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Nuer Pastoralists' Perception and Ecological Knowledge on Seasonal Dynamics in Botanical Composition and Nutritive Value of Vegetation, and Soil Nutrient Status of Gambella Rangelands, Southwestern Ethiopia

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ABSTRACT

This study was aimed at investigating perception and traditional ecological knowledge (TEK) of Nuer pastoralists regarding seasonal dynamics in the botanical composition and nutritive value of the vegetation, and soil nutrient status of the rangelands in Gambella, southwestern Ethiopia. The study was conducted between April and May 2014 in Itang and Jikawo districts. A structured questionnaire was employed to assess the perception of a total of 120 respondents. The general outcome was that the pastoralists have an in-depth knowledge and experience regarding the changes that the rangeland ecosystem has undergone. They have perceived rainfall variability as the principal factor that causes seasonal dynamism in the rangeland ecosystem. Nuer herders identified a total of 16 herbaceous and 5 woody species as the dominant forage and browse species, respectively, distributed over the seasonal grazing areas. They perceived that there is seasonal dynamics in botanical composition of the herbaceous layer but such dynamism was not a phenomenon for the woody layer. The herders ranked top eight and top four forage species which are highly desirable during the wet season and the dry season respectively. The pastoralists also ranked the top five highly desirable evergreen browse species. They perceived there exists seasonal dynamism in the nutritive value of the valuable herbaceous and browse species composition of the rangeland vegetation. The herders were able to classify the range soil on the basis of its physical characteristics such as color, texture, fertility and drainage levels. They perceived that soil nutrient status was closely associated with the vegetation and its seasonal dynamism in the entire grazing area. Generally, the study revealed that pastoralists have considerable traditional ecological knowledge (TEK) and experience in dealing with ecosystem dynamism indicating that such knowledge and experience is believed to have profound importance for possible integration into scientific principles and practices of sound rangeland management system.

Keywords: herbaceous layer, perceived acceptability; seasonal grazing areas, soil, traditional ecological knowledge, woody layer.

INTRODUCTION

Pastoralists' management practices are ecologically adapted to local environmental conditions (Fernandez-Gimenez, 2000). Transhumance pastoralism is based on more or less regular seasonal and cyclical migration of varying degrees between complementary ecological areas (Sulieman, 2013). Their mobility is a key strategy to gain access to seasonal availabilities of high quality forage and to reduce the vulnerability of livestock to local environmental risks (Kaimba *et al.*, 2011). The pastoral regions of Ethiopia, as elsewhere in Africa, have a fragile environment and unpredictable weather (PFE, IIRR and DF, 2010). Like other pastoral areas of Ethiopia, in Gambella, extensive pastoral production system is experienced, predominantly in areas where the Nuer Pastoral communities inhabit (Tilahun, 2007). The Region is endowed with a huge number of livestock and supports the livelihood of a larger segment of the society (GPNRS, 2011). Grazing land is an important and key resource for the livestock-based livelihood of the Nuer community. Major sources of livestock feed comes from the native vegetation of the open woodlands, riverine forest and woodland during the wet season, and the savanna grassland during the dry season. No other feed is provided to livestock (ACORD, 1998; Tilahun, 2007).

Pastoralists' perception and ecological knowledge of vegetation changes are often ignored in studies aimed to improve management of rangelands (Roba and Oba, 2009). The significance of traditional range management in the arid lands of East Africa is rarely considered in the research conducted by range ecologists in the past. Despite this, the present management of rangelands to a large extent is dependent on pastoralists' indigenous knowledge of such areas (Mapinduzi *et al*., 2003). Nowadays, many range scientists came to realize that pastoralists have extensive ecological knowledge (Berkes *et al*., 2000; Ladio and Lozada, 2009). Traditional ecological knowledge (TEK) is unique to different places and communities (Fernandez-Gimenez, 2000), and even to different individuals within a community (Kgosikoma *et al*., 2012). Examining such variability in the pastoralists' ecological knowledge under different cultural and environmental conditions is expected to provide a broader understanding of ecosystem dynamics (Kgosikoma *et al*., 2012).

