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Assessment of the Feeding Habits of Selected Artiodactyl Species in Kano Zoological Garden, Kano State, Nigeria

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SUMMARY

The feeding habits and nutritional requirements of Artiodactyl species, such as Antelopes, Bushbuck, Cape Eland, Deer, Gazelle, Cattle, and Warthog, are crucial for their survival and well-being in captivity. This study assessed the feeding habits of selected artiodactyl animal species in Kano Zoo, Nigeria. The objectives were to identify the available food types, assess the time spent on feed types fed to the animals and their food preference in the zoo. Four artiodactyl animal species were identified (Bushbuck, Cape Eland, Gazelle, and Warthog.). Data on the food and feeding preferences were obtained through spot observation during the animals' feeding. For data on food quality, samples of the preferred food were assessed for proximate analysis. Data obtained were subjected to descriptive statistics and one-way analysis of variance (ANOVA). The results obtained revealed that there were 12 different feeds available to the artiodactyl animal species in the study area. The preferred feeds/foods indicate that wheat offal (13.13%, 14.21%, 16.69%, 15.79%) formed the highest across the four artiodactyl animal species identified, while Brassica oleracea (11.27%), *Ageratum conyzoides* (10.67%, 11.14%), and *Syndrella nodiflora* (10.30%) formed the least. Provision of suitable and habitat-based food, as well as regular analysis of their nutrients, is recommended.

Keywords: Assessment, Feeding Habits, Artiodactyl Species, Zoological Garden, Kano

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INTRODUCTION

The feeding habits and nutritional requirements of Artiodactyl species, such as Antelopes, Bushbuck, Cape Eland, Deer, Gazelle, Cattle, and Warthog, are crucial for their survival and well-being in captivity (Nijboer et al., 2017). In zoos, providing optimal diets that mimic the natural feeding habits of these species is essential for maintaining their health, preventing nutritional disorders, and promoting their overall welfare (Nijboer et al., 2017). However, the quality and nutritional value of the diets provided to Artiodactyl species in zoos can vary significantly, potentially impacting their health and well-being (Mellor et al., 2020). Proper feeding and nutrition play vital roles in the care of some artiodactyl species in captivity. Meeting their nutritional needs is essential for maintaining their health, facilitating reproduction,

and ensuring their overall well-being (Lambert and Rothman, 2015). Food quality plays a vital role in ensuring well-being of captive animals, as it directly influences their growth, development, and overall physiological function (Sobreira et al., 2019). Most herbivores can be fed successfully on dry diets formulated for livestock, comprising agricultural grains and supplemental fresh or dried forages. Wild animal species have evolved specific dietary needs based on their natural habitats and feeding behaviors. Understanding these requirements is essential for designing an appropriate diet in captivity (Oliveira et al., 2020).

Captive artiodactyls must be fed according to their nutritional needs (Guillier et al., 2016). Artiodactyl species in captivity rely heavily on the provision of suitable diets to meet their nutritional requirements, maintain health, and support reproduction (Guillier et al., 2016). Whatever type of food the operators produce, process, and distribute, they are legally responsible for its safety and hygiene, so they have a duty to analyze and control the risks by implementing control measures for the foods given to the captive animals (Koutsoumanis and Aspridou, 2016). Artiodactyl species in captivity rely entirely on plant materials to meet their nutrient and energy requirements (Aruwayo et al., 2019). Captive herbivores are adapted to the food they usually ingest (e.g., grasses, forbs, browses) (Mao et al., 2013). Captive herbivores prefer eating mixed feed resources such as grasses, legumes, and browses (Petri et al., 2013). They face special challenges in selecting an optimal diet. Plants and their parts are not simply discrete packets of nutrients; they also contain a range of metabolites that are variously refractory to digestion and capable of lowering the efficiency with which nutrients can be obtained or are actually harmful to the animal through interference with normal physiological processes (Clauss et al., 2003).

