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Effects of Euphorbia nubica Encroachment on Herbaceous Species Composition in Borana Zone, Southern Ethiopia

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Abstract
The study was conducted in three districts of Borana Zone towards the end of the growing season, with the objective of examining the effects of encroaching Euphorbia nubica species on their encroached and non-encroached areas of herbaceous species composition in Borana rangelands and analysis the perception of pastoralist on encroaching of Euphorbia nubica species. A survey was conducted from two PA of each district by interviewed 34 pastoralists from each PA and a total 204 households were interviewed purposively to analysis pastoralist perceptions. Also, 20 m x 20 m main plots were laid out in encroached and non-encroached areas of Euphorbia nubica species. Then four sub-quadrants with 1 m x 1 m size were randomly placed in this main plot to determine herbaceous composition. The collected data was analyzed using General Linear Model (GLM) procures for significance test at an alpha level of 0.05, and the least significant differences test was used for mean separation for comparison of impacts of encroaching species. As Pastoralists' perception, Euphorbia nubica species are less important and increased in the rangelands by reducing rangeland production and productivity. In this study, the proportion of basal and litter cover was significantly different ($P < 0.05$) between non-encroached and encroached areas of Euphorbia nubica species. Also, grass and forbs of dry matter and diversity were significant ($P < 0.05$) among encroached and non-encroached areas of Euphorbia nubica species. Both pastoral perception and analyzed results indicate that the encroachment of Euphorbia nubica species has an impact on rangeland productivity by reducing productive grass species and increasing less desirable forbs species.
Keywords: Encroached, Non-encroached, Grass, non-grass and dry matter yield
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1. Introduction

Encroaching species can dramatically alter the habitat of native species through changes in the structure and composition of vegetation and the availability of food resources (Dan Bachen, 2011). Therefore, encroaching species are now considered as one of the primary causes of native species degradation in rangelands and is considered as a major cause of the reduction and extinction of many desirable species of the world. Mostly invading species degrade to human health and wealth, alter the structure and functioning of otherwise undisturbed ecosystems, and/or threaten native biological diversity (Vitousek et al., 1997). The interactions between climate change and exotic invasive species may combine to increase invasion risk to native ecosystems (Bradley 2009).

Encroachment has been among the major threats to the livelihoods of Borana pastoralists and their ecosystems (Gemedo et.al, 2006a). In addition to *Vachellia and Senegalia* species (spine species), *Euphorbia nubica* species (non-spine species) is one an encroaching species in Borana rangeland that threatening the productivity of the rangeland. Understanding the ecological requirement and characteristic of different encroaching species is an option for encroaching species management. The encroaching species compete with desirable grass for soil moisture and nutrients, a microclimatic condition that leads to suppress grass productivity (Roques et.al, 2001).

In some parts of rangelands, *Euphorbia nubica* species is encroaching shrub species where pastoralists pointed out as a major threat to rangeland production and productivities. These resulted in poor production of feed for livestock. Most studies are focused on thorny types of encroaching species while non-thorny encroaching species are also tufty growing that makes unable to grow desirable plant species that contribute to livestock feed. Therefore, for proper management, the overall effects of each encroaching *(Euphorbia)* species should be studies spatially in the rangeland of Borana. Therefore, the purpose of this study is to assess the impact of encroaching *Euphorbia nubica* species on rangeland herbaceous species composition and to suggest options for their management.

Objectives

- To examine the effect of encroaching *Euphorbia nubica* species on herbaceous species composition of the rangelands in selected districts of Borana zone.
- To analysis the perception of pastoralist on encroaching of *Euphorbia nubica* species

2. Materials and Methods

2.1. Description of the study area

The study was conducted in Dire districts of Borana zone, which is a semi-arid environment in the habitats of *Euphorbia nubica* species highly encroaching. Dire is located at a distance of 663 km from Addis Ababa in the southern part of Ethiopia. There is spatial and temporal variability in both the quantity and distribution of rainfall with an average annual rainfall varying from 353mm to about 900 mm per annum (McCarthy, *et al*., 2002). The mean annual temperature was reported to vary from 19 to 24 °C (Coppock, 1994). The soil is cracking black clay and volcanic light-colored silt clay soils predominate in the bottom valley, well-drained red sandy soils are predominant on the flat and hilly lands (Pratt and Gwynne, 1977). All discussions and interviews were performed in Afan Oromo language (the mother tongue of study areas).

