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The Ecology of the Usambara Double-collared Sunbird (Cinnyris usambaricus)

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SIT Study Abroad

The Ecology of the Usambara Double-collared Sunbird (*Cinnyris usambaricus)*

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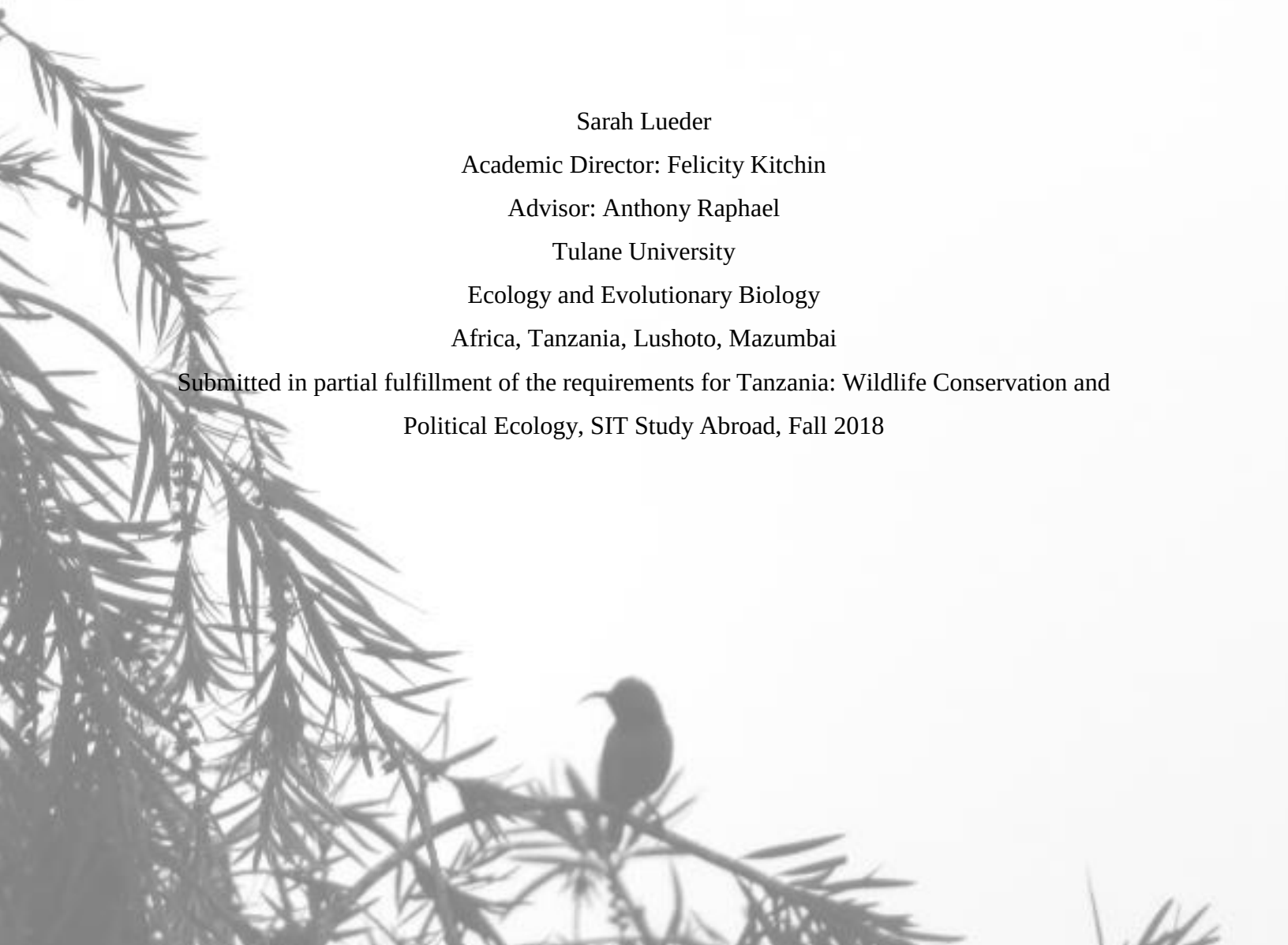

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Abstract

The ecology of the endemic Usambara Double-collared Sunbird (*Cinnyris usambaricus*) was investigated in the surrounding areas of and within Mazumbai Forest Reserve in the Lushoto District of Tanzania. As there is little known concerning the ecology of the species, this study sought to illuminate multiple aspects of their behavior and interactions. Over fourteen days (November 2nd-November 21st), the abundance of the species, their nesting behavior, their habitat preferences, their vocalizations, their diet, and their aggressive behaviors were observed and then analyzed. It was determined the species' activity likely peaks in the early morning, their nesting is similar to other species of equatorial sunbirds, their diet consisted of majority non-native plants, the majority of acts of aggression involved other sunbirds and that the species is found mainly in areas with limited crown cover. The results of this study suggest that the species may be able to adapt better than most to habitat changes in the area, like exotic plant infiltration and deforestation. However, the species limited range puts it at risk of suffering if habitat degradation destroys its food resources and nesting sites.

