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Seeing Stripes: A Study of How Dominance Rank Within a Herd of Resident Burchell's Zebra (Equus Burchelli) at Ndarakwai Ranch Correlate to Frequencies of Other Behaviors.

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Acknowledgements

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Abstract

Zebra are highly social ungulates that live in harems with a dominance hierarchy. This study attempted to determine if dominance rank within a herd of Burchell's zebra (*Equus burchelli*) correlated to frequencies of other behaviors. It was predicted that adult zebra would display the most vigilance, with vigilance decreasing with dominance rank. This study took place at Ndarakwai Ranch in the west Kilimanjaro basin of northern Tanzania from 11/7/10 until 11/22/10. Scans (n=199), follows, and all-group observations were used to collect data on opportunistic sightings of Burchell's zebra. Zebra were categorized into five age classes: stallion, adult females, sub-adults, juveniles, and infants and behavior was recorded in frequency tables. Pie-charts were used to display each age class and its percentage of each behavior, which included moving, feeding, resting, vigilance, and other. Chi-squared (α=0.05, df=4) was used to compare all age-classes to every other age-class using a critical value of 9.488. Eight statistically significant results were produced between age-class comparisons. It was found that within these eight age class comparisons, behavior was not independent of dominance rank. The two age-class comparisons that did not reject H_0 were found to be in comparison to infants, who were not observed for very long periods of time. The hypotheses formulated before the study were found to be true, with the stallion most often located on the periphery of the herd and displays of vigilance decreasing as dominance rank decreased. It seen that as the number of zebra in the proximity increased, vigilance decreased through all age groups, and more playful behavior was seen. Variables such as habitat and proximity to other herds of mammals were seen to have no effect on zebra behavior.

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Introduction

The plain's or Burchell's zebra (*Equus burchelli*) is arguably the most successful member of the horse family, equally suitable for both a savanna biome as well as tropical climates. The plains zebra are striped ungulates that are adapted for grazing in a number of different habitats. There is very little sexual dimorphism seen in the plains zebra, although males are sometimes 10% larger than the females (Estes 1991). The zebra is a member of the non-ruminant family and spend the majority of their day eating, sometimes spending up to 60% of their day grazing. Burchell's zebras often prepare the vegetation for the wildebeest they are often seen with.

Differing from the Grevy's zebra that exist in the north, plains zebra are socially organized into a harem, with one dominant stallion. This type of organization works best when resources are equally distributed, and resource defense is not needed. Males therefore defend their harem, rather than a territory. Even if the dominant zebra is replaced within a herd, female zebra will still tend to stay together. This is unique from other zebras because as long as the stallion is fit, his status within the herd is usually never challenged. If a stallion becomes old or ill, a new bachelor will begin to follow the harem and slowly pushes the aging stallion out. The process is gradual and no physical fighting takes place.

Social organization in Burchell's zebra is fairly easy to determine; the filing order in which the zebra travel in is correlated to their rank with in the herd. The stallion brings up the rear, with the most dominant female leading the herd. Her offspring follow her, which are then followed by the next dominant female and her offspring, and so on (Estes 1991). The stallion will sometimes take the lead if necessary, oftentimes when the herd is threatened by an intruder. Zebra foals leave the harem during adolescence. The males join bachelor herds until they reach sexual maturity, around the age of 5-6. Females are often abducted to other harems when they reach sexual maturity (Estes 1991). Bachelor herds usually consist of 2-15 zebras that are ranked according to age within their small herd. Most of their time is spent engaged in mock challenges and playful behavior with each other. At around the age of 5-6, the bachelors will leave their small herd and go searching for a filly that is in heat. With this filly, the bachelor will begin to start his own harem.

Currently, the biggest threat to both migratory and resident zebra is loss of habitat through both natural and man-made means. The inevitable road that will be paved through the Serengeti could potentially have catastrophic effects on the migrating herds of mammals, which include Burchell's zebra along with the more famous wildebeest migration. Natural disasters

such as fire can also lead to habitat destruction because fire destroys the zebras' main food source. Poaching is usually not a problem for zebra in Tanzania, as they are not often targeted. In addition, my study site has a well-established poaching control unit that works year round to ensure the safety of both resident and migratory animals.

The plain's zebras at my study site consisted of both migratory and resident herds. The migratory herds use the private game reserve as a wildlife corridor to reach many other game reserves and national parks in the area. I chose to study a resident herd of Burchell's zebra that live in my study site year round. Specifically, I examined how dominance rank within a herd of resident zebra correlated to frequencies of other behaviors. The variables I measured were age of zebra (adult, sub-adult, juvenile, infant), type of behavior, habitat type, proximity to other zebras within the herd (distribution/aggregation), and proximity to other herds of mammals. Behavioral categories were listed as moving, feeding, resting, vigilance, and other.

I hypothesized that adult zebras will display the most vigilance, with vigilance decreasing as dominance rank goes down, and juveniles/infants displaying the most feeding and playful behavior. I also predicted that the dominant male will be the farthest away in terms of proximity to the center of the herd.

