Grazing Pattern of Muturu Cattle under Sedentary Pastoral System as Influenced by Seasonal Variation on Range Land in South East, Nigeria

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Abstract

Sedentary pastoral management systems were monitored on the rangeland of Southeastern Nigeria from 2014 to 2023 to determine the impact of seasonal variation caused by climate change on rangeland condition during early rain (March – May), mid rain (June – August), late rain (September – November) and dry season (December – February). Range land characteristics such as forage density, biomass, forage unit and forage ranking were determined during the period. Muturu grazing pattern in terms of forage intake, cattle grazing-day-capacity and cattle index were determined and analyze with the Iso-intake curve. The result indicated significant reduction (p<0.05) forage biomass with decreasing annual cumulative rainfall. Dry season maintained the least forage biomass (1.05 tonnes/ha) with low forage ranking, while the late rain, mid rain and early rain had higher biomass values of 3.02 tonnes/ha, 3.85 tonnes/ha and 3.50 tonnes/ ha respectively. Forage density (Df) and Muturu live weight (MLW) were positively correlated with the grazing time (GT). The iso–intake curve indicated a remarkable climate changes effects on vegetation for the four seasons. As seasonal condition shifted from dry season, late rain, mid rain and early rain cattle day-grazing declined significantly (p<0.05). Dry season had the poorest cattle-day-grazing of 0.11kgDm/ha/day. Significant differences (p<0.05) were observed in the seasonal grazing time (GT), non-grazing time (NGT) and grazing walking distance (GWD). Grazing time (GT) reduced as rainfall declined, while non-grazing time (NGT) and Grazing walking distance (GWD) increased with the reduction of early rain, mid rain, late rain, and dry season. Dry season had lowest GT of 42.00 minutes but NGT and GWD recorded 318 minutes and 7.50 kilometer respectively. There were significant reduction of grazing capacity (GC), growth index (GI) and cattle index (CI) as seasonal variation occur for the four seasons. The climate change pattern played key role in all the values of GC, GI and CI results as the seasons changed from 2012 to 2021. The reduction of forage biomass as the seasonal changes occurs from the rainy season to the dry season affected GC, GI and CI performance

Keywords: Derived savanna-rangeland, climate change, cattle–grazing pattern, sedentary-pastoral farming.

Effet Des Variations Saisonnières Sur Les Pâturages De La Savane Dérivée Et Sur Les Habitudes De Pâturage Des Bovins Muturu Dans Le Cadre D'une Gestion Pastorale Sédentaire Dans Le Sud-Est Du Nigéria

Résumé

Des bovins Muturu élevés selon un système de gestion pastorale sédentaire ont fait l'objet d'un suivi sur les pâturages du sud-est du Nigeria de 2014 à 2023. L'objectif était de déterminer l'impact des variations saisonnières dues au changement climatique sur la superficie des pâturages pendant la saison des pluies précoces (mars-mai), la saison des pluies intermédiaires (juin-août), la saison des pluies tardives (septembre-novembre) et la saison sèche (décembre-février). Les caractéristiques des pâturages en termes de densité fourragère, de biomasse, d'unité fourragère et de classement fourrager ont été déterminées au cours de cette période. Le régime de pâturage des Muturu, en termes de consommation fourragère, de capacité journalière de pâturage et d'indice de bétail, a été déterminé et analysé à l'aide de la courbe d'iso-consommation. Les résultats ont montré une réduction significative (p < 0,05) de la biomasse fourragère avec la diminution des précipitations cumulées annuelles. La saison sèche a présenté la plus *faible biomasse fourragère (1,05 tonne/ha) avec un classement fourrager faible, tandis que les périodes de pluies tardives, intermédiaires et précoces ont affiché respectivement une biomasse de 3,02 tonnes/ha, 3,85 tonnes/ha et 3,50 tonnes/ha, avec un classement fourrager plus élevé. La densité fourragère (Df) et le poids vif des muturu (MLW) étaient positivement corrélés à la durée de pâturage (GT). L'apport en iso a mis en évidence des effets remarquables des changements climatiques sur la végétation au fil des quatre saisons. Le pâturage quotidien du bétail à Muturu a diminué de manière significative (p < 0,05) au fur et à mesure que les saisons se succédaient, dans l'ordre suivant : saison sèche, pluies tardives, pluies intermédiaires et pluies précoces. C'est pendant la saison sèche que le pâturage quotidien du bétail a été le plus faible, avec une valeur de 0,11 kgDm/ha/jour. Des différences significatives (p < 0,05) ont été observées concernant la durée saisonnière de pâturage (GT), la durée hors pâturage (NGT) et la distance parcourue pour paître (GWD). La GT saisonnière diminuait parallèlement à la baisse des précipitations, tandis que la NGT et la GWD augmentaient à mesure que les saisons des pluies précoces, moyennes et tardives, ainsi que la saison sèche, s'avançaient. La saison sèche présentait la durée de pâturage la plus faible (GT) avec 42,00 minutes, tandis que la durée de non-pâturage (NGT) et la distance de déplacement pour le pâturage (GWD) s'élevaient respectivement à 318 minutes et 7,50 kilomètres. On a observé une baisse significative de la capacité de pâturage (GC), de l'indice de croissance (GI) et de l'indice de bétail (CI) au fur et à mesure que les variations saisonnières se produisaient au cours des quatre saisons. L'évolution du changement climatique a joué un rôle clé dans toutes les valeurs des résultats relatifs à la GC, au GI et au CI au fur et à mesure que les saisons changeaient entre 2012 et 2021. La diminution de la biomasse fourragère, liée aux changements saisonniers entre la saison des pluies et la saison sèche, a affecté les performances de la GC, du GI et du CI.*

Mots-Clés: Savane-pâturage dérivé, changement climatique, bétail de Muturu – schéma de pâturage, élevage sédentaire-pastoral.

