BJNRD (2016), 3(1): 32-38

Bhutan Journal of Natural Resources & Development

Article

www.bjnrd.org

Open Access

ISSN 2409–2797 (Print)
ISSN 2409–5273 (Online)

doi: http://dx.doi.org/10.17102/cnr.2016.06

Effect of Different Grazing Regimes on the Growth of *Quercus semecarpifolia* Sm. Regeneration in Western Bhutan Himalaya (Thimphu)

Wangchuk[1] and Dhan B. Gurung[1]

Abstract

Temperate broadleaved forest of Bhutan is dominated by old-growth brown oaks (*Quercus semecarpifolia* Sm.) with a history of overgrazing. However, use of oak trees for firewood and practice of free range cattle grazing are being viewed as factors responsible for poor regeneration of *Q. semecarpifolia* in natural forests. Therefore, this research studied the response of oak seedlings under different grazing intensities in Chang and Dagala *Geogs* of Thimphu *Dzongkhag*. Three study sites of different grazing regimes (high, moderate and low) were identified using information from local people on the observed cattle number in forests around their communities. Three main plots of 20 m² were set up in each site. In every main plot, 10 sub plots of 4 m² were laid to measure the regeneration density and other parameters. There was a significant difference ($p < .05$) in seedling height and collar diameter between high, moderate and low grazing intensities. Grazing was strongly associated with shorter seedling height and increased seedling collar diameter. The lightly grazed area had a higher percentage of canopy cover (44.8%) followed by heavy (42.3%) and moderate grazing site (40.3%). Regeneration of *Q. semecarpifolia* was more in high canopy cover and controlled grazing sites.

Key words: Grazing, oak, regeneration, seedlings

Introduction

Free range grazing in natural forests by domestic cattle is an age-old tradition in Bhutan, which supports livelihood of rural people (Norbu, 2000). Broadleaved forests are widely preferred for cattle grazing due to availability of rich fodder resources. In 1980s and 1990s, the impact of forest grazing on regeneration had been a highly debated topic in Bhutan between conservation and livestock sector. Forest grazing reportedly has negative impacts on forest ecosystems such as soil erosion, depletion of nutrients, soil compaction, and soil acidification (Belsky and Blumenthal, 1997). Forest grazing damages tree through trampling and browsing and results in loss of species richness and diversity. Poor natural regeneration of *Quercus semecarpifolia* Sm. in temperate broadleaved forest is attributed to cattle grazing besides the influence on micro-environment (Sangay, 1997).

[1]Department of Forestry, College of Natural Resources, Royal University of Bhutan, Lobesa, Bhutan
Corresponding author: lekwang_1@yahoo.com

Received Oct. 2015, Accepted Mar. 2016

Forest grazing by cattle is sustainable if grazing intensity is controlled. Forest grazing can enhance tree growth by reducing the biomass of grasses and sedges, which otherwise outcompete tree seedlings (Belsky and Blumenthal 1997; Darabant *et al.,* 2007; Buffum *et al.,* 2008). Free range cattle grazing in broadleaved forest is an integral part of broadleaved forest management (Norbu, 2000). However, temperate broadleaved forest of Bhutan is predominated by oak species like *Quercus semecarpifolia* Sm., and *Q. lamellosa* Sm. Seedlings of these oak species are heavily browsed by cattle and wild ungulates, and the regeneration dynamics of such species are inadequately known. Some researchers have related the complex regeneration to cattle grazing (Norbu, 2000; Wangda and Ohsawa, 2006).

Understanding the effects of grazing on oak regeneration is vital to manage these forests sustainably. While a study on controlled plot (fenced) and free grazing (unfenced) was carried out by Tashi (2004) and Dorji (2012), no research has been conducted on the different grazing regimes (high, moderate, and low) in natural forest except for a grazing management in broadleaved forest by Norbu (2000). The study therefore, aims to evaluate the

effect of different grazing regimes on the regeneration of *Q. semecarpifolia* seedlings and associated species. An effort is also made to evaluate other parameters such as canopy closure and soil compactness which might affect regeneration.