Introduction

Biodiversity hotspots have been recognized as areas of value for their high levels of endemism and species richness. These areas contain a disproportionate number of the world's species by area. For this reason, efforts have increased to protect and prioritize conservation of these hotspots. One threat to these high-species regions, along with many other regions of the world, is climate change. While scholars do not expect climate change to unequally affect biodiversity hotspots compared to other regions, the endemic species within them may be especially vulnerable. Their vulnerability comes from their restricted range to the area (Malcolm et al. 2006).

One such high-species, high-endemism area is the Eastern Arc Mountains in Kenya and Tanzania. It is ranked as one of the most important areas in the world for endemic species conservation, yet it is also one of the most threatened areas of biodiversity importance (Burgess et al. 2007). Another threat to the area besides climate change is deforestation. This results in habitat reduction and fragmentation, which in turn leads to an increased rate of species extinction (Hall et al. 2009).

To help conserve the wildlife in the threatened areas, it is important to understand the ecology of the species to improve conservation assessment and policies. One such endemic species is the Usambara Double-collared Sunbird (*Cinnyris usambaricus*). Until 2004, scholars considered the Usambara Double-collared Sunbird to be a subspecies of the Eastern Double-collared Sunbird (*Cinnyris mediocris*). In addition to physical differences between the two, (i.e. *C. usambaricus* has a wider red breast-band), Bowie et. al (2004) found the DNA of the two differ significantly after molecular phylogenetic analyses, thus indicating the two as separate species. The split between the species is due to the geographical split into the northern (*C. mediocris)* and southern (*C. usambaricus*) lineages (Bowie et al. 2004).

Sunbirds are small birds with morphological, behavioral, and physiological convergent similarities to hummingbirds (Prinzinger et al. 1992). They have a decurved beak for feeding on nectar and insects and can hover for brief periods. The 132 species of sunbirds are resident to Africa, Asia and Australia. They are often strongly sexually dimorphic and they move quickly and often (Cheke et al. 2008).

While the ecology of other species of sunbirds had been previously described (Prinzinger et al. 1992, Riegert et al. 2014, Geerts and Pauw 2009), there is little literature about that of the

Usambara Double-collared Sunbird besides their physical description and range. The information available is as follows: The Usambara Double-collared Sunbird is around 11 cm in length. Males and females show strong sexual dimorphism. Males have an iridescent green head, violet uppertail-coverts, and two breast-bands: a narrow blue one with a thicker red below. Females are colored dull olive and paler plain yellowish-green (Stevenson and Fanshawe 2002). The range of the species includes the Usambara Mountains in Tanzania and the Taita Hills in Kenya (del Hoyo et al. 2018). The males and females are pictured below.

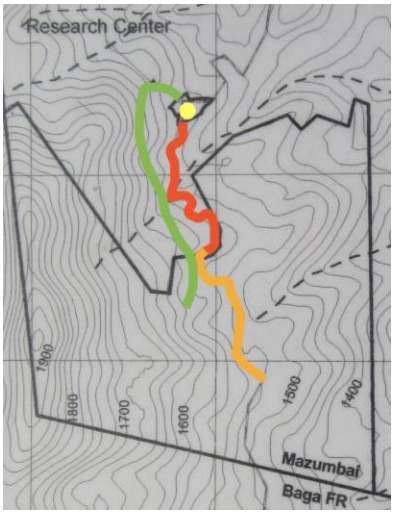
Figure 1: Male and females Usambara Double-collared Sunbirds. Left: male Usambara Double-collared Sunbird. Right: female Usambara Double-collared Sunbirds

As of October 2016, the International Union for Conservation of Nature listed this species as near threatened (BirdLife International 2016). As ecology is what connects individuals to their environment, it is vital to understand for effective conservation policies and practices in the future. Despite the importance of this information, there is a lack of knowledge concerning the ecology of the Usambara Double-collared Sunbird. For this reason, this study investigated aspects of the Usambara Double Collared Sunbird's ecology. The main categories of study were abundance of the species, nesting behavior, habitat preferences, vocalizations, diet, and aggressive behaviors.

Study Area

This study was conducted in Mazumbai Forest Reserve and its surrounding area. Mazumbai Forest Reserve (4º50'S, 30º30E) is a montane rainforest covering 320 ha between 1300 meters above sea level and 1900 meters above sea level. It is located in the Lushoto District in the West Usambara Mountains of Tanzania, which is within the Eastern Arc Mountains. The forest and the surrounding land hold some of the endemic species of the area. The forest reserve, owned for research and tourism by Sokonie University of Agriculture, is a pristine, climax rainforest. Surrounding the reserve are human populations and a forest that is governed by the community, Sagara forest. (Sokonie Unversity of Agriculture 2018).