Introduction

The global phenomenon of climate change, the rising limitations of free grazing livestock on rangelands in many parts of sub-Saharan Africa, including Southeast Nigeria (Nweze, 2003). Many grazing areas of the Sub-Saharan African region have experienced a decline in forage production in recent years (Olafadeham and Adewumi, 2010). Variations in annual forage production between the wet and dry seasons have been attributed to the effects of climate change and anthropogenic activities (Nweze and Ekwe, 2001; Nweze and Omeje, 2001). The unfavorable weather conditions, such as extreme temperatures, unreliable rainfall patterns and frequency, have created multiple challenges for the rangeland environment in recent years. The challenge has resulted in the limited survival of many pasture species within the region (Nweze, 2014). This situation is of serious concern to pastoralists who rely on natural forage resources for sustainable livestock production systems (Herge, 2017). The precarious situation of declining forage productivity and problems related to feeding ruminant animals under sedentary pastoral management in the derived savanna environment is a problem that needs attention under the present circumstances immediately. The grazing environment continues to change due to the impacts of Climate variability, which influences pasture growth, rangeland productivity, and livestock management practices. Reports have indicated that the carrying capacity (head/ha) of tropical rangeland is declining due to climate change (Otchere and Nuru, 1985). The low soil moisture, especially during the dry seasons in recent years, adversely affects forage growth, maturity and seed production (Nweze and Omeje, 2001;

Nweze *et al* 2000). Seasonal variations adversely affected the leave-to-stem ratio, which is an important indicator of forage quality in a grazing environment (Leeur and Hienaux, 1980).

Another adverse effect of climate change is the vulnerability of grazing lands to degradation processes such as erosion, flooding, and desertification. The grazing environment continues to change due to the impact of climate variability, which influences pasture growth, range land productivity and ruminant animal management practices. There is also grazing land hunger in Southeast Nigeria for feeding ruminant animals because of the continuous fragmentation of large parcel of land as the land ownership transfers their ownership to the next generation. This land tenure system in the Southeast Nigeria has resulted in the fragmentation of pasture land in such a way that the land for grazing of animals is insufficiently enough due to the competitive nature of land for food crop production, construction, mining, etc. by the land owners. Also Pastoral farming in this region is becoming unsafe due to some elements of criminal activities and banditry in some part the range land environment of the region. In view of this situation, it is important that proper assessment and planning of pastoral farming is important in this region for sustainable ruminant production. The use of a stochastic model through the feed intake algorithm of forages by ruminant animals can be one of the options explored for such assessment. The model was used to estimating the seasonal grazing variation through feed intake of Muturu cattle (Nweze and Otuma, 2020). Grazing indices such as grazing capacity (cow-day/ha), cattle index, and other related parameters can be adopted to assess seasonal forage variability in the tropical savanna region. Cattle walking distance on the grazing area, known as Grazing Walking Distance (GWD) and the grazing (GT) are indicators for forage availability and e intake. The GWD is influenced by forage density (D_F) while, the rate of forage consumption (GR) depends on the quantity of available forage (Q_F). The grazing time (GT), which is the time spent by cattle on continuous grazing and non-grazing time (NGT), the time spent on other activities such as grooming and social behaviour (Nweze, 2017), both depend on forage density (D_F). Therefore, forage density is an importance index in evaluating cattle performance feeding on range land under prevailing seasonal changes in Southeast, Nigeria.

Materials and Methods

The study was conducted at six locations, at Muturu Cattle Breeding and Multiplication Centre in Oshiri-Onicha, Abakaliki, Ezza North and South, Ikwo, Izzi and Ebonyi local government Areas of Southeast Nigeria within longitude 08˚20’E and latitude 06˚45’N [EBSMIC, 1999]. This location is within derived savanna with woodland. There is Ebonyi River aquifer that traverses the length of the grazing territory, which supports the diversities of plants species of mainly open canopy of scattered dwarf and tall trees. The closed canopy trees have been affected by deforestation, annual bush fire and human activities such as cropping, mining. The soil is of clay, silt, sand, and loam soil, which is mainly classified as dysteric leptosol (FAO/UNESCO, 1974). forages consist of mixed tuft tall and short grass/legume species, available mainly during mid and late rainy season, as well as legume and browse. There is perennial plant species, which include oil palm, cassia, gmelina, teak and other native shrubs (Table 1).

Table 1: Grazing territory characteristics of the derived savanna rang land of southeast Nigeria

Forage species	Forage descriptive morphology	Relative niche size	Relative community occupation size / habitat
Hyperrhenia spp	Herbaceous perennial erect grass	Very large	High in plain, hill, valley, low in forest, swamp and river bank.
Andropogon spp	Herbaceous perennial erect grass	Large	High in plain, hill, forest and river low in swamp.
Pennisetum spp	Herbaceous perennial erect grass	Large	High in plan, river bank, forest low in swamp and hill.
Panicum spp	Herbaceous perennial erect grass	Large	High in plain, river bank, forest low in swamp
Brachiaria spp	Herbaceous perennial erect grass	Small	High in plain, valley, hill, lowland swamp and forest.
Chloris spp	Herbaceous perennial erect grass	Small	High in plain, hill, valley low in swamp and forest
Seteria spp	Herbaceous perennial erect grass	Small	High in plain, hill, valley swamp, forest, low in river bank
Elusine spp	Staloniferus perennial grass	Small	High in plain valley swamp river bank
Imperata spp Eragrostatus spp	Staloniferus herbaceous annul erect	Small	High in plain, forest valley swamp low river bank
Axonopus Spp	Herbaceous creeping perennial grass	Small	High in plain, hill low in swamp, forest
Digitaria Spp	Herbaceous annual erect grass	Very large	High in plain, forest, low in swamp
Cynodon dactylon	Herbaceous creep/trailing perennial grass	Very large	High in plain, swamp and valley, low in forest
Centrosema spp	Herbaceous creeping perennial legume	Large	High in plain, hill, valley, forest, river bank ete.
Calopogonium spp	Herbaceous creeping perennial legume	Small	High in plain, hill, valley, forest, river bank ete.
Stylosanthes spp	Herbaceous creeping legume	Small	High in plain, hill, valley, forest, river bank ete.
Desmodium spp	Herbaceous creeping perennial legume	Small	High in plain, hill, valley, forest, river bank ete.
Lablab purpureus	Herbaceous creeping perennial legume	Small	High in plain, hill, valley, forest, river bank ete.
Acacia spp	Woody tap root plant	Small	Low in plant forest
oil palm spp	Woody prop root perennial plant		

Samples of these local forages were collected, analyzed using Alkane-implant wax marker and ranked accordingly based on range topography, forage species relative niche size and community occupation in the habitat. The ranking has a cumulative point of 48 with a maximum point of 6 for A, 5 for B, 4 for C, 3 for D, 2 for E and 1 for F. The ranking ranged from highest (6) to lowest/non (1) for all parameters except forage loss. The forage Unit (FU) was defined as the energy required for 250 kg live weight cattle/day. FU= 1, FU rank 1.00 to 0.00

$$\text{Percentage forage ranking} = \frac{\text{Aggregate rank}}{\text{cumulative rank}}$$

The experimental design was a Completely Randomized Block Design (CRBD). There were four seasons, (Early Rainy Season (March – May),Mid Rainy Season (June –August), Late Rainy Season (September-November) and Dry Season (December –February) observed from 2014 to 2023.

