Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 5, No. 6, p. 99-106, 2014
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Investigating short-term grazing capacity changes in steppe and semi-steppe regions

Fariba Shahsavand[1], HosseinArzani[2], Ali Tavili[2], Mohammad Jafari[2], Shahram Khaliqi Sygarudi[2]

[1]*Department of Range Management, Science and Research Branch, Islamic Azad University, Tehran, Iran*

[2]*Faculty of Natural Resources, Tehran University, Tehran, Iran*

Article published on December 06, 2014

Key words: Grazing capacity, steppe and semi-steppe regions, range production, vegetation, soil.

Abstract

One of the important objectives of natural resources management is to determine the range production in order to specify the range capacity. Determining the grazing capacity of forage plants may be based on the annual growth or mean long-term capacity. Grazing capacity is more likely to be determined by the complicated factors of plant production and consumption. Short-term estimation of grazing capacity will be meaningless unless natural elements as well as management factors are completely to be considered. This study was conducted in both semi-steppe and steppe regions. Statistical results of short-term capacity determination indicate that Pashmakan, Vardasht and Akhcheh (semi steppe region) with 0.5, 0.2 and 0.1 livestock have the highest grazing capacity, respectively. In steppe region, results showed that Nemati with 0.45 livestock has the highest capacity whereas Khoshkrood and Kachalu have 0.05 and 0.03 livestock, respectively. This topic indicate that in semi-steppe regions, grazing capacity has been affected by the range production due to the fixed range area elements, grazing period and daily livestock needs. As the range production increases, grazing capacity is enhanced. High precipitation and vegetation of these rangelands, especially grasses lead to the increase of production. Studying the production in steppe regions shows that range production and vegetation in Nemati rangeland are of more appropriate conditions due to its correct management plans as compared to Khoshkrood and Kachalu. Thus, suitable or unsuitable range management and climatic variations are regarded as important elements which can considerably affect the plant composition, production and vegetation.

***Corresponding Author:** Fariba Shahsavand ✉ Fariba.shahsavand@yahoo.com

Introduction

Rangeland is accounted as one of the most important and valuable national resources in Iran. Although rangelands are of significant importance because of byproducts including medicinal, industrial and food products, wildlife, soil conservation, control and increase of underground water storage, air stylization and environment improvement as well as relative humidity increase, the most fundamental exploitation of rangelands is to supply livestock forage. It is obvious that such range exploitation requires the optimized management and planning while preserving them. In this regard, prerequisite of any agreement in Range Department is to respect the grazing capacity. American Association of Ranch Owners (1964) defined the grazing capacity as the probable number of livestock in the area without destroying the vegetation and its related resources. Grazing capacity is the maximum number of livestock which may graze in a specific rangeland in a given period without destroying the rangeland and the other related resources such as water and soil qualitatively and quantitatively (Moghadam, 2008).

Different Factors such as forage quality and quantity, allowable utilization, daily forage need and length of grazing period are effective in the estimation of grazing capacity. By ignoring any one, an unrealistic estimation of the number of animals may be achieved which cause the destruction of Rangeland or Loss of forage (Pouzesh,2012).

Grazing capacity investigation not only contributes to the development of rangeland, but also gives valuable information on the creation of various rangelands' ecologic conditions (water resources, fences, roads and folds). Distance to water resources, the other harmful plant issues, grazing exploitation and forage production have to be provided in order to investigate the grazing capacity. Generally, we believe that grazing capacity investigations must be conducted every ten years (Galt, 2000)

Utilization of rangeland based on grazing capacity, range readiness and rehabilitation of degraded areas can improve suitability of rangelands in the region for their sustainable utilization (Arzani *et al.*, 2012).

Steven (2009) has suggested that some of the most important effective factors in the number of livestock are the livestock type, the used grazing systems (continuous or controlled ones), used forage systems (few-year or one-year ones), forage types, cold and hot seasons, soil type, fertility and climate.

Randal (2005) stated that vegetation variation model has reflected the considerable decrease in the number of livestock. Considering grazing capacity determination methods, Galt *et al.* (2000) have introduced such significant issues as the selection of quantitative forage production region, slope coefficient and distance to water resources.