The frequency of feeding employed can also impact animal health. Time-restricted feeding, for instance, has been shown to improve digestive health and reduce disease risk in broilers (Bampidis et al., 2020). In contrast, feeding animals too frequently can lead to overeating and obesity, which can negatively impact animal health (Zhang et al., 2019). Many parts of the foraging process of captive herbivores can be influenced by the specialization on certain forage plant types (Codron et al., 2019). Captive herbivores have to trade off a food item's potential energetic and nutritional gains against the risks of acquisition, such as the increased vulnerability to predation, exposure to plant toxins, or conspecific antagonism (Lambert et al., 2015). The objectives are to identify the available foods/ feeds types, assess the time spent on feed types fed to the animals and their food preference in the zoo

MATERIALS AND METHODS

DESCRIPTION OF THE STUDY AREA

This study was carried out at the Kano Zoological Garden, located in Kano State, Nigeria. The Kano Zoological Garden is one of the oldest and most popular zoos in Nigeria, covering an area of approximately 44 hectares. The Kano Zoological Garden is a park in Gandun Albasa, Kano Municipal, located on Zoo Road. It was officially opened in 1972 during the tenure of the military governor of Kano State, Late Alh. Audu Bako C.P., and it changed to Kano Zoological Garden later (Ajuonu, 2012).

Kano State is located in North-Western Nigeria. Created on May 27, 1967, from part of the Northern region, Kano State borders Katsina State to the Northwest, Jigawa State to the Northeast, Bauchi State to the Southeast, and Kaduna State to the Southwest. Kano State has geographic coordinates with a latitude range of 11°25'N – 12°53'N and longitude range of 80°25'E – 90°38'E (Figure 1) (Ojo, 2017). Historically, Kano State has been a commercial and agricultural state, known for the production of various cash and food crops as well as for its solid mineral deposits (Adeogun, 2013).

