

Forage Plants for Small Ruminant Feeding at Rural and Peri-Urban Sites in the Warm Humid Tropical Environment of Southeastern Nigeria

Futterpflanzen für die Fütterung kleiner Wiederkäuer in ländlichen und stadtnahen Gebieten in der feuchtwarmen tropischen Umgebung im Südosten Nigerias

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Summary

This study aimed at determining the diversity of forage plants utilized for small ruminant feeding in rural and peri-urban sites in Imo state, Nigeria. The survey was carried out at rural and peri-urban sites in Aboh Mbaise and Mbaitoli Local Government Areas (LGAs), respectively. Ten small ruminant farmers were purposively selected from each LGA across the study communities. Data on fodder diversity, proximate composition, and mineral concentration were collected and analyzed using descriptive statistics such as frequency counts, percentages, means, and standard deviation. It was observed that a higher diversity of fodder plants existed at the rural sites compared to the peri-urban sites and 43.4% of the fodder plants were common to both sites. Respondents identified 60.8% of the fodder plants also as food-bearing plants, with 55.6% and 80% of these found at the rural and peri-urban sites, respectively. There were no significant differences ($p > 0.05$) between the relative proximate or mineral supplies to the animals at the two sites. It was, therefore, concluded that despite the diversity and differences in forage selection at the two sites, the relative nutrient supplies to small ruminants will be similar if the cafeteria system of forage provision practiced at the sites is adhered to.

Keywords: forage, diversity, utilization, land pressure, population density, small ruminants

Zusammenfassung

Ziel dieser Studie war es, die Vielfalt der für die Fütterung von kleinen Wiederkäuern genutzten Futterpflanzen in ländlichen und stadtnahen Gebieten im nigerianischen Bundesstaat Imo zu bestimmen. Die Untersuchung wurde in ländlichen und stadtnahen Gebieten in den LGAs Aboh Mbaise und Mbaitoli durchgeführt. Aus jedem LGA der untersuchten Gemeinden wurden zehn Landwirte, die kleine Wiederkäuer halten, nach dem Zufallsprinzip ausgewählt. Die Daten über die Vielfalt des Futters, die Zusammensetzung der Inhaltsstoffe und die Mineralstoffkonzentration wurden mit Hilfe von deskriptiven Statistiken wie Häufigkeit, Prozentsatz, Mittelwert und Standardabweichung erhoben und ausgewertet. Es wurde festgestellt, dass an den ländlichen Standorten eine größere Vielfalt an Futterpflanzen vorhanden war als an den stadtnahen Standorten. 43,48 % der Futterpflanzen waren an beiden Standorten zu finden. 60,87 % der von den Befragten identifizierten Futterpflanzen waren auch Nahrungspflanzen, 55,56 % auf dem Land und 80,00 % in der Stadtrandlage. Es gab keine signifikanten Unterschiede ($p > 0,05$) zwischen der relativen proximalen oder mineralischen Versorgung der Tiere an den beiden Standorten. Daraus wurde gefolgert, dass trotz der Vielfalt und der Unterschiede in der Futterauswahl an den beiden Standorten die relative Nährstoffversorgung der kleinen Wiederkäuer ähnlich ist, wenn das an den Standorten praktizierte Cafeteria-System der Futtermittelversorgung beibehalten wird.

Schlagwörter: Futter, Vielfalt, Nutzung, Landdruck, Bevölkerungsdichte, kleine Wiederkäuer

1. Introduction

Livestock farmers in the warm, humid tropical rainforest agroecological zone of southeastern Nigeria have access to a rich diversity of plant resources in the form of trees, shrubs, herbs, woody vines, weeds, grasses, and forbs for feeding small ruminants. These plants represent an abundant ever-green feed resource in the compound bushes, farmlands, and forests and have continued to supply the nutrient needs of livestock and wildlife in the zone (Achonwa et al., 2017). The diversity, livestock feeding, food, medicinal, and other uses of these plants are well known to the indigenous ruminant farmers in the zone (Okoli et al., 2002 and 2003a; Obua, 2013; Achonwa et al., 2017). Okoli et al. (2003a) reported that more than 163 forage plants are utilized by farmers for small ruminant feeding in the diversity of the forage plants in Anambra, Abia, and Imo states of the zone. Obua (2013) specifically listed 177 forage plants used in the feeding of goats at the mostly agrarian Ohaji/Egbema/Oguta area of Imo state. Significant variations in forage plants preferred by farmers for feeding livestock have also been reported at different sites in the zone, and have been attributed to the effects of the different animal husbandry systems and environmental changes on forage usage and availability in the zone (Njoku, 2006; Okoli et al., 2014a). For example, at many sites in the zone, small ruminants are permanently confined and the fodder is cut and carried to them, while at other sites, they are allowed to roam extensively in search of feed or tethered during the day in the fallow or compound bushes (Gefu et al., 1994).

The southeastern zone was known to harbor a sizable percentage of the rainforest and biological diversity of southern Nigeria, which was exploited for its forest resources, arable farming, small-scale livestock keeping, and several other ecosystem services by the inhabitants (Ndaeyo et al., 2001; Ogbuewu et al., 2016; Chiaka et al., 2022). The fragile ecosystem of the zone has been degraded overtime by persistent anthropogenic pressure and climatic change events, resulting in depletion of the forest resources (Njoku, 2006 and 2009) and alterations in the livelihood activities of the inhabitants. The ruminant forage resource diversity and use habits of the smallholder farmers in the zone are also being altered by the increasing population density and land pressure (Gefu et al., 1994; Madu, 2005). Again, labor requirements and the frequent resource conflicts between livestock owners and crop farmers in recent times have made the livestock confinement option more favorable at most locations in Imo state (Okoli et al., 2014a; Anyanwu et al., 2020).

Under natural conditions, small ruminants spend more than 90% of their feeding time browsing a wide variety of forage plants to achieve about 50% of their total dry matter (DM) intake (Gefu et al., 1994). Age-long indigenous ruminant feeding practices such as the cafeteria method, which involves offering a cocktail of forage plants to the animals at the same time by local farmers in the zone, mimic this feeding habit of small ruminants (Boga et al., 2009). This feeding approach has been used by the ruminant farmers to achieve efficient forage and nutrient supply to the animals, while helping to complement and ameliorate the endogenous toxic effects of specific forages, thereby preventing the emergence of any adverse pathology (Etuk et al., 2005). Similar indigenous knowledge practices with positive outcomes on animal performance were also reported by Thorne et al. (1997) among smallholder ruminant farmers in rural Nepal. The impact of environmental change on forage diversity and availability in Imo state may, however, affect the choice of forage supplied by farmers to their animals and, therefore, their nutrient needs and health outcomes. Diminishing vegetal resources may lead to changes in forage preferences by the farmers and may also result in fewer plant varieties being included in the cocktail of fodder supplied to the animals. These impacts may vary at different sites in the state, especially between the rural and urban environments, in response to the variation in anthropogenic changes at these sites. This is exemplified by the report of Usman and Nichol (2022) that between 1980 and 2014, there was greater loss in forage resources at locations surrounding urban centers than in rural areas of the northern Savannah zone of the country. It is, therefore, possible that since 20 and 10 years ago when Okoli et al. (2003a) and Obua (2013), respectively, published their studies on the diversity of forage plants in southeastern Nigeria, significant changes may have occurred in the forage dynamics in Imo state to influence their availability and nutrient supply to small ruminants.