Study Site Description

This study took place at Ndarakwai Ranch, a private game reserve which is managed and owned by Peter Jones. Ndarakwai is located in the West Kilimanjaro Basin of Northern Tanzania. The game reserve is bordered by Amboseli National Park in Kenya to the northeast, Kilimanjaro National Park to the east, Longido Game Controlled Area to the northwest, and Arusha National Park to the south (Bohrman 2007).

During Tanzania's colonial period, when the country was ruled by the British and Germans, Ndarakwai was used mainly as grazing land for Maasai cattle herds. After Tanzania's independence in 1961 and Julius Nyerere's rise to power, Ndarakwai was converted into a plantation used for growing wheat and barley. Rights to the land were given to Tanzania Breweries Ltd. However, the intense farming on the land led to extreme soil degradation, and the land was unsuitable for any further agricultural use. In 1995, Peter and Margot Jones bought the 42-square kilometer piece of land and turned it into a private game reserve (Bohrman 2007). Very importantly, they also established an anti-poaching patrol that has been crucial in establishing Ndarakwai as an important wildlife corridor, especially with mammals coming down from southern Kenya. Ndarakwai has been labeled as a success story in terms of how privatization of land has contributed to increased conservation, because most conservation efforts are run by the government.

Today, Ndarakwai is now home to many species of migratory as well as resident species of mammals, including a couple herds of resident zebra. The many differing ecotones that Ndarakwai houses, such as grassland, riverine, savannah, woodland, and forest, also contribute to overall species diversity as well (Bohrman 2007). In addition, the soil quality has since recovered from the state that the Joneses found it in. Because cattle are not allowed to graze in Ndarakwai, no continuous grazing is seen. The grasses are allowed to recover when the migratory animals leave, allowing soil quality to improve as well. However, the Maasai are often seen trying to illegally graze their cattle on Ndarakwai's land (personal observation) which has led to some conflict within the surrounding area. Ndarakwai's anti-poaching has stationed *askaris* on lookout that help keep poachers out, as well as keep an eye out for Maasai livestock.

With the formation of Mount Kilimanjaro nearby also came the formation of many smaller mountains within Ndarkwai such as Lotigeli, Pasironga, Kilimatembo, Gawanya, and Magadini. Because of these mountains, a large deal of climatic variation (Knight 2000) has been seen in Ndarakwai. This study was conducted during the short rainy season. Almost everyday

intense short rains were seen all over the ranch, usually lasting no more than two hours. However, the weather was known to fluctuate greatly over one day, from cloudy to sunny to rainy within a couple hours.

Ndarakwai is crucial as a study site because it contains resident zebra herds during both the wet and dry seasons. Because the game reserve also contains other herds of resident mammals, such as impala and eland, the study site is also important in determining how proximity to other herds of mammals may affect zebra behavior. Ndarakwai allowed me the freedom to walk around on foot each day, and was helpful because the anti-poaching unit had radios that were used to determine where the resident herds were at any time of day.

Study Site Map

Methods

The sampling frame used in my study was herds of resident zebra at Ndarakwai Ranch. My sample population was any one of the resident herds, which was limited to opportunistic sightings. Because the short rains had started, the herds were dispersing farther away from the main watering hole. They now had other water sources available to them, so it was not possible to follow one herd for the entirety of my study. Originally, my study was to focus on a complete herd of zebra, both females and males, and not include data on any bachelor herds of males. However, because the zebra populations were so low, I collected data on any individuals I came across.

Data was collected from 8:00am until 1:00pm every day. Every other day I collected data in the afternoon as well, usually from 2:00pm until 5:00pm. The short rains often dictated when I collected data in the afternoon, because I could not write when it was raining. Data was collected for 15 days from November 7-22, with one day being used as a rest day.

I used three different methods to collect data on my sample population. The most common method I used was scans, although I also used follows and entire-group observations. When I located a herd of zebra, I would allow the first five minutes of my data collection to write down my location, weather, proximity of herd to other mammals, how many individuals were in the herd, and what type of habitat they were found in. Weather was not a variable but was recorded because it rained every day and often affected when I could perform scans. Depending on if they zebra were fairly stationary or not, I would begin scans that were five minutes long. Oftentimes I was not able to keep the times between scans consistent. This was because the zebra were often moving too quickly, and I decided to get as many scans in as I could before they ran off again. When the zebra were more quiet and stationary (either eating or resting), I made sure all my scans were five minutes long, with five minutes in between each scan to record more detailed behavior.

Most observations were made through binoculars because I was not able to get close enough without scaring them away. I made note of every time I changed position as well because the herd would almost always become vigilant. I would allow them two minutes to calm down before I started up scans again, in order to compensate for myself as a bias.

