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Supplementary Information for

Early hominins evolved within non-analog ecosystems

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Other supplementary materials for this manuscript include the following:

- Datasets S1 to S2

Supplementary Information Text

Detailed Materials and Methods

Materials. Our study examines modern and fossil herbivore communities, including species belonging to the orders Artiodactyla, Perissodactyla, and Proboscidea (i.e., ungulates). The database of 204 modern African herbivore communities (Dataset S1) comes from species lists for protected areas (e.g., national parks, game reserves) compiled by Kamilar et al. (1) and Rowan et al. (2). Their geographic locations are illustrated in Figure 1 (see also Table S1). Body mass data for each extant species were derived from Kingdon et al. (3), and taxa were assigned to one of five size classes that approximate a widely used scheme (4) for African mammals: Size 1 = < 18 kg; Size 2 = 18 to 80 kg; Size 3 = 80 to 350 kg; Size 4 = 350 to 1,000 kg; Size 5 = > 1,000 kg. Size 5 taxa are considered megaherbivores following Owen-Smith (5). Taxa were assigned to one of three dietary categories (browser, grazer, mixed feeder) based on Kingdon et al. (3) and other expert references (e.g., 6, 7).

The database of 101 fossil herbivore communities and the functional trait attributes of fossil species (Dataset S2; Table S2) is from Faith et al. (8). Fossil taxa were assigned to a size class based on published body mass estimates or descriptions provided in their taxonomic diagnoses (e.g., a fossil bovid described as similar in size to modern impala would be assigned to the same size class as impala: Size 2). In the absence of such information, size classes were assigned based on extant or fossil relatives or from our own personal experience and/or outside expert opinions. Dietary classifications were based primarily on published stable carbon isotopes ($\delta^{13}C$) of tooth enamel: $\delta^{13}C$ enamel values of >-1‰ = C_4 grazers; -1 to -8‰ = C_3-C_4 mixed feeders; < - 8‰ = C_3 browsers (following 9). For taxa lacking $\delta^{13}C$ data, dietary assignments were based on the diets of fossil or modern relatives, or other lines of paleodietary evidence (e.g., microwear, mesowear) when available. The primary sources of all body mass and dietary assignments are provided in Faith et al. (8).

Several of the large herbivore taxa in our fossil database are known to have shifted their diets through time (9, 10). Based on published $\delta^{13}C$ data, we use the following dietary classifications:

> *Notochoerus* spp.: mixed feeder >3.0 Ma; grazer <3.0 Ma.
>
> *Loxodonta* spp.: mixed feeder >3 Ma; grazer from 3 to 1.4 Ma; browser for records assigned to extant *Loxodonta africana*, all younger than 0.4 Ma. Our database has no records of *Loxodonta* from 1.4 to 0.4 Ma.
>
> *Elephas* spp.: mixed feeder >3.4 Ma; grazer <3.4 Ma.
>
> *Sivatherium* spp.: browser >2.5 Ma; mixed feeder 2.5 to 1.5 Ma; grazer <1.5 Ma.

Methods. We exclude all Size 1 taxa (< 18 kg) from analyses of modern and fossil communities to control for potential taphonomic biases against recovery of smaller herbivore taxa in the fossil record (11). Fidelity studies exploring the relationship between living vertebrate communities and their associated bone assemblages provide confidence that the size range considered here (Size 2 to 5) should not be substantially biased by size-mediated taphonomic processes (12).

We use a methodological approach established by Faith et al. (8) to control for potential biases in the fossil record, including time-averaging and sampling effort. This is critical for our study because greater time-averaging or sampling effort will increase the number of taxa recovered in a given fossil assemblage (13, 14). Assuming that the effects of time-averaging and sampling effort are independent of herbivore functional traits, it is possible to control for them by examining the richness of a given functional type (e.g., the number of grazers, ruminants, or Size 3 taxa) relative to overall community richness (i.e., the total number of species). In the fossil communities, richness is based on tallies of non-overlapping taxa (e.g., records of *Equus quagga* and *Equus* sp. represent a single species because the latter cannot be shown to represent a second species).

For the sample of modern communities, we generated ordinary least-squares linear regressions to model the richness of a given functional type as a function of overall community richness in the modern sample (Figure S1). We then calculated the residuals for the fossil assemblages by calculating the deviation between the observed richness of a given functional type and the expected richness based on the modern regression. Temporal trends in the fossil residuals are illustrated using locally estimated scatterplot smoothing (LOESS), with a smoothing factor of 0.75. This approach controls for the effects of differential sampling effort between assemblages, and has been shown ameliorate the effects of differential time-averaging between assemblages (8).

Though calculation of residuals for the more taxonomically rich fossil assemblages involves extrapolating beyond maximum richness observed in the modern dataset, we note that these residuals are strongly correlated with those obtained using an ordinary least-squares regression modelling the relationship between richness of a given functional trait and community richness across the fossil samples (S5: $r = 0.907$, $p < 0.001$; S4: $r = 0.993$, $p < 0.001$; S3: $r = 0.982$, $p < 0.001$; S2: $r = 0.712$, $p < 0.001$; non-ruminant: $r = 0.860$, $p < 0.001$; grazer: $r = 1.000$, $p < 0.001$; mixed feeder: $r = 0.996$, $p < 0.001$; browser: $r = 0.984$, $p < 0.001$), meaning that the results are little changed. This also means that our use of modern faunas as a baseline has not obscured the broad temporal changes in functional trait composition. Figure S2 shows that the temporal trends based on the fossil regressions are comparable to those illustrated in Figure 2 of the main text.