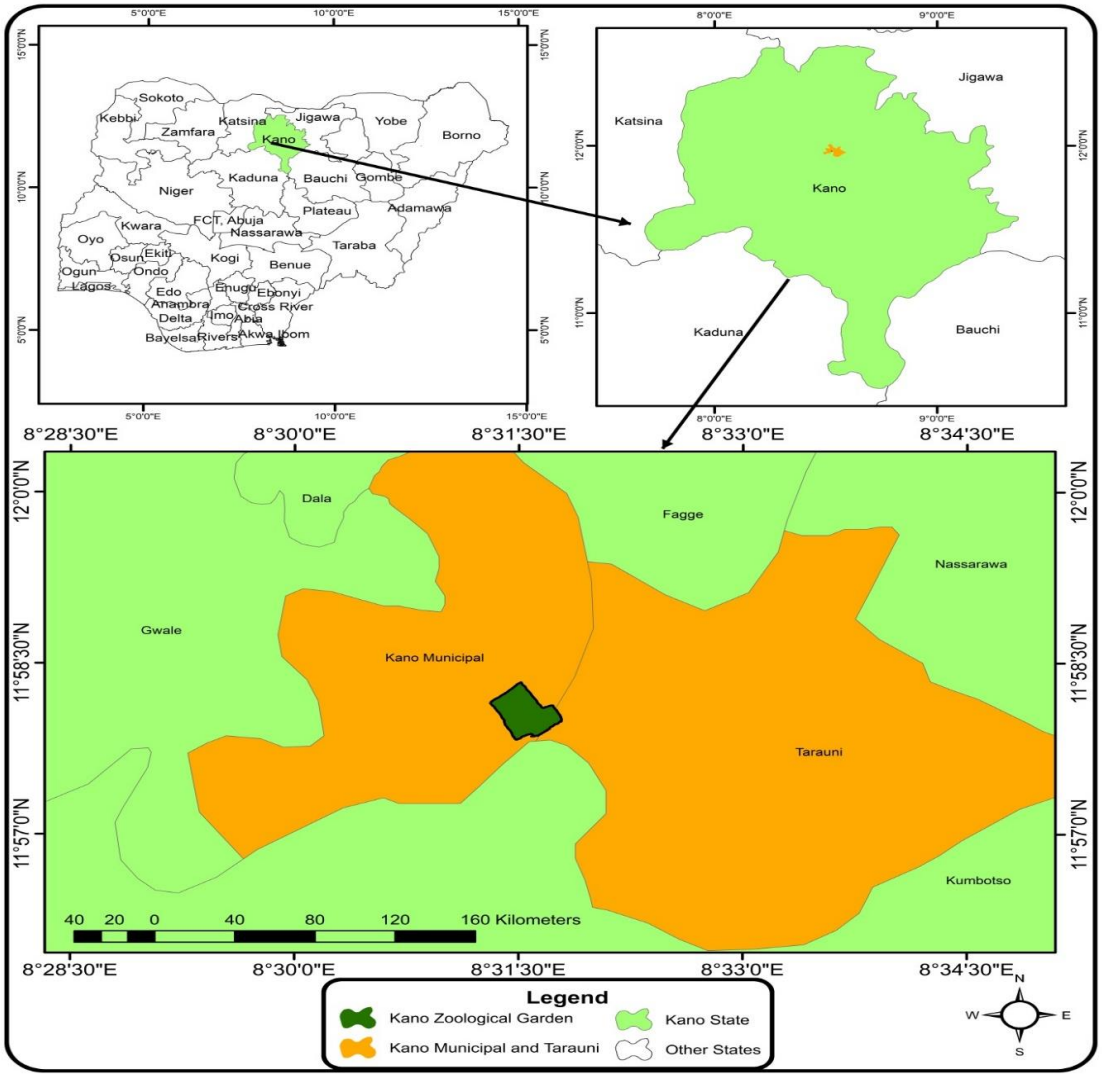

Figure 1: **Map of Nigeria showing Kano Source: GIS Laboratory, MAU Yola (2024).**

RECONNAISSANCE SURVEY

A reconnaissance survey was carried out for two days in the study area prior to the detailed study to assess the availability of feeds, species of artiodactyls, and their populations in the zoo.

STUDY DESIGN

The entire study area was classified into four (4) study areas/sites based on the number of artiodactyl animal species selected for the research in the study area. The type of feeds supplied to the selected animals was identified, the time spent on each type of feed, as well as the chemical composition of the feeds, were assessed. The study was carried out from the month of August to December 2024.

Data Collection

Data on the types of feeds fed to the artiodactyls, as well as the length of time spent feeding on each type, were collected by on-the-spot assessment/observation of the feeds and the animals, following Fatsuma (2016) method.

Identification of Feed type

Feed types were identified on-site during feeding using a manual and a plant identification application.

Time Spent on each Type of Feed and Preference Ranking

This was carried out by direct observation. The researcher commences observation immediately when the feeds are provided on the bunks. The length of time spent feeding on the feed/food species is recorded. The total time spent on each feed at the end of the observations is recorded. The percentage of the length of time spent on each feed is determined, from which the preference ranking is done.

Identification of the available feeds/foods

Descriptive Statistics involving the use of table was employed.

ASSES THE TIME SPENT ON FEED TYPES AND THEIR PREFERENCE RANKING

Food preference ranking was determined following Joel (2016). The formula is illustrated as follows:

$$P = \frac{xi\text{-}t}{yl\text{-}t} \times \frac{100}{1}$$

Where;

P= preferred food/forage

$x_{i\text{-}t}$ = number of times a species was fed on

$y_{l\text{-}t}$ = total number of times all the species were fed on.

The values of food preference calculated were ranked according to their order of magnitude (Joel, 2016).

