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The Aders's Duikers (Cephalophus adersi) of Mnemba Island, Zanzibar: A Study of the Behavior and Diet of a Critically Endangered Species

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SIT Study Abroad

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Table of Contents

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Abstract

Cephalophus adersi, commonly known as Aders's duiker, is an extremely rare, near endemic species to Unguja Island in the Zanzibar archipelago. It is a member of the suborder *Ruminantia* and is considered part of the red duiker family. *C. adersi* is critically endangered, and although it is protected by Zanzibari law, its population numbers have plummeted over the last thirty years due to hunting as well as habitat destruction and fragmentation. This study examines the behavior and ecology of a small population of Aders's duikers living on Mnemba, an island off the coast of the northeastern tip of Unguja. Four individual duikers were identified based upon unique scars and markings and were followed over the course of thirteen days. This study evaluates their tolerance for researcher presence, relationships between duikers, diet composition and habitat, as well as interactions and competition with the Suni antelope. It was found that each of the four duikers had different levels of tolerance for close proximity to humans at the start of the study, and that they did not seem to become more habituated during the course of the study. The possible relationships between the duikers studied included a mother and calf as well as one male female pair bond. The Aders's duikers of Mnemba were observed eating seven different species of plant, two of which were also consumed by the Suni antelope. This study found that careful control of the Suni antelope population in combination with the expansion of suitable habitat area for the Aders's duikers on Mnemba Island could both help increase the number of this endangered duiker living on Mnemba and contribute to the conservation of the species as a whole.

Introduction

Taxonomy and Description

Aders's duiker, *Cephalophus adersi*, is a rare species of small duiker native to Unguja Island in the Zanzibar archipelago and the Arabuko Sokoke forest in southern Kenya (Kanga, 1995). *C. adersi* is a member of the suborder *Ruminantia*, which includes all even-toed ungulates that chew the cud, from the 1.5 kg royal antelope to the 1900 kg giraffe (Estes, 1991). Duiker speciation was likely caused by the expansion and shrinking of the rainforest boundaries during and between the Ice Ages. Dry periods led to forest fragmentation and speciation, followed by wet periods when the forest fragments rejoined and the most adaptable species became dominant (Estes, 1991). Of the eighteen species of *Cephalophus, adersi* is the rarest and is considered a peripheral species of duiker that is likely a form from the early radiation of red duikers (Estes, 1991). Kingdon asserts that *C. adersi* is a primitive duiker, and that all present-day duiker species are descendents of the Aders's (Kingdon, 1982). However, its true taxonomic status is heavily debated by scientists and remains unclear.

The name *Cephalophus* is derived from the Greek roots *kephale*, meaning head, and *lophus* meaning crest. The *Cephalophus* genus was given this name due to the characteristic tuft of fur on the head between the ears. Aders's duiker was named after Dr. W. Mansfield Aders, a zoologist with the Zanzibar Government Service (www.ultimateungulate.com). The common name 'duiker' is Africaans for 'diver', a name that was given to members of the *Cephalophus* family due to their tendency to dive into undergrowth when startled (www.ultimateungulate.com).

Aders's duiker is the smallest member of the red duikers, ranging from 7.5 to 12 kg in weight, and thus *C. adersi* is often referred to as the dwarf red duiker. It has a head and body length of 66-72 cm and a shoulder height of 30 cm (Kingdon, 1982). They have short, thin legs, a rounded back, and the hindquarters are more developed and higher than the forequarters (Estes, 1991). The color of the Aders's duiker is typically reddish brown, but can also be a lighter yellow. Their fur tends to be greyer on the neck and face, and they have a characteristic wide band of white fur at the top of the hind leg that extends across the rump. Their undersides are white and they also have small white spots on their legs and a black patch above pointed hooves. Their tails are mostly hairless with a prominent tuft of white fur at the end. They have a red tufted crest on the tops of their heads with small pointed horns on either side that range from 3-6 cm in length (Kingdon, 1982). They have a pointed muzzle with a black nose and ears from 7-8.3 cm long (Kingdon, 1982). Aders's duiker also has two slits with preorbital glands on the face that appear as swollen bumps stretching from below the eye to just above the muzzle, a feature unique to duikers (Estes, 1991). These glands secrete a black sticky liquid that Aders's rub on trees and branches to mark their territories. There is very little if any sexual dimorphism in Aders’s (Estes, 1991).

Habitat and Ecology

The habitat of *C. adersi* includes coastal forest, thickets and woodlands (Wilson, 1987). They are able to survive in very dry forests near the ocean, and in Zanzibar live in tall thickets growing in coral rag forests (Kingdon, 1982). Kingdon found that *C. adersi* lives in male female pairs that defend a territory (Kingdon, 1997). Limited information exists on the reproduction of this rare species, but Kingdon reports that *C. adersi*

reproduces throughout the year. They are almost exclusively diurnal and are very rarely observed at night (Kingdon, 1982). They generally feed from first light until about 11:00 am, and then rest and ruminate until about 3:00 pm when they continue foraging until dusk (Kingdon, 1997). In general, Aders's duiker tends to be shy and often scares at sound. The *Cephalophus* species are specialized as forest frugivores, and their only real competitors are bush pigs and forest hogs where they share habitat (Estes, 1991). *C. adersi* feeds on fallen flowers, fruits and leaves as well as sprouts and leaf buds at ground level. Kingdon observed them eating pieces of fruits and flowers dropped by foraging birds and monkeys including the kudu berry *(Cassine aethiopica)*, bush guarri (*Euclea schimperi*), and ebony (*Diospyros consolataei*) (Kingdon, 1997).