Large Carnivoran Richness

To demonstrate trends in large carnivoran (>100 kg) richness (Figure 4F), we tallied the presence of carnivoran taxa in eastern Africa across 0.5 Myr time bins (Table S3). Our use of these bins is due to the rarity of large carnivorans in eastern African fossil assemblages, which precludes an analysis comparable to that provided for the herbivores. The >100 kg body mass threshold encompasses species capable of preying on megaherbivores (15), with fossil taxa assigned to the >100 kg size class on the basis of published mass estimates, morphological descriptions, or the size of fossil congeners (see Table S3). We did not include the massive otter *Enhydriodon dikikae*, given that its diet (and ability to procure megaherbivore prey) is unclear (16).

To ameliorate any influence of differential sampling effort across time bins, we generated an ordinary least-squares regression to model the relationship between the number of sites and the number of species (Figure S3). We then calculated residuals as the deviation between observed richness and expected richness based on the regression (shown in Figure 4F). We excluded the most recent time bin (the last 0.5 Myr) from analysis because the large carnivore guild is effectively modern at this time (17, 18), and because the large number of sites in this bin, many of which are Holocene (Table S2), would substantially skew the regression.

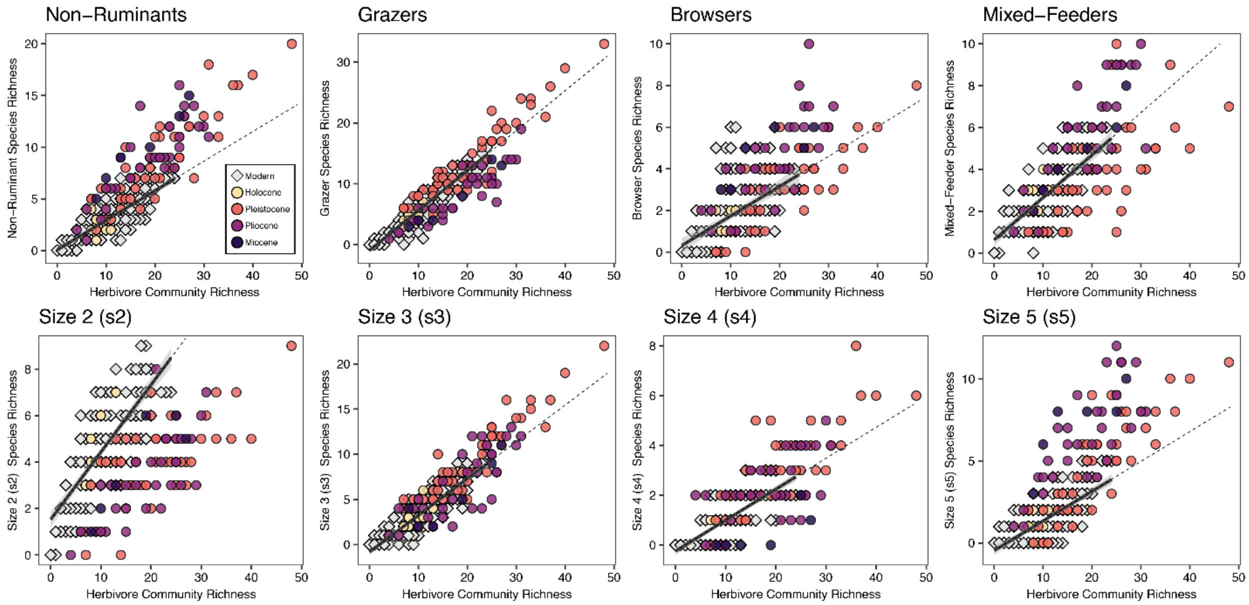

Fig. S1. The relationships between total herbivore community richness and the richness of a given functional trait in modern and fossil communities. Solid line indicates the ordinary least-squares regression for the modern data; dashed line is an extrapolation.

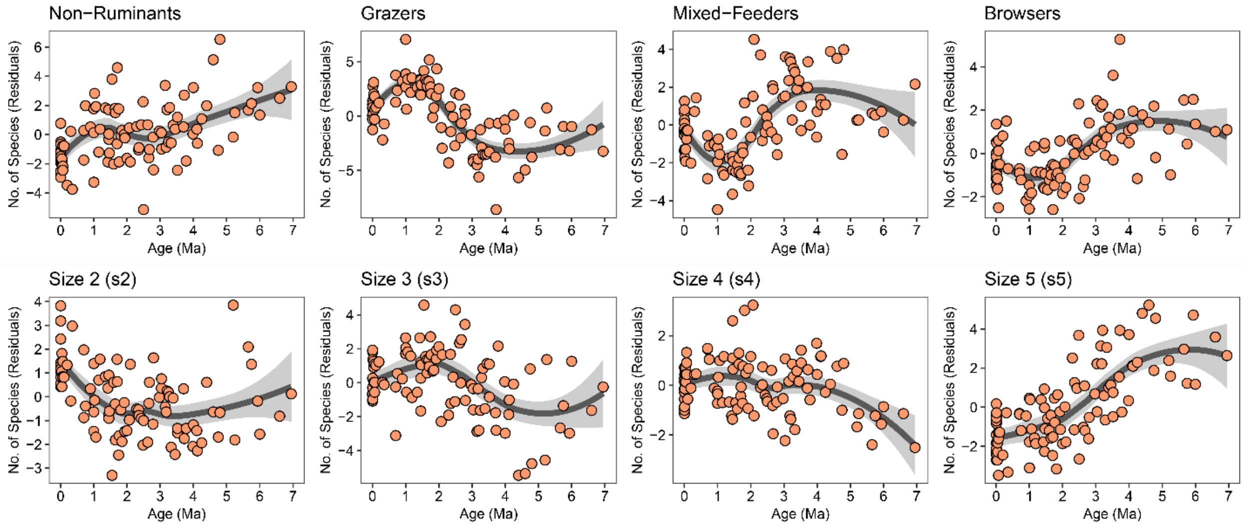

Fig. S2. Temporal trends in the functional trait composition of eastern African large herbivore communities over the last 7 Myr based on residuals derived from ordinary least-squares regressions for the fossil data.