Four sites were studied in the area: one at the Research Center, one on the path to and within the forest reserve, and two on the main road closest to the Research Center. The site at the Research Center, referred to as the Garden site, consisted of the Research Center and the surrounding garden. There was no significant crown cover in the area, and there was human traffic. This site is marked by the yellow circle on Map 1. The Forest site started at the Research Center, continued along the path leading to the forest reserve and ended about a quarter mile into Mazumbai Forest Reserve. The path leading to the forest consists of tea field and part of Sagara community forest. Within the forest there are heavily covered areas and glades. This site is marked with the green line on Map 1. The sites on the main road, Road I and Road II sites, varied between forest, tea fields, and forest glades. Both humans and vehicles frequented this area. These sites are marked by the red and orange lines on Map 1, respectively.



Map 1: Map of the study area. The Mazumbai Forest Reserve is outlined with the thick black line. The Garden site is indicated by the yellow dot. The Forest site is indicated by the green line. The Road I site is indicated by the red line. The Road II site is indicated by the orange line. Image source: Sokonie University of Agriculture.

Methods

Data were collected in two three-hour periods over fourteen days (November 2nd-November 21st), once in the morning 6:00-9:00 and once in the afternoon 15:00-18:00, for a total of 84 collection hours. This bidaily method is utilized by others studying sunbirds (Riegert et al. 2014). One and a half were spent at each site to record abundance and behaviors. For abundance, individuals were counted if they were seen or heard and were only counted once. The of recording at each site rotated daily to limit bias regarding behavioral aspects and to determine abundance with the same number of hours per site for each time slot. Each behavior observed was recorded as a separate event for the birds.

Non-nesting behavior

The following behavioral states were recorded for non-nesting behavior:

1) Aggression: aggression included chasing an intraspecific or interspecific individual or group
2) Evasion: evasion included being chased by an intraspecific or interspecific individual or group
3) Feeding: feeding included when an individual visited a food resource (flowers for nectar or plants for insects) and put their bills into the source to extract the food
4) Vocalization: vocalization included when an individual chirped or sang and was distinguished by type of song
5) Perching: perching included when an individual stood upon a substrate
6) Self-grooming: self-grooming included all feather and bill care actions

For the above behaviors the observations began when a bird was spotted and continued until the bird moved out of sight. Metadata was recorded for each event including which substrate the action was taken upon and the species and number of other biotic individuals involved. Identification of these species was completed using East African Plants, an online resource, and the help of the staff of Sokonie University of Agriculture.

Nesting behavior

Seven nests were routinely observed in the study sites: three in the Road I section, two in Road II section, two in the Forest section, and none in the Garden section. Nests were found

throughout the study period and observed at each visit to the site. Data were collected for 10 minutes per nest for the following behavioral activities:

1) Building: building included the individual bringing material to construct the nest
2) Incubating: incubating included when a female entered or was located within the nest during the incubation period
3) Chick feeding: chick feeding included when the individuals visited food resources, returned to the chick-inhabited nest, and inserted their beck into the nest to enable feeding
   Non-nesting behaviors were recorded in addition to the above behaviors. Nest building can be sectioned into three phases: nest building, incubation and chick feeding.

Statistical tests

T-tests were performed when comparing two population abundances. These instances were the species abundance over time and the number of individuals feeding over time. Z-tests were employed when comparing two population proportions. These instances were proportion of feeding instances by site, proportion of non-native plant feeding events and native plant feeding events, proportion of male singing events and female singing events, proportion of interspecies and intraspecies acts of aggression, and proportion of events comparing where the Usambara Double-collared Sunbird was located. For all tests a 95% confidence interval was used for analysis.

Ethics

This study was completed with minimal impact on the environment. The sites at which I recorded had predetermined paths, so no harm was done to the surrounding plants by clearing areas on which to walk. No animals were purposefully disturbed in the study period. This includes the Usambara Double-collared Sunbird and their nesting sites. I hired a guide for the study period, and he was paid at the School for International Training's standard guide pay. I interacted with numerous people who were passing through the sites during my data collection times. I greeted the people with respect and answered any questions they had related to what I was doing in the area.

Results

Abundance over time

All p-values for abundance comparisons are in Table 1, Appendix A. At the Garden site, significantly more individuals were counted from 6:00-7:30 compared to 7:30-9:00 (p=0.03627), 6:00-7:30 compared to 15:00-16:30 (p=0.03681), 16:30-18:00 compared to 7:30-9:00 (p=0.01516), and 16:30-18:00 compared to 15:00-16:30 (p=0.02848). At the Road I site, significantly more individuals were counted from 6:00-7:30 compared to 7:30-9:00 (p=0.0003890) and 6:00-7:30 compared to 15:00-16:30 (p=0.04637). The Forest site and the Road II site have no significant p-values; however, when the sites abundances were averaged, significantly more individuals were counted from 6:00-7:30 compared to the three other times (p=0.005541, p=0.006563, p=0.01874 respectively).