Materials and Methods

Study Area

Three study sites with different grazing intensities in the temperate broadleaved forest of Thimphu *Dzongkhag* (district) in western Bhutan having similar physiographic and edaphic-climatic conditions were selected for the study. The study compared the regeneration dynamic of *Q. semecarpifolia* in three different grazing intensities defined by Tshering

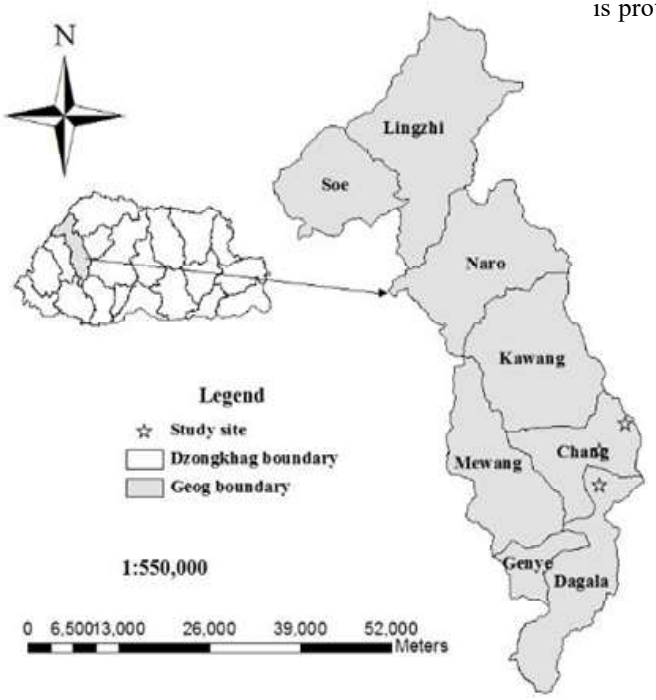

Figure 1. Map of the study site

(2005) as light, moderate, and heavy grazing (light – grazing by few stray cattle as indicated by no cattle droppings and few browsed seedlings, but without excluding wild animals; moderate – presence of cattle and wildlife foot prints < 2 and browsing; heavy – presence of cattle and wildlife foot prints > 2 and heavy browsing). To ascertain grazing pressure over these three sites, the cattle and yak population for last five years were retrieved from the Livestock Extension Office of the RNR-EC of Chang and Dagala *Geogs* (administrative blocks).

The Forest of Dagala geog (27°24'82"N, 89°42'263"E), which was handed over to local communities as Kachu Poenzshu Community Forest in the year 2010, is located at an altitude of 2850 to 3100 m above sea level. It is considered as a heavily grazed forest. The forest is under constant grazing pressure by local cattle during summer months and by yak during winter months. The second forest lies in vicinity of Tashigang Goenpa (27°28'991"N, 089°44'384"E), which was also handed over to Hongtsho Community as Hongtsho Tashi Pelkhil Community Forest in the year 2008. It lies approximately at an altitude of 2800 to 3980m and the forest is considered as moderately grazed by yaks and few cattle in winter months. The lightly grazed forest (27°27'9"N, 89°41'45"E) is located opposite to the Research Development Centre at Yusipang, which lies at an altitude of 2380 to 2900 m. The forest is protected as Royal hunting site and is grazed by few cattle. However, in all the three sites, grazing by wild animals cannot be excluded.

Inventory Method and Data Analysis

It was difficult to get a pure oak forest in the study sites. So, in this study we selected three oak dominated forests and laid three main plots of 20 x 20 m in each forest. In each main plot, 10 sub-plots of 4 x 4 m were laid systematically for regeneration survey in which the seedlings of all species were recorded. The recruits < 1.37 m height were considered as seedlings. Height, collar diameter, and approximate age of all the seedlings were recorded. Diameter at breast height (DBH) and height of all tree species were recorded. Soil compactness was measured using Push-Cone in millimetre (Soil hardness metre DIK-5553) and was further converted to kilo Pascal (kPa).

