribute to improving this for giraffe as well as other animals.

METHODS

In this review, we document the evolution of tracking units used on giraffe from the 1970s to today. First, to obtain any published information on giraffe tracking units and their performance, we conducted a Web of Science literature search using the terms: (‘giraffe’ OR ‘giraffa’) AND (‘tracking’ OR ‘VHF’ OR ‘GPS’ OR ‘GSM’ OR ‘UHF’ OR ‘LoRa’ OR ‘UTM’ OR ‘collar’ OR ‘tag’ OR ‘movement’ OR ‘spatial’). This search yielded 153 results (for the full exported list, see Supplementary Table S1) but after an initial review to remove irrelevant publications (*i.e.* those not including giraffe fitted with a GPS tracking unit), only 21 relevant publications remained (Table 1). We added additional relevant publications/reports that were known to us but missed in the literature search (noted in Table 1 with a ^). For each publication, we attempted to extract the following information: number of units deployed (*n*), scheduled fix rate (number of programmed GPS locations per day), achieved fix rate (number of recorded GPS locations per day), and deployment length (number of days the unit was active on a giraffe). Where possible, we also calculated the fix success rate (number of recorded fixes divided by the number of scheduled fixes) and deployment success rate (number of active deployed days divided by the expected number of days based on general manufacturer guidelines) for comparison across units. It is noted that some fix success rates are >1.00 (Table 1), which is possible as some units sent more data than scheduled. While this may appear positive, it can have implications on battery life. It is important to note that we report deployment length (days) as starting at the time the unit was affixed to a giraffe and not as the total unit lifespan from the date it was switched on. This information was unavailable for many units and was thus not included. All units were switched on for a trial period before deployment to check performance, and it is common for delays in obtaining permits and field logistics to prolong the deployment date. As such, the length of time that a unit was online and transmitting but not yet deployed on an animal can vary considerably.

Between 2011 and 2023, the Giraffe Conservation Foundation (GCF) and partners fitted 523 GPS tracking units in collaborative projects throughout Africa. Many of these units are described in publications highlighted by our literature search. However, we report the summary metrics described above for all 523 units as several units persist outside published study date ranges or have not yet been published. For units with data wholly/partly included in published literature, we note the relevant publication(s) in the text and Table 1. For all summary statistics, we report both the mean and the standard error. Where we estimated a metric due to insufficient detail reported, we note that with an * in Table 1. We have referred to each tracking unit chronologically (version 1.0, 1.1, 2.0 etc.), but this does not mean that they were developed sequentially or in parallel, as several units were developed independently by different manufacturers. We used data from a period of 12 years (October 2011 to December 2023). If the unit was still active at the time of writing, we assumed the deployment end date as the day of the data extraction (14 December 2023).

The GCF and its partners obtained all necessary permits and Institutional Animal Care and Use Committee approvals for the fitment of tracking

Table 1. Summary of the performance of tracking units affixed to giraffe over time. Those with a fix success rate ≥0.90 and deployment success rate ≥0.7 are highlighted in bold. Unk, unknown; NA, not available.

Unit type, version	Unit weight (g)	Deployed country	Deployed units (*n*)	Fix schedule (per day)	Fix achieved (mean/day)	Fix achieved (S.E./day)	Fix success rate	Deployment expected (days)	Deployment length (mean days)	Deployment length (S.E.)	Deployment success rate	Citation(s)
Neck collar 1.0	Unk	KEN	1	NA	NA	NA	NA	Unk	63.00	Unk	Unk	Foster & Dagg (1972) ^
Neck collar 1.0	3 500	ZAF	7	NA	NA	NA	NA	Unk	255.00	Unk	Unk	Langman (1973) ^
Neck collar 2.0	Unk	ZAF	3	NA	NA	NA	NA	Unk	810.00	Unk	Unk	du Toit (1990) ^
Neck collar 3.0	900	NAM	4	3	Unk	Unk	Unk	Unk	105.00	Unk	Unk	Fennessy (2004 ^ , 2009)
Neck collar 3.1	Unk	NAM	4	48	Unk	Unk	Unk	Unk	Unk	Unk	Unk	Guillemin, V., pers. comm.
Neck collar 3.2	10 000	NER	8	24	8.33	Unk	Unk	Unk	90.00	Unk	Unk	Suraud (2011) ^ *
Neck collar 4.0	635	ZAF	1	NA	NA	NA	NA	Unk	45.00	Unk	Unk	Deacon (2015) ^
Neck collar 3.3	Unk	ZAF	2	24	2.67	1.08	0.11	730	2.00	0.00	0.00	Marneweck *et al.* (this study)
Head harness 1.0	Unk	NAM	2	NA	NA	NA	NA	Unk	Unk	Unk	Unk	Scheepers (1992) ^
Head harness 1.1	Unk	KEN	3	NA	NA	NA	NA	Unk	135.00	Unk	Unk	King (2009) ^ *; Chege (2012) ^ *
Head harness 1.2	670	ZAF	8	6	5.46	0.43	**0.91**	Unk	613.00	Unk	Unk	Deacon (2015)*; Deacon & Smit (2017)*; Deacon *et al.* (2023a); Deacon *et al.* (2023b)
Head harness 1.2	670	BWA	4	6	4.86	0.78	0.81	730	181.50	29.65	0.25	Broekman *et al.* (2022); Brown *et al.* (2023); McQualter *et al.* (2016)
Head harness 1.2	670	NAM	6	24	7.88	0.42	0.33	730	225.89	37.83	0.31	Brown *et al.* (2023); Flanagan *et al.* (2016)
Head harness 1.2	670	COD	8	3	3.22	0.17	**1.07**	730	177.75	40.14	0.24	D'haen *et al.* (2018); Marneweck *et al.* (this study)
Head harness 1.2	670	NAM	2	6	6.31	0.28	**1.06**	730	234.50	80.25	0.32	Broekman *et al*. (2022); Marneweck *et al*. (this study)
Head harness 1.2	670	ETH	3	3	2.77	0.02	**0.93**	730	380.00	44.64	0.52	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study)
Head harness 1.2	670	UGA	5	24	23.87	2.31	**0.99**	730	97.60	13.96	0.13	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study); O'Connor *et al*. (2019)

Continued on p. 49

Table 1 (continued)

Unit type, version	Unit weight (g)	Deployed country	Deployed units (*n*)	Fix schedule (per day)	Fix achieved (mean/day)	Fix achieved (S.E./day)	Fix success rate	Deployment expected (days)	Deployment length (mean days)	Deployment length (S.E.)	Deployment success rate	Citation(s)
Head harness 1.2	670	ZWE	2	3	5.15	0.30	**1.72**	730	152.50	63.99	0.21	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study)
Head harness 1.2	670	ZAF	7	24	18.92	Unk	0.79	Unk	255.00	Unk	Unk	Scheijen (2021)*
Head harness 2.0	962	CAN	2	NA	NA	NA	NA	Unk	15.50	Unk	Unk	Brandes *et al*. (2021)
Head harness 2.0	423	DEU	1	NA	NA	NA	NA	Unk	15.50	Unk	Unk	Brandes *et al*. (2021)
Ankle bracelet 1.0	Unk	U.S.A.	4	NA	NA	NA	NA	Unk	Unk	Unk	Unk	Razal (2016)
Ankle bracelet 2.0	Unk	ZAF	2	24	19.12	0.45	0.80	730	123.00	36.06	0.17	Marneweck *et al*. (this study)
Ossi unit 1.0	180	COD	4	24	13.76	1.80	0.57	730	316.00	94.66	0.43	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study); Tucker *et al*. (2023)
Ossi unit 1.0	180	KEN	48	24	22.82	0.26	**0.95**	730	235.83	29.74	0.32	Broekman *et al*. (2022); Brown *et al*. (2023); Crego *et al*. (2021); Crego *et al*. (2023); Hart *et al*. (2020b); Marneweck *et al*. (this study); Tucker *et al*. (2023)
Ossi unit 1.0	180	NAM	40	24	23.37	0.17	**0.97**	730	904.85	90.42	**1.24**	Broekman *et al*. (2022); Brown *et al*. (2023); Hart *et al*. (2020a); Hart *et al*. (2020b); Marneweck *et al*. (this study); Tucker *et al*. (2023)
Ossi unit 1.0	180	NAM	1	48	46.61	0.43	**0.97**	730	184.00	571.87	0.25	Marneweck *et al*. (this study)
Ossi unit 1.0	180	NAM	1	144	140.63	0.57	**0.98**	730	1008.00	571.87	**1.38**	Marneweck *et al*. (this study)
Ossi unit 1.0	180	NER	19	24	23.20	0.39	**0.97**	730	320.11	64.71	0.44	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study); O'Connor *et al*. (2019); Tucker *et al*. (2023)

Continued on p. 50

Table 1 (continued)

Unit type, version	Unit weight (g)	Deployed country	Deployed units (*n*)	Fix schedule (per day)	Fix achieved (mean/day)	Fix achieved (S.E./day)	Fix success rate	Deployment expected (days)	Deployment length (mean days)	Deployment length (S.E.)	Deployment success rate	Citation(s)
Ossi unit 1.0	180	TCD	17	24	21.95	0.24	**0.91**	730	382.76	27.22	0.52	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study); Tucker *et al*. (2023)
Ossi unit 1.0	180	TZA	11	24	22.75	0.09	**0.95**	730	296.27	50.39	0.41	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study); Tucker *et al*. (2023)
Ossi unit 1.0	180	UGA	50	24	22.73	0.41	**0.95**	730	340.44	46.68	0.47	Broekman *et al*. (2022); Brown & Bolger (2020); Brown *et al*. (2023); Hart *et al*. (2020b); Marneweck *et al*. (this study); O'Connor *et al*. (2019); Tucker *et al*. (2023)
Ossi unit 1.0	180	ZWE	12	24	22.33	0.39	**0.93**	730	286.25	53.68	0.39	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study); Tucker *et al*. (2023)
Ossi unit 1.1	110	NAM	2	24	20.95	0.43	0.87	730	144.50	58.34	0.20	Marneweck *et al*. (this study)
Ossi unit 1.1	110	UGA	7	24	22.57	0.22	**0.94**	730	308.86	47.86	0.42	Brown *et al*. (2023); Marneweck *et al*. (this study); Tucker *et al*. (2023)
Ossi unit 1.2	100	NAM	6	24	22.41	1.40	**0.94**	730	669.50	126.16	**0.92**	Brown *et al*. (2023); Marneweck *et al*. (this study)
Ossi unit 2.0	Unk	ZAF	2	24	23.16	0.28	**0.97**	730	149.50	35.71	0.20	Marneweck *et al*. (this study)
Tail unit 1.0	135	ZAF	2	24	17.40	2.37	0.73	730	7.00	1.41	0.01	Marneweck *et al*. (this study)
Tail unit 2.0	Unk	MWI	2	4	3.01	0.07	0.76	730	387.50	6.72	0.53	Marneweck *et al*. (this study)
Tail unit 3.0	100	KEN	8	96	59.89	2.34	0.63	730	217.63	29.98	0.30	Marneweck *et al*. (this study)
Tail unit 3.0	100	KEN	35	24	17.37	0.88	0.72	730	73.43	14.33	0.10	Marneweck *et al*. (this study)
Tail unit 3.0	100	NAM	10	24	22.45	0.24	**0.94**	730	724.50	95.91	**0.99**	Brown *et al*. (2023); Marneweck *et al*. (this study)
Tail unit 3.0	100	NER	5	24	21.42	0.41	**0.89**	730	269.00	63.03	0.37	Marneweck *et al*. (this study)

Continued on p. 51

Table 1 (continued)

Unit type, version	Unit weight (g)	Deployed country	Deployed units (*n*)	Fix schedule (per day)	Fix achieved (mean/day)	Fix achieved (S.E./day)	Fix success rate	Deployment expected (days)	Deployment length (mean days)	Deployment length (S.E.)	Deployment success rate	Citation(s)
Tail unit 3.0	100	SSD	10	24	19.93	0.78	0.83	730	74.80	9.88	0.10	Marneweck *et al*. (this study)
Tail unit 3.0	100	TCD	8	24	7.61	0.20	0.32	730	163.13	25.36	0.22	Marneweck *et al*. (this study)
Tail unit 3.0	100	ZAF	1	24	17.04	0.79	0.71	730	135.00	0.00	0.18	Marneweck *et al*. (this study)
Ear tag 1.0	Unk	ZAF	Unk	Unk	Unk	Unk	Unk	Unk	Unk	Unk	Unk	Deacon, F., pers. comm; Haupt, M., pers comm.
Ear tag 2.0	25	ZAF	12	6	Unk	Unk	Unk	Unk	Unk	Unk	Unk	Nyathi (2020)
Ear tag 3.0	33	ZAF	0	12	7.56	Unk	0.63	Unk	252.00	Unk	Unk	Broekman *et al*. (2022); Brown *et al*. (2023); Marneweck *et al*. (this study); Wild *et al*. (2023)
Ear tag 4.0	32	AGO	17	4	2.90	0.11	0.72	1,095	170.71	31.73	0.16	Marneweck *et al*. (this study)
Ear tag 4.0	32	MOZ	21	4	2.77	0.09	0.69	1,095	184.95	39.58	0.17	Marneweck *et al*. (this study)
Ear tag 4.0	32	NAM	55	4	3.16	0.07	0.79	1,095	305.87	27.46	0.28	Marneweck *et al*. (this study)
Ear tag 4.0	32	NER	5	4	2.91	0.05	0.73	1,095	335.20	35.30	0.31	Marneweck *et al*. (this study)
Ear tag 4.0	32	SWZ	7	4	2.34	0.16	0.59	1,095	220.29	79.25	0.20	Marneweck *et al*. (this study)
Ear tag 4.0	32	SSD	3	4	2.21	0.07	0.55	1,095	170.33	37.52	0.16	Marneweck *et al*. (this study)
Ear tag 4.0	32	TCD	6	4	2.18	0.08	0.55	1,095	189.33	45.74	0.17	Marneweck *et al*. (this study)
Ear tag 4.0	32	UGA	24	4	1.61	0.05	0.40	1,095	268.71	45.24	0.25	Marneweck *et al*. (this study)
Ear tag 4.0	32	ZAF	12	4	3.47	0.11	0.87	1,095	294.33	82.45	0.27	Brown *et al*. (2023); Marneweck *et al*. (this study)
Ear tag 4.0	32	ZWE	12	4	2.29	0.06	0.57	1,095	506.00	43.00	0.46	Marneweck *et al*. (this study)
Ear tag 4.1	32	NAM	2	24	8.48	0.12	0.36	1,095	564.50	0.35	0.52	Marneweck *et al*. (this study)
Ear tag 4.1	32	ZAF	1	24	5.31	0.12	0.22	1,095	283.00	0.00	0.26	Marneweck *et al*. (this study)
Ear tag 4.1	32	ZWE	2	24	7.06	0.17	0.30	1,095	412.00	99.70	0.38	Marneweck *et al*. (this study)
Ear tag 5.0	22	NAM	6	12	6.96	0.16	0.58	1,095	140.67	8.55	0.13	Marneweck *et al*. (this study)
Ear tag 5.0	22	RWA	5	12	3.12	0.43	0.26	1,095	24.40	7.86	0.02	Marneweck *et al*. (this study)

^Publication not included in the literature search outcome.

*Numbers are estimates gathered from available information.

units to giraffe as part of their collaborative projects (for a full list of permits and agreements see Supplementary Table S2).

NECK COLLARS

Neck collar 1.0

The first recorded giraffe collaring was of a Masai giraffe in 1970 in Nairobi National Park (NP), Kenya. Foster & Dagg (1972) fitted a radio collar to the neck of a young female which transmitted data for 63 days. However, no details on the radio system or method of collaring were noted. In 1972, Langman (1973) tested various prototypes designed by the National Electrical Engineering Research Institute (Pretoria, South Africa) on penned South African giraffe (*G. giraffa giraffa*) before a final model was constructed. The final design was a 3.5 kg ellipse shape to stop constricting around the neck, padded to mitigate skin irritation, adjustable to fit a range of neck sizes, and weighted for counterbalance to mitigate lateral rotation (Fig. 1a). The final radio collar design was fitted to the base of the neck of seven South African giraffe in the Timbavati Private Nature Reserve (NR), South Africa. The ground range of the Very High Frequency (VHF) transmitters in the field fluctuated between 1.50–9.00 km with a mean transmitting life of 255.00 ± 24.05 days. There were no reported instances of collars sliding up the neck when giraffe drank (Langman, 1973).

Neck collar 2.0

In the late 1980s, du Toit (1990) fitted VHF radio collars to three South African giraffe in the Kruger NP, South Africa. The collars were modified from a design intended for African lion (*Panthera leo*), with VHF telemetry units made by Telonics attached to machine-belting collars and secured with aluminium rivets (J. du Toit, pers. comm.). The collars were placed at the base of the neck close to the shoulders and the author reported that the mane of the giraffe was stiff enough to hold the collar in place so that it did not slide forward when the neck was lowered (Fig. 1b,c; du Toit, 1990). Additionally, du Toit reported that the collar caused minimal stress to the giraffe (J. du Toit, pers. comm.). Only one of the three collars worked for a sufficient length of time to be included in their study (>10 consecutive months) and was removed after 27 months, with a signal range of up to 20 km (du Toit, 1990).

Neck collar 3.0

In 2002 the neck collar 3.0 was designed and constructed by Africa Wildlife Tracking (AWT), South Africa, and rested at the base of the neck and over the chest (Fig. 1d). The GPS unit (MT2000 terminal using the Inmarsat 3 satellite system), coupled with a battery pack that also served as a counterbalance, had a built-in VHF transmitter and weighed <900 g. Four Angolan giraffe (*G. g. angolensis*; three males and one female) were fitted with the neck collar 3.0 in 2002 in northwestern Namibia (Fennessy, 2004). The four collars were programmed to record data at eight-hour intervals for up to two years. In addition, three of the collars were also programmed to record hourly locations for 4–5 consecutive days each month. However, unexpected complications, including collars twisting and breaking inner wiring (Fig. 1e,f), meant that deployment length was <3.5 months (Fennessy, 2004, 2009). The collars were removed or fell off naturally. Despite their limited longevity, the collars were the first to transmit high-resolution data *via* GPS satellite and were used in home range and daily movement analyses that would not have been possible with VHF alone (Fennessy, 2004, 2009).

Neck collar 3.1

The neck collar 3.1 included an AWT GPS / Global System for Mobile Communication (GSM) unit (which transmits data over a cellular network), capable of obtaining up to 48 locations per day. In 2009, the neck collar 3.1 was fitted to four Angolan giraffe translocated to communal conservancies in Namibia (V. Guillemin, pers. comm.). However, without a counterbalance in this design, the neck collars tended to twist, often leading to the GPS unit sitting under the giraffe's neck and limiting the signal. Other collars fell off naturally and some individuals moved into areas out of the GSM network range (V. Guillemin, pers. comm.). Overall, these collars showed limited performance and little valuable data were retrieved due to poor GSM 2G network coverage at the site.

Neck collar 3.2

In 2010, the neck collar 3.2 was developed by AWT with the transmitter and battery moulded in a single block at the top of the collar, and a 5 kg lead counterweight on the opposite side to restrict movement. This culminated in a heavy collar of ~10 kg. Initially, three adult female West African giraffe (*G. c. peralta*) were fitted with the collars in

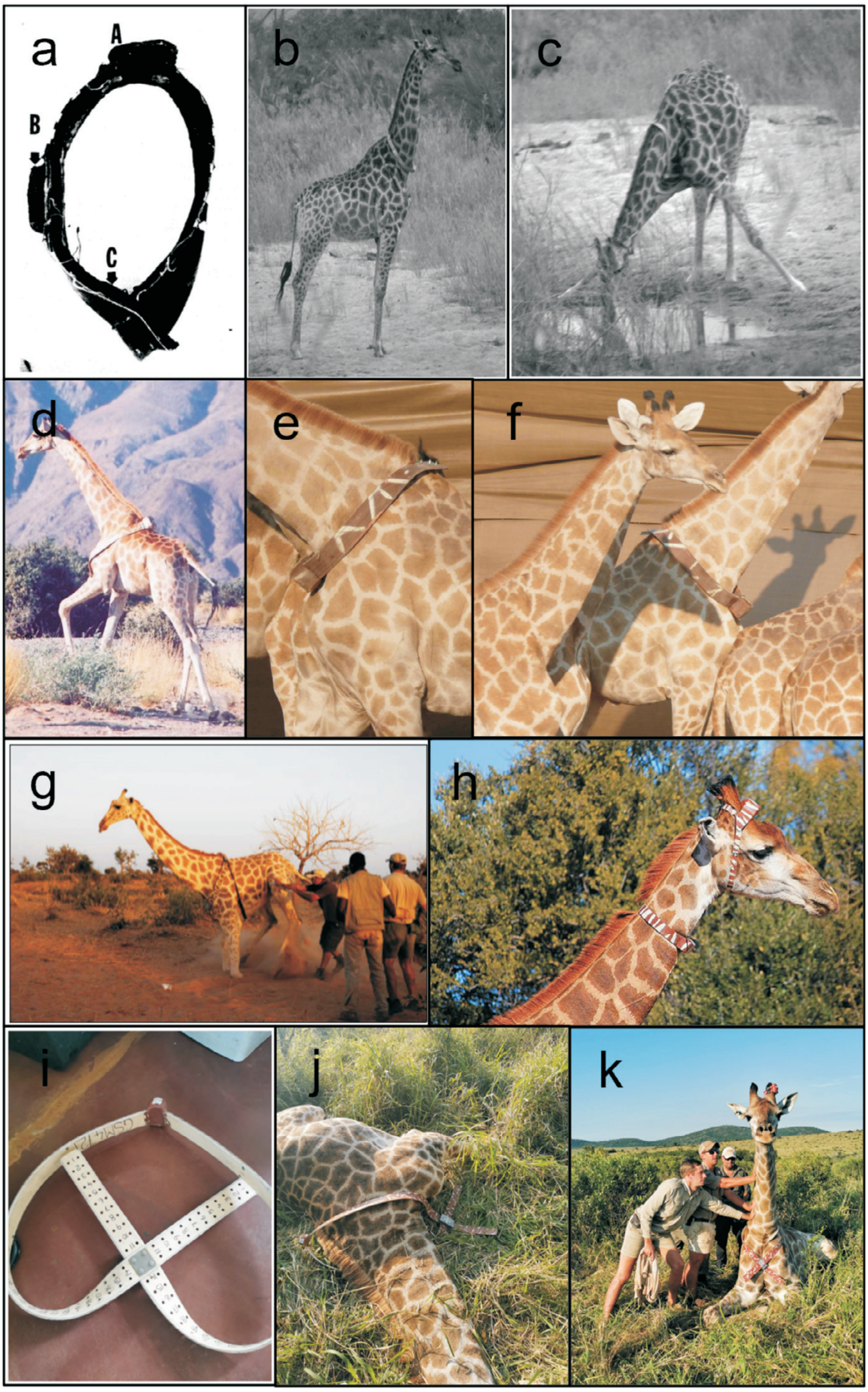

Fig. 1. **a**, Giraffe neck collar 1.0 (source: Langman,1973); **b**, **c**, neck collar 2.0 in South Africa (© du Toit, J.); **d**, neck collar 3.0 with enclosed battery counterbalance at the bottom fitted to a giraffe in Namibia (© GCF); **e**, **f**, neck collar 3.0 inverted due to lack of counterbalance (© Guilleman, V., ICEMA); **g**, neck collar 3.2 showing harness around the body (source: Suraud, 2011); **h**, neck collar 4.0 initial placement (source: Deacon, 2015); **i, j**, **k**, neck collar 3.3 showing counterbalance at the front (© Naylor, S.).

the 'Giraffe Zone' of Niger, but these fell off within a day (Suraud, 2011). To prevent this, a body harness consisting of an elastic strap was fitted to the collar and ran behind the front legs and under the body (Fig. 1g). A total of eight of these adapted neck collars were fitted to adult females (Suraud, 2011). Programmed to record hourly locations, one fell off and one failed, leaving six transmitting data over a three-month period (a total of 4 500 locations; Suraud, 2011). While the actual fix rate was not recorded, based on the number of locations and deployment length of six collars, we assume an average of 8.33 locations/day. After three months, all remaining collars were removed safely after it was noticed that the units started to irritate some of the giraffe (Suraud, 2011). Each giraffe was treated appropriately to ensure their long-term welfare (Suraud, 2011) and they were all subsequently recorded healthy during surveys in the following years (J. Fennessy, pers. obs.).

Neck collar 4.0

In 2011, AWT designed the neck collar 4.0 to fit around the upper part of the neck (Deacon, 2015). The collar weighed 635 g and was fitted to a single male South African giraffe as a trial in the Woodland Hills Wildlife Estate, South Africa (Fig. 1h). However, within 45 days, the neck collar slipped downward and was subsequently removed without any long-term impact on the giraffe. This collar prototype was fitted to a giraffe simultaneously as a head harness, and while both units had GPS capabilities, only GPS data from the head harness were recorded (see *Head harness 3.0;* Deacon, 2015).

Neck collar 3.3

More recently in 2021, a further modified neck collar fitted with a GPS/GSM device was designed by AWT and powered by two AA batteries. With narrower straps, the neck collar 3.3 was shorter in total length, had no counterbalance, and was designed to sit at the base of the giraffe neck (Fig. 1i–k). The collar was lightweight in comparison to previous neck collars, *i.e.* <635 g (J. Fennessy, pers. obs.). Fitted on two South African giraffe in Phinda Private Game Reserve (GR), South Africa (one male, one female), both collars fell off almost immediately, with a mean deployment length of 2 ± 0.00 days. Programmed to record hourly locations (24/day), during their short deployment time the achieved fixes was on average 2.67 ± 1.08 locations/day (Table 1, Table S3).

HEAD HARNESS

Head harness 1.0

The first recorded giraffe head harness was used by Scheepers (1992) who fitted 'scrum caps' equipped with Telonics VHF transmitters to two Angolan giraffe in northwestern Namibia in the late 1980s. The units were placed high on the neck, supported by a harness over the ossicones to prevent them from shifting down and each harness a different colour to enable easier identification. The signal could be received up to 25 km; however, no information could be obtained on their performance.