Conservation Status

Aders's duiker was first described in 1917 in Zanzibar and as of 2002, the Aders's duiker was considered a near endemic species to Zanzibar due to habitat destruction and a lack of confirmed sightings in Kenya (Finnie, 2002). Aders's duiker has been protected under Zanzibari law since June 22nd 1919 (Finnie, 2002). In 1996, the Forest Resources Management and Conservation Act No. 10 listed Aders's duiker as an Appendix 1 species, thus granting it total protection and prioritization for conservation in Zanzibar (Finnie, 2002). However, these laws have not been effectively enforced, and over the last thirty years, populations have plummeted (Finnie, 2002). In 2002, the IUCN listed Aders's duiker as endangered (Criteria C1) , but they are still not listed by CITES (www.ultimateungulate.com).

Three population surveys of *C. adersi* have been carried out in Zanzibar. In 1982, the population was estimated to be approximately 5000 animals, and in 1995 another survey determined that numbers were likely below 2000 (Williams, 1996). At that point, Aders's were found in five sub-populations in three areas throughout Zanzibar; Kiwengwa forest in the north, the Jozani-Chwaka Bay area, and Mtende in the south (Finnie, 2000). The most recent survey placed the population at approximately 600-650 individuals, which represented an 87% decrease in the population size over seventeen years (Kanga, 1999). Although, estimates of remaining world populations vary widely, it seems clear that there has been an alarmingly rapid decline in population levels. In February of 2000, five Aders's duikers were translocated to Chumbe Island where one female was already living, with the aim being to create a viable breeding population (Finnie, 2002). Unfortunately, this goal has thus far remained elusive, and currently the population of Chumbe Island is unknown. It is believed that the population of Aders's in Zanzibar is the last viable population in the world, and thus Zanzibar has a special responsibility to protect this extremely rare and vulnerable species.

Aders's duikers face multiple threats, with the main two being habitat destruction and fragmentation. Clearing of forests for agricultural land as well as harvesting of forest products has affected or eliminated most of the Aders's habitat in Zanzibar (www.ultimateungulate.com). Close proximity to human population also creates other threats to *C. adersi*, including dogs. On Funzi Island, feral dogs decimated the local introduced Aders's population (Kingdon 1997). Aders's are also subject to hunting pressure from both rural and urban hunters (Othman et. al). Their sweet meat and beautiful skins make them highly sought after, and their rarity makes them extremely

valuable (Kanga, 1995). Prior to the revolution of 1964, each village had its own hunting areas and hunting of Aders's duiker was controlled by village authorities. However, after the revolution, the mini-antelope became an open access resource, and the national government did not have the resources to enforce wildlife hunting laws. The villagers lost a sense of ownership of the mini-antelope population because the land belonged to the state, and hunting laws were no longer enforced at the local level (Finnie, 2002). Without protection on the part of the villagers or the state, hunting of mini-antelope, including Aders's duiker, increased uncontrollably (Othman, et. al). In 1994, the Department of Commercial Crops, Fruits and Forestry (DCCFF) began an attempt to control the hunting of mini-antelope in Zanzibar through hutting registers and village based community wildlife management (Othman, et. al). A closed season took place in 1995, and after a population survey, it was suggested that Village Hunter's Associations be established. Although twelve villages throughout Zanzibar now have hunting laws to protect mini-antelope, their effectiveness is currently unknown and hunting remains a serious threat to the future existence of *C. adersi* (Finnie, 2002). Limited and carefully controlled trophy hunting has been suggested as a method of raising money for Aders's duiker conservation efforts. As of 2002, the Ministry of Agriculture, Natural Resources and Environment had granted permission for trophy hunting on Unguja (Finnie, 2002). However, *C. adersi* is now so rare that loss of too many individuals to hunting could lead to lack of genetic diversity. For this reason, possibilities for future trophy hunting should be carefully examined for sustainability.

The second major threat to Aders's duiker is habitat destruction. Human population growth in Zanzibar has led to increasing pressure on the island's natural

resources, particularly forests. Deforestation has caused habitat destruction and fragmentation, causing a decline in the overall health and numbers of the Aders's population. However, many villagers rely on woodcutting as their main source of income, and many people have no other employment opportunities. This has created tension between villagers and law enforcement officers, making it difficult to form a framework for a viable solution for all stakeholders (Finnie, 2002). In 1995, Jozani-Chwaka Bay Conservation Project began efforts to slow and reverse habitat destruction rates by implementing village based natural resource management in eight villages surrounding Jozani forest (Finnie, 2002). Although this initiative has taken quite some time to move forward with accomplishing its objectives, village based conservation efforts hold promise for the future of forest habitat conservation.

In 2005, six Aders's duikers were translocated from Unguja to Mnemba Island in an attempt to create a protected breeding population and assist in the conservation of this endangered species. However, one of the six original duikers immediately ran into the sea and drowned. Thus, the original Aders's population on Mnemba was five individuals. This study aims to provide information about the population biology and ecology of the Aders’s duikers of Mnemba Island and their inter-specific competition with the Suni antelope also living on Mnemba. Knowledge of their tolerance for close researcher presence, relationships between the duikers and a preliminary dietary analysis will widen the limited knowledge base about Aders’s duikers. This information will hopefully help scientists, researchers and conservationists focus their efforts to save this critically endangered species.

Study Area

The Zanzibar archipelago is located 40 km off the coast of mainland Tanzania in the western Indian Ocean. It is made up two main islands, Unguja and Pemba; Unguja lies on the continental shelf just south of Pemba. Unguja experiences two monsoon seasons and two rainy seasons each year. The northeastern monsoon season known as 'kaskazi' lasts from November to March, and the southeastern monsoon known as 'kusi' stretches from June to September. In between the monsoon seasons are the two rainy seasons. Unguja has a tropical climate with annual temperatures ranging from 18C to 34C. This study took place on Mnemba Island, which is located 4.5 km off the northeastern tip of Unguja Island (S 05 49.219'E 039 22.959'). Mnemba has an area of approximately 11 hectares and a circumference of 1.5 km (Mnemba Island Website). Most of the island is covered by coral rag and both old and young stands of *Cassuarina* forests. For ten months out of the year, the island is home to the Mnemba Island Lodge. This study took place on Mnemba while the lodge was closed in April, 2011. A 1.29 hectare section of the forest on Mnemba Island was used for this study (Figure 1).