This paper presents the results of a study carried out at rural and peri-urban sites in Imo state, southeastern Nigeria, to determine the diversity and the nutrient compositions of the most preferred forage plants used for small ruminant feeding.

2. Materials and Methods

2.1. Study area

This study was carried out at rural sites in Aboh-Mbaise Local Government Area (LGA), located in the southwestern part of

Imo state and peri-urban sites in Mbaitoli LGA in the central part of the state in the southeastern agroecological zone of Nigeria. The state is located between latitude 6° and 8°N of the equator and longitude 5.83° and 6°E of the Greenwich Meridian. It has a land area of about 5135 km², a population of about 5.4 million persons, and population density of 1063 persons per km² (NPC, 2006 Projections, 2022). Aboh-Mbaise LGA hosts an estimated population of 270,700 persons, while Mbaitoli LGA has an estimated population of 330,100 persons and is the most populated LGA in the state. The climate is marked by a rainy season period, which extends from April to October, and a dry season, extending from November to March. Most of the mean rainfall reaches about 2152 mm per year and is associated with the maritime southwesterly trade winds from the Atlantic Ocean. The average relative humidity is about 80% and could reach up to 90% during the rainy season. The mean daily maximum air temperature ranges from 28°C to 35°C, while the mean daily minimum air temperature ranges from 19°C to 24°C.

The vegetation is typically rainforest (Agboola, 1979) and is characterized by many varieties of densely populated grasses, legumes, shrubs, herbages, and trees, which are not only nutritional, but also exploited for other economic and health purposes (Obua, 2013). The climate favors the production of roots, tubers, cereals, vegetables, nuts, and several cash crops, which are grown mostly by smallholder farmers in small plots of land. Most households rear animals such as sheep, goat, pigs, and poultry mostly on part-time basis (Okoli et al., 2004). Many rural families in southeastern Nigeria keep small ruminants as sources of income, animal manure, readily accessible meat, and for various cultural activities (Achonwa, 2017). Small ruminant farmers at the study sites practice permanent confinement of their animals, while forages are supplemented with kitchen wastes.

2.2. Sampling and identification of forage plants

The study was undertaken between May and June 2021. The rural area survey was carried out at Aboh Mbaise LGA, while the peri-urban survey was carried out at Mbaitoli LGA. Both LGAs and communities were selected based on the results of an informal survey of the study area, during which the researchers made themselves known to the community leaders and with their help, they identified the small ruminant farmers and explained the nature of the study to them (Achonwa, 2017). The ruminant farmers were selected based on their willingness to participate in the study, having

at least four small ruminants in their compounds, and having at least 5 years of experience in ruminant keeping. Ten ruminant farmers who met the selection criteria were selected purposively from each LGA across the study communities. Gender balance of respondents was ensured to generate representative data since according to Okoli et al. (2003a), information on diversity of forage plants varies across gender and study sites in the study area. The study was carried out by the same researchers to ensure data consistency.

Each farmer was visited once for the purposes of plant selection and identification. The researchers accompanied each farmer to the surrounding compound bushes and fallow lands for direct sampling, identification, and documentation of the fodder plants using their English and Igbo language names. Representative samples of the identified plants were collected, tagged, and stored for botanical identification. The farmers were also asked to identify the plants that served as food at the study sites. The information gathered at the sites in each LGA was pooled and used to build the list of forage plants fed to small ruminants in the LGA. All the plant samples were identified botanically at the Department of Crop Science and Technology, Federal University of Technology Owerri, Nigeria. Two of the sampled plants could not be readily identified and were preserved for future identification, while their Igbo names were adopted for the study. The listed fodder plants were ranked using their frequency of mention by the farmers. The seven most commonly occurring plants at each LGA were thereafter selected and analyzed for their nutrient values.

2.3. Proximate and mineral analysis of the most preferred forage plants

The apical leaves of the most commonly occurring forage plants were gathered and sun dried until they became crispy to touch. They were packed in polyethylene pouches, labeled, and sent to the laboratory for their proximate and mineral analysis using the methods described by Association of Official Analytical Chemists (AOAC) International (2016). The proximate analysis was carried out to determine the DM, crude protein (CP), ether extract (EE), crude fiber (CF), total ash (TA), and nitrogen-free extract (NFE) values. The mineral concentrations in the plants were also analyzed with an atomic absorption spectrophotometer (Model 210 VGB, Bulk Scientific) to determine the calcium (Ca), phosphorus (P), sodium (Na), potassium (K), magnesium (Mg), manganese (Mn) iron (Fe), zinc (Zn), copper (Cu), and lead (Pb)

content. Using the data generated, the mutual proportions of the individual minerals were calculated as ratios of Ca:P, K:Mg, Na:K, Ca:Mg $K(Ca + Mg)$, and $(K + Na):(Ca + Mg)$ (Jakubus and Graczyk, 2022). The unit milliequivalents per kg was used to calculate $K(Ca + Mg)$ and $(K + Na):(Ca + Mg)$ according to Oetzel (1993), while mg/100 g was used to calculate the other values.

2.4. Data analysis

The fodder diversity, proximate composition, and mineral concentration data were analyzed using descriptive statistics such as frequency counts, percentages, means, and standard deviation (SPSS, 2012). To predict the relative nutrient supply to the small ruminants at each study location, the proximate and mineral values of the seven most commonly identified fodder plants were adopted as the realistic representation of the daily fodder-derived nutrients supplied to the animals. This is based on the fact that the choice or cafeteria method of feeding which involves the offering of a cocktail of several forage plants at the same time is traditionally used by farmers to supply nutrients to permanently confined small ruminants at the study area (Gefu et al., 1994). Thus, the most commonly identified fodder plants were regarded as the daily cocktail of forage offered to the animals at the study sites. The overall mean proximate and mineral values of the forage plants at each study site were, therefore, compared using the Student's t-test method (SPSS, 2012) to determine the statistical differences in nutrient supply at the sites.

