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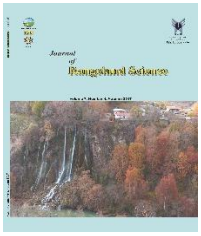

Research and Full Length Article:

Estimation of Browse Productivity for *Acacia seyal* (Delile) in Alazzazah Area, Blue Nile State, Sudan

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Received on: 09/10/2016
Accepted on: 05/01/2017

Abstract. Fodder trees and shrubs are crucial sources of animal feed in Sudan, particularly in arid and semi-arid areas. This is because they can fill up the feed gaps in the summer period when grassland growth is limited due to unfavorable weather conditions. The study was conducted in Elnour forest-southeastern Sudan in 2015, which is dominated by *Acacia seyal*. The objectives of this study were to estimate the browse productivity, and to establish relationships with the crown area for *Acacia seyal*. The twig-count method described in this study converts a count of twigs to weight of browse by use of an average weight per twig for individual trees. Regression analysis was used to establish relationships between browse biomass and crown area. The average available browse (8.1 kg/ha) and tree density (162 tree/ha) for *Acacia seyal* was low in the study area that makes the density as the main factor that determine the amount of available browse/ha. Strong positive correlations were found between browse biomass productivity (available and total browse) and crown area with average values of 0.86 and 0.90, respectively. The study concluded that crown area as the main parameters used for predicting the browse biomass productivity. It is recommended that more effort be made to expand the use of more species to investigate the relationships between browse biomass productivity and growth parameters.

Key words: Browse production, *Acacia seyal*, Tree density, Blue Nile State, Sudan

Introduction

Browse is a term referring to the tender shoots, twigs, and leaves of shrubs and trees that are eaten by livestock (Chriyaa, 2009). Several studies have shown that browse trees and shrubs play a significant role, mostly as supplements, in the nutrition of livestock in the arid and semi-arid lands of the world (Le Houérou, 1980). Over the years climate change and variability has impacted negatively on the ability of the local ecosystems to faithfully meet the ever increasing demand for feed resources for their animals. Therefore, the most important role of browse has been to provide valuable fodder when grasses and other herbaceous material is dry and it provides the only source of protein and energy during drought (Lefroy *et al.*, 1992). Browse species also provide fuel and shelter and are used in soil and water conservation. *Acacia seyal* tree is one of the most potential fodder sources for livestock in Sudan. The pods and leaves of *Acacia seyal* are nutritious and palatable to livestock (Orwa *et al.*, 2009). According to results of the study of Abdalla *et al.* (2014) it was concluded that the fruits of *Acacia seyal* offer high nutritional values especially protein and minerals for livestock and they have a sufficient fodder for overstock.

Browse production is influenced by many factors such as the climate, soil type, management and history of exploitation by man and animals. Chibinga *et al.* (2012) concluded that the important feeding adaptive strategies used by the agro-pastoralists are included; browse utilization, dambo grazing, grazing along streams and supplementary feeding during drought. While, during floods, upland grazing and browse grazing are important. Data on browse fodder available and accessible to the ruminants are rare. One of the main reasons is the lack of standardized methodologies to evaluate the production of woody forage and their consumption compared to what can be done in corresponding research on herbaceous pasture (Sanon *et al.*, 2005). Despite the wide use of the indigenous browse species, little has been documented with regard to the Knowledge of browse in term of availability, utilization and other related information under Sudan condition. Thus, the objectives of this study were to estimate the browse biomass productivity (available and total browse), and their relationships with the crown area for *Acacia seyal*.

Materials and Methods

Study area

This study was carried out in Elnour forest, east of Eldamazeen in the Blue Nile State, Sudan (Fig. 1). It was located in the southeastern part of Sudan between (11˚50˙ North and 34˚ 29˙ East) during 2015 and a linear 12-30 width and 9-30 in the north. The total area of Elnour forest it 11100 ha. The legal situation of the forest it has map of the certificate and its record. The climate is ranging from low rainfall savanna in the Northern part to rich savanna in the southern part of the state. The annual precipitation ranges between 600 and 800 mm. Mean daily temperature ranges from 43ºC in mid-summer (April-May) to 20ºC in mid-winter (December-January) (Kramala and Elneim, 2003).