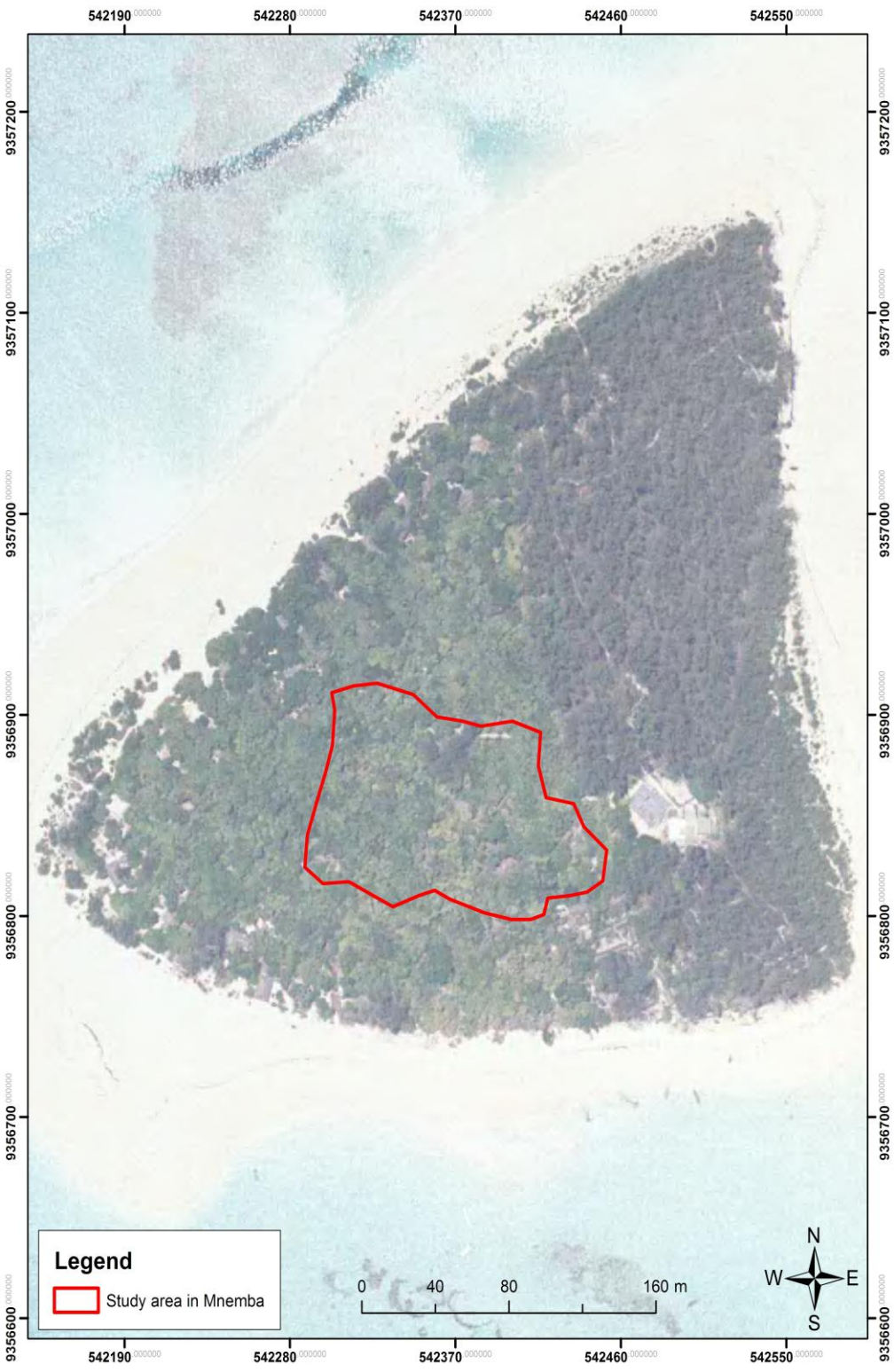

Figure 1. Study area on Mnemba Island (1.29 hectares). Map courtesy of Abbas Juma Mzee, April 2011.

Methodology

Duiker Observations

The section of forest selected for this study was based upon previously identified approximate territories of the duikers. Four Aders's duikers were identified by markings and scars (see results) and observed over a thirteen-day period from April 6th-April 18th, 2011, with two two-hour field sessions each day. Two males and two females were included in the study and were differentiated based upon sex, size and distinctive markings. Observations took place from approximately 7:00 am-9:00 am and from 3:00 pm-5:00 pm, with some sessions extending for longer periods when duikers were being successfully followed and observed. These times were chosen based upon the perceived highest period of activity during the day for this species of duiker. During each field session, observations were conducted by walking through the study area and following each duiker seen for as long as possible. Each observation period during which an individual was observed without losing visual contact for more than five minutes was considered a single 'track'. A track was ended after five minutes without seeing the particular duiker or duikers being observed. Observation durations ranged from a few seconds to over an hour depending on the movements of the animals. If more than one individual was located at a time, both were followed for as long as possible, and if one ran away, the observation was continued with the remaining duiker. All behaviors and the identity of each individual were recorded during the observation periods. Eleven distinct behavior types were observed during this study: foraging, resting, self-grooming, grooming others, sniffing others, staring at the researcher without movement, snorting, chewing cud, urinating, defecating and running away. During periods when more than

one duiker was observed, special attention was paid to the interactions between the two individuals. On occasion, other unidentified Aders's duikers were sighted in the study area. Their presence in the area and interactions with the four duikers included in this study were recorded, but they were not individually identified. Additionally, Suni antelope (*Neotragus moschatus*) were followed on April 19th, 20th and 22nd 2011 with two two-hour field sessions per day (during the same periods the Aders's were observed) in order to complete a preliminary and comparative dietary analysis. Individual Sunis were not identified or differentiated. Food species were identified with the assistance of Ali Hamis, a Wildlife Conservation Society employee with knowledge of local flora.