3. Results and Discussion

3.1. Diversity of fodder plants at rural and peri-urban sites

The results presented in Table 1 show that 21 and 15 fodder plants were identified at the rural and peri-urban sites, respectively, indicating a higher diversity of fodder plants at the rural site. Overall, 23 fodder plants were identified, indicating some level of homogeneity in farmers' forage knowledge at the two sites. The palm frond (*Eleasia guineensis*) was identified by all farmers at both the study sites, while the African Rosewood (*Pterocarpus santalinoides*) and Indian bamboo (*Bambusa tulda*) were also identified by all farmers at the peri-urban site. Two grass species (*Pennisetum purpureum* and *Achacha* field) were included in the rural list, while none was included in the peri-urban list. The

frequency of occurrence of the different fodder plants has been derived from the list in Table 1, and is presented in Table 2 and shows that most of the fodder plants at the rural site were identified once (38.89%) and twice (22.22%). At the peri-urban site, 26.67% of the plants were identified by four farmers and 20.0% each were identified by five and 10 farmers, while 6.67% each of the plants was identified by one and two farmers. The results also show that while 61.11% of the forage plants at the rural site were identified 1–2 times, the value for the peri-urban sites was only 13.34%. Inversely, 33.33% of the plants at the peri-urban site were identified 9–10 times, while only 5.56% at the rural site were similarly identified. These findings highlight major differences in fodder plant usage among the farmers at the two sites and may be attributed to loss of diversity and lesser fodder options at the peri-urban site than the rural site.

The number of fodder plants identified by the farmers in this study is much smaller than the more than 163 identified at three southeastern states (Anambra, Abia, and Imo states) of Nigeria and the 177 identified by Obua (2013) at Ohaji/Egbema/Oguta area of Imo state. This is probably due to the differences in the number of respondents sampled in the different studies and, more importantly, the possible erosion of forage diversity over time in the study area. Ekwe et al. (2020) also documented 26 forage species made up of 13 grasses, five legumes, two trees, and six shrubs in their more recent study of forages available to grazing goats at Abakiliki area of southeastern Nigeria. Anyanwu et al. (2020) have reported significant shifts from small ruminant farming (4.8%) to poultry farming (33.7%) and cultured fish farming (25.3%) among farming households in three LGAs of Imo state, although about 74.0% of these households had a history of small ruminant keeping. It is, therefore, probable that such significant decline in small ruminant keeping in the state will be accompanied by serious erosion of knowledge about fodder diversity. The differences observed between the fodder dynamics at the rural and peri-urban sites also support the recent report by Usman and Nichol (2022) that there is greater loss in forage resources at locations surrounding urban centers than in rural areas of the northern Savannah zone of Nigeria. These variations are arguably driven by anthropogenic and socioeconomic changes which may have varied impacts on forage resources and the options available to the smallholder farmers at the different sites.

The results presented in Table 3 show that 14 of the fodder plants used to feed small ruminants, which were identified by the farmers were also food-bearing plants – 10 (55.56%) at the rural site and 12 (80.00%) at the peri-urban site and 66.67% overall – thus highlighting again the variations in fod-

Table 1. Diversity of forage plants used in feeding small ruminants by farmers at the rural and peri-urban sites in Imo state

Tabelle 1. Vielfalt der Futterpflanzen, die von Landwirten in ländlichen und stadtnahen Gebieten im Bundesstaat Imo zur Fütterung kleiner Wiederkäuer verwendet werden

S/No.	Forage plant	English name	Igbo name	Frequency (%) in the rural site (n = 10)	Frequency (%) in the peri-urban site (n = 10)	Overall frequency (%) (n = 20)
1	<i>Pterocarpus mildraedii</i>	African Rosewood	Oha	1 (10.00)	2 (20.00)	3 (15.00)
2	<i>Dialium guineense</i>	African velvet tamarind	Icheku/Nchichi	8 (80.00)	5 (50.00)	13 (65.00)
3	<i>Persea americana</i>	Avocado	Ube Bekee	5 (50.00)	9 (90.00)	14 (70.00)
4	<i>Vernonia amygdalina</i>	Bitter leaf	Onugbu	3 (30.00)	1 (10.00)	4 (20.00)
5	<i>Costus afer</i>	Wild cane	Okpete	3 (30.00)	-	3 (15.00)
6	<i>Urena lobate</i>	Caesar weed	Udo	2 (20.00)	-	2 (10.00)
7	<i>Manihot esculanta</i>	Cassava	Akpu	2 (20.00)	4 (40.00)	6 (30.00)
8	<i>Pennisetum purpureum</i>	Elephant grass	Achara nwakita	3 (30.00)	-	3 (15.00)
9	<i>Gmelina abore</i>	Gmelina	Melina	1 (10.00)	-	1 (5.00)
10	<i>Psidium guajava</i>	Guava	Gova	1 (10.00)	5 (50.00)	6 (30.00)
11	<i>Chromolaena odorata</i>	Seam weed (Eliza)	Awolowo	2 (20.00)	-	2 (10.00)
12	<i>Pterocarpus santalinoides</i>	African rosewood	Oha Nturukpa	1 (10.00)	10 (100.00)	11 (55.00)
13	<i>Eleasia guineensis</i>	Palm fronds	Igu Nkwu	10 (100.00)	10 (100.00)	20 (100.00)
14	<i>Dacryodes edulis</i>	African pear	Ube	2 (20.00)	-	2 (10.00)
15	<i>Musa acuminata/paradisiaca</i>	Banana/plantain	Abirica/Une	1 (10.00)	9 (90.00)	10 (50.00)
16	<i>Aspilia africana</i>	Hemorrhage plant	Oranjila	4 (40.00)	6 (60.00)	10 (50.00)
17	<i>Bambusa tulda</i>	Indian bamboo	Ekwe achara	-	10 (100.00)	10 (50.00)
18	<i>Treculia africana</i>	Breadfruit	Ukwa	-	5 (50.00)	5 (25.00)
19	<i>Kola nitida</i>	Kola	Oji	-	4 (40.00)	4 (20.00)
20	<i>Microdesmus puberula</i>		Atumkpiri	-	4 (40.00)	4 (20.00)
21	<i>Spondia mombin</i>	African plum	Njikara	-	2 (20.00)	2 (10.00)
22			Mpupu	1 (10.00)	-	1 (5.00)
23			Achara field	1 (10.00)	-	1 (5.00)
Total				18	15	23

der use approach at the two sites. The overall value is much higher than the 22.06% reported by Okoli et al. (2003a) in their much wider study covering three states in southeastern Nigeria. The scenario at the peri-urban site is interesting and shows the possible human response to the diminishing compound bushes and fallows that traditionally harbor these forage plants. The results seem to support the report by Okoli et al. (2014b) that most rural farmers tend to selectively allow plants that have more than one value in their compound bushes. Furthermore, it is probable that as farm/forage lands shrink at the peri-urban site, the shared dependence of both the farmers and their animals on the available biological diversity for sustenance increasingly demands the conservation of plants that have multiple values (Obua, 2013). Indeed, Okoli et al. (2014b) postulated that the future of successful livestock feeding in southeastern Nigeria will partly depend on the identification and domestication of selected highly nutritious forage plants that have other values such as food, medicinal, fuel, shading, soil enrichment, and ornamental values.