Head harness 1.1

The head harness 1.1, designed by Lewa Wildlife Conservancy and Kenya Wildlife Service, was equipped with a Telonics VHF transmitter. In 2008, the canvas head harness 1.1 was fitted to three reticulated giraffe (two females and one male) during their translocation to Sera Wildlife Conservancy, Kenya (Fig. 2a; King, Leogusa Lemerketo & Lesimirdana, 2009; Chege, 2012). The head harness 1.1 was light and flexible, and no detrimental effects were noted on the giraffe (King *et al.*, 2009). This design used cotton thread to hold the harness together, which disintegrated over time as planned. However, the short transmission time of the VHF unit limited the signal to only two hours each day which made it difficult to locate the giraffe regularly. Because of the limited VHF signal, deployment longevity was therefore uncertain. King *et al.* (2009) reported that one giraffe died post-release; the team was unable to locate one giraffe after three months, and the third unit was still functional six months post-release. Therefore, we estimated that deployment longevity was a minimum of 135.00 ± 36.74 days (Table 1).

Head harness 1.2

The head harness 1.2 was designed by AWT in the early 2010s. Using the Globalstar satellite constellation network for data upload, better satellite reception was achieved by fitting the unit atop the skull and in front of the ossicones (Fig. 2b). The head harness 1.2 had a combination of GPS and built-in VHF transmitters that were now fitted with the battery in the same, single unit due to reduced component sizes. Additionally, AWT incorporated temperature sensors and offered the option of adding additional sensors (*e.g.* accelerometers; Deacon, 2015). The head harness 1.2 weighed ~670 g and was first trialled on a single male South African giraffe in South Africa (Deacon, 2015). After this trial, the head harness 1.2 was fitted to eight female giraffe in the Khamab Kalahari NR, South Africa (Deacon, 2015; Deacon & Smit, 2017; Deacon & Bercovitch, 2018; Deacon, Smit & Grobbelaar, 2023a,b). With one coming off early due to a broken strap, they were deployed on giraffe for 613.00 ± 9.42 days (with some units still functional upon removal; Deacon, 2015; Deacon & Smit, 2017). They were programmed to record data every four hours (six locations/day) and, although only summarized as total points and total days per giraffe (Deacon, 2015; Deacon & Smit, 2017), we estimated the achieved fix rate at 5.46 ± 0.43 locations/day (Table 1). Deacon (2015) reported that some skin wear was noted on the ossicones from persistent rubbing; however, it disappeared after the removal of the units. After this trial, the head harness 1.2 was used for more than 75 giraffe with reported success with >20 months deployment length but no detailed data available (F. Deacon, pers. comm.).

In 2012, four adult female South African giraffe were fitted with the head harness 1.2 in Wildlife Management Area NG26 on the western side of the Okavango Delta and Chobe NP, northern Botswana (McQualter, Chase, Fennessy, McLeod & Leggett, 2016). Programmed to record data every four hours (6/day), the achieved fix rate success was 0.81 and the deployment success rate was 0.25 (McQualter *et al.*, 2016). Monitoring revealed that the units eventually cut into the skin (K. McQualter, pers. comm.). All head harnesses were subsequently removed, and all individuals recovered fully (K. McQualter, pers. comm.).

The head harness 1.2 was also used by the Namibian Ministry of Environment, Forestry, and Tourism on Angolan giraffe in Namibia in 2011–2012 (Flanagan, Brown, Fennessy & Bolger, 2016). The head harness 1.2 was fitted to six giraffe (five females and one male) translocated from Etosha NP (and surrounds) to communal conservancies in northeastern and northwestern Namibia. The deployment success rate was 0.31

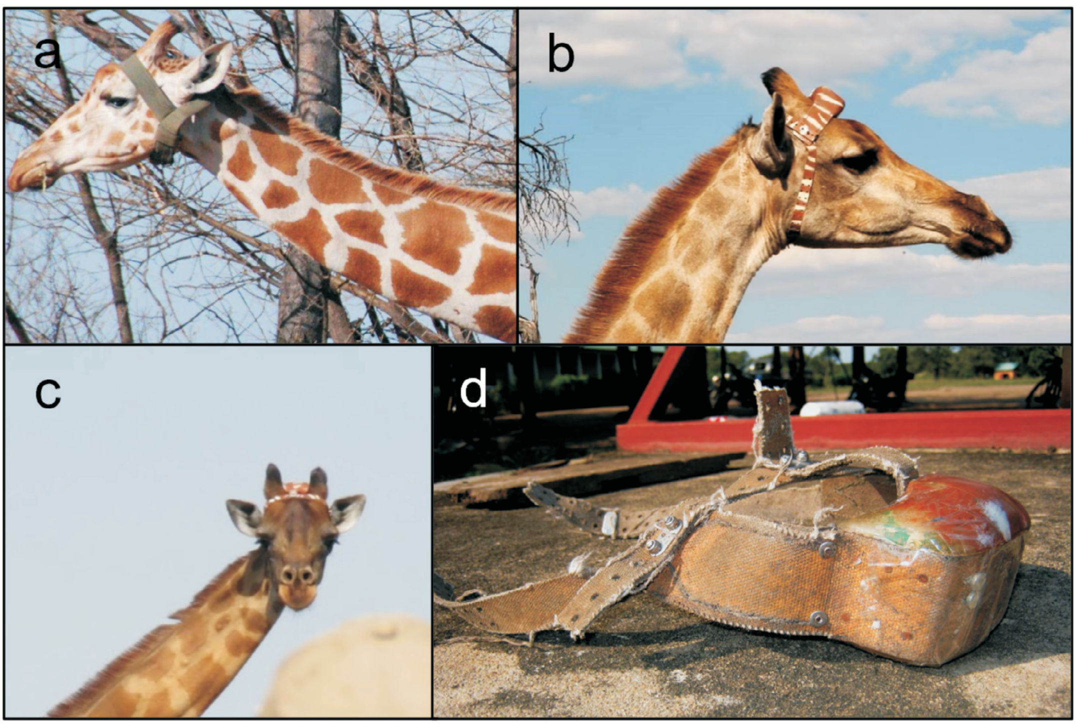

Fig. 2. **a**, Giraffe head harnesses 1.1 fitted to a giraffe in Kenya (© Craig, I., Northern Rangelands Trust); **b**, head harness 1.2 fitted to a giraffe in South Africa (source: Deacon, 2015); **c**, head harness 1.2 fitted backwards to a giraffe in Garamba National Park, Democratic Republic of Congo (© African Parks); **d**, retrieved head harness 1.2 after falling off a giraffe in Garamba National Park, Democratic Republic of Congo (© African Parks).

and, although scheduled to record hourly (24/day), the mean fix rate success was only 0.33 (Flanagan *et al.*, 2016; Table 1, Table S3).

In 2016, African Parks fitted the head harness 1.2 to eight Kordofan giraffe (six females and two males) in Garamba NP, Democratic Republic of Congo (Monico & Ortega, 2012; D'haen, 2018; D'haen Fennessy Stabach & Brandlová, 2019). All units were fitted backwards on the giraffe as the median ossicone was too large compared to the South African giraffe for which it was designed (P. Morkel, pers. comm.). The scheduled fix rate was three locations/day, which achieved a fix success rate of 1.07 because of one over-performing unit (Table S3). With a deployment success rate of 0.24 (Table 1), five were removed or fell off within a year, and the remaining three were subsequently removed. One unit had reportedly slipped off the head and onto the neck (D'haen, 2017). Upon removal, it was noted that some giraffe had wounds on the top of the head where the GPS unit was placed but all giraffe were treated and made a full recovery (M. D'haen, pers. comm.).

Between 2011 and 2016, GCF and collaborative partners in respective countries fitted the head harness 1.2 to five female Angolan giraffe translocated to communal conservancy areas in Namibia, five female Nubian giraffe in Murchison Falls NP, Uganda, three female Nubian giraffe in Gambella NP, Ethiopia, and two female South African giraffe in Bubye Valley Conservancy, Zimbabwe (Fig. 2c). Each unit was programmed to a different fix schedule (see Table 1 and Table S3 for details) and achieved a fix success rate of 1.17 and deployment success rate of 0.30 (Table 1, Table S3).

In 2017, Scheijen, Van der Merwe, Ganswindt & Deacon (2021) fitted the head harness 1.2 to 18 South African giraffe; however, only seven units worked sufficiently to be included in the study. While exact metrics were not reported, they noted that the giraffe were tracked for between 5 and 12 months and reported a total of 33 772 GPS locations (Scheijen *et al.*, 2021). Based on data recorded on 255 days across seven individuals we can estimate a fix success rate of 0.79 (Table 1).

Head harness 2.0

More recently, Brandes Sicks & Berger (2021) described using a head harness with attached accelerometers on three zoo-housed Nubian giraffe (two females at the African Lion Safari Park in Ontario, Canada, and one male in the Zoological Garden Berlin, Germany) in 2017. Two different accelerometers were tested: an e-obs (e-obs GmbH, Munich, Germany) and an AWT unit. The e-obs device was programmed to record for 2.43 seconds at 20-second intervals, resulting in 82 data points per axis per recording. Data were stored on board and later downloaded *via* radio and a base station. The AWT device was programmed to record one data point per axis continuously, which was directly transmitted *via* a UHF transceiver. Both devices were tested simultaneously on the two females, with the e-obs device taped to the AWT harness accounting for a total weight of 962 g. Only the e-obs device was tested on the male, taped to a leather harness with a total weight of 423 g. All devices were positioned to sit between the ossicones. Brandes *et al.* (2021) described that both devices showed limitations for deployment in the wild. The battery capacity was limited for both devices, which were actively deployed for 15.50 ± 1.50 days (Table 1). Furthermore, the e-obs device needs to be close to the base station for downloading (500 m to several km). Close proximity to other objects or the ground could disrupt the AWT accelerometer, limiting data transmission (Brandes *et al.*, 2021).

ANKLE BRACELETS

Ankle bracelet 1.0

The ankle bracelet 1.0 was first trialled at Brookfield Zoo, U.S.A., in 2015 (Razal, 2016, 2017). Custom-made ankle bracelets were fitted to four reticulated giraffe (three females, one male) made from elastic and secured with Velcro (Fig. 3a,b). Each ankle bracelet had a pouch holding a data logger with an accelerometer (Razal, 2016, 2017). The giraffe wore the ankle bracelets for a 24-hour period, one day per week, except for one female who would repeatedly remove the ankle bracelet. Additional information on these units and their achieved fix rate or deployment longevity was not reported.

Ankle bracelet 2.0

In 2021, GCF and its partners trialled ankle bracelets on two South African giraffe (one male and one female) in Phinda Private GR, South Africa. Made by AWT using the same rubberized belting material as used for the AWT head harness 3.0 and tail unit 1.0 (Fig. 3c), the units were more durable than the units used in the 2015 zoo trial.

Fig. 3. **a**, **b**, Giraffe ankle bracelet 1.0 fitted to a zoo-housed giraffe in the U.S.A. (source: Razal, 2016, 2017); **c**, ankle bracelet 2.0 fitted to two giraffe in Phinda Private Game Reserve, South Africa (© GCF).

Powered by two AA batteries, the ankle bracelets were programmed to record hourly fixes (24/day). They achieved a fix success rate of 0.45 and deployment success rate of 0.17 (Table 1, Table S3).

OSSICONE UNITS

The next development in the evolution of giraffe tracking was the 'ossi-unit', a device designed to attach to the ossicone of a giraffe. Giraffe are born with soft ossicones that exist as small bony cores which ossify separately from the bones of the skull and later fuse to the underlying skull (Davis, Brakora & Lee, 2011; Shorrocks, 2016). While ossicones are composed of living bone, they are completely ossified and fused to the skull by sexual maturity with no significant blood vessels documented, nor signs of haematopoiesis (formation of blood cells which occurs in the bone marrow of mammals; Fig. 4a,b; Ganey, Ogden & Olsen, 1990), making the attachment of the GPS ossi-unit safe for the giraffe.

Ossi-unit 1.0

In 2016, GCF partnered with Savannah Tracking Ltd (Kenya) to develop the ossi-unit 1.0, which contained a GPS satellite system with iridium-based data upload powered *via* a lithium polymer battery. Recharged by solar energy, the unit weighed approximately 180 g. A TA-UHF telemetry beacon, tri-axial accelerometer, geo-fencing alert, and full two-way communication were incorporated into the ossi-unit 1.0. The unit was attached to one ossicone with two stainless steel bolts and two durable (tensile strength of 1000–1500 daN), flat, UV-stable nylon straps 25 mm wide (Fig. 4e). The unit was placed in the middle of the ossicone, far from the nearest sinus connected to the cranium (Fig. 4c,d). Fitted while the giraffe was fully awake following individual immobilization, little to no signs of discomfort or pain were observed during fitment (S. Ferguson, pers. obs.). The unit was placed snugly against the ossicone while allowing for some movement to prevent any potential rubbing and subsequent infection, and the ends of the bolts were cut to ensure there were no protruding ends that may harm another giraffe when neck sparring.

GCF first trialled the ossi-unit 1.0 in 2017 on Okapuka Game Ranch, Namibia, on two Angolan giraffe (one male and one female). Programmed initially to send twice daily iridium data uploads of hourly data and a UHF telemetry beacon every two hours, one unit was later changed to record the location every 10 minutes. Initially, the two giraffe were physically monitored on a weekly basis. One giraffe was legally hunted on a neighbouring property. Inspection of the ossicone when the unit was removed revealed no visible signs of infection or damage to the bone (J. Fennessy, pers. obs.).

After some small physical modifications, the final ossi-uni 1.0 was deployed elsewhere, weighing 180 g (Fig. 4c–f). The battery was changed to an AA-sized lithium-ion rechargeable battery, deemed more durable than the lithium polymer

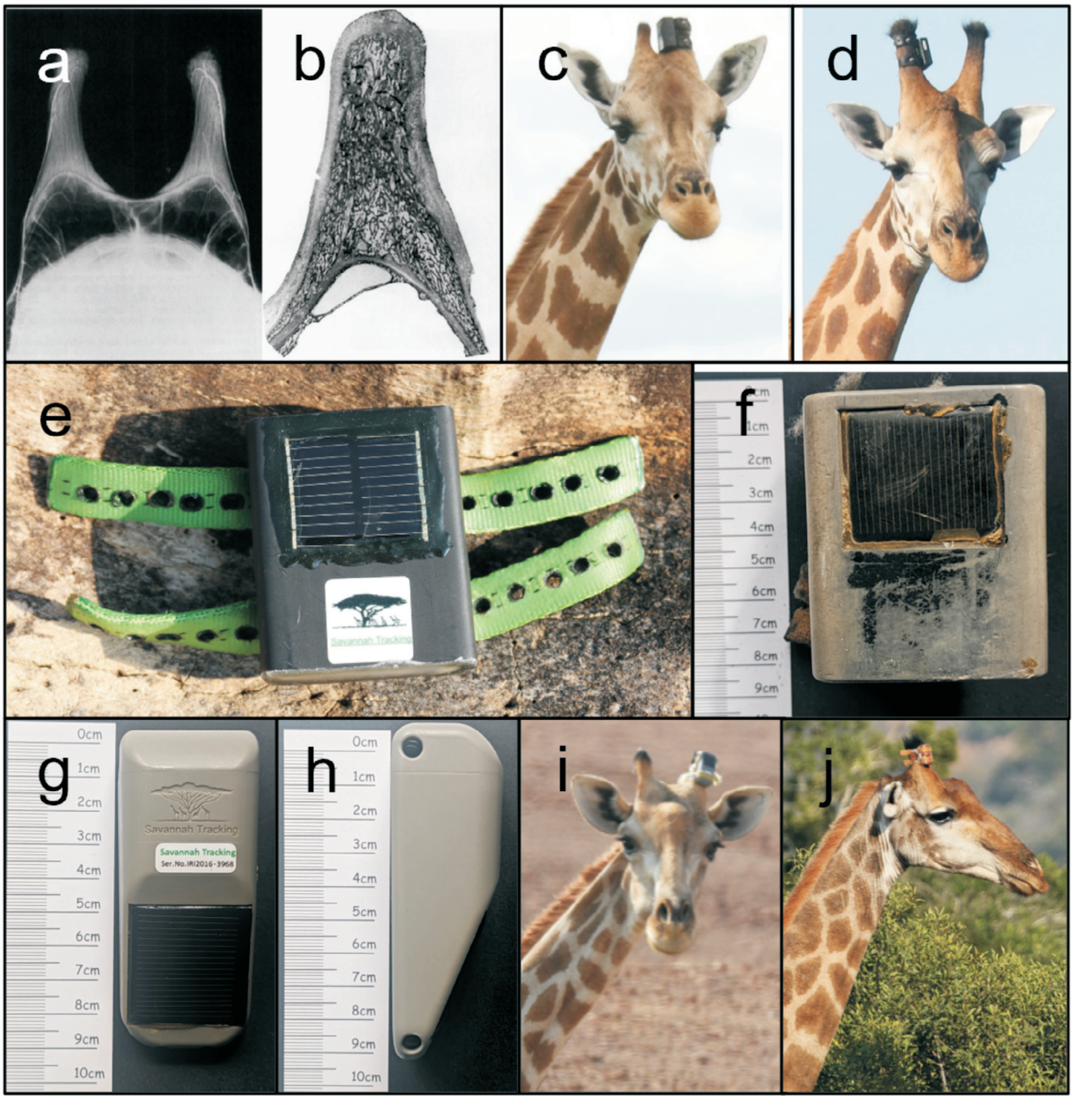

Fig. 4. **a**, Radiography of giraffe skull following perfusion of the carotid artery, which branches externally to the ossicones (source: Ganey, Ogden & Olsen, 1990); **b**, ossicone of a giraffe, showing separation of ossified bony tissues (source: Ganey, Ogden & Olsen, 1990); **c**, ossi-unit 1.0 on a female; **d**, ossi-unit 1.0 on a male; **e**, **f**, ossi-unit 1.1; **g**–**i**, ossi-unit 1.2; **j**, ossi-unit 2.0. (Photographs c–k © GCF).

(H. Rasmussen, pers. comm.). The performance of ossi-unit 1.0 was reviewed in detail by Hart, Fennessy, Rasmussen, *et al.* (2020). Of those in Kenya, Namibia, and Uganda, the fix success rate was 0.99 (n = 50 deployed units 2017–2019), and the battery never dropped below the cut-out threshold of 3.2 volts (n = 20 deployed units 2017–2019; Hart, Fennessy, Rasmussen, *et al.*, 2020). Between 2017 and 2021, GCF facilitated and/or assisted in the deployment of a total 203 ossi-units in Chad (Clark *et al.*, 2023), the Democratic Republic of Congo, Kenya (Crego *et al.*, 2021, 2023), Namibia (Hart, Fennessy, Hauenstein & Ciuti, 2020), Niger, Tanzania, Uganda (Brown & Bolger, 2020), and Zimbabwe (for more information on sites and deployments, see Table 1 and Supplementary Table S3). Collectively, these 203 units had a mean fix success rate of 0.92 and deployment success rate of 0.58 (Table 1, Table S3). Note that some of these units reported here include those also reviewed by (Hart, Fennessy, Rasmussen, *et al.*, 2020).

Ossi-unit 1.1

The ossi-unit 1.1 was developed resulting in a smaller unit that weighed ~110 g. The solar panel was halved in size, and the battery was changed to 2/3 AA to optimize space (H. Rasmussen, pers. comm.). GCF deployed nine of the ossi-unit 1.1 between 2019 and 2021 across three sites: two Angolan giraffe (one male and one female) in northwestern Namibia, and seven Nubian giraffe in Uganda (one male in Kipedo NP; three females in Murchison Falls NP; three females in Pian Upe Wildlife Reserve). Scheduled for hourly fixes (24 locations/day), the mean fix success rate was 0.91 with a mean deployment success rate of 0.31 (Table 1, Table S3; Brown *et al.*, 2023). Issues with sufficient battery life were noted and attributed to the smaller unit size and the component changes.

Ossi-unit 1.2

A final version of the Savannah Tracking ossi-unit was developed in 2021 with a slanted solar panel to increase solar exposure for recharging and circumvent battery issues of the ossi-unit 1.1 (Fig. 4h,i). With the same model interior as the previous version (*i.e.* 2/3 AA battery), the casing was now 3D printed and streamlined to improve charging and it weighed ~100 g. Six of the ossi-unit 1.2s were deployed on Angolan giraffe in northwestern Namibia (Fig. 4j; Brown *et al.*, 2023). Programmed to record hourly locations (24 locations/day), the mean fix success rate was 0.94 and the mean deployment success rate was 0.77 (Table 1, Table S3).

The ossi-unit was the best functioning unit to date in terms of reliability and longevity; however, <2% of cases resulted in a broken ossicone and, although this did not negatively impact the giraffe, some abnormal growth around the attachment site was observed on a few individuals (J. Fennessy, pers. obs.). With the welfare of the giraffe in mind, GCF requested an alteration to the bolt and strap placement so the units could be fitted to the tail. Subsequently, new standard operating procedures were adopted and GCF now only affixes these units to the tail of giraffe (see *Tail unit 3.0*).

Ossi-unit 2.0

At the same time as ossi-unit 1.2 (2021), an AWT ossi-unit 2.0 with GSM was also trialled on two female South African giraffe in Phinda Private GR, South Africa (Fig. 4k). Programmed to record hourly locations (24/day), the units had a mean fix success rate of 0.97, and a deployment success rate of 0.21 (Table 1, Table S3). Limitations with adequate GSM network coverage across the site were experienced and because the units were battery-operated, this limited their longevity.

In addition to the four ossi-units described above, there were several other prototypes developed by a range of companies, but they never made it to the field trial stage. Between ossi-unit 1.2 and 2.0, an ossi-unit with a slanted solar panel was developed by Savannah Tracking, but the prototype was not deployed in the field. During this time, Savannah Tracking also developed a prototype of a battery-powered ossi-unit, built to replace the solar-panelled version. But, due to its cumbersome size and shape, this unit was not taken to field trials.

TAIL UNITS

Tail unit 1.0

The first dedicated tail unit 1.0, manufactured by AWT, was trialled in Phinda Private GR, South Africa, in 2021 by J. Fennessy. Weighing 135 g, the belting was integrated into the unit design as one continuous component, powered by two AA batteries (Fig. 5a–c). The unit was placed along the caudal aspect of the tail over the most distal caudal vertebrae, proximal to the tail hair tassel. The tail unit 1.0 was fitted to one male and one female South African giraffe and programmed to record data every hour (24 locations/day). They had a mean fix success rate of 0.73 but a deployment success rate of only 0.01 (Table 1, Table S3). The reason for the lack of data received after only seven days is unknown, but like the ossi-unit 2.0, likely a result of unexpected poor GSM 2G coverage in the area.

Tail unit 2.0

In 2021, two GPS tail units that utilized the Long Range (LoRa) network for data transmission were trialled. These units were manufactured by AWT and fitted in the same way as tail unit 1.0 on two South African giraffe in Phinda Private GR, South Africa, which were later translocated to Majete Wildlife Reserve, Malawi (J. Fennessy, pers. comm.). Powered by two AA batteries, they were scheduled to record a location every six hours (four locations/day), and the units had a mean fix success rate of 0.76 and a mean deployment success rate of 0.53 (Table 1, Table S3).

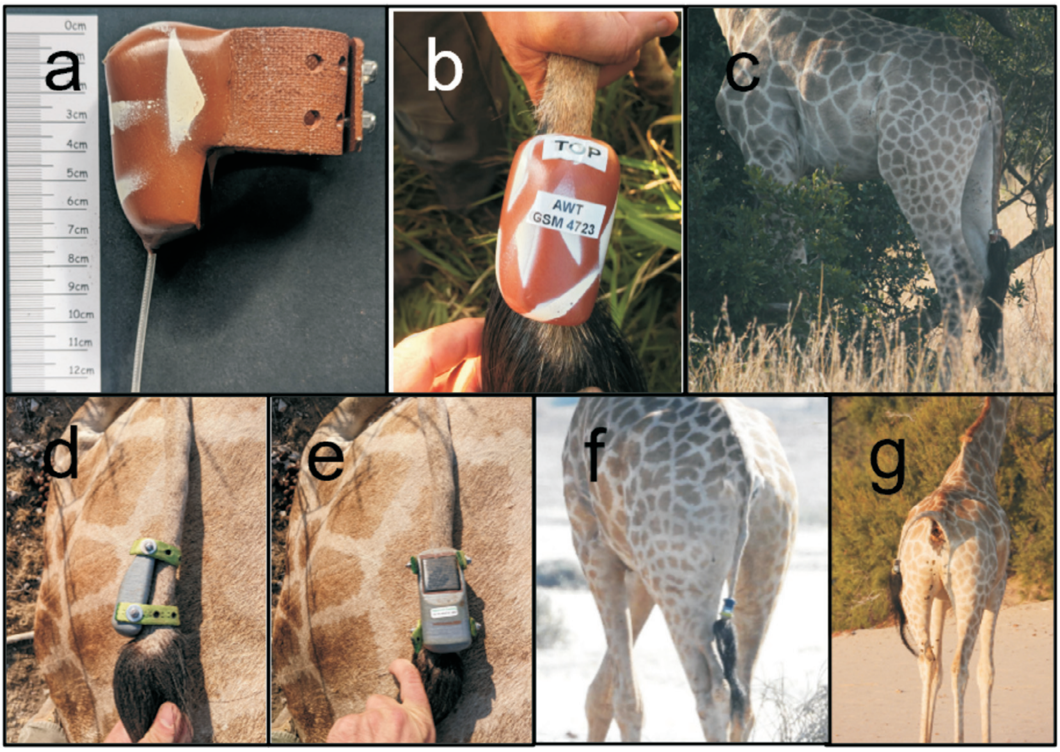

Fig. 5. **a**–**c**, Giraffe tail unit 1.0 in Phinda Private Game Reserve, South Africa; **d**–**g**, tail unit 3.0 to Angolan giraffe in northwestern Namibia (© GCF).

Tail unit 3.0

In 2021, Savannah Tracking modified the ossi-unit 1.2 to allow attachment to the tail (hereafter referred to as the tail unit 3.0; Fig. 5d–g). Unlike the tail unit 1.0 and 2.0 which were designed as one single piece with fixed straps, the tail unit 3.0 consists of a unit with separate attachment straps. The bolts were not integrated like the ossi-unit, with the bolt holes re-designed to allow for different bolt sizes to be used and allow more flexibility in attachment. The unit was secured by wrapping two parallel nylon straps around the tail and affixing them back onto bolts secured with washers and nuts (Fig. 5d,e). The unit was fitted snugly to minimize movement and subsequent abrasion while loose enough to not restrict circulation. Between 2021 and 2023, GCF and collaborative partners (*e.g.* African Parks, Smithsonian Institution, communal conservancies of northwest Namibia, Governments and Wildlife Authorities in Chad, Kenya, Namibia, Niger, and South Sudan), deployed 65 tail units across Chad ($n = 8$), Kenya ($n = 25$), Namibia ($n = 16$), Niger ($n = 5$), South Africa ($n = 1$), and South Sudan ($n = 10$), 43 of which are still active (as of December 2023). Overall, the mean fix success rate of the tail unit 3.0 was 0.72 with a deployment success rate of 0.32 (Table 1, Table S3; note 43/77 units still actively deployed).