Data Analysis

Data was analyzed to determine levels of tolerance of human presence and potential for further habituation, relationships between individuals, basic diet composition, and the nature of interactions and possible resource competition with the Suni antelope. Levels of human habituation were assessed based upon how long the researcher was able to follow each individual duiker, and potential for further habituation was evaluated based upon changes in the duration of tracks of individuals over the length of the study period. Relationships between duikers were evaluated based upon the duration and nature of interactions between specific individuals. Basic diet composition was determined by closely observing foraging activity and collecting samples of the species eaten by the duikers. These samples were then identified with help from Ali Hamis. Habitat type and suitability for Aders's duiker was assessed using the identified food species and a survey of Mnemba Island vegetation completed by Said Fakih and members of the Wildlife Conservation Society in April, 2011.

Results

During the course of the study period, forty-six hours were spent in the Mnemba forest study area observing the behavior and movement of Aders's duiker. Four individually distinct duikers were identified based upon their sex and markings. Two males and two females were seen regularly within the study area. Male 1 was much darker in color than male 2 and had no distinguishing scars. Male 2 had a large split in his right ear extending almost to the base of the ear. Female 1 was smaller and lighter in color than female 2 and had two darker patches of fur on her right flank as well as a hairless patch on her left hind leg. Female 2 was darker in color and larger than female 1 and had a small scar on her left flank. All of the Aders's included in this study were adults except for female 1 who appeared to be a subadult.

Tolerance of Researcher Presence

Each duiker exhibited different levels of tolerance for extended researcher presence at the start of the study and throughout its duration. Several parameters were used to evaluate the levels of human tolerance of each duiker. The number of sightings as well as the total amount of time spent observing each individual were calculated. Additionally, the average length in minutes of a single track (following a duiker without losing visual contact for more than five minutes) of each duiker was determined. Female 1 was sighted 24 times with a total of 514 minutes of observation, female 2 was sighted 20 times with a total of 339 minutes of observation, male 1 was sighted 15 times with a total of 127 minutes of observation, and male 2 was sighted 13 times with a total of 39 minutes of observation (Figures 2 and 3).

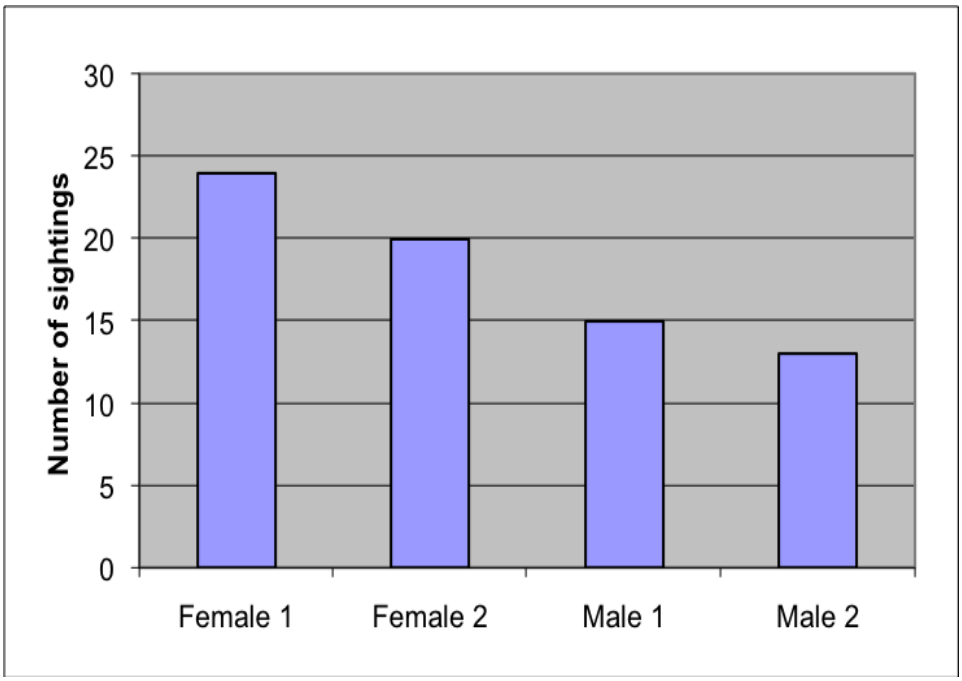

Figure 2. Total number of sightings of each duiker during the study period.

