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Botanical Composition, Biomass Yield and Nutrient Content of Major Browse Resources and Feeding Behavior of Buffaloes (*Syncerus caffer*) in Dhati Walal National Park, Western Ethiopia

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Abstract: A study on Biomass yield and nutrient content of major browse feed resources of Buffaloes (*Syncerus caffer*) was carried out in the Park, Western Ethiopia. Questionnaire survey and observation were used to collect data. Distribution and yields of major browse feed resources of buffaloes in the park were identified using transects. Representative samples from edible parts were taken and analyzed for nutrient contents following standard procedures. The collected data was analyzed using Statistical Package for Social Sciences (SPSS), version 21. Eight major browse species were identified. Not only herbage part of the browse species but also fruits from *A. chundra* plants were noted as the potential feed for buffaloes in the park. *V. amygdalina*, *O. rechetiana, R. ruspolii* and *G. ferruginea* were identified as major edible browse plants by buffaloes. Buffaloes in the Park used to graze especially at the night time and early morning. They also feed and move in group. In their feeding behavior they were restless more than cattle that they were watching out repeatedly the predators or hunters. The biomass productivity of the browse species was estimated at 82 tons /km^2 per harvest. The browse species generally had excellent content of crude protein (11.97-24.91%), wider range of fiber content (35.6 to 70.1%) and lignin (7.9 to 15.2%). Almost all the browse species were nutritious except *C. molle* plant that contained highest lignin and fiber but low crude protein. Hence the propagation of the most nutritious and high yielding browse species in the park is important to sustain the buffaloes' reproduction and conservation since dietary supplementation like domestic animals is impracticable.

Key words: Biomass Production · Browse Species · Buffalo · Chemical Composition · Species Composition · Park

INTRODUCTION

Africa owns the highest number and diversity of mammalian species in the world [1]. In Ethiopia, the profound geological history, broad latitudinal spread and diverse altitudinal ranges provide remarkable broad ecological regions that are composed of high mammalian diversity [2, 3]. Among these, most of the large mammals inhabit the southern and western lowland ecosystems of the country [4]. The wide agro-ecological zones and a range of environmental conditions have made Ethiopia to be one of the biodiversity rich countries in the world, both in large wild mammalian populations and livestock species [5]. Ethiopia has 18 major and 49 minor agro-ecological zones (AEZ). For such ecological and geographic variability reasons, the country remains suitable for livestock farming as well as wildlife-related tourism activities (EBI, 2014). The country owns the largest livestock population in Africa [6] that contributes significant share to the national growth domestic product (GDP) of the country. According to Metaferia *et al*. [7] the livestock sector alone contributed up to 16.5% of the GDP to the country. In addition to livestock, wildlife is also important sources of income and other social and ecological values to the country.

African buffalo is among the most successful mammals in terms of geographical distribution, abundance and biomass [8]. The African buffalo (*Syncerus caffer*) is

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a member of the family *Bovidae,* subfamily *Bovinae* and tribe Bovini [9]. They are divided only into two definite subspecies [10, 11]. These are: the lightly built, reddish, small-horned forest buffalo, *Syncerus caffer nanus* and the heavily built, darker, big horned savanna buffalo, *Syncerus caffer caffer* [12, 13]. The African buffaloes are widely distributed over most of the African continent [9]. The buffaloes in Dhati Walal National Park are categorized under the *Syncerus caffer caffer* type.

Recurrent drought and its subsequent effect on feed supply have been reported is reported as major factors that affect buffalo population in arid areas [14]. Poor physical condition as a result of low quality of grazing leads to lower antibody levels in the buffalo, making it a more susceptible host for most diseases [15]. Furthermore, seasonal feed availability which is caused by variation in total annual precipitation and distribution of rainfall might cause migration of animals from place to place sometimes demanding walking of long distances.

Animals are dependent upon energy and nutrients obtained from ingested feed and their survival and fertility are directly affected by nutrition [16]. Seasonal changes in the quality of vegetation and availability of water have altered both the ranging and feeding habits of *Syncerus caffer* [8, 17]. Sinclair [9] reported that the need for feed and water by buffalo was more important than protection from environmental extremes during the dry season.

