Ecological Response of *Chloris Roxburghiana* to Livestock and Wildlife Grazing in Chyulu Hills National Park and Environs, Kenya,

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Abstract

This study was an attempt to evaluate the responses to ecological disturbances of *Chloris roxburghiana which* is a dominant graminoid species and provide bulk of forage to both livestock and wildlife grazers inside and outside the Chyulu Hills National Park (CHNP). A Randomized Complete Block Design method was used. Micro-histological technique was applied on faecal samples from both livestock and wildlife was used to determine the presence or absence of *Chloris roxburghiana* in livestock and wildlife feacal material. Data was subjected to Analysis of Variance statistics. The results of clipped weights *of Chloris roxburghiana* showed that livestock only grazed areas had 8163.3kg/ha +/- 0.3, whereas wildlife combined with livestock grazed areas had 675510.2kg/ha +/- 0.7 and wildlife only grazed areas had 614285.7kg/ha +/- 1.2. Abundance of *Chloris roxburghiana* in faecal composition was 91.14% in cattle, 90.74% in sheep, 94.54% in zebra and 95.75% in gazelle. These results indicate that livestock grazing had a greater effect on biomass of *Chloris roxburghiana* than wildlife livestock and wildlife only grazing.

Key words: Livestock, Wildlife, Graminoid, Regrowth

1. Introduction

The management and effective utilization of natural resources is determined by the prevailing land use systems. The rules governing access to land resources and the manner of their current use affect the welfare needs of current and future generations as well as ecological status of the natural systems of which land is part. Resource use conflicts in Kenya are a function of an attempt to play a delicate balance between, on the one hand government policies, the agro- ecological factors and the socio-economic factors and on the other hand the need for individuals and communities to utilize and manage natural resources on a short or long term basis (Mishra *et. al.* 2004; Pekka, 2005; Reid *et. al.* 2005).

Due to the rapid demographic changes there has been effort by governments to control the livestock populations of the communities living adjacent to protected areas. (Mosse 2003) documented that the colonialists yearned to destock the Maasai because; the strategy of overstocking did not contribute to the development and progress of the colony, overstocking would threaten the wildlife and jeopardize revenue raising potential of the game reserve and overstocking and overgrazing of pastoral rangelands was contributing to increased environmental degradation.

Despite the government's goal to increase agricultural production for food self-sufficiency, it is a paradox that over the last three decades, a considerable growth in the number of protected areas has been observed in Kenya eating into available land for agriculture. At independence there were only four national parks and five reserves in Kenya, but at present the numbers stand at 22 national parks and 24 national reserves (KWS, 2008; Reid *et. al.*2005).

2. Materials and Methods

2.1 Study area

Chyulu Hills National Park is situated 250 kilometers southeast of Nairobi along the Nairobi- Mombasa highway in Kibwezi District. The park headquarters can be accessed through a murram road, a short distance from Kibwezi town as one drives towards Mombasa. It lies between latitudes 2^{0}21'S and 2^{0}50'S, and longitudes 37^{0}45'E and 38^{0}2'E. Mashuru and Loitokitok Divisions and West Chyulu Conservation Area of Kajiado District border the park to the west. The Kiboko River marks the park's boundary to the northwest, while Tsavo West National Park is on the southeast of the park (Fig.1)

The study area was the areas North West towards west of the park in the areas of Donyo Engeloreti, Ol Doinyo Sambu; these locations provided areas with cattle grazing in the park. Due to the distance and staffing levels it made establishing controls in this area difficult. The area of Ukatu to the North East provided an area with no cattle grazing with its electric fence and militarized KWS personnel. This is because the areas south west towards south had a conservancy and the remaining areas were inaccessible by humans and cattle. The park headquarters and Mkururo station are militarized zones thereby enforcing controls within these areas (GOK 2007a, 2007b, 2007c).

2.2 Research Methods

The research employed Randomized Complete Block Design with three blocks; outside CHNP, non patrolled zone inside CHNP and patrolled zone inside CHNP where treatment combinations were based on the type of animals occurring on the site impacting grazing on the *C. roxburghiana* hence Livestock only area, wildlife-livestock area and wildlife only area. The

main advantage of experimental approach is it eliminates bias and due to repetition/replication it improves accuracy (Joris & Han, 2006).

The three sites provided the blocks under study with the wildlife only area providing the control to be used in the study due to the perception of showing evidence in the livestock only area and the wildlife-livestock area being in contention as where the effects of livestock grazing were to be estimated. The patrolled zones had the electric fence that ensured that the micro environment was least impacted by the activities of livestock.

Grazing intensity and grazing frequency treatments were the grazing impacts by livestock and wildlife on the *C. roxburghiana*. Clipping of the grass at selected random sampling sites within the blocks were carried out to simulate grazing and the grass weighed (Joris & Han, 2006; Ecological Sampling Methods, 2009). This was done by use of transect lines