The grazing territory was divided into one hectare of grazing patches. Cattle were monitored on each patch by five enumerators. Each enumerator recorded grazing bites and grazing time of cattle on the patch. Muturu herd biomass and production were calculated using the individual cattle performance model expressed below as

$$Y = ax – bx^2 \quad \text{equation (1)}$$

Where y = average live weight (kg)

x = grazing Patch (ha)

a, = forage multiplier factors.

(b) = animal multiplier factors .

The Muturu stock rate (SR) is expressed as

SR= y/x, unit in (kg/ha).

In each patch,

$$SRmax = \frac{Ymax - Ymin}{xmax - Xmin} \qquad 2$$

Where $\frac{Ymax - Ymin}{Xmax - Xmin} \geq 0$

The grazing intake (G_I) was estimated in each patch using a model described by the general forage intake model in the real system (Nweze and Otuma, 2020), expressed as:

$$\mathbf{Y=[I-e^{-(px/m)}]}^{I}/_{h}$$

Where Y = forage intake

X = Forage biomass

m = upper limit

p = edible forages

h = X and Y curve.

Biomass and relative abundance were measured by quadrat sampling at a particular grazing patch. There were ten casts per patch before grazing and after grazing. The density of forages (D_F) was calculated by the expression:

$D_F=Q_F/A_F$

where D_F = Forage density

Q_F = Forage biomass.

A_F = area of grazing patches

$\therefore D_F = \frac{Fsp \ x \ C}{AF}$

Where Fsp = frequency of cast per patch

C = Number of quadrats cast.

The rate of forage intake (GR) is determined by the expression $GR = Q_F/G_T$.

Where Q_F = Forage Biomass

G_T =Grazing time

For (Q_F) = GR x G_T But $Q_F = Q_{FC} + Q_{FN}$,

$\sum QF = \sum Q_{FC} + \sum Q_{FN}$ $\sum Q_{FC} = \sum(G_F\text{-}Q_{FN})$

$$GR = \frac{\int Q_F - Q_{FN}}{G_T}$$

Q_{FC} = Consumable forage Biomass

Q_{FN} = non-consumable forage biomass

The rate of forage intake (GR) is dependent on the forage on a patch (G_F)

$$GR = \int_{GI}^{Gin} (QF)/GT$$

Where GR = Grazing Rate

QF = Quantity of forage biomass grazing in the territory per patch

G_1, G_{in} = variables, i.e., Forage species, weather condition, and sex, age and physical condition of the animal

Where $\frac{\partial GR}{\partial QF} \geq 0, GT = CONSTANT$

GR=Rate of forages grazed (g) per (minutes)

Q_{F} = quantity of forage grazed in gram.

Grazing area patch (A_{GT})= L_{GT} x B_{GT}

Where L_{GT} and B_{GT} are length and breath of grazing Patchtes respectively.

Density of grazed Forage $D_F = Q_F/A_{GF}$

Productive Biomass = $\frac{Total\ forage\ Biomass - wasted\ forage\ (kg)}{total\ Area\ of\ grazing\ patches(hectar)}$

An algorithm was used to estimate simulated intake of Muturu herds on rangeland under a sedentary pastoral system, using the grazing orbit correction factors, multiplier factors and the Muturu cattle grazing correction multiplier factors in Tables 2 and 3, as well as the feed intake expression represented below as

$I = m(d,t).m(D).m(t).m(x,t).m(p,t).q.W_t^{-0.73}$ (Nweze and Otuma 2020)

Where, I = Average daily feed intake

m(d,t) = daily digestibility of forage on offer in the territory

m(Q) = daily quantity of forage on offer in the territory

m(D) = Daily grazing time

m(t) = average age of cattle in the herd of the grazing territory

m(x,t) = physiological state of cattle

a = intake coefficient on metabolic weight

w_t = Live weight (Kg)

The cattle-day-grazing capacity (GC) was determined by the expression

$$GC = \frac{GI}{AF}$$

Where GC = -grazing capacity

A_F = Grazing patch (ha)

GI= Grazing intake.

$$GI = \frac{Mcwf - Mcw1}{Mcwf} \times \frac{100}{1}$$

Where GI = Growth Index

Mcwf = Muturu Cattle weight (final)

Mcw1 = Muturu cattle weight (initial)

Table 2: Grazing territory correction multiplier factors of the derived savanna range land of southeast Nigeria

Variables	ER	MR	LR	DS
Maximum forage on (Q) kgDm/ha /day	2,340	1,680	1,350	1,110
Threshold forage $(i)_{fm}$, (kgDm/ha/day)	780	560	360	296
Digestibility of forage (d) on after (%)	60.0	50.0	37.50	28.50
Forage efficiency (Fe)	0.78	0.56	0.45	0.37
Forage intake co-efficient (a)	0.83	0.65	0.53	0.40
Grazing orbit distance (D) (km/day)	2.5	3.5	7.0	10.0
Threshold distance affecting feed intake (km/day)	1.50	2.20	5.5	6.3
Maximum crude protein of forage on offer (%)	9.0	8.0	5.0	3.0
Threshold crude protein of forage on offer (%)	6.0	5.0	3.0	2.0
Maximum crude fibre of forage on offer (%)	35.0	35.0	30.0	40.0
Threshold crude fibre of forage on offer (%)	25.0	30.3	35.0	38.0
Net energy for maintenance(Em) MJ/day	26.0	27.0	29.0	30.0
Net energy for weight gain (Eg) MJ/day	13.0	14.0	15.0	15.0