The lists of seven most commonly identified forage plants for feeding small ruminants at the rural and peri-urban sites are shown in Table 4. Again, six out of the seven plants list-

ed at the peri-urban site (*E. guineensis*, *P. santalinoides*, *Musa acuminata/paradisiaca*, *Persea americana*, *B. tulda*, and *Aspilia africana*) were identified by 8–10 farmers, with the range being 5–10 farmers per plant. At the rural site, however, only two plants (*E. guineensis* and *Dialium guineense*) were identified by 8–10 farmers, with the range being 3–10, indicating that fodder use knowledge is more closely shared among the farmers at the peri-urban site than the rural site. Overall, four of the plants (*E. guineensis*, *P. americana*, *D. guineense*, and *A. africana*) were commonly identified at both sites. These findings support the observations by Okoli et al. (2003a) that changes in the abundance of forage resources may also lead to changes in forage preferences by farmers and may result in fewer plant varieties being included in the cocktail of fodder supplied to the ruminants in southeastern Nigeria.

3.2. Proximate compositions of fodder plants at the rural and peri-urban sites

The proximate compositions of the commonly identified fodder plants at the rural and peri-urban sites are present-

Table 2. The frequency of occurrence of forage plants used in feeding small ruminants at the rural and peri-urban sites

Tabelle 2. Häufigkeit des Vorkommens von Futterpflanzen, die zur Fütterung kleiner Wiederkäuer in ländlichen und stadtnahen Gebieten verwendet werden

Number of occurrence	Frequency (%) in rural sites (n = 18)	Frequency (%) in peri-urban sites (n = 15)	Overall frequency (%) (n = 33)
1	7 (38.89)	1 (6.67)	8 (24.24)
2	4 (22.22)	1 (6.67)	5 (15.15)
3	3 (16.67)	-	3 (9.09)
4	1 (5.56)	4 (26.67)	5 (15.15)
5	1 (5.56)	3 (20.00)	4 (12.12)
6	-	1 (6.67)	1 (3.03)
7	-	-	-
8	1 (5.56)	-	1 (3.03)
9	-	2 (13.33)	2 (6.06)
10	1 (5.56)	3 (20.00)	4 (12.12)
Total	18	15	33

ed in Table 5. The common fodders at the peri-urban site recorded higher mean DM (87.80 ± 0.99 g/100 g) than those at the rural site (86.97 ± 1.30 g/100 g). The CP values ranged from 5.96% to 15.17% (mean $10.09\% \pm 3.17\%$) at the rural site and from 5.97% to 14.06% (mean 9.83 ± 2.42 g/100 g) at the peri-urban site, indicating slightly higher value at the rural site. CP values recorded for *V. amygdalina*, *E. guineensis*, *P. purpureum*, and *M. paradisiaca* at both sites were comparable and within the range 17.92%–28.2%, 4%–10%, 11.9%, and 9.9%–17.9% reported for these plants by Islam et al. (2000), Shittu et al. (2011), and Ffoulkes et al.

(1977), respectively. The EE values (means 2.91 ± 1.68 and 2.69 ± 1.75 g/100 g, respectively) and the TA values (means 10.60 ± 1.88 and 9.12 ± 2.11 g/100 g, respectively) were also higher at the rural sites. Values recorded in this study for *A. africana*, *V. amygdalina*, and *E. guineensis* were similar and within the range of values (2.37%–5.07% and 9.17%–16.17%; 5.2%–5.5% and 9.30%–16.65%; 2.02%–7.1% and 5.2%) for EE and TA, respectively, reported by Okwuonu et al. (2017), Fadiyimu et al. (2011), and Usonumena and Okolie (2016). However, the EE value for *A. africana* at the peri-urban site was much below the range of value reported by these authors. The values of CF and NFE were higher at the peri-urban site. The highest CP, EE, CF, TA, and NFE values at the rural site were recorded in *V. amygdalina*, *A. africana*, *P. purpureum*, *A. africana*, and *D. guineense* sample, respectively, while at the peri-urban site, the highest values were recorded in *P. santalinoides* (CP and EE only), *E. guineensis*, *M. paradisiaca*, and *B. tulda*, respectively. The *A. africana* sample from the rural site recorded higher CP, EE, and TA values than the sample from the peri-urban site. The CP value for *A. africana* recorded at the rural site was comparable to the range of values (15.62%–17.1%) reported by Okwuonu et al. (2017) and Fadiyimu et al. (2011), while the CP values from the peri-urban site were much below these ranges of values reported by these authors. The *P. americana* sample from the peri-urban site recorded higher CP, EE, and NFE values than the sample from the rural site. Okoli et al. (2001) reported similar DM, EE, and CF but higher CP and lower NFE range in six browse plants sampled in three states of southeastern Nigeria. They specif-

Table 3. Distribution of food-bearing plants used as forage for small ruminants by farmers at the rural and peri-urban sites in Imo state

Tabelle 3. Verteilung der Futterpflanzen, die von Landwirten in ländlichen und stadtnahen Gebieten im Bundesstaat Imo als Futter für kleine Wiederkäuer verwendet werden.

S/N	Food-bearing plants	Part used as food	Frequency (%) at the rural sites (n = 10)	Frequency (%) at the peri-urban sites (n = 12)	Overall frequency (%) (n = 22)
1	<i>Pterocarpus mildbraedii</i>	Leaves	1 (10.00)	-	1 (4.55)
2	<i>Dialium guineense</i>	Seeds	8 (80.00)	5 (41.67)	13 (59.09)
3	<i>Persea americana</i>	Fruits	5 (50.00)	9 (75.00)	14 (63.64)
4	<i>Vernonia amygdalina</i>	Leaves	3 (30.00)	1 (8.33)	4 (18.18)
5	<i>Manihot esculanta</i>	Tuber	2 (20.00)	4 (33.33)	(27.27)
6	<i>Psidium guajava</i>	Fruits	1 (10.00)	5 (41.67)	6 (27.27)
7	<i>Pterocarpus santalinoides</i>	Leave	1 (10.00)	10 (83.33)	11 (50.00)
8	<i>Eleasia guineensis</i>	Oil nuts	10 (100.00)	10 (83.33)	20 (90.90)
9	<i>Dacryodes edulis</i>	Fruits	2 (20.00)	-	2 (9.09)
10	<i>Musa acuminata/paradisiaca</i>	Fruits	1 (10.00)	9 (75.00)	10 (45.45)
11	<i>Treulia africana</i>	Seeds	-	5 (41.67)	5 (22.73)
12	<i>Kola nitida</i>	Nuts	-	4 (33.33)	4 (18.18)
13	<i>Spondia mombin</i>	Plum	-	2 (16.67)	2 (9.09)
14	<i>Microdesmus puberula</i>	Leaves	-	4 (33.33)	4 (18.18)
Number and percentages of food bearing plants			10 (55.56)	12 (80.00)	22 (66.67)

Table 4. List of the seven most commonly identified forage plants for feeding small ruminants at rural and peri-urban sites in Imo state
Tabelle 4. Liste der sieben am häufigsten identifizierten Futterpflanzen für die Fütterung kleiner Wiederkäuer an ländlichen und stadtnahen Standorten im Bundesstaat Imo

