Population dynamics of the Maasai giraffe (*Giraffa camelopardalis tippelskirchi*) in Tarangire-Manyara Ecosystem

Project researcher: Abby Reich, Connecticut College, Connecticut College #4567 270 Mohegan Ave., New London, CT.
Project advisor: John Kioko, School for Field Studies, Box 304, Karatu.

Abstract

Demographic studies can show overall population performance, help understand population structure and recognize animal distribution and movement. In order to investigate the social structure of giraffes in the Tarangire-Manyara Ecosystem, data on population structure, sex ratios, age ratios and habitat preference were examined in three protected areas. These areas included Lake Manyara National Park, Manyara Ranch and Tarangire National Park. A total of 348 giraffes were sexed and aged in the three areas combined. Manyara Ranch had the largest maximum number of giraffes seen in one day with 85 individuals. The population was significantly skewed towards adult female giraffes, which comprised the majority of the population studied. The population performance is low since there is an apparent lack of reproductive success within the population due to the high presence of adult females compared to young. The most common group type in which individual giraffes dwelled in was mixed groups. The mean group size of giraffes was significantly largest in Manyara Ranch, which may indicate a higher concentration of resources in the area. Further study in the future should investigate the relation of body condition and activity patterns to social dynamics in order to reveal the essential factors that affect the overall performance of the giraffe population.

Introduction

The giraffe (*Giraffa camelopardalis tippelskirchi*) is an easy species to observe due to its unique height and patterned spots, which allow for unproblematic identification. The giraffe is generally widely distributed throughout the savannahs in Africa, and often prefers habitats such as savannahs, open woodlands and seasonal floodplains (Kingdon, 1997), with savannah and woodland/thicket containing species of Acacia being the main feeding zones (Wyatt, 1969). The population of giraffes has been reported to include 85 giraffes in Lake Manyara National Park (Van der Jeugd & Prins, 2000) and 1,377 giraffes in Tarangire National Park and surrounding Game Controlled Areas combined (Campbell & Huish, 1991). J.B. Foster's (1966) study in Nairobi National Park presented that the ratio of adult female to adult male giraffes was generally equal overall. In the same study, the ratio of adult female to juvenile giraffes was about 2:1 (Foster, 1966). Other studies that have researched the Maasai giraffe in Serengeti National Park have noted that the population of giraffes is skewed toward females, which may be the result of illegal hunting that often affects males (Marealle *et al*, 2010). Similar sex-ratio findings that are female-skewed have been noted in Sinnary's study (1998) in Manyara Ranch Limited. The ratio of juveniles to adult females in this study was about equal (Sinnary, 1998). It has recently been noted in the Maasai Mara Region of Kenya that the general population of giraffes has declined over the past couple of decades (Kanga *et al*, 2011). Some sources attribute this to direct and indirect anthropogenic impacts, which include poaching, habitat destruction, and rinderpest (Seeber *et al,* 2012).

The social organization of giraffes is loose, temporary, and constantly changing, although past studies have noted evidence for habitat-related adjustments of occurring social structures and of particular behaviors instead of fission-fusion structures (Seeber *et al,* 2012). Overall, inter-individual associations among giraffes are low. In previous studies based in Namibia, 60% of giraffes reside in herds of three or less 60% of the time. Also, they are most commonly found solitary, especially males who are most likely in search of a mate (Fennessy, 2004). Sex differences in feeding behavior exist in order to increase the reproductive success of the individual (Young & Isbell, 1991). Females with young are most commonly found in areas with shorter trees and low density, whereas mixed groups (male, female and young) and females without young are found in habitats with an even mixture of tree species (Young & Isbell 1991). Open habitats provide

mothers with better views of potential predators of their young. Also, mothers often leave their young in search for nutritious food sources, where the young juveniles of 6-8 months form crèches, or nursery groups, so they are not at high risk in their mother's absence. Males feed based on competition for mates by feeding at higher heights to increase their vigilance and advertise their presence as a high-ranking male (Young & Isbell, 1991). Giraffe densities are considerably lower on communal lands compared to highly protected areas. This may reflect the impact of human encroachment and illegal hunting activities, along with environmental factors such as extreme arid conditions, limited forage resources, and low population carrying capacity in the area (Fennessy, 2004).