EAR TAGS

Ear tag 1.0

The first GPS ear tag for giraffe was designed by AWT in 2015 and trialled on South African giraffe in the Sandveld NR, South Africa (Fig. 6a). The tag consisted of a Radio Frequency Identification (RFID) tracking system with a digital receiver, a GPS device, and a temperature sensor. However, according to AWT and the deploying team, the ear tags were too heavy and failed soon after deployment (F. Deacon, pers. comm.; M. Haupt, pers. comm.). It appears that the plastic material was not strong enough, and the tag itself broke in half, leaving the stud remaining in the ear with no unit attached (F. Deacon, pers. comm.).

Ear tag 2.0

The ear tag 2.0 was developed in 2019 by Ecotone (Ecotone Telemetry, Poland), and con-

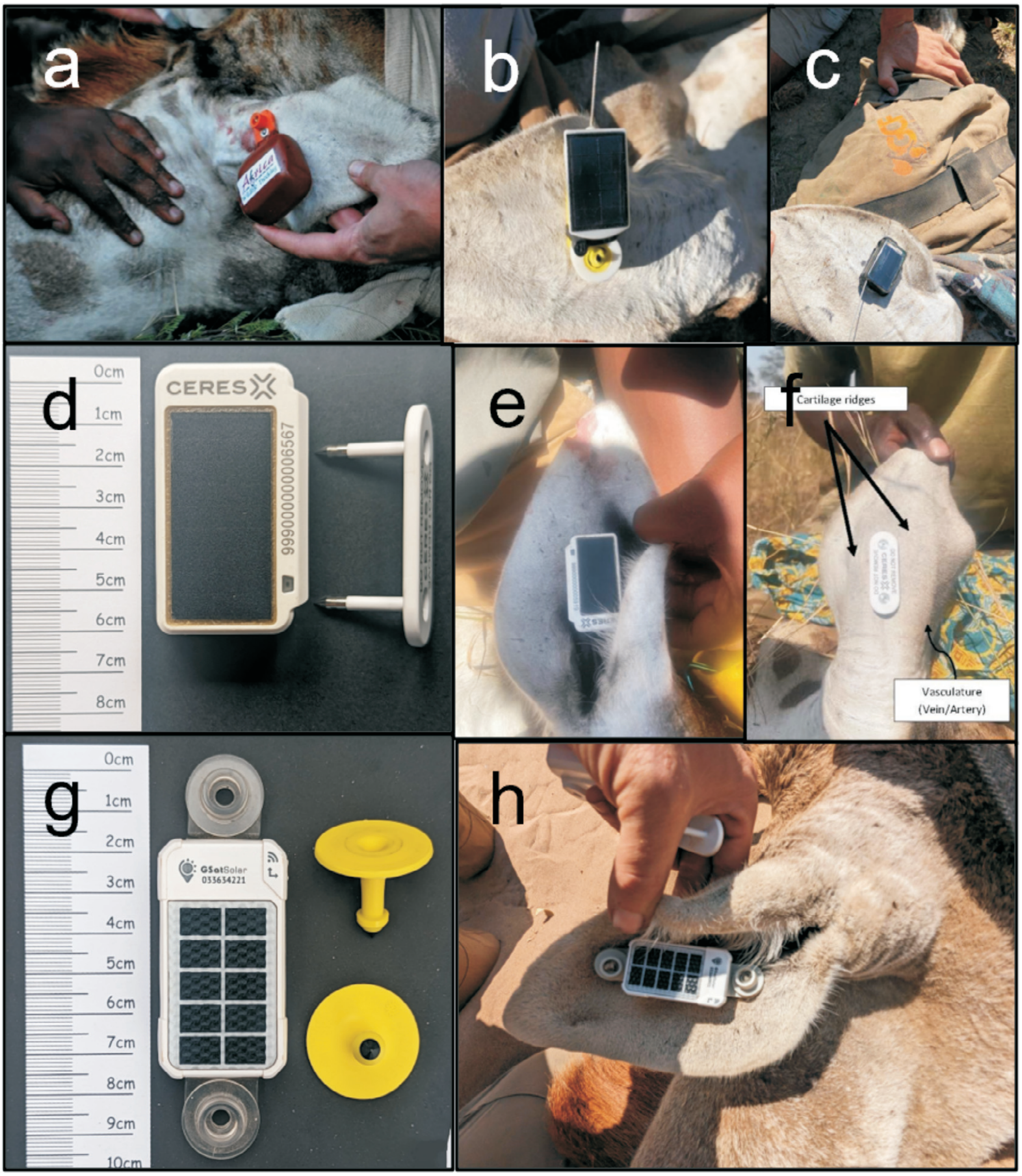

Fig. 6. **a**, Giraffe ear tag 1.0 (© AWT); **b**, ear tag 2.0 fitted in South Africa (source: Nyathi, 2020); **c**, ear tag 3.0 fitted in South Africa; **d**, ear tag 4.0; **e**, ear tag 4.0 fitment; **f**, ear tag 4.0 fitment on giraffe avoiding cartilage ridges and vasculature; **g**, ear tag 5.0; **h**, ear tag 5.0 fitted to a giraffe in Namibia. (Photographs d–g © GCF).

sisted of a GPS-Ultra High Frequency (UHF) plastic ear tag weighing ~25 g (Fig. 6b). The ear tag 2.0 was deployed in 2019 on 12 South African giraffe (seven males and five females) in the Zingela Conservation Area, South Africa (Nyathi, 2020). Programmed to send a GPS location every four hours (6 locations/day), neither the achieved fix rate nor actual deployment length was reported (Nyathi, 2020).

Ear tag 3.0

In 2020, in partnership with the Max Planck Institute and GCF, four SigFox ear tags were deployed onto four female South African giraffe in the greater Kruger region (Balule Private GR and Thornybush GR), South Africa (Fig. 6c; Wild *et al.*, 2023). These ear tags used the ICARUS (International Cooperation for Animal Research Using Space) satellite Internet of Things (IoT) system. Attached with a single pin, the units held a lithium polymer battery with a solar cell encased in 3D printed housing and weighed <33 g (Fig. 6c; Wild *et al.*, 2023). They were programmed to send a GPS location every two hours (12 locations/day), with a fix success rate of 0.63 and a mean deployment length of 252 days Table 1; Wild *et al.*, 2023). It was noted that, regardless of the fix schedule, they sometimes sent additional transmissions when the battery was fully charged (O.L. van Schalkwyk, pers. comm.).

Ear tag 4.0

In 2021, Ceres Tag (Australia) launched their solar-powered ear tags which utilize the Globalstar satellite network for data transmission (Fig. 6d). Although initially designed for livestock, these units were quickly adapted for wildlife use due to their small size, light weight (~32 g), and low cost. The developments of these units enhanced the scale of application as they were an order of magnitude cheaper than previous head, ossicone, or tail units. The Ceres Trace model is attached *via* a two-pronged back plate to the middle part of the ear, avoiding vasculature and cartilage ridges (Fig. 6e,f). Between 2021 and 2023, GCF and collaborative partners assisted in the deployment of 162 ear tags 4.0 (Ceres Trace model) on giraffe in Angola (*n* = 17), Chad (*n* = 6), Eswatini (*n* = 7), Mozambique (*n* = 212, Namibia (*n* = 55), Niger (*n* = 5), South Africa (*n* = 12), South Sudan (*n* = 3), Uganda (*n* = 24), and Zimbabwe (*n* = 12). Ninety-six of these tags are still active (as of 14 December 2023). Default programmed to record 4 locations/day, the fix success rate was on average 0.65 and the mean deployment success rate of 0.24 (Table 1, Table S3; note 96/169 units still actively deployed).

Ear tag 4.1

Ceres Tag released a Ceres Wild model (hereafter ear tag 4.1) in 2022 which is capable of recording up to 24 locations per day. The only observable difference from ear tag 4.0 (Ceres Trace model) is the colour; the weight and attachment remain the same. GCF deployed five of the ear tag 4.1 models across Namibia (*n* = 2), South Africa (*n* = 1), and Zimbabwe (*n* = 2), and found a mean fix success rate of 0.29 and a deployment success rate of 0.38 (Table 1, Table S3; note 3/5 units still actively deployed).

Ear tag 5.0

As technology becomes more readily available, ongoing advances have led to more small, solar tracking units entering the market. For example, Global Satellite Engineering, U.S.A., have launched their GSat Solar tag (Fig. 6g); solar powered with a lithium polymer battery, they weigh ~22 g and come with several mounting options for attachment to ears, collars, etc. Capable of two-way communication to alter the schedule when within Bluetooth range, they can be programmed to record up to 24 locations per day. Preliminary field deployments by GCF in northwest Namibia (*n* = 6) and Rwanda (*n* = 5) show a mean fix success rate of 0.42 and deployment success rate of 0.08 but note that they have been actively deployed for <180 days (Table 1, Table S3; note 9/11 of these units still actively deployed).

CONCLUSIONS

The technology for tracking giraffe has evolved considerably since its first trials in 1970 (Fig. 7). The technology started with heavy (10 kg) VHF neck collars and has evolved to lightweight (32 g) solar GPS ear tags. Without a strong economic drive, the development of many prototypes and field trials was driven, undertaken, and financed by a few conservation not-for-profit organizations and academic researchers, most notably GCF. While several designs were tested with varied success, the gained data have and will continue to help improve unit designs and the welfare of giraffe considerably. As most unit types are manufactured in small, non-commercial production processes, there is limited quality control and guaranty for consistency in manufacturing. Human error, changes in components, and firmware updates affect batch consistency and make independent assessment of performance limitations difficult. Moreover, while terms and conditions may make allowances for replacing or refurbishing faulty units, the main risk remains with the buyer as these units are often deployed at great cost and risk, and finding and replacing inactive units on wildlife is rarely a plausible option. Expected unit longevity is another important consideration for unit choice. While a small percentage of unit failures are expected and considered acceptable, we have experienced high failure rate, with only

50/347 (14%) of units with closed deployments showing a deployment success rate ≥0.70 (Table 1, Fig. 8). Based on the data above and on current availability, we suggest the following two recommendations to inform unit choice depending on the desired outcome (Table 2):

(1) For low-resolution monitoring (for example, three months post-translocation monitoring), we recommend the ear tag 4.0 (Ceres Trace) or ear tag 5.0 (GSat Solar; but note the limited deployments thus far) for all giraffe species. While the fix success is lower (mean success rate 0.66, frequently resulting in temporal irregularity) and communication is only one way, they are available at an affordable price and are quick and easy to affix to animals.

(2) For high-resolution monitoring and/or research questions, there is currently no unit on the market that shows a sufficient performance success for giraffe. While there are units with high fix success rates (*e.g.* tail unit 3.0), the low deployment success rates do not justify the risk and expense of affixing to animals in the field. We are currently working with manufactures to further develop a unit that can persist for an acceptable duration.

Some units are complicated to fit or require considerable expertise and/or time to fit (*e.g.* head harness, ossicone unit), and there are now alternatives available. It is important to stress that no giraffe that was fitted with these devices by GCF or during GCF collaborative projects sustained any life-threatening or severe injury. Giraffe that were observed showing signs of minor injury (irritation, skin rubbing or local infections, etc.), the units were removed as soon as logistically possible and there were no long-lasting impacts on the animals.

We hope that this information can assist conservation management and research on giraffe as well as add value for the GPS tagging of other species. While it is not appropriate to compare the performance of giraffe-specific units with those deployed on other species that are able to carry different devices, payloads, units with different solar exposure and network coverage, the perfor-

Fig. 7. Timeline of the evolution of giraffe tracking devices from the 1970s to today (all images courtesy of GCF except the first left image; source: Langman, 1973).

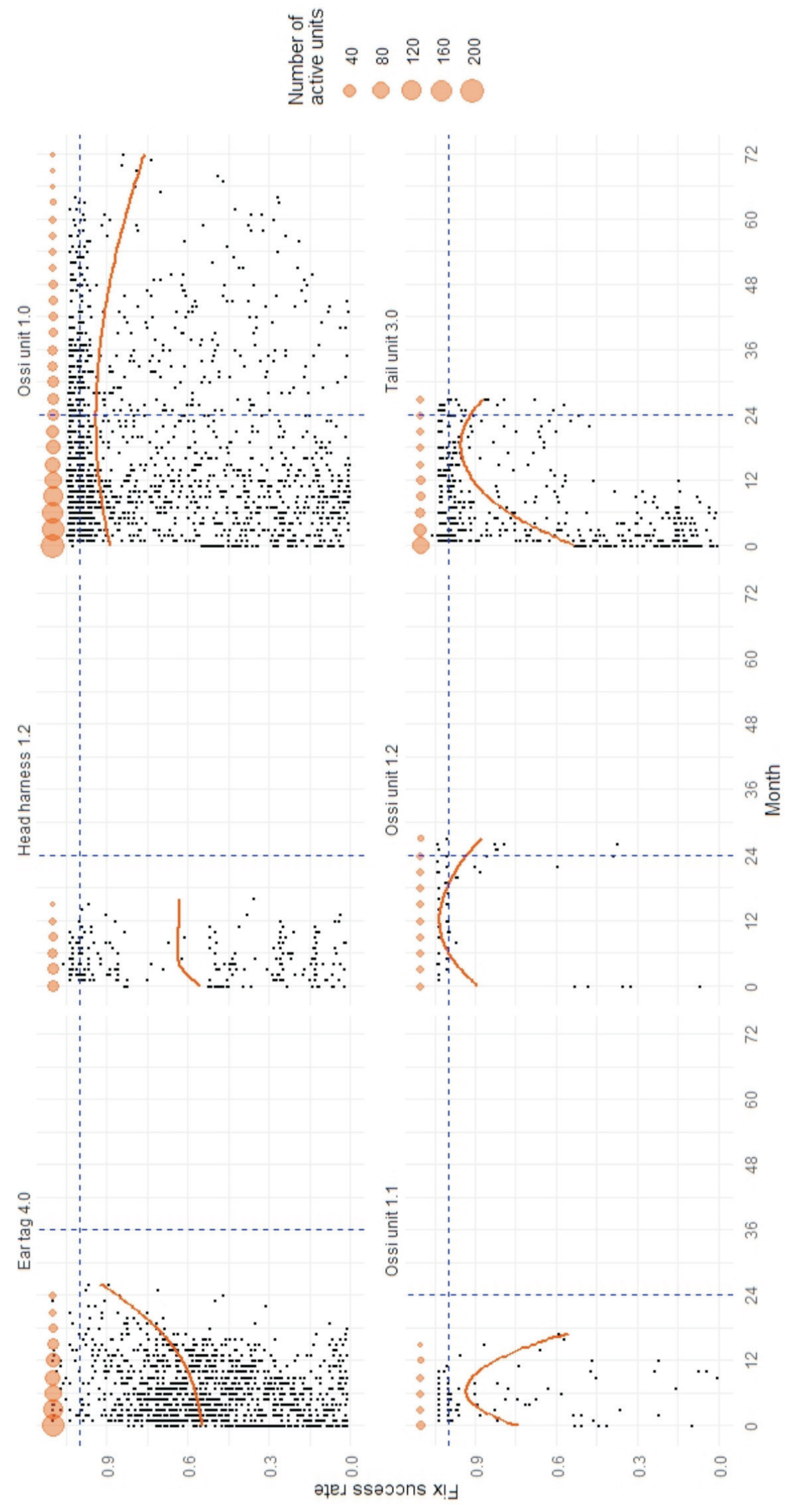

Fig. 8. The monthly mean fix success rate (achieved fixes / scheduled) of the four unit types for which we have $n > 2$ closed deployments. The vertical blue dashed line represents the manufacturer advertised longevity, the horizontal blue dashed line represents perfect success rate of 1.0, and the orange solid line represents the loess best fit line.

Table 2. Summary of the pros and cons of the most viable (*i.e.* mean fix success >0.60 and mean deployment length >3 months) versions of each tracking GPS unit type for giraffe. Cost estimates are calculated from the date of last purchase and are to be used as a guide only.

Unit type and version	Manufacturer (model where applicable)	Fix success rate (mean achieved/ scheduled)	Deployment success rate (mean days/ expected)	Cost (estimate)	Attachment time (excl. sedation/ capture)	Other considerations
Head harness 1.2	Africa Wildlife Tracking	0.96	0.28	Unit: USD1300 Data: USD44/month (incl. tax)	3–5 minutes	Potential of straps rubbing the skin
Ossi unit 1.2	Savannah Tracking	0.94	0.92	Unit: USD1460 Data: USD25/month (varies depending on data package) (excl. tax)	5–10 minutes	Implications with behaviour; *e.g.* males sparring and causing damage Requires careful placement and additional tools
Tail unit 3.0	Savannah Tracking	0.72	0.32	Unit: USD1190 Data: USD25/month (varies depending on data package) (excl. tax)	~3 minutes	
Ear tag 4.0	Ceres (Trace)	0.65	0.24	Unit: USD205 Data: USD0.17/ month varies depending on software) (incl. tax)	<1 minute	Can be fitted during mass capture without sedation

mance of the current units used on giraffe is just below average compared to other species. For the GPS tail unit 3.0 (Savannah Tracking), the average fix rate success is 0.68. In comparison, the fix rate success of Loteck LifeCycle GPS collars was on average 0.88 for bison (*Bison bison*) and 0.65 for Caribou (*Rangifer tarandus*) in Canada (Jung *et al*., 2018). Schlippe, Rosell & Mayer (2018) reported a fix rate success of 0.86 for GPS devices attached to Eurasian beavers (*Castor fiber*) in Norway. Pastorini, Prasad, Leimgruber, Isler & Fernando (2015) tested several brands of GPS collars on Asian elephant (*Elephas maximus*) in Sri Lanka, averaging a 0.78 fix success rate. However, such comparisons are not always helpful as factors impacting the unit performance vary between locations even within species. For example, our experience has shown that the GPS tail unit (3.0) performs much better on giraffe in an arid landscape (*e.g.* Namibia) than in more mesic environments (*e.g.* Kenya), with fix success rates of 0.94 and 0.71, respectively, and deployment success rates of 0.99 and 0.14, respectively (cloud cover, satellite coverage, and manufacturing issues are likely the main factors impacting the performance). It is possible that the less-conventional attachment methods to animals (such as the giraffe) decrease the likelihood of both high fix and deployment success; however, site-specific variables also need to be considered. In addition, variation in production batches appear to be another relevant factor for performance.

For giraffe, future development of tracking technology requires an innovative approach to unit and attachment design. While GCF has put considerable resources into testing giraffe-specific units, performance is still not as reliable and high as those obtained with traditional neck collars on other species. There are many studies reporting the performance of stationary units (*e.g.* Moore, Beaman, Brice & Burke da Silva, 2023), and many more publications using GPS tracking units that do not sufficiently report performance to allow for comparison and/or interpretation which limits our ability to learn from these studies. With such species- and site-specific variables to consider, we encourage others to report these basic performance metrics. Specifically, we encourage future studies to report their fix success rate and deployment success rate so that we can continue to compare performance across unit types and species. We recommend establishing a wildlife tracking consortium with non-commercial interest to collaboratively share experiences and work collaboratively on developing reliable solutions, similar to what is currently done by EarthRanger in the data sharing and visualization space. By sharing field experiences and subsequent data outputs we can further develop remote tracking technology and encourage modern options for improved species conservation and the welfare of animals wearing these devices.

ACKNOWLEDGEMENTS

We would like to thank the various government authorities for providing the appropriate permission to facilitate the work of GCF and our collaborative partners in fitting and monitoring the various tracking units on giraffe throughout Africa. Additionally, we thank our numerous conservation partners, wildlife veterinarians, donors, and supporters who have provided valuable technical and financial assistance in making this work possible, Lastly, we thank the various telemetry companies and academics with whom we have worked during the evolution of these tracking units, in particular African Wildlife Tracking, Ceres Inc., and Savannah Tracking Ltd.

§ORCID iDs

C.J. Marneweck orcid.org/0000-0002-5064-1979
M.B. Brown orcid.org/0000-0002-0119-0614
S. Fennessy orcid.org/0000-0002-3365-1075
S. Ferguson orcid.org/0000-0002-8086-6706
A.B. Muneza orcid.org/0000-0002-2128-1820
J. Fennessy orcid.org/0000-0001-5871-8267

REFERENCES

Adams, L. (1965). Progress in ecological biotelemetry. *BioScience*, 15, 83–86.

Bolger, D., Ogutu, J., Strauss, M., Lee, D., Muneza, A., Fennessy, J. & Brown, D. (2019). *Giraffa camelopardalis* ssp. *Tippelskirchi* (e. T88421036A88421121). *The IUCN Red List of Threatened Species*.

Brandes, S., Sicks, F. & Berger, A. (2021). Behaviour classification on giraffes (*Giraffa camelopardalis*) using machine learning algorithms on triaxial acceleration data of two commonly used GPS devices and its possible application for their management and conservation. *Sensors*, 21, 2229.

Broekhuis, F., Madsen, E.K., Keiwua, K. & Macdonald, D.W. (2019). Using GPS collars to investigate the frequency and behavioural outcomes of intraspecific interactions among carnivores: a case study of male cheetahs in the Maasai Mara, Kenya. *PLOS ONE*, 14, e0213910.

Brown, M.B. & Bolger, D.T. (2020). Male-biased partial migration in a giraffe population. *Frontiers in Ecology and Evolution*, 7, 524.

Brown, M.B., Fennessy, J.T., Crego, R.D., Fleming, C.H., Alves, J., Brandlová, K., Fennessy, S., Ferguson, S., Hauptfleisch, M. & Hejcmanova, P. (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.

Brown, M.B., Kulkarni, T., Ferguson, S., Fennessy, S., Muneza, A., Stabach, J A. & Fennessy, J. (2021). Conservation status of giraffe: evaluating contemporary distribution and abundance with evolving taxonomic perspectives. In *Imperiled: the Encyclopedia of Conservation* (pp. 471–487). Elsevier. https://doi.org/10.1016/B978-0-12-821139-7.00139-2

Chege, S. (2012). Giraffe translocation from Aberdare Country Club to Sera Wildlife Conservancy. *Giraffa*, 6, 9–13.

Clark, R.K., Fennessy, J., Ferguson, S., Fraticelli, C., Honig, N., Morrison, T.A. & Brown, M.B. (2023). Seasonal dynamics impact habitat preferences and protected area use of the critically endangered Kordofan giraffe (*Giraffa camelopardalis antiquorum*). *African Journal of Wildlife Research*, 53, 119–134. https://doi.org/10.3957/056.053.0119

Crego, R.D., Fennessy, J., Brown, M.B., Connette, G., Stacy-Dawes, J., Masiaine, S. & Stabach, J.A. (2023). Combining species distribution models and moderate resolution satellite information to guide conservation programs for reticulated giraffe. *Animal Conservation*.

Crego, R.D., Wells, H.B.M., Ndung'u, K.S., Evans, L., Nduguta, R.N., Chege, M.A., Brown, M.B., Ogutu, J.O., Ojwang, G.O., Fennessy, J., O'Connor, D., Stacy-Dawes, J., Rubenstein, D.I., Martins, D.J., Leimgruber, P. & Stabach, J.A. (2021). Moving through the mosaic: identifying critical linkage zones for large herbivores across a multiple-use African landscape. *Landscape Ecology*, 36, 1325–1340. https://doi.org/10.1007/s10980-021-01232-8

Davis, E.B., Brakora, K.A. & Lee, A.H. (2011). Evolution of ruminant headgear: a review. *Proceedings of the Royal Society B: Biological Sciences*, 278(1720), 2857–2865. https://doi.org/10.1098/rspb.2011.0938

Davies, A.B., Tambling, C.J., Marneweck, D.G., Ranc, N., Druce, D.J., Cromsigt, J.P., le Roux, E. & Asner, G.P. (2021). Spatial heterogeneity facilitates carnivore coexistence. *Ecology*, 102(5), e03319.

Deacon, F. (2015). *The spatial ecology, habitat preference and diet selection of giraffe* (Giraffa camelopardalis giraffa) *in the Kalahari region of South Africa.* (Ph.D. thesis). Bloemfontein, South Africa: University of the Free State.

Deacon, F. & Bercovitch, F.B. (2018). Movement patterns and herd dynamics among South African giraffes (*Giraffa camelopardalis giraffa*). *African Journal of Ecology*, 56(3), 620–628.

Deacon, F., Smit, G.N. & Grobbelaar, A. (2023a). Climatic factors affecting seasonal movements of giraffes (*Giraffa camelopardalis*) in a semi-arid region of South Africa. *African Journal of Ecology*, 62, e13204.

Deacon, F., Smit, G.N. & Grobbelaar, A. (2023b). Resources and habitat requirements for giraffes' (*Giraffa camelopardalis*) diet selection in the northwestern Kalahari, South Africa. *Animals*, 13(13), 2188.

Deacon, F. & Smit, N. (2017). Spatial ecology and habitat use of giraffe (*Giraffa camelopardalis)* in South Africa. *Basic and Applied Ecology*, 21, 55–65.

D'haen, M. (2017). *Quarterly conservation update – Kordofan giraffe* (Giraffa camelopardalis antiquorum), *Garamba National Park, Democratic Republic of Congo.* Giraffe Conservation Foundation.

D'haen, M. (2018). *Quarterly conservation update – Kordofan giraffe* (Giraffa camelopardalis antiquorum), *Garamba National Park, Democratic Republic of Congo.* Giraffe Conservation Foundation.

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

Dickie, M., McNay, S.R., Sutherland, G.D., Cody, M. & Avgar, T. (2020). Corridors or risk? Movement along, and use of, linear features varies predictably among large mammal predator and prey species. *Journal of Animal Ecology*, 89, 623–634. https://doi.org/10.1111/1365-2656.13130

du Toit, J. (1990). Home range—Body mass relations: a field study on African browsing ruminants. *Oecologia*, 85, 301–303.

Fennessy, J. (2004). *Ecology of desert-dwelling giraffe* Giraffa camelopardalis angolensis *in northwestern Namibia*. (Ph.D. thesis). Sydney, Australia: University of Sydney.

Fennessy, J. (2009). Home range and seasonal movements of *Giraffa camelopardalis angolensis* in the northern Namib Desert. *African Journal of Ecology*, 47, 318–327.

Fennessy, J. & Marais, A. (2018). *Giraffa camelopardalis* ssp. *Antiquorum* (p. e.T88420742A88420817). *The IUCN Red List of Threatened Species*. http://dx.doi.org/10.2305/IUCN.UK.20182.RLTS.T88420742A88420817.en

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.