Substantial research and development works have been conducted in most of the arid and semi-arid rangelands of Ethiopia. However, in the Gambella Regional State in general and the Nuer pastoral areas in particular, research and development interventions have been insignificant (Tilahun, 2007). Moreover, issues of TEK about seasonality of the various ecological factors, which are important for proper rangeland management are generally ignored. The aim of this study was, therefore, to assess the perception and ecological knowledge of the Nuer pastoralists on seasonal dynamics in the vegetation's botanical composition as well as its nutritive value, and soil nutrient status of the rangelands of Gambella, southwestern Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted in the rangelands of Gambella from the two districts, Itang and Jikawo located between 06°10'70" to 08°21'59" N and 034°66'25" to 093°47'49" E with an altitude range of 391 to 438 m.a.s.l. The annual rain fall of the region ranges between 800-1200 mm with uni- modal distribution (Woube, 1999) and the average annual temperature is 27.5^{0}C (Kassahun and Asfaw, 2008). Oil types in the region: fertile but poorly drained Vertisols (47%), relatively infertile well-drained orthic Acrisols (14%), relatively fertile eutric Fluvisols (27%) occasionally with high water tables and deep well drained dystric Nitosols of moderate fertility (11%). The existing land cover (vegetation) types of the region are identified as cultivated land, forest land, wood land, bush land, shrub land, grass land, bamboo, wet (marsh land) (GPNRS, 2011).

Data Collection

Formal household survey was conducted between April and May 2014 using a structured questionnaire to generate qualitative information on pastoralists' perception and traditional ecological knowledge regarding seasonal dynamics in botanical composition, nutritional quality of the rangeland vegetation and soil fertility. The questionnaire included both closed (single response) and open (multiple responses) questions. A pre-test of the questionnaire was made before the actual survey, and appropriate modifications and corrections have been done as needed. Moreover, group discussions, semi-structured interviews and consultation meetings were conducted with pastoral elders and their council leaders so as to capture data on the existing pastoralists' livelihood. The survey was administered to a total of 120 respondents in the two districts (Sixty respondents per district).

Statistical Analysis

Qualitative data on pastoralists' perceptions and ecological knowledge were converted to numerical values by EXCEL spread sheet and analyzed quantitatively using Statistical Package for the Social Sciences (IBM SPSS Statistics, 2011). Cross-tabulation and Chi-square tests were used to determine differences between pastoralists' responses between districts, gender and age groups. As indicated by Kgosikoma *et al.* (2012) the response rates to some questions, such as dominant species in seasonal grazing areas, species acceptability to livestock and soil quality attributes, were too low to make comparisons between districts. In such cases, the responses were grouped together irrespective of study districts, and the general pattern was reported.

RESULTS

Pastoralists' Perception and Ecological Knowledge on Seasonal Dynamics in Botanical Composition

Nuer herders identified a total of 16 herbaceous dominant forage species distributed over the seasonal grazing areas (Table 1) and were also able to rank their abundance in the vegetation across seasons. A significant proportion of pastoralists 88.3%, 52.8%, 72.4% and 82.5% respectively identified *Echinochloa pyramidalis*, *Setaria incrassata, Setaria verticillata* and *Sporobolus pyramidalis* as a dominant grass species during the wet seasons in savanna grasslands, woodlands, open woodlands and riverine forests. About 56% of the pastoralists mentioned *Setaria incrassata*, 76% each of *Panicum maximum* and *Tetrapogon villosa* and 72% *Cynodon dactylon* as dominant grass species during the dry seasons in woodlands, open woodlands, riverine forests and savanna grasslands respectively (Table 1).

Fifty five percent and 90.0% of the pastoralists in Itang and Jikawo districts, respectively, perceived that there is seasonal dynamics in botanical composition of the herbaceous layer in their locality. In terms of gender and age groups, males (92.6%) and of females (91.7%), age groups 35-45 (50%), 46-55 (69.2%), 56-60 (96.2%) and all above age group 60 of the respondents perceived the presence of seasonal dynamics in herbaceous layer of their locality. Their perceptions did not show a marked variation between districts (x^2 = 1.08, $P > 0.01$) and gender ($x^2 = 0.01$, $P > 0.01$). However there is a significant perception variation among the age groups (x^2= 30.74, $P <0.001$).