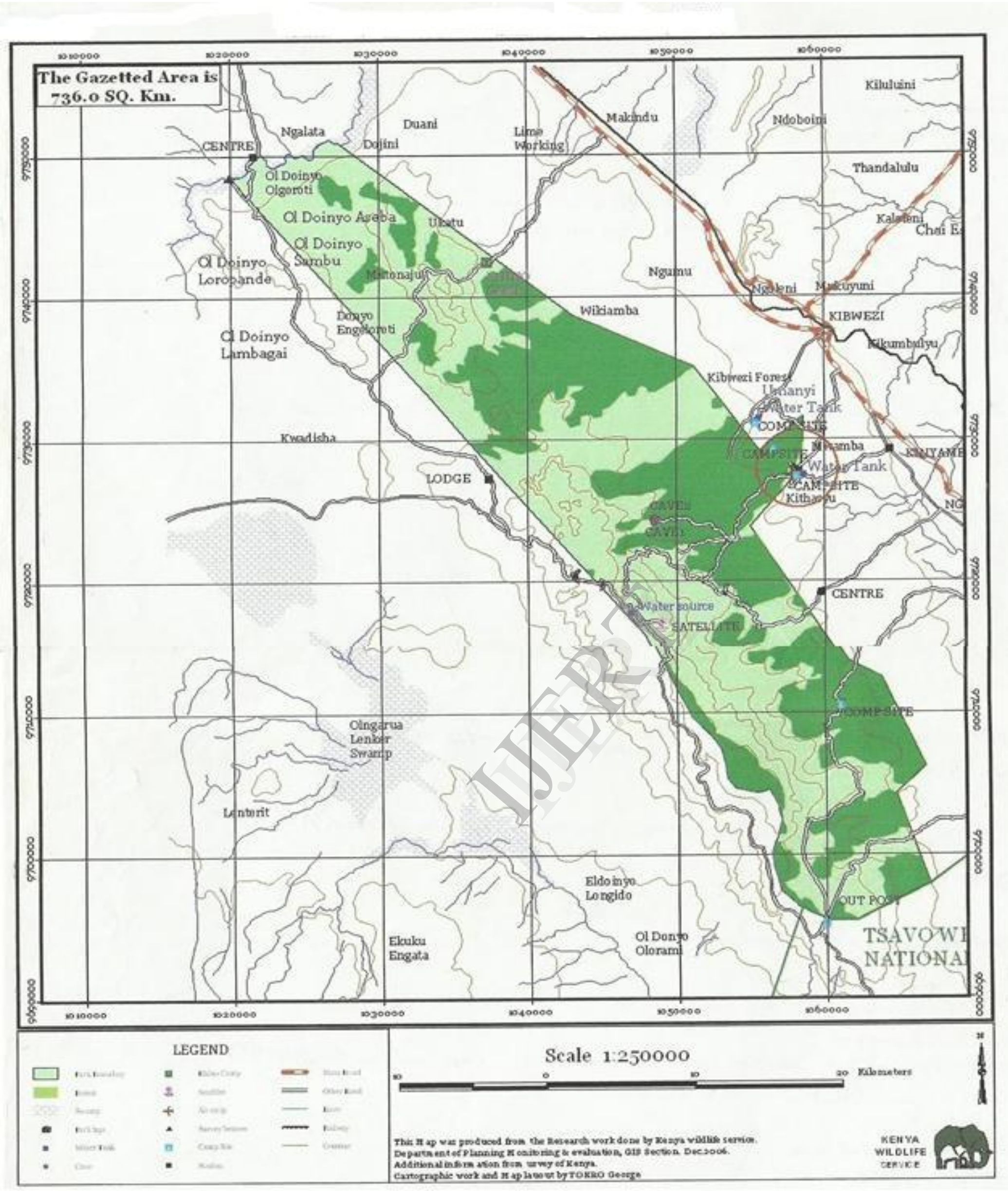

Fig. 1: Location of Study area (Source Kenya Wildlife Service 2010)

measuring 20km cutting across the blocks and six 100m by 100m being selected on either side of the transect.

Initial cover conditions for the livestock only area was degraded area with little graminoid presence, while the wildlife livestock area had abundance of cover as well as the control wildlife only area. This provided for a base where to measure the effects of grazing on *C. roxburghiana*.

The three sites provided 12 areas used as sampling frames within which clipping of the *C. roxburghiana* would be performed in smaller quadrants to avoid negative effects to the environment. The 12 sampling frames thus offered sufficient replications for the study to be statistically valid (Valerio *et al.* 2004; Joris and Han, 2006; Ecological Sampling Methods 2009).

In order to simulate the natural conditions to an accuracy of 95%, the blocks set were not to be enclosed (Valerio *et al.* 2004; Joris and Han, 2006; Ecological Sampling Methods 2009). The variables to be controlled were the type of animals grazing on a particular site. This resulted due to the antecedent conditions where livestock only area was distinctly clear with pastoralism as the key economic activity with no evidence of another type of land use. The wildlife-livestock area was selected with evidence of livestock encroachment within the known CHNP boundary.

The micro histological feacal analysis technique was used to establish the composition in feacal material from various wildlife and livestock species. Comparison of feacal matter was done to provide insight on the presence or absence of *C. roxburghiana* in the diet of livestock and wildlife. Micro histological analysis involves identifying and quantifying epidermal and/or cuticle fragments of ingested plants. This is possible as the plant cuticle, an indigestible layer covering the epidermis, bears a specific pattern of underlying epidermal cells and hairs along with structures of its own. This pattern is best developed in mature leaves and can be identified down to species level, even after passage through the herbivore gut. For this method to be successful, a reference slide "library" of the possible food items must be established. This procedure involved Specimen accessioning where all the collected dung was put in sample bags and numbered. This was done to clearly identify the source as well as the site the dung was retrieved. Gross examination of the dung collected was done with description in further details to include the quadrat of sourcing and type of animal whether cattle, sheep, zebra or gazelle. Tissue fixation this was preservation of cells and tissue constituents through use of airtight sample bags. This coagulates tissue proteins and constituents to prevent their loss during processing.

Tissue processing of the dung samples was done with an objective to embed the tissue in a solid medium firm enough to support the tissue with sufficient rigidity to enable thin sections to be cut. Proceeding after the collection is sun drying the matter for 48hours to lose as much moisture as possible, then oven drying at 70^{0}C for 24 hours. Once the faecal matter is dry it is ground to fragments and sieved using a 200um sieve where small scoops of dried material was put in 50 vials for which processing ensued.

Dehydration is done on the samples to remove as much water and fixative as possible through use of the sun and then ethanol to remove all the water. Clearing a procedure where use of paraffin wax which is miscible with both the dehydrating fluid ethanol and an embedding medium is applied. Impregnation where embedding medium epoxy resin is utilized is performed on the dung samples.