Foster, J. & Dagg, A. (1972). Notes on the biology of the giraffe. *African Journal of Ecology*, 10, 1–16.

Ganey, T., Ogden, J. & Olsen, J. (1990). Development of the giraffe horn and its blood supply. *The Anatomical Record*, 227, 497–507.

Hart, E.E., Fennessy, J., Hauenstein, S. & Ciuti, S. (2020). Intensity of giraffe locomotor activity is shaped by solar and lunar zeitgebers. *Behavioural Processes*, 178, 104178.

Hart, E.E., Fennessy, J., Rasmussen, H.B., Butler-Brown, M., Muneza, A.B. & Ciuti, S. (2020). Precision and performance of an 180g solar-powered GPS device for tracking medium to large-bodied terrestrial mammals. *Wildlife Biology*, 2020(3), 1–8.

Katzner, T.E. & Arlettaz, R. (2020). Evaluating contributions of recent tracking-based animal movement ecology to conservation management. *Frontiers in Ecology and Evolution*, 7, 519. https://doi.org/10.3389/fevo.2019.00519

Kays, R., Crofoot, M.C., Jetz, W. & Wikelski, M. (2015). Terrestrial animal tracking as an eye on life and planet. *Science*, 348(6240), aaa2478.

King, J., Leogusa, M., Lemerketo, J. & Lesimirdana, D. (2009). *Post-release monitoring of translocated giraffe in Sera Wildlife Conservancy* [*Interim Report*]. Northern Rangelands Trust, Sera Wildlife Conservancy.

Langman, V. (1973). Radio-tracking giraffe for ecological studies. *Journal of the South African Wildlife Management Association*, 3, 75–78.

McQualter, K.N., Chase, M.J., Fennessy, J.T., McLeod, S.R. & Leggett, K.E. (2016). Home ranges, seasonal ranges and daily movements of giraffe (*Giraffa camelopardalis giraffa*) in northern Botswana. *African Journal of Ecology*, 54, 99–102.

Monico, M. & Ortega, N. (2012). Five giraffe successfully collared in Garamba National Park, DRC. *Giraffa*, 6, 4–5.

Moore, C., Beaman, J., Brice, M. & Burke da Silva, K. (2023). A case report assessing the utility of a low-cost tracking GPS device for monitoring terrestrial mammal movements. *Animal Biotelemetry*, 11, 35.

Muller, Z., Bercovitch, F., Brand, R., Brown, D., Brown, M.B., Bolger, D., Carter, K., Deacon, F., Doherty, J., Fennessy, J., Fennessy, S., Hussein, A.A., Lee, D., Marais, A., Strauss, M., Tutchings, A. & Wube, T. (2018). *Giraffa camelopardalis* (amended version of 2016 assessment) (e. T9194A136266699). *The IUCN Red List of Threatened Species*. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T9194A136266699.en

Muneza, A., Doherty, J.B., Hussein, A.A., Fennessy, J., Marais, A., O'Connor, D. & Wube, T. (2018). *Giraffa camelopardalis* ssp. *Reticulata* (p. e.T88420717A88420720). *The IUCN Red List of Threatened Species*. http://dx.doi.org/10.2305/IUCN.UK.20182.RLTS.T88420717A88420720.en

Nyathi, M.J.J. (2020). Ecology of the South African giraffe (*Giraffa camelopardalis giraffa*) across a land-use gradient in central KwaZulu-Natal, South Africa. (M.Sc. thesis). Pietermaritzburg, South Africa: University of KwaZulu-Natal.

Owen-Smith, N. (2014). Spatial ecology of large herbivore populations. *Ecography*, 37, 416–430. https://doi.org/10.1111/j.1600-0587.2013.00613.x

Pastorini, J., Prasad, T., Leimgruber, P., Isler, K. & Fernando, P. (2015). Elephant GPS tracking collars: is there a best? *Gajah*, 43, 15–25.

Ranc, N., Moorcroft, P.R., Ossi, F. & Cagnacci, F. (2021). Experimental evidence of memory-based foraging decisions in a large wild mammal. *Proceedings of the National Academy of Sciences*, 118, e2014856118.

Razal, C. (2016, April 11). Giraffe activity. *CZS Insights*. https://www.czs.org/giraffeactivity-2

Razal, C. (2017, June 6). Giraffe project update. *CZS Insights*. https://www.czs.org/giraffe-study-2

Scheepers, J.L. (1992). Habitat selection and demography of a giraffe population in northern Namib desert, Namibia. *Ongulés/Ungulates*, 91, 223–228.

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.

Schlippe, J.L., Rosell, F. & Mayer, M. (2018). Performance of GPS units for deployment on semiaquatic animals. *PLOS ONE*, 13(12), e0207938. https://doi.org/10.1371/journal.pone.0207938

Seidel, D.P., Dougherty, E., Carlson, C. & Getz, W.M. (2018). Ecological metrics and methods for GPS movement data. *International Journal of Geographical Information Science*, 32(11), 2272–2293.

Shorrocks, B. (2016). *The giraffe: biology, ecology, evolution and behaviour*. John Wiley & Sons.

Suraud, J.P. (2011). *Identifier les contraintes pour la conservation des dernières girafes de l'Afrique de l'Ouest: Déterminants de la dynamique de la population et patron d'occupation spatiale*. (Ph.D. thesis). Villeurbanne, France: Université Claude Bernard-Lyon I.

Wild, T.A., van Schalkwyk, L., Viljoen, P., Heine, G., Richter, N., Vorneweg, B., Koblitz, J. C., Dechmann, D.K.N., Rogers, W., Partecke, J., Linek, N., Volkmer, T., Gregersen, T., Havmøller, R.W., Morelle, K., Daim, A., Wiesner, M., Wolter, K., Fiedler, W., … Wikelski, M. (2023). A multi-species evaluation of digital wildlife monitoring using the Sigfox IoT network. *Animal Biotelemetry*, 11, 13. https://doi.org/10.1186/s40317-023-00326-1

Wube, T., Doherty, J., Fennessy, J. & Marais, A. (2018). *Giraffa camelopardalis* ssp. *Camelopardalis* (e. T88420707A88420710). *The IUCN Red List of Threatened Species*. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T88420707A88420710.en

Responsible Editor: M.W. Hayward

Supplementary material to:

Courtney J. Marneweck, Michael B. Brown, Stephanie Fennessy,
Sara Ferguson, Rigardt Hoffman, Arthur B. Muneza & Julian Fennessy

The evolution of tracking technology for wild giraffe (*Giraffa* spp.)

African Journal of Wildlife Research **54**: 46–68 (2024)

Table S1. Results from Web of Science literature review.

Table S2. List of permit numbers and agreements for Giraffe Conservation Foundation giraffe GPS tracking across Africa.

Table S3. Performance details of each Giraffe Conservation Foundation tracking unit deployed across Africa.

Table S1. The Web of Science literature search export (16 November 2023) with annotations for relevance to this paper (i.e., include a giraffe being fitted with a GPS unit).

								WOS EXPORT					AUTHOR FILTERS		
Authors	**Article Title**	**Source Title**	**ISSN**	**eISSN**	**Year**	**Vol**	**Iss**	**Start Page**	**End Page**	**Article Number**	**DOI Link**	**UT (Unique WOS ID)**	**Giraffe**	**GPS unit**	**Inclusion**
Alasaad, S; Ndeereh, D; Rossi, L; Bornstein, S; Permunian, R; Soriguer, RC; Gakuya, F	The opportunistic Sarcoptes scabiei: A new episode from giraffe in the drought-suffering Kenya	VETERINARY PARASITOLOGY	0304-4017	1873-2550	2012	185	2	359	363		http://dx.doi.org/10.1016/j.vetpar.2011.10.039	WOS:000302839700050	Y	N	N
Alexander, KA; Blackburn, JK; Vandewalle, ME; Pesapane, R; Baipoledi, EK; Elzer, PH	Buffalo, Bush Meat, and the Zoonotic Threat of Brucellosis in Botswana	PLOS ONE	1932-6203		2012	7	3			e32842	http://dx.doi.org/10.1371/journal.pone.0032842	WOS:000303062000017	Y	N	N
Assémat, F; Gendron, E; Hammer, F	The FALCON concept:: multi-object adaptive optics and atmospheric tomography for integral field spectroscopy -: principles and performance on an 8-m telescope	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711	1365-2966	2007	376	1	287	312		http://dx.doi.org/10.1111/j.1365-2966.2007.11422.x	WOS:000244886400038	N	NA	N
Babusiaux, C; Katz, D; Hill, V; Royer, F; Gómez, A; Arenou, F; Combes, F; Di Matteo, P; Gilmore, G; Haywood, M; Robin, AC; Rodriguez-Fernandez, N;	Metallicity and kinematics of the bar in situ	ASTRONOMY & ASTROPHYSICS	1432-0746		2014	563				A15	http://dx.doi.org/10.1051/0004-6361/201323044	WOS:000333798000015	N	NA	N

Sartoretti, P; Schultheis, M														
Badlangana, NL; Bhagwandin, A; Fuxe, K; Manger, PR	Observations on the giraffe central nervous system related to the corticospinal tract, motor cortex and spinal cord: What difference does a long neck make?	NEUROSCIENCE	0306-4522	1873-7544	2007	148	2	522	534	http://dx.doi.org/10.1016/j.neuroscience.2007.06.005	WOS:000249638100019	Y	N	N
Baiano, C; Job, X; Santangelo, G; Auvray, M; Kirsch, LP	Interactions between interoception and perspective-taking: Current state of research and future directions	NEUROSCIENCE AND BIOBEHAVIORAL REVIEWS	0149-7634	1873-7528	2021	130		252	262	http://dx.doi.org/10.1016/j.neubiorev.2021.08.007	WOS:000709411900005	N	NA	N
Battaglia, G; Tolstoy, E; Helmi, A; Irwin, MJ; Letarte, B; Jablonka, P; Hill, V; Venn, KA; Shetrone, MD; Arimoto, N; Primas, F; Kaufer, A; Francois, P; Szeifert, T; Abel, T; Sadakane, K	The DART imaging and CaT survey of the Fornax dwarf spheroidal galaxy	ASTRONOMY & ASTROPHYSICS	1432-0746		2006	459	2	423	U148	http://dx.doi.org/10.1051/0004-6361:20065720	WOS:000241822800012	N	NA	N
Baxter, PWJ; Getz, WM	A model-framed evaluation of elephant effects on tree and fire dynamics in African savannas	ECOLOGICAL APPLICATIONS	1051-0761	1939-5582	2005	15	4	1331	1341	http://dx.doi.org/10.1890/02-5382	WOS:000230876900021	N	NA	N
Bercovitch, FB; Berry, PSM	Reproductive life history of Thornicroft's giraffe in Zambia	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2010	48	2	535	538	http://dx.doi.org/10.1111/j.1365-2028.2009.01145.x	WOS:000277320000027	Y	N	N
Berger, J	Population constraints associated with the use of black rhinos as an umbrella species for desert herbivores	CONSERVATION BIOLOGY	0888-8892		1997	11	1	69	78	http://dx.doi.org/10.1046/j.1523-1739.1997.95481.x	WOS:A1997WJ11100013	N	NA	N

Berry, PSM; Bercovitch, FB	Leadership of herd progressions in the Thornicroft's giraffe of Zambia	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2015	53	2	175	182		http://dx.doi.org/10.1111/aje.12173	WOS:000353453300007	Y	N	N
Bond, ML; König, B; Ozgul, A; Farine, DR; Lee, DE	Socially Defined Subpopulations Reveal Demographic Variation in a Giraffe Metapopulation	JOURNAL OF WILDLIFE MANAGEMENT	0022-541X	1937-2817	2021	85	5	920	931		http://dx.doi.org/10.1002/jwmg.22044	WOS:000637854800001	Y	N	N
Bond, ML; Lee, DE; Ozgul, A; Farine, DR; König, B	Leaving by staying: Social dispersal in giraffes	JOURNAL OF ANIMAL ECOLOGY	0021-8790	1365-2656	2021	90	12	2755	2766		http://dx.doi.org/10.1111/1365-2656.13582	WOS:000727071800006	Y	N	N
Bond, ML; Strauss, MKL; Lee, DE	Soil Correlates and Mortality from Giraffe Skin Disease in Tanzania	JOURNAL OF WILDLIFE DISEASES	0090-3558	1943-3700	2016	52	4	953	958		http://dx.doi.org/10.7589/2016-02-047	WOS:000385846300026	Y	N	N
Bond, WJ; Loffell, D	Introduction of giraffe changes acacia distribution in a South African savanna	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2001	39	3	286	294		http://dx.doi.org/10.1046/j.1365-2028.2001.00319.x	WOS:000170905600007	Y	N	N
Börger, L	Research Highlight: Social dispersal in giraffes	JOURNAL OF ANIMAL ECOLOGY	0021-8790	1365-2656	2021	90	12	2726	2728		http://dx.doi.org/10.1111/1365-2656.13624	WOS:000727071800003	Y	N	N
Brandes, S; Sicks, F; Berger, A	Behaviour Classification on Giraffes (Giraffa camelopardalis) Using Machine Learning Algorithms on Triaxial Acceleration Data of Two Commonly Used GPS Devices and Its Possible Application for Their Management and Conservation	SENSORS		1424-8220	2021	21	6			2229	http://dx.doi.org/10.3390/s21062229	WOS:000652711400001	Y	Y	Y
Broekman, MJE; Hilbers, JP; Huijbregts, MAJ; Mueller,	Evaluating expert-based habitat suitability information of	GLOBAL ECOLOGY AND BIOGEOGRAPHY	1466-822X	1466-8238	2022	31	8	1526	1541		http://dx.doi.org/10.1111/geb.13523	WOS:000792120800001	Y	Y	Y

T; Ali, AH; Andrén, H; Altmann, J; Aronsson, M; Attias, N; Bartlam-Brooks, HLA; van Beest, FM; Belant, JL; Beyer, DE; Bidner, L; Blaum, N; Boone, RB; Boyce, MS; Brown, MB; Cagnacci, F; Cerne, R; Chamaillé-Jammes, S; Dejid, N; Dekker, J; Desbiez, ALJ; Diaz-Muñoz, SL; Fennessy, J; Fichtel, C; Fischer, C; Fisher, JT; Fischhoff, I; Ford, AT; Fryxell, JM; Gehr, B; Goheen, JR; Hauptfleisch, M; Hewison, AJM; Hering, R; Heurich, M; Isbell, LA; Janssen, R; Jeltsch, F; Kaczensky, P; Kappeler, PM; Krofel, M; LaPoint, S; Latham, ADM; Linnell, JDC; Markham, AC; Mattisson, J; Medici, EP; Mourao, GD; Van Moorter,	terrestrial mammals with GPS-tracking data	

B; Morato, RG; Morellet, N; Mysterud, A; Mwiu, S; Odden, J; Olson, KA; Ornicans, A; Pagon, N; Panzacchi, M; Persson, J; Petroelje, T; Rolandsen, CM; Roshier, D; Rubenstein, D; Saïd, S; Salemgareyev, AR; Sawyer, H; Schmidt, NM; Selva, N; Sergiel, A; Stabach, J; Stacy-Dawes, J; Stewart, FEC; Stiegler, J; Strand, O; Sundaresan, S; Svoboda, NJ; Ullmann, W; Voigt, U; Wall, J; Wikelski, M; Wilmers, CC; Zieba, F; Zwijacz-Kozica, T; Schipper, AM; Tucker, MA												
Brondum, ET; Wang, T; Hasenkam, M; Secher, NH; Nygaard, H; Kastberg, K; Buhl, R; Aalkjaer, C	REGULATION OF BLOOD PRESSURE DURING HEAD MOVEMENT IN THE ANESTHETIZED GIRAFFE	JOURNAL OF PHYSIOLOGICAL SCIENCES	1880-6546	2009	59	1	99	99	WOS:000271023100508	Y	N	N
Brondum, ET; Wang, T; Hasenkam, M; Nygaard, H; Secher, NH; Petersen, KK;	Regulation of blood pressure during head movement in the anaesthetized giraffe	FASEB JOURNAL	0892-6638	2007	21	6	A1400	A1400	WOS:000245708705343	Y	N	N

Buhl, R; Aalkjær, C															
Brown, MB; Bolger, DT	Male-Biased Partial Migration in a Giraffe Population	FRONTIERS IN ECOLOGY AND EVOLUTION	2296-701X		2020	7				524	http://dx.doi.org/10.3389/fevo.2019.00524	WOS:000531596200001	Y	Y	Y
Brown, MB; Fennessy, JT; Crego, RD; Fleming, CH; Alves, J; Brandlova, K; Fennessy, S; Ferguson, S; Hauptfleisch, M; Hejcmanova, P; Hoffman, R; Leimgruber, P; Masiaine, S; McQualter, K; Mueller, T; Muller, B; Muneza, A; O'Connor, D; Olivier, AJ; Rabeil, T; Seager, S; Stacy-Dawes, J; van Schalkwyk, L; Stabach, J	Ranging behaviours across ecological and anthropogenic disturbance gradients: a pan-African perspective of giraffe (Giraffa spp.) space use	PROCEEDINGS OF THE ROYAL SOCIETY B-BIOLOGICAL SCIENCES	0962-8452	1471-2954	2023	290	2001			20230912	http://dx.doi.org/10.1098/rspb.2023.0912	WOS:001016116300001	Y	Y	Y
Burger, AL; Fennessy, J; Fennessy, S; Dierkes, PW	Nightly selection of resting sites and group behavior reveal antipredator strategies in giraffe	ECOLOGY AND EVOLUTION	2045-7758		2020	10	6	2917	2927		http://dx.doi.org/10.1002/ece3.6106	WOS:000521040300014	Y	N	N
Burger, AL; Hartig, J; Dierkes, PW	Shedding light into the dark: Age and light shape nocturnal activity and sleep behaviour of giraffe	APPLIED ANIMAL BEHAVIOUR SCIENCE	0168-1591	1872-9045	2020	229				105012	http://dx.doi.org/10.1016/j.applanim.2020.105012	WOS:000557873400002	Y	N	N
Cameron, EZ; Du Toit, JT	Social influences on vigilance behaviour in giraffes, Giraffa camelopardalis	ANIMAL BEHAVIOUR	0003-3472		2005	69	6	1337	1344		http://dx.doi.org/10.1016/j.anbehav.2004.08.015	WOS:000230036400012	Y	N	N

Carretta, E; Bragaglia, A; Gratton, RG; Lucatello, S; Catanzaro, G; Leone, F; Bellazzini, M; Claudi, R; D'Orazi, V; Momany, Y; Ortolani, S; Pancino, E; Piotto, G; Recio-Blanco, A; Sabbi, E	Na-O anticorrelation and HB VII. The chemical composition of first and second-generation stars in 15 globular clusters from GIRAFFE spectra	ASTRONOMY & ASTROPHYSICS	0004-6361		2009	505	1	117	138		http://dx.doi.org/10.1051/0004-6361/200912096	WOS:000270436000013	N	NA	N
Carter, KD; Seddon, JM; Frère, CH; Carter, JK; Goldizen, AW	Fission-fusion dynamics in wild giraffes may be driven by kinship, spatial overlap and individual social preferences	ANIMAL BEHAVIOUR	0003-3472	1095-8282	2013	85	2	385	394		http://dx.doi.org/10.1016/j.anbehav.2012.11.011	WOS:000314683000012	Y	N	N
Castles, MP; Brand, R; Carter, AJ; Maron, M; Carter, KD; Goldizen, AW	Relationships between male giraffes' colour, age and sociability	ANIMAL BEHAVIOUR	0003-3472	1095-8282	2019	157		13	25		http://dx.doi.org/10.1016/j.anbehav.2019.08.003	WOS:000493780600003	Y	N	N
Chirima, GJ; Owen-Smith, N; Erasmus, BFN	Changing distributions of larger ungulates in the Kruger National Park from ecological aerial survey data	KOEDOE	0075-6458	2071-0771	2012	54	1			1009	http://dx.doi.org/10.4102/koedoe.v54i1.1009	WOS:000326033200001	Y	N	N
Ciofolo, I; Le Pendu, Y	The feeding behaviour of giraffe in Niger	MAMMALIA	0025-1461	1864-1547	2002	66	2	183	194		http://dx.doi.org/10.1515/mamm.2002.66.2.183	WOS:000177159800003	Y	N	N
Codron, D; Codron, J; Lee-Thorp, JA; Sponheimer, M; de Ruiter, D; Sealy, J; Grant, R; Fourie, N	Diets of savanna ungulates from stable carbon isotope composition of faeces	JOURNAL OF ZOOLOGY	0952-8369	1469-7998	2007	273	1	21	29		http://dx.doi.org/10.1111/j.1469-7998.2007.00292.x	WOS:000249429800004	Y	N	N
Cohen, RE; Mauro, F; Alonso-García, J; Hempel, M;	Deep Hubble Space Telescope Imaging of Globular Clusters toward the	ASTRONOMICAL JOURNAL	0004-6256	1538-3881	2018	156	2			41	http://dx.doi.org/10.3847/1538-3881/aac889	WOS:000437755000001	N	NA	N

Sarajedini, A; Ordoñez, AJ; Geisler, D; Kalirai, JS	Galactic Bulge: Observations, Data Reduction, and Color-magnitude Diagrams														
Coimbra, JP; Bertelsen, MF; Manger, PR	Retinal ganglion cell topography and spatial resolving power in the river hippopotamus (Hippopotamus amphibius)	JOURNAL OF COMPARATIVE NEUROLOGY	0021-9967	1096-9861	2017	525	11	2499	2513		http://dx.doi.org/10.1002/cne.24179	WOS:000402832600004	N	NA	N
Coimbra, JP; Hart, NS; Collin, SP; Manger, PR	Scene from above: Retinal ganglion cell topography and spatial resolving power in the giraffe (Giraffa camelopardalis)	JOURNAL OF COMPARATIVE NEUROLOGY	0021-9967	1096-9861	2013	521	9	2042	2057		http://dx.doi.org/10.1002/cne.23271	WOS:000318045400005	Y	N	N
Colston, KPJ; Johnson, CL; Nyugha, D; Goué, AM; Penny, SG	Viability analysis of Kordofan giraffe (Giraffa camelopardalis antiquorum) in a protected area in Cameroon	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2023						http://dx.doi.org/10.1111/aje.13196	WOS:001042065800001	Y	N	N
Crego, RD; Fennessy, J; Brown, MB; Connette, G; Stacy-Dawes, J; Masiaine, S; Stabach, JA	Combining species distribution models and moderate resolution satellite information to guide conservation programs for reticulated giraffe	ANIMAL CONSERVATION	1367-9430	1469-1795	2023						http://dx.doi.org/10.1111/acv.12894	WOS:001034354800001	Y	Y	Y
Crego, RD; Ogutu, JO; Wells, HBM; Ojwang, GO; Martins, DJ; Leimgruber, P; Stabach, JA	Spatiotemporal dynamics of wild herbivore species richness and occupancy across a savannah rangeland: Implications for conservation	BIOLOGICAL CONSERVATION	0006-3207	1873-2917	2020	242				108436	http://dx.doi.org/10.1016/j.biocon.2020.108436	WOS:000517855100025	Y	N	N
Crego, RD; Wells, HBM; Connette, G;	Monitoring spatiotemporal dynamics of large	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2023						http://dx.doi.org/10.1111/aje.13219	WOS:001084151600001	Y	N	N

Stabach, JA; Soit, N; Thompson, S	herbivores across an African rangeland using hierarchical multi-species distance sampling														
Crego, RD; Wells, HBM; Ndung'u, KS; Evans, L; Nduguta, RN; Chege, MA; Brown, MB; Ogutu, JO; Ojwang, GO; Fennessy, J; O'Connor, D; Stacy-Dawes, J; Rubenstein, DI; Martins, DJ; Leimgruber, P; Stabach, JA	Moving through the mosaic: identifying critical linkage zones for large herbivores across a multiple-use African landscape	LANDSCAPE ECOLOGY	0921-2973	1572-9761	2021	36	5	1325	1340		http://dx.doi.org/10.1007/s10980-021-01232-8	WOS:000628723700001	Y	Y	Y
Crossley, DA; Burggren, WW; Reiber, CL; Altimiras, J; Rodnick, KJ	Mass Transport: Circulatory System with Emphasis on Nonendothermic Species	COMPREHENSIVE PHYSIOLOGY	2040-4603		2017	7	1	17	66		http://dx.doi.org/10.1002/cphy.c150010	WOS:000394186300002	N	NA	N
Curry, CJ; White, PA; Derr, JN	Genetic analysis of African lions (Panthera leo) in Zambia support movement across anthropogenic and geographical barriers	PLOS ONE	1932-6203		2019	14	5			e0217179	http://dx.doi.org/10.1371/journal.pone.0217179	WOS:000469759100034	N	NA	N
Cusack, JJ; Dickman, AJ; Kalyahe, M; Rowcliffe, JM; Carbone, C; MacDonald, DW; Coulson, T	Revealing kleptoparasitic and predatory tendencies in an African mammal community using camera traps: a comparison of spatiotemporal approaches	OIKOS	0030-1299	1600-0706	2017	126	6	812	822		http://dx.doi.org/10.1111/oik.03403	WOS:000402820600006	N	NA	N
Damiani, F; Bonito, R; Prisinzano, L; Zwitter, T; Bayo, A;	The Gaia-ESO Survey: dynamics of ionized and neutral gas in the	ASTRONOMY & ASTROPHYSICS	1432-0746		2017	604				A135	http://dx.doi.org/10.1051/0004-6361/201730986	WOS:000408480100128	N	NA	N

