Ungulate Ecology, Health, and Conservation in Tanzania including Giraffe Population Genetics and Demography

Annual Progress Report 2024 & Permit Renewal Proposal 2025

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EXECUTIVE SUMMARY

- This project continues to provide data and analyses to inform priority research areas as described in Tanzania Wildlife Research Agenda 2021-2031 (TAWIRI 2021) including: **Wildlife ecology and ecological interactions** [priority areas i.Behavioural and nutrition ecology, ii.Population, distribution and reproductive ecology, vi.Range ecology/management, vii.Population genetics, xiii.Migratory routes, corridors, buffer zones and dispersal areas, xvi.Ecological monitoring methods]; **Wildlife population monitoring** [priority areas i.Population monitoring of large mammals, ii.Population monitoring of rare, endemic and endangered species, iv.Ecological monitoring methods and applications, vii.Social, environmental and ecological drivers of population dynamics, viii.Wildlife population monitoring methods]; **Habitat and biodiversity conservation** [priority areas ii.Composition, distribution and abundance of wildlife in protected areas and non-protected areas, vii.Conservation policy analysis]; **Wildlife diseases** [priority areas ii.Ecology, epidemiology and control of wildlife diseases]; **Wildlife conservation policies** [priority areas iv.Land use planning for supporting livelihoods and conservation goals, viii.Community-based natural resource management (CBNRM) in conservation].

- This project also provides data and analyses to answer research targets in TAWIRI's Giraffe Conservation Research Framework 2020, namely research on: 2.1 giraffes' habitat use and foraging preference, 2.2 giraffe health and impact on survival, 2.3 population size, distribution and connectivity, 2.4 human dimensions and giraffe conservation.

- During the past permit period, we completed 3 giraffe photo capture-mark-recapture surveys in Tarangire Ecosystem, 3 surveys in Serengeti Ecosystem.

- We published two manuscripts in scientific journals regarding giraffes and other ungulates (attached). Three manuscripts are in progress.

- We ask to continue giraffe photographic surveys to obtain robust estimates of population size, trend, and demographic rates for giraffes in northern Tanzania.

- We will conduct giraffe photo surveys in the coming year in Tarangire National Park, Serengeti National Park, Lake Manyara National Park, Arusha National Park, Ruaha National Park, Nyerere National Park, Ngorongoro Conservation Area, Manyara Ranch, Burunge WMA, Randilen WMA, Ikona WMA, Grumeti Game Reserve, Ikorongo Game Reserve, Mtowambu GCA, Lake Natron GCA, and Lolkisale GCA.

- We ask permission to be allowed free entry to the areas listed above. While working in the parks, conservation area, and WMAs, we also request continued permission to camp while collecting data and to drive off-road when necessary because these data cannot be collected only from the roads.

INTRODUCTION

Populations of giraffe (*Giraffa camelopardalis*) have declined throughout the species' range in recent years, leaving remaining populations increasingly isolated. We seek to better understand the metapopulation dynamics and genetic structure of giraffes across a large region of Tanzania. We are continuing demographic studies based upon photographic capture-recapture data in the Tarangire Ecosystem (Tarangire NP, Randilen and Burunge WMAs, Manyara Ranch, Mtowambu GCA, Lolkisale GCA, and Lake Natron GCA, and Lake Manyara NP), Serengeti Ecosystem (Serengeti National Park, Ngorongoro Conservation Area, Ikona WMA, Grumeti GR, and Ikorongo GR), and Arusha National Park. These photo capture-recapture data build upon our long-term database that can be used to estimate population sizes, survival, and reproduction rates at each site. We completed all giraffe DNA sampling collected under previous permits, and these are being processed and analyzed. We have no plans for additional DNA sampling at this time.

Objectives and Conservation Implications

This project objective is to provide data and analyses to inform priority research areas as described in Tanzania Wildlife Research Agenda 2021-2031 (TAWIRI 2021) including: Wildlife ecology and ecological interactions [priority areas i.Behavioural and nutrition ecology, ii.Population, distribution and reproductive ecology, vi.Range ecology/management, vii.Population genetics, xiii.Migratory routes, corridors, buffer zones and dispersal areas, xvi.Ecological monitoring methods]; Wildlife population monitoring [priority areas i.Population monitoring of large mammals, ii.Population monitoring of rare, endemic and endangered species, iv.Ecological monitoring methods and applications, vii.Social, environmental and ecological drivers of population dynamics, viii.Wildlife population monitoring methods]; Habitat and biodiversity conservation [priority areas ii.Composition, distribution and abundance of wildlife in protected areas and non-protected areas, vii.Conservation policy analysis]; Wildlife diseases [priority areas ii.Ecology, epidemiology and control of wildlife diseases]; Wildlife conservation policies [priority areas iv.Land use planning for supporting livelihoods and conservation goals, viii.Community-based natural resource management (CBNRM) in conservation].