Tissue embedding a process where tissues are orientated in the desired direction and surrounded by wax medium which when it solidified provided sufficient external support during sectioning. In sectioning the hardened tissue samples are cut into very this sections 3-5 microns through use of a microtone. Herbaceous material was boiled in hydrochloric acid (HCL) and water for 2 hours to simulate digestion. One drop of pellet solution or a small portion of the herb mixture was placed on a glass slide. Treatments consisted of adding Hertwig's solution and boiling the mixture, adding a dye and boiling, adding Hertwig's and dye and boiling, and adding Melzer's reagent in combination with the other dyes. Dyes used were cotton blue, safranin, Gram's iodine, phloxine B, trypan blue, and Melzers' reagent. Control slides 6 in number had no Hertwig's solution or dyes and were not heated. Two drops of polyvinyl alcohol (PVA, a mounting medium, Johnson and others 1983) were added to the mixture, which was then covered with a 22- by 40-millimeter cover slip. Fifty slides were made for each study site. We then subjectively compared the degree of specific staining of fungal and plant material, the effects of clearing on identifying fungi and plant structures, and the effects of clearing on staining (Ecological Sampling Methods, 2009).

Making micro-histological slides for comparison with known graminoid slides called reference slides that have been made and stored at various research centers" herbariums to identify the common graminoid species between wildlife and livestock through identification of botanical fragments (Valerio *et al.* 2004; Joris & Han, 2006; Ecological Sampling Methods, 2009). Determination of the diet through analysis of faecal material collected from the field as used by Martin (1982), Waweru (1985), and Barker (1986) was adopted in this study.

Thus the reference slides made were 6 for each species of grass found as they provided control to compare with the ones at the established herbarium at the Kenya National Museums Herbarium.

Unlike other food habits techniques the micro histological faecal analysis techniques provided an objective way of validating the records reported by an observer. The basis of this technique is the ability to identify fragments of plants in herbivore faecal material mounted on the microscopic slides .The sampling involves gathering of the faecal material which is relatively simple (FAO, 2010).

Using a binocular compound microscope equipped with phase contrast, the reference slides were studied and for each plant species the identifiable unique characteristics were noted and digital photos taken as shown in Plate 5 where epidermal tissues with stomatal complexes are used to identify samples. On each slides 25 then 50 microscopic fields were studied and in every field identifiable fragments were recorded using present or absent technique. A minimum of 3 characteristics were used for species identification.

Faecal matter was collected from each site and prepared for micro histological comparison. With the area being sampled being mono stand in terms of grass species occurring on the site reference slides made were from the species with the rest developed after analysis of the dung samples.

Duration of experiment was designed for 1 year the appropriate period for studying a perennial graminoid species (Ecological Sampling methods, 2009). The study started in June 2009 which was the marked month for the beginning of the short rains (GoK, 1997b) and first clippings were done in the month of August to allow for rain to cause any growth, the second and final clipping was done in May of 2010 with the end of the long rains period (GoK, 1997b). this periods provided seasonality regimes desired to measure growth and biomass.

3. Results

In the livestock grazed area, the category of 1-10cm *C. roxburghiana* tuft height was the only category present. This meant that the area had no *C. roxburghiana* growing for a while and the *Chloris roxburghiana* tufts available had been grazed hence their low height (Figure 2).

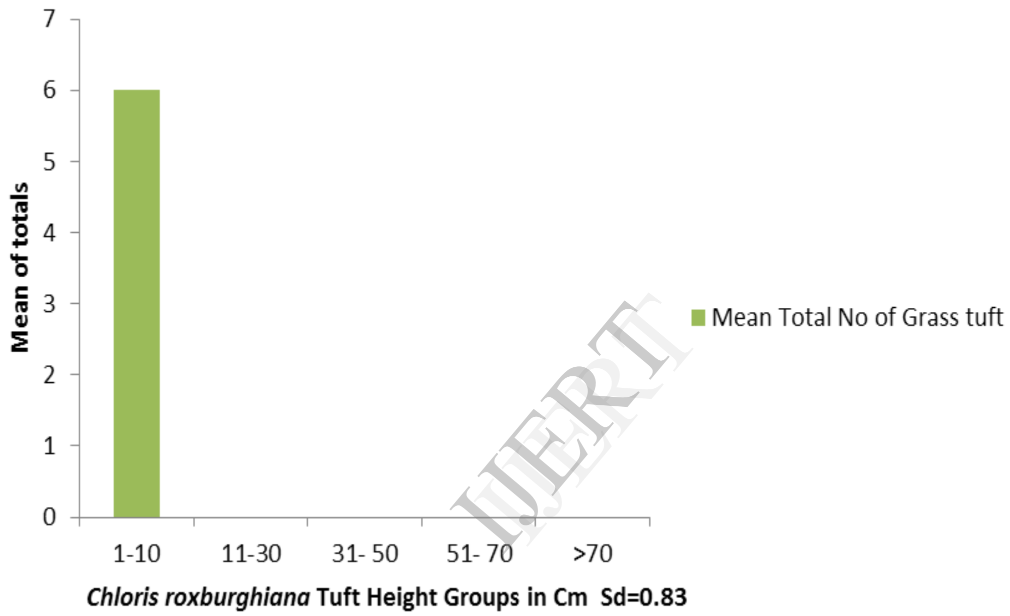

Figure 2: Mean numbers of C. roxburghiana tuft height categories in livestock only area.

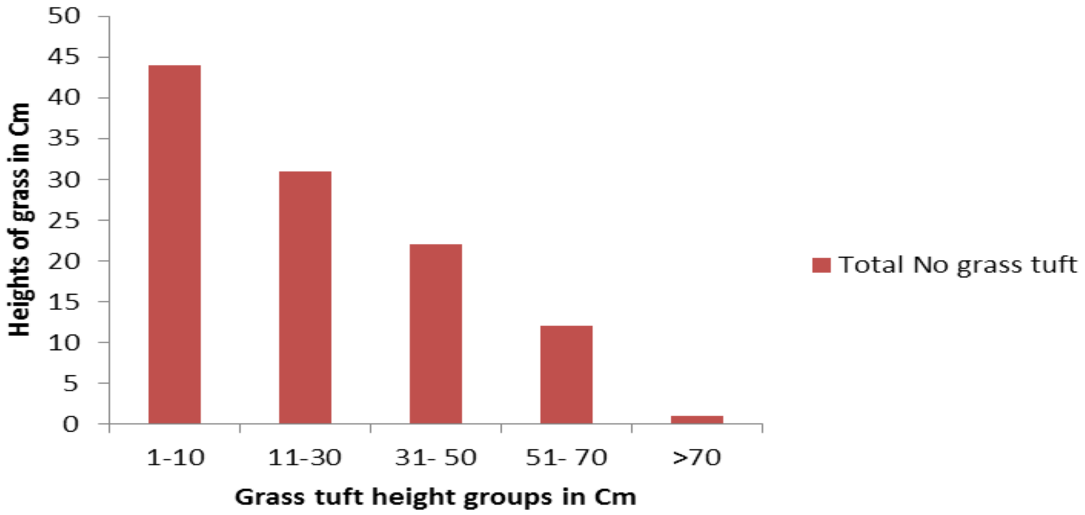

Figure 3: Mean numbers of C. *roxburghiana* tuft heights in wildlife only area.