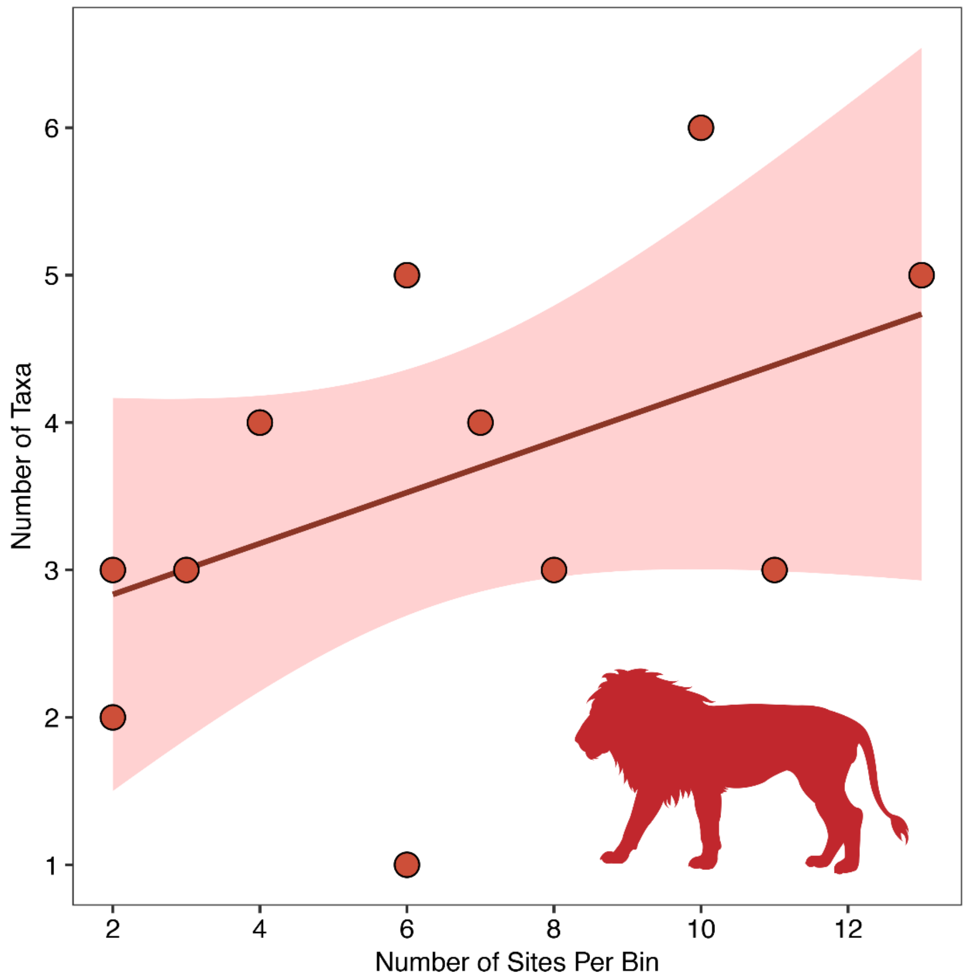

Fig. S3. The relationships between the number of fossil sites and the number of large carnivore (> 100 kg) taxa across 0.5 Myr time bins. Solid line indicates the ordinary least-squares regression.

Table S1. Modern African herbivore communities. Site codes correspond to those used in Dataset S1, which provides the taxonomic data.

Site	Code	Latitude	Longitude
Aberdares NP, Kenya	ABER	-0.24	36.5
Abijatta-Shalla Lakes NP, Ethiopia	ABI-SHA	7.3	38.3
Abou Telfane Faunal Reserve, Chad	ABTL	12.1	18.88
Addax Sanctuary, Niger	ADX	19.31	9.37
Ai-Ais Hot Spring Game Park, Namibia	AIHS	-27.91	17.15
Akagera NP, Rwanda	AKA	-1.65	30.69
Amboseli NP, Kenya	AMB	-2.38	37.14
Luiana National Park, Angola	ANG	-15.5	15.3
Reserve Temporaire de Faune d'Ansongo-Menaka, Mali	ANME	15.55	1.7
Arly Partial Faunal Reserve, Burkina Faso	APFR	11.39	1.16
Arawale NR, Kenya	ARAW	-1.43	40.15
Arusha NP, Tanzania	ARU	-3.25	36.83
Arly Total Faunal Reserve, Burkina Faso	ATFR	11.56	1.44
Aïr and Ténéré National Nature Reserve, Niger	ATNR	18.83	9.47
Awash NP, Ethiopia	AWA	9.2	40.2
Badiar NP, Guinea	BAD	12.34	-13.17
Baie de Khnifiss, Morocco	BAIE	28.01	-12.27
Bale Mountains NP, Ethiopia	BALE	6.4	39.4
Banc d'Arguin, Mauritania	BANC	-11.53	30.72
Bangweulu Swamps, Zambia	BAN	20.23	-16.11
Bahr Salamat Faunal Reserve, Chad	BASA	10.59	19.42
Bazaruto NP, Mozambique	BAZ	-21.75	35.43
Boumba Bek/Neki NPs, Cameroon	BBN	2.51	14.72
Belezma NP, Algeria	BELZ	35.59	6.04
Benoue NP, Cameroon	BEN	8.36	13.82
Bururi Forest NR, Burundi	BF	-3.94	29.6
Banhine NP, Mozambique	BHINE	-22.9	32.86
Bikuar NP, Angola	BIK	-15.28	14.76
Binder- Léré Faunal Reserve, Chad	BIN	9.63	14.41
Bonioli Total Faunal Reserve, Burkina Faso	BON	10.86	-3.11
Bou-Hedma NP, Tunisia	BOUH	34.47	9.61
Budongo forest, Uganda	BUD	1.73	31.55
Bufalo Partial Reserve, Angola	BUF	-12.78	13.81
Chambi NP, Tunisia	CHAM	35.18	8.71
Chobe NP, Botswana	CHO	-18	24.5
Cliffs of Bandiagara, Mali	CLB	14.41	-3.4
Campo Ma'an NP, Cameroon	CMA	2.46	10.3
Comoé NP, Ivory Coast	COM	9.06	3.42
Conkouati- Douli NP, Congo	CON	-3.9	11.45
Congo Basin, DRC	CONG	2.5	22
East of Cross River, Nigeria	CROS	5	6
Deux Bales NP, Burkina Faso	DEUX	11.59	-2.97
Diawling NP, Mauritania	DIAW	16.31	-16.4
Djurdjura NP, Algeria	DJU	36.46	4.16
Daan Viljoen Game Park, Namibia	DVGP	-22.53	16.96
(Gebel) Elba NP, Egypt	ELB	22.9	35.75
East of Niger River, Nigeria	ENIG	5	7.5