Basal (BA) area was calculated from DBH for each tree as cross-sectional area of the stem at breast height. Relative basal area (RBA in %) was calculated for each species by dividing the sum of BA of each species by total BA of all species in a plot, and used as the abundance measure of species in a community. These data were analysed using Pivot Table in Microsoft Excel.

Hemi View Camera was used to assist in reliable measurement of canopy opening and regeneration. In each plot, six hemi-pictures were taken (three in open and three in close canopy). The hemi-pictures obtained were analysed using CanopON 2 Software. SPSS was used to find relationship between variables like canopy cover percentage, soil compactness, slope percentage, and altitude.

Results and Discussion

During the last five years, cattle population in Dagala geog has reduced from 21% in 2010 to 9% in 2014, whereas the yak population increased from 14% in 2010 to 21% in 2014 (Table 1). There was no change in horse population though. In Chang geog however, the cattle population was concentrated in Hongtsho as the other half of the geog falls within the municipal area of Thimphu city. There was no change in cattle population, but the horse population vanished by 2012. Interviews with few elderly people of Hongtsho

Table 1. Livestock population (2010-2014) in Chang and Dagala geogs

Livestock	Dagala					Chang				
	2010	2011	2012	2013	2014	2010	2011	2012	2013	2014
Cattle	114	137	124	111	49	420	410	390	452	382
Yaks	1857	2951	2439	2830	2740	0	0	0	0	0
Horse	178	152	155	192	190	5	2	0	0	0

Source: RNR-EC, Chang & Dagala geogs

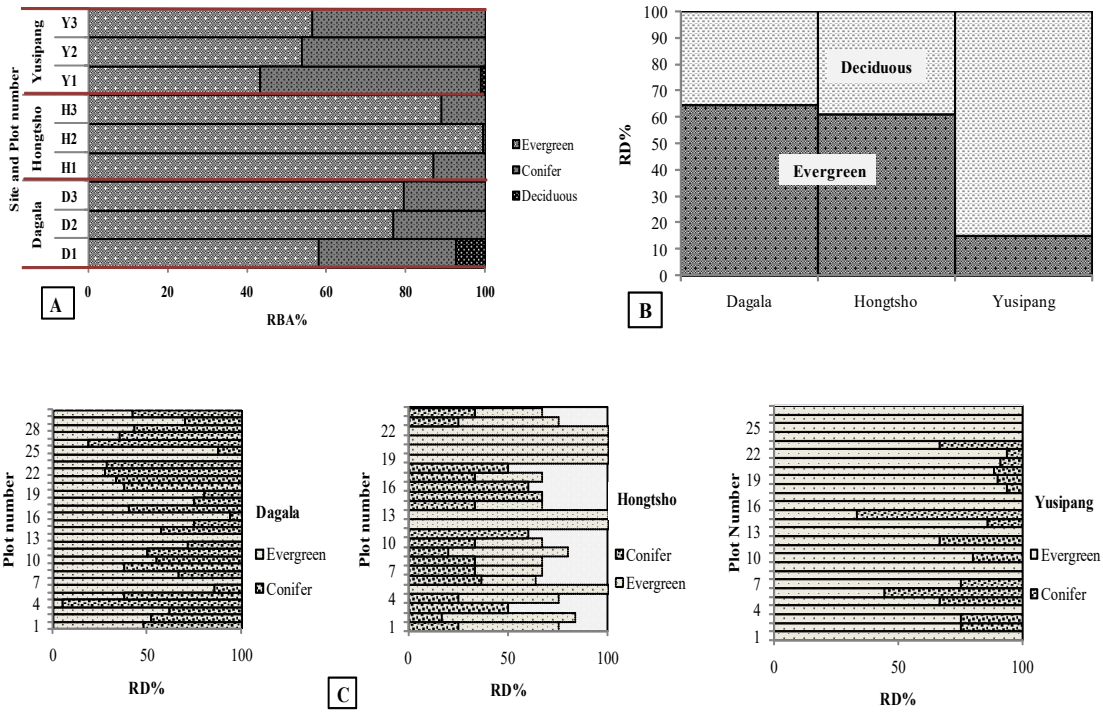

Figure 2. (A) Tree species life form, (B) Shrub species life form, (C) Regeneration