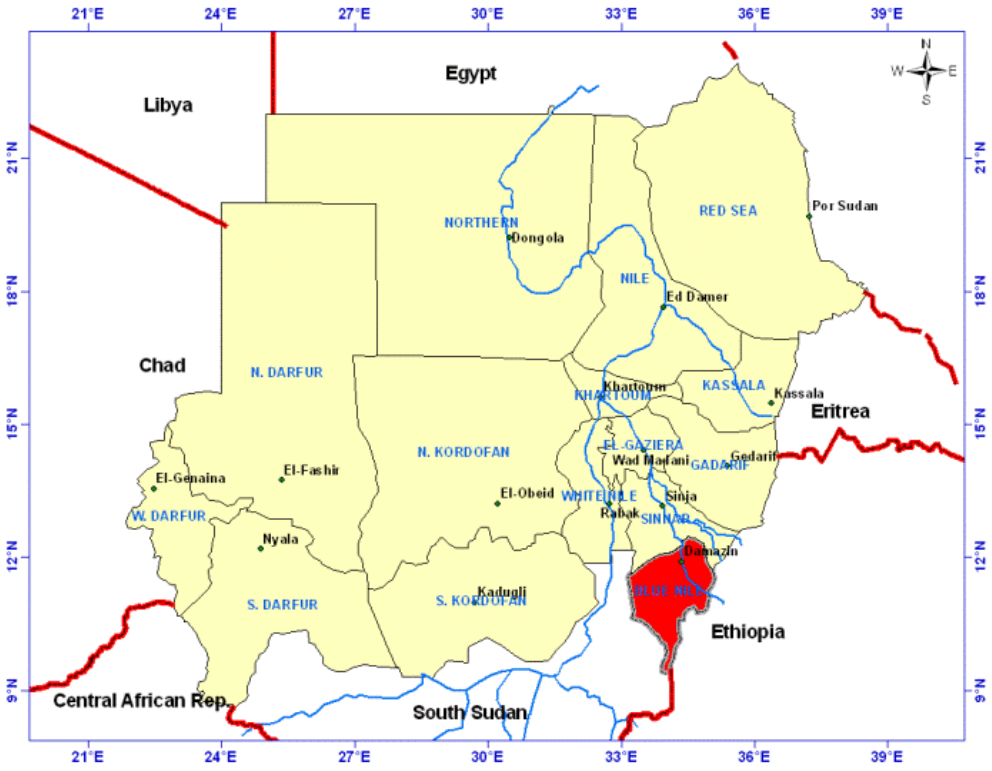

Fig. 1. Map of Sudan, the Location of the study area is highlighted with red color

Sampling method

In this study, one plot of two ha (100 × 200m), which was dominated by *Acacia seyal* was selected based on the Releve method of sampling (Michael *et al.*, 1987). In the plot, eight line transects of 100-m long was laid randomly. Two *Acacia seyal* trees were selected, one to the right and the other to the left of the line along the transect at 20 m intervals to measure diameter of twig at browsing point (d.b.p) (diameter of the twig at the terminal point of browsing) and browsing level (the height from the ground up to the highest point at the tree crown that animal can reach). Density for *Acacia seyal* were obtained by using the point-centered quarter method suggested by Cottam and Curtis (1965). Eight transects of 100 m were used in the plot. The data were collected from a systematic point with 20 m intervals along the 100 m each transect. The distance between the point and nearest plant into four 90° quadrants was measured. The mean distance, mean area per plant, and density were calculated as follow (Cottam and Curtis, 1965) (Equations 1 & 2):

$$\overline{D} = \frac{\sum D}{n} \qquad \text{(Equation 1)}$$

$$d = \frac{10^4}{(\overline{D})^2} \qquad \text{(Equation 2)}$$

Where:

$\overline{D}$ = The mean distance (m)

D= Distances (m)

n= number of samples

d= Total density (trees/ha)

A total of 20 trees were taken randomly into plot and the diameter of the crown was measured by projecting the edges of the crown to the ground and measuring the length along one axis from edge to edge through crown center; then two perpendicular directions were averaged (Lazim and Dawelbait, 2014). Crown area of the tree was calculated as circle. Seven trees were selected according to crown areas which were arranged in classes to estimate browse biomass productivity. Twigs count method was applied for estimating available browse and total browse (Hassan *et al.*, 2015).