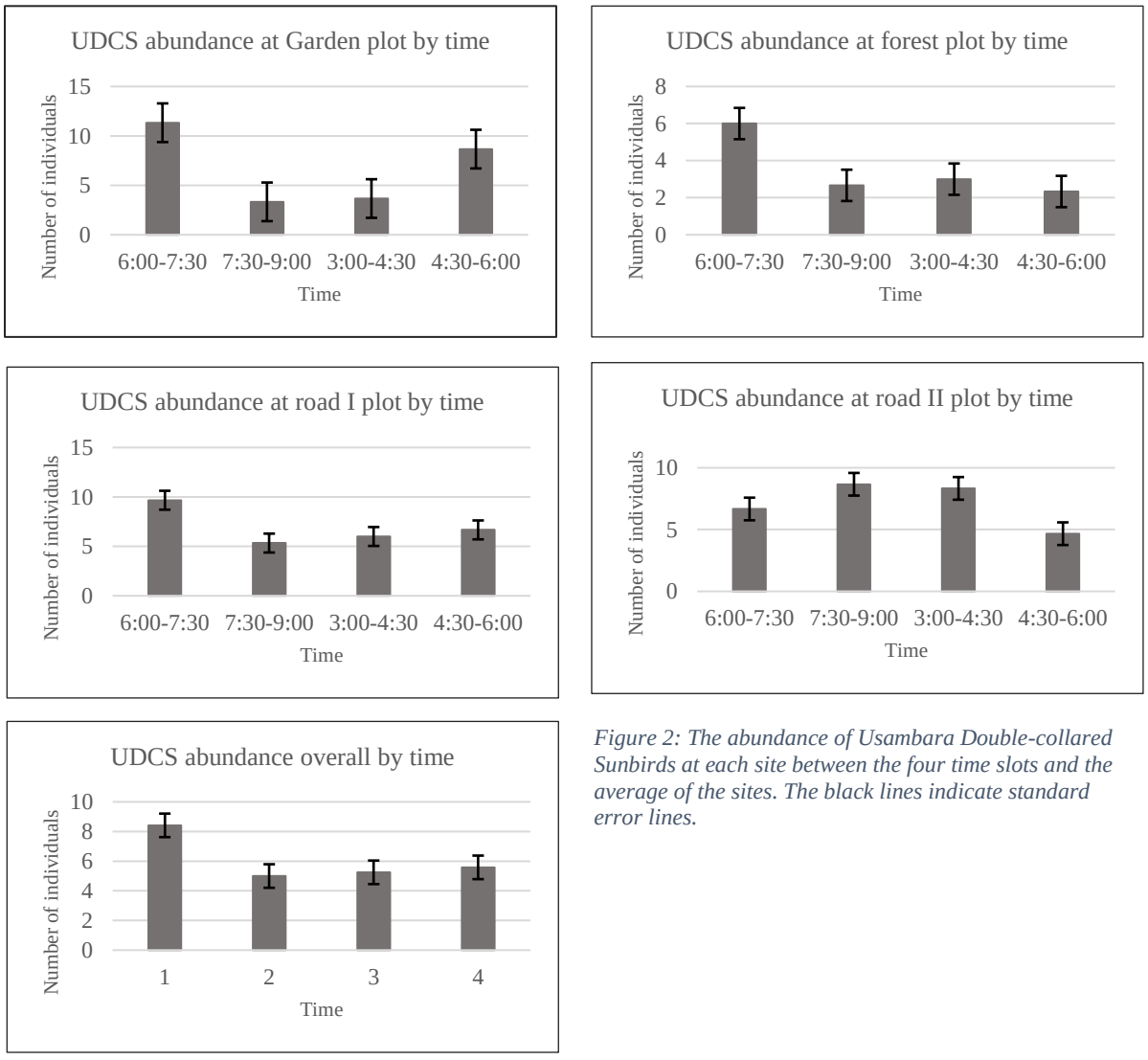


Figure 2: The abundance of Usambara Double-collared Sunbirds at each site between the four time slots and the average of the sites. The black lines indicate standard error lines.

Nesting behavior

The following nesting phases were observed: nest building (n=62), incubation (n=24), and chick feeding (n=8). Only females were seen building the nest (n=62) and incubating (n=24). Both males and females were seen participating in chick feeding (n=8). The longest building period observed was five days; however, the female was already building the nest when it was found. The longest incubation period observed was ten days; however, the female was still incubating the last day the nest was observed. The females built the nests to be purse-like, enclosed structure (Figure 2). All nests were built upon thin branches and only one was built in an area with crown cover other than that of the tree on which it was located. The Usambara Double-collared Sunbirds seem to have multiple breeding cycles throughout the year, as they started building again after fledglings had left or their nest had been destroyed (n=2). Only one male and one female were observed at each nesting site at a time.