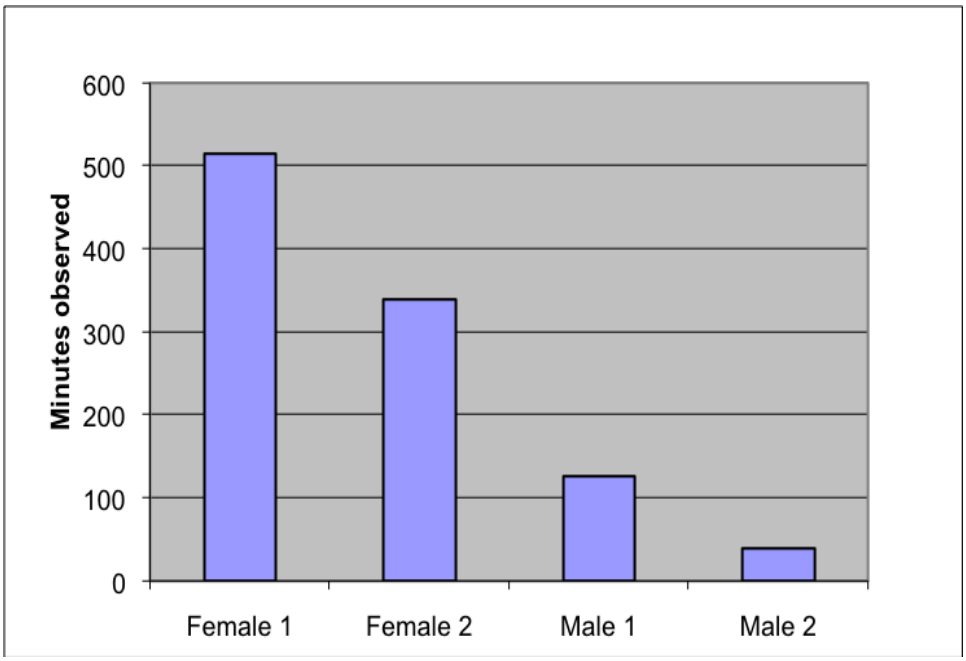

Figure 3. Total number of minutes spent observing each duiker during the study period

The average track lengths for each duiker were as follows: for female 1 23.8 minutes, for female 2 17.5 minutes, for male 1 8.3 minutes, and for male 2, 3 minutes (Figure 4). The duration of individual tracks did not appear to change over time in any predictable way for any of the duikers.

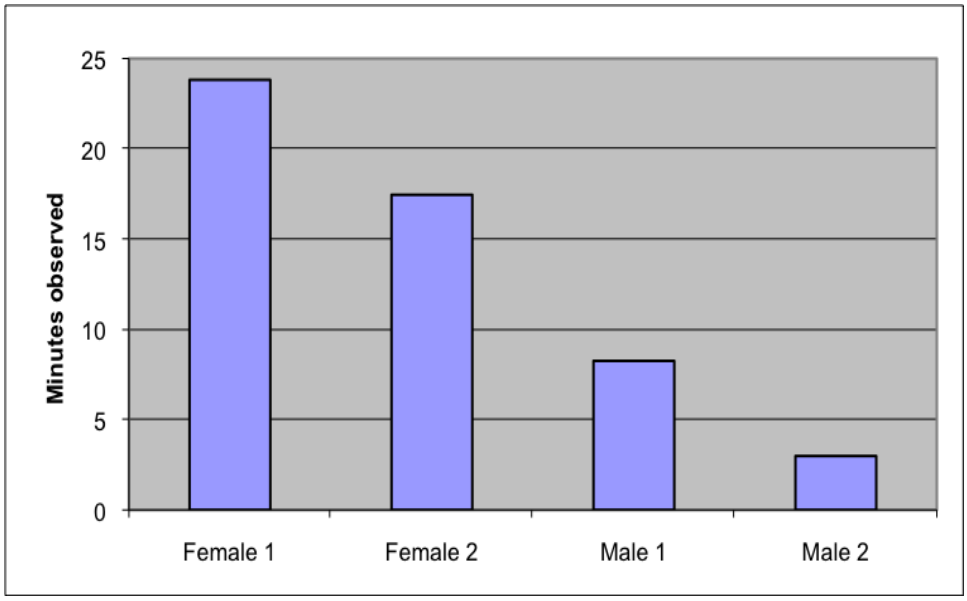

Figure 4. Average duration of a single track of each duiker.

Relationships Between Duikers

Possible relationships between individual duikers were evaluated based upon how much time each duiker spent with each of the other three duikers and the nature of those interactions. Female 1 spent 67% of her observed time alone (346 minutes) and 33% of her time (168 minutes) with one or more other duikers. Of the 33% of her time spent with other duikers, female 1 was seen with female 2 for 99% of the time (167 minutes), with male 1 for 10% of the time (17 minutes) and with male 2 for 0% of the time. Female 2 was seen on her own for 10% of her observed time (34 minutes) and with other duikers for 90% of the time (305 minutes). Of the 90% of her time spent with other duikers, she

was seen with female 1 for 55% of the time (167 minutes), with male 1 for 36% of the time (110 minutes) and with male 2 for 9% of the time (28 minutes). Male 1 was observed alone for 1.5% of the time (2 minutes) and with others for 98.5% of the time (125 minutes). Of the 98.5% of the time he was observed with one or more of the others, he was seen with female 1 for 14% of the time (7 minutes), with female 2 for 88% of the time (110 minutes), and with male 1 for 6% of the time (7 minutes). Male 2 was seen alone for 28% of the total time we was observed (11 minutes) and with other duikers for 72% of the time (28 minutes). Of the 72% of the time he spent with one or more other duikers, he was seen with female 1 for 0 minutes, with female 2 for 100% of the time (28 minutes) and with male 2 for 18% of the time (7 minutes). These results are summarized in figures 5 and 6. Physical interactions between individuals were also recorded in order to assess possible relationships between individual duikers. Physical interactions include sniffing, licking, and rubbing faces together. Male 1 and female 2 had 6 physical interactions during the study period, and female 1 and female 2 had 3 physical interactions.