The estimations of available and unavailable browse were as follows:

Available browse*:* twigs between the ground level up to camel browsing level (2.5m) with diameter equal or less than diameter at browsing point (1.8 mm) were counted for each selected tree to estimate available browse.

Unavailable browse[3]: all twigs above camel browsing level (2.5m) with diameter equal or less than diameter at browsing point (1.8mm) for each selected tree were counted to estimate unavailable browse.

100 twigs were clipped and collected randomly from selected trees according to diameter proximately equal (1.8mm) and then the selected twigs were oven dried for 48 hour at 70°C. The average dry weight of the twig was obtained.

Available browse/tree were calculated by multiplying the average twig weight by the total number of the available twigs/tree and then the average available browse/tree was calculated. The available browse/ha was calculated by multiplying the density of *Acacia seyal* /ha by average available browse/tree.

The unavailable browse/ha was calculated using the same method as mention before. Total browse was calculated by summing up its available browse with its unavailable browse.

Statistical analysis

Regression analysis was applied to establish relationships between browse biomass productivity (available and total browse) and crown area using Excel software.

Results and Discussion

Tree density

Reslts in Table 1 show that the density of trees found to be 162 tree/ha with availble browse 8.1 kg/ha. The resluts indicated that tree density almost low in the area. This could be attributed to increase population growth as a result of migration and displacement from war zones, this leads to incease the pressure on trees and shrubs in the area caused over exploitation by human and their animals. This may explain the low available browse as result of low tree density in the area. This reslut agree with those of (Hassan *et al.,* 2015) stated that there was a positive relationship between browse availability and tree density.

Estimation of browse biomass productivity

The results in Table 1 reveals that available browse (0.05 kg/tree) and unavailable browse (0.07kg/tree) in *Acacia seyal* nearly the same in the area. This result may attributed to selected trees have almost the same height and majority of them are directly accessible to camel browsing level. According to Abdalla *et al*. (2015) height of the trees is very important when determining accessibility. The lower browse biomass yield of *Acacia seyal* in the area might be due to cutting of trees by human and excessive browsing by animals.

[3] Twigs are not accessible by browse animals and will be counted above their browsing level

Table 1. Browse biomass productivity for *Acacia seyal* in Blue Nile State

Density (tree/ha)	Available browse (kg/tree)	Available browse (kg/ha)	Unavailable browse (kg/tree)	Unavailable browse (kg/ha)	Total browse (tone/ha)
162	0.05	8.1	0.07	11.3	0.02

Relationships between browse productivity and crown area

The Result of relationships between browse productivity and crown area is presented in Table 2. The results indicated that there were strong positive correlations between browse productivity (available and total browse) and crown area Fig. 2. Correlation between available browse and crown area (R^2=0.86) was less than that of total browse (R^2 =0.90). This result could be attributed to fact that available browse depend mainly on browsing level and sometimes it may not be affected by the change in the tree crown area. Similar findings were found by Lazim and Dawelbait (2014) who reported that there was strong positive correlations between browse biomass yield (total and available browse) and crown area. Similar results with also reported by (Gaiballa *et al.*, 2003) they stated that there was strong positive correlation between available browse and various tree growth parameters (height, crown area and diameter at the base of stem) in both *Acacia tortilis* and *Acacia mellifera*.

Table 2. Relationships between browse biomass yield (available and total browse) (y) and crown area (x) for *Acacia seyal* in Blue Nile State in 2015

Dependent variable (Y)	Independent variable (x)	Equation	R^2
Available browse (kg)	Crown area (m²)	y = 0.0008x +0.0174	0.86
Total browse (kg)	Crown area (m²)	y = 0.0025x + 0.0149	0.90