Wildlife only area recorded the highest number of *C. roxburghiana* tufts of height 1-10cm and registered tufts as tall as above 70cm tall.

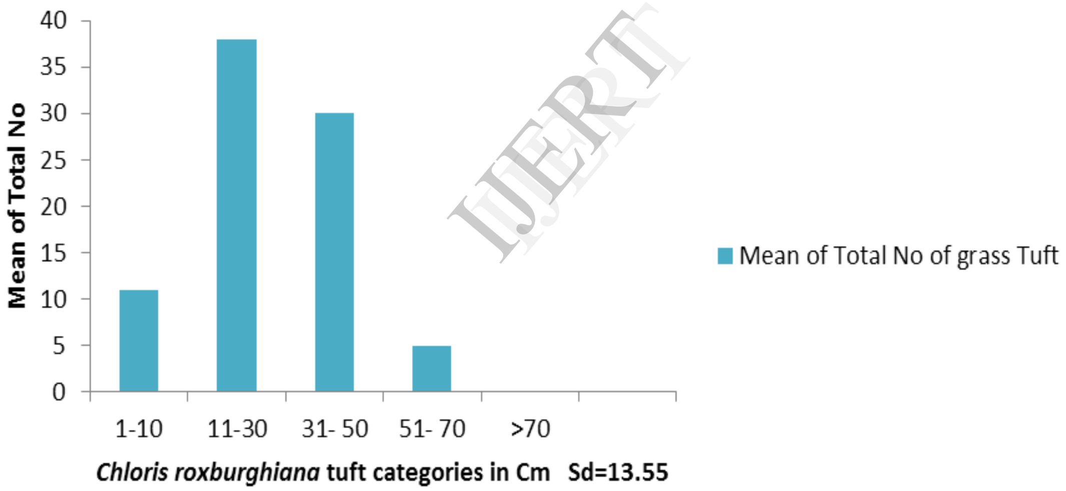

Figure 4: Mean numbers of of C. roxburghiana tuft height categories in wildlife and livestock mixed area.

In the livestock-wildlife area, the *C. roxburghiana* tufts of various heights were recorded in all categories except for above 70cm. The greatest numbers of *C. roxburghiana* were recorded in the 11-30cm category.

The comparison of the three sites in terms of the grass tuft height demonstrated that the livestock only area recorded the least *C. roxburghiana* tuft heights in the 1-10cm category, whereas the wildlife only area recorded the highest numbers and the wildlife only to have recordings in the above 70cm height category.

The comparison of the three sites showing the Trends in the grass height distribution among the three sites revealed high values in the wildlife - livestock and the wildlife areas with low values in the livestock area (Figure 5). The sites showed a general reduction in grass height numbers. In other words the sites exhibited the greater numbers of *C. roxburghiana* culms in the shorter categories suggesting higher grazing pressure.

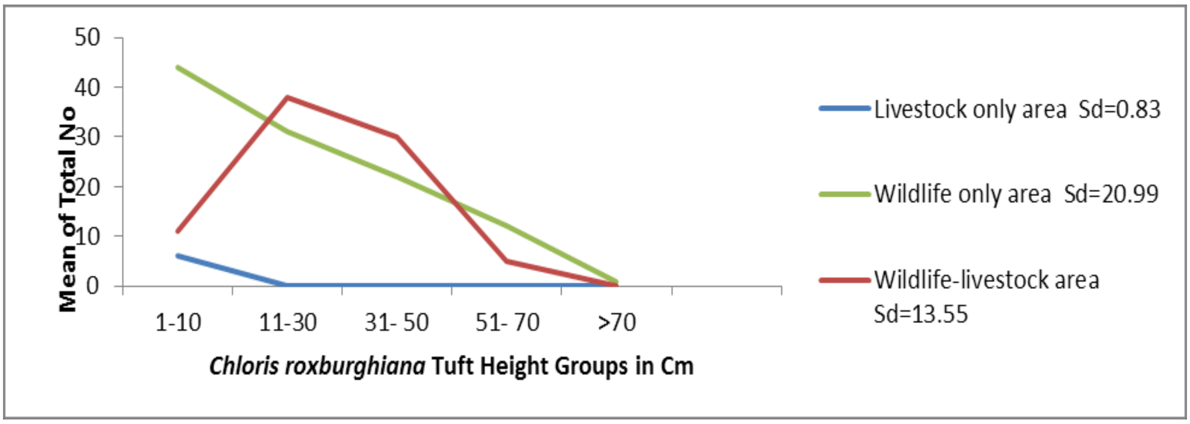

Figure 5: distribution comparisons of *C. roxburghiana* tuft height categories in different sites.

The distribution trends comparing all the sites show emerging culms of all categories from wildlife and livestock area and from wildlife area being high in all categories as compared to the livestock area (Figure 6).