Pastoralists identified 5 woody browse plant species as dominant all the year round within all the grazing areas except the savanna grasslands. *Acacia hockii, Acacia seyal* and *Balanites aegyptiaca* were perceived by Nuer pastoralists as dominant species in their locality (Table 2). *Acacia hockii* (85.8%) followed by *Balanites aegyptiaca* (73.3%) and *Acacia seyal* (70%) were perceived to be dominant by pastoralists at woodlands, while *Acacia seyal* was considered to be the dominant species in the open woodlands by 82.5% of pastoralists. *Acacia hockii* was also largely perceived by 82.5% pastoralists to be dominant in riverine forests (Table 2). In Itang (85%) and Jikawo (90%), male (88.9%) and females (75%) and 35-

45 (66.7%), 46-55 (76.9%), 56-60 (86.5%) and >60 age groups of the respondents perceived that there is no seasonal dynamics in botanical composition of the woody layer. Their perception showed no significant difference between districts ($²$ = 0.69, P > 0.01) gender ($²$ = 1.91, P > 0.01) and age groups ($²$ = 9.46, P > 0.01).

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Nuer herders perceived that seasonal dynamics in botanical composition of the key grass species are common under their seasonal grazing areas (Figure 1).
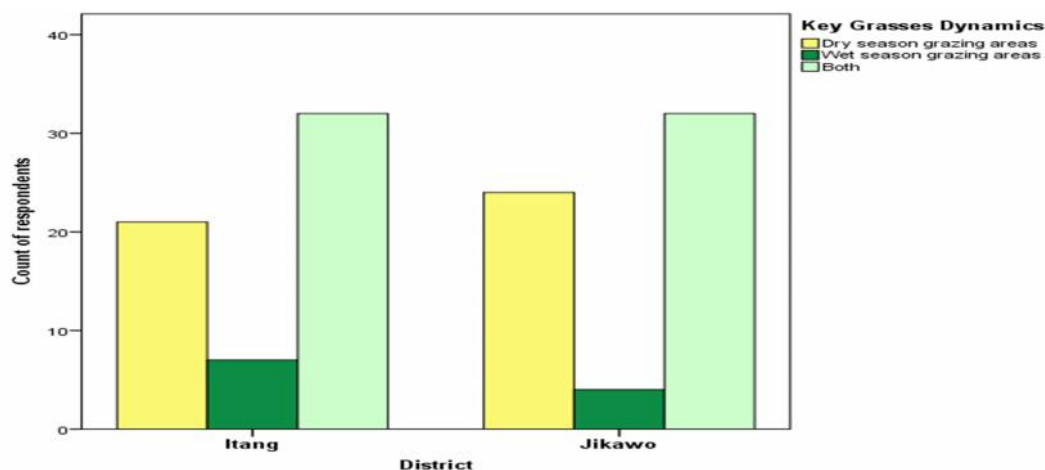

Figure 1: Perception of Nuer pastoralists regarding seasonal dynamics in botanical composition of key grass species over seasonal grazing areas

Pastoralists' Perception and Ecological Knowledge on Seasonal Dynamics in Nutritive Value of Forage Species

Nuer herders were identifying a total of 11 and 5 herbaceous species which are known for their nutritive value during the wet and dry seasons respectively. They perceived that the seasonal dynamics in nutritional value of the herbaceous layer was directly associated with availability and contribution of nutritious species in the botanical composition. The herders were also able to rank these species according to nutritional value across seasons. They perceived that the nutritional value of a particular forage species was attributable to its desirability. Accordingly, the herders classify forage species on the basis of index of their livestock species preferences. They have given four desirability indexes: highly desirable, moderately desirable, less desirable and undesirable that were ranked first through fourth respectively. However, during the questionnaire survey, the respondents listed and ranked herbaceous species of the first two categories (i.e., those of the highly desirable and moderately desirable ones). They also further ranked each key species under their perceived acceptability (i.e., Ranks 1 to 8 for highly desirable species and Rank 9-11 for moderately desirable ones) (Table 3).

Table 1: Ranking of seasonal dynamics in botanical composition of herbaceous layer over grazing areas by Nuer pastoralists (N=120)