Figure 3. Two nesting sites at the first day of observation and after the building phase. Top left: nest at Road II site on first day seen during the building process. Top right: same nest at Road II site after the female completed the building phase. Bottom left: nest at Forest site on first day seen during the building process with a female on the nest. Bottom right: same nest at Forest site after the female completed the building phase.

Feeding

The proportion of Usambara Double-collared Sunbirds seen feeding in the Garden area was significantly higher compared to the Road I area (p <.00001), Road II area (p= 0.00024), and Forest area (p= 0.00244). The birds were seen feeding from eight different species of plants throughout the study period. Six of the eight species were non-native to Tanzania. There was a significantly different proportion of non-native to native plants fed from (p<.00001), with sixty-nine events for non-native plants and three events for native plants (Appendix A Table 2). There were no significant differences in abundance of individuals feeding at the four time slots when the sites were averaged (Table 3).

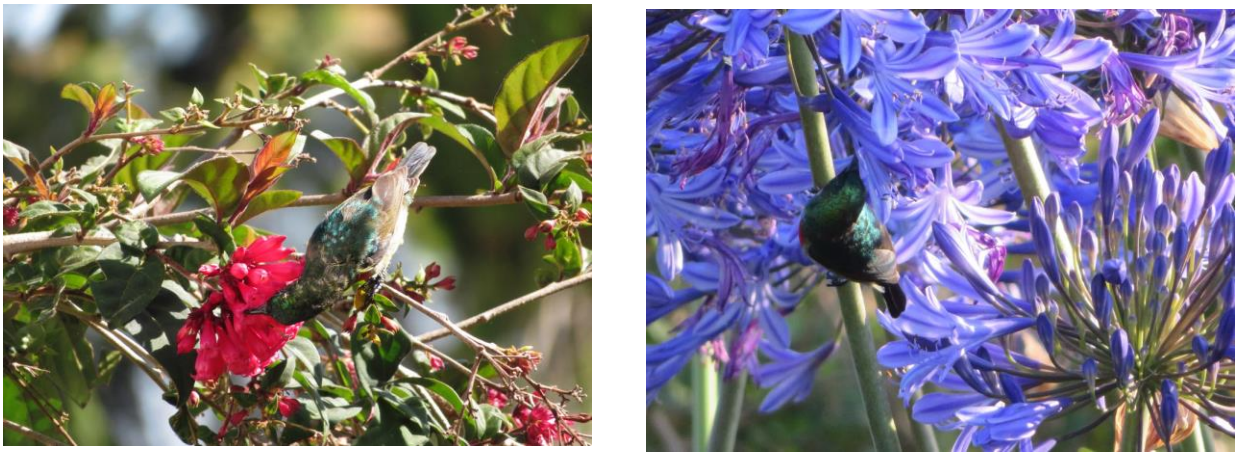


Figure 4: Male Usambara Double-collared Sunbirds feeding on non-native plants. Left: a male Usambara Double-collared Sunbird feeding from a red flowering bush at the Garden site. Right: a male Usambara Double-collared Sunbird feeding from an Agapanthus africanus at the Garden site

Singing

Apart from chirping, the Usambara Double-collared Sunbirds have a distinct, trilling song. Twenty-two individuals were seen and heard making this call. Of these twenty-two, twenty were male birds and two were female birds. There is a significant difference (p<0.00001) between the proportions of these two populations.

Aggression

Fourteen acts of aggression were observed. There was not a significant difference (p=1) in the number of intraspecies acts of aggression (n=7) compared to interspecies acts of aggression (n=7). However, there was a significant difference (p=.00252) in the number of acts

of aggression between Usambara Double-collared Sunbird and any species of sunbird (n=11) compared to acts of aggression between Usambara Double-collared Sunbird and species that are not sunbirds (n=3). All but two of the aggressive behaviors were observed at the Garden site. The other two were observed near nesting sites in the Road II site.

Location

Location was distinguished between areas with crown cover, areas without crown cover, and areas bordering an area without crown cover. The location was recorded for 309 individuals. 299 of these Usambara Double-collared Sunbirds were found at areas without crown cover or areas bordering an area without crown cover. This is a strongly significant difference ($p<.00001$).

Discussion

Abundance

The abundance of Usambara Double-collared Sunbirds was significantly higher at 6:00-7:30 compared to the other times when all the four of the sites were combined (Table 1, Appendix A). This follows a trend seen with many other bird species, as birds activity typically peaks at the hour centered around sunrise (Robbines 1981). The individual sites defy this tendency, which could be because of limited data. The Road I site almost follows the trend with the exception of the 6:00-7:30 and 16:30-18:00 comparison (Table 1, Appendix A).