2.2. Site selection and household survey

In encroaching areas of Dire district, two pastoral associations namely Har-hallo and Madhacho PA were selected to study the effects of *Euphorbia nubica* species on herbaceous composition of encroached areas. During site selection, pastoral communities took the lead and identified encroacher areas by encroaching *Euphorbia nubica* species. Further, from each peasant association (PA) 34 key pastoralists were selected and interviewed purposively based on their knowledge and experience on rangeland management and total from 68 pastoral households were interviewed on this encroaching species trends, importance and impacts on rangeland productivities.

2.3. Sampling and data collected

A systematic stratified sampling method was used to collect vegetation data after stratifying the rangeland areas into encroached and non-encroached by the study species. In order to collect vegetation data, the quadrant was randomly thrown in the habitats of encroaching species to laying out the main plot of 20 m x 20 m size from each habitat of the study species, i.e., from encroached and non-encroached habitats. Then from four corners and a center sub-quadrants of 1 m x 1 m size was placed in encroached and non-encroached habitats of the encroaching species to determines basal cover, litter cover, and herbaceous species diversity and dry matter yield of the rangelands. All these data were collected towards the end of the growing season or May.

2.4. Data analysis

Plant diversity of the rangeland was analyzed using Paleontological Statistical software (PAST, version 3.10) (Hammer et. al, 2001). The general linear model (GLM) was used to compare the effect of encroaching species on rangeland by comparing encroached and non-encroached habitats of basal and litter cover, herbaceous diversity and dry matter yield. All statistical analyses were performed using SAS software (version 9.0; SAS Institute, 2002) and the least significant differences (LSD) test was used for means comparison at alpha level of 0.05.

The model of ANOVA used was $Yfij = \mu + Lj + ej$

Where: Yj = observation (basal cover, litter cover, herbaceous richness, diversity, and dry matter yield), μ = the overall mean, Lj = habitat effect, and ej = error effect

3. Results and Discussion

3.1. Pastoralists' perception of the importance of Euphorbia nubica species

Euphorbia nubica is a stem pale green with prominent leaf scars and encroached in a wide range in the semi-arid area of study sites that had affected rangeland productivity. This species propagates in different systems that enable it to easily spread on rangeland. According to pastoralists' perception about 100% of *Euphorbia nubica* species was less important for pastoralists' livelihood (Table 1). As a pastoralist point of view, *Euphorbia nubica (Annoo)* was adversely affecting rangeland condition and its productivity because this species was reduced the rangeland feed resources through reducing desirable herbaceous species and shrinkage of grazing areas of rangelands. *Euphorbia nubica* species are no services as feed resources even when severe feed and water shortage season while it was tufty occupied areas of grazing rangeland. According to the interviewed community, the main cause of this encroaching species was a ban of rangeland fire. A study by Gemedo (2004) also confirmed that besides overgrazing, the ban of rangeland fire has a significant contribution to the current bush encroachments in the Borana rangelands.

Table 1: Response of pastoralists on importance and trend of *Euphorbia nubica* encroaching species in study sites

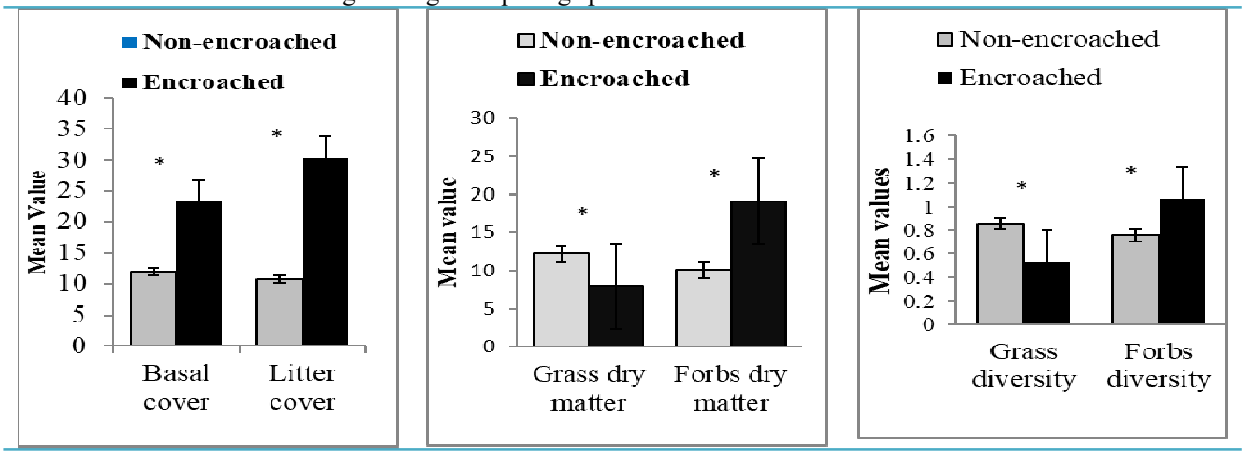
No	Perception of Pastoralist		Total number of respondents (N = 68)	
			N	Percentage(%)
1	On the importance of species	Important	0	0
		Less important	68	100
2	On the trend of species after ten years	Stable	0	0
		Decreasing	0	0
		Increasing	68	100