RESULTS AND DISCUSSION

AVAILABLE FEEDS FED TO THE ANIMALS IN THE KANO ZOOLOGICAL GARDEN

The result of available feeds and their sources fed to the selected artiodactyl animal species in the Kano Zoological Garden consists of a diverse selection of forages, grain by-products, and vegetables aimed at meeting the dietary requirements of artiodactyl animal species. As shown in Table 1, a total of 12 different feed types were identified. These consist of eight (8) forages, two (2) vegetables, and two (2)

grain by-products. These feeds were observed through direct field observation and were selected based on availability, nutritional value, and suitability for the artiodactyl animal species in the zoo.

Table 1: Available Feeds Fed to the Animals in the Kano Zoological Garden.

Feed	Type (Forage/Grain/Vegetable)	Description
Ageratum conyzoides	Forage	A common herbaceous plant often used as animal fodder.
Albizia kalkora	Forage	A leguminous tree providing protein-rich leaves.
Brassica oleracea	Vegetable	Includes leafy greens like cabbage and kale.
Cowpea husk	Grain by-product	A residue from cowpea processing, rich in fiber.
Cynodon dactylon	Forage	Commonly known as Bermuda grass, used as animal feed.
Solanum tuberosum	Vegetable	Potatoes, a carbohydrate source.
Syndrella nodiflora	Forage	A leafy herb with potential nutritional benefits.
Wheat offal	Grain by-product	Residual wheat bran, rich in fiber and energy.
Azadirachta indica	Forage	Commonly known as neem; leaves are used for medicinal and nutritional purposes.
Tridica sebira	Forage	A grass species often used for grazing or silage.
Panicum miliaceum	Forage	Commonly known as proso-millet, a nutritious grass with high carbohydrate content.
Leucaena leucocephal	Forage	A fast-growing leguminous shrub rich in protein, often used as livestock fodder.

Source: Field Survey, 2024

FOOD AND FEED PREFERENCE AS SHOWN BY CAPE ELAND

Table 2 presents the total time spent feeding, along with the percentages and preference rankings for Cape Eland in the zoo. *Azadirachta indica* had the highest percentage utilization at 13.53%, ranking first. It was followed by wheat offal, which had a utilization percentage of 13.13% and ranked second. *Albizia kalkora* came in third with a percentage of 11.34%, while *Leucaena leucocephala* ranked fourth with a percentage of 11.23%. *Triadica sebifera* was fifth, with a percentage of 11.01%, followed by Cowpea husk at sixth place with 10.59%. *Cynodon dactylon* and *Solanum tuberosum* ranked seventh and eighth, with percentages of 10.28% and 9.49%, respectively. Finally, *Brassica oleracea* (leafy greens) had a comparatively lower consumption rate, ranking ninth with a percentage of 9.40%.

Table 2: Time Spent Feeding on Food Types and Preference Ranking for Cape Eland.

Feed Type	Total Time Spent on Feed (Hours)	Percentage of Feeding Time (%)	Preference Ranking
Azadirachta indica	42.45	13.53%	1
Wheat offal	41.20	13.13%	2
Albizia kalkora	35.60	11.34%	3
Leucaena leucocephala	35.25	11.23%	4
Triadica sebifera	34.55	11.01%	5
Cowpea husk	33.22	10.59%	6
Cynodon dactylon	32.27	10.28%	7
Solanum tuberosum	29.77	9.49%	8
Brassica oleracea	29.50	9.40%	9
Total	313.81	100%	

Source: Field Survey, 2024

FOOD AND FEED PREFERENCE AS SHOWN BY BUSHBUCK

Table 3 presents the results of the total time spent feeding, percentage, and preference ranking for Bushbuck in the zoo. Wheat offal has the highest percentage utilization (14.21%) and is ranked first, followed by cowpea husk with a percentage of (14.06%) and ranked second. *Solanum tuberosum* has a percentage of (13.15%) and is ranked third, followed by *Cynodon dactylon* with a percentage of (12.18%) and ranked fourth. *Albizia kalkora* has a percentage of (12.06%) and is ranked fifth. *Syndrella nodiflora* and *Brassica oleracea* had percentages of (11.89%) and (11.78%), respectively, and are ranked sixth and seventh. Meanwhile, *Ageratum conyzoides* showed comparatively lower consumption rates with a percentage of (10.67%) and is ranked eighth.