The abundance of Usambara Double-collared Sunbird individuals was significant at the Garden site for the 6:00-7:30 and 16:30-18:00 times when compared to the 7:30-9:00 and 15:00-16:300 times (Table 1, Appendix A). In addition, the Garden site also contained a higher proportion of feeding birds compared to the other three sites ($p < .00001$, $p = 0.00024$, $p = 0.00244$). While there were not more individuals feeding in the morning and the evening (Table 3, Appendix A), it is possible Usambara Double-collared Sunbirds visit shared food resources more frequently early in the morning and in the evening.

As feeding was not found to be time-dependent, this cannot be used as an explanation for the increased abundance in the mornings. It is possible the birds are less abundant during the late morning and early afternoon to avoid predators, as raptors may be using the thermal currents for soaring during these times. This would also make sense with the data as the two most covered areas, the Road II site and the Forest site, had no significant values. This may indicate that the trend in abundance is particularly prevalent for more open areas.

Nesting

The nesting ecology of the study species is similar to that of other sunbirds. In many other species the females build the nest and incubate and the males help raise the young, confirming these patterns for the Usambara Double-collared Sunbird. The Usambara Double-collared Sunbird was seen building a nest soon after finishing rearing their young or when their nest was destroyed. Since other equatorial species breed throughout the year (Lindsey 1991), this suggests that this species breeds throughout the year as well. Since there were only ever one male and one female observed at the nesting sites at a time, this suggests that Usambara Double-collared Sunbirds are monogamous like other species generally are (Lindsey 1991).

The length of the phases of nesting (building, incubating and chick feeding) could not be determined because a phase was never observed from start to finish. However, since there are many similarities between other sunbirds' and the Usambara Double-collared Sunbird's breeding ecology, it is likely the breeding phases are of comparable length. For example, the Northern Double-collared Sunbird builds for 5-7 days, incubates for 10-12 days and feeds chicks for 10-12 days (Riegert et al. 2014). More information is needed to understand the cycle of breeding.

Feeding

The number of events observed in which the Usambara Double-collared Sunbirds fed on non-native plants (n=69) was markedly higher than that of native plants (n=3). This significant value ($p<.00001$) indicates that this species does not necessarily need a high abundance of native flowering plants. Rather, the species thrives on a variety of flowering plants. This would suggest the threat of habitat degradation in the area might not be as significant to the species as it would be to those who rely heavily on native plants. In addition, changes to the flowering species composition (e.g. via introduction of exotic species), might not be harmful to the species. This suggests that the Usambara Double-collared Sunbird can prosper in a human modified landscape. In addition, other African sunbirds feed on non-native plants and some have even implemented behavioral adaptations to exploit these resources (Sjirk and Anton 2009). This furthers the idea the Usambara Double-collared Sunbird can thrive while exploiting non-native plants.

These results could be altered by the time of the year and it is possible that in a different season the numbers would change based on availability of native and non-native flowering plants.

Singing

The males were found to sing the trilling song significantly more than females ($p<0.00001$). Since males are typically more the territorial and defensive than females (Lindsey 1991), this song could be used as a territorial song. This information could be useful to future studies investigating the territorial or aggressive behaviors of the Usambara Double-collared Sunbird. In addition, the song can be used to identify the species for future studies.

Aggression

The greatest number of observed aggressive behaviors occurred at the Garden site, with 12 of the 14 behaviors seen there. Since there was a high concentration of birds and food resources in this area, the aggression could have been a result of competition over food. This is also supported by the majority of aggressive acts occurring between Usambara Double-collared Sunbirds and other sunbirds. Since they occupy the same niche, competition for food is materialized into aggression between them. Because no nests were seen in the Garden site, the possibility of the aggression occurring over nesting territory is slim.

The other two acts of aggression were observed at the Road II site near nests. There are multiple possibilities for why there were more acts of aggression near food resources than nesting sites. It could indicate males are more likely to become aggressive over their shared food resources than their territories. However, the increased aggression events could have been because of the increased concentration of individuals in the area. Likely, the reason is a combination of the shared food resources and the area being concentrated with individuals.

It is possible that the number of acts of aggression would be different at different times of the year, such as when food is more limited. This could also affeect the number of interspecies conflicts occurring. Further information is needed to understand the interspecies and intraspecies acts of aggression.

Location

While many sunbird species are able to occupy a range of habitats and some have adapted to human modified landscapes (Cheke et al. 2008), the habitat preferences of the Usambara Double-collared Sunbird are so far undescribed. The species was recorded significantly more in areas without crown cover or areas bordering an area without crown cover compared to areas with crown cover. In addition, the species built all but one of the nests in areas that had no crown cover other than that of the tree on which it was located. Their location preferences are likely because the open areas contain more flowering plants from which they can feed.

As the Usambara Double-collared Sunbird does not appear to rely heavily on areas with crown cover, it is possible that the threat of deforestation is less urgent an issue to the species. It

is also possible that with a changing availability of food through the seasons, these location preferences would change for the Usambara Double-collared Sunbird.