Grazing area	Scientific name	Vernacular name	Wet season		Dry season	
			Rank	% respondents	Rank	% respondents
Woodlands						
	Setaria incrassata	*Hol*	1	52.8	1	55.8
	Panicum maximum	*Gaw*	2	54.2	2	55.8
	Eragrostis multiplosa	*Lum*	3	46.7	-	-
	Rottboellia cochinchinensis	*Pon*	4	53.3	-	-
	Senna obtusifolia	*Reir*	5	80.0	-	-
Open woodlands						
	Setaria verticillata	*Dreck*	1	74.2	-	-
	Panicum maximum	*Gaw*	2	62.5	1	77.5
	Digitaria ternata	*Gam*	3	70.8	2	79.2
	Echinochloa procera	*Nyiew*	4	60.8	-	-
	Paspalum scrobiculatum	*Gok*	5	69.2	-	-
Riverine Forests						
	Sporobolus pyramidalis	*Thoat*	1	82.5	-	-
	Tetrapogon villosa	*Thir*	2	81.7	1	77.5
	Chloris gayana	*Bok*	3	82.5	3	55.8
	Cynodon dactylon	*Moth*	4	81.7	2	66.7
	Oryza longistaminata	*Pon*	5	78.3	4	59.2
Savanna Grasslands						
	Echinochloa pyramidalis	*Bor*	1	88.3	-	-
	Oryza longistaminata	*Pon*	2	68.3	2	71.7
	Ipomoea aquatica	*Theach*	3	58.3	-	-
	Chloris gayana	*Bok*	4	61.7	-	-
	Cynodon dactylon	*Moth*	5	70.0	1	71.7

Table 2: Ranking of seasonal dynamics in botanical composition of woody layer over grazing areas by Nuer pastoralists (N=120)

Grazing areas	Scientific name	Vernacular name	Wet season		Dry season	
			Rank	% respondents	Rank	% respondents
Woodlands						
	Acacia hockii	*Lor*	1	85.8	1	74.2
	Balanites aegyptiaca	*Thow*	2	73.3	2	63.3
	Acacia seyal	*Theap*	3	70.0	3	60.0
	Acacia senegal	*Chidock*	4	78.3	4	75.0
	Cadaba farinosa	*Neth*	5	80.0	5	77.5
Open woodlands						
	Acacia seyal	*Theap*	1	82.5	1	81.7
	Acacia hockii	*Lor*	2	72.5	2	69.2
	Balanites aegyptiaca	*Thow*	3	76.7	3	75.0
Riverine Forests						
	Acacia hockii	*Lor*	1	82.5	1	78.3
	Acacia seyal	*Theap*	2	75.0	2	70.0
	Balanites aegyptiaca	*Thow*	3	66.7	3	60.8
	Cadaba farinosa	*Neth*	4	64.2	4	60.0
	Acacia senegal	*Chidock*	5	80.0	5	76.7

Nuer pastoralists ranked *Brachiaria semiundulata, Echinochloa pyramidalis, Panicum maximum, Chloris gayana , Digitaria ternatea, Echinochloa procera, Oryza longistaminata* and *Paspalum scrobiculatum* as the top eight highly desirable, while *Cynodon dactylon, Ipomoea aquatica* and *Senna obtusifolia* were largely perceived as only moderately desirable species by livestock during the wet seasons. Among nutritious grasses, *Panicum maximum* followed by *Chloris gayana, Digitaria ternatea* and *Oryza longistaminata* were mainly perceived as the top four highly desirable species during the dry seasons. *Cynodon dactylon* is the only moderately desirable grass species during the dry period as perceived by the pastoralists (Table 3).

About 95.0% and 98.3% of the respondents in Itang and Jikawo, respectively, perceived the existence of seasonal dynamics in nutritive value of the herbaceous layer. On the basis of gender, 98.1% of males and 85.7% of female respondents, respectively, shared the perception. Respondents of age groups 35-45 (83.3%), 46-55 (88.2%), 56-60 (98.0%) and all of >60 age groups perceived the existence of seasonal dynamism in nutritive value of the herbaceous layer. Their perception showed no significant difference between districts (x^2 = 1.03, $P > 0.01$), between gender (x^2 = 5.9, $P > 0.01$) and among the age groups (x^2 = 8.97, $P>$ 0.01).