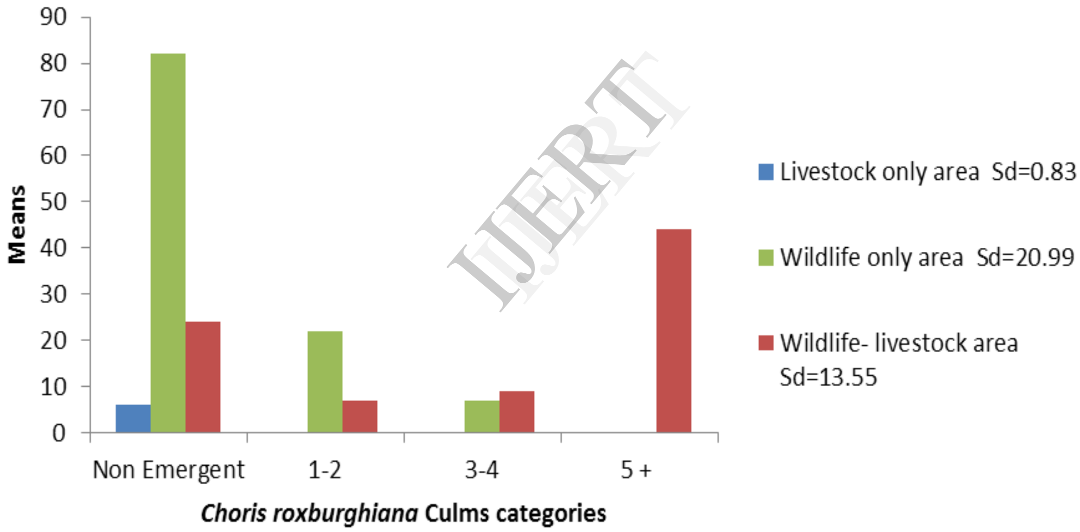

Figure 6: Comparisons of culms of C. roxburghiana categories in study sites.

The comparison of different quadrants in different sites showing higher biomass observed in the samples from wildlife only area and wildlife and livestock area with very low mass of samples in the livestock only areas.

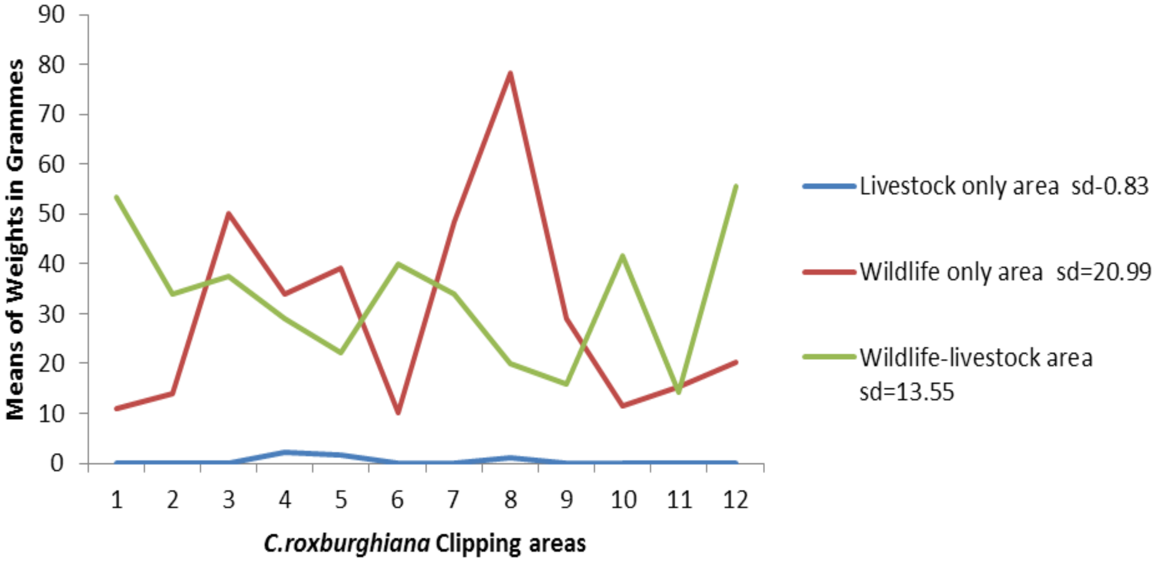

Figure 7: D istribution trends showing weights of clipped *C, roxburghiana* in comparison by sites

F r e q u e n c y o f *C.roxburghiana* culms categories was tabulated and compared per sites. This showed high values on the wildlife-livestock area and in the wildlife only area with low values in the livestock only area.

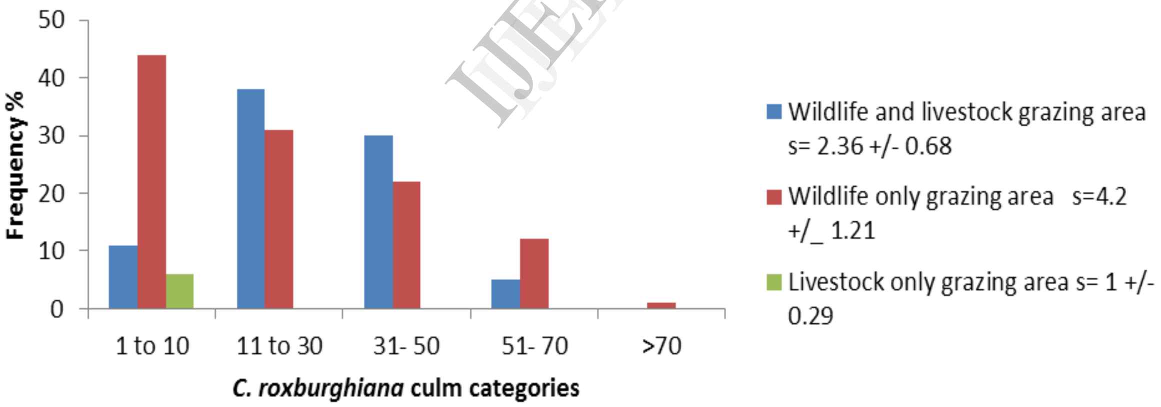

Figure 8 : F requency of *C. roxburghiana* culm categories comparison by site

The total counts of *C .roxburghiana* were taken per sampled sites and means derived to show comparison of abundance per study area. Highest counts were recorded in the wildlife only area

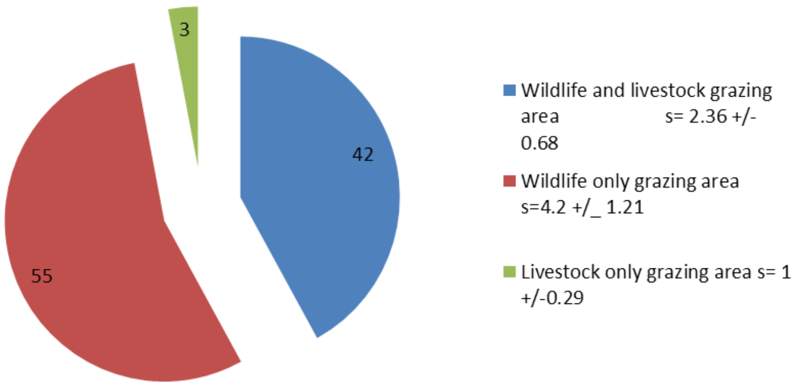

Figure 9: Percentage abundance of *C. roxburghiana* comparison by sites.