Kalari, V; Jiménez-Esteban, FM; Costado, MT; Jofré, P; Randich, S; Flaccomio, E; Lanzafame, AC; Lardo, C; Morbidelli, L; Zaggia, S	Lagoon nebula (M 8)														
Deacon, F; Bercovitch, FB	Movement patterns and herd dynamics among South African giraffes (Giraffa camelopardalis giraffa)	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2018	56	3	620	628		http://dx.doi.org/10.1111/aje.12514	WOS:000440898700022	Y	Y	Y
Deacon, F; Smit, GN; Grobbelaar, A	Resources and Habitat Requirements for Giraffes' (Giraffa camelopardalis) Diet Selection in the Northwestern Kalahari, South Africa	ANIMALS	2076-2615		2023	13	13			2188	http://dx.doi.org/10.3390/ani13132188	WOS:001031150700001	Y	Y	Y
Deacon, F; Smit, GN; Grobbelaar, A	Climatic factors affecting seasonal movements of giraffes (Giraffa camelopardalis) in a semi-arid region of South Africa	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2023						http://dx.doi.org/10.1111/aje.13204	WOS:001051730000001	Y	Y	Y
Deacon, F; Smit, N	Spatial ecology and habitat use of giraffe (Giraffa camelopardalis) in South Africa	BASIC AND APPLIED ECOLOGY	1439-1791	1618-0089	2017	21		55	65		http://dx.doi.org/10.1016/j.baae.2017.04.003	WOS:000406938700006	Y	Y	Y
Debattista, VP; Ness, M; Gonzalez, OA; Freeman, K; Zoccali, M; Minniti, D	Separation of stellar populations by an evolving bar: implications for the bulge of the Milky Way	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711	1365-2966	2017	469	2	1587	1611		http://dx.doi.org/10.1093/mnras/stx947	WOS:000406629100025	N	NA	N
Dekker, B; vanRooyen, N; Bothma, JD	Habitat partitioning by ungulates on a game ranch in the Mopani veld	SOUTH AFRICAN JOURNAL OF WILDLIFE RESEARCH	0379-4369		1996	26	4	117	122			WOS:A1996XB57400006	Y	N	N
D'haen, M; Fennessy, J;	Population structure and	ECOLOGY AND EVOLUTION	2045-7758		2019	9	19	11395	11405		http://dx.doi.org/10.1002/ece3.5640	WOS:000485557000001	Y	Y	Y

Stabach, JA; Brandlová, K	spatial ecology of Kordofan giraffe in Garamba National Park, Democratic Republic of Congo														
Di Matteo, P; Haywood, M; Gómez, A; van Damme, L; Combes, F; Hallé, A; Semelin, B; Lehnert, MD; Katz, D	Mapping a stellar disk into a boxy bulge: The outside-in part of the Milky Way bulge formation	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2014	567				A122	http://dx.doi.org/10.1051/0004-6361/201322958	WOS:000341185300035	N	NA	N
Doherty, M; Arnaboldi, M; Das, P; Gerhard, O; Aguerri, JAL; Ciardullo, R; Feldmeier, JJ; Freeman, KC; Jacoby, GH; Murante, G	The edge of the M87 halo and the kinematics of the diffuse light in the Virgo cluster core	ASTRONOMY & ASTROPHYSICS	1432-0746		2009	502	3	771	786		http://dx.doi.org/10.1051/0004-6361/200811532	WOS:000268944000005	N	NA	N
Dupuis-Desormeaux, M; Davidson, Z; Pratt, L; Mwololo, M; MacDonald, SE	Testing the effects of perimeter fencing and elephant exclosures on lion predation patterns in a Kenyan wildlife conservancy	PEERJ	2167-8359		2016	4				e1681	http://dx.doi.org/10.7717/peerj.1681	WOS:000370940400004	N	NA	N
Dupuis-Desormeaux, M; Kaaria, TN; Mwololo, M; Davidson, Z; MacDonald, SE	A ghost fence-gap: surprising wildlife usage of an obsolete fence crossing	PEERJ	2167-8359		2018	6				e5950	http://dx.doi.org/10.7717/peerj.5950	WOS:000452454000006	Y	N	N
Eckenwiler, L	Displacement and solidarity: An ethic of place-making	BIOETHICS	0269-9702	1467-8519	2018	32	9	562	568		http://dx.doi.org/10.1111/bioe.12538	WOS:000450332600004	N	NA	N
Epinat, B; Amram, P; Balkowski, C; Marcelin, M	Evidence for strong dynamical evolution in disc galaxies through the last 11 Gyr.	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711		2010	401	4	2113	2147		http://dx.doi.org/10.1111/j.1365-2966.2009.15688.x	WOS:000273687800001	N	NA	N

	GHASP VIII - a local reference sample of rotating disc galaxies for high-redshift studies														
Fennessy, JT; Leggett, KEA; Schneider, S	Distribution and status of the desert-dwelling giraffe (Giraffa camelopardalis angolensis) in northwestern Namibia	AFRICAN ZOOLOGY	1562-7020		2003	38	1	184	188			WOS:000183535000019	Y	N	N
Fennessy, J	Home range and seasonal movements of Giraffa camelopardalis angolensis in the northern Namib Desert	AFRICAN JOURNAL OF ECOLOGY	0141-6707		2009	47	3	318	327		http://dx.doi.org/10.1111/j.1365-2028.2008.00963.x	WOS:000269086000008	Y	Y	Y
Ferry, N; Dray, S; Fritz, H; Valeix, M	Interspecific interference competition at the resource patch scale: do large herbivores spatially avoid elephants while accessing water?	JOURNAL OF ANIMAL ECOLOGY	0021-8790	1365-2656	2016	85	6	1574	1585		http://dx.doi.org/10.1111/1365-2656.12582	WOS:000388354200016	Y	N	N
Flanagan, SE; Brown, MB; Fennessy, J; Bolger, DT	Use of home range behaviour to assess establishment in translocated giraffes	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2016	54	3	365	374		http://dx.doi.org/10.1111/aje.12299	WOS:000388181700013	Y	Y	Y
Flores, H; Puech, M; Hammer, F; Garrido, O; Hernandez, O	GIRAFFE multiple integral field units at VLT: A unique tool to recover velocity fields of distant galaxies	ASTRONOMY & ASTROPHYSICS	0004-6361		2004	420	3	L31	L34		http://dx.doi.org/10.1051/0004-6361:20040160	WOS:000223249600004	N	NA	N
Fuentes, SAS; De Ridder, J	RRab Lyrae metallicity gradient in the Galactic bulge	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2014	571				A59	http://dx.doi.org/10.1051/0004-6361/201424436	WOS:000345282600079	N	NA	N
Furumatsu, T; Fujii, M; Kodama, Y; Ozaki, T	A giraffe neck sign of the medial meniscus: A characteristic	JOURNAL OF ORTHOPAEDIC SCIENCE	0949-2658	1436-2023	2017	22	4	731	736		http://dx.doi.org/10.1016/j.jos.2017.03.013	WOS:000407394700025	N	NA	N

	finding of the medial meniscus posterior root tear on magnetic resonance imaging														
GERSTNER, GE; GOLDBERG, LJ	EVIDENCE OF A TIME CONSTANT ASSOCIATED WITH MOVEMENT PATTERNS IN 6 MAMMALIAN-SPECIES	ETHOLOGY AND SOCIOBIOLOGY	0162-3095		1994	15	4	181	205		http://dx.doi.org/10.1016/0162-3095(94)90013-2	WOS:A1994PH98000001	Y	N	N
Ginnett, TF; Demment, MW	Sex differences in giraffe foraging behavior at two spatial scales	OECOLOGIA	0029-8549		1997	110	2	291	300		http://dx.doi.org/10.1007/s004420050162	WOS:A1997WW15700019	Y	N	N
Giraffa, G	Studying the dynamics of microbial populations during food fermentation	FEMS MICROBIOLOGY REVIEWS	0168-6445	1574-6976	2004	28	2	251	260		http://dx.doi.org/10.1016/j.femsre.2003.10.005	WOS:000221375300005	N	NA	N
Gonzalez, OA; Rejkuba, M; Zoccali, M; Valent, E; Minniti, D; Tobar, R	Reddening and metallicity maps of the Milky Way bulge from VVV and 2MASS	ASTRONOMY & ASTROPHYSICS	0004-6361		2013	552				A110	http://dx.doi.org/10.1051/0004-6361/201220842	WOS:000317912000109	N	NA	N
Gonzalez, OA; Rejkuba, M; Zoccali, M; Valenti, E; Minniti, D; Schultheis, M; Tobar, R; Chen, B	Reddening and metallicity maps of the Milky Way bulge from VVV and 2MASS II. The complete high resolution extinction map and implications for Galactic bulge studies	ASTRONOMY & ASTROPHYSICS	0004-6361		2012	543				A13	http://dx.doi.org/10.1051/0004-6361/201219222	WOS:000306597200013	N	NA	N
Gravett, N; Bhagwandin, A; Sutcliffe, R; Landen, K; Chase, MJ; Lyamin, OI; Siegel, JM; Manger, PR	Inactivity/sleep in two wild free-roaming African elephant matriarchs - Does large body size make elephants the shortest mammalian sleepers?	PLOS ONE	1932-6203		2017	12	3			e0171903	http://dx.doi.org/10.1371/journal.pone.0171903	WOS:000395983500020	N	NA	N

Grieco, V; Matteucci, F; Pipino, A; Cescutti, G	Chemical evolution of the Galactic bulge: different stellar populations and possible gradients	ASTRONOMY & ASTROPHYSICS	1432-0746		2012	548				A60	http://dx.doi.org/10.1051/0004-6361/201219761	WOS:000311901200060	N	NA	N
Guiglion, G; Recio-Blanco, A; de Laverny, P; Kordopatis, G; Hill, V; Mikolaitis, S; Minchev, I; Chiappini, C; Wyse, RFG; Gilmore, G; Randich, S; Feltzing, S; Bensby, T; Flaccomio, E; Koposov, SE; Pancino, E; Bayo, A; Costado, MT; Franciosini, E; Hourihane, A; Jofré, P; Lardo, C; Lewis, J; Lind, K; Magrini, L; Morbidelli, L; Sacco, GG; Ruchti, G; Worley, CC; Zaggia, S	The Gaia-ESO Survey: New constraints on the Galactic disc velocity dispersion and its chemical dependencies	ASTRONOMY & ASTROPHYSICS	1432-0746		2015	583				A91	http://dx.doi.org/10.1051/0004-6361/201525883	WOS:000365072200030	N	NA	N
Gunji, M; Endo, H	Functional cervicothoracic boundary modified by anatomical shifts in the neck of giraffes	ROYAL SOCIETY OPEN SCIENCE	2054-5703		2016	3	2			150604	http://dx.doi.org/10.1098/rsos.150604	WOS:000377969000020	Y	N	N
Harper, RM; Kesavan, K	Neuromodulatory Support for Breathing and Cardiovascular Action During Development	FRONTIERS IN PEDIATRICS	2296-2360		2021	9				753215	http://dx.doi.org/10.3389/fped.2021.753215	WOS:000708867600001	N	NA	N
Hart, EE; Fennessy, J; Chari, S; Ciuti, S	Habitat heterogeneity and social factors drive behavioral	JOURNAL OF MAMMALOGY	0022-2372	1545-1542	2020	101	1	248	258		http://dx.doi.org/10.1093/jmammal/gyz191	WOS:000518554900026	Y	N	N

	plasticity in giraffe herd-size dynamics														
Hart, EE; Fennessy, J; Hauenstein, S; Ciuti, S	Intensity of giraffe locomotor activity is shaped by solar and lunar zeitgebers	BEHAVIOURAL PROCESSES	0376-6357	1872-8308	2020	178				104178	http://dx.doi.org/10.1016/j.beproc.2020.104178	WOS:000555776300016	Y	Y	Y
Hart, EE; Fennessy, J; Rasmussen, HB; Butler-Brown, M; Muneza, AB; Ciuti, S	Precision and performance of an 180 g solar-powered GPS device for tracking medium to large-bodied terrestrial mammals	WILDLIFE BIOLOGY	0909-6396	1903-220X	2020	2020	3			wlb.00669	http://dx.doi.org/10.2981/wlb.00669	WOS:000595600400004	Y	Y	Y
Harvie, DS; Smith, RT; Moseley, GL; Meulders, A; Michiels, B; Sterling, M	Illusion-enhanced Virtual Reality Exercise for Neck Pain A Replicated Single Case Series	CLINICAL JOURNAL OF PAIN	0749-8047	1536-5409	2020	36	2	101	109		http://dx.doi.org/10.1097/AJP.0000000000000780	WOS:000506613400006	N	NA	N
Hayward, MW; Kerley, GIH	Prey preferences of the lion (Panthera leo)	JOURNAL OF ZOOLOGY	0952-8369	1469-7998	2005	267	3	309	322		http://dx.doi.org/10.1017/S0952836905007508	WOS:000233183700008	N	NA	N
Hilbers, JP; van Langevelde, F; Prins, HHT; Grant, CC; Peel, MJS; Coughenour, MB; de Knegt, HJ; Slotow, R; Smit, IPJ; Kiker, GA; de Boer, WF	Modeling elephant-mediated cascading effects of water point closure	ECOLOGICAL APPLICATIONS	1051-0761	1939-5582	2015	25	2	402	415		http://dx.doi.org/10.1890/14-0322.1	WOS:000350556400008	Y	N	N
Hon-Nami, K; Ueno, S; Endo, H; Nishimura, H; Igarashi, T; David, L; Iwashita, S	A novel Giraffidae-specific interspersed repeat with a microsatellite, originally found in an intron of a ruminant paralogous p97bcnt gene	GENE	0378-1119	1879-0038	2004	340	2	283	290		http://dx.doi.org/10.1016/j.gene.2004.07.016	WOS:000224607600013	N	NA	N
Hu, LH; Fernandez,	Longitudinal and transverse variation of trace	ENVIRONMENTAL MONITORING	0167-6369	1573-2959	2018	190	11			644	http://dx.doi.org/10.1007/s10661-018-7038-z	WOS:000447809200019	Y	N	N

DP; Cerling, TE	element concentrations in elephant and giraffe hair: implication for endogenous and exogenous contributions	AND ASSESSMENT													
Hua, ALC; Martin, K; Shen, YZ; Chen, NCL; Mou, CTRE; Sterk, M; Reinhard, B; Reinhard, FF; Lee, SP; Alibhai, S; Jewell, ZC	Protecting endangered megafauna through AI analysis of drone images in a low-connectivity setting: a case study from Namibia	PEERJ	2167-8359		2022	10				e13779	http://dx.doi.org/10.7717/peerj.13779	WOS:000838293600001	Y	N	N
Ishida, Y; de Groot, PJV; Leggett, KEA; Putnam, AS; Fox, VE; Lai, J; Boag, PT; Georgiadis, NJ; Roca, AL	Genetic connectivity across marginal habitats: the elephants of the Namib Desert	ECOLOGY AND EVOLUTION	2045-7758		2016	6	17	6189	6201		http://dx.doi.org/10.1002/ece3.2352	WOS:000383362700014	N	NA	N
James, NL; Bond, ML; Ozgul, A; Lee, DE	Trophic processes constrain seasonal ungulate distributions at two scales in an East African savanna	JOURNAL OF MAMMALOGY	0022-2372	1545-1542	2022	103	4	956	969		http://dx.doi.org/10.1093/jmammal/gyac050	WOS:000809428900001	Y	N	N
Kasozi, H; Linden, DW; Roloff, GJ; Montgomery, RA	Evaluating the prevalence and spatial distribution of giraffes injured by non-target poaching	JOURNAL OF ZOOLOGY	0952-8369	1469-7998	2023	319	2	152	162		http://dx.doi.org/10.1111/jzo.13033	WOS:000880070200001	Y	N	N
Kolomiecas, E; Dobrovolskas, V; Kucinskas, A; Bonifacio, P; Korotin, S	Abundance of zirconium in the globular cluster 47 Tucanae: a possible Zr-Na correlation?	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2022	660				A46	http://dx.doi.org/10.1051/0004-6361/202141970	WOS:000781443500009	N	NA	N
Le Pendu, Y; Ciofolo, I	Seasonal movements of giraffes in Niger	JOURNAL OF TROPICAL ECOLOGY	0266-4674		1999	15	3	341	353			WOS:000082152100008	Y	N	N
Lee, DE; Bolger, DT	Movements and source-sink dynamics of a	POPULATION ECOLOGY	1438-3896	1438-390X	2017	59	2	157	168		http://dx.doi.org/10.1007/s10144-017-0580-7	WOS:000404903900007	Y	N	N

	Masai giraffe metapopulation													
Lee, DE; Bond, ML	The Occurrence and Prevalence of Giraffe Skin Disease in Protected Areas of Northern Tanzania	JOURNAL OF WILDLIFE DISEASES	0090-3558	1943-3700	2016	52	3	753	755	http://dx.doi.org/10.7589/2015-09-247	WOS:000381528700048	Y	N	N
Lee, DE; Bond, ML; Kissui, BM; Kiwango, YA; Bolger, DT	Spatial variation in giraffe demography: a test of 2 paradigms	JOURNAL OF MAMMALOGY	0022-2372	1545-1542	2016	97	4	1015	1025	http://dx.doi.org/10.1093/jmammal/gyw086	WOS:000383262100001	Y	N	N
Lee, DE; Lohay, GG; Madeli, J; Cavener, DR; Bond, ML	Masai giraffe population change over 40 years in Arusha National Park	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2023					http://dx.doi.org/10.1111/aje.13115	WOS:000917954700001	Y	N	N
Leggett, K; Fennessy, J; Schneider, S	A study of animal movement in the Hoanib River catchment, northwestern Namibia	AFRICAN ZOOLOGY	1562-7020	2224-073X	2004	39	1	1	11		WOS:000223231700001	Y	N	N
Leggett, K; Fennessy, J; Schneider, S	Does land use matter in an arid Environment? A case study from the Hoanib River catchment, north-western Namibia	JOURNAL OF ARID ENVIRONMENTS	0140-1963	1095-922X	2003	53	4	529	543	http://dx.doi.org/10.1006/jare.2002.1066	WOS:000181147200008	Y	N	N
Leggett, K	Daily and hourly movement of male desert-dwelling elephants	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2010	48	1	197	205	http://dx.doi.org/10.1111/j.1365-2028.2009.01101.x	WOS:000274199800025	N	NA	N
Leggett, KEA	Home range and seasonal movement of elephants in the Kunene Region, northwestern Namibia	AFRICAN ZOOLOGY	1562-7020	2224-073X	2006	41	1	17	36	http://dx.doi.org/10.3377/1562-7020(2006)41[17:HRASMO]2.0.CO;2	WOS:000239363200003	N	NA	N
LeGrice, RJ; Tezanos-Pinto, G; de Villemereuil, P; Holwell, GI; Painting, CJ	Directional selection on body size but no apparent survival cost to being large in wild New Zealand giraffe weevils	EVOLUTION	0014-3820	1558-5646	2019	73	4	762	776	http://dx.doi.org/10.1111/evo.13698	WOS:000467993300010	N	NA	N

Levi, M; Lee, DE; Bond, ML; Treydte, AC	Forage selection by Masai giraffes (Giraffa camelopardalis tippelskirchi) at multiple spatial scales	JOURNAL OF MAMMALOGY	0022-2372	1545-1542	2022	103	3	737	744		http://dx.doi.org/10.1093/jmammal/gyac007	WOS:000768441600001	Y	N	N
Lucey, M; Hawkins, K; Ness, M; Nelson, T; Debattista, VP; Luna, A; Bensby, T; Freeman, KC; Kobayashi, C	The COMBS Survey - III. The chemodynamical origins of metal-poor bulge stars	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711	1365-2966	2022	509	1	122	144		http://dx.doi.org/10.1093/mnras/stab2878	WOS:000741326000010	N	NA	N
Mahenya, O; Mathisen, KM; Andreassen, HP; Skarpe, C	Hierarchical foraging by giraffe in a heterogeneous savannah, Tanzania	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2016	54	2	136	145		http://dx.doi.org/10.1111/aje.12270	WOS:000376151600002	Y	N	N
Martínez-Freiría, F; Tarroso, P; Rebelo, H; Brito, JC	Contemporary niche contraction affects climate change predictions for elephants and giraffes	DIVERSITY AND DISTRIBUTIONS	1366-9516	1472-4642	2016	22	4	432	444		http://dx.doi.org/10.1111/ddi.12406	WOS:000372883000006	Y	N	N
Masiaine, S; Pilfold, N; Moll, RJ; O'connor, D; Larpei, L; Stacy-Dawes, J; Ruppert, K; Glikman, JA; Roloff, G; Montgomery, RA	Landscape-level changes to large mammal space use in response to a pastoralist incursion	ECOLOGICAL INDICATORS	1470-160X	1872-7034	2021	121				107091	http://dx.doi.org/10.1016/j.ecolind.2020.107091	WOS:000604878500007	Y	N	N
McQualter, KN; Chase, MJ; Fennessy, JT; McLeod, SR; Leggett, KEA	Home ranges, seasonal ranges and daily movements of giraffe (Giraffa camelopardalis giraffa) in northern Botswana	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2016	54	1	99	102		http://dx.doi.org/10.1111/aje.12232	WOS:000370193500013	Y	Y	Y
Monreal-Ibero, A; Walsh, JR;	He I in the central giant H II region of NGC 5253 A	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2013	553				A57	http://dx.doi.org/10.1051/0004-6361/201321387	WOS:000319858700057	N	NA	N

Westmoquette, MS; Vílchez, JM	2D observational approach to collisional and radiative transfer effects													
Muneza, AB; Linden, DW; Kimaro, MH; Dickman, AJ; Macdonald, DW; Roloff, GJ; Hayward, MW; Montgomery, RA	Exploring the connections between giraffe skin disease and lion predation	JOURNAL OF ZOOLOGY	0952-8369	1469-7998	2022	316	1	49	60	http://dx.doi.org/10.1111/jzo.12930	WOS:000698585000001	Y	N	N
Muneza, AB; Linden, DW; Montgomery, RA; Dickman, AJ; Roloff, GJ; Macdonald, DW; Fennessy, JT	Examining disease prevalence for species of conservation concern using non-invasive spatial capture-recapture techniques	JOURNAL OF APPLIED ECOLOGY	0021-8901	1365-2664	2017	54	3	709	717	http://dx.doi.org/10.1111/1365-2664.12796	WOS:000401239100004	Y	N	N
Muneza, AB; Montgomery, RA; Fennessy, JT; Dickman, AJ; Roloff, GJ; Macdonald, DW	Regional variation of the manifestation, prevalence, and severity of giraffe skin disease: A review of an emerging disease in wild and captive giraffe populations	BIOLOGICAL CONSERVATION	0006-3207	1873-2917	2016	198		145	156	http://dx.doi.org/10.1016/j.biocon.2016.04.014	WOS:000377735400017	Y	N	N
Nataf, DM; Cassisi, S; Athanassoula, E	On the correlation between metallicity and the X-shaped morphology of the Milky Way bulge	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711	1365-2966	2014	442	3	2075	2080	http://dx.doi.org/10.1093/mnras/stu805	WOS:000339924300013	N	NA	N
Ness, M; Freeman, K; Athanassoula, E; Wylie-de-Boer, E; Bland-Hawthorn, J; Asplund, M; Lewis, GF; Yong, D;	ARGOS - III. Stellar populations in the Galactic bulge of the Milky Way	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711		2013	430	2	836	857	http://dx.doi.org/10.1093/mnras/sts629	WOS:000318275000008	N	NA	N

Lane, RR; Kiss, LL															
Nilsson, R; Brandeker, A; Olofsson, G; Fathi, K; Thébault, P; Liseau, R	VLT imaging of the ? Pictoris gas disk	ASTRONOMY & ASTROPHYSICS	0004-6361		2012	544				A134	http://dx.doi.org/10.1051/0004-6361/201219288	WOS:000308290100134	N	NA	N
Njenga, MK; Kemunto, N; Kahariri, S; Holmstrom, L; Oyas, H; Biggers, K; Riddle, A; Gachohi, J; Muturi, M; Mwatondo, A; Gakuya, F; Lekolool, I; Sitawa, R; Apamaku, M; Osoro, E; Widdowson, MA; Munyua, P	High real-time reporting of domestic and wild animal diseases following rollout of mobile phone reporting system in Kenya	PLOS ONE	1932-6203		2021	16	9			e0244119	http://dx.doi.org/10.1371/journal.pone.0244119	WOS:000707051200002	Y	N	N
Noonan, MJ; Fleming, CH; Tucker, MA; Kays, R; Harrison, AL; Crofoot, MC; Abrahms, B; Alberts, SC; Ali, AH; Altmann, J; Antunes, PC; Attias, N; Belant, JL; Beyer, DE; Bidner, LR; Blaum, N; Boone, RB; Caillaud, D; de Paula, RC; de la Torre, JA; Dekker, J; DePerno, CS; Farhadinia, M; Fennessy, J; Fichtel, C; Fischer, C;	Effects of body size on estimation of mammalian area requirements	CONSERVATION BIOLOGY	0888-8892	1523-1739	2020	34	4	1017	1028		http://dx.doi.org/10.1111/cobi.13495	WOS:000540800500001	N	N	N

Ford, A;
Goheen, JR;
Havmoller,
RW; Hirsch,
B; Hurtado, C;
Isbell, LA;
Janssen, R;
Jeltsch, F;
Kaczensky, P;
Kaneko, Y;
Kappeler, P;
Katna, A;
Kauffman, M;
Koch, F;
Kulkarni, A;
LaPoint, S;
Leimgruber,
P; Macdonald,
DW;
Markham,
AC;
McMahon, L;
Mertes, K;
Moorman, CE;
Morato, RG;
Mossbrucker,
AM; Mourao,
G; O'Connor,
D; Oliveira-
Santos, LGR;
Pastorini, J;
Patterson, BD;
Rachlow, J;
Ranglack, DH;
Reid, N;
Scantlebury,
DM; Scott,
DM; Selva, N;
Sergiel, A;
Songer, M;
Songsasen, N;
Stabach, JA;
Stacy-Dawes,
J; Swingen,
MB;
Thompson, JJ;
Ullmann, W;
Vanak, AT;
Thaker, M;
Wilson, JW;
Yamazaki, K;
Yarnell, RW;

Zieba, F; Zwijacz-Kozica, T; Fagan, WF; Mueller, T; Calabrese, JM														
O'connor, D; Stacy-Dawes, J; Muneza, A; Fennessy, J; Gobush, K; Chase, MJ; Brown, MB; Bracis, C; Elkan, P; Zaberirou, ARM; Rabeil, T; Rubenstein, D; Becker, MS; Phillips, S; Stabach, JA; Leimgruber, P; Glikman, JA; Ruppert, K; Masiaine, S; Mueller, T	Updated geographic range maps for giraffe, Giraffa spp., throughout sub-Saharan Africa, and implications of changing distributions for conservation	MAMMAL REVIEW	0305-1838	1365-2907	2019	49	4	285	299	http://dx.doi.org/10.1111/mam.12165	WOS:000480127900001	Y	Y	Y
O'Kane, CAJ; Duffy, KJ; Page, BR; Macdonald, DW	Effects of resource limitation on habitat usage by the browser guild in Hluhluwe-iMfolozi Park, South Africa	JOURNAL OF TROPICAL ECOLOGY	0266-4674	1469-7831	2013	29	1	39	47	http://dx.doi.org/10.1017/S0266467413000035	WOS:000314991300004	Y	N	N
Olivier, IR; Tambling, CJ; Müller, L; Radloff, FGT	Lion (Panthera leo) diet and cattle depredation on the Kuku Group Ranch Pastoralist area in southern Maasailand, Kenya	WILDLIFE RESEARCH	1035-3712	1448-5494	2022					http://dx.doi.org/10.1071/WR22019	WOS:000901682800001	N	NA	N
Penderis, CA; Kirkman, KP	Using partial volumes to estimate available browse biomass in Southern African semi-arid savannas	APPLIED VEGETATION SCIENCE	1402-2001	1654-109X	2014	17	3	578	590	http://dx.doi.org/10.1111/avsc.12084	WOS:000337725300019	N	NA	N
Périquet, S; Valeix, M;	Individual vigilance of	ANIMAL BEHAVIOUR	0003-3472	1095-8282	2010	79	3	665	671	http://dx.doi.org/10.1016/j.anbehav.2009.12.016	WOS:000274587400020	Y	N	N