Table 3: Rank of seasonal dynamics in nutritious herbaceous species by Nuer pastoralists (N=120)

Scientific name	Vernacular name	Perceived acceptability	Wet season		Dry season	
			Rank	% respondents	Rank	% respondents
Brachiaria semiundulata	*Dit*	HD	1	80.0	-	-
Echinochloa pyramidalis	*Bor*	HD	2	65.0	-	-
Panicum maximum	*Gaw*	HD	3	73.3	1	76.7
Chloris gayana	*Bok*	HD	4	49.2	2	62.5
Digitaria ternatea	*Gam*	HD	5	59.2	3	60.0
Echinochloa procera	*Nyiew*	HD	6	53.3	-	-
Oryza longistaminata	*Pon*	HD	7	71.7	4	53.3
Paspalum scrobiculatum	*Gok*	HD	8	52.5	-	-
Cynodon dactylon	*Moth*	MD	9	52.5	5	77.5
Ipomoea aquatica	*Theach*	MD	10	51.7		
Senna obtusifolia	*Reir*	MD	11	70.8	-	-

HD=Highly desirable; MD=Moderately desirable

Nuer herders identified a total of 6 and 3 browse species which are known for their nutritive value throughout the year and during dry seasons respectively. The pastoralists also perceived that the dominant evergreen (Table 2) and the top five highly desirable browse species available in their locality were *Acacia seyal, Acacia senegal, Cadaba farinosa, Balanites aegyptiaca* and *Tamarindus indica* (Table 4). About 78.3% and 86.7% of the respondents in Itang ang and Jikawo, respectively, perceived the existence of seasonal dynamics in nutritive value of the woody layer. About 91.7% and 93.3% of the respondents in Itang and Jikawo perceived the existence of seasonal dynamics in nutritive value of the woody layer. On the basis of gender, 93.4% of males and 85.7% of female respondents shared the perception. Respondents of age groups 35-45 (66.7%), 46-55 (82.4%), 56-60 (93.9%) and >60 (97.9%) perceived the existence of seasonal dynamism in nutritive value of the woody layer. Their perception showed no significant difference between districts (x^2 = 0.12, $P > 0.01$), between gender (x^2 = 1.05, $P > 0.01$) and among the age groups (x^2 = 10.46, $P>$ 0.01).

The Nuer pastoralists are knowledgeable about the relationship between nutritious pasture species and animal factors such as gut-fill, animal activities, high milk yield, short calving intervals, libido in bulls, heat in heifers and cows, smooth and shiny coat, good body condition, rapid animal weight gain, resistance to diseases and parasites and reduced calve mortality. They also employed vegetation indicators for grazing quality assessment such as height, greenness and tillering ability of the herbaceous layer and degree of sprouting and production of new leaves and pods for the browse species.

Table 4: Rank of seasonal dynamics in nutritious browse species by Nuer pastoralists (N=120)

Scientific name	Vernacular name	Perceived acceptability	Wet season		Dry season	
			Rank	% respondents	Rank	% respondents
Acacia seyal	*Theap*	HD	1	81.7	1	85.0
Acacia senegal	*Chidock*	HD	2	63.3	2	69.2
Cadaba farinosa	*Neth*	HD	3	45.8	3	54.2
Balanites aegyptiaca	*Thow*	HD	4	55.8	4	46.7
Tamarindus indica	*Koat*	HD	5	71.7	5	63.3
Ziziphus mauritiania	*Bow*	HD	6	66.7	-	-
Piliostigma thonningii	*Goany*	MD	7	49.2	-	-
Catunaregam nilotica	*Koeck*	MD	8	60.8	-	-
Acacia hockii	*Lor*	MD	9	74.2	6	66.7