The justification for this study is that broad research on the Maasai giraffe has not been extensively conducted in the TME, and this research would give further information on the population dynamics of the Maasai giraffe. Demographic studies can show overall population performance, help understand population structure and recognize animal distribution and movement, which are all collectively important when regarding the conservation of giraffes. It is imperative to conduct a population dynamics study because of the area's rapidly changing environment outside and inside of the park. Along with climate change, land use changes in the region, such as the recent shift from pastoral lifestyle to agricultural, has the ability to affect the density, diversity, and habitat selection of species in an ecosystem as biologically diverse as the Tarangire-Manyara Ecosystem. The overall aim of the study is to compare giraffe population dynamics through age, sex and group structure across the Tarangire Manyara ecosystem. It is predicted that:

i. There will be sex segregation among giraffes in the Tarangire-Manyara ecosystem.
ii. The ratio of females to males will be higher overall in the Tarangire-Manyara ecosystem.
iii. The population of sub-adults and juveniles will be greater in fully protected areas compared to less protected areas.

Study Area

This study will be conducted in three different study sites within the Tarangire-Manyara ecosystem: Lake Manyara National Park (LMNP), Manyara Ranch (MR), and Tarangire National Park (TNP). Located on the edge of the Great Rift Valley escarpment of East Africa, the Tarangire-Manyara ecosystem, comprising of 22,000 square kilometers, is a typical African grassland savanna that is most well known for its large-scale seasonal migration of large grazing ungulates (Sachedina, 2006). The region has a semiarid and semi humid climate, and it receives varied rainfall from 375-1250mm per year with wet seasons lasting from November to December as well as March to May (Cohen, *et al* 1993). The ecosystem includes two national parks, LMNP and TNP, as well as other conservation areas, like MR.

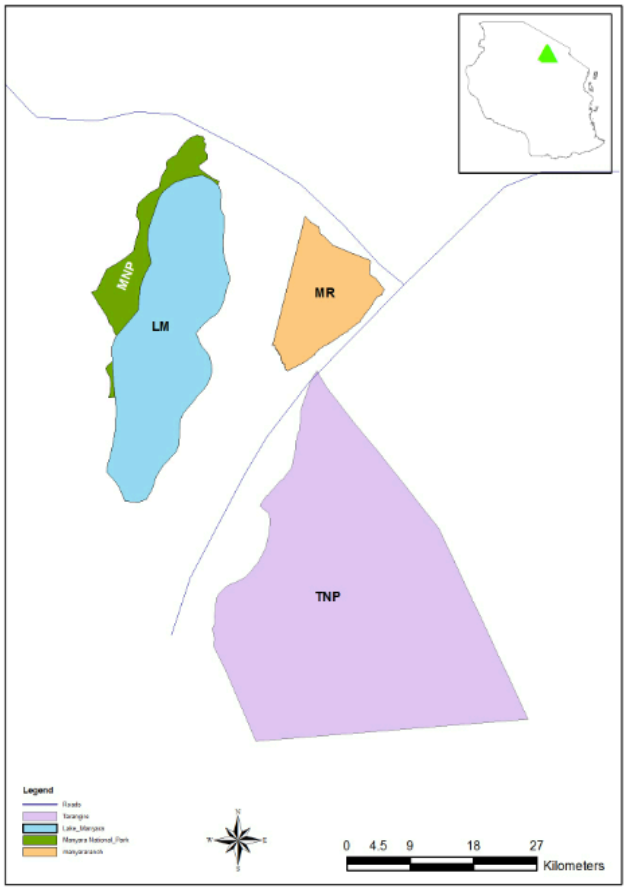

Figure 1. Study areas within TME.