This project also provides data and analyses to answer research targets in TAWIRI's Giraffe Conservation Research Framework 2020, namely research on: 2.1 giraffes' habitat use and foraging preference, 2.2 giraffe health and impact on survival, 2.3

population size, distribution and connectivity, 2.4 human dimensions and giraffe conservation.

METHODS

Study Areas

Field research takes place in Tarangire National Park, Lake Manyara National Park, Ruaha National Park, Nyerere National Park, Arusha National Park, Serengeti National Park, Ngorongoro Conservation Area, Manyara Ranch, Lolkisale Game Controlled Area, Mtowambu Game Controlled Area, Lake Natron Game Controlled Area, Burunge WMA, Randilen WMA, Ikona WMA, Grumeti Game Reserve, and Ikorongo Game Reserve.

Road Surveys

We conduct daytime vehicle road surveys. Driving speed is between 15 and 20 kph on all transects. Sampling design is a robust design with 2 sampling events at each site during each sampling occasion. A sampling event consists of 1 round of driving all fixed-route road transects within a site. Study design calls for sampling occasions 3 times per year near the end of each precipitation season (vuli, masika, and kiangazi). Thus, sampling is scheduled from mid Jan-mid Feb, mid May-mid Jun, and mid Sep-mid Oct each year.

During sampling events we attempt to photograph every individual giraffe encountered. Each photographic image constitutes the application of a new mark, or the recapture of an existing mark. We employ Wild-ID pattern recognition software to identify individuals by their unique coat patterns (Bolger et al. 2012). Photographed animals are considered 'marked' when their first photograph is taken, while animals already in the photo database are photographically 'recaptured'. Every individual giraffe encountered is classified to age class (calf, subadult, adult) and sex (male, female), photographed for individual identification and size quantification, location recorded as GPS coordinates and site designation. Distance (in meters) to each giraffe is measured using a laser range finder. These data are analyzed using open, robust design models in program MARK to estimate population size, survival probability, and recapture probability.

We also collect covariate data relevant to estimates of giraffe density, population size, survival and reproduction. These include vegetation type, species composition, and density. DNA samples were collected under previous permits, these samples are being processed and analyzed. No new samples are required.

RESULTS

Previous findings:

We documented spatial variation in demographic rates of giraffes among the 5 sites in the Tarangire Ecosystem (**Lee et al. 2016a**). The Tarangire giraffe metapopulation is still interconnected by a few movements among sites, but LMNP and MGCA are nearly isolated from the rest of the ecosystem (**Lee & Bolger 2017**). The Tarangire