From the micro-histological analyses of both livestock and wildlife for increase of credibility first occurrence per sample was conducted for the samples from which slides were derived. In comparison of the abundance of *C. roxburghiana* of both livestock and wildlife species there was relative similarity in abundance as shown by the histograms in Figure 10 & 11.

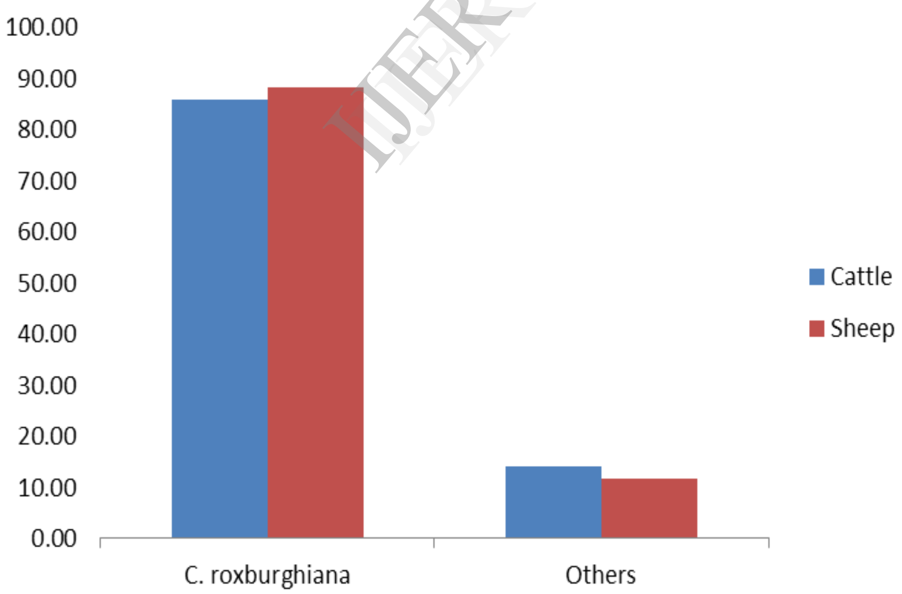

Figure 10: Abundance of *C.roxburghiana* in livestock feacal material.

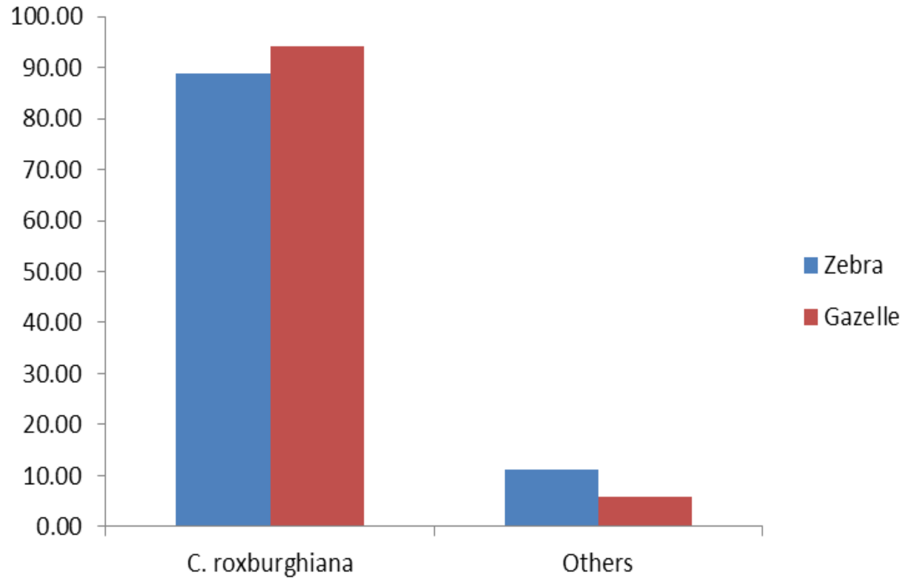

Figure11: Abundance of *C.roxburghiana* in wildlife feacal material

Analysis of variance showing the comparison of mean weight of *C. roxburghiana* among wildlife only areas, wildlife – livestock area and livestock only areas through statistical analysis to give comparison among wildlife only area, livestock only area and wildlife - livestock area.

Table 3; ANOVA results from clipping means

	1st clipping Mean	Standard Deviation	2nd clipping Mean	Standard Deviation
Wildlife	26.38	16.96	33.8	25.47
Livestock	0.68	1.07	0.20	0.50
Wildlife-Livestock	36.03	10.68	30.22	16.42

	F Calc	F Tab
F-test for wildlife against livestock	0.08	0.8600
F-test for livestock against both	0.10	0.8600
F-test for wildlife against both	0.85	0.8600

4. Discussion

In order to assess the effects of livestock and wildlife grazing on the amount and abundance of *C. roxburghiana*

in CHNP and its environs, the various measurements were performed for amounts and biomass to simulate grazing and dietary composition were recorded with observations of evidence to show areas where significant growth was observed. Anderson (1974) highlighted that the species originated in Kenya.
Observations in regard to the biomass of *C. roxburghiana* indicated scanty vegetation in grasses season long in the livestock only areas, this was also accompanied by a two year long drought. Various researchers have noted similar patterns in areas grazed where there are pure stands. Williams, (2012) documented continuous defoliation which depleted the whole stand of the grass species where the grazing was intense. This was evidenced through high intensity high frequency grazing treatment on the *C. roxburghiana* in the livestock only area. Thus due to the prolonged drought the grass never recovered as to have significant regeneration. In the measurement of emerging culms the livestock grazed area realized very low numbers from all the areas sampled under livestock only. The results in Table 3 show the biomass of *C. roxburghiana* was 8163.3kg/Ha implying that grazing pressure impacted on the *C. roxburghiana* affected the regrowth capacity of the grass thereby causing loss of vegetation materials. As a response mechanism to high intensity grazing *C . roxburghiana* is inhibited in terms of its growth vigour in the livestock only grazing than in wildlife livestock area and wildlife only area.