S/No.	Forage plant	Frequency at the rural site	Frequency at the peri-urban site
1	<i>Eleasia guineensis</i>	10	10
2	<i>Pterocarpus santalinoides</i>	-	10
3	<i>Musa acuminata/paradisiaca</i>	-	9
4	<i>Persea americana</i>	5	9
5	<i>Bambusa tulda</i>	-	9
6	<i>Dialium guineense</i>	8	5
7	<i>Aspilia africana</i>	4	8
8	<i>Vernonia amygdalina</i>	3	-
9	<i>Pannisetum purpureum</i>	3	-
10	<i>Costus afer</i>	3	-
Total		7	7

ically published similar DM, EE, and TA values, higher CP and CF values, and lower NFE value in *Costus afer* sample from Abia state. Chidolue (1993) reported a CP range of 11.20%–18.36% in selected browses from the Owerri area of Imo state, indicating that some of our values fell below the lower margin of that range. Again, Okoli et al. (2003b) reported higher mean DM, CP, and EE values, but lower CF and TA values in selected browses from Imo state. All the proximate values recorded in *V. amygdalina* in their work, with the exception of NFE, were particularly higher than the values recorded in the present study. The average CP and TA contents of West African forages have been reported by Le Houerou (1980) to be 12.50% and 10.90%, respectively. The four commonly identified plants (*E. guineensis*, *P. americana*, *D. guineense*, and *A. africana*) also recorded varied proximate values at the different sites. For example, *E. guineensis* and *P. americana* recorded higher CP, EE, and NFE values at the peri-urban site than the rural site, while *A. africana* recorded higher CP, EE, and TA values at the rural site. Such variations in the proximate values have been attributed to within-species differences, the stage of plant growth, plant part, harvesting regime, season, soil type, and laboratory analysis (Mecha and Adegbola, 1980; Norton, 1994).

3.3. Mineral concentrations in fodder plants at the rural and peri-urban sites

The mineral concentrations (mg/kg) in the most commonly identified forage plants at the study sites are shown in Ta-

ble 6. Generally, the macromineral concentrations in the forage plants are low in comparison to the range of values recommended for goats (Mcdowell, 1985; Kessler, 1991; NRC 2007) and vary across study sites and within plant species. Mean concentrations of Ca, P, Na, K, and Mg at the rural and peri-urban sites were 195.3 ± 93.2 and 350.9 ± 351.8 mg/kg, 307.8 ± 363.8 and 524.3 ± 356.7 mg/kg, 363.9 ± 240.7 and 315.8 ± 156.9 mg/kg, 170.7 ± 61.6 and 128.0 ± 40.7 mg/kg, and 53.3 ± 56.3 and 39.2 ± 17.5 mg/kg, respectively. The mean mineral concentrations of Ca and P were higher at the peri-urban site, while the concentrations of Na, K, and Mg were higher at the rural site. The highest concentrations of Ca, P, and Na at the rural site were recorded in the *P. americana* leaves, while the highest values of the minerals at the peri-urban site were recorded in the *A. africana*, *M. paradisiaca*, and *E. guineensis* leaves, respectively. *V. amygdalina* and *P. purpureum*, however, recorded the highest K and Mg concentrations at the rural site, while the values recorded in *D. guineense* and *A. africana* were the highest at the peri-urban site. Most of the macromineral values recorded at the study sites were below the range recommended for ruminants (Underwood, 1981; Mcdowell, 1992 and 1997; Islam et al., 2003; Suttle, 2010). Exceptionally low levels of Mg were, however, recorded in *P. santalinoides* leaves (10.87 mg/kg) at the peri-urban site and in *E. guineensis* (23.58 mg/kg), *D. guineense* (24.37 mg/kg), *A. africana* (11.87 mg/kg), and *V. amygdalina* (18.25 mg/kg) at the rural site, indicating that many forage plants in the study area may be endemically low in Mg content. The *E. guineensis* and *A. africana* leaves from the rural site were also exceptionally low in their P contents (74.68 and 79.55 mg/kg, respectively) and fell below the range of 1.8–4.8 g/kg reported by Mcdowell (1997). Therefore, these forage plants may not be able to meet the Mg or P requirements of ruminants when fed as sole forage without mineral supplementation and may affect the performance and health of animals (Muraina et al., 2020; Dele et al., 2021). Again, higher P and Na levels were recorded in *P. americana* (1108.57 and 724.17 mg/kg, respectively) and also Na levels in *A. africana* (615.98 mg/kg) at the rural sites, while at the peri-urban site, the Ca level in *A. africana* (1105.11 mg/kg) and P level in *M. paradisiaca* (1108.14 mg/kg) were also higher than the levels recorded in the other plants.

The mean concentrations of microminerals in the forage plants also varied across study sites and within plant species. Mean concentrations of Mn, Fe, Zn, Cu, and Pb at the rural and peri-urban sites were 19.11 ± 7.04 and 18.83 ± 4.54 mg/kg, 17.43 ± 7.04 and 21.13 ± 6.53 mg/kg, 2.94 ± 0.58 and 3.38 ± 0.89 mg/kg, 1.63 ± 1.17 and $1.69 \pm$

Table 5. Proximate compositions (g/100 g) of the mostly commonly identified forage plants at the study sites

Tabelle 5. Nahrungszusammensetzung (g/100 g) der am häufigsten identifizierten Futterpflanzen an den Untersuchungsstandorten

Forage plant	DM	CP	EE	CF	TA	NFE
Rural site						
<i>Eleasia guineensis</i>	85.29	5.96	2.18	19.84	11.64	45.67
<i>Dialium guineense</i>	89.35	9.04	1.85	8.66	9.42	60.02
<i>Persea americana</i>	86.78	8.74	2.01	20.74	10.16	45.13
<i>Aspilia africana</i>	87.24	13.63	5.73	10.74	14.37	47.77
<i>Veronia amygdalina</i>	87.47	15.17	4.96	6.94	10.35	50.05
<i>Pannisetum purpureum</i>	85.81	9.11	1.98	22.28	9.21	43.23
<i>Costus afer</i>	86.85	9.00	1.66	13.53	9.05	53.57
Minimum	85.81	5.96	1.66	6.94	9.05	43.23
Maximum	89.35	15.17	5.73	22.28	14.37	60.02
Mean	86.97	10.09	2.91	14.67	10.60	49.35
SD	1.30	3.17	1.68	6.25	1.88	5.82
Peri-urban site						
<i>Pterocarpus santalinoides</i>	88.64	14.06	6.11	9.95	8.56	49.96
<i>Eleasia guineensis</i>	86.35	9.12	2.25	19.71	9.61	45.66
<i>Musa paradisiaca</i>	87.94	9.09	1.47	26.15	11.87	38.85
<i>Bambusa tulda</i>	88.46	10.14	2.04	10.16	10.34	55.78
<i>Aspilia africana</i>	87.35	5.97	0.96	22.65	5.15	52.62
<i>Persea americana</i>	86.86	10.86	3.85	10.15	8.33	53.67
<i>Dialium guineense</i>	89.04	9.61	2.18	17.69	10.02	49.54
Minimum	86.35	5.97	0.96	9.95	5.15	38.85
Maximum	89.04	14.06	6.11	26.15	11.87	55.78
Mean	87.80	9.83	2.69	16.64	9.12	49.44
SD	0.99	2.42	1.75	6.65	2.11	7.70

DM = dry matter, CP = crude protein, EE = ether extract, CF = crude fiber, TA = total ash, NFE = nitrogen-free extract, SD = standard deviation.