National Park and Manyara Ranch subpopulations are the engines of metapopulation growth and health, but anthropogenic impacts outside protected areas have a negative effect on overall metapopulation growth resulting in an overall declining metapopulation (**Lee & Bolger 2017**). Presence of migratory herds of wildebeest and zebras increased local giraffe calf survival (**Lee et al. 2016b**). Giraffe calf survival varied by season of birth, with highest survival found in calves born during the dry season (**Lee et al. 2017**). Giraffe Skin Disease prevalence varied significantly among sites and appeared to vary according to soil fertility. There is no mortality due to GSD disease (**Lee & Bond 2016, Bond et al. 2016**). In **Lee et al. (2018)** we demonstrated that some characteristics of giraffe coat spot shape were heritable, and that variation in neonatal survival was associated with spot size and shape covariates. A habitat model and corridor detection algorithm delineated the Tarangire Ecosystem wildebeest migration habitat between Tarangire NP and Lake Natron (**Bond et al. 2017**). We documented the ecological success of CBNRM in Wildlife Management Areas (WMAs) for wildlife conservation (**Lee & Bond 2018, Lee 2018**). We published the first account of a wild giraffe nursing multiple calves (**Bond & Lee 2019**). We quantified giraffe home range sizes in the Tarangire Ecosystem and found home range sizes across Africa were correlated with rainfall (**Knüsel et al. 2019**). In **Bond et al. (2019)**, we found food availability rather than predation risk mediated grouping dynamics of adult giraffes, while predation risk was the most important factor influencing congregations with calves. Two papers, Giraffe translocations: A review and discussion of considerations **(Muller et al. 2020)** and Giraffe translocation population viability analysis **(Lee et al. 2020)** provide strong guidance to biologists and managers planning translocations of giraffe. Using one of the largest-scale metapopulation networks ever studied in a wild mammal, in **Bond et al. (2020)** we reveal that social communities of giraffes living closer to human settlements exhibit weaker relationship strengths and more exclusive social associations. In **Bond et al. (2021)** Sociability increases survival in adult female giraffes, we found that females that grouped with more other females leads to higher survival. Benefits of female grouping may include cooperative care of young, more efficient foraging, and reduced stress in general. Effect of sociability on survival was more than that of the natural surrounding or proximity to people, although living closer to towns also lowered survival. Female Masai giraffes live in distinct social communities of up to 90 other friends, and although areas used by these communities often overlap, they have very different rates of reproduction and calf survival, we showed in **Bond et al (2021)** Socially defined subpopulations reveal demographic variation in a giraffe metapopulation. This means that population structure can arise from social behavior rather than discrete space use. Calf survival and reproductive rates were higher in the social communities that spent more time outside of the national parks. Dispersal, the process where animals reaching sexual maturity move away from family, is important for maintaining genetic diversity and is key to the long-term persistence of natural populations. For most animals, this involves having to make risky journeys into the unknown in the hope of finding new communities in which to settle and reproduce. However, many animal societies—including those of humans—have structured social communities that overlap in space with one-another. These potentially provide opportunities for maturing individuals to disperse socially without having to make large physical displacements. **Bond et al (2021)** Leaving by staying: Social dispersal in giraffes, shows that this strategy is employed by young dispersing giraffes. We studied social relationships of more than 1000 giraffes in the Tarangire Ecosystem over 5 years. In **LaVista-Ferres et al (2021)** Social connectedness and movements among communities of giraffes vary by sex and age class, we found that males were more socially connected than females to all the other giraffes. Adult males wander long distances looking for mating opportunities. Young males visit many different groups as they explore their social environment before moving permanently away from their mothers and sisters. Females had stronger and enduring social relationships over the years than males. In the end, female giraffes have closer 'friends' than male giraffes, while males have more 'acquaintances' than females. This information is important for understanding population dynamics, spread of information, and even how diseases move through a population and is therefore important for conservation. A native bush-encroaching shrub species called Sickle Bush (*Dichrostachys cinerea*) is disliked by livestock keepers and rangeland managers, but loved as forage by wild giraffes, according to Forage selection by Masai giraffes (*Giraffa camelopardalis tippelskirchi*) at multiple spatial scales (**Levi et al. 2022**). The findings showed that giraffe significantly preferred foraging on bush-encroaching species such as the native Sickle Bush at local and landscape spatial scales and in both the wet and dry seasons. The results of this study suggest that browsing wildlife such as giraffes could be adversely affected by the removal of Sickle Bush from rangelands. In Trophic processes constrain seasonal ungulate distributions at two scales in an East African savanna (**James et al. 2022**), we found giraffe distribution in the Tarangire Ecosystem was less constrained by water (they were not closer to rivers and waterholes during the dry season than the wet seasons) but more constrained by the seasonal presence of preferred food such as *Vachellia drepanolobium* in the long rains. These results provide important information for effective conservation strategies for giraffes and other ungulates in the Tarangire Ecosystem. Animal coat patterns may have several functions, one of which might be to help individuals to recognize each other. In Phenotypic matching by spot pattern potentially mediates female giraffe social associations (**Morandi et al. 2022**), we revealed that spot traits were individually variable among adult female giraffes in the Tarangire Ecosystem, and that females showed stronger associations with other females that had similar spot shapes. Spot patterns of giraffes could be a visual cue for communicating and for recognizing related family members. In Masai giraffe population change over 40 years in Arusha National Park **(Lee et al. 2023)**, we enumerated individual giraffes to see how well they were doing compared to 40 years ago and collected DNA from dung samples to assess the genetic connectivity of the park's giraffes with other giraffe populations in the region. We documented a 49% population decline and changes in the age distribution, adult sex ratio, reproductive rate, and movement patterns relative to the previous study. In Effects of local climate anomalies on giraffe survival **(Bond et al. 2023)**, we found that in an East African savanna, higher temperatures positively affected adult giraffe survival, indicating this mega-herbivore is adapted to hot conditions, but adult and juvenile giraffe survival was reduced during rainier wet seasons, possibly due to parasites and disease and/or increased stalking cover for predators. Higher vegetation greenness also reduced adult giraffe survival, potentially because faster leaf growth reduces nutrient quality. Climate effects were most pronounced for giraffes living closer to the edge of the protected areas during the short rains, possibly because of higher livestock-mediated disease risk and/or muddier conditions that prevent effective anti-poaching patrols. Projected climate changes in East Africa, including heavier rainfall during the short rains, will likely threaten persistence of giraffes in one of Earth's most important landscapes for large terrestrial mammals, pointing to the need for effective land-use planning and law enforcement to provide giraffes more resilience to the coming changes. In Genetic evidence of population subdivision among Masai giraffes separated by the Gregory Rift Valley in Tanzania **(Lohay et al. 2023)**, we showed that populations of Masai giraffes separated geographically by the Great Rift Escarpment have not interbred — or exchanged genetic material — in more than a thousand years, and in some cases hundreds of thousands of years. We recommend that the two populations be considered separately for conservation purposes, with separate but coordinated conservation efforts to manage each population. In Extinction risks and mititgation for a megaherbivoe, the giraffe, in a human-influenced landscape under climate change **(Bond et al. 2023)**, we combined the information learned from previous studies of giraffes to create an individual-based model that simulated realistic population dynamics and extinction risk under different scenarios of environmental change over 50 years. Results showed that the greatest risk of population declines and extinction for giraffes is caused by a reduction in wildlife law enforcement leading to more poaching. The study highlights the great utility of law enforcement as a nature conservation tool.

