Title: Dietary Composition and Feeding Preference of Mantled guereza *Colobus guereza* (Rüppell, 1835),in Maze National Park, Ethiopia

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ABSTRACT

Knowledge of feeding ecology is essential for effective management of a primate and its habitat. The Mantled guereza *Colobus guereza* is a predominantly folivorous monkey that occurs in different parts of Africa, including the Maze National Park in Ethiopia. Despite many studies conducted in the area, there is no up-to-date data that was carried out on feeding ecology of the *Colobus guereza*. The aim of this study is to determine the dietary composition and feeding preference of the *Colobusguereza* in the park. To better understand this, we randomly selected three study groups along the Maze River. We used instantaneous scan sampling method was used to collect feeding data from September 2021-August 2022. We followed guerezas from 6:30 to 10:30 in the morning and 13:30 to 17:25 in the afternoon collecting feeding activity data between 5 minute intervals during 10-minute scan duration. Overall, guerezas were observed to eat eight plant species and unidentified invertebrates in the park. Of these, *Trichilia emetica* contributed the highest proportion accounted 53.36% and 27.83% in the wet and dry season respectively, while unidentified invertebrates were rarely utilized over the course of this study. We also found that young leaves were consumed more (75.31%) in the wet while mature leaves were eaten more (43.61%) in the dry season. These results suggest that the *guerezas* in the park exhibit temporal dietary flexibility. The observed dietary flexibility may be partly due to seasonal changes in availability of food plant parts in the groups' home ranges in the park. . Our results suggest that maintaining the park is critical to protect food plant species for this primate, which at present constitutes only a few.

Keywords/Phrases: *Colobus guereza*, Conservation, Dietary composition, Feeding Preference, Habitat, Matured leaf, Maze river, Season, Young leaf

INTRODUCTION

Understanding species' dietary composition and preferences is fundamental for guiding the development of sound conservation practices for a species and its habitat (*Ramesh & Downs, 2013*). They can also serve to identify crucial food resources and their spatio-temporal availability, assisting in the protection and restoration of important habitats of species (*Sengupta et al., 2015*).

The ongoing habitat modification due due to a variety of anthropogenic pressures *(Estrada et al., 2017; Estrada et al., 2020; Estrada & Garber, 2022; Garber, 2022*), and climate change provides a strong premise for studying diet composition and food preference in primate species For instance, about 65% of primate species are threatened with extinction, and ~75% have declining populations as a result of persistent human pressures on natural environments leading to widespread loss and degradation of tropical forests *(Estrada et al., 2017; Rudran, 2019*). Habitat loss and degradation result in loss or decline of important food plant species for primates (REFERENCE???), and this may eventually drive a primate species into extinction. Even those primate species that occupy protected areas like national parks are equally affected by climate change. Climate change could affect availability of primates' food resources through in part by altering phenological patterns of some food plant species (REFERENCE???). The effect of climate change provides a strong basis for studying feeding ecology for primate species in protected areas in order to provide baseline feeding data that can be monitored in the future.

Primates feed on a diverse array of plant items and animal tissues to meet their nutritional needs (*Coiner-Collier et al., 2016*). In response to habitat changes, they can develop ecological and behavioural flexibility (*Arroyo-Rodríguez & Fahrig 2014; Mekonnen et al., 2018*). The studies show that species display microhabitat preferences, occupying specific forest strata or habitat types (*Campbell et al.,2018; Matsuda et al., 2022*) in order to exploit different sources to meet their nutritional demands. Studies have also shown that spatial and temporal resource availability

is among the factors which can determine the distribution of a primate species (REFERENCE???).

food availability in an animal's diet is influenced by seasonal variations among other environmental factors *(Chouteau, 2006*). Some primate food resources, for instance, young leaves decline in dry season and this may compel folivorous primates to include more barks and mature leaves in their diet (REFERENCE HERE). Dietary shifts typically correspond with seasonal resource scarcity (*Yiming, 2006; Hanya & Chapman, 2013)* and probably seasonal changes in chemical composition of food plant species (REFERNCES???). Thus, a shift in an individual's diet should reflect the most profitable foods available at a specific time and place, which may also mean the most nutritious, the easiest to find, or the easiest to process (*Lambert & Rothman,2015*).