Table 3: Time Spent Feeding on Food Types and Preference Ranking for Bushbuck.

Feed Type	Total Time Spent on Feed (Hours)	Percentage of Feeding Time (%)	Preference Ranking
Wheat offal	29.30	14.21%	1
Cowpea husk	29.00	14.06%	2
Solanum tuberosum	27.12	13.15%	3
Cynodon dactylon	25.12	12.18%	4
Albizia kalkora	24.87	12.06%	5
Syndrella nodiflora	24.52	11.89%	6
Brassica oleracea	24.30	11.78%	7
Ageratum conyzoides	22.00	10.67%	8
Total	206.23	100%	

Source: Field Survey, 2024

FOOD AND FEED PREFERENCE AS SHOWN BY GAZELLE

The results of the total feeding and percentages of feeding time for gazelle are shown in Table 4. The highest percentage of feeding time and preference ranking was observed for wheat offal, with a percentage of 16.69% and first in ranking, followed by cowpea husk, with a percentage of 14.80% and second in ranking. *Cynodon*

dactylon has a percentage of 14.72% and third in ranking, while *Solanum tuberosum* has a percentage of 13.89% and fourth in ranking. This is followed by *Ageratum conyzoids*, with a percentage of 13.43% and fifth in ranking, and *Brassica oleracea*, which has a percentage of 13.23% and seventh in ranking. Meanwhile, *Syndrella nodiflora* showed comparatively lower consumption rates, with a percentage of 13.23% and seventh in ranking.

Table 4: Time Spent Feeding on Food Types and Preference Ranking for Gazelle.

Feed Type	Total Time Spent on Feed (Hours)	Percentage of Feeding Time (%)	Preference Ranking
Wheat offal	30.13	16.69%	1
Cowpea husk	26.73	14.80%	2
Cynodon dactylon	26.58	14.72%	3
Solanum tuberosum	25.08	13.89%	4
Ageratum conyzoides	24.25	13.43%	5
Brassica oleracea	23.90	13.23%	6.5
Syndrella nodiflora	23.90	13.23%	6.5
Total	180.57	100%	

Source: Field Survey, 2024

FOOD AND FEED PREFERENCE AS SHOWN BY WARTHOG

The result of the total feeding and percentages of feeding time for Warthog is shown in Table 5. The highest percentage of feeding time and preference ranking was observed for wheat offal, with a percentage of (15.79%) and first in ranking, followed by *Panicum miliaceum* with a percentage of (14.13%) and second in ranking. *Solanum tuberosum* has a percentage of (13.43%) and third in ranking, *Cynodon* has a percentage of (12.17%) and fourth in ranking, Cowpea husk with a percentage of (11.76%) and fifth in ranking, *Brassica oleracea* has a percentage of (11.27%) and sixth in ranking, *Ageratum conyzoides* has a percentage of (11.14%) and seventh in ranking, while *Syndrella nodiflora* has a percentage of (10.30%), showing comparatively lower consumption and ranked eighth.

AVAILABLE FEEDS/FOODS FED TO THE ANIMALS IN THE STUDY AREA

Assessing the types of food provided to zoo animals is crucial for determining whether their nutritional needs are adequately met. This study found that Kano Zoo offers a variety of food options designed to meet the species-specific dietary requirements of its residents. These options include plant-based diets for herbivores and mixed diets for omnivorous species. For herbivores such as Artiodactyls (e.g., Bushbuck, Cape Eland, Gazelle, and Warthog), the zoo provides a combination of grasses, browse plants, vegetables, roots, tubers, and occasionally grains. This finding aligns with the research of Verde *et al*. (2009), which indicated that herbivores in zoos are typically fed diets consisting of grasses and browse plants. Similarly, Mao *et al*. (2016) observed that some zoos offer hay, leafy vegetables, and fortified pellets to herbivores. In general, the feeds provided to zoo animals can be categorized into forage and browse, concentrates, animal-based diets, and supplements.