Buffaloes like other domesticated ruminants meet their protein and energy requirements from fermentation end products (Microbial protein and volatile fatty acids [18]. Nutritive quality of range varies from area to others, between seasons and growing stages. The potential of any feed to support animal production depends on the quality consumed by the animal to the extent the consumed feed meets energy, protein, minerals and vitamin requirement of animals [19].

Dhati walal park is among the few youngest protected areas in the western tropical forest belt of Ethiopia with diversified faunal resources [20]. Nevertheless, no attempt was made regarding identification of available feeds, productivity and their nutritive values and feeding behaviors. The current study, therefore, was conducted in Dhati Walal National Park with the following objectives.

- To investigate and determine biomass productivity and nutrient content of major browse feed resources available in the Park
- To identify the botanical compositions of browsing resources in the park
- To identify feeding preferences and feeding behavior of buffaloes in the park

MATERIALS AND METHODS

The Study Area: The study was conducted in Dhati Walal National Park which is located on the border between West Wollega and Kellem Wollega Zones of Oromia Regional State, Western Ethiopia. The park is situated at a distance of 645km from Addis Ababa to the West direction. The area is located between 67° 55' and 72° 45' E longitude and between 10° 05'and 10° 51' N latitude [21].

Ecologically, the area contains a relatively intact wetland habitat. This ecosystem composes a considerable papyrus reed land that represents a very distinct ecosystem, holding the richest habitat for the Sudan Giunea Biome of the world's hotspot biodiversity assemblage of the country [22]. According to the author, all the soil features are important for wide agricultural activities and suitable for clay based cottage industries. The organic carbon, nitrogen and phosphorus content of the soil were higher in the wetland than in the surrounding woodland.

The minimum and maximum rainfall of the area is reported as 1200 mm and 1500 mm, respectively. While the minimum and maximum temperature values recorded were 20°C and 25°C, respectively. The maximum mean temperature record was during March and April and lower values recorded were observed from July to August [23].

Sample Collection Procedures: Data for the current study was collected by using questionnaire and field observation on feeding behavior of the buffaloes and direct sampling of feeds in the park. Before conducting field observation and questionnaire survey the scouts in the park were given orientation about the research purpose. They were used as individual respondents and some of the most experienced scouts were involved in focus group discussion. The respondents know the major browse resources buffaloes like to consume and helped the researcher to identify them in the park during the field work. The data from the group discussion were recorded and taken. Finally the field observation was conducted with most experienced scout in the park by following the direction where buffaloes herd frequently available. During field study, dungs and foot prints of the buffaloes observed were used to estimate areas where buffaloes are frequently browsing. From the field observation all necessary points were recorded whenever it was felt relevant for the study. After identifying all the major browse species consumed by buffaloes, plants which were identified in the discussions and in observation were taken for further analyses.

Feed Sample Collection and Preparation: Among several techniques of feed analyses, direct observation method was employed using a pair of binoculars and unaided vision on the bases of distance and habitat types during the daylight hours. This method demands minimal equipment; however, it has a problem when there is a need to identify plant species consumed from a distance [24, 25]. To quantify the vegetation the buffalo cut its leaves, backtracking method was used, where the diet of the animal is identified and quantified after the animals have moved from the browsing bush or tree.

With the aid of foot marks and color of the part where there is the bite on the plant, one can identify browse species consumed. A direct observation of a particular herd was performed sequentially and feeding sites of each herd were observed. Finally samples were collected and organized for further analysis.

Biomass (DM) Yield Estimation: During the questionnaire interviews, respondents were asked to identify the major browse feed resources of buffaloes in the park. Observation was followed for confirmation. This was followed by measuring each of the browse feed resources height, trunk diameter, trunk circumference and basal area where the plant is standing. After getting measurement, biomass yield of browse resources were calculated by allometrric equation log w = 2.24 log dt-1.5 following [26].

Where: W = leaf DM yield in kg, dt = diameter of trunk (cm) at 1.2 meter height (For tree leaf biomass).