Etosha NP, Namibia	ETO	-19	15.75
Fada Archei Fauna Reserve, Chad	FADA	16.96	21.4
Gadabedji Faunal Reserve, Niger	GAD	15.14	7.15
Gambela NP, Ethiopia	GAM	8	34
Garamba NP, Democratic Rep. of Congo	GAR	4.19	29.48
Kgalagadi Transfrontier NP, South Africa	GEM	-25.7	20.4
Ghonarezhou NP, Zimbabwe	GHO	-21.66	31.86
Gile GR, Mozambique	GILE	-16.53	38.44
Gishwati Forest Reserve, Rwanda	GISH	-1.75	29.42
Golden Gate NP, South Africa	GOLD	-28.3	28.4
Gombe NP, Tanzania	GOMB	-4.66	29.63
Gorongosa NP, Mozambique	GOR	-18.83	34.51
Guinea Woodland, Nigeria	GUS	7.5	7.5
Hadar, Ethiopia	HAD	11.6	40
Hluhluwe NP, South Africa	HLU	-28.2	31.5
Hwange NP, Zimbabwe	HWA	-19.19	26.62
Iles Tristao Wetlands of International Importance, Guinea	ILES	10.95	-14.95
Iona NP, Angola	IONA	-16.5	12.54
Lake Mweru, Zambia	ITG	-8.4	29.2
Kabore-Tambi National Park, Burkina Faso	KAB	11.5	-1.25
Kafue Flats, Zambia	KAFF	-15.5	25.4
Kakamenga National Park, Kenya	KAK	0.3	34.85
Kalahari Thornveld (Tswalu Kalahari Reserve), South Africa	KALT	-25.62	20.43
Kameia NP, Angola	KAM	-11.85	21.67
Kangandala NP, Angola	KANG	-9.81	16.77
Kapama NP, South Africa	KAP	-24.3	31
Kasungu NP, Malawi	KAS	-12.56	33.84
Kibira NP, Burundi	KBIR	-3.6	29.32
Kabalega/Murchison Falls NP, Uganda	KFAL	2.25	31.8
Kafue NP, Zambia	KFNP	-14.4	26.13
Khaudom NP, Namibia	KHA	-18.75	20.76
Kibale NP, Uganda	KIB	0.53	30.38
Kidepo NP, Uganda	KID	3.53	33.5
Kilimanjaro, Tanzania	KILI	-3	37.5
Kisama NP, Angola	KIS	-9.77	13.62
Kizigo GR, Tanzania	KIZ	-6.37	34.28
Kruger NP, South Africa	KNP	-24	31.4
Knysna/Wilderness NP, South Africa	KNYS	-33.5	22.6
Korup NP, Cameroon	KOR	5.1	8.51
Kourtiagou Partial Forest Reserve, Burkina Faso	KOU	11.55	1.95
Lac d'Afennourir, Morocco	LACA	33.33	-5.17
Lac Fitri (Wetlands of International Importance), Chad	LACF	12.79	17.44
Réserve Intégrale du Lac Ouberïa, Algeria	LACO	36.84	8.39
Réserve Intégrale du Lac Tonga, Algeria	LACT	36.86	8.5
Lake Chilwa Wetlands, Malawi	LCHIL	-15.16	35.41
Lefini Faunal Reserve, Congo	LEF	-2.96	15.42
Lengwe NP, Malawi	LEN	-16.16	34.45
Linyanti Swamp, Botswana	LIN	-18.11	23.24
Liwonde NP, Malawi	LIW	-14.5	35.2
Lake Magadi, Great Rift Valley, Kenya	LMAG	-1.86	36.26