C. roxburghiana is a dominant species in dryland areas of Kenya, and is usually found growing in association with *Chrysopogon aucheri* (Rattray, 1960). Despite its wide distribution, Herlocker (1999) treats this vegetation type as a subtype of the *Chrysopogon* mid- grass region. *Chloris roxburghiana* is widespread throughout the entire region of CHNP and is an important species for livestock and wildlife, in the areas from mid to north western of CHNP it occurs in pure stands. This species contributes up to 90 percent of the diet of wild herbivores in eastern Kenya (IBPGR, 1984) but is in danger of disappearing due to overgrazing and land degradation. In livestock grazed areas it was the most abundant graminoid species in the faecal matter of livestock as confirmed through micro-histological analysis. This scenario further confirms that livestock in communal lands overutilise the available pasture due to high grazing intensity and also trampling impacts (Flintan *et al*, 2011). In this ecological area of CHNP *C. roxburghiana* was the dominant graminoid species and also in terms of frequency many of the sampled areas registered zero for any other graminoid species.

The ANOVA confirmed that grazing by livestock on the livestock only area had significantly reduced the potential for the livestock only area to allow for re-growth of *C. roxburghiana*. Results showed there is significant difference in areas grazed by wildlife- livestock and areas grazed by livestock only. Cattle use wooded and open habitats more opportunistically (Hartnett *et. al.*1997). Williams, (2012) in his studies of depletion of graminoid species due to grazing, confirmed that in pure stands especially the preferred vegetation type chances of depletion is high due to livestock numbers being high as most of those areas are common property and also livestock tends to overstay in those areas during months of drought. Flintan *et al*, (2011) in his studies of land fragmentation observed how community land size has shrunk resulting in severe grazing impacts. The livestock only areas are undergoing through many changes in the Soil-Plant-Animal- continuum (SPAC) which is highlighted in Flintan *et al*, (2011) showing how trampling impacts due to large numbers of livestock grazing in one area would cause a loss of production in terms of reduced frequency and growth of food resources such as the impact on *C. roxburghiana* as confirmed by Figure 9. The data shows Livestock only area with the smallest portion in the pie charts authenticates overutilization of grazing resources by livestock. In other studies the rangeland and the pastoral society have experienced significant change including almost total resource privatization of grazing areas and water. In the majority of areas there has been subdivisions of the rangelands into individual household plots for grazing and some crop production. This has completely restricted the movement of livestock along traditional migration routes and across grazing areas.

Wildlife-Livestock area had abundance of *C. roxburghiana* recorded from the clipping weights as shown in Figure 8. This area despite being frequented by both wildlife and livestock exhibited high numbers of biomass available for grazing. In terms of graminoid species availability and abundance *C. roxburghiana* occurred in pure stands in these areas this was due to anthropogenic fires in CHNP (Ngene *et. al.,* 2011) and also was very abundant as all sampling areas within wildlife-livestock areas registered pure stands of *C. roxburghiana.* Studies show that North American prairies developed under the influence of fire and bison (Coppedge & Shaw, 1998). These are huge areas with pure stand grass that benefits from regeneration. The study indicates that the combination of fire and bison grazing created the prairie ecosystem; not just fire or bison acting alone. Fire may be an important determinant of the pattern of large herbivore grazing activity, which is often spatially and temporally heterogeneous.

In rangelands where pastoral people graze their livestock, wildlife avoid areas that livestock graze heavily (around water points and villages), which cover about 10 % of the land area. In the remaining and extensive lands with fewer people and livestock, wildlife and livestock graze together (Reid, 2011). This is explained by the high numbers of livestock but due to the forage availability the animals were grazing in larger areas than when the observation was made in the livestock only area. Reid (2011) also recorded in his study that pastoral people may only enrich savannas when they use them at low to moderate levels because higher use will extinguish biodiversity. This is what was shown in the livestock only area where there were areas without grass growing after the rain season.

The total emergent culms of *C. roxburghiana* recorded were more than the non- emergent culms Figure 6. This suggests the presence of growth in wildlife-livestock and wildlife only areas. However, wildlife-livestock area did not record *C. roxburghiana* grass category at tuft height above 70cm, the same area also recorded the area to have majority of the tufts category of 11-30cm which showed that the *C. roxburghiana* grass tufts were fairly even in this study site as the next major category was 31-50cm height. This confirmed the low grazing pressure experienced in the wildlife- livestock grazed area also that the feeding habits utilized the tall *C. roxburghiana* species allowing for the growing culms to grow. Bourne and Blench (1999) have suggested that in rangeland dynamics and resilience livestock management is less ecologically damaging if pastoralists have access to more diverse sources of grazing and water.

Wildlife grazed area was cordoned off livestock hence the reduced production which was at 26.13 % meaning the growth of *C. roxburghiana* is limited by its own abundance when it is exposed to low grazing intensity and pressure. Thus the grass would remain at a low height and delay maturity (Anderson, 1974; IBPGR, 1984). The abundance of *C. roxburghiana* in wildlife grazed area was also high as all the quadrants sampled registered only this graminoid species. Thus showing that *C. roxburghiana* as a graminoid species has colonized the ecological area. This has also been shown by Ngene *et al,* (2011) in similar studies recorded that abundance of feed resources inhibits it's growth. In Anderson, (1974) the genus was noted to have inhibited growth when left unutilized

Comparison by trend of the sites as shown in Figure 2 highlighting the wildlife livestock area realizing recordings in all the emergent culm categories thus showed that the interaction of livestock and wildlife in the same grazing area causes a balance as the area would still realize increased biomass of the *C. roxburghiana* than in the wildlife only area where the low grazing intensity caused the area to have highest numbers of non-emergent culms and also increased biomass than in the livestock only area where the grazing intensity was highest thus causing zero biomass available. This has been confirmed in the studies by English Nature (2005) and Vavra (2005). Figure 7 was made from means of clipped *C. roxburghiana* by the sampling quadrants in the season and there were very many recordings of zero weights in the livestock grazed area. Also the trend in both the wildlife only area and wildlife-livestock area was recordings in all the quadrants with varying peaks. Thus the means recorded and the standard errors realized were well within the confidence limits of 95% and the difference among the sites was very clear when the two sites; wildlife-livestock area and wildlife only area was compared to the livestock only area which showed the difference in grazing intensity on the livestock only area than the other two sites.