New findings:

In **Sexual dimorphisms in body proportions of Masai giraffes and the evolution of the giraffe's neck (Cavener et al. 2024)**, we measured differences in body proportions between male and female giraffes, both captive and wild, and found females have a proportionally longer neck and torso, whereas males have proportionally longer forelegs and more massive necks. We speculate the initial evolution of the long neck and legs was driven by female nutritional demands (reaching deep into bushes and higher into trees) and mating (males with longer legs can mount females) and later the neck mass was increased in males as a result of neck sparring.

In **Anthropogenic and climatic drivers of population densities in an African savanna ungulate community (Bierhoff et al. 2024)**, we quantified population trends, determined the primary environmental correlates of densities, and identified covariation in densities among species. Large fluctuations in climatic factors mediated highly synchronous temporal density variation among all species. We documen- ted more spatial than temporal variation in four of the five species, suggesting that spatial heterogeneity may provide some buffer against temporal variation in the environment. Protection of sufficient habitats and water sources should allow ungulates to respond to a temporally changing world by moving across space. Further, among-species covariation patterns identified two potential ungulate guilds (impala—dik–dik—waterbuck; eland—Grant's gazelle) that should aid in developing efficient and coordinated management actions. See attached papers for more details.

DISCUSSION AND CONSERVATION RECOMMENDATIONS

Our data benefit managers and policymakers by providing information on status and trends for economically important endangered wildlife species such as giraffe and other ungulates.

The population management actions with highest expected effectiveness are those aimed at increasing adult female survival, such as expanding anti-poaching patrols outside NPs and reducing tarmac road speed limits with signs, police presence, and speed bumps on roads near protected areas to prevent vehicle collisions. We also suggest efforts be made to protect habitats outside National Parks for the migratory wildebeest and zebra populations, particularly between Tarangire NP and the Lake Natron-Gelai Plains breeding grounds. Protecting the long-distance migration and breeding grounds directly benefits Tarangire NP tourism revenues and indirectly benefits giraffe calf survival. Conserving connectivity habitat between protected areas will help ensure natural movements of giraffes and other species can continue.

We strive to assist wildlife and land management authorities by collecting data to answer management-related questions, so utility can be maximized during surveys. If there are any ancillary data or results desired by wildlife researchers, authorities, or managers that we can collect during our surveys, we will do our best to provide them. Any stakeholder with interest in these data or the ongoing surveys should contact the author of this report at Derek@WildNatureInstitute.org or +14157630348.

CONTINUATION OF CURRENT RESEARCH ACTIVITIES IN 2025

Due to the nature of population studies, more data, particularly longer time spans of data, increase the utility and power to make strong inferences. In 2025 we are asking to continue this project to add to the long-term data already collected.

We will conduct activities in the coming year in Tarangire National Park, Lake Manyara National Park, Ruaha National Park, Nyerere National Park, Arusha National Park, Serengeti National Park, Ngorongoro Conservation Area, Manyara Ranch, Lolkisale Game Controlled Area, Mtowambu Game Controlled Area, Lake Natron Game Controlled Area, Burunge WMA, Randilen WMA, Ikona WMA, Grumeti Game Reserve, and Ikorongo Game Reserve.

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