The *C. guereza*, a Least Concern species by IUCN (de Jong et al., 2019) feeds mainly on leaves (Harris & Chapman 2007; Matsuda et al., 2020). The amount of different plant parts eaten vary among groups and seasons (Harris & Chapman 2007; Ibrahim et al., 2017; Matsuda et al., 2020). The *C. guereza* occurs in different parts of equatorial Africa, including Ethiopia. In Ethiopia, the species was reported to be present in the Maze National Park by Dansan & Tekalign (2022). Despite many studies on its feeding ecology on different parts of its geographical range, the species was not studied in the in the Maze National Park up to present.

The aim of this study was to determine dietary composition, and feeding preferences of *C. guereza* in the park. Here, we hypothesized that seasonal change affects food availability, which in turn determines the dietary composition and feeding preference of the study species. Our findings suggest that season affects the accessibility of diet components and consequently influence feeding preferences of the *C. guereza*. This study is expected to offer an opportunity to create and implement successful habitat conservation strategies to preserve important food resources in the Park.

METHODS AND MATERIALS

Study area

We conducted this study at the Maze National Park (MzNP) along the Maze River, which is major habitat of target species. The area is located between Gamo and Gofa Zones, Southern Ethiopia. It is surrounded by five districts, such as Daramalo in the south and southeast, Qucha in

the east, Qucha Alfa in the northwest, Zala in the southwest and Kambazuria in the south. The Park is located between 06°18'30 and 06°29'00" N latitude and 37°7'30" to 37°22'30" E longitude (Figure 1).The elevation rangesbetween 900 and 1200 meters above sea level (*Befekadu & Afework, 2006*). The area is one of semi-arid agro-ecological zone of Ethiopia. The annual rainfall varies between 843 to 1321mm. Maze area experiences a rainy season that extends from March to October, while the dry season is from November to February. The lowest temperature recorded during the wet season is 15.3℃ in June and the highest during the dry season is 33.5℃ in February *(Mamo,2012; Tekalign & Bekele, 2011*). The Park has remarkable population of mammalian fauna such as orbi (*Ourebi aourebi*), bohor red buck (*Redunca redunca*), buffalo (*Bubalus bubalis*), warthog (*Phacochoerus africanus*), bush buck (*Tragelaphus scriptus*), greater kudu (*Tragelaphus strepsiceros*), lesser kudu (*Tragelaphus imberbis*), Water buck (*Kobus ellipsiprymnus*), bush pig (*Potamocherus larvatus*), anubus baboon (*Papio anubis*), vervet monkey (*Chlorocebus pygerythrus*), colobus monkey (*Colobusguereza*), lion (*Pantheraleo*) leopard (*Pantherapardus*), wildcat (*Felis silvestris*), and serval cat (*Leptailurus serval*, in addition to varied floral composition,that the portions of this text were previously published as preprint *(Tolcha et al., 2024)*. Itcomprisesvarieties of bird species, reptiles, amphibians and insects. Moreover, 39 larger and medium sized mammals and 196 bird species have been recorded in the Park (*Tekalign & Bekele, 2011; MzNP annual officereport, 2018*).

The Park is covered by savannah grassland with scattered deciduous broad leaved trees. Most of the Park area is plain, and is covered by open *Combretum* and *Terminalia* wooded vegetation. The River Maze begins from the surrounding highlands of the Park and drains in to the southern part of the area along with different tributaries, and traverses the Park from the northern to southern end of the area. This makes an important riverine habitat to primates, particularly for guerezas, in which no feeding activity has been detected rather than the riverine habitat over the study period (Fig. 1).

Study groups

Three groups of *C. guereza* were targeted for this study. One group with three individuals at Maze camp site (group-1); another group with two individuals at Domba site (group-2); and the third group with three individuals at Lemasse site (group-3); were randomly selected along the

River Maze. We monitored those groups in their home ranges for the duration of the study, with a research team assigned to each group to look at dietary ecology and potential differences in feeding activities.

Data collection

Diet composition

We collected feeding data for12-month period between September 2021 to August 2022) using instantaneous scan sampling (*Altmann 1974,2009*). For the dry season, we collected data from September 2021 to February 2022, and for the wet season, from March 2022 to August 2022.The feeding data were collected through direct observation, with the help of a binocular,from proper viewpoints (*Altmann, 2009*) for a fixed period of 10 minutes with 5 minutes interval from 6:30 to 10:30 in the morning and 13:30 to 17:25 in the afternoon(*Fashing et al.,2007*).