I recorded all of my data in a field notebook, and frequencies of behaviors were noted in tables that I made for each scan. The tables consisted of age-class, (stallion, female adult, sub-adult, infant), and tally marks for how many times that individual performed a behavior within each five-minute scan. The behavioral categories consisted of Moving, Feeding, Resting, Vigilance, and Other. Behaviors such as playing, kicking, and biting were put under "Other" (see Appendix 2 for behavioral definitions). Each time an individual changed behavior, a new tally mark was made in the appropriate category. This explains why I often had more tally marks for the number of individuals present in each scan. Between scans, I took detailed notes on overall group movement, what behaviors may have been directed at another individual, each individual's position within the herd and proximity to the stallion, and if any other herds of mammals affected behavior. At the end of each day, the tables were transcribed into an Excel spreadsheet into frequency tables for each age-class.

When I was not able to complete scans on my herds, I chose to do overall group observations. This was often used when many zebra were present, oftentimes forty or more. I used this method when I was making observations at the watering hole, where scans were almost impossible to complete because of the rapid movements made by many tightly clumped individuals.

For all-group observations, I would take notes on everything that related to dominance, noting especially what order the zebras were drinking in or who was fighting for a position to drink. This method was also used when the zebra were moving away from me. When there was only one herd in sight I was forced to follow them and was not able to get scans while moving. I took the opportunities when they stopped for a second to write down as much information as I could. Overall group observations were also used when dominance rank was hard to determine. Oftentimes, I was not able to get physical confirmation on a stallion, and did not want to complete scans where I was unsure of dominance rank. Group observations helped me in determining dominance ranks within the herd because I could closely monitor group distribution and aggregation which often gave insight into dominance ranks.

Follows were also used in my data collection. Follows were only done in two instances, where the only zebras I was able to find were two stallions. Because the bachelor herd was so small, it was easy to follow each individual and determine dominance rank between the two. For the follows I wrote down every change in behavior for each of the two stallions, noting the time at each behavioral change. Scans were also done on the two stallions as well.

Results

Throughout data collection, it was determined that the stallions were consistently dominant over the females, adult-females dominant over sub-adults, sub-adults dominant over juveniles, and juveniles dominant over infants. The most common type of zebra groupings found contained a stallion and many females in a harem, with sub-adults, juveniles, and infants less common. Stallions and adult females had the highest total number of behaviors seen (see Table 1.0).

Table 1.0. Frequencies of Behaviors Seen in Individual Age Classes.

Age Category	**Resting**	**Feeding**	**Vigilance**	**Movement**	**Other**	**Total**
Stallions	63	78	134	69	10	**354**
Adult Females	478	312	247	367	21	**1425**
Sub-Adults	28	14	14	39	12	**107**
Juveniles	25	4	0	12	3	**44**
Infants	5	2	1	0	0	**8**
Total	**599**	**410**	**396**	**487**	**46**	**1938**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Frequencies were put into percentages by age class and behavior. It was found that the stallions displayed the highest frequencies of vigilance, 37.85% (134/354) and almost half the amount of resting (17.80% or 63/354) that adult females did. Adult females were found to spend 33.5% (478/1425) of their time resting and 25.75% (376/1425) moving. Sub-adults spent the most time moving at 36.45% (39/107), while infants were seen to have no movement. Juveniles had the least amount of time spent feeding at 9.10% (4/44), and were seen to display no vigilance.

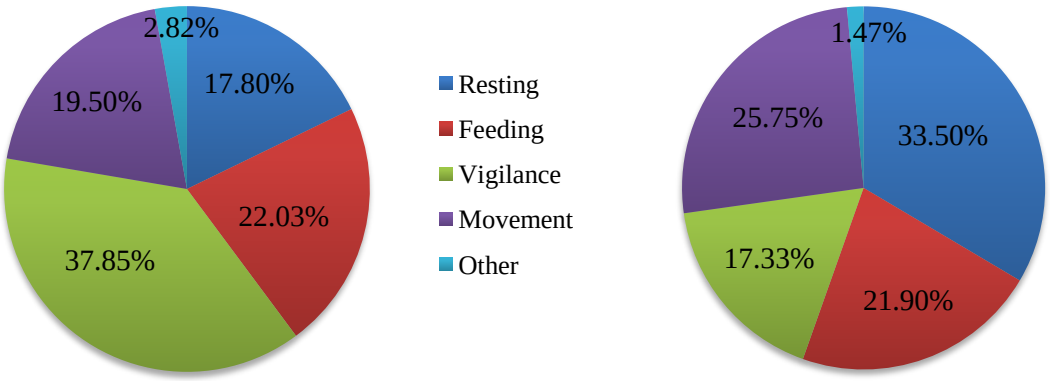

Figure 1.0. Percentages of behavior seen in stallions and adult females. This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