indicated that most people have changed cattle from local to improved breeds and they do not allow their cattle for free range grazing in the forest. However, as per the Community Forestry Management Group (CFMG) members of Hongtsho Tashi Pelkhil Community Forest, 50% of cattle still graze in the area during summer months. There are also few migratory herds of yaks from Dagala, which move down from alpine region and are allowed to graze in these localities every winter. However, there was no data on the population of yaks.

In Yusipang, there were few local cattle that belonged to an apple orchard caretaker near our study area. The area is very far from settlements and is protected as per the information provided by the Forest Beat In-charge of Hongtsho.

Floristic Compositions by Major Life Forms

A total of 12 tree species were recorded from three study sites. The species were grouped into three major life forms of evergreen, conifer, and deciduous species. Out of 12 species, 6 species were evergreen, 2 were conifers, and 2 were deciduous species. In all three sites, evergreen tree species, particularly *Q. semecarpifolia*, dominated the forests followed by conifer and few deciduous tree species (Figure 2). *Q. semecarpifolia* trees were found mixed with conifer species like *Tsuga dumosa* (Don) Eichler,

Picea spinulosa (Griff.) Henry, *Pinus wallichiana* Jacks, and *Rhododendron* spp. The tree seedlings comprised of nine species, and amongst these nine species *Q. semecarpifolia* had the highest relative density in all three grazing sites followed by *P. wallichiana* and *R. arboreum* (Table 2). Shrub vegetation consisted of 15 species, which was dominated by *Berberis* spp. and *Rosa* spp., with the tallest height of 4–6 m. The cover percentage of bamboo was higher in high grazing intensity site, but the bamboo's were all browsed and left with bare stems (Figure 3). Similar observations were made by Tashi (2004) and Dorji (2012) who mentioned that the cattle browsed bamboo, but it is only the leaves and soft tender shoots that were browsed and not the tough stems. The tough stems seemed to provide protection for the *Q. semecarpifolia* seedlings against trampling and browsing.

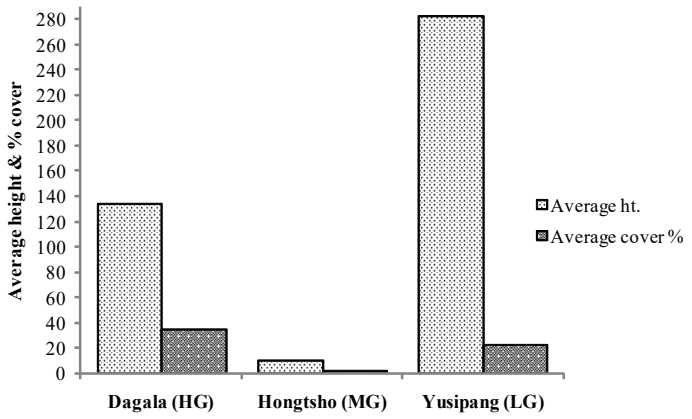

Figure 3. Mean height and cover percentage of bamboo in three sites

Effect of grazing and canopy cover on Q. semecarpifolia regeneration

Abundance of *Q. semecarpifolia* tree was similar in all the plots of the three study sites. However, matured stand was observed in moderate grazing site compared to two other sites based on the basal area and DBH class distribution of the species. Seedling abundance had relation to different grazing intensities. *Q. semecarpifolia* recruits were more abundant in lightly grazed area (Yusipang) compared to medium and heavily grazed sites indicating that the grazing had effect on the regeneration density of *Q. semecarpifolia*. Seedlings of *P. spinulosa* and *T. dumosa* were also found abundant in heavily and moderately grazed sites which