Table 3: Muturu cattle grazing correction multiplier factors

Variables	Values
Considered age range for the study (t)	6 month – 4 yrs
Mean live weight for bull (W_{bu}/kg)	175.0
Mean live weight cows W_{co}(W_{co}) kg	1.50.0
Mean live weight for calves (W_{ca}) kg	12.5
Co-efficient of variation (kt)	2.5
Upper limit of live weight muturu bull (W_{bumax}) kg	180.5
Threshold limit of live weight Muturu bull (W_{bumin}) kg	150.50
Upper limit of live weight Muturu cow (W_{comax}) kg	165.50
Threshold of live weight Muturu Cow ($W_{co\ maxim}$) kg	135.00
Upper limit of Muturu calves (W_{camax}) kg	45.4
Threshold limit muturu calves (W_{camin}) kg	15.7
Voluntary free grazing intake (k_gDm/day)	5.60
Potential weight gain/month (kg)	0.25

The forage productivity of the grazing area was determined by using the individual animal performance model and gain per unit area models (Nweze, 2017).

Expressed as $y = ax-bx^2$

Where; y = cattle weight gain per grazing patches, x = Grazing patch

a, b, = constants obtained from individual forage species consumed by cattle.

The cow index (CI) is expressed as CI = $\frac{WCF+WMK}{WC}$

Where CI = cow index of the cattle in the grazing patch

WCF = weight of a yearling calf in the grazing patch

WMK = total weight of milk off-take in the grazing patch

Muturu cattle with a very low no milk off take, CI can be represented as shown below

$W_{MK} \leq 0, \quad \frac{WCF+O}{WC} \qquad \therefore \text{CI} = \frac{WCF}{WC}$

The growth index GI is expressed as GI = $\frac{Wg}{Wc}$,

Where GI = growth index of cattle on grazing territory, WC = weight gain and cattle body weight respectively.

The data were subjected to least square means analysis to compare the means (Harvey, 1977)

Results and Discussion

Table 4 shows the forage attribute ranking of the study for the seasons. Early rainy season had the highest ranking, in terms of dominance, climax community, forage growth and accessibility. This highest ranking was observed for grass and legume forages during early, mid and late rain. The average forage unit was highest in the early rain and progressively declined towards the dry season. The trend reflected the ecological and climatic adaptation of the forage species in the derived savanna zone as influenced by seasonal weather changes. This was consistent with findings of Polley *et al.* (2013), who reported that forages in the tropical zone were influenced by seasonal weather conditions.

The entire biodiversity of the grazing territory was affected by seasonal variation with noticeable changes from early rain to dry season. Ekwe, *et al. (*2020) gave a similar report for forage characteristics and adaptation Southeast ecological zone. This is also in line with the tropical savanna ecosystem adaptation (Lascano, *et al., 1982*).

Table 4: Forage attributes ranking of grazing territory.

Parameter	Early Rain				Mid Rain				Late Rain				Dry Season			
	GR	**LE**	**BR**	**FO**	**GR**	**LE**	**BR**	**F0**	**GR**	**LE**	**BR**	**F0**	**GR**	**LE**	**BR**	**FO**
Forage dominance	A	B	C	B	A	B	C	C	B	C	C	C	D	C	C	C
Forage growth	A	B	B	B	B	B	C	C	E	D	D	C	E	D	D	D
Forage accessibility	A	A	B	C	C	C	D	F	E	C	C	F	F	E	D	F
Forage palatability	A	A	B	F	C	C	C	F	D	D	D	F	E	E	E	F
Forage leaf/stem ratio	B	B	C	E	C	C	D	E	D	D	D	F	F	E	E	F
Forage lignin	B	B	B	F	C	C	D	E	D	D	D	F	E	D	E	F
Forage losses	B	B	B	A	B	C	C	F	C	D	D	F	E	E	C	A
Forage digestibility	B	B	C	F	C	C	D	F	A	A	E	F	E	D	D	F
Forage % ranking	91.55	87.50	81.25	52.03	75.0	70.83	50.00	31.25	54.12	66.67	52.08	20.84	31.25	41.67	47.91	31.25
Forage unit	0.91	0.87	0.81	0.52	0.75	0.70	0.50	0.31	0.54	0.54	0.52	0.21	0.31	0.41	0.47	0.31
Average forage unit	0.78				0.56				0.45				0.37			

Key: GR = grass, LE = legumes, BR = Browses, FO = forbs.
Ranking: Highest = A(6), High = B(5) overage = C(4), low = D(3), very low = E(2), Little/non = F(1)
Forage loss: Very low = A (6), low = B(5) Medium = C(4), high = D(3), very high E(2) completely F(1).
Max. rank=6, min. rank=1, total=6x8=48
Forage unit (FU): The energy provided by a mature cattle weighing 25 kg live weight equivalent in a day on one hectare =1

The forage productivity including stocking rate, crude protein, fibre, forage moisture level as fed and biomass decreased as the rain progressed from early rain to dry season (Table 5). The amount of annual rainfall influences the evapotranspiration, surface runoff, drainage and water storage, which determines the water availability for plant productivity. Variations in precipitation influence soil water condition, and soil nutrients dynamics; consequently, affecting vegetation growth and distribution. (Yamel *et al.*, 2022). High temperature and erratic rainfall increases evapotranspiration rates which t may negatively affect vegetative growth, damage forage root development, inhibit tillering and may encourage lignification (Polley *et al.*, 2013).

Table 5: Forage productivity on the grazing territory.