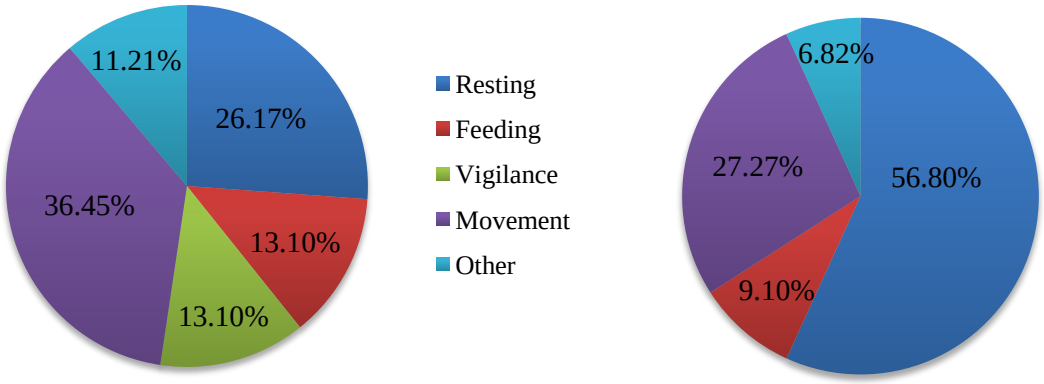

Figure 2.0. Percentages of behaviors seen in sub-adults and juveniles. This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

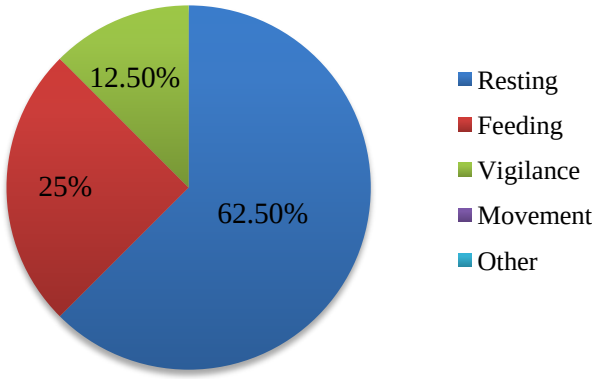

Figure 3.0. Percentages of behaviors seen in infants. This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

The table below (Table 2.0) shows the results of chi-squared tests to see if any significance existed between dominance ranks. The null hypothesis (H_0) was that behaviors are independent of dominance rank. Expected frequency values for all age classes and frequency tables can be found in Appendix 1. Eight age classes rejected the null hypothesis and are statistically significant.

Table 2.0. Results of Chi-Squared

α=0.05, Df=4, critical value=9.488	Reject H_0?
Stallions/Adult Females, X^2= 86.46	Yes
Stallions/Sub-Adults, X^2= 44.07	Yes
Stallions/Juveniles, X^2= 49.85	Yes
Stallions/Infants, X^2= 11.50	Yes
Adult Females/Sub-Adults, X^2= 54.58	Yes
Adult Females/Juveniles, X^2= 25.04	Yes
Adult Females/Infants, X^2= 4.31	**No**
Sub-Adults/Juveniles, X^2= 14.39	Yes
Sub-Adults/Infants, X^2= 7.98	**No**
Juveniles/Infants, X^2= 9.93	Yes

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Two days of data were also taken on a small bachelor herd of two stallions.

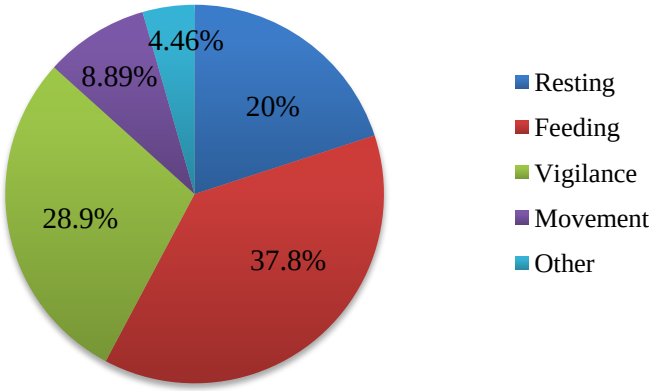

Figure 4.0. Percentages of behaviors seen in Stallion #1**.** This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

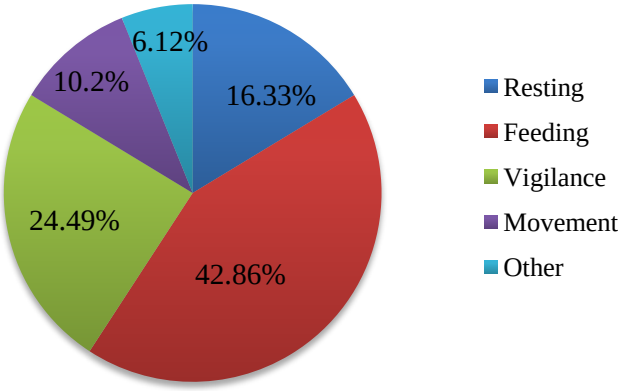

Figure 5.0. Percentages of behaviors seen in Stallion #2**.** This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 3.0. Frequencies of Behaviors Seen in Two Adult Males

	Resting	**Feeding**	**Vigilance**	**Movement**	**Other**	**Total**
Stallion # 1	9	17	13	4	2	**45**
Stallion # 2	8	21	12	5	3	**49**
Total	**17**	**38**	**25**	**9**	**5**	**94**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

It was found that Stallion #1 displayed a higher percentage of vigilance at 28.9% (13/45), but less time feeding (Figure 6.0). Stallion #2 showed higher percentages of moving and other behaviors, such as playing and kicking. Expected frequencies can be found in Appendix 1. When chi-squared was applied (α=0.05, df=4), it was found to be 0.662. The null hypothesis is not rejected and still holds true.