Table 2. Regeneration species composition (RD%)

Parameters	Dagala	Hongtsho	Yusipang
Altitude	2800	2870	2380
Aspect	SW	SW	NW
Slope (%)	38	45	40
Species richness(Nos.)	8	8	5
Max. Collar Dia (cm)	2.7	1.7	2.1
Max.Ht.(cm)	180	95	100
Regeneration plot (m²)	16	16	16
Conifer		**RD%**	
Tsuga dumosa	25.4	4.4	
Pinus wallichiana	12.2	11.7	13.9
Picea spinulosa	3.2	5.7	
Taxus baccata	2.1	3.9	
Juniperus recurva		0.8	
Sub total	**42.9**	**26.4**	**13.9**
Evergreen		**RD%**	
Quercus semecarpifolia	16.8	49.3	74.2
Ilex dipyrena	14.7	13.9	2.7
Rhododendron arboreum	14.6	10.3	2.7
Quercus glauca	11.0		6.5
Sub total	**57.1**	**73.6**	**86.1**
Grand Total	**100.0**	**100.0**	**100.0**

were usually browsed and trampled by cattle during seedling stage. As reported by Tenzin *et al*. (2008), heavy grazing tends to decrease the number of conifer regeneration due to browsing and trampling and removal of soil protective layer and soil compaction. Other researchers like Belsky *et al*. (1997) and Hester *et al.* (2000) found that grazing by livestock changes in tree species composition. The study conducted by Wangchuk (2002) showed that there is only a limited time for the cattle preferred species to grow as the area is grazed by cattle in summer and yaks in winter. Norbu (2002) reported that by February all palatable grasses and shrubs are either dried up or are eaten by cattle. Cattle wander into nearby forests looking for forage and this is the time when tree seedlings and saplings are either browsed or trampled.

Canopy cover of the sites were measured using hemispherical photographs and it was found that the lightly grazed area had a canopy cover of 44.8% (± 13.7 *SD*) followed by heavy (42.3% ± 11.9 *SD*) and moderate grazing site (40.3% ± 3.1*SD*). Canopy closure had an effect on regeneration of *Q. semecarpifolia*. The number of seedlings was more in high canopy cover compared to other two sites, which indicates that oak seedlings require shade during early age (Table 3). Similar results were also reported by Tashi (2004) and Veetas (2000).

Effect of soil sompactness on the Q. semecarpifolia regeneration

In our study sites, the compactness of soil increased with increasing grazing intensity. Compactness of soil was 226.2 kPa (± 19.2 *SD*) in high grazing site followed by 147.1 kPa (± 37.2 *SD*) in moderate grazing site, and 61.5 kPa (± 4.0 *SD*) in light grazing site (Table 3). Regeneration density decreased with increased grazing intensity. However, there was no significant difference in the density of seedlings in high and moderate grazing sites as these two sites were exposed to other disturbances like firewood collection. Density of seedlings was significantly higher in low grazing site, which may be explained by low compactness of soil besides less browsing (Figure 4).