Identification of Species Composition: The transect line approach was used to study botanical composition of browse species in the park using a 20m intervals transect. The plant touching the line was recorded with its use or not by buffaloes.

Description of feeding behavior of Buffaloes: The feeding behavior of buffaloes in the park was qualitatively studied by observing them with the aid of binoculars and by interviewing knowledgeable people, particularly the Dhati Walal National Park staff. Additionally the areas where they are feeding also give their feeding behavior. Every activity of the buffaloes was studied starting from early morning to late evening. In case when buffaloes were in the forest, observation was made by climbing on the trees in order to watch from a distance and due to aggressiveness of the buffalos. In general, the feeding behavior observed and information gathered from respondents were organized, analyzed and lastly presented in a descriptive way.

Determination of Feed Nutrient Composition: For determination of nutrient composition for browse species, samples were collected from identified plant species. The leaves, edible twigs and fruits of browse plants in the park were sampled and prepared. The samples were sorted with their categories, sun dried on open field and finally the dried samples were taken to Wollega University Biology laboratory where the samples were further dried at 60°C for 24 hours. The samples dried in this way were ground to pass through 1mm sieve and stored carefully with clean paper folder for chemical analysis at Debre-Birhan Research Center laboratory.

Feed Samples Chemical Analysis: The DM and ash were determined according to the procedure of Kassahun *et al*. [26]. The DM content of the different samples was determined by drying the samples at 105°C for 24 hours in air forced draft oven. Ash content was determined by complete burning of the feed samples in a muffle furnace at 500°C overnight. The feed sample reserved for chemical analysis was dried in oven at 60°C for 24 hours and ground at 1mm sieve size in Wiley mil. Following that the total Nitrogen (N) was determined by the Kjeldahl method AOAC [27] and crude protein (CP) content also calculated by N x 6.25. The structural plant constituents such as Neutral detergent fibers (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) were analyzed using the detergent extraction method Van Soest and Robertson [28].

Statistical Analyses: Data collected from simple survey, observation and interviews with the park staff and measurements taken on botanical composition of the major browses used by buffaloes, biomass yields, nutrient content and related data collected were analyzed using descriptive statistics of the Statistical Procedure for Social Sciences (SPSS --year) software at α=0.05.

RESULTS AND DISCUSSION

Main browse feed resources for buffaloes in Dhati Walal National Park: The lists, based on interviews and backtracking observations, for browse species were given in Table 1. Buffaloes in the study area are mostly grazer but at a time when grasses run out or not available in dry periods and when they try to hide themselves from hunters and predators, they are forced to use browse plants. Similar results were reported in different literatures [29, 30] that buffaloes are predominantly grazers but prefer browsing when grasses become over matured, became standing straw and lignified. Contrary to the current

findings, De Graaf *et al.* [31] reported that buffaloes in the Addo Elephant National Park could rather be considered browsers than grazers. The authors result was probably of dubious value as their study was done during a drought and that their findings were based on the stomach contents of dead animals that died because of the drought. It was possible that the buffaloes were forced to make use of more browse than grazing being forced by drought conditions that demanded animals' life [29].

In the Dhati Walal Park, there were 10 identified browse species that buffaloes consume. Out of these, eight dominant ones were selected. *A. chundra* fruit was the most preferred feed of buffaloes with a percentage of 25%. The *A. chundra* fruit is known by its good odor which is recognized by smelling whether this plant is available around or not. This result may also indicate good sensory value of this plant. As majority of the respondents disclosed when buffaloes get into the forest they are found under this plant collecting the fruits from the ground. These fruits may help the buffaloes as natural concentrate supplement, mainly energy that is lacking in lowland grasslands like the Dhati Walal National Park, since it is believed to contain more soluble fractions compared to other grass species.