Discussion

The results of this study show that statistical significance (α=0.05) exists between behavioral frequencies and dominance ranks in some age classes. The sampling frame used was herds of resident zebra at Ndarakwai Ranch. The sample population was any one of the resident herds, which was limited to opportunistic sightings. The main variable analyzed was age of zebra and their relative dominance rank within the herd. The other variables were found to have very little effect on zebra behavior, but are mentioned in the discussion.

Groupings of zebra were often consistent from day to day. Stallions were seen in association with females on all occasions but two, when the small bachelor herd of two individuals was seen. On days where only one type of zebra grouping could be found, more data was collected on stallions and adult females because younger zebra were not present. This explains why sub-adults, juveniles, and infants have the lowest frequencies of behaviors (see Table 1.0).

Pie charts were made with frequencies of behaviors. It was hypothesized that adult zebras would display the most vigilance, with vigilance decreasing as dominance rank goes down, and juveniles/infants displaying the most feeding and playful behavior. Stallions were seen to have the highest percentage of vigilant behavior at 37.85% (134/354) (Figure 1.0), with percentages decreasing as dominance rank went down. Juveniles were seen to have the highest frequency of "other" behaviors (see Figure 2.0) which included playing, biting, and kicking, and which supports my previously made hypothesis.

However, infant zebra were seen to have higher vigilance than juvenile zebra (Figure 2.0 and Figure 3.0). This is mostly likely due to the fact that both of these age-classes were not observed for very long periods of time. The juveniles were seen with their mothers, occasionally grazing farther away with other adult females. The juveniles were also seen at the rear of the herd while moving, meaning they had one of the lowest dominance ranks (Estes 1991). The infant zebra did not leave its mother's side, and when resting the mother stood guard over it, which explains its lower amount of vigilance compared to the other age-classes.

Stallions displayed the most vigilance out of all the age-classes. The stallion holds responsibility for his herd, and is therefore more likely to be on the lookout for predators and spend less time resting, which can be seen in Figure 1.0. Less vigilance was seen when the herd was seen in association with other zebra herds however. When the herd was alone, the stallion was always seen bringing up the rear and displaying vigilance anytime I moved.

However, when seen with other zebra (sometimes up to 80 individuals), the stallion was often less vigilant and engaged in more social behaviors. It was also noticed that stallions from different herds intermingled and engaged in playing behavior when more zebra were present. On three occasions, stallions were seen biting and playing together, either with another stallion or an adult female. They would run and chase each other, stopping only to bite at each other's flanks and run in a tight circle (see Appendix B for behavioral definitions). This behavior was not observed when a solitary herd was found.

The comparison of the two bachelor stallions shows that Stallion #1 was seen to have a slightly higher percentage of vigilant behavior than that of Stallion # 2 (see Figures 6.0 and 7.0). Stallion #2 was seen to show higher displays of resting and feeding. Stallion #1 was labeled as "1" because I hypothesized that he was the more dominant stallion.

Chi-squared (α=0.05, df=4) was run on a comparison of all-age classes in relation to each other. Statistically significant results came from comparisons of all age classes except adult females to infants, and sub-adults to infants.

Although both stallions and females were the most dominant members of the herd, when chi-squared (α=0.05, df=4) was applied, it was found that their frequencies of behaviors was statistically significant. This is due to the fact that although percentages of behaviors were often similar, stallions were found to switch behaviors much more often than adult females. When vigilant, adult females were found to return to grazing or resting much quicker than the stallion. The stallions often switched back and forth between grazing and vigilance, or resting and vigilance, and were seen to proportionally display more vigilant behavior.

The comparison of stallions to sub-adults, juveniles, and infants were all statistically significant as well, meaning that behaviors were not independent of dominance rank. This is most likely due to the large age difference between age-classes. Stallions are responsible for their herd and will display more vigilance. If more time is devoted to vigilance, less time can be devoted to other activities such as feeding and resting. The same explanation can be given for the comparison of adult-females to the other age classes (with the exception of infants). The adult zebra are more likely to be vigilant and engage in less social behavior than the younger age classes. The same can be said about feeding; because younger zebras do not have to allocate as much time to vigilance, behaviors such as resting and feeding are seen to be higher.

The comparison of adult females to infants is surprising. Adult females are prone to be more vigilant because of their age, while the infants should display more feeding behavior.

However, an infant was only observed for one day, while adult females were observed for every day of data collection with the exception of two. This may have caused data to become skewed because although infants had much lower frequencies in all age-classes in comparison to adult females (see Table 1.0), the relative percentages were similar and even seen to be higher in some behavioral categories, such as feeding. More data would need to be collected on infants over a longer period of time in order to truly assess the relationship between dominance rank and frequencies of behavior between the two.