During scans, the plant species,plant parts, growth forms, and other animals consumed were recorded*(Fashing et al.,2014; Jarvey et al., 2018; Mekonnen et al., 2018*). We categorized the food components as Young leaf: a newly grown leaf that is still developing and has not yet reached its full maturity, often smaller, softer, and lighter in color compared to mature leaf; Mature leaf: a fully developed leaf that has reached its maximum size and structural maturity, typically tougher, darker in color compared to young leaf; Fruit: the reproductive structure of a plant that contains the seeds, ripe and often eaten by animals; Bark: the protective outer layer of the stem or trunk of a woody plant, and composed of multiple layers, not to mean dead layers but, living layers; Shoot: the aboveground vegetative part of a plant includes the stem and buds; Flower: the reproductive structure of a plant, and are responsible for sexual reproduction in plants; Unidentified invertebrates: Small, non-vertebrate animals that could not be identified to a specific taxonomic level, particularly insects. We then compared the number of feeding observations for each food items.

Data analysis

We combined feeding data from the three groups were into a one dataset before the computations of proportions of each diet component. The analyses were executed in XLSTAT 2023.1.3 (1407) and SPSS software version 22. Of the total of 11520 scans, we recorded 5168 (44.86%) feeding activities over the study period, (Wet: 2382, 46.09%; Dry: 2786, 53.91%). We computed the

proportion of the diet components for seven food classes (young leaf, mature leaf, fruit, bark, shoot, flower, unidentified invertebrates) recorded through the study period by dividing the number of records of a particular diet component by the total number records from all diet components. The proportion of each diet component was then converted into percentages. The chi-square test was employed to test forthe seasonal and monthly variations in proportions of the diet components.

Field permit

The Office of Executive Research Directorate and the Biodiversity Research and Conservation Center, Arba Minch University were approved the fieldwork under research permit (AMU/TH2/BRCC/09/2014). Hereby, we can guarantee that no animal capture and tissue or blood sample was taken from the subject species, as data were recorded through direct observation without animal capture.

RESULTS

~~We illustrated that seven tree plants and one shrub species, those grouped in to eight families comprised the major plant species identified as colobus feed sources in the area; of these, six plant sections were utilized by colobus as food and consumed in different proportions depending on the availability across seasons (Table 1).Nonetheless, we found no differences in the three research groups' feeding behaviors.~~

~~Food classes used by colobus between seasons~~

Food plant species consumption and preferences

We found that six tree plants (*Acacia polyacantha*, *Millettia ferruginea*, *Moringa stenopetala*, *Syzygium guineense*, *Trichilia emetica* and *Ficus sycomorus*) and two shrub species (*Carissa spinarum*, *Grewia villosa*) that weregrouped under seven families (Apocynaceae, Fabaceae, Myrtaceae, Moringaceae, Meliaceae, Moraceae and Malvaceae) were consumed by *C. guereza* in the study site. Except for the Fabaceae, all are represented by a single species. Overall, *Trichilia emitica* was the most top plant species preferred to the rest (Table 1).

During the wet season, *T. emetica* contributed the largest proportion to the total amount of young leaf consumption, accounting for 52.84% (n=948). This was followed by *Grewia villosa* at 20.68% (n=371), while *Moringa stenopetala* was rarely reported, with only 0.5% contributions (n=9) (Table 2) The second most popular food item this season was mature leaves, with *Trichilia emetica* and *Grewia villosa* making up the largest portions making up 53.12% and 46.88% respectively (Table 2). During the dry season, the *Moringa stenopetala* contributed the largest portion (386, 49.87%) of all young leaf consumption and *Millettia ferruginea* contributed the least, (0.13%) (Table 3).

Diet composition of guerezas

The annual diet of *C. guereza* comprised of young leaf, matured leaf, fruit, bark, shoot and flower (Table 4). Young leaf was the most consumed plant part in the overall annual diet. Based on seasons, there was seasonal variation in number of feeding records of all food plant items (Young leaf: $\chi 2 = 405.140$, df = 1, $p < 0.05$; Mature leaf: $\chi 2 = 651.563$, df = 1, $p < 0.05$; Fruit: $\chi 2 = 105.593$, df = 1, $p < 0.05$; Shoot: $\chi 2 = 125.063$, df = 1, $p < 0.05$). Young leaf as the major food item wasmore frequently consumed in the wet season (75.31%) while mature leaves were consumed more during the dry (43.61%) than wet season (Table 4) Interestingly, consumption of unidentified invertebrates was also recorded to increase by about 83% in the dry season (Table 4). The results also demonstrate some monthly variations in consumption of different plant parts or diet components by guerezas (Table 5).