Stocking rate range (head/ha)	8 – 4	5 – 3	3 - 2	2 – 1
Forage moisture range (%)	80 – 70	85 – 75	70 – 60	65 - 50
Forage crude protein (%)	7 – 5	6 - 4	6 – 3	5 – 2
Forage crude fibre (%)	30 – 25	35 – 30	38 – 35	38 – 35
2.Legume species				
Stocking rate range (head/ha)	5 – 3	5 – 3	3 – 2	3 – 1
Forage moisture range (%)	80 – 70	85 – 75	25 – 70	70 – 65
Forage crude protein (%)	9 – 6	8 – 5	5 – 3	7 – 2
Forage crude fibre range (%)	30 – 34	35 – 38	40 – 35	40 – 38
3. Browse plant species				
Stocking rate range (head/ha)	4 – 2	4 – 2	3 – 1	2 – 1
Forage moisture (%)	79 – 70	75 – 70	72 – 70	70 – 60
Forage crude protein (%)	8 – 5	6 – 4	4 – 3	3 – 1
Forage crude fibre (%)	32 – 30	35 – 30	40 – 32	40 – 35

Table 6 shows the forage biomass, cumulative annual rainfall, temperature and humidity range of the grazing territory. The forage biomass differed significantly ($p<0.05$) among the grazing areas. The reason for the variability of forage biomass could be due to the pattern and frequency of rainfall and other weather condition, in agreement with findings of Ibe *et al*. (2023). NIMET, (2022) predicted the consequence adverse weather change on crop within these years. Also, Adegbola and Onayinka (1968) and Dahl and Hjort (1979), as well as Milligant *et al* (1979), have all reported that the micro-environment, and ecological and climatic conditions influenced forage yield. Forage biomass was significant differed ($p<0.05$) across the grazing areas. Forage biomass yield was lower in the years 2018 and 2021 than the other year due to lower rainfall in the years. The trend was evident in 2017 and 2023, when the forage biomass was higher than in other years. This is in line with Nweze and Omeje (2001) and Otchere and Nuru (1985), who reported declining forage yield due to inadequate rainfall. The result also shows that the mid rainy season, which occurs from June to August in Southeast Nigeria, had the highest forage biomass, followed by the early rain (March-May) and late rain (September – November) in that order. However, the dry season period (December – February) had the lowest forage biomass. The rainfall cumulative value for the year shows that the dry season had the lowest value of about 820mm during this period, as against 2275mm and 2168mm for mid and late rain, respectively. It has been reported that drought conditions significantly reduced the dry matter yield as well as the nutritional status of forage materials (Gleditsch and Peters, 2013). There is a scarce forage resource during the dry season because of drying up and death of forage species (Nweze and Omeje 2001). The late rains that occur during September to November in the Southeast result in forage species getting mature, lignified and start producing fruits. As a result of this, the plant species begin to lose their nutritional values that could affect the performance of the ruminant animals in this area (Nweze, 2017). Also, the late rain period affects the free movement of ruminant livestock in the region because this is the peak of arable crop farming and sometimes the pastoralist and the crop farmer clash because of the available space for livestock grazing. The frequency of rainfall in the mid-rain sometimes causes water log within the grazing area, which could prevent the free movement of cattle. Although there is relative high biomass in the early and mid-rainy season, the presence of anti-nutritional factors that occur among some forage species, especially the leguminous forage species, could cause bloat among ruminant animals. It was estimated that the crude protein of grasses decreased from 6% to 2% in dry seasons (Otchere and Nuru, 1985).

Table 6: Least Square means of forage biomass (Q_F), the cumulative rainfall, temperature and humidity range of the grazing territory.

Variables	Biomass (ton/ha)	Rainfall (mm)	Temperature (˚C)	Humidity (%)
Overall LSM Year	**4.50**	**185**	**28-3**	68-59
2014	2.12^{b}	1865	28-35	70-60
2015	2.22^{b}	1972	28-35	70-55
2016	2.20^{b}	1960	28-35	75-50
2017	3.42^{c}	2140	28-32	75-55
2018	1.88^{a}	1732	29-35	60-55
2019	2.02^{b}	1810	28-32	75-55
2020	2.15^{b}	1800	28-35	70-55
2021	1.93^{a}	1790	29-35	65-50
2022	2.98^{c}	2050	28-35	70-55
2023	3.21^{b}	2100	28-35	75-55
Early rain	3.50^{c}	1858	28-35	70-65
Mid rain	3.85^{c}	2275	24-35	80-60
Late rain	3.20^{c}	2168	22-35	85-55
Dry season	1.05^{a}	820	30-37	65-50

Note: a, b, c, d, e, mean in the same row with different superscripts are significantly different ($p < 0.05$).
Key: early rain (March-May), mid rain (June-August), late rain (Sept-Nov), dry (Dec- Feb)

Table 7 shows a relationship between grazing time (GT), forage density (D_F) and Muturu cattle live weight (MLW). The results indicated that D_F is positively correlated with G_T across the season. The density of grazing territory is made up of mixed forage species of consumable and non-consumable plant materials, which could affect the grazing time. The rate of forage consumption is dependent on many factors, including MLW. It was also revealed that Muturu's body weight (MLW) is positively correlated to grazing time (GT). One of the major criteria for determining a suitable grazing area by the pastoralist is D_F. Forage density is an important indicator used by pastoralists in selecting grazing areas, for adequate forage availability for livestock survival and productivity. (Muhammed *et al.*, 2024). Scarcity of forage resources could pose an impediment to ruminant production in tropical environment.

Table 7: Correlation expression of forage density (D_f), Muturu Cattle live weight (MLW) and grazing time (GT) on free grazing for the grazing patches.

Average Live weight	= 95.60 kg
Average forage Density (D_F)	=8.86 kg MD/ha
Total grazing time (GT)	= 360 minute/day
Annual rainfall range	= 1000 – 2000 mm
Annual temperature range	= 28-34˚C
Annual Humidity range	= 78-53%
Early rain	D_F = 350+156GT, R^2 = 14.00
	MLW = 30+11GT, R^2 = 0.61
Mid rain D_F = 420+166GT, R^2 = 25.00	
	MLW = 25.10+8.35GT, R^2 = 0.81
Late rain D_F = 381+152GT, R^2 = 21.52	
	MLW = 20.50+7.26GT, R^2 = 7.26
Dry season	D_F = 210.15+147 GT, R^2 = 16.21
	MLW = 7.12+5.21GT, R^2 = 0.91

Key: MLW = M live weight, GT = Grazing time, $D_{F=}$Forage density, R= Correlation co-efficient

Body weight of livestock determines the forage intake as well as the grazing rate (Nweze, 2003), because animals eat to satisfy their nutrient needs. The cattle graze longer when there is declined in forage density due to low rainfall. Therefore, it is required to make a provision of supplemental diets for animals managed on derived savanna under sedentary system in Southeast, Nigeria during dry seasons, which is characterized by low forage density.