LMNP covers 330 square kilometers and uniquely features a groundwater forest and a lake, which undergoes substantial expansion and retraction during wet and dry seasons. The lake is primarily fed by the Mbu River and Makuyuni River, and the lake

drains Pre Cambrian metamorphic and Neogene sedimentary and volcanic bedrock (Cohen, *et al* 1993). Serving as a dry season refuge, giraffe densities in Manyara are high compared to other areas within the Maasai ecosystem (van der Jeugd & Prins, 1999). TNP spans 2,850 square kilometers and is best known for its large populations of elephants, zebras, and wildebeests. The wildlife present in the park is provided with water by the Tarangire River, which crosses through the park and even in small quantity, serves throughout the dry season. MR, a trust land focused on conservation management as well as the improvement of local livelihoods, functions as a wildlife corridor for migratory species. The Ranch is highly suitable for livestock grazing and is increasingly being used by surrounding villages for this use (Lowassa, 2011).

Land use changes throughout the ecosystem have been occurring throughout the region and are all similarly affecting the three study areas. Human settlement has increased around protected areas, and rangelands have shifted from pastoral use to agricultural cultivation (Sachedina, 2006), all of which have strong contribution to insuralization of the national parks within the region.

Materials and Methods

Observations were collected daily for 9 days in November 2013 in three protected area for three days in each location: LMNP, MR, TNP. A group was defined as individuals that were less than 100 meters from another individual and were partaking in coordinated similar activities. An individual was studied if it was seen within 500 meters of the vehicle on the road (van der Jeugd & Prins, 1999). Background information was taken for each group: date, season, place weather, time of day, group type, total number of individuals, location (Garmin GPSmap 76Cx coordinates), and habitat type: bushland, grassland, or wetland. Additionally, the interspatial distance between individuals as well as the direction the individual is facing was recorded.

Demography

In order to determine the structure and dynamics of giraffe populations within each area, the sex and age of each individual was recorded. The sex of the individual was defined by the presence of male or female genitalia. If the genitalia was

not visible, or further verification was necessary, the sex was defined by color (Brand, 2007), where males are darker in color, or by the presence of additional horn-like protrusions on their skulls in addition to the two typical horns, which could be seen in males (van der Jeugd & Prins, 1999).

The age of each individual was classified into three categories: juvenile, sub-adult, and adult. Juveniles were estimated height under 2.5 meters and would usually be accompanied by a mother, sub-adults were estimated height between 2.5 and 4 meters, and adults were estimated height over 4 meters (Van der Jeugd & Prins, 2000).

Data Analysis

A Kruskall Wallis test was used to test if group size differed among location, habitat, and group type. Chi-square goodness of fit test was used to test if age-ratios and sex-ratios differed among the three protected areas and habitats within each area.

Results

Population structure

A total of 435 giraffes were recorded within the area. Of these, age and sex were determined for 348 giraffes (Table 1). Within LMNP, 155 giraffes were seen, 116 of which were sexed and aged (Table 1). The maximum number seen in one day was 64 giraffes. In MR, 193 giraffes were seen, 158 of which could be sexed and aged (Table 1). The maximum number seen in one day was 85 giraffes. Within TNP, 87 giraffes were seen, 74 of which could be sexed and aged (Table 1). The maximum number seen in one day was 34 giraffes.

The overall age distribution of giraffes combined among the three areas and within each park significantly differed from expected (Overall x^2=402.276, p<0.001; LMNP x^2=150.845, p<.001; MR x^2=176.367, p<.001; TNP x^2=76.243, p<.001). Adult giraffes (84%) combined comprised the greatest proportion of the population overall and juvenile (5%) were the least (Table 1). There was no significant difference between the population of juveniles and subadults and location (LMNP 13%, MR 17%, TNP 19%). Within each park, the cumulative age distribution was also skewed towards adults (LMNP 87%, MR 83%, TNP 81%).