Fruits of *G. ternifolia*, leaves of *C. molle* and *R. tridentata* were also important feeds with 18.7%, 12.5% and 12.5%, respectively next to *A. chundra* fruit. Except *A. chundra* and *G. ternifolia* fruits, other browse species fed by buffaloes are from the shorter parts of plant at enough height to take. In some cases buffaloes try taking plant parts by upholding their neck. The browse plant parts buffaloes like to feed were the fruits and leafy parts. The emerging plant shoots as understory of the main plant is the main feed buffaloes get mostly.

Feeding Behavior of Buffaloes: Mostly behavioral subjects are qualitative in their nature. In natural habitats, animals spend most of their time in foraging activities [32] and the activity patterns are correlated with their daily mode of life [33]. Buffaloes in Dhati Walal National Park spent more of their time on foraging especially at the night time and early in the morning. Their preference of night time could be their wilderness in behavior so that they do not have link with peoples. This result is similar to study on Chebera Churchura National Park where observations showed that the feeding time of the African buffalo was longer than other activities in the park [34]. In disagreement with the current study finding, Beekman and Prins [32] reported that buffaloes preferred to graze around mid-day.

Table 1: Description of some browse species mostly consumed by Buffaloes

Browse species	Edible part	Frequency (%)	Percent
Acacia chundra	fruit	8	25
Gardenia ternifolia	Fruit and leaf	6	18.7
Combretum molle	Leaf	4	12.5
Rhoicissus tridentata	Leaf	4	12.5
Olinia rechetiana	Leaf	3	9.37
Grewia ferruginea	Leaf	2	6.25
Vernonia amygdalina	Leaf	2	6.25
Rhus ruspolii	Leaf	1	3.13
Soyoma[§]	Leaf	1	3.13
Dombeya torrida	Leaf	1	3.13
Total		32	100

[§]Soyoma is Oromo name and it is a bushy brose plant found in the forest (Its scientific name not yet tracked).

In the Dhati Walal National Park, buffaloes usually move and feed in groups and this agrees with reports on buffaloes of the Dzanga-Ndoki National Park, where they feed and move in group. The male buffaloes, which were leaders of the group, used to graze being at the corner of the herd in four directions, in order to defend the herd from predators. The leaders are alert and vigilant than the rest of the members of the group to actively attend any predator or hazardous thing comes to attack the group. In the Dhati Walal National Park, the main predator of buffalo is lion and sometimes hyena can prey on young buffaloes grazing alone.

The speed of feeding (Bit rate) is somewhat similar to cattle's, however restlessness is observed more in buffaloes since they are looking repeatedly into their environment to take care of themselves from prey. Melletti *et al*. [35] also reported observations of the herd standing in alert postures for a few minutes and then fleeing a few hundred meters within the same clearing (When the herd smelled the observers or a predator), but on some occasions the buffalo moved to another clearing, with an adult female always leading the group. Such situations may be a factor forcing buffaloes to graze more during night at relatively free time from visitors.

During grazing, buffaloes in Dhati Walal National Park did not compete each other for feeds. They only fight at the time of reproduction. In other angle, animals like cattle, common bushbuck and hippopotamus are the main competitor on forage resources. When these animal fed around they are social to them even they cannot drive them away from the area. Especially common reedbuck is most of the time graze near to them and this may indicate that the small sized common reedbuck can be protected from predators by being harmonized with buffaloes. Buffaloes also have highest ability to sense the smell of other animals from a very long distances, especially when wind is there it notice every predator from long distance.

Almost all buffaloes in Dhati Walal National Park were fed on morning and night and rest from late morning to early night. Similarly, reports indicate that buffaloes tended to rest more during the day time than at night, particularly during the warm wet season. And also other studies [36, 37] stated that the herds had a long mid-day rest period, after the morning grazing peak. According to respondents, buffaloes prefer to enter into forest to take rest and ruminate for longer time. Besides the availability of quality and quantity feed, some environmental constraints such as weather conditions, human activity and predation risk could also influence feeding behavior of buffaloes [38].

Water Source and Watering Behavior of Buffaloes: The vast proportion of the Park (80%) is occupied by wetland environments revealing excess water availability throughout the year [22]. This indicates that the buffaloes in the park have wider chances of habitat choices and less limited due to watering because of vast water availability in the park. In accordance with this [39] reported that buffalo has three basic habitat requirements. These are: adequate permanent water, enough of the right feed and shelter from predators and heat. It was also reported that habitat selection by large herbivores may be determined by water supply [40].