As respondent community, the trend of this species encroachment was increasing on study sites of rangeland (Table 1). This condition was come out due to lack of appropriate management of rangeland especially lack prescribed burning and overstocking beyond the capacity of rangeland. In addition, *Euphorbia nubica* species has the ability to easily spread themselves on rangeland through different mechanisms of reproduction (stem, seed, and root) by tolerating erratic nature of rainfall, dry and drought season of the environments. Due to this reason, the encroached areas of rangeland grazing were shirked by replacing the productivity of native desirable perennial species.

3.4. Effects of *Euphorbia nubica* species on basal and litter cover, herbaceous species diversity and dry matter yield.

There was a significance difference ($P < 0.05$) in basal and litter cover between encroached of *Euphorbia nubica* (Figure 3). The basal and litter cover was higher in the encroached than the non-encroached sites. Because in encroached areas of *Euphorbia nubica* species the presence of a higher proportion of less desirable and annual forbs species were enhanced basal and litter cover values than non-encroached areas. Also, in encroached areas high dropping leaves and succulent forbs species were increase the values of basal and litter covers due to the thick shade of *Euphorbia nubica* protection from the effect of livestock grazing and trampling.

The result of herbaceous species (forbs and grass) diversity and dry matter were significantly different ($P > 0.05$) between encroached and non-encroached habitats of *Euphorbia nubica* (Figure 3). In encroached areas of *Euphorbia nubica* species, the diversity and dry matter yield of grass species was lower while forbs species was higher than non-encroached areas. Oppositely, in non-encroached areas, the diversity and dry matter yield of grass species were higher while forbs species diversity and dry matter yield were lower than encroached areas. This result indicates that the encroachment of *Euphorbia nubica* species has negative impacts on species composition and productivity of desirable herbaceous species (grass) of the study site of rangeland. The morphological feature of *Euphorbia nubica* species has a thick shading effect, which interferes with light penetration and competes for nutrients with perennial of understory species as compared with non-encroached areas. This result was in agreement with Sharma (2013), who reported that canopy cover had impacts on understory species via interference with amounts of sunlight availability and soil nutrient competition. In most studies, plant species richness and diversity increased outside canopy than under canopy. Similarly, Gilliam (2014) confirmed that the herbaceous layer under tree canopy led to a decrease in species richness and diversity because an increase in soil nitrogen input will lead to the loss of many nitrogen efficient species, which brings about the dominance of few high nitrogen-requiring species.



[1] *Only bars with an asterisk (*) are significantly different at P< 0.05.*

Figure 2: Mean and standard errors of basal and litter cover (%), herbaceous dry matter (t ha^{-1}), richness and diversity in the encroached and non-encroached habitats of *Euphorbia nubica*.

3.2. Effects of *Euphorbia nubica* on rangeland herbaceous species composition

The effect of *Euphorbia nubica* species on rangeland species composition, the relative density, and frequency of herbaceous species of study site are presented in table 2. From a total grass species recorded in the study site the most palatable, productive and perennial species included *Cenchrus ciliaris, Chrysopogon aucheri, Pennisetum mezianum, and Digitaria naghellensis* were found in the non-encroached areas but these species were declined and disappeared in the encroached areas of *Euphorbia nubica* habitats. The less desirable forbs species such as *Solanum somalense, Pupalia lappacea, Volkensinia prostrate, Ocimum urticifolium, Tagetes minuta L., and Endostemon kelleri* were found in the encroached than non-encroached habitats. This indicates that *Euphorbia nubica* species have negative impacts on rangeland's palatable species of study sites. due to its high competition and thick shade formation. This finding is in agreement with Angassa (2008) who reported that the disappearances of productive perennial grasses were due to bush encroachment species on rangeland.