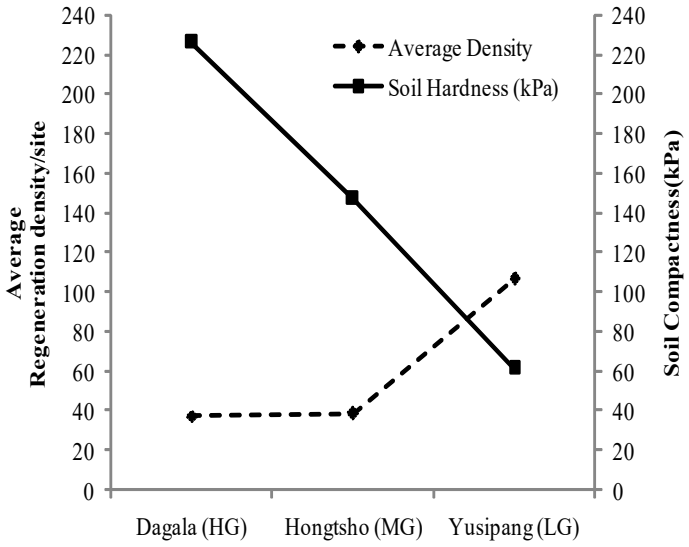

Figure 4. Soil compactness versus Q. semecarpifolia regeneration of three sites

Q. semecarpifolia seedling height and collar diameter in different grazing intensities

Height of seedling is a key parameter for determining the success of growth and establishment of natural regeneration of any seedling (Dorji, 2004). Growth of seedling height and collar diameter of *Q. semecarpifolia* for different grazing intensities was analysed. Mean height of *Q. semecarpifolia* seedlings in low grazing was highest (20 cm ± 18.76 *SD*) followed by moderate grazing site (11 cm ± 9.73 *SD*) and high grazing intensity (10 cm ± 3.74 *SD*). Mean seedling collar diameter was higher in moderate grazing intensity (0.50 cm ± 0.04 *SD*) followed by high grazing intensity (0.30 cm ± 0.20 *SD*) and low grazing intensity (0.29 cm ± 0.26 *SD*) (Table 4). Kruskal Wallis test among the three grazing intensity sites

Table 3. Mean canopy, soil compactness, and average *Q. semecarpifolia* seedlings in three sites

Grazing site	Mean Canopy %	Std.Deviation	Mean Soil compactness (kPa)	Std. Deviation	Mean Q.semecarpifolia seedlings/site
Dagala (HG)	42.3	11.9	226.2	19.2	38
Hongtsho (MG)	40.3	3.1	147.1	37.2	39
Yusipang (LG)	44.8	13.7	61.5	4.0	107

(HG) High Grazing, (MG) Moderate Grazing & (LG) Low Grazing

showed significant difference in seedlings height, $H(3) = 25.9$, $p < .05$ and collar diameter, $H(3) = 18.7$, $p < .05$. Pair wise comparison using Mann Whitney test between the moderate and low, and high and low grazing intensities indicated significant difference ($p < 0.01$) in both the seedling height and collar diameter. These results show that the grazing has impact on the growth in height and collar diameter of seedlings.

Height and collar diameters of *Q. semecarpifolia* seedlings were associated in all the grazing sites (Figure 5). The highest coefficient of determination was found in low grazed forest type with $R^2 = 0.835$ and lowest with $R^2 = 0.038$ in highly grazed forest. The medium grazed forest had $R^2 = 0.623$. There was positive association between the recruit heights and collar diameter in three different grazing intensities (Figure 5). However, association was higher in low grazing intensity site than in heavy and moderate grazing sites. This indicates that repeated grazing restricts height growth and expansion of collar diameter in high and moderate grazing sites, which will affect the transition from seedling to saplings stage. In a similar study by Adams *et al*. (2001) and Dorji (2012), seedling height and collar diameter increased in fenced seedlings than in unfenced seedlings, suggesting that mammalian herbivory may be an important factor affecting seedling survival. As per Turner (2001), herbivore mammals may eat the whole seedling before it becomes woody therefore