0.50 mg/kg, and 0.09 ± 0.19 and 0.26 ± 0.39 mg/kg, respectively. The mean Fe, Zn, Cu, and Pb contents were higher in the forage samples from the peri-urban site, while the Mn value was higher at the rural site. *P. americana* recorded the highest Mn and Zn levels, while *V. amygdalina* and *E. guineensis* recorded the highest Fe and Cu levels, respectively, at the rural site. However, *A. africana* recorded the highest Mn and Fe, while *B. tulda* and *D. guineense* recorded the highest Zn and Cu levels, respectively, at the peri-urban site. The Mn values recorded at the two study sites were generally higher than 10 mg/kg needed in the diets of ruminants for optimal growth performance (Spear, 1994). The Zn and Cu concentrations in the forages were generally low. The Cu level fell below 5–15 mg/kg needed in ruminant feedstuff for normal metabolic functions (MacPherson, 2000). Similarly, low Cu and Zn concentrations were also reported by Akinsoyinu and Onwuka (1988) and Ogbede et al. (1995) in some forage plants from southwest and north central Nigeria. However, the Zn levels were within the range needed by ruminants for their normal physiologic

functions (Dele et al., 2021) and much lower than the maximum permissible limit of 99.4 mg/kg (Ahmad et al., 2022). The Fe contents of the forages were lower than the range of 138.40–174.80 mg/kg DM reported by Ajayi et al. (2009) in forage plants from western Nigeria.

The Pb levels were generally low, with the highest values being 1.06 and 0.51 mg/kg in *M. paradisiaca* and *E. guineensis* leaves, respectively, at the peri-urban site and 0.51 mg/kg recorded in *P. americana* leaves at the rural site. These values were much lower than the range of 9.50–14.14 mg/kg reported by Ahmad et al. (2022) in five forage plants fed to cattle in Pakistan. Concentrations as high as 1312.73 mg/kg have, however, been reported in forage grasses at a rural location in Zamfara state, Northwest Nigeria (Udiba et al., 2013). Overall, the order of mean mineral concentrations in the forages at the rural and peri-urban sites were $\text{Na} > \text{P} > \text{Ca} > \text{K} > \text{Mg} > \text{Mn} > \text{Fe} > \text{Zn} > \text{Cu} > \text{Pb}$ and $\text{P} > \text{Ca} > \text{Na} > \text{K} > \text{Mg} > \text{Fe} > \text{Mn} > \text{Zn} > \text{Cu} > \text{Pb}$, respectively, indicating differences in the Na, P, Ca, Mn, and Fe positions.

3.4. Mineral ratios in fodder plants at the rural and peri-urban sites

Some mineral elements may antagonize or synergize each other during their uptake from the soil by forage plants and can therefore influence their values and quantitative ratios in the plant tissue (Rietra et al., 2017). However, limited information exists on the mineral ratios in the forages fed to ruminants in southeastern Nigeria, despite its importance in livestock nutrition and health. Such information is valuable for the establishment of the levels of supplementation needed in animals fed indigenous forage plants (Kumar and Soni, 2014; Reine et al., 2020). The mean ratios at the rural and peri-urban sites were: for Ca:P 1.24 ± 0.99 and 0.90 ± 0.93 , for Na:K 2.27 ± 1.52 and 2.70 ± 1.22 , for Ca:Mg 6.46 ± 4.13 and 9.28 ± 6.72 , for K:Mg, 6.87 ± 5.70 and 2.28 ± 2.95 , for K:(Ca + Mg) 0.88 ± 0.67 and 0.59 ± 0.52 , and for (K + Na):(Ca + Mg) 2.56 ± 1.48 and 1.93 ± 1.52 , respectively (Table 7). The ratios were mostly varied across study sites in response to the variations in the mineral contents of the forages from the sites. The Ca:P, K:Mg, and K:(Ca + Mg) ratios calculated at the rural site were higher than those of the peri-urban sites, while the others were lower. Balanced Ca and P levels in the forage are particularly important to ensure their availability, utilization, and optimal animal health. The Ca:P ratios in *E. guineensis*, *A. africana*, and *P. purpureum* sampled at the rural site and *P. santalinoides* and *A. africana* at the peri-urban site were within the 1–2:1 range recommended for optimal rumi-

Table 6. Mineral concentrations (mg/kg) in the most commonly identified forage plants at the study sites

Tabelle 6. Mineralstoffkonzentrationen (mg/kg) in den am häufigsten identifizierten Futterpflanzen an den Untersuchungsstandorten

Forage plant	Ca	P	Na	K	Mg	Mn	Fe	Zn	Cu	Pb
Rural site										
<i>Eleasia guineensis</i>	211.64	74.68	406.75	128.16	23.58	6.85	10.64	2.84	3.54	0.00
<i>Dialium guineense</i>	116.86	133.74	375.37	192.66	24.37	14.18	21.52	3.58	1.09	0.03
<i>Persea americana</i>	341.72	1108.57	724.17	173.59	62.18	27.22	21.21	3.60	1.07	0.51
<i>Aspilia africana</i>	165.65	79.55	615.98	151.56	11.87	19.64	12.60	2.71	1.56	0.08
<i>Veronia amygdalina</i>	116.18	317.62	194.51	291.35	18.25	17.85	38.81	1.94	0.41	0.00
<i>Pennisetum purpureum</i>	299.76	168.94	121.85	161.64	60.88	25.91	7.69	2.74	2.96	0.01
<i>Costus afer</i>	115.87	271.92	108.72	96.37	172.63	22.11	9.53	3.16	0.76	0.01
Minimum	115.87	74.68	108.72	96.37	11.87	6.85	7.69	1.94	0.41	0.00
Maximum	341.72	1108.57	724.17	291.35	172.63	27.22	38.81	3.60	3.54	0.51
Mean	195.38	307.86	363.91	170.76	53.38	19.11	17.43	2.94	1.63	0.09
SD	93.29	363.84	240.73	61.68	56.33	7.04	10.91	0.58	1.17	0.19
Peri-urban site										
<i>Pterocarpus santalinoides</i>	202.76	118.72	486.85	106.86	10.87	15.26	17.47	3.16	1.85	0.09
<i>Eleasia guineensis</i>	418.61	928.46	500.84	137.93	55.76	19.53	23.44	3.54	1.07	0.51
<i>Musa paradisiaca</i>	328.76	1108.14	111.76	95.85	31.33	22.32	10.06	3.17	1.89	1.06
<i>Bambusa tulda</i>	99.67	412.65	295.16	179.64	33.10	19.40	20.17	4.52	2.03	0.01
<i>Aspilia africana</i>	1105.11	416.86	310.74	121.20	61.46	26.20	31.53	3.15	1.83	0.17
<i>Persea americana</i>	194.22	292.81	121.76	74.19	50.31	12.66	23.28	1.82	0.86	0.00
<i>Dialium guineense</i>	107.83	392.47	383.63	180.64	31.57	16.42	21.95	4.29	2.17	0.02
Minimum	99.67	118.72	111.76	74.19	10.87	12.66	10.06	1.82	0.86	0.00
Maximum	1105.11	1108.14	500.84	180.64	61.46	26.20	31.53	4.52	2.17	1.06
Mean	350.99	524.30	315.82	128.04	39.20	18.83	21.13	3.38	1.69	0.26
SD	351.80	356.76	156.97	40.74	17.57	4.54	6.53	0.89	0.50	0.39