Loveridge, AJ; Madzikanda, H; Macdonald, DW; Fritz, H	African herbivores while drinking: the role of immediate predation risk and context														
Péron, G; Bonenfant, C; Gagnon, R; Mabika, CT	The two oxpecker species reveal the role of movement rates and foraging intensity in species coexistence	BIOLOGY LETTERS	1744-9561	1744-957X	2019	15	10			20190548	http://dx.doi.org/10.1098/rsbl.2019.0548	WOS:000504838100018	Y	N	N
Portail, M; Wegg, C; Gerhard, O; Ness, M	Chemodynamical modelling of the galactic bulge and bar	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711	1365-2966	2017	470	1	1233	1252		http://dx.doi.org/10.1093/mnras/stx1293	WOS:000406842600076	N	NA	N
Pretorius, Y; de Boer, WF; Kortekaas, K; van Wijngaarden, M; Grant, RC; Kohi, EM; Mwakiwa, E; Slotow, R; Prins, HHT	Why elephant have trunks and giraffe long tongues: how plants shape large herbivore mouth morphology	ACTA ZOOLOGICA	0001-7272	1463-6395	2016	97	2	246	254		http://dx.doi.org/10.1111/azo.12121	WOS:000373023000010	N	NA	N
Puech, M; Flores, H; Lehnert, M; Neichel, B; Fusco, T; Rosati, P; Cuby, JG; Rousset, G	Coupling MOAO with integral field spectroscopy: specifications for the VLT and the E-ELT	MONTHLY NOTICES OF THE ROYAL ASTRONOMICAL SOCIETY	0035-8711	1365-2966	2008	390	3	1089	1104		http://dx.doi.org/10.1111/j.1365-2966.2008.13808.x	WOS:000260106400017	N	NA	N
Puech, M; Flores, H; Yang, Y; Neichel, B; Lehnert, M; Chemin, L; Nesvadba, N; Epinat, B; Amram, P; Balkowski, C; Cesarsky, C; Dannerbauer, H; Alighieri, SDS; Fuentes-Carrera, I; Guiderdoni, B;	Images -: III.: The evolution of the near-infrared Tully-Fisher relation over the last 6 Gyr	ASTRONOMY & ASTROPHYSICS	0004-6361		2008	484	1	173	187		http://dx.doi.org/10.1051/0004-6361:20079313	WOS:000256309400017	N	NA	N

Kembhavi, A; Liang, YC; Östlin, G; Pozzetti, L; Ravikumar, CD; Rawat, A; Vergani, D; Vernet, J; Wozniak, H															
Puech, M; Hammer, F; Flores, H; Neichel, B; Yang, Y	A forming disk at z ? 0.6: collapse of a gaseous disk or major merger remnant?	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2009	493	3	899	906		http://dx.doi.org/10.1051/0004-6361:200810521	WOS:000262641100014	N	NA	N
Queiroz, ABA; Chiappini, C; Perez-Villegas, A; Khalatyan, A; Anders, F; Barbuy, B; Santiago, BX; Steinmetz, M; Cunha, K; Schultheis, M; Majewski, SR; Minchev, I; Minniti, D; Beaton, RL; Cohen, RE; da Costa, LN; Fernández-Trincado, JG; Garcia-Hernández, DA; Geisler, D; Hasselquist, S; Lane, RR; Nitschelm, C; Rojas-Arriagada, A; Roman-Lopes, A; Smith, V; Zasowski, G	The Milky Way bar and bulge revealed by APOGEE and Gaia EDR3	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2021	656				A156	http://dx.doi.org/10.1051/0004-6361/202039030	WOS:000730818900005	N	NA	N
Ramis, F; Mohr, M; Kohn, G; Gibson, Q; Bashaw, M;	Spatial Design of Guest Feeding Programs and Their Effects on Giraffe	JOURNAL OF APPLIED ANIMAL WELFARE SCIENCE	1088-8705	1532-7604	2022	25	3	224	243		http://dx.doi.org/10.1080/10888705.2020.1824787	WOS:000575797900001	Y	N	N

Maloney, D; Maple, T	Participation and Social Interactions														
Rojas-Arriagada, A; Recio-Blanco, A; Hill, V; de Laverny, P; Schultheis, M; Babusiaux, C; Zoccali, M; Minniti, D; Gonzalez, OA; Feltzing, S; Gilmore, G; Randich, S; Vallenari, A; Alfaro, EJ; Bensby, T; Bragaglia, A; Flaccomio, E; Lanzafame, AC; Pancino, E; Smiljanic, R; Bergemann, M; Costado, MT; Damiani, F; Hourihane, A; Jofré, P; Lardo, C; Magrini, L; Maiorca, E; Morbidelli, L; Sbordone, L; Worley, CC; Zaggia, S; Wyse, R	The Gaia-ESO Survey: metallicity and kinematic trends in the Milky Way bulge	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2014	569				A103	http://dx.doi.org/10.1051/0004-6361/201424121	WOS:000343092100093	N	NA	N
Roque, DV; Macandza, VA; Zeller, U; Starik, N; Göttert, T	Historical and current distribution and movement patterns of large herbivores in the Limpopo National Park, Mozambique	FRONTIERS IN ECOLOGY AND EVOLUTION	2296-701X		2022	10				978397	http://dx.doi.org/10.3389/fevo.2022.978397	WOS:000860635700001	Y	N	N
Rose, A; Liao, SY; Bonneau, A	Regional Economic Impacts of a Verdugo Scenario Earthquake Disruption of Los	EARTHQUAKE SPECTRA	8755-2930		2011	27	3	881	906		http://dx.doi.org/10.1193/1.3610245	WOS:000293792600012	N	NA	N

	Angeles Water Supplies: A Computable General Equilibrium Analysis														
Ryde, N; Schultheis, M; Grieco, V; Matteucci, F; Rich, RM; Uttenthaler, S	CHEMICAL EVOLUTION OF THE INNER 2 DEGREES OF THE MILKY WAY BULGE: [?/Fe] TRENDS AND METALLICITY GRADIENTS	ASTRONOMICAL JOURNAL	0004-6256	1538-3881	2016	151	1			1	http://dx.doi.org/10.3847/0004-6256/151/1/1	WOS:000368250900001	N	NA	N
Saito, M; Bercovitch, FB; Idani, G	The impact of Masai giraffe nursery groups on the development of social associations among females and young individuals	BEHAVIOURAL PROCESSES	0376-6357	1872-8308	2020	180				104227	http://dx.doi.org/10.1016/j.beproc.2020.104227	WOS:000581915800003	Y	N	N
Sathar, F; Badlangana, NL; Manger, PR	Variations in the Thickness and Composition of the Skin of the Giraffe	ANATOMICAL RECORD-ADVANCES IN INTEGRATIVE ANATOMY AND EVOLUTIONARY BIOLOGY	1932-8486	1932-8494	2010	293	9	1615	1627		http://dx.doi.org/10.1002/ar.21190	WOS:000281498500017	Y	N	N
Scheijen, CPJ; van der Merwe, S; Ganswindt, A; Deacon, F	Anthropogenic Influences on Distance Traveled and Vigilance Behavior and Stress-Related Endocrine Correlates in Free-Roaming Giraffes	ANIMALS	2076-2615		2021	11	5			1239	http://dx.doi.org/10.3390/ani11051239	WOS:000653348900001	Y	Y	Y
Schmidt, JM; Henken, S; Dowd, SE; McLaughlin, RW	Analysis of the Microbial Diversity in the Fecal Material of Giraffes	CURRENT MICROBIOLOGY	0343-8651	1432-0991	2018	75	3	323	327		http://dx.doi.org/10.1007/s00284-017-1383-y	WOS:000424877100012	Y	N	N
Schuette, P; Creel, S; Christianson, D	Ungulate distributions in a rangeland with competitors, predators and pastoralists	JOURNAL OF APPLIED ECOLOGY	0021-8901	1365-2664	2016	53	4	1066	1077		http://dx.doi.org/10.1111/1365-2664.12610	WOS:000380065600011	Y	N	N

Schultheis, M; Chen, BQ; Jiang, BW; Gonzalez, OA; Enokiya, R; Fukui, Y; Torii, K; Rejkuba, M; Minniti, D	Mapping the Milky Way bulge at high resolution: the 3D dust extinction, CO, and X factor maps	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2014	566				A120	http://dx.doi.org/10.1051/0004-6361/201322788	WOS:000338681500038	N	NA	N
Shen, LQ; Wang, MY; Zheng, QZ; Zhu, YJ; Li, Y; Zhou, M; Sheng, Y; Zeng, FG; Meng, XX	Development of Stereotypical Behaviour in Captive Fawns of Alpine Musk Deer Moschus chrysogaster Hodgson, 1839 (Artiodactyla: Moschidae)	ACTA ZOOLOGICA BULGARICA	0324-0770		2021	73	4	613	620			WOS:000743551200018	N	NA	N
Simon, JD; Drlica-Wagner, A; Li, TS; Nord, B; Geha, M; Bechtol, K; Balbinot, E; Buckley-Geer, E; Lin, H; Marshall, J; Santiago, B; Strigari, L; Wang, M; Wechsler, RH; Yanny, B; Abbott, T; Bauer, AH; Bernstein, GM; Bertin, E; Brooks, D; Burke, DL; Capozzi, D; Rosell, AC; Kind, MC; D'Andrea, CB; da Costa, LN; DePoy, DL; Desai, S; Diehl, HT; Dodelson, S; Cunha, CE; Estrada, J; Evrard, AE;	STELLAR KINEMATICS AND METALLICITIES IN THE ULTRA-FAINT DWARF GALAXY RETICULUM II	ASTROPHYSICAL JOURNAL	0004-637X	1538-4357	2015	808	1			95	http://dx.doi.org/10.1088/0004-637X/808/1/95	WOS:000359062500095	N	NA	N

Neto, AF; Fernandez, E; Finley, DA; Flaugher, B; Frieman, J; Gaztanaga, E; Gerdes, D; Gruen, D; Gruendl, RA; Honscheid, K; James, D; Kent, S; Kuehn, K; Kuropatkin, N; Lahav, O; Maia, MAG; March, M; Martini, P; Miller, CJ; Miquel, R; Ogando, R; Romer, AK; Roodman, A; Rykoff, ES; Sako, M; Sanchez, E; Schubnell, M; Sevilla, I; Smith, RC; Soares-Santos, M; Sobreira, F; Suchyta, E; Swanson, MEC; Tarle, G; Thaler, J; Tucker, D; Vikram, V; Walker, AR; Wester, W														
SKARPE, C	IMPACT OF GRAZING IN SAVANNA ECOSYSTEMS	AMBIO	0044-7447		1991	20	8	351	356		WOS:A1991GZ89800003	N	NA	N
Strauss, MKL; Kilewo, M; Rentsch, D; Packer, C	Food supply and poaching limit giraffe abundance in the Serengeti	POPULATION ECOLOGY	1438-3896	1438-390X	2015	57	3	505	516	http://dx.doi.org/10.1007/s10144-015-0499-9	WOS:000360084700006	Y	N	N
Strauss, MKL; Packer, C	Using claw marks to study lion predation on giraffes of the Serengeti	JOURNAL OF ZOOLOGY	0952-8369		2013	289	2	134	142	http://dx.doi.org/10.1111/j.1469-7998.2012.00972.x	WOS:000313833200008	Y	N	N

Strauss, MKL; Muller, Z	Giraffe mothers in East Africa linger for days near the remains of their dead calves	AFRICAN JOURNAL OF ECOLOGY	0141-6707		2013	51	3	506	509		http://dx.doi.org/10.1111/aje.12040	WOS:000321759300015	Y	N	N
Strauss, S; Barby, S; Hartner, J; Neumann, N; Moseley, GL; Lotze, M	Modifications in fMRI Representation of Mental Rotation Following a 6 Week Graded Motor Imagery Training in Chronic CRPS Patients	JOURNAL OF PAIN	1526-5900	1528-8447	2021	22	6	680	691		http://dx.doi.org/10.1016/j.jpain.2020.12.003	WOS:000659279900004	N	NA	N
Sumiyoshi, C; Fujino, H; Sumiyoshi, T; Yasuda, Y; Yamamori, H; Fujimoto, M; Hashimoto, R	Semantic Memory Organization in Japanese Patients With Schizophrenia Examined With Category Fluency	FRONTIERS IN PSYCHIATRY	1664-0640		2018	9				87	http://dx.doi.org/10.3389/fpsyt.2018.00087	WOS:000427948800001	N	NA	N
Trinkel, M; Fleischmann, PH; Steindorfer, AF; Kastberger, G	Spotted hyenas (Crocuta crocuta) follow migratory prey.: Seasonal expansion of a clan territory in Etosha, Namibia	JOURNAL OF ZOOLOGY	0952-8369	1469-7998	2004	264	2	125	133		http://dx.doi.org/10.1017/S0952836904005588	WOS:000224718300003	N	NA	N
Tucker, MA; Böhning-Gaese, K; Fagan, WF; Fryxell, JM; Van Moorter, B; Alberts, SC; Ali, AH; Allen, AM; Attias, N; Avgar, T; Bartlam-Brooks, H; Bayarbaatar, B; Belant, JL; Bertassoni, A; Beyer, D; Bidner, L; van Beest, FM; Blake, S; Blaum, N; Bracis, C; Brown, D; de	Moving in the Anthropocene: Global reductions in terrestrial mammalian movements	SCIENCE	0036-8075	1095-9203	2018	359	6374	466	469		http://dx.doi.org/10.1126/science.aam9712	WOS:000423283200049	Y	N	N

Bruyn, PJN;
Cagnacci, F;
Calabrese, JM;
Camilo-Alves,
C; Chamaillé-
Jammes, S;
Chiaradia, A;
Davidson, SC;
Dennis, T;
DeStefano, S;
Diefenbach,
D; Douglas-
Hamilton, I;
Fennessy, J;
Fichtel, C;
Fiedler, W;
Fischer, C;
Fischhoff, I;
Fleming, CH;
Ford, AT;
Fritz, SA;
Gehr, B;
Goheen, JR;
Gurarie, E;
Hebblewhite,
M; Heurich,
M; Hewison,
AJM; Hof, C;
Hurme, E;
Isbell, LA;
Janssen, R;
Jeltsch, F;
Kaczensky, P;
Kane, A;
Kappeler, PM;
Kauffman, M;
Kays, R;
Kimuyu, D;
Koch, F;
Kranstauber,
B; LaPoint, S;
Leimgruber,
P; Linnell,
JDC; López-
López, P;
Markham,
AC;
Mattisson, J;
Medici, EP;
Mellone, U;
Merrill, E;
Mourao, GD;

Morato, RG; Morellet, N; Morrison, TA; Díaz-Muñoz, SL; Mysterud, A; Nandintsetseg, D; Nathan, R; Niamir, A; Odden, J; O'Hara, RB; Oliveira-Santos, LGR; Olson, KA; Patterson, BD; de Paula, RC; Pedrotti, L; Reineking, B; Rimmler, M; Rogers, TL; Rolandsen, CM; Rosenberry, CS; Rubenstein, DI; Safi, K; Saïd, S; Sapir, N; Sawyer, H; Schmidt, NM; Selva, N; Sergiel, A; Shiilegdamba, E; Silva, JP; Singh, N; Solberg, EJ; Spiegel, O; Strand, O; Sundaresan, S; Ullmann, W; Voigt, U; Wall, J; Wattles, D; Wikelski, M; Wilmers, CC; Wilson, JW; Wittemyer, G; Zieba, F; Zwijacz-Kozica, T; Mueller, T													
Tucker, MA; Schipper, AM;	Behavioral responses of	SCIENCE	0036-8075	1095-9203	2023	380	6649	1059	1064	WOS:001059663700007	Y	Y	Y

Adams, TSF; Attias, N; Avgar, T; Babic, NL; Barker, KJ; Bastille-Rousseau, G; Behr, DM; Belant, JL; Beyer, DE ; Blaum, N; Blount, JD; Bockmühl, D; Boulhosa, RLP; Brown, MB; Buuveibaatar, B; Cagnacci, F; Calabrese, JM; Cerne, R; Chamaillé-Jammes, S; Chan, AN; Chase, MJ; Chaval, Y; Chenaux-Ibrahim, Y; Cherry, SG; Cirovic, D; Çoban, E; Cole, EK; Conlee, L; Courtemanch, A; Cozzi, G; Davidson, SC; DeBloois, D; Dejid, N; DeNicola, V; Desbiez, ALJ; Douglas-Hamilton, I; Drake, D; Egan, M; Eikelboom, JAJ; Fagan, WF; Farmer, MJ; Fennessy, J; Finnegan, SP; Fleming, CH; Fournier, B; Fowler, NL;	terrestrial mammals to COVID-19 lockdowns

Gantchoff,
MG; Garnier,
A; Gehr, B;
Geremia, C;
Goheen, JR;
Hauptfleisch,
ML;
Hebblewhite,
M; Heim, M;
Hertel, AG;
Heurich, M;
Hewison,
AJM; Hodson,
J; Hoffman, N;
Hopcraft,
JGC; Huber,
D; Isaac, EJ;
Janik, K;
Jezek, M;
Johansson, Ö;
Jordan, NR;
Kaczensky, P;
Kamaru, DN;
Kauffman,
MJ; Kautz,
TM; Kays, R;
Kelly, AP;
Kindberg, J;
Krofel, M;
Kusak, J;
Lamb, CT;
LaSharr, TN;
Leimgruber,
P; Leitner, H;
Lierz, M;
Linnell, JDC;
Lkhagvaja, P;
Long, RA;
López-Bao,
JV; Loretto,
MC;
Marchand, P;
Martin, H;
Martinez, LA;
McBride, RT ;
McLaren,
AAD;
Meisingset, E;
Melzheimer, J;
Merrill, EH;
Middleton,
AD; Monteith,

KL; Moore,
SA; Van
Moorter, B;
Morellet, N;
Morrison, T;
Müller, R;
Mysterud, A;
Noonan, MJ;
O'Connor, D;
Olson, D;
Olson, KA;
Ortega, AC;
Ossi, F;
Panzacchi, M;
Patchett, R;
Patterson, BR;
de Paula, RC;
Payne, J;
Peters, W;
Petroelje, TR;
Pitcher, BJ;
Pokorny, B;
Poole, K;
Potocnik, H;
Poulin, MP;
Pringle, RM;
Prins, HHT;
Ranc, N;
Reljic, S;
Robb, B;
Röder, R;
Rolandsen,
CM; Rutz, C;
Salemgareyev,
AR; Samelius,
G; Sayine-
Crawford, H;
Schooler, S;
Sekercioglu,
ÇH; Selva, N;
Semenzato, P;
Sergiel, A;
Sharma, K;
Shawler, AL;
Signer, J;
Silovsky, V;
Silva, JP;
Simon, R;
Smiley, RA;
Smith, D;
Solberg, EJ;
Ellis-Soto, D;

Spiegel, O; Stabach, J; Stacy-Dawes, J; Stahler, DR; Stephenson, J; Stewart, C; Strand, O; Sunde, P; Svoboda, NJ; Swart, J; Thompson, JJ; Toal, KL; Uiseb, K; VanAcker, MC; Velilla, M; Verzuh, TL; Wachter, B; Wagler, BL; Whittington, J; Wikelski, M; Wilmers, CC; Wittemyer, G; Young, JK; Zieba, F; Zwijacz-Kozica, T; Huijbregts, MAJ; Mueller, T															
van der Walt, MS; Daffue, W; Goedhals, J; van der Merwe, S; Deacon, F	A Preliminary Study on the Siphon Mechanism in Giraffe (Giraffa camelopardalis)	ANIMALS	2076-2615		2022	12	23			3348	http://dx.doi.org/10.3390/ani12233348	WOS:000895379300001	Y	N	N
VanderWaal, KL; Atwill, ER; Isbell, LA; McCowan, B	Linking social and pathogen transmission networks using microbial genetics in giraffe (Giraffa camelopardalis)	JOURNAL OF ANIMAL ECOLOGY	0021-8790	1365-2656	2014	83	2	406	414		http://dx.doi.org/10.1111/1365-2656.12137	WOS:000331469200010	Y	N	N
VanderWaal, KL; Wang, H; McCowan, B; Fushing, H; Isbell, LA	Multilevel social organization and space use in reticulated giraffe (Giraffa camelopardalis)	BEHAVIORAL ECOLOGY	1045-2249	1465-7279	2014	25	1	17	26		http://dx.doi.org/10.1093/beheco/art061	WOS:000328380000005	Y	N	N
vanVuuren, M; vanVuuren, R;	Ungulate responses and habituation to	PLOS ONE	1932-6203		2023	18	7			e0288975	http://dx.doi.org/10.1371/journal.pone.0288975	WOS:001038263300037	N	NA	N

Silverberg, LM; Manning, J; Pacifici, K; Dorgeloh, W; Campbell, J	unmanned aerial vehicles in Africa's savanna														
Warshaw, DM; Guilford, WH; Freyzon, Y; Krementsova, E; Palmiter, KA; Tyska, MJ; Baker, JE; Trybus, KM	The light chain binding domain of expressed smooth muscle heavy meromyosin acts as a mechanical lever	JOURNAL OF BIOLOGICAL CHEMISTRY	0021-9258		2000	275	47	37167	37172		http://dx.doi.org/10.1074/jbc.M006438200	WOS:000165577700097	N	NA	N
Yamashita, T; Gaynor, KM; Kioko, J; Brashares, J; Kiffner, C	Antipredator behaviour of African ungulates around human settlements	AFRICAN JOURNAL OF ECOLOGY	0141-6707	1365-2028	2018	56	3	528	536		http://dx.doi.org/10.1111/aje.12489	WOS:000440898700012	Y	N	N
Zoccali, M; Valenti, E; Gonzalez, OA	Weighing the two stellar components of the Galactic bulge	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2018	618				A147	http://dx.doi.org/10.1051/0004-6361/201833147	WOS:000448103200001	N	NA	N
Zoccali, M; Vasquez, S; Gonzalez, OA; Valenti, E; Rojas-Arriagada, A; Minniti, J; Rejkuba, M; Minniti, D; McWilliam, A; Babusiaux, C; Hill, V; Renzini, A	The GIRAFFE Inner Bulge Survey (GIBS) III. Metallicity distributions and kinematics of 26 Galactic bulge fields	ASTRONOMY & ASTROPHYSICS	0004-6361	1432-0746	2017	599				A12	http://dx.doi.org/10.1051/0004-6361/201629805	WOS:000395821900104	N	NA	N

Table S2. List of permit numbers and agreements for Giraffe Conservation Foundation giraffe GPS tracking across Africa.