Forage density and forage characteristics affect ruminant behavior and intake by impacting both physical and metabolic limitations (Henry *et al*., 2012). Such limitation is observed in the adjustment of grazing time (GT), grazing rate (GR), rumination time, nutrient absorption and utilization due to the quality and quantity of forage species on grazing environment

The result in this study of the Southeast derived savanna rang land, the grazing behavior of Muturu cattle is represented with a graphical tool from a mathematical model shown in fig 1 (Iso-intake curve). There is complex voluntary forage intake by Muturu cattle on the grazing area due to varying forage characteristics as a result of seasonal changes from early rain to dry season. The grazing time (GT), in X-axis, forage density (D_F) in Y-axis, the co-ordinates A, B, C, and D as well as the shaded areas DS, LR, ER and MR representing dry season, late rain, early rain and mid rain is shown in the forage iso–intake curve. The curve indicated different combinations of forage density ($D_{F)}$ and grazing time (GT) to obtain different grazing rates (GR) at the same forage intake (GI). The feasible zone of ISO-intake curve of DF and GT is the shaded area of coordinates A to C. The maximum grazing rate (GR) is found in point C and the area above coordinate C is the trade-off set that is critical in grazing environments and grazing management.

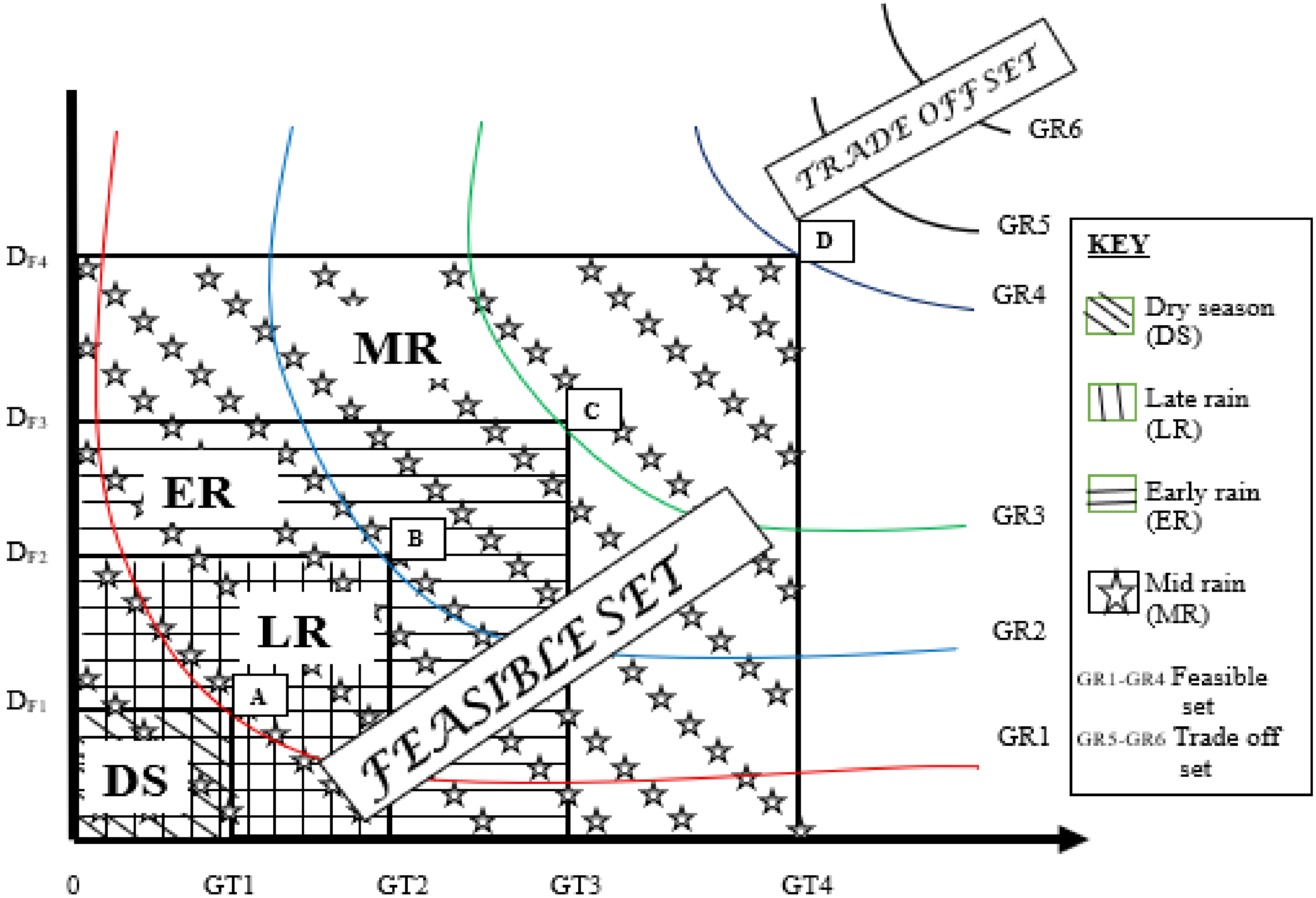

Fig 1: Iso-intake curve and grazing rate of Muturu cattle for the four seasons of the year on the Derived savannah range land, Southeast Nigeria.

The complex grazing environment as affected by seasonal change and Muturu grazing behavior, as represented in fig. 1 shows the complex relationship of forage density, grazing rate and time. The DS area with coordinate A, representing dry seasons. The season, even within a feasible set of grazing rate has the lowest forage density (D_{F1}) and the highest grazing walking distance as shown in Table 9. The challenge posed by DS area is the inadequate quality and quantity of forage resources prevalent in this season. Pastoralists sustain their cattle feeding with agro-byproducts supplement during period of forage unavailability.. The season is characterized by low stock rates, low forage unit, and forage ranking (Table 3 due to scarcity of fresh forage causing changes of grazing intake, rumination and digestibility by Muturu cattle. The changes is an adaptation strategy of meeting the daily nutritional requirement of Muturu cattle leading to spending more time on long distance walking and non-grazing activities. The challenge is compounded in the region by shortage of grazing area and the prevention of free movement of cattle in some parts of the zone by the tethered system. Under a tethered system, the animals are restricted from free voluntary feed intake, a situation that modifies their grazing behavior and they are most unlikely to obtain sufficient bites of forage in a day within a patch of grazing area to meet the cattle's daily nutrient. The sedentary pastoral farming in this area is characterized by a dry period by extensive use of agro by-products such as rice re-growth, stalk, and haulms, as well as browse plants supplementation.