Pupalia lappacea was found to have the highest relative frequency, followed by *Barleria spinisepala* and *Endostemon kelleri* in the encroached areas of *Euphorbia nubica species*; *Chrysopogon aucheri* had the highest relative frequency, followed by *Pennisetum mezianum*

Table 2: The relative frequency and density (RF and RD, respectively) of herbaceous species in the encroached and non-encroached habitats of *Euphorbia nubica* species

Scientific name	Vernacular name	Family name	Growth form	Encroached area		Non-encroached area	
				RF	RD	RF	RD
Cenchrus ciliaris L.	Mata guddeessa	Poaceae	G	0.00	0.00	1.96	0.75
Sporobolus pellucidus	Salaqoo	Poaceae	G	2.63	1.69	7.84	5.26
Barleria spinisepala	Qilxiphee	Fabaceae	NG	10.53	10.17	7.84	6.02
Volkensinia prostrate	Gurbii	Amaranthaceae	NG	7.89	8.47	5.88	3.01
Cyperus species	Saattuu	Poaceae	G	0.00	0.00	7.84	13.53
Digitaria naghellensis	Ilmogorii	Poaceae	G	2.63	1.69	3.92	2.26
Endostemon kelleri	Urgoo	Lamiaceae	NG	10.53	8.47	7.84	3.76
Justicia odora	Agaggaroo harree	Acanthaceae	NG	0.00	0.00	1.96	0.75
Pupalia lappacea (L.)	Hanqarree	Amaranthaceae	NG	13.16	11.86	1.96	0.75
Chlorophytum gallabatense	Miirtuu	Anthericaceae	NG	7.89	10.17	3.92	2.26
Aristida kenyensis	Bilaa	Poaceae	G	2.63	3.39	7.84	9.77
Chrysopogon aucheri	Alaloo	Poaceae	G	5.26	3.39	13.73	14.29
Commelina africana	Qaayyoo	Commelinaceae	NG	5.26	3.39	5.88	3.76
Digitaria velutina		Poaceae	G	7.89	10.17	5.88	6.02
Cynodon dactylon	Sardoo	Poaceae	G	7.89	8.47	5.88	3.76
Tagetes minuta L.	Suunkii	Asteraceae	NG	5.26	8.47	0.00	0.00
Pennisetum mezianum	Ogoondhichoo	Poaceae	G	5.26	5.08	7.84	23.31
Ocimum urticifolium	Hancabbii	Lamiaceae	NG	2.63	1.69	1.96	0.75
Solanum somalense F.	Hiddii gaagee	Solanaceae	NG	2.63	3.39	0.00	0.00

Key:- G= Grass and NG=None-grass

and *Cyperus species* in the non-encroached habitat of *Euphorbia nubica* comparison to other species. *Pupalia lappacea* and *Pennisetum mezianum* species were found to have the highest relative density respectively in encroached and non-encroached areas of *Euphorbia nubica* relative to other species. This indicates that the encroachment of *Euphorbia nubica* species has a negative impact on relative frequency and density of desirable species than less desirable species. However, *Cynodon dactylon* is a desirable grass species that recorded in the encroached than the non-encroached habitat of *Euphorbia nubica* species was due to its protection from grazing but it had poor performance due to effect of *Euphorbia nubica* species encroachment.

4. Conclusion and Recommendation

4.1. Conclusion

In addition to *Vachellia* and *Senegalia* species, non-spine species like *Euphorbia nubica* species have adversely affected rangeland conditions and their productivity. The study was examining the impacts of *Euphorbia nubica* species on rangeland herbaceous species. Based on pastoralists' perceptions most of this species are less important because it does not serve as feed resources especially, in the dry season, even when severe feed and water shortage while tufty occupied on rangeland that encourage shrinkage of grazing areas of rangeland through reducing and disappearing desirable species. The result showed a significant difference ($P < 0.05$) in litter cover between encroached and non-encroached habitats of encroaching *Euphorbia nubica* species but not for dry matter yield.

Generally, the encroachment of *Euphorbia nubica* species on the study site have negative impacts on the rangeland ecosystem because they alter the species composition through the displacement of productive grass species and increasing less desirable perennial and annual forbs species.

4.2. Recommendation

Attentions should be required on prevention and controlling on where encroachment spineless species like *Euphorbia nubica* species in order to reduce their impact on rangeland production.

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