DISCUSSION

Food plant species consumption and preferences

Comparable to other studies on feeding ecology of *C. guereza* across its geographical range, our study reports very few plant species consumed by this primate. In this study, we recorded eight plant species in the Maze National Park which are fewer than that observed in Kalinzu Forest (39 plant species) by Matsuda et al. (2020). Of these eight species, only two plant species *Trichilia emitica* (39.6%) and *Grewia villosa* (21.01%) had the highest feeding records and thus dominate

monkeys' diet. The observation of few plant species eaten by guerezas suggests that the dietary plant richness of this primate is very low in the park. This provides an urgent need to conserve the park to ensure the long-term presence of important food plant species. It appears that the guerezas in MzNP consumes food plant species as expected from its availability across its home range. Most of the plant species preferred (having high selection ratios) are those which are quite abundant in the groups's home ranges. However, this does not mean that these plant species are the most preferred plant species but rather they are fed because they are quite abundant in the habitat and not because they are most nutritious. Future studies should analyze nutrient content and other phytochemical composition of plants eaten in order to draw decisive conclusion on plant food preferences.

Our study demonstrates a seasonal variation in frequency with which certain plant species were eaten. For example, *T. emitica* was most frequently eaten during the dry season while *Syzigium guinense and Grewia villosa* were eaten in the dry season. Seasonal variation in plant phenological patterns can in part explain the observed variation in feeding plant species between seasons. We observed that monthly dietary diversity increased as the number of available plants with young leaves reduced during the dry season (Table 3). For example, the plant species such as *Ficussycomorus*, *Millettia ferruginea* and *Moringa stenopetala* were not used as food source for the study species during the wet season, because of sufficient young leaves, with exceptions thus *Moringa stenopetala* only contributed small amount in May (Table S2). On the other hand, *Moringa stenopetala* significantly contributed to the study species bearing more young leaves during the dry season (Table 4). This way, eight plant species from seven families and one non-plant source, i.e., unidentified invertebrates offered food items to the *C. guereza*in the study area. This was particularly due to the effects of the declining availability of young leaves from *Trichilia emetica* and *Grewia villosa*. Much of the dietary diversity in the study group is seemingly attributable to the availability young leaf portion of their diet.

Many colobine species, have increased dietary extent during times and areas with low availability or quality of resources (*Hu, 2011; Clink et al.,2017*). The present study depicted, the dietary extent increased with decreasing in young leaf availability during the dry season.

Food plant parts/item consumption.

We found that the guerezas exploited different plant parts, leaves being mostly eaten in the MzNP. However, it is not surprising for them to consume mostly young leaves because these monkeys like other colobines are anatomically adapted to feed on leaves (e.g. Mola et al., 2022; REFERENCES). In line with this, studies show that leaves accounted for high proportion (42–49%) by folivorous-frugivorous monkeys (*Lima et al., 2024*). Another study has shown that Bale monkey, a folivore specialist, spend more time munching on new bamboo tree leaves in Southern Ethiopia (Mekonnen *et al*., 2018). Similarly, the leaves accounted for highest proportion of *Colobusguereza's* food items;(71.6%) in Borena-Sayint National Park, Northern Ethiopia (*Hussein et al., 2017*)and 82% in Bale Mountains National Park, Ethiopia (*Petros et al., 2018*).

Furthermore, young leaves were highly eaten compared to mature leaves. This observation is in line with a study on feeding ecology of guerezas at Saja Forest, Kaffa Zone, Southwest Ethiopia, that reported the monkeys to eat young leaves over mature leaves (Mola et al., 2022). Similarly, Matsuda et al., (2020)reported the *C. guereza* to consume up to 87% young leaves in the Kalinzu Forest in Uganda. Young leaves are preffered because they have low fiber content, high nutrients and easier to digest (REFERENCE). Thus by preferentially consuming these food items, the guerezas are able to maximize their nutrient intake while minimizing the ingestion of toxic compounds. Interestingly, the guerezas were observed to increase the consumption of invertebrates during the dry season by 83% (Table 4). The high consumption of invertebrates during the dry season could be strategy to increase intake of proteins from invertebrates rather than getting it from young leaves which were lowly eaten in this season.