Table 5: Time Spent Feeding on Food Types and Preference Ranking for Warthog.

Feed Type	Total Time Spent on Feed (Hours)	Percentage of Feeding Time (%)	Preference Ranking
Ageratum conyzoides	31.10	11.14%	7
Brassica oleracea	31.45	11.27%	6
Cowpea husk	32.82	11.76%	5
Cynodon dactylon	33.98	12.17%	4
Panicum miliaceum	39.45	14.13%	2
Solanum tuberosum	37.48	13.43%	3
Syndrella nodiflora	28.75	10.30%	8
Wheat offal	44.08	15.79%	1
Total	279.11	100%	

Source: Field Survey, 2024

ASSESSING THE TIME SPENT ON FEED TYPES AMONG THE AVAILABLE FEEDS TO ARTIODACTYL SPECIES IN THE ZOO

The findings on the feed types and time spent on feeds shown by the selected artiodactyls (Bushbuck, Cape Eland, Gazelle, and Warthog) in the zoo indicated that artiodactyls are primarily grazers, feeding mostly on grasses, grain by-products, and sometimes on vegetables; therefore, they tend to be diet-specific. Artiodactyls, in particular, benefit from multiple smaller feedings throughout the day to replicate their natural feeding behaviors. Time spent on feed and feed preference among zoo animals are influenced by factors such as species-specific dietary adaptations, palatability, and seasonal availability of feeds. Understanding the preferred feed types among animals in Kano Zoological Garden is essential for optimizing diet formulations, improving feeding efficiency, and ensuring overall health and well-being. This study's findings are in agreement with the research conducted by Robinson (2017), who emphasized that feed preference plays a crucial role in captive animal nutrition, as offering preferred feeds enhances consumption rates and prevents malnutrition. Similarly, Raubenheimer *et al*. (2009) found that herbivores and omnivores tend to select feeds based on nutrient balance, while carnivores often show strong preferences for fresh, high-protein diets.

Artiodactyl species, including Cape eland, bushbuck, gazelle, and warthog, strongly prefer fresh grasses, browse, and legumes because of their high fiber content and digestibility. At Kano Zoological Garden, gazelles and bushbucks often choose fresh browse over dry hay. This preference aligns with the findings of Schilcher *et* al. (2013), who noted that fresh leaves and twigs are more palatable and offer essential micronutrients. Similarly, Rothman et al. (2011) observed that primates and small ruminants tend to engage in selective feeding behavior, favoring young, tender leaves over mature foliage due to their lower fiber and higher protein content. In contrast, omnivores like warthogs have a more varied diet, consuming both plant-based and animal-based feeds. Siciliano-Martina *et* al. (2021) found that omnivorous species prefer diets high in carbohydrates and proteins, often favoring energy-dense options such as grains, root vegetables, and occasional meat-based supplements. At Kano Zoological Garden, warthogs demonstrate a preference for root crops like sweet potatoes and carrots, which provide both energy and fiber.

Feed preferences at the Kano Zoological Garden generally reflect the natural feeding behaviors seen in the wild. However, variations in feed supply, seasonal changes, and financial constraints hinder the zoo's ability to consistently provide preferred types of feed. To enhance feeding efficiency, improve health outcomes, and reduce food waste, a more structured feeding program based on animal preferences and dietary requirements, as recommended by Taylor *et* al. (2013), could be beneficial. The study indicates that Artiodactyls, such as Cape eland, Bushbuck, and Gazelles, graze and browse throughout the day with minimal breaks. In the zoo setting, feeding frequency typically varies depending on management practices, the species present, and the resources available.