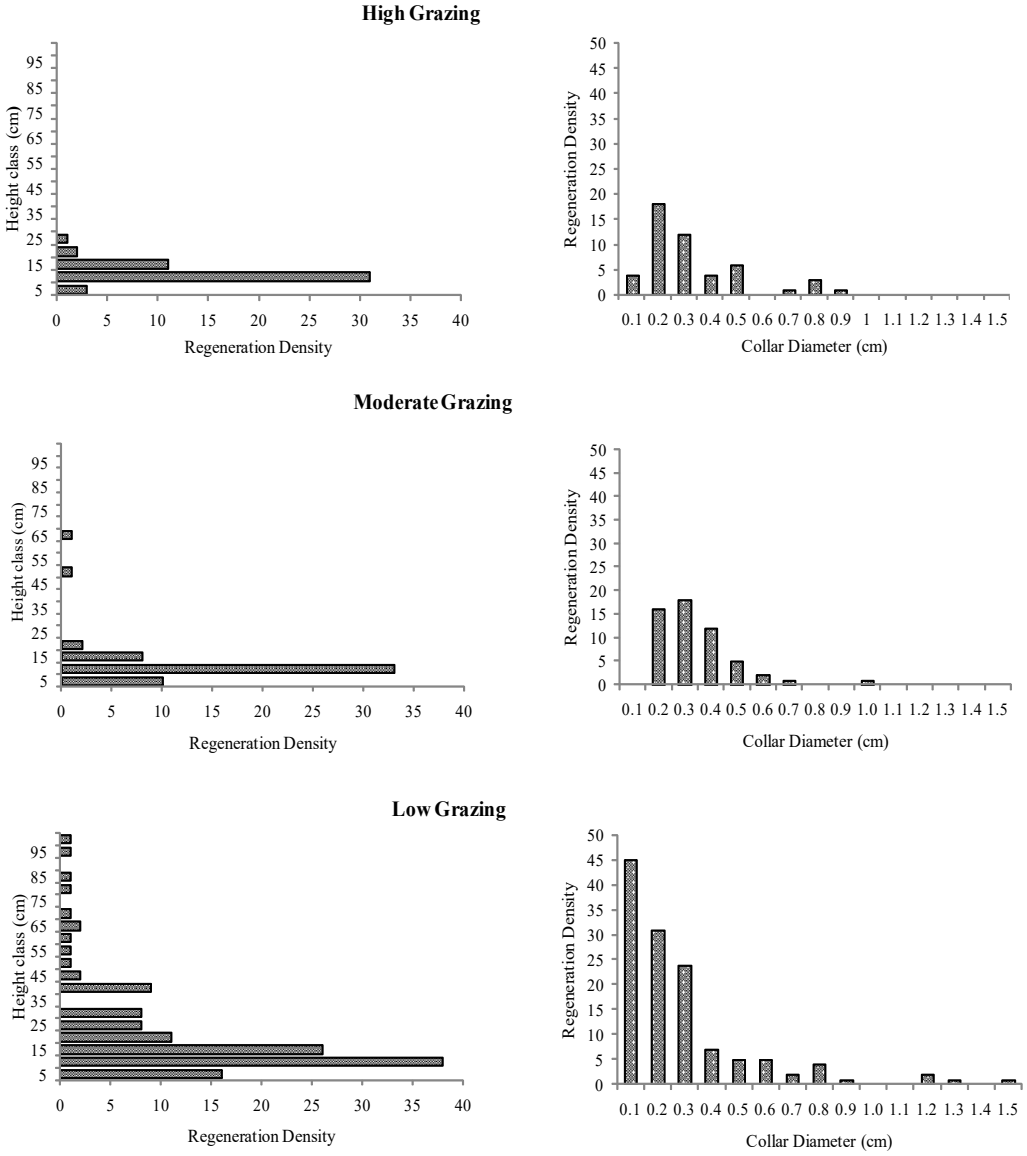

Figure 5. Height and collar diameter of *Q. semecarpifolia* seedlings in three sites

Table 4. Mean height and collar diameter of *Q. semecarpifolia* in three sites

Grazing Intensity	Mean height (cm)	*SD* (Height)	Mean collar dia (cm)	*SD* (collar)
High	10	3.74	0.30	0.20
Moderate	11	9.73	0.50	0.04
Low	20	18.76	0.29	0.26

exclusion of mammals from the forest significantly reduces seedlings mortality rates.