The results of this study have demonstrated some seasonal dietary flexibility for the guerezas in the study site. We observed the study species use young leaves and matured leaves interchangeably during the wet and dry seasons. They consume a lot of young leaves during the wet season and mature leaves during the dry season vice versa. Throughout the study months, there were considerable changes in availability and consumption rate of diet items (Table 5). This is attributed to seasonal variations in phenological patterns that affect the availability of food items which eventually influence seasonal dietary composition for the guerezas. For instance, in the field, we observed that when young leaves were insufficient during the dry season, hence the monkeys change their diet use by increasing consumption of mature leaves. This is

consistent with the previous study where resource availability is highly variable; leaf monkeys eat more leaves during periods of low fruit availability *Hanya & Bernard (2012)*. Research findings found, proboscis monkeys varied in response to monthly changes in food availability, but did not vary among forest types (*Feilen & Marshall,2020*). In addition, the influence of seasonality on the diet reported at Tanjung Putting National Park, thus fruits comprised high proportion of the diet from January to May, while young leaves consumed the highest proportion of the diets from June to December (*Yeager,1989*). This might be attributed the fact, that the season contribute to the availability and even the quality of diet components and this drives the flexibility for feeding of the species. However, *Colobusguereza*consumed high amount of young leaf during the study period, in riverine habitat of the park.

The results of this study demonstrate that the guerezas exhibit seasonal and monthly dietary variability in response to availability of food components across months or seasons (Table 4 and 5). Dietary flexibility is a strategy that enables primates to survive during periods of food shortage (*Feilen & Marshall,2020*) or exploit different parts having different food resources across their home ranges or habitats (REFERENCE).

CONCLUSION

The results of this study demonstrate low richness of dietary plant species for guerezas in the park. The observation of only eight plant species with only two mostly eaten by the monkeys provide impetus for effective protection of the park to ensure the long-term presence of important food plant species. The reliance of this primate on few plant species gives a daunting future to the survival of this population in the face of ongoing climate change. However, seasonal dietary flexibility in plant species and food plant items (plant parts and invertebrates) provide some promising future as this observation suggest that the primate can respond to habitat changes through ecological flexibility. Our research showed that the habitat found in rivers plays

a significant role containing all essential food plants and making a suitable place for the species to reside. We found that plant species' parts, particularly leaves i.e., young and mature, are a fundamental diet items to the *Colobusguereza*. The plant species such as *Trichilia emetica*, *Grewia villosa*, *Syzygium guineense* and *Moringa stenopetala* were reported among the most important food sources provide sufficient leaves (young, mature) to the subject species over the study period, and we suggest to be conserved for sustainable conservation of the species. Overall, we strongly recommend that the protection of the riverine habitat will result in effective conservation of *Colobus guereza* and its habitat in the Maze National Park.

Acknowledgements

We are grateful to the Biodiversity Research and Conservation Centerand the Office of Executive Research Directorate, Arba Minch University for granting us the field permit needed to carry out this study. Our thanks should also go to all staff members of Maze National Park, for their cooperation and support throughout this work.

Funding

We, Abraham Tolcha and the team were funded by the Biodiversity Research and conservation Center, ArbaMinch UniversityEthiopia, with the project code GOV/AMU/TH2/BRCC/09/2014. The funder offered some logistics and covered financial costs during our field work.

Grant Disclosures

The following grant information was disclosed;Biodiversity Research and conservation Center, ArbaMinch University, Ethiopia,GOV/AMU/TH_2/BRCC/09/2014.

Competing Interests

The authors have no competing interests to declare.

Author Contributions

Abraham Tolcha: conceived and designed the all research work, led the project, performed the experiments and field data collection, analyzed the data, prepared the draft manuscript, reviewed the draftmanuscript and enriched, and approved the final version.

MatewosMasne: conceived and designed the experiments, performed the field data collection, analyzed the data, reviewed the draft manuscript, and approved the final draft.

Belayneh Ayechw: conceived and designed the experiments, performed the field data collection, analyzed the data, reviewed the draft manuscript, and approved the final draft.

Data Availability

Data will be available based on the data sharing policies and procedures of the journal.**Supplemental Information**

Supplemental information for this work can be found online at web site of this journal.