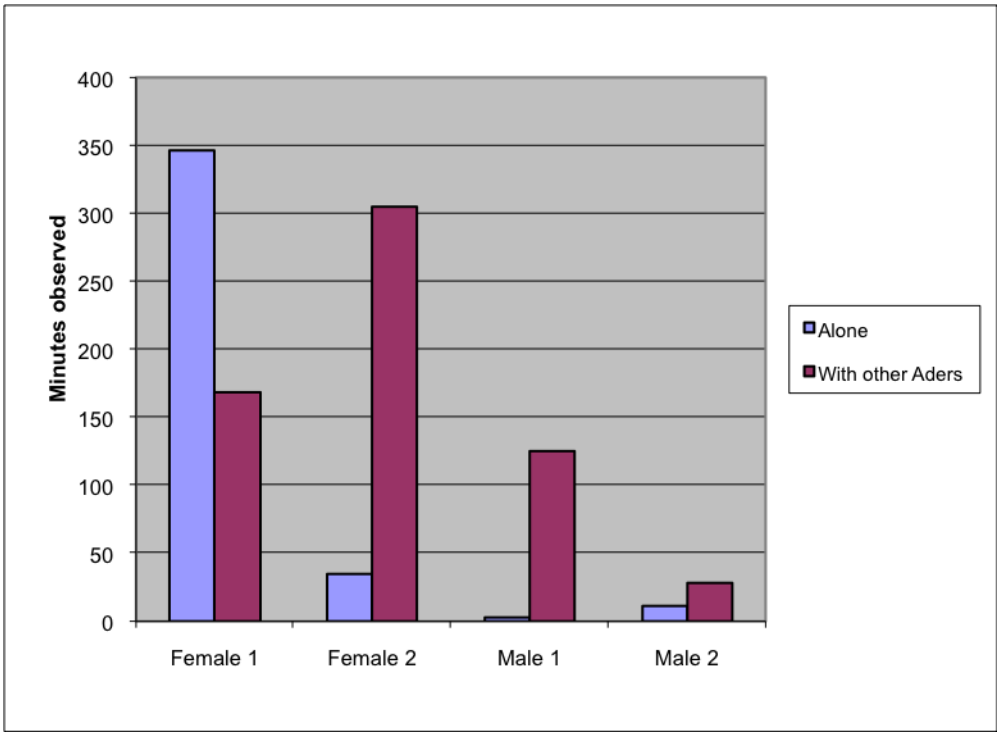

Figure 5. Amount of time each duiker spent alone and with other duikers.

	Female 1	Female 2	Male 1	Male 2
Female 1	Self	99%	10%	0%
Female 2	55%	Self	36%	9%
Male 1	14%	88%	Self	6%
Male 2	0%	100%	18%	Self

Figure 6. Percentage of time each duiker spent with each of the other three duikers. Percentages taken from total time spent in the presence of other duikers.

Diet Composition and Habitat

During the study period, the four Aders's duikers observed were seen eating seven different food species. This included six different species of plants and one type of fruit. The types of plants eaten by the Aders's included *Suregada zanzibariensis* (Mdimu Msitu), *Ficus lutea* (Mlandege), *Guettarda speciosa* (Mkungu wa pwani), *Tetraceara boivaniana* (Pumba za paka), *Grewia glandulosa* (Mkole) and *Cassytha filifomis* (Mlangamia, a vine). The fruit eaten was *Mimusops fruticosa* (Mpuvuu). Only the buds of *S. zanzibariensis* were eaten by the duikers, and only the young buds and stems of the mature leaves of the *F. lutea* were consumed. The *C. filifomis* vine was only observed being eaten on one occasion by female 1. The mature leaves of *G. speciosa, T. boivaniana,* and *G. glandulosa* on low lying branches and on the ground were eaten on multiple occasions by different individuals. Suni antelope were observed eating the mature leaves of G. *speciosa* and *T. boivaniana* during a three-day study period.

According to both Kingdon and Wilson, the habitat of Aders's duiker consists of tall thicket and coral rag forest. On Mnemba Island, duikers spend most of their time living in the mixed forest area where their preferred food species can be found in the highest abundance and where they can remain somewhat hidden in the undergrowth. On Mnemba, the area of suitable habitat for Aders's duiker is 5.0 hectares and the area of unsuitable habitat is 6.0 hectares. This means that 45% of the land on Mnemba Island is currently suitable for inhabitation by Aders's duiker.

Interactions Between Aders's Duiker and Suni Antelope

Interactions between Aders's duiker and Suni antelope were observed on ten different occasions. Two times the Aders's ran away in response to an alarm sound made by a Suni, and on one occasion female 1 ran away in response to a Suni running away with no alarm sound. Five of the instances where Aders's and Suni were observed at close range to one another, no reaction was observed in either species. No direct physical contact was observed between the Aders's and the Sunis, however on one occasion female 1 sniffed a Suni and on another a Suni sniffed female 1.

Discussion

Human Habituation

The number of sightings of each Aders's duiker, the total number of minutes each individual was observed over the course of the study period, and the average duration of a single track combine to suggest that each duiker identified had a different level of tolerance for close proximity to humans. It is important to note that the duration of a single track did not change over time in a predictable way for any of the duikers, which suggests that the levels of tolerance for researcher presence exhibited by each of the Aders's existed before the start of the study. Furthermore, this study was likely too short to see any increased levels of human tolerance, and a longer study period would be necessary to determine if these animals can become increasingly habituated to humans. Female 1 had the most sightings, the highest total number of minutes observed and the longest average track length. These parameters suggest that she was the most habituated to human presence at the start of the study. The second most habituated duiker was female 2, followed by male 1, with male 2 showing the least tolerance for a close human presence. Both the females showed a higher tolerance of researcher presence than both of the males, as evidenced by the average length of a single track. The average track lengths for the two females were 23.8 and 17.5 minutes, and the average track lengths for the males were 8.3 and 3 minutes. This could be due to the territoriality of the males, a behavior common to duikers. Additionally, both males were observed making snorting noises on a regular basis when in the presence of the researcher, while the females were rarely observed snorting. This behavior could also be an indication of higher levels of territoriality and mate guarding in males as compared to females.