Species	**Country**	**Site**	**Authorising institutions, permits, and protocols**
Giraffa camelopardalis antiquorum	COD	Garamba National Park	African Parks partnership with Government of DRC
Giraffa camelopardalis antiquorum	CPD	Garamba National Park	African Parks partnership with Government of DRC
Giraffa camelopardalis antiquorum	TCD	Zakouma National Park	African Parks partnership with Government of Chad
Giraffa camelopardalis antiquorum	TCD	Zakouma National Park	African Parks partnership with Government of Chad
Giraffa camelopardalis camelopardalis	ETH	Garamba National Park	FP26133952
Giraffa camelopardalis camelopardalis	UGA	Kidepo Valley National Park	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Murchison Falls National Park	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Murchison Falls National Park	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Murchison Falls National Park	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Murchison Falls National Park, South	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Murchison Falls National Park, South	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Pian Upe Wildife Reserve	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Pian Upe Wildife Reserve	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis camelopardalis	UGA	Pian Upe Wildife Reserve	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa camelopardalis giraffa	ZWE	Save Valley Conservancy	Permit No. 23(1) (C) (II) 35/2019
Giraffa camelopardalis peralta	NER	Giraffe Zone	Government of Niger approval

Giraffa camelopardalis peralta	NER	Giraffe Zone	Government of Niger approval
Giraffa camelopardalis reticulata	KEN	Northern Kenya (region)	Permit no. KWS/BRM/5001
Giraffa giraffa angolensis	NAM	Damaraland	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Damaraland	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	EtoshaHeights Private Game Reserve	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Etosha National Park	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Etosha National Park	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Huab (region)	
Giraffa giraffa angolensis	NAM	Northwest Namibia (region)	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Northwest Namibia (region)	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Northwest Namibia (region)	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Northwest Namibia (region)	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa angolensis	NAM	Okapuka Game Reserve	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa giraffa angolensis	NAM	Pro Namib Nature Reserve	2018011402/AN2028011402/RVIV00042018-22
Giraffa giraffa giraffa	BWA	Abu Concession	Botswana Government - Research Permit number: EWT 8/36/4 XVII (57)
Giraffa giraffa giraffa	BWA	Chobe National Park	Botswana Government - Research Permit number: EWT 8/36/4 XVII (57)
Giraffa giraffa giraffa	MOZ	Karingani Game Reserve	African Parks partnership with Government of Mozambique
Giraffa giraffa giraffa	MWI	Majete WR	African Parks partnership with Government of Malawi

Giraffa giraffa giraffa	UGA	Kidepo Valley National Park	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa giraffa giraffa	UGA	Kidepo Valley National Park	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa giraffa giraffa	UGA	Kidepo Valley National Park	MoU between Uganda Wildlife Authority and GCF; UWA/TBDP/RES/50
Giraffa giraffa giraffa	ZAF	Kruger National Park	Permit number: 09787
Giraffa giraffa giraffa	ZAF	Makalali Game Reserve	Permit number: 09787
Giraffa giraffa giraffa	ZAF	Phinda Private Game Reserve	Permit number: 09787
Giraffa giraffa giraffa	ZAF	Selati Game Reserve	Permit number: 09787
Giraffa giraffa giraffa	ZWE	Bubye Valley Conservancy	Permit No. 23(1) (C) (II) 35/2019
Giraffa tippelskirchi	KEN	Amboseli (region)	Permit no. KWS/BRM/5001
Giraffa tippelskirchi	TZA	Serengeti National Park	COSTECH: 2020-313-NA-2019-084 TANAPA: BE.161/376/01 NCAA: BD.158/711/01/76
Giraffa tippelskirchi	TZA	Tarangire National Park	COSTECH: 2020-313-NA-2019-084 TANAPA: BE.161/376/01 NCAA: BD.158/711/01/76

Table S3. Performance details of each Giraffe Conservation Foundation tracking unit deployed across Africa. (Unit status as of 14 December 2023)

Year	Unit type	Country	Region	Fix schedule (per day)	Fixes per day (mean)	Fixes per day (std err)	Fix success rate	Deployment expected (days)	Deployment length (days)	Deployment success rate	Unit status
2011	Head harness 1.2	NAM	Hoanib	24	23.67	0.25	0.99	730	86	0.12	inactive
2011	Head harness 1.2	NAM	Hoanib	24	7.72	0.43	0.32	730	378	0.52	inactive
2011	Head harness 1.2	NAM	Zambezi	6	11.62	0.55	1.94	730	357	0.49	inactive
2011	Head harness 1.2	NAM	Zambezi	6	1.00	0.00	0.17	730	112	0.15	inactive
2012	Head harness 1.2	BWA	Abu	6	5.94	0.03	0.99	730	249	0.34	inactive
2012	Head harness 1.2	BWA	Chobe	6	5.59	0.07	0.93	730	122	0.17	inactive
2012	Head harness 1.2	BWA	Chobe	6	2.89	0.10	0.48	730	232	0.32	inactive
2012	Head harness 1.2	BWA	Chobe	6	5.29	0.09	0.88	730	123	0.17	inactive
2012	Head harness 1.2	NAM	Hoanib	24	4.75	0.39	0.20	730	180	0.25	inactive
2012	Head harness 1.2	NAM	Hoanib	24	4.66	0.30	0.19	730	131	0.18	inactive
2015	Head harness 1.2	ETH	Gambella	3	2.91	0.02	0.97	730	333	0.46	inactive
2015	Head harness 1.2	ETH	Gambella	3	2.66	0.03	0.89	730	318	0.44	inactive
2015	Head harness 1.2	ETH	Gambella	3	2.75	0.02	0.92	730	489	0.67	inactive
2016	Head harness 1.2	COD	Garamba	3	5.35	0.97	1.78	730	155	0.21	inactive
2016	Head harness 1.2	COD	Garamba	3	2.55	0.05	0.85	730	258	0.35	inactive
2016	Head harness 1.2	COD	Garamba	3	2.95	0.03	0.98	730	111	0.15	inactive
2016	Head harness 1.2	COD	Garamba	3	2.97	0.01	0.99	730	278	0.38	inactive
2016	Head harness 1.2	COD	Garamba	3	2.89	0.03	0.96	730	132	0.18	inactive
2016	Head harness 1.2	COD	Garamba	3	3.16	0.19	1.05	730	48	0.07	inactive

2016	Head harness 1.2	COD	Garamba	3	2.92	0.04	0.97	730	48	0.07	inactive
2016	Head harness 1.2	COD	Garamba	3	2.99	0.01	1.00	730	392	0.54	inactive
2016	Head harness 1.2	NAM	Hoanib	24	8.67	0.30	0.36	730	135	0.18	inactive
2016	Head harness 1.2	NAM	Hoanib	24	6.95	0.14	0.29	730	313	0.43	inactive
2016	Head harness 1.2	NAM	Hoanib	24	6.79	0.14	0.28	730	304	0.42	inactive
2016	Head harness 1.2	NAM	Hoanib	24	5.35	0.06	0.22	730	384	0.53	inactive
2016	Head harness 1.2	NAM	Hoanib	24	4.28	0.13	0.18	730	122	0.17	inactive
2016	Head harness 1.2	UGA	MurchisonFalls	24	16.60	2.69	0.69	730	67	0.09	inactive
2016	Head harness 1.2	UGA	MurchisonFalls	24	23.75	2.52	0.99	730	76	0.10	inactive
2016	Head harness 1.2	UGA	MurchisonFalls	24	25.64	2.52	1.07	730	82	0.11	inactive
2016	Head harness 1.2	UGA	MurchisonFalls	24	25.74	1.76	1.07	730	153	0.21	inactive
2016	Head harness 1.2	UGA	MurchisonFalls	24	27.61	2.08	1.15	730	110	0.15	inactive
2016	Head harness 1.2	ZWE	Bubye	3	5.55	0.53	1.85	730	243	0.33	inactive
2016	Head harness 1.2	ZWE	Bubye	3	4.75	0.06	1.58	730	62	0.08	inactive
2017	Ossi unit 1.0	KEN	Leparua	24	23.86	0.04	0.99	730	647	0.89	inactive
2017	Ossi unit 1.0	KEN	Leparua	24	23.82	0.05	0.99	730	424	0.58	inactive
2017	Ossi unit 1.0	KEN	Leparua	24	23.11	0.10	0.96	730	984	1.35	inactive
2017	Ossi unit 1.0	KEN	Leparua	24	23.78	0.10	0.99	730	220	0.30	inactive
2017	Ossi unit 1.0	KEN	Loisaba	24	23.84	0.11	0.99	730	50	0.07	inactive
2017	Ossi unit 1.0	KEN	Loisaba	24	22.71	0.16	0.95	730	874	1.20	inactive
2017	Ossi unit 1.0	KEN	Loisaba	24	22.29	1.56	0.93	730	13	0.02	inactive
2017	Ossi unit 1.0	KEN	Loisaba	24	23.76	0.22	0.99	730	106	0.15	inactive
2017	Ossi unit 1.0	KEN	Loisaba	24	23.86	0.10	0.99	730	208	0.28	inactive

2017	Ossi unit 1.0	KEN	Loisaba	24	23.84	0.12	0.99	730	49	0.07	inactive
2017	Ossi unit 1.0	KEN	Loisaba	24	23.78	0.19	0.99	730	112	0.15	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	22.43	0.13	0.93	730	1455	1.99	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	22.17	0.50	0.92	730	131	0.18	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	23.55	0.06	0.98	730	1853	2.54	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	23.85	0.06	0.99	730	145	0.20	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	23.86	0.11	0.99	730	202	0.28	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	23.90	0.19	1.00	730	88	0.12	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	22.91	0.10	0.95	730	1940	2.66	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	23.33	0.05	0.97	730	2202	3.02	inactive
2017	Ossi unit 1.0	NAM	Hoanib	24	23.91	0.05	1.00	730	1064	1.46	inactive
2017	Ossi unit 1.0	NAM	Okapuka	144	140.63	0.57	0.98	730	1008	1.38	inactive
2017	Ossi unit 1.0	NAM	Okapuka	48	46.61	0.43	0.97	730	184	0.25	inactive
2017	Ossi unit 1.0	UGA	Kidepo	24	45.74	1.08	1.91	730	38	0.05	inactive
2017	Ossi unit 1.0	UGA	MurchisonFalls	24	20.29	3.50	0.85	730	6	0.01	inactive
2017	Ossi unit 1.0	UGA	MurchisonFalls	24	23.70	0.19	0.99	730	212	0.29	inactive
2017	Ossi unit 1.0	UGA	MurchisonFalls	24	22.62	0.52	0.94	730	71	0.10	inactive
2017	Ossi unit 1.0	UGA	MurchisonFalls	24	23.87	0.09	0.99	730	269	0.37	inactive
2017	Ossi unit 1.0	UGA	MurchisonFalls	24	23.79	0.04	0.99	730	266	0.36	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.86	0.04	0.99	730	1089	1.49	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.69	0.03	0.99	730	1060	1.45	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.25	0.04	0.97	730	1091	1.49	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.88	0.09	0.99	730	247	0.34	inactive

2018	Ossi unit 1.0	NAM	Hoanib	24	23.92	0.01	1.00	730	1838	2.52	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.89	0.02	1.00	730	671	0.92	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.94	0.03	1.00	730	892	1.22	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.81	0.02	0.99	730	1460	2.00	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.93	0.02	1.00	730	1223	1.68	inactive
2018	Ossi unit 1.0	NAM	Hoanib	24	23.90	0.01	1.00	730	1971	2.70	active
2018	Ossi unit 1.0	NER	GiraffeZone	24	17.07	0.37	0.71	730	551	0.75	inactive
2018	Ossi unit 1.0	NER	GiraffeZone	24	14.39	0.25	0.60	730	1369	1.88	inactive
2018	Ossi unit 1.0	NER	GiraffeZone	24	23.63	0.19	0.98	730	135	0.18	inactive
2018	Ossi unit 1.0	UGA	Kidepo	24	23.89	0.06	1.00	730	347	0.48	inactive
2018	Ossi unit 1.0	UGA	Kidepo	24	23.49	0.30	0.98	730	88	0.12	inactive
2018	Ossi unit 1.0	UGA	Kidepo	24	23.82	0.07	0.99	730	487	0.67	inactive
2018	Ossi unit 1.0	UGA	Kidepo	24	23.24	0.09	0.97	730	1553	2.13	inactive
2018	Ossi unit 1.0	UGA	Kidepo	24	23.00	0.79	0.96	730	21	0.03	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	22.91	0.35	0.95	730	134	0.18	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	18.19	0.43	0.76	730	374	0.51	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	20.37	0.36	0.85	730	438	0.60	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	22.39	0.31	0.93	730	194	0.27	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	19.77	0.57	0.82	730	112	0.15	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	20.83	1.94	0.87	730	11	0.02	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	22.97	0.16	0.96	730	439	0.60	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.65	0.25	0.99	730	22	0.03	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	14.00	3.36	0.58	730	7	0.01	inactive

2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.58	0.28	0.98	730	47	0.06	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.12	0.20	0.96	730	342	0.47	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	21.45	0.44	0.89	730	176	0.24	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	22.90	0.25	0.95	730	232	0.32	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.66	0.27	0.99	730	86	0.12	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.38	0.31	0.97	730	93	0.13	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.47	0.13	0.98	730	439	0.60	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.29	0.13	0.97	730	537	0.74	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.67	0.11	0.99	730	401	0.55	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	19.57	0.43	0.82	730	321	0.44	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	8.25	0.72	0.34	730	145	0.20	inactive
2018	Ossi unit 1.0	UGA	MurchisonFalls	24	23.82	0.07	0.99	730	342	0.47	inactive
2019	Ossi unit 1.0	KEN	BiliqoBulesa	24	23.19	0.15	0.97	730	443	0.61	inactive
2019	Ossi unit 1.0	KEN	Loisaba	24	22.19	0.29	0.92	730	114	0.16	inactive
2019	Ossi unit 1.0	KEN	Loisaba	24	23.75	0.05	0.99	730	463	0.63	inactive
2019	Ossi unit 1.0	KEN	Loisaba	24	23.01	0.17	0.96	730	146	0.20	inactive
2019	Ossi unit 1.0	KEN	Loisaba	24	22.86	0.08	0.95	730	43	0.06	inactive
2019	Ossi unit 1.0	KEN	Loisaba	24	23.45	0.12	0.98	730	200	0.27	inactive
2019	Ossi unit 1.0	KEN	Melako	24	22.55	0.41	0.94	730	54	0.07	inactive
2019	Ossi unit 1.0	KEN	Melako	24	21.39	0.35	0.89	730	263	0.36	inactive
2019	Ossi unit 1.0	KEN	Melako	24	23.54	0.09	0.98	730	387	0.53	inactive
2019	Ossi unit 1.0	KEN	Melako	24	23.29	0.13	0.97	730	282	0.39	inactive
2019	Ossi unit 1.0	KEN	Melako	24	23.88	0.11	0.99	730	185	0.25	inactive

2019	Ossi unit 1.0	KEN	Melako	24	23.70	0.04	0.99	730	318	0.44	inactive
2019	Ossi unit 1.0	KEN	Melako	24	23.67	0.08	0.99	730	304	0.42	inactive
2019	Ossi unit 1.0	KEN	Mpala	24	23.19	0.18	0.97	730	133	0.18	inactive
2019	Ossi unit 1.0	KEN	Mpala	24	23.16	0.18	0.96	730	132	0.18	inactive
2019	Ossi unit 1.0	KEN	Samburu	24	23.55	0.10	0.98	730	289	0.40	inactive
2019	Ossi unit 1.0	KEN	Samburu	24	21.79	1.08	0.91	730	18	0.02	inactive
2019	Ossi unit 1.0	KEN	Samburu	24	22.91	0.21	0.95	730	129	0.18	inactive
2019	Ossi unit 1.0	KEN	Sera	24	17.87	0.48	0.74	730	173	0.24	inactive
2019	Ossi unit 1.0	KEN	Sera	24	23.50	0.11	0.98	730	361	0.49	inactive
2019	Ossi unit 1.0	KEN	Sera	24	23.74	0.06	0.99	730	393	0.54	inactive
2019	Ossi unit 1.0	KEN	Sera	24	22.44	0.40	0.94	730	8	0.01	inactive
2019	Ossi unit 1.0	KEN	Sera	24	23.19	0.18	0.97	730	214	0.29	inactive
2019	Ossi unit 1.0	KEN	Sera	24	13.78	1.57	0.57	730	30	0.04	inactive
2019	Ossi unit 1.0	KEN	Sera	24	22.35	0.50	0.93	730	39	0.05	inactive
2019	Ossi unit 1.0	KEN	Sera	24	23.33	0.12	0.97	730	294	0.40	inactive
2019	Ossi unit 1.0	KEN	Shaba	24	23.64	0.05	0.99	730	268	0.37	inactive
2019	Ossi unit 1.0	KEN	WestGate	24	22.62	0.32	0.94	730	68	0.09	inactive
2019	Ossi unit 1.0	NAM	EtoshaHeights	24	22.47	0.15	0.94	730	848	1.16	inactive
2019	Ossi unit 1.0	NAM	EtoshaHeights	24	23.64	0.06	0.98	730	1063	1.46	inactive
2019	Ossi unit 1.0	NAM	EtoshaHeights	24	23.02	0.17	0.96	730	452	0.62	inactive
2019	Ossi unit 1.0	NAM	EtoshaHeights	24	19.17	3.58	0.80	730	5	0.01	inactive
2019	Ossi unit 1.0	NAM	EtoshaHeights	24	21.70	0.34	0.90	730	172	0.24	inactive
2019	Ossi unit 1.0	NAM	Hoanib	24	23.72	0.06	0.99	730	1338	1.83	inactive

2019	Ossi unit 1.0	NAM	Hoanib	24	23.45	0.10	0.98	730	716	0.98	inactive
2019	Ossi unit 1.0	NAM	Hoanib	24	22.76	0.07	0.95	730	952	1.30	inactive
2019	Ossi unit 1.0	NAM	Hoanib	24	22.90	0.03	0.95	730	643	0.88	inactive
2019	Ossi unit 1.0	NAM	Hoanib	24	22.93	0.06	0.96	730	164	0.22	inactive
2019	Ossi unit 1.0	NAM	Hoanib	24	23.94	0.03	1.00	730	896	1.23	inactive
2019	Ossi unit 1.0	NAM	Hoanib	24	23.89	0.03	1.00	730	688	0.94	inactive
2019	Ossi unit 1.0	NAM	Hoanib	24	23.84	0.06	0.99	730	193	0.26	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	22.98	0.09	0.96	730	460	0.63	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	22.88	0.18	0.95	730	266	0.36	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	22.78	0.10	0.95	730	385	0.53	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	13.40	0.49	0.56	730	190	0.26	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	22.72	0.12	0.95	730	319	0.44	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	22.19	0.72	0.92	730	30	0.04	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	22.49	0.45	0.94	730	40	0.05	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	26.18	1.09	1.09	730	359	0.49	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	23.43	0.09	0.98	730	249	0.34	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	46.01	2.65	1.92	730	311	0.43	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	23.51	0.09	0.98	730	264	0.36	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	22.75	0.20	0.95	730	51	0.07	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	23.80	0.12	0.99	730	217	0.30	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	23.63	0.04	0.98	730	337	0.46	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	23.67	0.04	0.99	730	375	0.51	inactive
2019	Ossi unit 1.0	NER	GiraffeZone	24	23.30	0.07	0.97	730	174	0.24	inactive

2019	Ossi unit 1.0	TCD	Zakouma	24	18.59	0.38	0.77	730	423	0.58	inactive
2019	Ossi unit 1.0	TCD	Zakouma	24	21.29	0.44	0.89	730	231	0.32	inactive
2019	Ossi unit 1.0	TCD	Zakouma	24	22.39	0.25	0.93	730	429	0.59	inactive
2019	Ossi unit 1.0	TCD	Zakouma	24	22.29	0.27	0.93	730	359	0.49	inactive
2019	Ossi unit 1.0	TCD	Zakouma	24	20.09	0.46	0.84	730	275	0.38	inactive
2019	Ossi unit 1.0	TCD	Zakouma	24	16.44	0.49	0.68	730	310	0.42	inactive
2019	Ossi unit 1.0	TCD	Zakouma	24	23.59	0.17	0.98	730	172	0.24	inactive
2019	Ossi unit 1.0	TCD	Zakouma	24	19.20	0.36	0.80	730	480	0.66	inactive
2019	Ossi unit 1.0	UGA	Kidepo	24	22.82	0.16	0.95	730	590	0.81	inactive
2019	Ossi unit 1.0	UGA	Kidepo	24	23.74	0.17	0.99	730	139	0.19	inactive
2019	Ossi unit 1.0	UGA	Kidepo	24	21.45	0.15	0.89	730	1568	2.15	inactive
2019	Ossi unit 1.0	UGA	Kidepo	24	23.97	0.02	1.00	730	395	0.54	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.79	0.11	0.99	730	294	0.40	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.85	0.10	0.99	730	176	0.24	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.92	0.05	1.00	730	621	0.85	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.96	0.02	1.00	730	945	1.29	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.84	0.09	0.99	730	275	0.38	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.88	0.10	0.99	730	208	0.28	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	22.68	0.19	0.94	730	430	0.59	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	16.00	0.36	0.67	730	538	0.74	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	22.99	0.12	0.96	730	864	1.18	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.85	0.07	0.99	730	482	0.66	inactive
2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.70	0.11	0.99	730	422	0.58	inactive

2019	Ossi unit 1.0	UGA	MurchisonFalls	24	23.56	0.24	0.98	730	111	0.15	inactive
2019	Ossi unit 1.0	UGA	PianUpe	24	23.59	0.36	0.98	730	58	0.08	inactive
2019	Ossi unit 1.0	UGA	PianUpe	24	22.03	0.20	0.92	730	656	0.90	inactive
2019	Ossi unit 1.0	ZWE	Save	24	23.59	0.13	0.98	730	313	0.43	inactive
2019	Ossi unit 1.0	ZWE	Save	24	18.96	0.52	0.79	730	212	0.29	inactive
2019	Ossi unit 1.0	ZWE	Save	24	19.58	0.30	0.82	730	582	0.80	inactive
2019	Ossi unit 1.0	ZWE	Save	24	23.89	0.09	1.00	730	264	0.36	inactive
2019	Ossi unit 1.0	ZWE	Save	24	21.25	1.16	0.89	730	24	0.03	inactive
2019	Ossi unit 1.0	ZWE	Save	24	23.34	0.12	0.97	730	513	0.70	inactive
2019	Ossi unit 1.0	ZWE	Save	24	20.68	0.28	0.86	730	498	0.68	inactive
2019	Ossi unit 1.0	ZWE	Save	24	23.41	0.52	0.98	730	40	0.05	inactive
2019	Ossi unit 1.0	ZWE	Save	24	22.67	1.20	0.94	730	17	0.02	inactive
2019	Ossi unit 1.0	ZWE	Save	24	23.13	0.10	0.96	730	362	0.50	inactive
2019	Ossi unit 1.0	ZWE	Save	24	23.69	0.11	0.99	730	395	0.54	inactive
2019	Ossi unit 1.0	ZWE	Save	24	23.77	0.11	0.99	730	215	0.29	inactive
2019	Ossi unit 1.1	NAM	Hoanib	24	18.27	0.51	0.76	730	227	0.31	inactive
2019	Ossi unit 1.1	UGA	Kidepo	24	20.86	0.65	0.87	730	67	0.09	inactive
2019	Ossi unit 1.1	UGA	MurchisonFalls	24	22.86	0.12	0.95	730	293	0.40	inactive
2019	Ossi unit 1.1	UGA	MurchisonFalls	24	20.23	0.34	0.84	730	305	0.42	inactive
2019	Ossi unit 1.1	UGA	MurchisonFalls	24	22.30	0.22	0.93	730	533	0.73	inactive
2020	Ossi unit 1.0	COD	Garamba	24	17.33	6.42	0.72	730	2	0.00	inactive
2020	Ossi unit 1.0	COD	Garamba	24	3.60	0.14	0.15	730	457	0.63	inactive
2020	Ossi unit 1.0	COD	Garamba	24	11.37	0.52	0.47	730	473	0.65	inactive

2020	Ossi unit 1.0	COD	Garamba	24	22.75	0.11	0.95	730	332	0.45	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	19.76	0.32	0.82	730	376	0.52	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	23.75	0.17	0.99	730	152	0.21	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	23.76	0.15	0.99	730	153	0.21	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	22.76	0.18	0.95	730	509	0.70	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	23.74	0.18	0.99	730	160	0.22	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	23.52	0.37	0.98	730	57	0.08	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	23.72	0.17	0.99	730	134	0.18	inactive
2020	Ossi unit 1.0	KEN	Amboseli	24	23.38	0.42	0.97	730	55	0.08	inactive
2020	Ossi unit 1.0	KEN	IshaqbiniHirola	24	20.89	0.32	0.87	730	286	0.39	inactive
2020	Ossi unit 1.0	NAM	Damaraland	24	23.74	0.06	0.99	730	935	1.28	inactive
2020	Ossi unit 1.0	NAM	Damaraland	24	23.94	0.07	1.00	730	172	0.24	inactive
2020	Ossi unit 1.0	NAM	EtoshaHeights	24	23.92	0.02	1.00	730	804	1.10	inactive
2020	Ossi unit 1.0	NAM	EtoshaHeights	24	23.97	0.02	1.00	730	1239	1.70	active
2020	Ossi unit 1.0	NAM	EtoshaHeights	24	23.97	0.02	1.00	730	766	1.05	inactive
2020	Ossi unit 1.0	NAM	EtoshaHeights	24	22.49	0.13	0.94	730	1236	1.69	active
2020	Ossi unit 1.0	NAM	EtoshaHeights	24	23.53	0.07	0.98	730	1239	1.70	active
2020	Ossi unit 1.0	NAM	EtoshaHeights	24	23.94	0.03	1.00	730	1051	1.44	inactive
2020	Ossi unit 1.0	TZA	Serengeti	24	23.53	0.12	0.98	730	307	0.42	inactive
2020	Ossi unit 1.0	TZA	Serengeti	24	23.97	0.03	1.00	730	396	0.54	inactive
2020	Ossi unit 1.0	TZA	Serengeti	24	23.95	0.04	1.00	730	574	0.79	inactive
2020	Ossi unit 1.0	TZA	Serengeti	24	23.74	0.10	0.99	730	398	0.55	inactive
2020	Ossi unit 1.0	TZA	Serengeti	24	23.86	0.07	0.99	730	142	0.19	inactive

2020	Ossi unit 1.0	TZA	Serengeti	24	23.90	0.05	1.00	730	524	0.72	inactive
2020	Ossi unit 1.0	TZA	Serengeti	24	23.86	0.12	0.99	730	145	0.20	inactive
2020	Ossi unit 1.0	TZA	Tarangire	24	23.91	0.07	1.00	730	358	0.49	inactive
2020	Ossi unit 1.0	TZA	Tarangire	24	23.66	0.28	0.99	730	76	0.10	inactive
2020	Ossi unit 1.0	TZA	Tarangire	24	23.90	0.07	1.00	730	285	0.39	inactive
2020	Ossi unit 1.0	TZA	Tarangire	24	12.00	0.00	0.50	730	54	0.07	inactive
2020	Ossi unit 1.1	UGA	PianUpe	24	23.91	0.08	1.00	730	296	0.41	inactive
2020	Ossi unit 1.1	UGA	PianUpe	24	23.92	0.06	1.00	730	364	0.50	inactive
2020	Ossi unit 1.1	UGA	PianUpe	24	23.91	0.07	1.00	730	304	0.42	inactive
2021	Ankle bracelet 2.0	ZAF	Phinda	24	19.89	0.27	0.83	730	174	0.24	inactive
2021	Ankle bracelet 2.0	ZAF	Phinda	24	18.35	0.62	0.76	730	72	0.10	inactive
2021	Neck collar 3.3	ZAF	Phinda	24	2.67	1.08	0.11	730	2	0.00	inactive
2021	Neck collar 3.3	ZAF	Phinda	24	2.67	1.08	0.11	730	2	0.00	inactive
2021	Ossi unit 2.0	ZAF	Phinda	24	23.52	0.14	0.98	730	200	0.27	inactive
2021	Ossi unit 2.0	ZAF	Phinda	24	22.80	0.41	0.95	730	99	0.14	inactive
2021	Tail unit 1.0	ZAF	Phinda	24	16.30	1.52	0.68	730	9	0.01	inactive
2021	Tail unit 1.0	ZAF	Phinda	24	18.50	3.21	0.77	730	5	0.01	inactive
2021	Tail unit 2.0	MWI	Majete	4	1.23	0.02	0.31	730	378	0.52	inactive
2021	Tail unit 2.0	MWI	Majete	4	4.79	0.11	1.20	730	397	0.54	inactive
2021	Ear tag 4.0	NAM	EtoshaHeights	4	3.91	0.04	0.98	1095	799	0.73	active
2021	Ear tag 4.0	NAM	EtoshaHeights	4	3.79	0.12	0.95	1095	81	0.07	inactive
2021	Ear tag 4.0	NAM	EtoshaHeights	4	4.25	0.08	1.06	1095	255	0.23	inactive
2021	Ear tag 4.0	NAM	EtoshaHeights	4	4.03	0.08	1.01	1095	219	0.20	inactive