The area marked with LR with co-ordinate C, indicating late rain. The area is still within a feasible set of grazing rates, but with multiple limitations such as poor grazing environment in the form of swamp, water log, and bushy grazing area that hinder grazing, bad weather conditions and high prevalence of pests and parasites constitute physical and parasitology limitations causing alteration to cattle grazing behavior (Polley *et al.*, 2013). Although the cattle may have sufficient grazing bites in a patch for recticulo-rumen fill, feed digestion and utilization may not be encouraged as there is low forage crude protein and high lignification. There is also an indication of forage search constraint (Johnstone-Wallace *et al*., 2017) within this period, compelling farmers to provide their cattle with fodder and agro by-products in a paddock or tether the cattle on a nearby plant re-growth where the animal could have some forage access.

The area marked ER with co-ordinate C is early rain, which provided satisfactorily grazing rate. The period here has a high forage ranking due to the greater availability of young grass tillers, succulent legume and browse plant species in a patch of grazing territory that enhanced recticulo-rumen fill and adequate cattle rumen flow (Emenike *et al.*, 2016). There is an indication that the number of cattle bites/minute and the bite size in a patch of grazing territory may be more than in other seasons. The grazing rate may be higher due to forage palatability, succulence, and low stem/leaf ratio. The Muturu cattle farmers take the opportunity of this season graze cattle on a nearby range land due to the good grazing environment, resulting in higher cattle-day-grazing.

The area marked with MR with co-ordinate D is the mid rain, which has high forage density. MR period is unreliable due to changes in the climatic conditions of Southeast Nigeria over the years. The MR could start early (June) or late (July or even August), resulting in unpredictable available soil water and plant nutrients, which impact forage seed germination, grass tillers, growth, maturity, seed production and distribution on range land. The forage density is affected by the seasonal changes, leaving Muturu cattle different options, such as a seasonal tethered system and a scavenging system (Nweze, 2017).

Table 8 shows the Muturu cattle–day grazing under the range system in kilogram dry matter per hectare. The result shows that the four seasons significantly differ ($P<0.05$) in the values of cattle day grazing from 2014 to 2023. The dry season maintained the least, followed by the late rain, the mid rain and the early rainy season in that order. The high cattle-day-grazing value is understandable because of the abundance of forages during early and mid-summer of the year. Reports have shown that the consumption pattern of animal depends on the acceptability of the forage materials, which is in turn dependent on the availability of the forages, nutrient composition including DM and CP. These factors differs across seasons (Nweze, 2018; Nweze *et al.,* 2001).

Table 8: Cattle-day-grazing of Muturu cattle under range system (kg DM/ha/day)

Annual Cumulative rainfall range	1000-2000mm
Annual Temperature range	$28^{\circ} – 34^{\circ}$c
Annual Humidity range	78 -53%
Maximum forage on offer early rain	1,250 kg DM/ha/year
Maximum forage on offer mid rain	937.5kg DM/ha/year
Maximum forage on offer late rain	650kg DM/ha/year
Maximum forage on offer dry season	312kg DM/ha/year
Standard Cow-day-grazing	602.5kg DM for 250kg
Muturu-cow-day- range 45-120kg	1.12-210 kg DM

Table 9: Effect of Muturu cattle under grazing time (GT)

Year	Early rain	Mid rain	Late rain	Dry season
2014	1.25 ± 0.01^{b}	1.10 ± 0.12^{b}	0.64 ± 0.05^{c}	0.24 ± 0.05^{e}
2015	1.12 ± 0.03^{b}	1.08 ± 0.10^{b}	0.72 ± 0.05^{c}	0.38 ± 0.01^{e}
2016	1.33 ± 0.03^{b}	1.00 ± 0.11^{b}	0.58 ± 0.03^{c}	0.29 ± 0.04^{e}
2017	1.12 ± 0.04^{b}	1.12 ± 0.10^{b}	0.40 ± 0.03^{d}	0.15 ± 0.01^{f}
2018	1.52 ± 0.01^{a}	1.48 ± 0.10^{a}	0.80 ± 0.03^{c}	0.43 ± 0.03^{d}
2019	1.65 ± 0.04^{a}	1.55 ± 0.13^{a}	0.45 ± 0.05^{d}	0.17 ± 0.05^{f}
2020	1.82 ± 0.02^{a}	1.50 ± 0.10^{a}	0.30 ± 0.05^{d}	0.11 ± 0.04^{f}
2021	1.90 ± 0.03^{a}	1.80 ± 0.10^{a}	1.00 ± 0.05^{b}	0.62 ± 0.05^{c}
2022	1.12 ± 0.03^{b}	0.75 ± 0.13^{c}	0.30 ± 0.04^{e}	0.12 ± 0.01^{f}
2023	1.09 ± 0.03^{b}	0.66 ± 0.10^{c}	0.35 ± 0.04^{e}	0.11 ± 0.02^{f}

Note: a, b, c, d, e, f mean in the same row with different superscripts are significantly different ($p <0.05$).

The least square mean of grazing time (GT), non-grazing time (NGT) in hours per day and grazing walking distance in kilometers per day is represented in Table 9.

There was significant difference ($P<0.05$) among these variables. There were declining grazing time (GT) except in 2019 and 2014. The non-grazing time (NGT) and grazing walking distance (GWD) increased as DT decreased. This may be due to changes in the environment of the grazing territory that affected the available quantity of forage on offer. There was a positive correlation between the forage density and grazing time, as well as walking grazing distance (WGD). The dry season (GT) was significantly ($p<0.05$) low (42.00 ± 31.20 minutes) as against the (GT) of 91.20 ± 69.00 minutes, 174.00 ± 72.00 minutes and 171.05 ± 72.00 minutes for early rain, mid rain and late rain, respectively. The reverse was in the case of NGT and GWD. This clearly explains the fact that available forage on offer determined the grazing time, non-grazing time and grazing-walk-distance.