Relationships Between Duikers

Based upon the amount of time spent alone versus with one or more other duikers, it appears that female 1 does not yet have a pair bond with a male. She was the only duiker included in this study that spent more time alone than with other duikers. Furthermore, she did not have any physical contact with either of the males and was only seen with one of them for a total of seventeen minutes. There is also evidence to suggest that female 1 is the calf of female 2. Of the total amount of time female 1 spent with other Aders's, 99% was spent with female 2. The two females also had three physical interactions, with female 2 grooming female 1 for the majority of the physical contact time. Female 1 was also smaller than female 2, which may mean that she is a subadult, another possible explanation for her lack of a pair bond. Lastly, female 1 showed the highest level of tolerance for human presence as demonstrated by her average track time, which could be due to being born and raised on a small island in constant close proximity to humans. All of these observations combine to suggest that female 1 is likely the calf of female 2.

In contrast to female 1, female 2 was seen with other duikers far more often than on her own. Of the total amount of time she spent in the presence of other duikers, 55% was spent with female 1 and 36% with male 1. Furthermore, female 2 and male 1 showed physical interactions on six different occasions that included grooming and sniffing one another. Additionally, 88% of the time that male 1 was observed with other Aders's duikers were spent with female 2. The amount of time and nature of the interactions between female 2 and male 1 suggest that they have a pair bond and are likely mating partners.

Diet Composition and Habitat

During the period of observation, the diet of the Aders's duikers on Mnemba Island consisted mostly of different types of leaves. Aders's were observed eating leaves both off the ground and from low lying branches. The leaves of *F. lutea* are particularly tough, and in this case the duikers either ate the young buds or the softer stems of mature leaves. The Aders's were also observed eating *M. fruticosa* off the ground on a regular basis. Female 1 and female 2 were seen chewing their cud on several occasions for up to thirty minutes at a time. Aders's duikers are ruminants, and like other species in the suborder *Ruminantia* they regurgitate their food after it has been consumed in order to further break down tough fibers by rechewing the plant material.

According to Williams, Aders's has very specific habitat requirements, with the ideal habitats being older growth high thickets (Williams, 1996). The Aders's duikers living on Mnemba Island rely on the presence of their food species in a relatively small area. According to Said Fakih of the Wildlife Conservation Society, in the 5.2 hectares of Mnemba covered by *Cassuarina* and the .8 hectares covered by *Pandanos spp.*, the food species of *C. adersi* are unable to grow due the thick forest litter created by foliage falling from both *Cassuarina* and *Pandanos spp.* Thus, the duikers are only able to inhabit the 45% of the island covered in mixed forest where their food species are able to grow. If the area of Mnemba covered by suitable duiker habitat were increased, it is possible that the population size of the Aders's could increase as well. In the 1.29 hectares of the study area, four individual Aders's duiker were seen on a regular basis. According to these numbers and the area of Mnemba covered with suitable Aders's habitat, the current population of Aders's duikers on Mnemba can be estimated at 15-16 individuals.

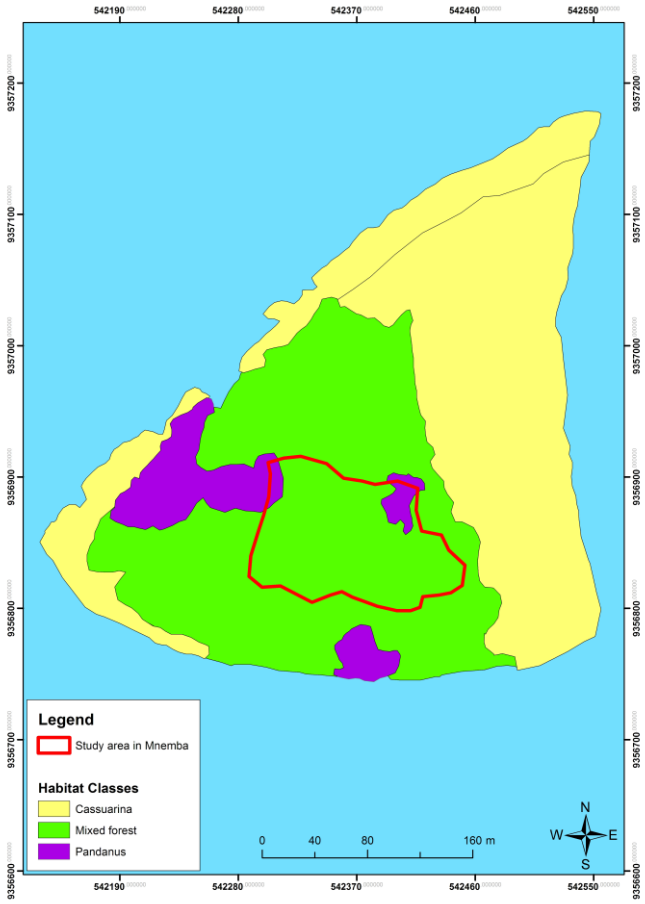

Figure 7. *Cassuarina*, mixed forest, and *Pandanos spp.* vegetation classes on Mnemba Island. Map courtesy of Abassi Juma Mzee and Wildlife Conservation Society, April 2011.

Inter-specific Competition Between Aders's Duiker and Suni Antelope

Approximately three Suni antelope were introduced to Mnemba in 1991. Since then, there have four relocations of the Suni to Jozani forest in order to prevent overgrazing of the island, with the most recent being the removal of 96 individuals in March, 2011. Although Aders's duiker and Suni antelope are both part of the *Bovidae* family, they are still genetically distant species and the Suni is relatively common in comparison to the Aders's. Because these two species are sharing a habitat on Mnemba, it

is important to consider the possibility of competition for resources, including space and food, which could occur between the two species. Sunis were observed eating the mature leaves of *G. spiciosa* and *T. boivaniana*, both of which are also a part of the Aders's diet on Mnemba. This means that the Suni and the Aders's are directly competing for food resources. After the March 2011 Suni relocation, there appears to be plenty of food available for all the island's duikers and antelope. However, the Sunis reproduce very quickly, and their populations will likely rebound within the next two years to reach pre-2011 relocation levels. With larger numbers of Sunis on the island, it is possible that the Aders's could suffer due to competition for food. Furthermore, this study only included a preliminary three-day study of the diet of the Sunis on Mnemba, and it is possible that the Sunis share more than just these two food species in common with the Aders's.