2021	Ear tag 4.0	NAM	EtoshaHeights	4	4.15	0.05	1.04	1095	799	0.73	active
2021	Ear tag 4.0	NAM	EtoshaHeights	4	4.48	0.11	1.12	1095	78	0.07	inactive
2021	Ear tag 4.0	NAM	EtoshaHeights	4	3.65	0.06	0.91	1095	426	0.39	inactive
2021	Ear tag 4.0	NAM	EtoshaHeights	4	4.17	0.08	1.04	1095	255	0.23	inactive
2021	Ear tag 4.0	UGA	MurchisonFalls	4	3.01	0.05	0.75	1095	852	0.78	active
2021	Ear tag 4.0	ZAF	Makalali	4	3.84	0.05	0.96	1095	860	0.79	active
2021	Ear tag 4.0	ZAF	Makalali	4	4.69	0.10	1.17	1095	174	0.16	inactive
2021	Ear tag 4.0	ZAF	Makalali	4	4.04	0.30	1.01	1095	27	0.02	inactive
2021	Ear tag 4.0	ZAF	Makalali	4	4.44	0.10	1.11	1095	114	0.10	inactive
2021	Ear tag 4.0	ZAF	Selati	4	4.49	0.06	1.12	1095	444	0.41	inactive
2021	Ear tag 4.0	ZAF	Selati	4	3.98	0.06	1.00	1095	444	0.41	inactive
2021	Ear tag 4.0	ZAF	Selati	4	3.67	0.12	0.92	1095	116	0.11	inactive
2021	Ear tag 4.0	ZAF	Selati	4	3.58	0.05	0.89	1095	861	0.79	active
2021	Ossi unit 1.0	TCD	Zakouma	24	23.86	0.07	0.99	730	298	0.41	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	22.00	0.32	0.92	730	281	0.38	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	23.53	0.15	0.98	730	348	0.48	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	23.77	0.05	0.99	730	500	0.68	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	22.05	0.24	0.92	730	499	0.68	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	23.91	0.04	1.00	730	499	0.68	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	23.55	0.12	0.98	730	420	0.58	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	23.92	0.04	1.00	730	617	0.85	inactive
2021	Ossi unit 1.0	TCD	Zakouma	24	22.74	0.23	0.95	730	366	0.50	inactive
2021	Ossi unit 1.1	NAM	Damaraland	24	23.62	0.34	0.98	730	62	0.08	inactive

2021	Ossi unit 1.2	NAM	Hoanib	24	23.84	0.06	0.99	730	891	1.22	active
2021	Ossi unit 1.2	NAM	Hoanib	24	23.17	0.15	0.97	730	788	1.08	inactive
2021	Ossi unit 1.2	NAM	Hoanib	24	23.93	0.05	1.00	730	650	0.89	inactive
2021	Ossi unit 1.2	NAM	Hoanib	24	23.95	0.03	1.00	730	800	1.10	inactive
2021	Ossi unit 1.2	NAM	Hoanib	24	16.00	8.03	0.67	730	2	0.00	inactive
2021	Ossi unit 1.2	NAM	Hoanib	24	23.54	0.09	0.98	730	886	1.21	active
2021	Tail unit 3.0	NAM	EtoshaHeights	24	22.20	0.16	0.92	730	874	1.20	active
2021	Tail unit 3.0	NAM	EtoshaHeights	24	23.41	0.09	0.98	730	874	1.20	active
2021	Tail unit 3.0	NAM	EtoshaHeights	24	23.01	0.21	0.96	730	252	0.35	inactive
2021	Tail unit 3.0	NAM	EtoshaHeights	24	23.34	0.10	0.97	730	874	1.20	active
2021	Tail unit 3.0	NAM	EtoshaHeights	24	18.71	0.23	0.78	730	801	1.10	active
2021	Tail unit 3.0	NAM	Hoanib	24	22.33	1.29	0.93	730	8	0.01	inactive
2021	Tail unit 3.0	NAM	Hoanib	24	21.74	0.14	0.91	730	886	1.21	active
2021	Tail unit 3.0	NAM	Hoanib	24	23.85	0.03	0.99	730	893	1.22	active
2021	Tail unit 3.0	NAM	Hoanib	24	23.53	0.03	0.98	730	891	1.22	active
2021	Tail unit 3.0	NAM	Hoanib	24	22.41	0.07	0.93	730	892	1.22	active
2021	Tail unit 3.0	ZAF	Makalali	24	17.04	0.79	0.71	730	135	0.18	inactive
2022	Ear tag 4.0	AGO	Cuatir	4	2.42	0.05	0.60	1095	379	0.35	active
2022	Ear tag 4.0	AGO	Cuatir	4	2.70	0.05	0.67	1095	379	0.35	active
2022	Ear tag 4.0	AGO	Cuatir	4	2.17	0.05	0.54	1095	379	0.35	active
2022	Ear tag 4.0	AGO	Cuatir	4	2.25	0.05	0.56	1095	379	0.35	active
2022	Ear tag 4.0	MOZ	Karingani	4	2.19	0.12	0.55	1095	60	0.05	inactive
2022	Ear tag 4.0	MOZ	Karingani	4	2.29	0.06	0.57	1095	280	0.26	inactive

2022	Ear tag 4.0	MOZ	Karingani	4	2.95	0.04	0.74	1095	481	0.44	inactive
2022	Ear tag 4.0	MOZ	Karingani	4	2.19	0.05	0.55	1095	312	0.28	inactive
2022	Ear tag 4.0	MOZ	Karingani	4	2.47	0.04	0.62	1095	652	0.60	active
2022	Ear tag 4.0	MOZ	Karingani	4	2.26	0.09	0.57	1095	91	0.08	inactive
2022	Ear tag 4.0	MOZ	Karingani	4	2.54	0.04	0.63	1095	651	0.59	active
2022	Ear tag 4.0	MOZ	Karingani	4	1.00	0.00	0.25	1095	2	0.00	inactive
2022	Ear tag 4.0	NAM	EtoshaHeights	4	2.37	0.04	0.59	1095	562	0.51	active
2022	Ear tag 4.0	NAM	EtoshaHeights	4	2.30	0.04	0.58	1095	561	0.51	active
2022	Ear tag 4.0	NAM	EtoshaHeights	4	2.73	0.04	0.68	1095	492	0.45	active
2022	Ear tag 4.0	NAM	EtoshaHeights	4	2.88	0.04	0.72	1095	493	0.45	active
2022	Ear tag 4.0	NAM	EtoshaHeights	4	2.44	0.04	0.61	1095	561	0.51	active
2022	Ear tag 4.0	NAM	EtoshaHeights	4	1.10	0.02	0.28	1095	463	0.42	active
2022	Ear tag 4.0	NAM	EtoshaHeights	4	2.24	0.04	0.56	1095	525	0.48	active
2022	Ear tag 4.0	NAM	Hoanib	4	2.29	0.04	0.57	1095	483	0.44	active
2022	Ear tag 4.0	NAM	Hoanib	4	1.80	0.04	0.45	1095	484	0.44	active
2022	Ear tag 4.0	NAM	Hoanib	4	2.46	0.04	0.62	1095	484	0.44	active
2022	Ear tag 4.0	NAM	Hoanib	4	2.55	0.04	0.64	1095	484	0.44	active
2022	Ear tag 4.0	NAM	Mangetti	4	1.96	0.04	0.49	1095	408	0.37	inactive
2022	Ear tag 4.0	NAM	Mangetti	4	3.03	0.11	0.76	1095	35	0.03	inactive
2022	Ear tag 4.0	NAM	Mangetti	4	2.36	0.07	0.59	1095	178	0.16	inactive
2022	Ear tag 4.0	NAM	Mangetti	4	2.08	0.07	0.52	1095	179	0.16	inactive
2022	Ear tag 4.0	NAM	Mangetti	4	1.79	0.04	0.45	1095	446	0.41	active
2022	Ear tag 4.0	NAM	Mangetti	4	1.41	0.03	0.35	1095	428	0.39	active

2022	Ear tag 4.0	NAM	Mangetti	4	1.87	0.05	0.47	1095	322	0.29	inactive
2022	Ear tag 4.0	NAM	Mangetti	4	2.34	0.12	0.58	1095	71	0.06	inactive
2022	Ear tag 4.0	NAM	Mangetti	4	2.40	0.09	0.60	1095	109	0.10	inactive
2022	Ear tag 4.0	NAM	Mangetti	4	1.63	0.06	0.41	1095	168	0.15	inactive
2022	Ear tag 4.0	NAM	NamibRand	4	6.14	0.07	1.53	1095	584	0.53	active
2022	Ear tag 4.0	NAM	NamibRand	4	2.11	0.28	0.53	1095	8	0.01	inactive
2022	Ear tag 4.0	NAM	NamibRand	4	5.20	0.08	1.30	1095	583	0.53	active
2022	Ear tag 4.0	NAM	NamibRand	4	2.87	0.12	0.72	1095	62	0.06	inactive
2022	Ear tag 4.0	NAM	NamibRand	4	2.70	0.04	0.68	1095	584	0.53	active
2022	Ear tag 4.0	NAM	NamibRand	4	4.54	0.07	1.14	1095	584	0.53	active
2022	Ear tag 4.0	NAM	Onduli	4	4.37	0.12	1.09	1095	323	0.29	inactive
2022	Ear tag 4.0	NAM	Onduli	4	2.86	0.04	0.72	1095	481	0.44	active
2022	Ear tag 4.0	NER	Gadabeji	4	2.98	0.06	0.74	1095	211	0.19	inactive
2022	Ear tag 4.0	NER	Gadabeji	4	2.91	0.05	0.73	1095	393	0.36	active
2022	Ear tag 4.0	NER	Gadabeji	4	2.80	0.06	0.70	1095	272	0.25	inactive
2022	Ear tag 4.0	NER	GiraffeZone	4	3.05	0.05	0.76	1095	400	0.37	active
2022	Ear tag 4.0	NER	GiraffeZone	4	2.83	0.05	0.71	1095	400	0.37	active
2022	Ear tag 4.0	SWZ	Panata	4	2.28	0.16	0.57	1095	40	0.04	inactive
2022	Ear tag 4.0	SWZ	Panata	4	2.28	0.09	0.57	1095	125	0.11	inactive
2022	Ear tag 4.0	SWZ	Umfomoti	4	1.00	0.00	0.25	1095	1	0.00	inactive
2022	Ear tag 4.0	SWZ	Umfomoti	4	2.50	0.71	0.63	1095	1	0.00	inactive
2022	Ear tag 4.0	SWZ	Umfomoti	4	2.58	0.05	0.64	1095	458	0.42	active
2022	Ear tag 4.0	SWZ	Umfomoti	4	3.16	0.04	0.79	1095	458	0.42	active

2022	Ear tag 4.0	SWZ	Umfomoti	4	2.60	0.04	0.65	1095	459	0.42	active
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.87	0.04	0.47	1095	519	0.47	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.43	0.03	0.36	1095	373	0.34	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.70	0.10	0.43	1095	58	0.05	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.38	0.10	0.34	1095	39	0.04	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.43	0.04	0.36	1095	340	0.31	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.51	0.03	0.38	1095	621	0.57	active
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.26	0.03	0.32	1095	226	0.21	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.25	0.03	0.31	1095	272	0.25	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.74	0.03	0.44	1095	604	0.55	active
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.50	0.15	0.38	1095	22	0.02	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.43	0.03	0.36	1095	406	0.37	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.55	0.04	0.39	1095	400	0.37	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.80	0.04	0.45	1095	470	0.43	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.56	0.05	0.39	1095	170	0.16	inactive
2022	Ear tag 4.0	UGA	MurchisonFalls	4	1.58	0.05	0.39	1095	249	0.23	inactive
2022	Ear tag 4.0	ZAF	Balule	4	2.66	0.08	0.67	1095	150	0.14	inactive
2022	Ear tag 4.0	ZAF	Balule	4	1.57	0.05	0.39	1095	237	0.22	inactive
2022	Ear tag 4.0	ZAF	Balule	4	2.17	0.20	0.54	1095	24	0.02	inactive
2022	Ear tag 4.0	ZAF	Ukuwela	4	2.46	0.11	0.62	1095	81	0.07	inactive
2022	Ear tag 4.0	ZWE	Hwange	4	2.58	0.04	0.65	1095	542	0.49	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.09	0.04	0.52	1095	553	0.51	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.31	0.04	0.58	1095	551	0.50	active

2022	Ear tag 4.0	ZWE	Hwange	4	2.02	0.04	0.50	1095	552	0.50	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.47	0.04	0.62	1095	551	0.50	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.67	0.04	0.67	1095	551	0.50	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.07	0.04	0.52	1095	551	0.50	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.03	0.04	0.51	1095	553	0.51	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.62	0.25	0.65	1095	12	0.01	inactive
2022	Ear tag 4.0	ZWE	Hwange	4	2.76	0.04	0.69	1095	553	0.51	active
2022	Ear tag 4.0	ZWE	Hwange	4	2.09	0.04	0.52	1095	552	0.50	active
2022	Ear tag 4.0	ZWE	Hwange	4	1.77	0.04	0.44	1095	551	0.50	active
2022	Ear tag 4.1	NAM	EtoshaHeights	24	3.50	0.10	0.15	1095	565	0.52	active
2022	Ear tag 4.1	NAM	EtoshaHeights	24	13.46	0.14	0.56	1095	564	0.52	active
2022	Ear tag 4.1	ZAF	Balule	24	5.31	0.12	0.22	1095	283	0.26	inactive
2022	Ear tag 4.1	ZWE	Hwange	24	11.03	0.15	0.46	1095	553	0.51	active
2022	Ear tag 4.1	ZWE	Hwange	24	3.09	0.19	0.13	1095	271	0.25	inactive
2022	Tail unit 3.0	KEN	Kapiti	96	91.17	1.13	0.95	730	248	0.34	inactive
2022	Tail unit 3.0	KEN	Kapiti	96	48.49	2.80	0.51	730	146	0.20	inactive
2022	Tail unit 3.0	KEN	Maanzoni	96	49.73	2.96	0.52	730	126	0.17	inactive
2022	Tail unit 3.0	KEN	Machakos	24	18.25	0.63	0.76	730	347	0.48	active
2022	Tail unit 3.0	KEN	Machakos	96	50.67	2.97	0.53	730	140	0.19	inactive
2022	Tail unit 3.0	KEN	Mwambi	96	50.39	1.65	0.52	730	369	0.51	active
2022	Tail unit 3.0	KEN	Swara	96	52.05	2.66	0.54	730	195	0.27	inactive
2022	Tail unit 3.0	KEN	Swara	96	72.67	1.56	0.76	730	373	0.51	active
2022	Tail unit 3.0	KEN	Swara	96	63.92	2.97	0.67	730	144	0.20	inactive

2022	Tail unit 3.0	NER	Gadabeji	24	21.83	0.28	0.91	730	356	0.49	inactive
2022	Tail unit 3.0	NER	Gadabeji	24	17.75	0.79	0.74	730	117	0.16	inactive
2022	Tail unit 3.0	NER	Gadabeji	24	22.91	0.17	0.95	730	393	0.54	active
2022	Tail unit 3.0	NER	GiraffeZone	24	21.79	0.62	0.91	730	79	0.11	inactive
2022	Tail unit 3.0	NER	GiraffeZone	24	22.84	0.19	0.95	730	400	0.55	active
2023	Ear tag 4.0	AGO	Iona	4	3.12	0.21	0.78	1095	16	0.01	inactive
2023	Ear tag 4.0	AGO	Iona	4	3.06	0.07	0.76	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	2.96	0.07	0.74	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	3.24	0.06	0.81	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	3.16	0.06	0.79	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	3.48	0.05	0.87	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	2.96	0.07	0.74	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	2.88	0.07	0.72	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	2.70	0.18	0.67	1095	32	0.03	inactive
2023	Ear tag 4.0	AGO	Iona	4	3.41	0.05	0.85	1095	162	0.15	active
2023	Ear tag 4.0	AGO	Iona	4	2.93	0.33	0.73	1095	14	0.01	inactive
2023	Ear tag 4.0	AGO	Iona	4	3.39	0.22	0.85	1095	17	0.02	inactive
2023	Ear tag 4.0	AGO	Iona	4	2.42	0.27	0.60	1095	11	0.01	inactive
2023	Ear tag 4.0	MOZ	Karingani	4	2.69	0.09	0.67	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.63	0.09	0.66	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	6.69	0.37	1.67	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.79	0.09	0.70	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.70	0.09	0.67	1095	105	0.10	active

2023	Ear tag 4.0	MOZ	Karingani	4	2.79	0.09	0.70	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	3.41	0.09	0.85	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.80	0.08	0.70	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.95	0.09	0.74	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.79	0.09	0.70	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.83	0.08	0.71	1095	105	0.10	active
2023	Ear tag 4.0	MOZ	Karingani	4	2.67	0.10	0.67	1095	104	0.09	active
2023	Ear tag 4.0	MOZ	Maputo	4	2.47	0.10	0.62	1095	96	0.09	inactive
2023	Ear tag 4.0	NAM	EtoshaHeights	4	2.89	0.06	0.72	1095	187	0.17	active
2023	Ear tag 4.0	NAM	EtoshaHeights	4	2.85	0.07	0.71	1095	138	0.13	active
2023	Ear tag 4.0	NAM	EtoshaHeights	4	3.38	0.07	0.84	1095	134	0.12	active
2023	Ear tag 4.0	NAM	EtoshaHeights	4	3.56	0.06	0.89	1095	137	0.13	active
2023	Ear tag 4.0	NAM	Hoanib	4	2.81	0.08	0.70	1095	130	0.12	active
2023	Ear tag 4.0	NAM	Hoanib	4	2.80	0.08	0.70	1095	128	0.12	active
2023	Ear tag 4.0	NAM	Hoanib	4	1.00	0.00	0.25	1095	56	0.05	inactive
2023	Ear tag 4.0	NAM	Hoanib	4	3.29	0.07	0.82	1095	128	0.12	active
2023	Ear tag 4.0	NAM	Hoanib	4	3.34	0.07	0.83	1095	132	0.12	active
2023	Ear tag 4.0	NAM	NamibRand	4	6.43	0.12	1.61	1095	199	0.18	active
2023	Ear tag 4.0	NAM	NamibRand	4	5.70	0.12	1.42	1095	199	0.18	active
2023	Ear tag 4.0	NAM	NamibRand	4	6.03	0.12	1.51	1095	199	0.18	active
2023	Ear tag 4.0	NAM	NamibRand	4	5.00	0.12	1.25	1095	199	0.18	active
2023	Ear tag 4.0	NAM	NamibRand	4	5.43	0.12	1.36	1095	199	0.18	active
2023	Ear tag 4.0	NAM	Ongongo	4	2.02	0.08	0.50	1095	144	0.13	inactive

2023	Ear tag 4.0	NAM	Ongongo	4	3.21	0.06	0.80	1095	186	0.17	active
2023	Ear tag 4.0	NAM	Ongongo	4	2.22	0.08	0.56	1095	186	0.17	active
2023	Ear tag 4.0	NAM	Ongongo	4	2.59	0.11	0.65	1095	85	0.08	inactive
2023	Ear tag 4.0	RWA	Akagera	4	1.93	0.14	0.48	1095	47	0.04	active
2023	Ear tag 4.0	RWA	Akagera	4	1.93	0.14	0.48	1095	49	0.04	active
2023	Ear tag 4.0	RWA	Akagera	4	1.74	0.13	0.43	1095	47	0.04	active
2023	Ear tag 4.0	RWA	Akagera	4	2.19	0.12	0.55	1095	49	0.04	active
2023	Ear tag 4.0	RWA	Akagera	4	1.73	0.11	0.43	1095	48	0.04	active
2023	Ear tag 4.0	RWA	Akagera	4	1.79	0.13	0.45	1095	47	0.04	active
2023	Ear tag 4.0	RWA	Akagera	4	2.33	0.12	0.58	1095	48	0.04	active
2023	Ear tag 4.0	SSD	Badingilo	4	2.15	0.07	0.54	1095	166	0.15	inactive
2023	Ear tag 4.0	SSD	Badingilo	4	2.92	0.05	0.73	1095	252	0.23	active
2023	Ear tag 4.0	SSD	Badingilo	4	1.55	0.09	0.39	1095	93	0.08	inactive
2023	Ear tag 4.0	TCD	Zakouma	4	1.57	0.05	0.39	1095	268	0.24	active
2023	Ear tag 4.0	TCD	Zakouma	4	2.57	0.06	0.64	1095	268	0.24	active
2023	Ear tag 4.0	TCD	Zakouma	4	1.80	0.15	0.45	1095	9	0.01	inactive
2023	Ear tag 4.0	TCD	Zakouma	4	2.84	0.06	0.71	1095	269	0.25	active
2023	Ear tag 4.0	TCD	Zakouma	4	1.54	0.10	0.39	1095	55	0.05	inactive
2023	Ear tag 4.0	TCD	Zakouma	4	2.77	0.05	0.69	1095	267	0.24	active
2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.89	0.06	0.47	1095	212	0.19	inactive
2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.00	0.00	0.25	1095	5	0.00	inactive
2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.00	0.00	0.25	1095	14	0.01	inactive
2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.44	0.05	0.36	1095	153	0.14	inactive

2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.93	0.07	0.48	1095	131	0.12	inactive
2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.92	0.05	0.48	1095	232	0.21	active
2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.60	0.14	0.40	1095	15	0.01	inactive
2023	Ear tag 4.0	UGA	MurchisonFalls	4	1.74	0.09	0.43	1095	66	0.06	inactive
2023	Ear tag 5.0	NAM	EtoshaHeights	12	8.70	0.18	0.72	1095	137	0.13	active
2023	Ear tag 5.0	NAM	EtoshaHeights	12	7.80	0.12	0.65	1095	187	0.17	active
2023	Ear tag 5.0	NAM	Hoanib	12	8.09	0.16	0.67	1095	128	0.12	active
2023	Ear tag 5.0	NAM	Hoanib	12	4.55	0.20	0.38	1095	132	0.12	active
2023	Ear tag 5.0	NAM	Hoanib	12	2.37	0.18	0.20	1095	132	0.12	active
2023	Ear tag 5.0	NAM	Hoanib	12	10.25	0.12	0.85	1095	128	0.12	active
2023	Ear tag 5.0	RWA	Akagera	12	2.36	0.30	0.20	1095	42	0.04	active
2023	Ear tag 5.0	RWA	Akagera	12	3.88	0.59	0.32	1095	7	0.01	inactive
2023	Ear tag 5.0	RWA	Akagera	12	3.80	0.55	0.32	1095	4	0.00	inactive
2023	Ear tag 5.0	RWA	Akagera	12	3.00	0.43	0.25	1095	22	0.02	inactive
2023	Ear tag 5.0	RWA	Akagera	12	2.54	0.28	0.21	1095	47	0.04	active
2023	Tail unit 3.0	KEN	Amboseli	24	12.82	1.38	0.53	730	43	0.06	active
2023	Tail unit 3.0	KEN	Amboseli	24	5.33	2.08	0.22	730	13	0.02	inactive
2023	Tail unit 3.0	KEN	Amboseli	24	15.25	1.07	0.64	730	51	0.07	active
2023	Tail unit 3.0	KEN	Amboseli	24	6.50	7.78	0.27	730	1	0.00	inactive
2023	Tail unit 3.0	KEN	Amboseli	24	18.85	1.33	0.79	730	27	0.04	inactive
2023	Tail unit 3.0	KEN	Amboseli	24	11.49	1.03	0.48	730	58	0.08	active
2023	Tail unit 3.0	KEN	Amboseli	24	20.89	0.62	0.87	730	59	0.08	active
2023	Tail unit 3.0	KEN	Amboseli	24	16.06	0.90	0.67	730	54	0.07	active

2023	Tail unit 3.0	KEN	Amboseli	24	12.94	1.29	0.54	730	33	0.05	active
2023	Tail unit 3.0	KEN	Amboseli	24	14.00	1.00	0.58	730	53	0.07	active
2023	Tail unit 3.0	KEN	Amboseli	24	9.07	0.97	0.38	730	52	0.07	active
2023	Tail unit 3.0	KEN	Amboseli	24	8.82	0.73	0.37	730	57	0.08	active
2023	Tail unit 3.0	KEN	Amboseli	24	8.67	0.69	0.36	730	52	0.07	active
2023	Tail unit 3.0	KEN	Mara	24	21.76	0.53	0.91	730	86	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	22.46	0.29	0.94	730	60	0.08	inactive
2023	Tail unit 3.0	KEN	Mara	24	23.44	0.21	0.98	730	87	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	22.94	0.26	0.96	730	87	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	23.53	0.21	0.98	730	86	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	22.97	0.20	0.96	730	85	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	3.00	0.00	0.13	730	0	0.00	inactive
2023	Tail unit 3.0	KEN	Mara	24	23.38	0.19	0.97	730	84	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	17.66	0.82	0.74	730	89	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	19.08	0.75	0.80	730	79	0.11	active
2023	Tail unit 3.0	KEN	Mara	24	24.58	0.67	1.02	730	89	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	23.19	0.21	0.97	730	89	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	18.45	0.77	0.77	730	85	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	23.24	0.21	0.97	730	88	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	23.67	0.20	0.99	730	88	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	16.11	0.87	0.67	730	88	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	13.75	0.88	0.57	730	86	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	23.71	0.17	0.99	730	86	0.12	active

2023	Tail unit 3.0	KEN	Mara	24	16.77	1.10	0.70	730	86	0.12	active
2023	Tail unit 3.0	KEN	Mara	24	22.32	0.51	0.93	730	56	0.08	inactive
2023	Tail unit 3.0	KEN	Mara	24	23.11	0.23	0.96	730	86	0.12	active
2023	Tail unit 3.0	SSD	Badingilo	24	23.42	0.18	0.98	730	86	0.12	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	18.04	0.66	0.75	730	121	0.17	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	20.47	0.59	0.85	730	99	0.14	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	19.00	1.51	0.79	730	29	0.04	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	19.00	1.30	0.79	730	22	0.03	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	22.67	0.48	0.94	730	72	0.10	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	16.20	0.72	0.68	730	117	0.16	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	20.15	0.77	0.84	730	70	0.10	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	22.00	0.60	0.92	730	72	0.10	inactive
2023	Tail unit 3.0	SSD	Badingilo	24	18.30	1.00	0.76	730	60	0.08	inactive
2023	Tail unit 3.0	TCD	Zakouma	24	19.17	0.76	0.80	730	72	0.10	inactive
2023	Tail unit 3.0	TCD	Zakouma	24	20.20	0.49	0.84	730	176	0.24	inactive
2023	Tail unit 3.0	TCD	Zakouma	24	3.77	0.08	0.16	730	65	0.09	inactive
2023	Tail unit 3.0	TCD	Zakouma	24	3.61	0.05	0.15	730	174	0.24	inactive
2023	Tail unit 3.0	TCD	Zakouma	24	3.60	0.04	0.15	730	265	0.36	active
2023	Tail unit 3.0	TCD	Zakouma	24	3.61	0.06	0.15	730	127	0.17	inactive
2023	Tail unit 3.0	TCD	Zakouma	24	3.40	0.07	0.14	730	157	0.22	inactive
2023	Tail unit 3.0	TCD	Zakouma	24	3.54	0.04	0.15	730	269	0.37	active