Biases and Limitations

Potential biases arise in this study from the length of study. The brief time period allowed for limited observations and excluded ecological changes of the Usambara Double-collared Sunbird over other seasons. Another bias is that the sites were partially chosen based on the presence of the study species. The only birds studied were those that could be seen or heard from the site which excluded birds that were unable to be seen or heard from the results. Another bias was the presence of the observer, which could have altered the behavior of the species. Lastly, the lack of banding on the birds for identification created an inability to record data on individuals and limited the amount of data that could be recorded.

Recommendations

For future studies the subject may benefit from observations over multiple seasons and for a longer period. The changing seasons may affect multiple behaviors of the Usambara Double-collared Sunbird and their study would create a more complete picture. In addition, a longer period would allow for the study of the complete breeding cycle. Studying the species in a different area of the Usambaras or the Taita Hills in Kenya would also contribute to a better understanding of the ecology of the species as this study was completed in one area only. Utilizing camera traps and bird banding would be two useful practices for future studies.

Conclusion

This study was undertaken in an attempt to describe aspects of the ecology of the Usambara Double-collared Sunbird. The study provides an overview of the multiple areas of the species behavior and interactions. It was determined that the species' activity likely peaks in the early morning, just as with many other species of bird (Robbines 1981). The nesting behavior proved similar to other species of equatorial sunbirds. The species seemed to prefer feeding on non-native plants rather than native plants, as they were much more likely to be observed feeding from the exotic species. There were more acts of aggression observed between the Usambara Double-collared Sunbird and other sunbirds, possibly suggesting other genera in the area are not competing for the same niche. Lastly, the species was found mainly in areas with limited crown cover.

While this species has a near-threatened status (BirdLife International 2016), this study's findings indicate that the species might be able to adapt to the habitat degradation occurring by feeding on non-native plants, thriving in open areas, and having limited non-sunbird competition. In addition, most other species of sunbird are resistant to changes in habitat (Cheke et al. 2008), further indicating the Usambara Double-collared Sunbird may be able to withstand human-caused environmental alterations. However, as an endemic species their range is limited, so habitat degradation that destroys food resources and nesting sites could be detrimental to the species.

Bibliography

BirdLife International 2016. n.d. “Cinnyris Usambaricus.” The IUCN Red List of Threatened Species 2016.

Bowie, Rauri C. K., Jon Fjeldså, Shannon J. Hackett, and Timothy M. Crowe. 2004. “Systematics and Biogeography of Double-Collared Sunbirds from the Eastern ArcMountains, Tanzania.” *The Auk* 121 (3): 660–81.

Bowie, Rauri C. K., Jon Fjeldså, Jacob Kiure, and Jan Bolding Kristensen. 2016. “A New Member of the Greater Double-Collared Sunbird Complex (Passeriformes: Nectariniidae) from the Eastern Arc Mountains of Africa.” *Zootaxa* 4175 (1): 23. https://doi.org/10.11646/zootaxa.4175.1.3.

Burgess, N.D., T.M. Butynski, N.J. Cordeiro, N.H. Doggart, J. Fjeldså, K.M. Howell, F.B. Kilahama, et al. 2007. “The Biological Importance of the Eastern Arc Mountains of Tanzania and Kenya.” *Biological Conservation* 134 (2): 209–31. https://doi.org/10.1016/j.biocon.2006.08.015.

Cheke, Robert, Mann Clive, and Josep del Hoyo. 2008. “Family Nectariniidae (Sunbirds).” In *Handbook of the Birds of the World*, 13: Penduline-tits to Shrikes:196–243. Barcelona: Lynx Editions.

Forshaw, Joseph Michael. 1991. *Birds*. London: Merehurst.

Geerts, Sjirk, and Anton Pauw. 2009. “African Sunbirds Hover to Pollinate an Invasive Hummingbird-Pollinated Plant.” *Oikos* 118 (4): 573–79.

Goethe Universität, Senckenberg: world of biodiversity. East African Plants: A photo guide (2010) Retrieved from http://www.eastafricanplants.senckenberg.de/root/index.php

Hall, Jaclyn, Neil D. Burgess, Jon Lovett, Boniface Mbilinyi, and Roy E. Gereau. 2009. “Conservation Implications of Deforestation across an Elevational Gradient in the Eastern Arc Mountains, Tanzania.” *Biological Conservation* 142 (11): 2510–21. https://doi.org/10.1016/j.biocon.2009.05.028.

Hoyo, J. del, and N. Collar. 2018. “Usambara Double-Collared Sunbird (Cinnyris Usambaricus).” In *Handbook of the Birds of the World Alive*. Barcelona: Lynx Editions.

Lindsey, Terence. 1991. *Encyclopeaedia of Animals: Birds*. Edited by Joseph Michael Forshaw. London: Merehurst.

Malcolm, Jay R., Canran Liu, Ronald P. Neilson, Lara Hansen, and Lee Hannah. 2006. “Global Warming and Extinctions of Endemic Species from Biodiversity Hotspots.” *Conservation Biology* 20 (2): 538–48.