The lowest GT was observed in the dry season. The reason why early rain and mid rain had more GT than late rain and dry season was because of the availability of rain. It is believable that during this period of insufficient rain, the forage productivity is low, as such the animal spent more time locating the desired forage material, hence, more GWD and NGT.

Table 10: Least Square mean for grazing time (GT), Non-Grazing Time (NGT) and Grazing Walking Distance (GWD) of Muturu Cattle on free range grazing.

Variable	
Annual Cumulative rainfall range	1000-2000mm
Annual Temperature range	28˚ – 34˚c
Annual Humidity range	78 -53%
Total grazing period per day minutes	360
Cattle body weight range	45-120kg
Forage intake range/day DM	1.08-2.00kg

Table 11: grazing time (GT), Non-Grazing Time (NGT) and Grazing Walking Distance (GWD) of Muturu Cattle on free range grazing

Overall LSM Year	GT (Mins)	NGT (mins)	GWD (km)
	173.40±72.00	185.60±72.00	5.56±1.25
2014	129.00±72.00^{a}	231.00±90.00^{b}	3.50±1.00^{b}
2015	123.005±48.00^{a}	237.00±66.60^{b}	3.87±1.30^{b}
2016	132.00±90.00^{a}	228.00±1500^{ab}	4.28±2.10^{b}
2017	99.00±51.00^{ab}	261.00±50.00^{ab}	5.18±1.50^{ab}
2018	84.00±48.00^{b}	276.00±15.00^{ab}	5.50±1.20^{ab}
2019	90.00±33.00^{b}	270.00±34.00^{ab}	6.10±1.20^{a}
2020	72.00±48.60^{b}	280.00±60.00^{ab}	6.20±1.85^{a}
2021	166.00±16.50^{b}	194.00±66.00^{b}	4.92±1.80^{a}
2022	81.00±15.00^{b}	279.00±51.00^{b}	6.95±1.75^{a}
2023	93.00±39.00^{b}	267.00±72.00^{b}	6.00±1.00^{a}
Early rain	171.005±72.00^{a}	189.00±69.00^{ab}	3.80±1.15^{b}
Mid rain	174.00±72.00^{a}	186.00±72.00^{b}	3.50±1.20^{b}
Late rain	91.20±69.00^{b}	268.80±72.00^{b}	5.00±2.00^{ab}
Dry season	42.00±31.20^{c}	318.00±72.00	7.50±1.45^{c}
Bull (95kg)	150.00±72.00	210.00±66.00^{b}	4.00±2.00^{b}
Dry cow (90kg)	140.00±72.00	220.00±72.00^{ab}	4.10±1.2^{b}
Pregnant cow (110kg)	180.00±66.00	180.00±72.00^{c}	3.80±1.55^{a}
Calf (48 kg)	108.00±50.00	252.00±66.60^{a}	5.50±1.50^{ab}

Note: a, b, c, means in the same row with different superscript numbers are significantly different ($p < 0.05$). KEY:GT, NGT = grazing and non-grazing time, GWD=Grazing walking distance.

Table 10 shows the grazing capacity, growth index and cow index of Muturu cattle on free range grazing of Southeast Nigeria. There were significant differences ($P<0.05$) in the parameters used in estimating the performance of Muturu Cattle under free range grazing.

The three parameters show a similar trend in terms of seasonal changes. The lowest values were from the dry season, followed by the late rain, and mid rain in that order. The year from 2014 to 2023 also shows variability according to the weather changes. These explain the importance of climate adaptation strategies in improving Muturu cattle production in the region

Table 10: Least Squares means for Grazing capacity (GC), growth index (GI), and cow index (CI) of Muturu cattle on free range grazing

Variables	N	GC (Herd/Ha)	GI	CI	CV
Overall LSM	200	8.00	45.00^{a}	3.10^{a}	0.10
Early rain	50	8.00^{a}	40.50^{a}	20.50^{b}	0.10
Mid rain	50	5.00^{b}	35.00^{ab}	15.00^{c}	0.10
Late rain	50	2.00^{b}	20.00^{b}	10.00^{d}	0.10
Dry season	50	1.00^{c}	15.00	04.00^{e}	0.10
2014	50	6.00^{a}	40.00^{a}	22.00^{b}	0.21
2015	50	6.00^{a}	41.00^{a}	20.00^{b}	0.20
2016	20	7.00^{ab}	42.00^{a}	22.00 ^{b}	0.23
2017	30	5.00^{b}	31.00^{ab}	20.00^{b}	0.20
2018	20	4.00^{b}	26.00^{b}	20.00^{b}	0.24
2019	20	5.00^{b}	28.00^{ab}	22.00^{b}	0.20
2020	30	3.00^{ab}	25.00^{b}	20.00^{b}	0.25
2021	40	2.00^{b}	20.00^{b}	10.00^{b}	0.25
2022	20	2.00^{b}	21.00^{b}	12.00^{d}	0.20
2023	50	2.10^{b}	20.00^{b}	10.00^{d}	0.21

Note: a, b, c, d, e, mean in the same row with different superscription are significantly different ($p < 0.05$).
GC = Grazing capacity
GI = Growth Index
CI = Cow Index

Conclusion

Seasonal variation significantly affects forage productivity and the grazing pattern of Muturu cattle in the derived savanna rangeland of Southeastern region of Nigeria. Sedentary pastoral farming is difficult to sustain due to declining grazing and nutritionally poor available forages. Improved pasture production could be achieved through proper management practices such as forage establishment, irrigation and drainage. Muturu cattle on free-grazing systems in Southeasten Nigeria are challenged by climatic variability and human activities.

Climate change imposes both nutritional and physical limitations on forage species, with unproductive impact on Muturu cattle in Southeast Nigeria. Efforts on climate change mitigation are important for pastoral farming in the region.

Hence, there is a need to review the system of Muturu cattle production systems practice t in the region.. For consideration, intensive production system such as ranching and improved grazing management is suggested as a viable options. Pastoralists should adopt improved and sustainable production practices under persistent change in climate.

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Date received: 2nd February, 2026

Date accepted: 8th May, 2026