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Table 1 Feeding preference (selection ratio) of food plant species consumed by *Colobus guereza* during the study period.

Family	Species		Mean annual proportion (%)	Stem/ha	Selection ratio	Rank
Apocynaceae	*Carissaspinarum*	Shrub	4.22	7.22	0.58	6
Fabaceae	*Millettiaferruginea*	Tree	2.32	4.16	0.56	7
Myrtaceae	*Syzygiumguineense*	Tree	17.92	5	3.58	2
Moringaceae	*Moringastenopetala*	Tree	7.64	4.16	1.84	4
Meliaceae	*Trichiliaemetica*	Tree	39.59	9.16	4.32	1
Moraceae	*Ficussycomorus*	Tree	0.81	4.16	0.19	8
Malvaceae	*Grewiavillosa*	Shrub	21.01	9.44	2.22	3

Fabaceae	*Acaciapolyacantha*	Tree	5.24	4.44	1.18	5

Table 2: Diet components consumed per plant species during wet season

Plants pecies used	Food components consumed during wet season(%)						
	YL	ML	FR	Bk	Sh	FL	Total
Carissaspinarum	0	0	6.04	0	0	0	6.04
Millettiaferruginea	0	0	0	0	0	0	0
Syzygiumguineense	12.93	0	0	0	0	0	12.93
Moringastenopetala	0.38	0	0	0	0	0	0.38
Trichiliaemetica	39.80	5.37	0	0	8.19	0	53.36
Ficussycomorus	0	0	0	0	0	0	0
Grewiavillosa	15.57	4.75	0	0	0	0	20.32
Acaciapolyacantha	6.63	0	0	0	0	0	6.63
Unidentified invertebrates							0.34
Total	75.31	10.12	6.04	0	8.19	0	100

Table 3: Diet components consumed per plant species during the dry season

Plantspeciesused Foodcomponentsconsumedduring drseason(%)							
	YL	ML	FR	Bk	Sh	FL	Total
Carissaspinarum	0	0	2.67	0	0	0	2.67
Millettiaferruginea	0.06	0	1.83	2.40	0	0.06	4.35
Syzygiumguineense	1.90	10.37	3.30	0	0.1	6.49	22.16
Moringastenopetala	13.86	0	0	0	0	0	13.86
Trichiliaemetica	6.44	17.30	3.55	0	0.54	0	27.83
Ficussycomorus	0	0	1.5	0	0	0	1.5
Grewiavillosa	5.57	15.94	0	0	0	0.1	21.61
Acaciapolyacantha	0	0	0	4.05	0	0	4.05
Unidentified invertebrates							1.97
Total	27.82	43.61	12.85	6.45	0.64	6.65	100

Table 4: Percentage composition of annual and seasonal dietary composition

Plant parts eaten	YL	ML	FR	Bk	Sh	Fl	Unidentified inveretebrates
Wet season	75.31	10.12	6.06	0	8.19	0	0.34
Dry season	27.82	43.82	12.85	6.45	0.64	6.65	1.97
Annual /Overall	51.57±23.7	26.97±16.9	9.46±3.4	3.22±3.2	4.42±3.7	3.32±3.3	1.16±0.8

Table 5 Proportion of diet components used by Colobus monkeys for each month during the 13 study period

No.	Food components	Diet components consumed by Colobus monkey over months of the year (%)											
		Nov. 2021	Dec. 2021	Jan. 2022	Feb. 2022	Mar. 2022	Apr. 2022	May 2022	June 2022	July 2022	Aug. 2022	Sep. 2022	Oct. 2022
1	Young leaf	20	21	25	27	38	39.5	41	46	49.5	46.5	43	40
2	Matured leaf	28.5	24	27.5	31	28	23.5	21.5	19.5	27	28	29.5	31
3	Fruit	21	17.5	15	10.5	7.5	12	8.5	13.6	6	8	9.75	9
4	Flower	14	10	9.3	8.5	6.5	9	10.5	4.5	2.5	3.5	6	4
5	Bark	3.5	4	3.45	3	2.5	2.3	3	3.4	1.2	2	1.5	4
6	Shoot	4	12.5	9	7	6	5.7	9	7	4.3	5.5	3	2.5
7	Unidentified invertebrates	9	11	10.75	13	11.5	8	6.5	6	9.5	6.5	7.25	9.5

563