Prinzinger, R., T. Schäfer, and K. Schuchmann. 1992. “Energy Metabolism, Respiatory Quotient and Breathing Parameters in Two Convergent Small Bird Species: The Fork-Tailed Sunbird Aethopyga Christinae (Nectariniidae) and the Chilean Hummingbird Sephanoides Sephanoised (Trochilidae).” *J. Therm. Biol.* 17 (2): 71–79.

Riegert, Jan, Marcin Antczak, Drahomíra Fainová, and Pavla Blažková. 2014. “Group Display in the Socially Monogamous Northern Double-Collared Sunbird (Cinnyris Reichenowi).” *Behavioural Processes* 103 (March): 138–44. https://doi.org/10.1016/j.beproc.2013.12.006.

Robbines, C.S. 1981. “Effect of time of day on bird activity.” In *Estimating Numbers of Terrestrial Birds*, 275.

Sokonie Unversity of Agriculture. 2018. “Mazumbai Training Station.” Sokonie Unversity of Agriculture: College of Forestry, Wildlife and Tourism. www.cfwt.sua.ac.tz/index.php/reserach/mazumbai.

Stevenson, T, and J Fanshawe. 2002. *Field Guide to the Birds of East Africa*. T & AD Poyser.

Appendix A

Individual Abundance by time P-value chart					
Overall					
Time	*P-value*	Time	*P-value*	Time	*P-value*
6:00-7:30 v 7:30-9:00	**0.005540885**	7:30-9:00 v 3:00-4:30	0.41236737	3:00-4:30 v 4:30-6:00	0.38818951
6:00-7:30 v 3:00-4:30	**0.006562745**	7:30-9:00 v 4:30-6:00	0.31882362		
6:00-7:30 v 4:30-6:00	**0.018735558**				
Garden					
Time	*P-value*	Time	*P-value*	Time	*P-value*
6:00-7:30 v 7:30-9:00	**0.036275243**	7:30-9:00 v 3:00-4:30	0.34251882	**3:00-4:30 v 4:30-6:00**	**0.02847904**
6:00-7:30 v 3:00-4:30	**0.036816443**	**7:30-9:00 v 4:30-6:00**	**0.01515594**		
6:00-7:30 v 4:30-6:00	0.201642611				
Forest					
Time	*P-value*	Time	*P-value*	Time	*P-value*
6:00-7:30 v 7:30-9:00	0.092428675	7:30-9:00 v 3:00-4:30	0.38627746	3:00-4:30 v 4:30-6:00	0.33877799
6:00-7:30 v 3:00-4:30	0.121031636	7:30-9:00 v 4:30-6:00	0.42409094		
6:00-7:30 v 4:30-6:00	0.084376142				
Road I					
Time	*P-value*	Time	*P-value*	Time	*P-value*
6:00-7:30 v 7:30-9:00	**0.000388954**	7:30-9:00 v 3:00-4:30	0.31742581	3:00-4:30 v 4:30-6:00	0.35479863
6:00-7:30 v 3:00-4:30	**0.046367646**	7:30-9:00 v 4:30-6:00	0.19848866		
6:00-7:30 v 4:30-6:00	0.068978172				
Road II					
Time	*P-value*	Time	*P-value*	Time	*P-value*
6:00-7:30 v 7:30-9:00	0.183336089	7:30-9:00 v 3:00-4:30	0.44173053	3:00-4:30 v 4:30-6:00	0.05530506
6:00-7:30 v 3:00-4:30	0.156018178	7:30-9:00 v 4:30-6:00	0.072352		
6:00-7:30 v 4:30-6:00	0.136114201				

Table 2: P-values of abundance of individuals between time slots. Significant p-values are bolded.

Plant fed from	Number of events	Native or non-native
Brugmansia suaveoiens	30	Non-native
Salvia leucantha	1	Non-native
Agapanthus africanus	3	Non-native
Callistemon viminalis	9	Non-native
Hibiscus acetosella	1	Non-native
*Bush with red flowers**	23	Non-native
Impatiens	1	Native
Otiophora	2	Native
Total non-native plants	69	
Total native plants	3	

Table 3: The species, number of events, and native standing of the plants the Usambara Double-collared Sunbird was seen feeding from. The bush with red flowers was unable to be identified, but staff of Sokonie University of Agriculture contributed the bush was a non-native species.

Numbers of individuals feeding by time p-value chart					
Time	*P-value*	Time	*P-value*	Time	*P-value*
6:00-7:30 v 7:30-9:00	0.15370501	7:30-9:00 v 3:00-4:30	0.18047471	3:00-4:30 v 4:30-6:00	0.3899708
6:00-7:30 v 3:00-4:30	0.40447933	7:30-9:00 v 4:30-6:00	0.27011604		
6:00-7:30 v 4:30-6:00	0.31471991				

Table 4: The number of individuals seen feeding compared to other times p-values. None were significant.