Buffaloes in the study area usually drink water at a mid-day. However, Winterbach and Bothma [36] found that buffalo drank in the early afternoon; this may be due to the difference in environment conditions where buffaloes are grazing or due to preference to rest at sunny time. Whereas, Grimsdell and Field [41] reported that buffaloes usually drink water in the mid-morning. This shows that there might be differences in the timing of drinking based on the type of feeds, season of the year, habitat types or the geographical locations and prevailing weather. There are ponds, which are drawn during the walk of the hippos in Dhati Walal National Park. This line like ponds can hold water and wild animals drink from this freely.

Botanical Composition of Major Browse Species: The botanical composition of browse feed resources in the park is shown in Table 2. It was determined by using transect and counting each species within the transect lines. From browse feed resources of buffaloes in the park, the most dominant one was *C. molle* (31.83%) followed by *G. ternifolia*, *R. ruspolii*, *R. tridentata*, *A. chundra* fruit, *O. rechetiana*, *G. ferruginea* and *V. amygdalina* in their respective order.

Table 2: Botanical composition of the major browse feed resources in the park

Browse species	Percentage (%)	
Combretum molle	31.83	1
Gardenia ternifolia	21.27	2
Rhus ruspolii	17.08	3
Rhoicissus tridentata	12.76	4
Acacia chundra fruit	6.36	5
Olinia rechetiana	6.36	5
Grewia ferruginea	2.17	6
Vernonia amygdalina	2.17	6
Total	100	

Identification of the browse species in the park helps to distinguish its biomass production and nutritional contribution to the animals. In this case, it may be important to determine the nutritional potential of these dominating browses in the park as indicated in Table 4. Such information or knowledge of species composition may also be relevant in grazing land management.

Biomass Yield of Major Browse Resources in Dhati Walal National Park: From the total forest land of the park (135 km^2), about 86.92km^2 is covered by browse plants which buffaloes are fed on them, this mean that 64.4% of browse plant in the park is eaten by buffaloes indicating that above half feed resources of browse in the park is suitable to be eaten by buffaloes. 11, 097,249.53kg (=11,097.24 tons) of DM can be obtained from those browse plants which are edible to buffaloes in the park. In other words, about 21,088,102 browse plants from 8 major feed species of buffaloes in the park are eaten by buffaloes. This shows that the biomass productivity of the browse species was 82 tons /km^2 per harvest. This figure was the general biomass production potential of the browse plants, however, all the plants could not be taken due to their long height above the ground that the buffaloes might not reach.

From all browse plants, buffaloes consuming in the park, the highest total biomass yield in DM basis was obtained from *R. tridentata* (4,063.67tons, 36.61%) and the least one was from *G. ferruginea* which produce biomass yield of about 260.29 tons (2.34%). Totally from both the grassland and forest land production of feed resources, about 38,299.75 tons of biomass yields were obtained in Dhati Walal National Park. The biomass yield of major browse plants used by buffaloes in the park was indicated in Table 3.

Chemical Composition of Major Browse Resources: The chemical compositions of some of the major browse resources used by buffaloes in the study area were given

Table 3: The biomass yield of major browse plants used by buffaloes

Type of browse plants	ACP (cm)	ATD (cm)	CCA (m^2)	Average DMY (kg)	TDMY (tons)
Gardenia ternifolia	57.30	18.23	22.9	1.32kg¥	1065.79
Acacia chundra fruit	54.43	17.32	11.34	1.27kg¥	619.32
Combretum molle	60.40	19.22	40.72	1.37kg¥	930.94
Rhus ruspolii	61.20	19.48	12.57	1.38kg¥	1630.31
Olinia rechetiana	38.10	12.12	6.16	0.92kg¥	825.90
V. amygdalina	37.40	11.90	7.07	0.90kg¥	1701.00
Rh. Tridentata	20.00	6.36	0.79	0.29kg¥	4063.67
Grewia ferruginea	18.60	5.92	1.67	0.23kg¥	260.29
Total				7.68kg	11097.22