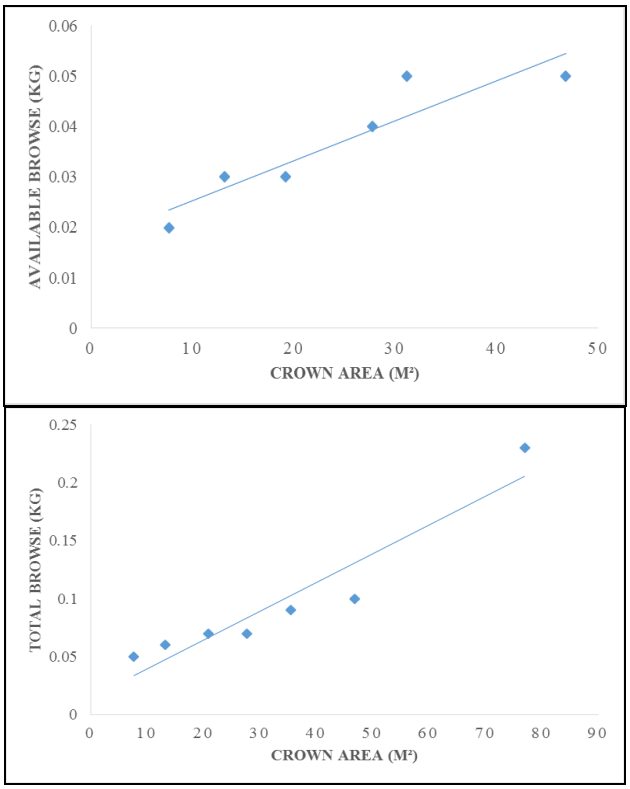

Fig. 2. Relationship between browse productivity (available and total browse) and crown area for *Acacia seyal* in the late rainy season

Conclusion

The important result from this study is the relationships between browse availability and tree density. Strong positive correlations between browse biomass productivity (available and total browse) and crown area were found. The study also found that correlation between available browse and crown area was less than that of total browse. The results of this study indicated that crown area on of the main parameters used for predicting the total browse biomass. It is recommended that more effort be made to expand the use of more species to investigate the relationships between browse biomass productivity and growth parameters.

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برآورد بهره‌وری علوفه اقاقیا (*Acacia seyal*) در منطقه آلزازا از ایالت نیل آبی کشور سودان

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تاریخ دریافت: ۱۳۹۵/۰۷/۱۷
تاریخ پذیرش: ۱۳۹۵/۱۰/۱۶

چکیده. علوفه درختان و درختچه‌ها منابع حیاتی خوراک دام در سودان، به ویژه در مناطق خشک و نیمه خشک می‌باشند. به این دلیل که آنها می‌توانند در تابستان کمبود خوراک دام را که ناشی از محدودیت رشد گیاهان مرتعی به علت شرایط آب و هوایی نامساعد است را جبران کنند. این مطالعه در جنگل‌های النور در جنوب شرقی سودان در سال ۱۳۹۴، با ارزیابی گونه اقاقیا، انجام شد. هدف از این مطالعه، برآورد بهره‌وری علوفه مورد چرا، و بررسی تاج پوشش درخت اقاقیا (*Acacia seyal*) با شرایط محیطی بود. در این مطالعه از روش شمارش شاخه و با استفاده از وزن متوسط در هر شاخه درخت و وزن علوفه مورد چرا انجام شد. برای ایجاد روابط بین زیست توده علوفه و سطح تاج پوشش از تجزیه و تحلیل رگرسیونی استفاده شد. متوسط علوفه در دسترس (۸/۱ کیلوگرم در هکتار) و تراکم درخت (۱۶۲ درخت در هکتار) بود. این موضوع نشان می‌دهد، در منطقه مورد مطالعه تراکم عامل اصلی در تعیین میزان علوفه در دسترس در هکتار است و نقش مهمی دارد. همبستگی مثبت و قوی بین بهره‌وری علوفه زیست توده (موجود و علوفه کل) و سطح تاج پوشش با ارزش متوسط ۰/۸۶و ۰/۹۰ درصد بدست آمد. مطالعه نشان داد که سطح تاج پوشش به عنوان پارامتر اصلی برای پیش‌بینی بهره‌وری زیست توده علوفه می‌باشد. در نتیجه استفاده از گونه‌های بیشتر برای بررسی ارتباط بین بهره‌وری زیست توده علوفه و پارامترهای رشد توصیه می‌شود.

کلمات کلیدی: بهره‌وری علوفه، اقاقیا *Acacia seyal*، تراکم درخت، استان نیل‌آبی، سودان