Lake Manyara NP, Tanzania	LMNY	-3.5	35.83
Lake Nkuru, Kenya	LNAK	-1	36.5
Lake Naivasha & Hell's Gate NP, Great Rift Valley, Kenya	LNHG	-0.88	36.3
Lopé Reserve, Gabon	LOP	-0.16	11.85
Lac Télé Community Reserve, Congo	LTCR	1.1	17.26
Luando Integral Nature Reserve, Angola	LUA	-11.11	17.62
Madjoari (Total Faunal) Reserve, Burkina Faso	MAD	11.37	1.27
Mago NP, Ethiopia	MAGO	5.4	36.1
Mahango Game Reserve, Namibia	MAH	-18.22	21.66
Majete WR, Malawi	MAJ	-15.56	34.35
Makakou, Gabon	MAK	-0.66	12.72
Mamili NP, Namibia	MAM	-18.41	23.68
Mana Pools NP, Zimbabwe	MAN	-15.98	29.44
Manda NP, Chad	MAND	9.32	19.97
Maputo GR, Mozambique	MAP	-26.39	32.81
Mare aux Hippootames Bird Reserve, Burkina Faso	MARE	11.59	-4.15
Marromeu GR, Mozambique	MARO	-18.77	35.95
Marsabit NP, Kenya	MARS	2.32	37.98
Massif du Ziama NR, Guinea	MASF	8.3	-9.36
Masai Mara, Kenya	MASM	-1.3	35.1
Matusadona NP, Zimbabwe	MAT	-16.95	28.61
Matobo NP, Zimbabwe	MATO	-20.55	28.54
Mavinga Partial Reserve, Angola	MAV	-15.5	20.93
Mbam et Djerem NP, Cameroon	MED	5.86	12.77
Meru NP, Kenya	MER	0.08	38.33
Manovo-Gounda-Saint Floris National Park, Central African Republic	MGSF	8.89	21.43
Mahale Mountain National Park, Tanzania	MHA	-6.12	29.5
Mikumi NP, Tanzania	MIKU	-7.2	37.13
Mandelia Faunal Reserve, Chad	MNDL	11.56	15.22
Mount Nimba Strict NR, Guinea	MNIM	7.4	-8.23
Mocamedes Partial Reserve, Angola	MOC	-15.71	12.4
Merja Sidi Boughaba, Morocco	MSID	34.23	-6.68
Mount Assirik, Senegal	MTAS	12.88	-12.76
Mount Elgon NP, Kenya	MTE	1.13	34.7
Mont Fouari Faunal Reserve, Congo	MTFO	-2.78	11.67
Mount Kenya NP, Kenya	MTK	-0.12	37.32
Mudumu NP, Namibia	MUD	-18.09	23.53
Mupa NP, Angola	MUPA	-15.91	15.59
Mushandike Sanctuary, Zimbabwe	MUSH	-8.68	29.44
Mweru-Wantipa, Zambia	MWA	-8.41	29.26
Mwabvi WR, Malawi	MWAB	-16.72	35.01
Merja Zerga Biological Reserve, Morocco	MZER	34.85	-6.29
Nairobi NP, Kenya	NAI	-1.37	36.85
Namib Desert, Namibia	NAM	-21.5	14.4
Natal Woodland, South Africa	NAT	-27.4	32.15
Namib Naukluft Game Park, Namibia	NAUK	-24.58	15.43
Ngorongoro Crater Conservation Area, Tanzania	NGCR	-3.2	35.46
Ngotto Forest, Central African Republic	NGO	3.96	17.01
Niassa GR, Mozambique	NIA	-12.24	36.98
Nkhota-Kota WR, Malawi	NKK	-12.88	34.02

Nouabalé-Ndoki NP, Congo	NOU	2.52	16.6
Nyganga Nord Faunal Reserve, Congo	NYG	-2.81	12
Nyika NP, Malawi	NYK	-10.8	33
Nyungwe Forest Reserve, Rwanda	NYU	-2.56	29.21
Odzala-Koukoua NP, Congo	ODZ	0.89	14.88
Okavango Delta, Botswana	OKA	-19	23
Olifants Sub-Region of Kruger NP, South Africa	OLI	-24	31.4
El Omayed Biosphere Reserve, Egypt	OMBR	30.75	29.15
Omo NP, Ethiopia	OMO	6.03	35.76
Ouadi Rimé- Ouadi Achim Faunal Reserve, Chad	OROA	15.77	19
Pama Partial Faunal Reserve, Burkina Faso	PAMA	11.4	0.82
Qarun Lake NR, Egypt	QLNR	29.56	30.61
Ras Mohammed NP, Egypt	RMOH	27.88	34.34
Rio Pongo Wetlands of International Importance, Guinea	RPON	10.12	-14.17
Ruaha NP, Tanzania	RUA	-7.5	35
Rukwa Valley, Tanzania	RUK	-7	31.2
Rusizi NP, Burundi	RUS	-3.24	29.25
Ruvubu NP, Burundi	RUV	-3.13	30.38
Rwenzori NP, Uganda	RWEN	0.13	30
Sahel Partial Faunal Reserve, Burkina Faso	SAHB	14.54	-0.64
Sahel Savanna, Nigeria	SAH	13.3	13.2
Salongo NP, Democratic Rep. of Congo	SALO	-2.36	20.97
Samburu NR, Kenya	SAM	0.57	37.57
Serengeti Bushland, Tanzania	SBS	-2	34
Selous GR, Tanzania	SELO	-8.86	37.41
Shimba Hills NR, Kenya	SHIM	-4.21	39.41
Simien Mountain NP, Ethiopia	SIM	13.11	38.04
Singou Total Faunal Reserve, Burkina Faso	SING	11.64	0.98
Siniaka-Minia Faunal Reserve, Chad	SINM	10.42	18.2
Skeleton Coast Park, Namibia	SKE	-19.17	12.84
Arabuko-Sokoke Forest, Kenya	SOK	-3.33	39.86
Serengeti Plains, Tanzania	SP	-2.19	34.5
SS Grasslands, South Africa	SSG	-26.35	25.4
Sudan Woodland, Nigeria	SUD	10	7.5
Southwest Arid (Nama Karoo), South Africa	SWA	-26	20
Tai Forest, Ivory Coast	TAI	5.35	-7.1
Talassamtane NP, Morocco	TALA	35.18	-5.21
Tamou Total Reserve, Niger	TAM	12.62	2.31
Tarangire NP, Tanzania	TAR	-4	36
Tassili N'Ajjer NP, Algeria	TAS	24.64	9.7
Tongwe NP, Tanzania (Ugalla River Game Reserve)	TON	-5.46	31.8
Tsavo NP, Kenya	TSA	-2.52	38.5
Tsoulou Faunal Reserve, Congo	TSO	-3.62	12.46
Volcans NP, Rwanda/DRC	VOL	-1.45	29.42
Vwaza Marsh WR, Malawi	VWA	-11	33.45
Wadi el Assuiti, Egypt	WAS	27.13	31.37
Waza NP, Cameroon	WAZ	11.29	14.69
W du Burkina Faso NP , Burkina Faso	WBKF	11.91	2.2
West Lunga NP, Zambia	WLU	-12.48	24.45
West of Niger River, Nigeria	WNI	6.5	6

W' du Niger NP, Niger	WNIG	12.52	2.66
Waterberg Plateau Park, Namibia	WPP	-20.44	17.25
Wadi el Rayan, Egypt	WRAY	29.2	30.28
Yangudi-Rasa NP, Ethiopia	YAN-RUS	11	40.5
Zakouma NP, Chad	ZAK	10.85	19.7
Zemongo Faunal Reserve, Central African Republic	ZEM	6.59	25.25
Zinave NP, Mozambique	ZIN	-21.59	33.54

Table S2. Eastern African fossil sites spanning the last 7 Myr. See Dataset S2 for taxonomic data.