HD=Highly desirable; MD=Moderately desirable

Perception of Nuer pastoralists regarding nutritional dynamics in the key forage species at different seasons of a year is presented in Figure 2.
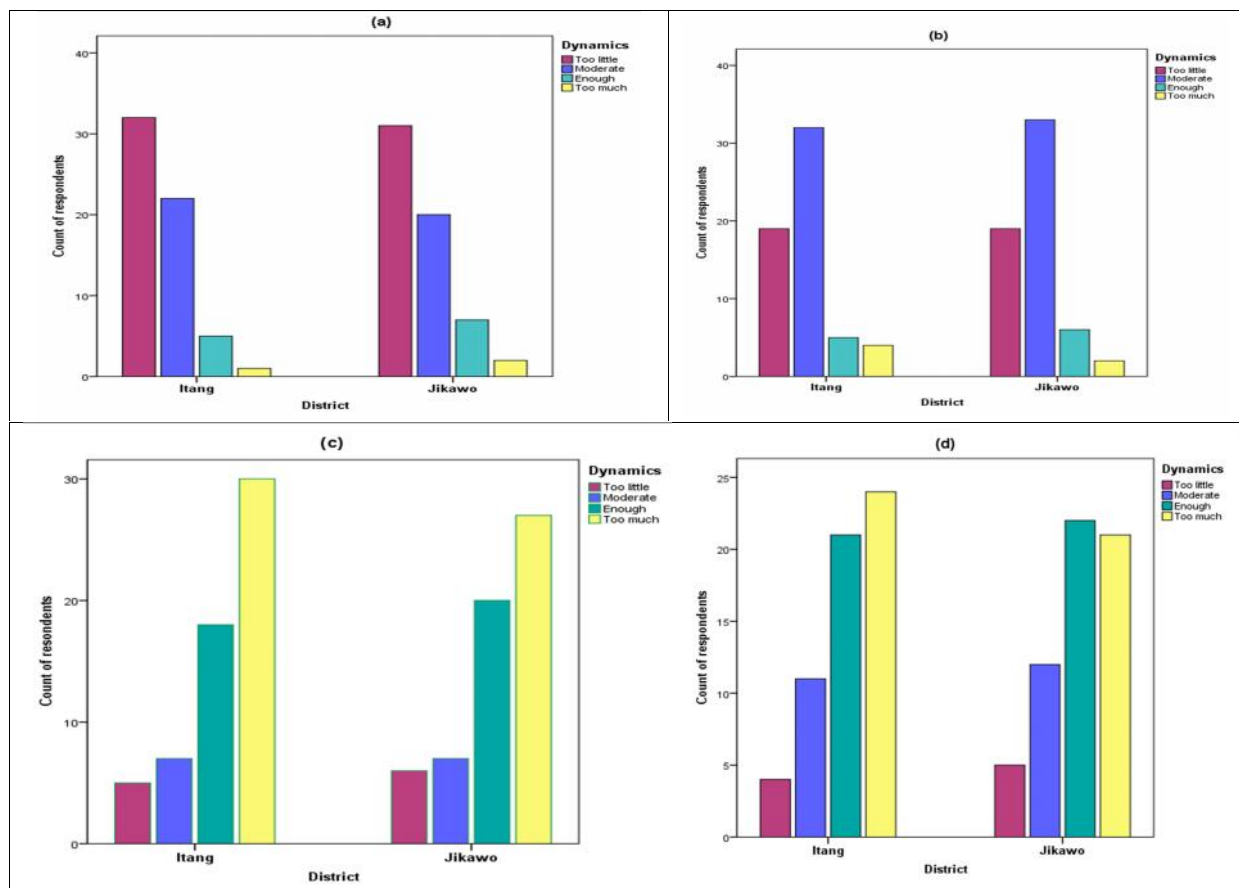

Figure 2: Perception of Nuer pastoralists regarding seasonal dynamics in nutritive value of key herbaceous species during wet season (a) and dry seasons (b) and of key browse species during wet season (c) and dry season (d).

Pastoralists' Perception and Ecological Knowledge on Seasonal Dynamics in Soil Nutrient Status

Soil classification and characterization in terms of grazing areas and vegetation attributes as perceived by Nuer pastoralists is presented in Table 5. The Nuer pastoralists use local indicators of soil quality such as soil color '*mun bil*', soil texture '*mun sur*', fertility '*mun liet*', muddiness '*mun juack*' and flooding (poorly drained soil) '*mun ngech*'. On the basis of

soil colour they classify the soil into two types: red soil '*mun mulwal/mun pin'* and black soil '*mun michar/mun dock'*. Based on texture they also classify the soil into four types: stony '*pum',* sandy '*leth',* loam '*lum'* and clay '*doc'.*

Nuer pastoralists associate the nutrient status of soil with their major seasons in the grazing areas. During wet season red soil is perceived as fertile soil '*mun liet'* attributed by best quality pasture but infested with tsetse. On the other hand, the black soil, which is muddy and flooded during the wet season still perceived as fertile enough to support good quality forage especially after the receding of the flood. Black soil is generally perceived as fertile soil; it is the feature of dry season grazing areas which are open grassland savannas '*tor'*, tsetse free and associated with herbaceous layer '*juach'*. Whereas red soil is the characteristics of the wet season grazing areas (open woodlands '*kur'*, woodlands '*rup'* and riverine forests '*lol'*) or woody layer '*jiath'*.