The comparison of sub-adults to juveniles was found to be surprising because the similarity in age should have accounted for similar behaviors, but chi-squared revealed that behaviors were not independent of dominance rank. This may have been because juveniles were seen to display no vigilance, while sub-adults did. Juveniles were also seen to display less feeding time than sub-adults, possibly because all juveniles were still seen nursing from their mothers and not feeding on grass as much.

The comparison of sub-adults to infants was not found to be statistically significant. This is not surprising because both age classes were lower in age than the stallions or adult females, and are more likely to display similar frequencies of behaviors in all categories. The infant had no need to be as vigilant as the adult females because they often had their mothers watching over them. Sub-adults were seen displaying playful behaviors the most, and less time was given to displays of vigilance as well.

The comparison of juveniles to infants was also surprising, because they are the most similar in age and should therefore display similar behaviors, following the trend shown by the other age classes. Again however, because infants were not observed for long periods of time, data may have affected the significance of the chi-squared test. It was also seen that infants showed no moving behavior, while juveniles did, which could also account for significance. Infants were also seen to show vigilance behavior, whereas juveniles were seen to display no vigilance at all.

Chi-squared (α=0.05, df=4) was also used to determine if dominance rank played a role in behavioral frequencies between the two bachelor stallions. There was seen to be no correlation between the more dominant stallion, Stallion #1, and the frequencies of behaviors seen in the less dominant stallion, even though Figure 6.0 supports the hypothesis that a more dominant individual would display more vigilance. In the comparison of all age-classes, vigilance was a large factor in determining dominance levels. This may have been because both stallions were

similar in age and therefore displayed similar behaviors. Stallion #2 appeared smaller in size and younger in age, and was the reason I originally hypothesized that he was the less dominant stallion. Both stallions were also not responsible for a herd and may be the reason that overall vigilance for both bachelors was less than stallions seen with a herd of females (see Figures 1.0, 6.0, and 7.0). With no females or young to look after, the bachelor stallions could allocate more time to feeding and resting.

Stallions and adult females were more likely to show "dominance displays" (see Appendix B for definition) in the area around the waterhole, although this was not included as a category in the ethogram. This behavior was most often seen in the form of biting and chasing away less dominant members of the herd who were competing for a place to drink. The stallion was seen drinking first, with dominant females coming next. Sub-adults were seen to drink last and were often chased away by more dominant members of the herd. Some individuals were observed to not have drunk at all, which I hypothesized were the members of the herd with the lowest dominance ranking.

Affection was seen between stallions and adult females when the group was in association with other herds. Affection (see Appendix B for definition) was observed several times in stallions, but more frequently between adult females, and a mother and her young.

Habitat type was one variable measured and was found to have no effect on zebra behavior, and was therefore not included in results. Behavior was not seen to differ whether the zebra were seen in scrubland or grassland, and were not observed in any other type of habitat. Most frequently, the zebra were found in a small valley bordered by three mountains. The landscape had been recently burned from an uncontrolled fire and new shoots of green grass were starting to crop up with the arrival of the short rains. All times a herd was seen in association with other zebra herds, they were seen in this habitat.

Proximity to other mammal herds seemed to affect zebra behavior minimally and is the reason why this variable was also not included in the results. On many occasions, a lone wildebeest was seen grazing with the herd and moving with them. The zebra usually did not take notice, except for one occasion where the wildebeest displaced the stallion, standing in exactly the same spot the stallion had been. This was the only time the stallion had backed away from any other mammals. The females were occasionally seen moving off to the side when eland were seen passing through the herd, but did not become vigilant. Spooking behavior was seen a couple times, mostly due to birds or warthogs rapidly moving away, especially at the watering hole.

Whenever a spook was observed, the stallion and adult females often became vigilant for a couple seconds right after the occurrence. However, the number of spooks that occurred in the herd was so little that it did not affect overall vigilance percentages.

Within the herd, stallions were almost always located on the periphery, while females were seen clumped and centrally located. The stallions would often stand vigilant off to the side while the females grazed or rested. The females were able graze more frequently because the stallion would be watching over the herd, which explains higher display of vigilance from the stallions. When moving, the stallions were almost always bringing up the rear of the herd, while initial movement within the herd started from the dominant female at the head of the group. During movement, the stallion also displayed the most vigilance, because most movement was made to either walk away from me or some other disturbance. On one occasion, the stallion was seen to lead his herd, but this was only seen when the zebra were frantically running away from a Land Rover that had come too close.

The adult females were almost always seen clumped in groups of three or four while grazing or resting. Very frequently females would rest with another individual and stand with their bodies parallel and heads facing opposite directions. This has social implications because zebras, as well as horses, often stand like this to keep flies out of each other's faces. A stallion was only seen to do this once throughout all 199 scans, and was seen resting with another female. Because females were seen displaying this resting position so frequently, the behavior also became helpful in identifying adult females. Females would also rest with their heads over another female's back or neck. This was most commonly seen between the juvenile and its mother, and never observed in stallions.

Females were also more likely to rest lying down; again a stallion was only seen resting lying down once, and the infant was seeing lying down the majority of its time resting. The females would often rest on the ground with one or two females standing over them. When resting, the stallions were frequently on the periphery of the group seen alone, while the females were clumped in groups of three or four.