Site	Country	Lat	Long	Formation/Sequence	Min. Age	Max. Age	Mean Age	Age Ref(s).	Faunal Ref(s).
Amboseli	Kenya	-2.60	37.30	Ol Tukai Beds	0.031	0.049	0.040	(8)	(19)
Apak	Kenya	2.90	36.05	Nachukui Fm	4.200	5.000	4.600	(20)	(21-23)
Aramis	Ethiopia	10.30	40.30	Sagantole Fm	4.400	4.400	4.400	(24)	(20, 25, 26)
Asa Koma	Ethiopia	10.30	40.26	Adu-Asa Fm	5.540	5.770	5.655	(27)	(23, 28, 29)
Asbole	Ethiopia	11.05	40.67	Busidima Fm	0.600	0.800	0.700	(30)	(30, 31)
Bed I	Tanzania	-2.98	35.30	Olduvai Gorge	1.800	2.038	1.919	(32)	(22, 33-38)
Bed III	Tanzania	-2.98	35.30	Olduvai Gorge	0.800	1.200	1.000	(39)	(22, 36-38, 40)
Bed IV	Tanzania	-2.98	35.30	Olduvai Gorge	0.600	0.800	0.700	(39)	(22, 36-38, 40)
Boolihinan	Ethiopia	11.15	40.32	Busidima Fm	1.500	1.700	1.600	(41)	(41)
C Island	Kenya	-0.81	36.41	Crescent Island	-	-	0.005	Holocene mean age	(42)
Chari	Kenya	4.00	36.37	Koobi Fora Fm	0.750	1.380	1.065	(43)	(44, 45)
Chemeron Mabaget	Kenya	-0.57	35.95	Chemeron Fm	4.300	5.300	4.800	(39)	(20, 22, 33, 35, 46, 47)
Daka	Ethiopia	10.28	40.53	Bouri Fm	0.966	1.040	1.003	(48)	(48, 49)
Danauli	Ethiopia	11.10	40.58	Busidima Fm	-	-	2.000	(8)	(8)
Dark Paleosol	Ethiopia	11.15	40.32	Busidima Fm	0.900	1.400	1.150	(41)	(41)
Denen Dora	Ethiopia	11.10	40.58	Hadar Fm	3.120	3.240	3.180	(50)	(51-55)
EyM DBS	Kenya	-0.78	36.22	Enkapune ya Muto	-	-	0.005	Holocene mean age	(42)
EyM RBL2.1	Kenya	-0.78	36.22	Enkapune ya Muto	-	-	0.005	Holocene mean age	(42)
Garba IV	Ethiopia	9.56	39.11	Melka Kunture	0.800	1.000	0.900	(39)	(56)
Gogo 3	Kenya	-0.54	34.35	Gogo Falls	-	-	0.005	Holocene mean age	(42)
Gombore I	Ethiopia	9.56	39.11	Melka Kunture	1.600	1.700	1.650	(57)	(56)
Gurumaha	Ethiopia	11.40	40.90	Lee Adoyta Basin	2.750	2.820	2.785	(58)	(58-61)
GvJm19 Hol	Kenya	-1.47	37.08	Lukenya Hill	-	-	0.005	Holocene mean age	(42)
GvJm19 Pleis	Kenya	-1.47	37.08	Lukenya Hill	-	-	0.014	(62)	(42)
GvJm22 Hol	Kenya	-1.47	37.08	Lukenya Hill	-	-	0.005	Holocene mean age	(42)
GvJm22 Pleis	Kenya	-1.47	37.08	Lukenya Hill	0.026	0.046	0.036	(63)	(42)
GvJm46 Pleis	Kenya	-1.47	37.08	Lukenya Hill	-	-	0.040	(62)	(42)
Hata	Ethiopia	10.28	40.53	Bouri Fm	2.500	2.500	2.500	(64)	(60, 64-66)
Ibole	Tanzania	-3.80	33.58	Wembere-Manonga Fm	5.000	5.500	5.250	(39)	(20, 67)