Among the three areas combined, the cumulative ratio of female giraffes to male giraffes significantly differed from an expected even distribution, and it was overall skewed towards females (x^2=105.931, p<.001). The cumulative data showed that there was 3.46 times the amount of females (78%) than males (22%). Among the three areas combined, the cumulative ratio of juvenile giraffes to adult female giraffes significantly differed as well (x^2=170.468, p<0.001). Adult females (93%) outnumbered juveniles (7%) by 12.2 times (Table 3).

Table 1. Number of observed giraffes in different age class dynamics in LMNP, MR and TNP (11-21 November 2013).

Location	Juvenile	Subadults	Adults	Adult females	Adult Males	Total
LMNP day 1	3 (9%)	6 (17%)	26 (74%)	19 (54%)	7 (20%)	35 (100%)
LMNP day 2	0 (0%)	3 (9%)	37 (93%)	30 (75%)	7 (18%)	40 (100%)
LMNP day 3	3 (7%)	0 (0%)	38 (93%)	22 (54%)	16 (39%)	41 (100%)
LMNP (cumulative)	6 (5%)	9 (8%)	101 (87%)	71 (66%)	30 (26%)	116 (100%)
MR day 1	4 (9%)	9 (20%)	32 (71%)	22 (49%)	10 (22%)	45 (100%)
MR day 2	1 (3%)	3 (8%)	33 (89%)	24 (65%)	9 (24%)	37 (100%)
MR day 3	2 (3%)	8 (11%)	66 (88%)	55 (72%)	11 (14%)	76 (100%)
MR (cumulative)	7 (4%)	20 (13%)	131 (83%)	101 (64%)	30 (19%)	158 (100%)
TNP day 1	4 (12%)	5 (15%)	24 (73%)	19 (58%)	5 (15%)	33(100%)
TNP day 2	1 (3%)	4 (12%)	29 (85%)	21 (62%)	8 (24%)	34 (100%)
TNP day 3	0 (0%)	0 (0%)	7 (100%)	7 (100%)	0 (0%)	7 (100%)
TNP (cumulative)	5 (7%)	9 (12%)	60 (81%)	47 (64%)	13 (18%)	74 (100%)
Overall (cumulative)	18 (5%)	38 (11%)	292 (84%)	219 (63%)	73 (21%)	348 (100%)

Table 2. Female to male sex ratios of giraffes in LMNP, MR and TNP.

Location	Juvenile	Subadults	Adults	All Ages
LMNP day 1	1:0	1:0.20	1:0.37	1:0.29
LMNP day 2	0:0	1:0	1:0.23	1:0.21
LMNP day 3	1:0	0:0	1:0.73	1:0.64
LMNP (cumulative)	1:0	1:0.13	1:0.42	1:0.38
MR day 1	1:0	1:0.13	1:0.45	1:0.32
MR day 2	0:1	1:0	1:0.38	1:0.37
MR day 3	1:0	1:0.33	1:0.20	1:0.21
MR (cumulative)	1:0.16	1:0.17	1:0.29	1:0.27
TNP day 1	1:0	1:0	1:0.26	1:0.18
TNP day 2	1:0	1:0	1:0.38	1:0.31
TNP day 3	0:0	0:0	1:0	1:0
TNP (cumulative)	1:0	1:0	1:0.27	1:0.21
Overall (cumulative)	1:0.06	1:0.12	1:0.33	1:0.29

Table 3. Juvenile to Adult female ratios of giraffes in LMNP, MR, and TNP.