Sources of Error

This study had several sources of error that should be considered when evaluating the significance of the results. First, although individual duikers were identified based upon unique markings as well as sex, female 2 and male 1 had very few markings and it is possible that they were misidentified on several occasions. In order to increase the likelihood that they were in fact the same individuals, the study area was confined to a single section of forest. Because Aders's tend to be territorial, it is very likely that female 2 and male 1 were identified correctly because they were seen multiple times in the same area. In addition, another duiker pair was seen in a section of forest adjacent to the study area that had black fur on their necks and were visually distinct from female 2 and male 1. These darker duikers were likely living in a territory adjacent to the study area, again

suggesting that female 2 and male 1 were in fact distinct individuals that were correctly identified.

There also may have been errors in the diet analysis of the Aders's. Plant samples were only collected by the researcher when there was no uncertainty about which type of leaf had been consumed. Oftentimes the duikers were observed eating leaves off the ground, but because there were multiple types of leaves in the observed feeding area, it was unclear which type was being consumed. In these cases, no plant samples were collected in an attempt to avoid misidentifying food species. Because of this methodology, it is possible that some food species were overlooked.

Conclusion

The purpose of this study was to quantify levels of human tolerance, evaluate possible relationships between individuals, begin a dietary analysis, and make a rough population estimate of the Aders's duikers on Mnemba Island, Zanzibar. It was found that each individual duiker included in this study exhibited different levels of tolerance for human presence, with the females being more tolerant than the males based upon the average length of a single track. Territorial snorting behavior by the males also suggests that they were less tolerant of close proximity to humans. Although the females were more relaxed in the presence of humans than the males, they did not become more habituated to researcher presence during the study period. According to the amount of time each duiker spent with the other duikers and the nature of their interactions, it appears that female 1 is the calf of female 2, and that female 2 and male 1 have a mating pair bond. During the study period, the four Aders's duikers observed were seen eating seven different species of plant, including one type of fruit. A three-day preliminary dietary analysis of the Suni antelope of Mnemba Island revealed that they share at least two food species in common with the Aders's duiker. Although the Suni population is currently estimated to be between fifty and sixty individuals, competition for food resources could intensify with higher Suni populations. Using the number of individual Aders's sighted on a regular basis within the 1.29 hectare study area and the total area of Mnemba covered by suitable duiker habitat, the carrying capacity for the Aders's population on the island was estimated to be between 15-16 individuals. Because only 45% of Mnemba is covered by duiker habitat, it is possible that the Aders's population could increase with an expansion of suitable habitat area.

Recommendations

It is important to consider the critically endangered status of the Aders's duiker when making decisions about the management of both the Aders's and Suni populations on Mnemba. Mnemba and Chumbe are the most protected areas where Aders's are currently living, and thus Mnemba has the potential to play an essential role in the conservation of this extremely rare species. The safety of Mnemba for the Aders's also means that they are much more tolerant of close proximity to researchers than those found in Jozani Forest on Unguja or Arabuko Sokoke in southern Kenya. This means that Mnemba Island also has the potential to continue being an important place for research on Aders's duikers. Furthermore, this study has shown that the Aders's and Suni share at least two food species, which creates inter-specific competition. Thus, the Suni population should continue to be carefully controlled or possibly eliminated on Mnemba Island. Although Sunis are currently removed from the island approximately every two years in order to prevent overgrazing of the island, the Aders's may benefit from living on the island without the Sunis. It also does not appear that the Sunis and the Aders's have any important interspecies interactions that would be absent if all the Sunis were removed and relocated. The elimination of the Sunis and potential proliferation of the Aders's would also be an attraction for the Mnemba Island Lodge to advertise to potential visitors, as Mnemba is one of only a few places in the world where Aders's duikers can be seen. Although there is currently no evidence to suggest that the Aders's population will necessarily increase in the absence of the Sunis, the situation faced by the Aders's duiker means that the removal of the Sunis could be a risk worth taking in order to increase the Aders's chances for population growth.

Because the original population of Aders's translocated to Mnemba was very small, the population could eventually suffer from a lack of genetic diversity. This could result in inbreeding and a deterioration of the physical fitness of the population. Thus, it would be beneficial to bring more Aders's from other populations to Mnemba in order to increase genetic diversity and maintain the health of the population. Increasing the area of mixed forest on Mnemba that supports the food species of *C. adersi* could further increase the potential for the duikers to proliferate and thrive on the island. Because *Cassuarina* and *Pandanos spp.* deposit a thick forest litter that prevents the growth of the seedlings, removal of forest litter could allow for the successful growth of Aders's food species. Removal of the litter would be even more effective if combined with thinning of the *Cassuarina* forest, thus removing the source of the suffocating forest litter. According to Said Fakih of the Wildlife Conservation Society, enrichment planting of the Aders's food species identified in this study could also be beneficial by increasing the area of Mnemba Island inhabitable to duikers. Expansion of habitable area for the Aders's duiker would likely increase the carrying capacity of the island and allow for the proliferation of this critically endangered duiker species.

Finally, this study only included a preliminary three-day study on the diet of the Suni antelope on Mnemba. It would be beneficial to conduct a longer and more complete dietary analysis of the Suni antelope in order to determine if they share more than two food species in common with the Aders's duiker. If they do, that would indicate an even higher level of inter-specific competition between the Aders's and the Suni than was found in this study. On the whole, very little research has been conducted on Aders's

duiker due to their rarity. It is important to continue doing research on these animals in order to increase our understanding of their biology and focus conservation efforts.

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