Kada Hadar	Ethiopia	11.10	40.58	Hadar Fm	2.950	3.120	3.035	(50)	(51-55)
Kaitio	Kenya	2.90	36.05	Nachukui Fm	1.550	1.870	1.710	(43)	(44)
Kaiyumung	Kenya	2.90	36.05	Nachukui Fm	3.000	3.500	3.250	(20)	(21-23)
Kalochoro	Kenya	2.90	36.05	Nachukui Fm	1.870	2.330	2.100	(43)	(44)
Kanapoi	Kenya	2.33	35.92	Kanapoi Fm	4.070	4.170	4.120	(68)	(20, 22, 69, 70)
Kantis	Kenya	-1.39	36.72	Indet.	3.400	3.500	3.450	(71)	(71)
Karungu	Kenya	-0.83	34.15	-	0.035	0.100	0.068	(72, 73)	(74)
Kataboi	Kenya	2.90	36.05	Nachukui Fm	3.440	3.970	3.705	(43)	(44)
KBS	Kenya	4.00	36.37	Koobi Fora Fm	1.530	1.870	1.700	(43)	(37, 44)
Kibish I	Ethiopia	5.00	36.00	Kibish Fm	-	-	0.198	(75)	(76, 77)
Kibish III	Ethiopia	5.00	36.00	Kibish Fm	-	-	0.104	(75)	(76, 77)
Kibish IV	Ethiopia	5.00	36.00	Kibish Fm	0.008	0.012	0.010	(75)	(76, 77)
Kiloleli	Tanzania	-3.80	33.58	Wembere-Manonga Fm	4.000	4.500	4.250	(39)	(20, 67)
Konso 1	Ethiopia	5.30	37.40	Konso Fm	1.800	1.900	1.850	(78)	(78)
Konso 2	Ethiopia	5.30	37.40	Konso Fm	1.700	1.800	1.750	(78)	(78)
Konso 3	Ethiopia	5.30	37.40	Konso Fm	1.500	1.600	1.550	(78)	(78)
Konso 4	Ethiopia	5.30	37.40	Konso Fm	1.400	1.500	1.450	(78)	(78)
Konso 5	Ethiopia	5.30	37.40	Konso Fm	1.300	1.400	1.350	(78)	(78)
Konso 6	Ethiopia	5.30	37.40	Konso Fm	0.700	1.300	1.000	(78)	(78)
Kuseralee	Ethiopia	10.43	40.45	Sagantole Fm	-	-	5.200	(29)	(23, 28, 29)
Lainyamok	Kenya	-1.79	36.20	-	0.320	0.390	0.355	(79)	(30)
Lee Adoyta	Ethiopia	11.40	40.90	Lee Adoyta Basin	2.580	2.670	2.625	(58)	(58-61)
Lemudongo	Kenya	1.30	35.95	Lemudongo Fm	-	-	6.000	(80)	(80)
Lokalalei	Kenya	2.90	36.05	Nachukui Fm	2.330	2.530	2.430	(43)	(22, 44)
Lokochot	Kenya	4.00	36.37	Koobi Fora Fm	3.440	3.600	3.520	(43)	(37, 44)
Lonyumun	Kenya	4.00	36.37	Koobi Fora & Nachukui Fm	3.970	4.000	3.985	(43)	(37, 44)
Lower Laetolil	Tanzania	-3.20	35.20	Laetolil Beds	3.850	4.360	4.105	(81)	(82)
Lower Lomekwi	Kenya	2.90	36.05	Nachukui Fm	3.130	3.440	3.285	(43)	(22, 44)
Lower Nawata	Kenya	2.90	36.05	Nawata Fm	6.500	7.400	6.950	(39)	(21-23)
Lower Bed II	Tanzania	-2.98	35.30	Olduvai Gorge	1.740	1.790	1.765	(83)	(36, 83)
Luanda	Kenya	0.02	34.59	Luanda	-	-	0.005	Holocene mean age	(42)
Lukeino	Kenya	-0.79	35.86	Lukeino Fm	5.730	6.140	5.935	(39)	(20, 22, 47, 84)
Makaamitalu	Ethiopia	11.10	40.58	Busidima Fm	-	-	2.350	(85)	(8)

Marula	Kenya	-0.78	36.22	Marula Rockshelter	-	-	0.005	Holocene mean age	(42)
Mb A	Ethiopia	5.00	36.00	Shungura Fm	3.440	3.600	3.520	(43)	(20, 38)
Mb B	Ethiopia	5.00	36.00	Shungura Fm	2.970	3.440	3.205	(43)	(20, 22, 38)
Mb C	Ethiopia	5.00	36.00	Shungura Fm	2.530	3.070	2.800	(43)	(20, 22, 38)
Mb D	Ethiopia	5.00	36.00	Shungura Fm	2.440	2.530	2.485	(43)	(22, 38, 66)
Mb E	Ethiopia	5.00	36.00	Shungura Fm	2.320	2.400	2.360	(43)	(22, 38, 66)
Mb F	Ethiopia	5.00	36.00	Shungura Fm	2.270	2.320	2.295	(43)	(22, 38, 66)
Mb G	Ethiopia	5.00	36.00	Shungura Fm	1.870	2.270	2.070	(43)	(22, 38, 66)
Mb H	Ethiopia	5.00	36.00	Shungura Fm	1.760	1.870	1.815	(43)	(22, 38, 66)
Mb J	Ethiopia	5.00	36.00	Shungura Fm	1.530	1.760	1.645	(43)	(22, 38)
Mb K	Ethiopia	5.00	36.00	Shungura Fm	1.380	1.530	1.455	(43)	(22, 38)
Mb L	Ethiopia	5.00	36.00	Shungura Fm	1.000	1.380	1.190	(43)	(22, 38)
Mfangano	Kenya	-0.47	34.07	Waware Beds	0.035	0.100	0.068	(72, 73)	(86)
Middle Lomekwi	Kenya	2.90	36.05	Nachukui Fm	2.820	3.130	2.975	(43) Interpolation (Division of Mb into three units)	(22, 44)
Moiti	Kenya	4.00	36.37	Koobi Fora Fm	3.600	3.970	3.785	(43)	(44)
Mpesida	Kenya	0.67	36.00	Mpesida Beds	6.200	7.000	6.600	(39)	(20, 22, 47)
Mursi	Ethiopia	6.00	36.00	Mursi Fm	-	-	4.000	(87)	(87)
Naivasha RW	Kenya	-0.81	36.41	Naivasha Railway Rock Shelter	-	-	0.005	Holocene mean age	(42)
Nariokotome	Kenya	2.90	36.05	Nachukui Fm	0.750	1.300	1.025	(43)	(44)
Narosura	Kenya	-1.54	35.86	Narosura	-	-	0.005	Holocene mean age	(42)
Natoo	Kenya	2.90	36.05	Nachukui Fm	1.300	1.550	1.425	(43)	(44)
Ngenyn 3	Kenya	0.60	36.01	Ngenyn	-	-	0.005	Holocene mean age	(42)
Okote	Kenya	4.00	36.37	Koobi Fora Fm	1.380	1.530	1.455	(43)	(37, 44)
Olkesiteti	Kenya	-1.58	36.43	Oltulelei Fm	0.295	0.320	0.308	(88)	(88)
Olorgesailie	Kenya	-1.58	36.43	Olorgesailie Fm	0.500	1.000	0.750	(89)	(88)
Prolonged Drift	Kenya	-0.49	36.09	Prolonged Drift	-	-	0.005	Holocene mean age	(42)
Rusinga	Kenya	-0.41	34.18	Wasiriya Beds	0.035	0.100	0.068	(72, 73)	(86)
Shulumai	Kenya	-0.10	37.29	Shulumai Rockshelter	-	-	0.005	Holocene mean age	(42)
Sidi Hakoma	Ethiopia	11.10	40.58	Hadar Fm	3.240	3.420	3.330	(50)	(51-55)
South Turkwell	Kenya	2.90	36.05	Nachukui Fm	3.200	3.580	3.390	(90)	(38)
Tinde	Tanzania	-3.80	33.58	Wembere-Manonga Fm	4.500	5.000	4.750	(39)	(20, 67)
Tulu Bor	Kenya	4.00	36.37	Koobi Fora Fm	2.640	3.440	3.040	(43)	(37, 44)