Conclusions

Regeneration of *Q. semecarpifolia* is complex and is attributed to many factors, among which grazing is one of the most important factors that affect growth of seedling height and collar diameter. Results from this study show that the successful regeneration of *Q. semecarpifolia* depend on canopy cover and low grazing intensity in early years of regeneration and seedling establishment. The study shows that grazing in moderation is beneficial for regeneration of *Q. semecarpifolia* seedlings. In Bhutanese context, where technological interventions in rugged mountain terrain is not possible, moderate grazing will continue to support the age old tradition of livestock rearing and prepares forest ground for regeneration. However, manipulation of canopy cover, which is equally important for regeneration, may have to be continued in the form of allowing controlled firewood collection and timber harvest. Since the study was conducted for *Q. semecarpifolia* in Thimphu only, similar studies for other broadleaved species spread over wider areas will be useful to understand the regeneration ecology of different species.

Acknowledgement

The authors would like to gratefully acknowledge Dr. Pema Wangda, Chief of the Watershed Management Division of the DOFPS, MOAF, for his advice in data analysis. We also would like to thank SFED for providing partial funding to this study and extend our gratitude to the two anonymous reviewers who commented on improving this paper.

References

Adams, A.S. and Rieske, L.K. (2001). Herbivory and Fire Influence White Oak (*Quercus alba* L.) Seedling Vigor.

Belsky, A.J. and Blumenthal, D.M. (1997). *Effects of livestock grazing on stand dynamics and soils in upland forests of the interior west*. Cambridge, UK.

Buffum, B., Gratzer, G. and Tenzin, Y. (2008). Forest grazing and natural regeneration in a late successional broadleaf community forest in Bhutan. *Mountain Research and Development,* 29:30-35.doi: http://dx.doi.org/10.1659/mrd.991.

Darabant, A., Rai, P.B., Tenzin, K., Roder, W. and Gratzer, G. (2007). Cattle grazing facilitates tree re-generation in a conifer forest with palatable bamboo understorey. *Forest Ecology and Management*, 252: 73-83. doi:10.1016/j.foreco.2007.06.018

Dorji, S. (2004). *Natural regeneration at cable crane logged sites in the mixed conifer belt of Gidakom Forest management unit.*

Hester, A.J., Edenius, L., Buttenschon, R.M. and Kuiters, A.T. (2000). Interactions between forests and herbivores: the role of controlled grazing experiments. *Oxford Journal,* 381-391.

Tenzin, K., Gratzer, G., Darabant, A. and Rai, P.B. (n.d.). *Conifer regeneration and herbaceous competition in a spruce-dominated mixed conifer forest in central Bhutan 17 years after salvage operations.*

Norbu, L. (2000). *Cattle grazing: an integral part of broadleaf forest management planning in Bhutan.* (Doctoral dissertation). Swiss Institute of Technology, Zurich, Switzerland.

Sangay. (1997). *Analysis of Silvicultural systems for the management of broadleaf hardwood forest in Bhutan- A case from Korila forest management unit (KFMU).* Unpublished MS thesis, University of British Columbia, Canada.

Tashi, S. (2004). *Regeneration of Quercus semecarpifolia Sm. in an Old Growth Forest under Gidakom FMU-Bhutan*. (MSc Dissertation) Forest Ecology and Forest Management**.** Department of Forestry, Wageningen University and Research Centrum, the Netherlands.

Turner, I.M. (2001). *The Ecology of Trees in the Tropical Rain Forest*. Cambridge University.

Vetaas, O.R., (2000). The effect of environmental factors on the regeneration of *Quercus semecarpifolia* Sm. in Central Himalaya, Nepal. *Plant ecology,* 146, 137-144.

Wangchuk, S. (2002). Grazing management in National parks and protected areas: Science, Socio- Economic and Legislation (Tenure). *Journal of Bhutan Studies*, 61-81.

Wangda, P. and Ohsawa, M. (2006). Structure and regeneration dynamics of dominant tree species along altitudinal gradient in a dry valley slopes of the Bhutan Himalaya. *Forest Ecology and Management*, 230:136-15.doi:10.1016/j.foreco.2006.04.027.