Figure 8 compares the mean of the clipped *C. roxburghiana* by the sites and also confirms the difference by site between livestock only area and the two sites wildlife-livestock and wildlife only areas. Results of ANOVA indicated that there were no significant differences in the means of the wildlife livestock and the wildlife only area, however there were significant differences in the livestock only area and the other two sites. This is to show when extrapolated in Kg/Ha the abundance of *C. roxburghiana* in the wildlife only areas and wildlife-livestock area confirm the availability of grazing resource whilst the livestock only area has very little available grazing resource. This shows the over extraction of grazing resource in areas of little control.

C. roxburghiana was the selected graminoid species the frequency was calculated by comparison with the percentage cover on each sampled quadrant by the culms counted. Thus the higher frequency values were realized in the wildlife only area and wildlife-livestock area to also confirm the clipping weights as there is similarity within the two sites. Figure 9 is a pie chart showing which area had more *C. roxburghiana* than the other and it is evident the wildlife only area had most followed by the wildlife –livestock and in distant third was the livestock only area.

There was different utilization behavior in the wildlife grazed area Figure 3 and in the livestock grazed area with higher grazing pressure being realized from the areas of livestock grazing as shown in Figure 2. This confirms that livestock only grazed areas had high grazing intensity than wildlife only grazed areas.

Livestock only area's F-calculated (0.10) is less than F- tabulated (0.8600) indicating that there was significant difference in biomass in the areas dominantly used by livestock only having little or no *C. roxburghiana* with α=0.05. this has been confirmed by other studies such as Ngene *et al*, (2011) ; English Nature (2005) and who reported the detriment livestock in previous areas have had on the grazing resource with depletion of grazing resources being documented in common property areas. Williams (2012) in his studies of depletion of graminoid species due to grazing, confirmed that in pure stands especially the preferred vegetation type chances of depletion is high due to livestock numbers being high as most of those areas are common property and also livestock tends to overstay in those areas during months of drought.

Since wildlife only area's F-calculated (0.08) is less than F-tabulated (0.8600) then there is no significant difference of biomass in the areas dominantly used by wildlife and wildlife-livestock with α=0.05. Belesky *et. al*, (2002) that certain species of grasses have been known to predominate huge area and that as even evidenced in English Nature (2005) where cattle has been shown not to be detrimental to sites provided they do not overstay in an area confirm the case in both wildlife livestock and wildlife only area.

Figures 10 & 11 showed similarity in abundance of *C. roxburghiana* in the faecal content thus confirming the dietary overlap of the livestock and wildlife. The selected graminoid species was determined to be *C. roxburghiana* with 95% confidence (Anderson, 1974; FAO, 2010) after comparison of faecal matter of both selected livestock and selected wildlife herbivores through micro histological analysis. The area under livestock had over utilization of the *C. roxburghiana* until the land was left bare.

Results of microhistological studies indicated that *C. roxburghiana* was common in diet of both the wildlife and livestock. This was supported by Figures 18 and 19 where the relatively high abundance was shown with others species not raising even 10%. At the grazing patch scale, cattle are more selective foragers (Peden *et. al.* 1973; Plumb & Dodd, 1993). This explained the findings in the micro histological study such that cattle preferred the *C. roxburghiana* hence the higher percentages in its diet. Patch diversity can also be affected by dung and urine composition and trampling (Knapp et al. 1999), but this is likely to occur with cattle. Thus the pure stand is maintained due to such preference as the *C. roxburghiana* grows faster. Forage intake rate and grazing density may be much greater for cattle (Towne et al. 2005).

In the livestock only area the faecal matter was drier than in the other areas thus confirming the observation that the wildlife-livestock and wildlife only area had more animals grazing regularly in those sites and that the ones which used to graze in the livestock only area had moved. Hosten *et al.* 2007 reported diet overlap in grazing species of wildlife and livestock. Studies that have evaluated livestock forage utilization on open ranges show that cattle favor green grass over forbs and shrubs (Mohammad *et. al*. 1996, Hosten *et al.* 2007). Diets comprised a higher percent grass composition (Hosten *et. al.* 2007). Browsing of shrubs by cattle, particularly upland shrubs, usually occurs when more palatable food is depleted from the available range (Mohammad *et. al.* 1996). This explains the presence of the other species in the gut of the animals as it confirms that even with the areas for grazing having near pure stand of *C. roxburghiana* the animals have to also complement their diet with other species. The same behavior is found on wildlife too (Hosten *et. al.* 2007).

5.0 CONCLUSIONS AND RECOMENDATIONS

5.1 Conclusions

There are significant differences in the heights of *C. roxburghiana* in the areas dominantly used by livestock only, wildlife-livestock and wildlife only.

High utilization of *C. roxburghiana* impacts on the growth and thus the low biomass.

The *C. roxburghiana* was consumed significantly by livestock and wildlife and therefore there is no significant difference in the diet composition of livestock and wildlife grazers in the areas around and inside CHNP.

5.2 Recommendations

Since *C. roxburghiana* is common as a diet for livestock and wildlife, the park management and the pastoralists should be sensitized on sustainable use of grazing resource.

This study identifies the need for training of communities adjacent to national parks to take measures in regards to their grazing areas and stocking rates. This would cause reduced grazing intensity on the forage resources thus minimizing the park incursions.

Further research should be done on utilization of other grass species and browse in national parks with different climatic conditions to show the effect of the intensity of browsing by wildlife of forage resources.

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