SD = standard deviation.

nant performance (NRC, 2007). A range of 1–4 g/kg Na is considered adequate for tropical forage plants (Underwood, 1981), while an intake of about 0.85 g/kg is required to maintain adequate Na:K ratio in small ruminants (Mirzaei, 2012). *P. americana*, *A. africana*, and *E. guineensis* recorded the highest Na:K ratios (4.17, 4.06, and 3.17, respectively) at the rural site, while the highest values at the peri-urban site were recorded in *P. santalinoides* and *E. guineensis* (4.56 and 3.63, respectively). The Ca:P and Na:K values recorded in the present study were generally higher than the values reported by Okoli et al. (2001) in forage plants sampled in three states of southeastern Nigeria and by Okoli et al. (2019) in Imo state. All the forage plants with the exception of *C. afer* (0.65) recorded much higher Ca:Mg ratios than the 2–3:1 recommended for animals (Durlach, 1989), in response to the much higher Ca levels in the forage plants. Similar high Ca:Mg ratios were also reported by Okoli et al. (2001) in forage plants growing in a different state of southeastern Nigeria. Imbalance in the Ca and Mg content of forage has been associated with adverse health conditions like milk fever and tetany in livestock (Martin-Tereso and Martens, 2014; Ostrowska and Porebska, 2017). Again, *D. guineense*, *A. africana*, and *V. amygdalina* at the rural site and *P. santalinoides* at the peri-urban site recorded higher K:Mg ratio

values than the recommended 2–6:1 range recommended for forage plants (Mackowiak et al., 2011; Jakubus and Bakinowska, 2020). However, Okoli et al. (2001) reported a K:Mg ratio range of 1–5.35:1 of 1–5.35:1 in forage plants collected from three states in southeastern Nigeria, indicating near-optimal values.

The forage plants recorded lower K:(Ca + Mg) ratios than the maximum tolerable ratio range of 1.6–2.2:1 recommended by NRC (2000), indicating that symptoms associated with magnesium deficiency, such as grass tetany, will not occur in the ruminants consuming these forage plants (Dele et al., 2021). Again, the (K + Na):(Ca + Mg) ratios recorded in *P. purpureum* and *C. afer* at the rural site and in *P. purpureum*, *A. africana*, and *P. americana* at the peri-urban site were lower than the recommended optimal ratio (1.9–2.1:1) for forage plants (Mackowiak et al., 2011; Jakubus and Bakinowska, 2020). The other plants recorded a ratio range of 1.35–4.47. The symptoms associated with the poor interactions of these minerals will particularly manifest when the Mg level in the forage is less than 2.0 g/kg or the Ca level is less than 4.0 g/kg (Blevins and Sanders, 1993/94; Stewart, 2013).

The mean Zn:Cu and Fe:Cu ratios in the forage plants were 2.71 ± 1.57 and 22.92 ± 34.41 , respectively, at the rural site and 2.11 ± 0.57 and 14.43 ± 7.85 , respectively, at the

Table 7. Mean mineral ratios in the preferred forage plants at the sites

Tabelle 7. Mittlere Mineralstoffverhältnisse in den bevorzugten Futterpflanzen an den Standorten

Forage plant	Ca:P	Na:K	Ca:Mg	K:Mg	K:(Ca + Mg)	(K + Na): Ca + Mg)	Zn:Cu	Fe:Cu
Rural site								
<i>Eleasia guineensis</i>	2.83	3.17	8.98	5.44	0.55	2.27	0.80	3.01
<i>Dialium guineense</i>	0.87	1.95	4.80	7.90	1.36	4.02	3.28	19.74
<i>Persea americana</i>	0.31	4.17	5.50	2.79	0.43	2.22	3.37	19.82
<i>Aspilia africana</i>	2.08	4.06	13.96	12.77	0.85	4.32	1.73	8.08
<i>Veronia amygdalina</i>	0.37	0.67	6.37	15.96	2.17	3.61	4.73	94.66
<i>Pannisetum purpureum</i>	1.77	0.75	4.92	2.66	0.45	0.79	0.93	2.59
<i>Costus afer</i>	0.43	1.13	0.67	0.56	0.33	0.71	4.16	12.54
Minimum	0.31	0.67	0.67	0.56	0.33	0.71	0.80	2.59
Maximum	2.83	4.06	13.97	12.77	2.17	4.47	4.16	94.66
Mean	1.24	2.27	6.46	6.87	0.88	2.56	2.71	22.92
SD	0.99	1.52	4.13	5.70	0.67	1.48	1.57	34.41
Peri-urban site								
<i>Pterocarpus santalinoides</i>	1.71	4.56	18.65	9.84	0.50	2.78	1.71	9.44
<i>Eleasia guineensis</i>	0.45	3.63	7.51	2.47	0.29	1.35	3.31	21.91
<i>Musa paradisiaca</i>	0.30	1.17	10.49	3.06	0.27	0.58	1.68	5.32
<i>Bambusa tulda</i>	0.24	1.64	3.01	5.43	1.35	3.58	2.23	9.94
<i>Aspilia africana</i>	2.65	2.56	17.98	1.97	0.10	0.37	1.72	17.23
<i>Persea americana</i>	0.66	1.64	3.86	1.47	0.30	0.80	2.12	27.07
<i>Dialium guineense</i>	0.27	2.12	3.41	5.72	1.31	4.08	1.98	10.12
Minimum	0.30	1.17	3.01	1.47	0.10	0.37	1.68	5.32
Maximum	2.65	4.56	18.65	9.84	1.35	4.08	3.31	27.07
Mean	0.90	2.47	9.28	2.28	0.59	1.93	2.11	14.43
SD	0.93	1.22	6.72	2.95	0.52	1.52	0.57	7.85

SD = standard deviation.