Limitations and Recommendations

The biggest limitation I came across in doing my study was finding a zebra herd each day. Some days, I had to walk for two or three hours before I found any zebra, so observer fatigue was an issue. Tracking wild herds is not easy, and I recommend any studies done at Ndarakwai utilize the many askaris that are available to help. Another limitation I came across was my ability to sex zebra, even through binoculars. There were some days when I would take scans for an hour before I realized I had wrongly identified the stallion. It is *very* hard to identify the stallion by behavior alone, so I would often need to wait for physical confirmation. If I was unable to find the stallion, scans were essentially useless as well because I could not differentiate between dominance ranks.

Physical obstructions also often hindered data collection, as well as the presence of a bull elephant in musth. If the zebra were behind trees, I was not able to complete scans if only part of the herd was visible.

It would be interesting for possible future studies to use my study question but become more detailed, such as focusing on what role the stallion plays within the herd. I also realized early on that it is almost impossible to determine dominance rank of females unless they are moving in a single file line. Because of this, it would have been easier to rework my study question to focus more on one dominant individual instead of the entire herd.

Another recommendation would be to re-do this study during the wet season, when more herds of mammals are present. It could be interesting to see how an increase in other mammal herds affected the zebras' behavior.

Conclusion

The findings in this study were limited to opportunistic sightings of Burchell's zebra over a sixteen day period. The hypotheses formulated at the beginning of this study turned out to be correct. Adult zebra displayed the most vigilance, with vigilance decreasing as dominance rank decreased as well. It was also predicted that the stallion would be located on the periphery of the herd, which also turned out to be correct. The stallion was only found to be centrally located when many other herds of zebra were present and when seen associating with other stallions.

Chi-squared (α=0.05, df=4) was used to assess the relationship between age-classes. Except for two age-class comparisons (adult females/infants and juveniles/infants) all other age-class comparisons were found to be statistically significant. This meant that dominance rank correlated positively with frequencies of other behaviors. The most dominant individuals (stallions) were seen to have more displays of vigilance than any other age group, while the least dominant individuals (juveniles and infants) were seen to display the most resting behavior.

Two age-class comparisons were found to have no statistical significance: adult females/infant and sub-adults/infants. The comparison between adult females and infants was a surprising result because the difference in age was so great, but infants were only observed for one day, which may have skewed data. Surprising results also came from the comparison of sub-adults to juveniles, for the reason that those age-classes were similar in age and should have displayed similar frequencies of behaviors, but were found to be significant. Sub-adults and infants rejected H_0 because the similarity in age meant that similar behaviors were seen and that behaviors were independent of dominance rank.

It also was noted that as the number of zebra in the proximity increased, vigilance decreased through all age groups, and more playful behavior was seen. In juvenile zebra, no vigilance was seen at all.

When resting and feeding, adult female zebra were seen to clump together while the stallion tended to be more solitary. Proximity to groupings of other mammals was found to slightly increase behaviors such as vigilance and spooking, while habitat was found to have no effect on zebra behavior.

Citations

Bohrman, J. SIT:TZE Spring 2007. The Bachelor Life: A study of social and dominance relations among resident male impala (*Aepyceros melampus*) of Ndarakwai Ranch.

Estes, R. 1991. The Behavior Guide to African Mammals. Russel Friedman Books, South Africa.

Knight, E. SIT:TZE Spring 2000. Walking in Ndarakwai: A Study in GPS Mapping.

Zar, J. 199. Biostatistical Analysis. Prentice Hall, New Jersey.

"Nuts and Bolts"

Travel: Traveling to Ndarakwai often takes the majority of the day because you have to switch buses a couple times. Take a bus from Arusha to Boma N'gombe, then take a dala-dala to Sanya Juu, and finally another dala-dala to Ngare Nairobi. You will have to take a taxi to Ndarakwai Ranch (ask to go to reception) from there, and be prepared to pay 12,000 Tsh for the taxi ride!

Accommodations/Food: Be sure to get in contact with Peter Jones, who owns Ndarakwai. He will have to approve your project before you can begin, and you will need to make a $100 "donation" to Ndarakwai in order to stay there for ISP. Peter's number is 0786293387. Be very gracious to him and make sure to thank him every time you see him around Ndarakwai. He will really help you out if you are nice. Myself and another student camped outside Thomas's house, who is the assistant manager. His number is 0784895542. His maid Bahati cooked all of our meals and washed all of our laundry for only 4,000 Tsh per day. You will have to pay for the cost of food as well. Bring lots of chocolate, phone minutes, peanut butter, or anything else you think you would need because you won't be able to buy any of that once you are at Ndarakwai. Amenities are basic, with a squat toilet and bucket showers. We were also able to use electricity at the tented camp to charge our phones, Ipods, and computers.

Askaris: You have to get an askari to walk around Ndarakwai; they cost 10,000 Tsh per day, but their knowledge is invaluable. I recommend Meyshack, who helped me find zebra each day. It's a good way to practice Swahili as well.