This would indicate that pastoralists do perceive the dynamics of soil nutrients and its association with the forage quality and quantity of the grazing areas across seasons. In Itang (83.3%) and Jikawo (80.3%) of the respondents perceived that there is seasonal dynamics in soil nutritional status. On the basis of gender this perception is of males (85.7%) and females (81.3%). Age groups 35-45 (50.0%), 46-55 (64.7%), 56-60 (84.0%) and >60 (89.6%) share the perception. No significant perceptional difference was shown between districts ($x^2 = 0.18$, $P > 0.01$), gender ($x^2 = 0.16$, $P > 0.01$) and age groups ($x^2 = 9.46$, $P > 0.01$).

DISCUSSIONS

Pastoralists' Perception and Ecological Knowledge on Seasonal Dynamics in Botanical Composition

Pastoralists have local knowledge on a large diversity of plant species that provide food for livestock (Mapinduzi *et al*., 2003). Local knowledge is widely acknowledged to be a valuable source of data on the historical distribution of species which are generally difficult to assess using classical ecological methods (Lykke *et al*., 2004) and especially in the case when other historical and ecological information is not available (Sulieman *et al*., 2012). Pastoral herders monitor changes in their plant species composition over time, based on historical knowledge (Oba and Kaitira, 2006).

Similarly, in the Nuer pastoral community there has been an in-depth ecological knowledge on seasonal dynamics in botanical composition of the rangeland. Knowledge of botanical composition dynamics helps them in monitoring of their range quality and make decisions in their transhumance mobility. This is inconsistence with the study of Kilongozi *et al*. (2005) who noted that Maasai and Barbaigs herders perceive the knowledge of botanical composition of rangeland as of particular importance in rating range suitability for livestock grazing. Like the Borana pastoralists (Ayana and Fekadu, 2003) Nuer herders also perceived that botanical composition was inferred from the body condition of their animals.
Rainfall is attributed to be the dominant factor driving vegetation dynamics (Hermann *et al*., 2005). The rainfall patterns often coincide with the effects of seasonality which in turn have an effect on the productivity of grassland pastures (Ospina *et al*., 2012). In semi-arid rangelands, pastoralists perceived that among the factors to cause the differences between wet and dry season forage quantity are attributable to variation in rainfall over the seasons (Oba and Kaitira, 2006; Kgosikoma *et al*., 2012; Egeru *et al*., 2014).

According to herders, the amount and time of precipitation were the most important determinants of changes in plant species (Sulieman and Ahmed, 2013) in terms of short and long-term productivity (Fernandez-Gimenez, 2000). Similarly, the Nuer pastoralists attributed dynamics in the composition of the herbaceous layer in their ecosystem as mainly due to rainfall variability.

Table 5: Soil classification and characterization over seasonal grazing areas and vegetation attributes as perceived by Nuer pastoralists

Soil classification criteria					Grazing area	Vegetation attributes
Color	Texture	Fertility	Muddiness (Stickiness)	Flooding		
Red	Loam	Fertile	Non-muddy, non-sticky,	Flood free	Open woodland	Scattered trees and shrubs predominate by Acacia specis and *Panicum maximum* dominated herbaceous layer beneath.
Red	Loam	Fertile	Non-muddy, non-sticky,	Flood free	Woodland	Trees and shrubs predominate by Acacia specis and *Balanites aegyptiaca* and *Echinochloa colona and Setaria incrassata* dominated herbaceous layer beneath.
Red with some black	Loam with some clay	Fertile	Moderately muddy, sticky and	Flooded	Riverine forest	Trees predominate by Acacia specis and *Balanites aegyptiaca* and *Brachiaria semiundulata* and *Eriochloa fatmensis* dominated herbaceous layer beneath.
Black	Clay	Fertile	Muddy, sticky, cracks when dry	extremely flooded	Savanna grassland	Open grassland entirely layer of herbaceous species covered with grass vegetation dominated by *Echinochloa pyramidalis, Oryza longistaminata, Cynodon dactylon* and herbs mostly *Ipomoea aquatica.*

Consistency in the Nuer pastoralists' experience and knowledge regarding seasonal dynamics in botanical composition of the rangelands is in contrast with the suggestion of (Fernandez-Gimenez, 2000) knowledge of specific species is quite variable among herders of differing gender. The marked variation between age groups disagreed with Sop and Oldeland (2011) who explained that age was not found to impact people's opinions on vegetation dynamics and the strong perception consensus among informants demonstrates that local people are all aware of the changes affecting vegetation dynamics in their environment.