Location	Juvenile:Female
LMNP day 1	1:6.33
LMNP day 2	0:30.0
LMNP day 3	1:7.33
LMNP (cumulative)	1:11.8
MR day 1	1:5.50
MR day 2	1:24.0
MR day 3	1:27.5
MR (cumulative)	1:14.4
TNP day 1	1:4.75
TNP day 2	1:21.0
TNP day 3	0:7.00
TNP (cumulative)	1:9.40
Overall (cumulative)	1:12.2

Social structure

The average giraffe group size differed by location (Kruskall Wallis x^2=20.163, df=2, P<0.001). Group size average was greatest in MR (6.05 ±3.57SE) and was smallest in TNP (3.98 ±2.33SE). There was a significant difference between giraffe group size and habitat (Kruskall Wallis x^2=21.415, df=2, P<0.001). The habitat with the most groups was bushland (63%), but the habitat with the highest group size average was grassland (6.57 ±4.05SE). There was a significant difference between giraffe group size and group type (Kruskall Wallis x^2=134.893, df=2, P<0.001). The group type with the greatest group size (6.91 ±3.24SE) was mixed groups (50%). Male groups (7%) had the smallest group size (1.50 ±1.14SE). Female groups (43%) had a mean group size of 3.41 ±2.17SE. The mean cumulative group size for all group types among the three areas was 5.02 ±3.34SE. There was no significant difference between group type and habitat (x^2=5.585, df=4, P=0.232). There was a significant difference between giraffe group type and location (x^2=11.588, df=4, P=.021). The dominant group type in each area was mixed (52.8% LMNP, 57.1% MR, 33.3% TNP). The least prevalent group type in each area was all male (7.4% LMNP, 6.4% TNP, 9.3% TNP), and female groups comprised 42.4% of the overall combined population for all three areas.

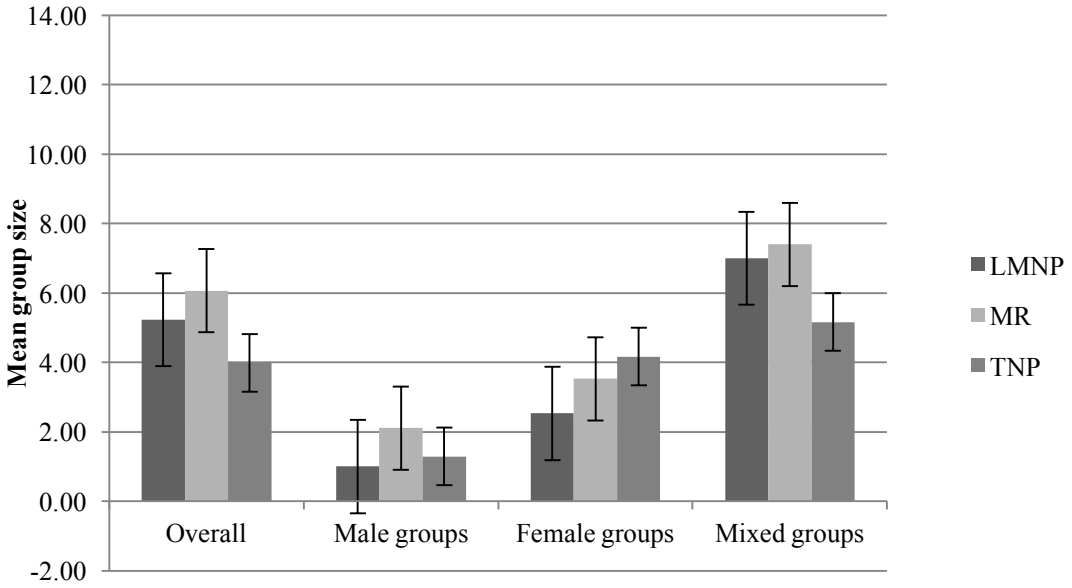

Fig. 1 Mean group sizes of giraffe male groups, female groups and mixed groups in LMNP, MR an TNP (11-21 November 2013).