TIME SPENT FEEDING ON FOOD TYPES FOR CAPE ELAND

The feeding frequency of Cape eland (*Taurotragus oryx*) in zoos is structured to mimic its natural grazing and browsing habits. As a large herbivore, the Cape eland requires frequent feeding to support its metabolism, digestive efficiency, and overall health. Ejidike and Ajayi (2016) found that elands in the wild typically graze throughout the day, consuming a variety of grasses, browse, and legumes. In Kano Zoological Garden, Cape elands are provided with fresh grass and hay twice daily, ensuring a continuous supply of fiber for rumination and gut health. In addition to grasses, elands are also fed browse plants, particularly leguminous species, which are offered once or twice a day. The findings of this study agree with those of Salem and Smith (2008), who reported that browse contributes significantly to the protein intake of ruminants, and frequent feeding ensures adequate nutrient absorption. This contrasts with Sharma et al. (2003), who found that consistent access to mineral blocks helps to regulate electrolyte balance and improve skeletal health in large herbivores. Mineral supplements, such as salt licks, are available ad libitum to prevent nutrient deficiencies.

TIME SPENT FEEDING ON FOOD TYPES FOR BUSHBUCK

Bushbucks (*Tragelaphus scriptus*) are selective feeders who prefer fresh browse, fruits, and nutrient-rich forages. In Kano Zoological Garden, they are primarily fed twice daily, with morning and evening feedings to match their natural foraging patterns. The findings of this study agree with those of Rothman *et al* (2011), who observed that small ruminants exhibit a preference for young, tender leaves and high-protein browse species, which are offered at least twice a day to bushbucks in captivity. Fruits and vegetables are provided once daily as a supplementary source of vitamins and minerals, in line with Rutter (2010), who noted that incorporating fruits into the diet of captive herbivores enhances digestibility and provides essential micronutrients.

TIME SPENT FEEDING ON FOOD TYPES FOR GAZELLE

Gazelles (*Gazella spp*) are primarily grazers but also consume browse and legumes to meet their nutritional needs. At Kano Zoological Garden, they are typically fed twice a day, ensuring a steady intake of fiber and nutrients. This study's findings align with those of Robinson (2017), who noted that frequent feeding in captive gazelles' mimics natural grazing behavior and supports digestion. Fresh grass and hay are provided twice daily, while legumes such as alfalfa and acacia leaves are offered once a day. Sharma *et al.* (2003) found that leguminous browse is particularly beneficial for gazelles due to its high protein and mineral content. Additionally, fruits like watermelons and apples are included in their diet once a day to provide essential vitamins and hydration, as suggested by Rothman *et al.* (2011).

TIME SPENT FEEDING ON FOOD TYPES FOR WARTHOG

Warthogs (*Phacochoerus africanus*) have a more omnivorous diet than other herbivores in Kano Zoological Garden. They are fed twice daily, with a combination of plant-based and protein-rich feeds. Siciliano-Martina et al. (2021) noted that omnivorous species benefit from diverse diets that include both plant and animal sources, which agrees with the present study. Root crops, such as sweet potatoes, carrots, and cassava, are offered once a day, providing essential carbohydrates and fiber. Fruits and vegetables, including bananas and pumpkins, are included once daily to enhance dietary variety and nutrient intake; in contrast, Slavin (1987) observed that wild pigs and warthogs prefer tubers and fruits due to their high sugar content because of poor government policy in conservation.

CONCLUSION

The study concludes that the feeding management system at Kano Zoological Garden is generally effective in supplying a diverse range of feeds to meet the dietary needs of various animal species. However, there are several areas for improvement, particularly in optimizing feed quality, and monitoring feeding frequency to align with species-specific requirements. Additionally, the study emphasizes the necessity of regular nutritional assessments and diet formulations based on scientific principles to improve the well-being of zoo animals.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made to improve the feeding and nutritional management of artiodactyl animals in Kano Zoological Garden:

i. The Kano Zoological Garden Management should ensure the continuous supply of high-quality fresh forage, browse plants, and hay to support artiodactyl animal species.
ii. Feeding schedules should be structured based on species-specific dietary needs, ensuring that continuous grazers receive adequate feeding sessions.

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