TDMY= Total dry matter yield in the park; ¥ = yield per plant; ACP=Average Circumference of browse plant; ATD= Average Trunk diameter; CCA= Average Canopy Coverage Area of one browse plant

Table 4: Nutrient content of browse species consumed by buffaloes in study area

Types of sample	Chemical composition					
Grass species	DM %	Ash %	CP %	NDF%	ADF%	ADL%
Acacia chundra fruit	97	5.15	12.19	55.71	43.3	10.87
Gardenia ternifolia	95	6.32	11.97	47.65	35.79	7.37
Olinia rechetiana	96	9.37	24.91	42.46	31.25	10.94
Vernonia amygdalina	96	11.46	23.41	37.46	25	8.62
Combretum molle	92	8.7	16.53	70.12	58.7	15.24
Grewia ferruginea	96	13.54	24.84	35.62	25	7.92
Rhus ruspolii	95	5.26	19.19	38.79	27.37	10
Rhoicissus tridentata	95	6.32	16.13	65.71	52.63	13.75

DM= Dry Matter; CP= crude protein; NDF=neutral detergent fiber; ADF= acid detergent fiber; ADL= acid detergent lignin

in Table 4. Dry matter content of the feeds was ranged from 92% to 97%. The highest DM was obtained from *A. chundra* fruit whereas the lowest value was for *C. molle.* The crude protein contents of the browses were in a range from 11.97% to 24.91%. The lowest content of crude protein was for *G. ternifolia* (11.97%) and the highest was for *O. rechetiana* (24.91%). The buffalo's minimum requirement for protein is 7% to 8% of the diet [11]. In these study, all the browse plants consumed by buffaloes contained crude protein value above the minimum requirement (7%).

The NDF content of feeds was known as a reliable predictor of voluntary dry matter (DM) intake under certain conditions [19]. DM intake decreases sharply as NDF concentration increase over 45.8% in animals [42]. In the current study, NDF% was highest in *C. molle* (70.12%) indicating that less intake, by buffaloes, of this plant was expected. In addition, browses such *G. ternifolia, A. chundra* fruit and *R. tridentate* contained NDF value more than 45% indicates that they are low quality herbages and they are expected to reduce buffaloes feed intake.

The primary chemical component of feeds that determines their rate of digestion is Acid-detergent fiber (ADF). *C. molle* followed by *R. tridentate,* had highest amount of this component indicating lowest digestibility of these browses [43]. In this finding the less dominant plant in the park was *G. ferruginea* but it may have highest rate of digestibility estimation because it had the least ADF percentage from all browses feed resources of the park. This result indicates that the most dominant feed resources of buffaloes in the park have less expected intake and digestion rate, based on their fiber content, than the less dominant plant in the park.

CONCLUSION

During the current study eight major browse species of buffalo were identified. In the rainy season when the bottom land grazing areas are flooded by water, browse species were the main sources of feeds for buffaloes in the park. From browse species identified, though its maturity was seasonal, fruits of *A. chundra* were the most palatable feed used by buffaloes. Buffaloes fed especially at the night time and early morning. During feeding, they were restless indicating their fear of predators. When feeding buffaloes do not fight each other to compete for feed but they are social to one another and graze nearby each other.

The browse species in the park were estimated to produce about 82 tons/ km^2 of DM per harvest. From all browse plants consumed by buffaloes in the park, the

highest total biomass yield in DM basis was from *R. tridentata* (4,063.8 tons) (36.61%). The fiber content ranged from 35.6% to 70.1%. The crude protein content of the browses ranged between 5.69 to 24.91%. In general, the browse plants in the park had a good contribution for protein nutrition of the buffaloes.

Recommendation: It is important to encourage the propagation of the most nutritious browse species in the park. Additional evaluation of browse resources through digestibility trials is important. Park boundary should be established and controlled by the government to avoid competition of domestic animals for feed resources.

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