Pastoralists' Perception and Ecological Knowledge on Seasonal Dynamics in Nutritive Value of Forage Species

It is known that local knowledge-based management strategies could ensure a focus on the optimal use of species and vegetation types that are most valuable to local communities (Sulieman *et al*., 2012). Herders recognize all the desirable and undesirable plant species by local names (Gemedo-Dalle *et al*., 2005). The herders categorized forage plants into desirability classes based on livestock preferences. The 'very desirable' forages are highly selected by livestock and given preference during grazing. During the dry season when the most desirable species were over-utilized, the livestock tended to be less selective in their feeding habits (Dabasso *et al*., 2012). Use of desirability indexes by Nuer pastoralists for the ranking of valuable grasses and browse species is in line with classification of forage species on the ecological status determined by their perceived acceptability to animals (Amsalu and Baars, 2002; Gemedo–Dalle *et al*., 2006; Dabasso *et al*., 2012).

Grasslands have generally been observed to have nutritious and palatable forage (Reid *et al*., 2005). Under arid conditions, the nutritional quality of herbaceous species is typically influenced by the seasonality of rainfall. In East African rangelands, grazers are greatly influenced by the nutritional dynamics of forage, especially during the dry season. (Teka *et al*., 2012). Local communities harbor important information on valuable plants and vegetation dynamics (Lykke, 2000). The use of browse species as fodder to ruminants has increasingly become important in African semi-arid environments (Abdulrazak *et al*., 2000). As elsewhere in Africa (Selemani *et al*., 2012) in the study area, Acacia trees are considered to be dominants and are important sources of feed to livestock throughout the year. Nuer herders have a profound knowledge about nutritive value of browse species. This is agreement with the thought of Kgosikoma *et al*. (2012) who reported that pastoralists in semi-arid rangelands of Botswana generally acknowledged the importance of woody vegetation as a browsing resource, though not all woody plants were identified as suitable for browsing. In agreement with the Maasai communities (Kilongozi *et al*., 2005) the Nuer pastoralists are experienced and knowledgeable in nutritive values of the forage species assessment which could have a sound contribution in monitoring of livestock productivity and health. Consistency in the perception of seasonal dynamics in the nutritive value of forage species between genders is in line with Fernandez-Gimenez (2000), suggesting that forage preference ranking exercises conducted independently with male and female herders agree on the value of major forage species.

Pastoralists' Perception and Ecological Knowledge on Seasonal Dynamics in Soil Nutrient Status

The basis for classification and use of soil by the Nuer pastoralists is almost similar with those of the Maasai and the Barbaigs communities (Kilongozi *et al*., 2005), which are largely according to surface and sub-surface characteristics namely colour, texture and consistency. In agreement with Kilongozi *et al.,* (2005) case studies, soil colour and texture are related to both quality and quantity of the pasture as perceived by the herders. Similarly, black (clay) soils were described as muddy and sticky when wet and cracking upon drying and thus offer a modest quality pasture. It is associated with average fodder production and average livestock performance. Moreover, black/clay soil is perceived to be associated with high organic matter

content, and supports better quality grasses, which are rich in minerals. In contrast to Kilongozi *et al*. (2005), red soils are perceived to produce a surplus amount of highly desirable grasses. As indicated by Reed *et al*. (2008), soil looseness has been perceived as a potential indicator of fertility by pastoralists.

Nutritional quality of herbaceous plants has been reported to be influenced by soil nutrient status (Tessema *et al.*, 2011). The availability of huge trees and lush vegetation in an area meant that the area is rich in soil minerals (Kilongozi *et al*., 2005). As a function of fertility, variations in the composition of dominant woody plants in a particular area could be explained by landscape patches and heterogeneity (Boone, 2005; Tefera *et al*., 2008; Kgosikoma *et al*., 2012). Pastoralists' perception and ecological knowledge regarding soil nutrient status was directly related with vegetation quantity and quality attributes.

CONCLUSIONS

The Nuer pastoralists have an in-depth ecological knowledge and experience about changes under going in their ecosystems. They perceived that there were seasonal dynamics in their rangeland botanical composition, vegetation nutritive values and soil nutrient status. This knowledge is consistently shared within the pastoral community. It can be, therefore, concluded that pastoralists' perception and ecological knowledge has a profound importance and potential for integration into scientific knowledge of range science, and practical value in in ecologically sound rangeland management.

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