Upper Laetolil	Tanzania	-3.20	35.20	Laetolil Beds	3.600	3.850	3.725	(81)	(82)
Upper Lomekwi	Kenya	2.90	36.05	Nachukui Fm	2.530	2.820	2.675	(43)	(44)
Upper Nawata	Kenya	2.90	36.05	Nawata Fm	5.000	6.500	5.750	(39)	(21-23)
Upper Ndolanya	Tanzania	-3.20	35.20	Ndolanya Beds	2.660	2.660	2.660	(81)	(82)
Upper Bed II	Tanzania	-2.98	35.30	Olduvai Gorge	1.200	1.740	1.470	(83)	(36, 83)
Upper Burgi	Kenya	4.00	36.37	Koobi Fora Fm	1.870	2.000	1.935	(43)	(37, 44)
Usno	Ethiopia	4.50	36.00	Usno Fm	3.000	3.300	3.150	(39)	(38)

Table S3. The occurrence of large carnivorans (>100 kg) across 0.5 Myr time bins, with references for body mass estimate and representative sites for each bin. Tally of species richness based on total number of non-overlapping taxa (occurrences in red do not count as a distinct species for the given time bin); number of sites per bin from Table S2. R = range-through taxon assumed to be present based on its occurrence in younger and older intervals.

Taxon	0.5 to ≤ 1.0	1.0 to ≤ 1.5	1.5 to ≤ 2.0	2.0 to ≤ 2.5	2.5 to ≤ 3.0	3.0 to ≤3.5	3.5 to ≤4.0	4.0 to ≤4.5	4.5 to ≤5.0	5.0 to ≤5.5	5.5 to ≤ 6.0	6.5 to ≤7	Mass Ref.	Sites Ref(s).
Homotherium aff. *problematicum*	0	0	0	1	0	0	0	0	0	0	0	0	(91, 92)	(64)
Homotherium hadarensis	0	0	0	0	0	1	0	0	0	0	0	0	(91, 92)	(93)
Homotherium sp.	0	1	1	1	1	1	1	1	0	0	0	0	(91, 92)	(38, 71, 94, 95)
Lokotunjailurus emageritus	0	0	0	0	0	0	0	0	0	0	1	1	(96)	(95)
Machairodus sp.*	0	0	0	0	0	0	0	1	R	1	1	0	(97)	(25, 98, 99)
Dinofelis aronoki	0	0	1	R	R	1	0	0	0	0	0	0	(96)	(94, 95)
Dinofelis diastemata	0	0	0	0	0	0	0	0	0	0	1	0	(96)	(100)
Dinofelis petteri	0	0	0	0	1	1	1	1	0	0	0	0	(96)	(95)
Dinofelis piveteaui	0	1	0	0	0	0	0	0	0	0	0	0	(96)	(94, 95)
Dinofelis cf. *piveteaui*	0	1	1	0	0	0	0	0	0	0	0	0	(96)	(78)
Dinofelis sp.	0	1	1	1	1	1	1	R	R	1	1	1	(96)	(44, 94, 95, 99, 101)
Panthera leo	1	1	1	0	0	0	0	0	0	0	0	0	(3)	(94, 95)
Panthera aff. *leo*	0	0	0	0	0	0	1	0	0	0	0	0	(3)	(82)
Crocuta eturono	0	0	0	0	0	1	0	0	0	0	0	0	(96)	(94, 95)
Crocuta cf. *eturono*	0	0	1	R	R	1	0	0	0	0	0	0	(96)	(94, 95)
Pachycrocuta brevirostris	0	0	0	0	1	1	0	0	0	0	0	0	(102)	(95)
Agriotherium aecuatorialis	0	0	0	0	0	0	0	0	1	0	0	0	(100)	(100)
Agriotherium sp.	0	0	0	0	0	0	0	1	0	1	1	0	(100)	(25, 99)
cf. *Agriotherium* sp.	0	0	0	0	0	1	1	0	0	0	0	0	(100)	(94)
Species Richness	1	3	5	3	5	6	4	4	3	3	4	2		
Number of Sites	6	11	13	8	6	10	7	4	3	2	4	2		

*The genus *Machairodus* has been reported from several late Miocene and early Pliocene sites in eastern Africa (25, 98, 99), though Sardella and Werdelin (103) suggest these remains are best placed in *Amphimachairodus* (see also 95).

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