peri-urban site. The values ranged from 0.80 to 4.16 and from 2.59 to 94.66 at the rural site and from 1.68 to 3.31 and from 5.32 to 27.07 at the peri-urban site, respectively. High level of Zn in the forage has been shown to antagonize copper absorption, while Zn:Cu ratios greater than 16 have been associated with adverse conditions in both humans and animals (Turnlund, 1988; Ma and Betts, 2000). Hodzic et al. (2013) reported a range of 3.58–7.60 for Zn:Cu ratios in medicinal plants from Bosnia and Herzegovina. Achonwa et al. (2019), reported a Zn:Cu ratio of 1.03 in *Ficus microcarpa*, a domesticated browse plant in Anambra state, southeastern Nigeria. Okoli et al. (2019) also reported ratios of 3.85, 1.88, and 0.36 in *Gongronema latifolium*, *Mucuna pruriens*, and *Garcinia kola* leaves, respectively, from Imo state. A less than 10:1 Fe:Cu ratio is recommended for forage plants (NRC, 2007; Diet by Design, 2020), indicating that all the values obtained at the rural site, except *P. purpureum* and *A. africana* values, were higher than the optimal values. Similarly, the values for *E. guineensis*, *A. africana*, *P. americana*, and *D. guineense* at the peri-urban site were also higher than the recommended optimal value. Achonwa et al. (2019) reported a very high Fe:Cu ratio (22:1) in *Ficus microcarpa* leaves, while Okoli et al. (2019) reported ratios

of 19.69, 7.51, and 7.03 in *G. latifolium*, *M. pruriens*, and *G. kola* leaves, respectively.

3.5. Comparison of the nutrient supplies from forage plants at the study sites

Feeding of trees, shrubs, herbs, woody vines, weeds, grasses, and forbs is the traditional method of supplying nutrients to permanently confined small ruminants at several locations in southeastern Nigeria. Under this production system, several forage plants are cut and supplied to the animals as a cocktail, thus creating a choice or cafeteria feeding that gives the animals the chance to make their own diets to match their nutritional requirements (Gefu et al., 1994; Boga et al., 2009). The results presented in Tables 8 and 9 represent comparisons of the relative nutrient supplies to small ruminants at the rural and peri-urban sites. There were no significant differences ($P > 0.05$) between the relative proximate or mineral supplies to the animals at the two sites, although virtual differences in means were observed. These results imply that despite the diversity and differences in forage selection at the two sites, the relative nutrient supplies to small

Table 8. Comparison of the relative nutrient supplies for small ruminants at the rural and peri-urban sites
Tabelle 8. Vergleich der relativen Nährstoffzufuhr für kleine Wiederkäuer an den ländlichen und stadtnahen Standorten

Proximate parameter (%)	Rural site	Peri-urban site	SEM	p < 0.05
Dry matter	86.97	87.80	0.32	0.202
Crude protein	10.09	9.83	0.72	0.867
Ether extract	2.91	2.69	0.44	0.818
Crude fiber	14.67	16.64	1.68	0.580
Total ash	10.60	9.12	0.55	0.193
Nitrogen-free extract	49.35	49.44	1.48	0.977

SEM=Standard error of difference of mean

ruminants are likely to be similar if the cafeteria system of forage provision practiced at the sites is adhered to. The relative protein and energy supplies represented by the mean proximate values were high enough to sustain rumen microbial activities and growth of ruminant animals (Ikhatua et al., 1985; Babyemi et al., 2014). The relative macro-minerals (Ca, P, Na, K and Mg) and micro mineral (Fe and Mn) supplies at the sites are also adequate and will sustain the requirements of these minerals in small ruminants (Mc-dowell, 1997; Islam et al., 2003; Suttle, 2010). Provision of a forage cocktail containing disproportionate amounts of *E. guineensis* and *A. africana* may, however, result in inadequate supply of phosphorus to the animals. The relative Zn and Cu supplies are particularly low and may, therefore, be

Table 9. Comparison of the relative mineral supplies for small ruminants at the rural and peri-urban sites
Tabelle 9. Vergleich der relativen Mineralstoffversorgung für kleine Wiederkäuer an den ländlichen und stadtnahen Standorten

Minerals (mg/kg)	Rural site	Peri-urban site	SEM	p < 0.05
Calcium	195.38	350.99	69.52	0.280
Phosphorus	307.86	524.30	97.39	0.284
Sodium	363.91	315.82	52.60	0.666
Potassium	170.76	128.04	14.67	0.152
Magnesium	53.39	39.20	10.89	0.536
Manganese	19.11	18.83	1.52	0.931
Iron	17.43	21.13	2.36	0.456
Zinc	2.94	3.38	0.20	0.293
Copper	1.63	1.67	0.23	0.928
Lead	0.09	0.26	0.08	0.310
Ca:P	1.24	0.90	0.25	0.521
Na:K	2.27	2.47	0.36	0.788
Ca:Mg	6.46	9.27	1.48	0.364
K:Mg	6.87	4.28	1.22	0.307
K:(Ca + Mg)	0.88	0.59	0.16	0.386
(K + Na):Ca + Mg)	2.56	1.93	0.40	0.448
Zn:Cu	2.71	2.11	0.31	0.354
Fe:Cu	22.92	14.43	6.17	0.514

inadequate for their optimal metabolic functions in the ruminants (MacPherson, 2000), especially when there is a preponderance of *V. amygdalina* in the forage cocktail. Earlier studies by Akinsoyinu and Onwuka (1988) and Ogbede et al. (1995) have also reported low Zn and Cu concentrations in forage plants growing at different locations in southern and northern Nigeria, indicating the need for their supplementation in ruminant diets.

4. Conclusions

It can be concluded from the results of this study that a higher diversity of fodder plants exists at the rural sites compared to the peri-urban sites. There is greater loss in forage resources at locations surrounding urban centers than in rural areas. This can be attributed to anthropogenic and socioeconomic changes. Majority (80%) of the fodder plants identified by the small ruminant farmers at the peri-urban sites were also food-bearing plants, showing the possible human response to the diminishing compound bushes and fallows that as farm/forage lands shrink at the peri-urban site, the shared dependence of both the farmers and their animals on the available biological diversity for sustenance increases.

Overall, four of the plants (*E. guineensis*, *P. americana*, *D. guineense*, and *A. africana*) were most commonly identified at both sites. The common fodders at the peri-urban site recorded higher mean DM, CF, and NFE values than those at the rural site, while the mean CP, EE, and TA values followed the reverse trend. The mean mineral concentrations of Ca and P were higher at the peri-urban site, while the concentrations of Na, K, and Mg were higher at the rural site. The mean Fe, Zn, Cu, and Pb contents were higher in the forage samples from the peri-urban site, while the Mn value was higher at the rural site. The Ca:P, K:Mg, and K:(Ca + Mg) ratios at the rural site were higher than those of the peri-urban sites, while the other (Na:K, Ca:Mg, (K + Na):(Ca + Mg), Zn:Cu, and Fe:Cu) ratios were lower. There were no significant differences ($p > 0.05$) between the relative proximate or mineral supplies to the animals at the two sites.

It was concluded that despite the diversity and differences in forage selection at the two sites, the relative nutrient supplies to small ruminants will likely be similar if the cafeteria system of forage provision practiced at the sites is adhered to. The future of successful livestock feeding in southeastern Nigeria will partly depend on the identification and domestication of selected highly nutritious forage plants that have other values such as food, medicinal, fuel, shading, soil enrichment, and ornamental values.

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