Appendix A: Expected frequencies for all age classes and frequency tables

Table 1.0. Expected frequencies of behaviors seen in stallions and adult females.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Stallions	107.65	77.61	75.81	86.76	6.17	**354**
Adult Females	433.35	312.39	305.19	349.24	24.83	**1425**
Total	**541**	**390**	**381**	**436**	**31**	**1779**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 2.0. Expected frequencies of behaviors seen in stallions and sub-adults.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Stallions	69.88	70.65	113.65	82.93	16.89	**354**
Sub-Adults	21.12	21.35	34.35	25.07	5.11	**107**
Total	**91**	**92**	**148**	**108**	**22**	**461**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 3.0. Expected frequencies of behaviors seen in stallions and juveniles.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Stallions	78.27	72.93	119.19	72.05	11.56	**354**
Juveniles	9.73	9.07	14.81	8.95	1.44	**44**
Total	**88**	**82**	**134**	**81**	**13**	**398**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 4.0. Expected frequencies of behaviors seen in stallions and infants.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Stallions	66.5	78.23	132.91	67.47	9.78	**354**
Infants	1.50	1.77	2.98	1.52	0.22	**8**
Total	**68**	**80**	**135**	**69**	**10**	**362**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 5.0. Expected frequencies of behaviors seen in adult females and sub-adults.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Adult Females	470.66	303.23	242.77	377.64	30.69	**1425**
Sub-Adults	35.34	22.78	18.23	28.36	2.30	**107**
Total	**506**	**326**	**261**	**406**	**33**	**1532**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 6.0. Expected frequencies of behaviors seen in adult females and juveniles.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Adult Females	487.93	306.54	239.60	367.65	23.28	**1425**
Juveniles	15.10	9.46	7.4	11.35	0.72	**44**
Total	**503**	**316**	**247**	**379**	**24**	**1469**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 7.0. Expected frequencies of behaviors seen in adult females and infants.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Adult Females	480.30	312.25	246.62	364.95	20.88	**1425**
Infants	2.69	1.75	1.38	2.04	0.12	**8**
Total	**483**	**314**	**248**	**367**	**21**	**1433**

Table 8.0. Comparison of frequencies between adult females and infants. Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 8.0. Expected frequencies of behaviors seen in sub-adults and juveniles.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Sub-Adults	37.56	12.75	9.92	36.14	10.63	**107**
Juveniles	15.44	5.24	4.08	14.86	4.37	**44**
Total	**53**	**18**	**14**	**51**	**15**	**151**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 9.0. Expected frequencies of behaviors seen in sub-adults and infants.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Sub-Adults	30.70	14.89	13.96	36.29	11.17	**107**
Infants	2.30	1.11	1.04	2.71	0.83	**8**
Total	**33**	**16**	**15**	**39**	**12**	**115**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 10.0. Expected frequencies of behaviors seen in juveniles and infants.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Juveniles	25.38	5.08	0.85	10.15	2.54	**44**
Infants	4.62	0.92	0.15	1.85	0.46	**8**
Total	**30**	**6**	**1**	**12**	**3**	**52**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Table 11.0. Expected frequencies of behaviors seen in two adult males.						
	Resting (Rt)	**Feeding (Fd)**	**Vigilance (Vg)**	**Movement (Mv)**	**Other**	**Total**
Stallion # 1	8.14	18.19	11.97	4.31	2.39	**45**
Stallion # 2	8.86	19.81	13.03	4.69	2.61	**49**
Total	**17**	**38**	**25**	**9**	**5**	**94**

Note: This data was collected at Ndarakwai Ranch in Northern Tanzania from 11/7/10 until 11/22/10. Data was collected using scans (n=199), follows, and all-group observations on opportunistic sightings of Burchell's zebra.

Appendix B: Definition of Behaviors

1. **Moving (Mv):** taking more than four steps in any direction
2. **Feeding (Fd):** consuming grass or other small shrubs
3. **Resting (Rt):** can either be standing up or lying down. Standing up means that head is low and relaxed. Often, a hind foot is cocked.
4. **Alert Resting:** body is still in a relaxed pose (hind foot still often cocked), but head is more erect and ears are both forward.
5. **Vigilance (Vg):** all four feet are on the ground, and head is erect and both ears are forward. Often, only tail-swishing is seen here.
6. **Playing:** can often involve running, rubbing heads together, play kicking, etc.
7. **Dominance display:** behaviors in which an individual asserts his/her dominance over another individual. Can include herding (where one individual moves another individual around), chasing, biting, or kicking. Differentiate from play behavior because ears are normally flat on head, and head is seen low when running. Can also include something as subtle as displacing an individual and replacing them when grazing or resting.
8. **"Circle behavior:"** scientific name is not known. Took place between two individuals who would gallop and chase each other, often with ears pinned back and kicking out with both hind legs. The two individuals would then run in a tight circle together, nipping at each other's flanks and lying down on their sides to avoid being bitten. They would then get up and run some more and then repeat the behavior. This behavior was most often seen in younger stallions, but on occasion was seen in a stallion and adult female, and two females.