Discussion

The results suggested that there was sex segregation among giraffe populations in the Tarangire-Manyara ecosystem. Due to the presence of male and female groups, it is clear that separation between sexes exists. Even though the presence of sex groups exists, mixed groups are the dominant group type within the ecosystem. This intermediary assemblage could be explained by comparing it to typical ungulate social organization patterns, where one or several males defend a group of females and young against other males, or a harem system (Van der Jeugd & Prins, 2000).

Although mixed groups occurred the most often and had the largest group size among the three group types, group size for all female groups was significantly larger than all male groups, which is consistent with Van der Jeugd and Prins' study (2000). Group size in this study was almost double the previous study based in Namibia (Fennessy, 2004), but this is most likely due to the difference in location and subspecies of giraffe. The large group size of females may be due to the overall high ratio of females to males within the parks. A high density of females may be a strong indicator for good population performance because of the increased amount of available reproductive individuals, but other findings contradict this implication. The extremely large population

of adults, especially adult females, compared to the population of juveniles is distressing when formulating population performance because of the apparent lack of reproductive success and persistence of future giraffe populations.

There are several indicators that give reason to the age discrepancy. The average group size and density of giraffes in a given area or habitat has increased since Van der Jeugd and Prins' study (2000), and this could reveal that the concentration of resources is not evenly dispersed within the area, especially Manyara ranch where average group size was largest among the three areas. With an uneven dispersal of resources comes a high concentration of individuals in certain areas, which increases competition for resources, leaving the carrying capacity of the habitat lower than what suits the needs of the population. With an unfit carrying capacity of resources, the overall fitness of the giraffe will decrease, and the success of reproduction will also decrease. Similar results occurred in 1984 when the giraffe population crashed due to reduced browse availability following a prolonged drought (Sinnary, 1998). The results differ from previous studies and showed that there was no preference for habitat based on sex, where in Young and Isbell's study (1991) revealed that females prefer low tree density vegetation. This may differ because of the low ratio of juveniles to adult females, where females do not have to look after their young, or a higher population of young in general. It could also be possible that calving abundance is lower in the dry season compared to the wet season, when more resources for forage and cover are available.

The low proportion of juveniles to adult females in this study was similar to the study done in Nairobi National Park in 1966. Assuming that giraffes give birth every two years, the low number of juveniles indicates that there is a high mortality rate of young of a low birth rate (Foster, 1996). Since the population of young (juvenile and subadult) was not linked to location, the survival of young giraffes could be linked to the presence and level of predation risk of other species, including humans, for most young giraffes usually do not survive past their first year (Sinnary, 1998).

A study in the Serengeti discussed the notion that young giraffes are prone to predation, especially lions, in dense habitats where the lion can approach giraffes unnoticed (Marealle *et al*, 2010), which may also account for low population of young in the current study. Although the results differed from Sinnary's (1998) juvenile to adult

ratio, similar reasoning regarding the presence of lion predation defends the proportion. The both studies in the Serengeti (Marealle *et al*, 2010) and Manyara Ranch Limited (Sinnary, 1998) also had similar results regarding sex ratios. In the Serengeti, the proportion of females across ages ranged from 62.1% to 67.2%, which was attributed to the illegal hunting of males in high risk areas. With such similar ratios, it might be assumed that similar poaching practices are taking place within the three study areas, which results in an extremely female-skewed sex proportion.

Management and research recommendations

In order to improve the study, the study should also be performed in the wet season in order to obtain annual information and note any differences in social dynamics between seasons. Since individuals were not differentiated and park maximums were not used, it is likely that repeated observations were performed due to the analysis of the population as a combined or cumulative group. In the future, individual identification would benefit in order to reduce double counting as well as tracking whether herd structures are comprised of the same individual in separate observations. Individual identification would also help in further studying the population performance of the giraffe population in the Tarangire-Manyara ecosystem by studying activity patterns and body condition of individuals and applying the results to further the investigation. Vegetation sampling of biomass and species density overtime annually and by season would be recommended in order determine if the resources in the area are changing, and how that effects the giraffe population in the Tarangire-Manyara ecosystem.

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