Kothmann and Hinnant (1992) have explained that in specific years, forage production was lower than the average of long-term forage production; therefore, annual grazing capacity is to be calculated for the livestock adaptation every year. Hacker (1992) proposed that a ranch owner should regulate his/ her own management policies on the basis of seasonal conditions. Dorga *et al.* (1994) have computed the range grazing capacity through measuring annual forage production changes in Barabengal, India for grazing the sheep. Perry (1977) believes that range capacity has to be determined and managed based on range tendency changes.

Pouzesh (2012) stated that the most important factors considered for the estimation of short-term grazing capacity are dry matter production, utilization level and2conditions, palatability and quality of species. Results showed that ignoring any of these factors, it offers incorrect estimates of the optimal number of animals in order to determine the grazing capacity.

In the present study, grazing capacity is calculated for one time during the grazing season which coincides

with the maximum growth of rangeland species. This causes more livestock entry into the rangeland during the grazing season and consequently, more degradation is occurred. Since it is not possible to measure the range production during the grazing season each year, it is necessary to measure it during the months of grazing season in a few years andaccordingly, the long-term grazing capacity of key range species could be computed (Najafi *et al.*, 2013). This study aims to compare short-term capacity changes in steppe and semi-steppe regions.

Materials and Methods

Case study

Steppe rangelands

Studied areas are located in 60 km north east of Saveh, Markazi province between50° 36° to 50° 45´eastern longitude and 35°24´ and 35° 32´northern latitude.According to the long-term statics of Synoptic station in Saveh, the mean annual precipitation and mean annual temperature are 200 mm and 19°c, respectively. The climate of area based on Domarten class is sandy and loamyclay. Case studies include:

1-Kachalu Rangeland: The site is located in 65km of East of the city. Mean height of the area is1125m above sea level and the meanannual precipitationisabout152mminaccordancewithDomarten classification. Vegetation type in this area is *Stipabarbata-Artemisia sieberi* and can be accounted as a winter pasture.

2-Nemati Rangeland: This rangeland is a part of winter pastures and for 6 months per year, it is grazed as rest-rotational with moderate grazing intensity. *Artemisia sieberi –Salsolalaricina* is the main species in this rangeland. Mid May is the time of livestock entrance to this area and the exit time is early November.

3- Khoshkrood Rangeland: The site is located in 56 km North East of Saveh. Mean height of area is 1405 m above sea level. Mean annual precipitation is about 190 mm per yearand based onDomarten classification,the climate is dry desert. Vegetation type in this area is *Noaeamucronata-Hultemiapersica* and can be accounted as a winter pasture.

Semi-steppe rangelands

1- Vardasht Rangeland: This site is located in SemiromSefli around Isfahan between 51° 39´ 1˝longitudeand 31° 36´30 ˝latitude. Meanheight of the area is 2503 m above sea level. Meanprecipitation is 491 mm. The dominant species is *Scariolaorientalis-Bromustomentellus* and it is among the ranges with the moderate temperature. The extent of area is 4590 hectares. Sheep and goat are the dominant livestock. Soil texture is sandy and it has a granular structure.

2- Pashmakan Rangeland: This site is located in SemiromOlia, Isfahan between 51° 30´ 14˝ eastern longitude and 31° 23´ 38˝northern latitude. Meanheight of the area is 2900 m above sea level and meanprecipitation is 681 mm. Dominant species of this area is *Astragalussusianus-Bromustomentellus* and it can be accounted as a rangeland with moderate temperature. This area includes 40500 hectares which constitutes 6 % of pastures in the province. Sheep is the dominant livestock and also, there are few goats in cattle. The soil texture in most of the area is sandy and loamy with limestone formations. The amount of Lime in the underground part is high but it is not a limiting factor.

3- Akhcheh Rangeland: This site is located in Fereidounshahr between 50°1´36˝ easternlongitude and 33°2 ´18˝ northernlatitude. Mean height of the area is 2800 mabove sea levelandthe mean precipitationis624mm. The dominant species is *Scariolaorientalis-Cousiniacylindracea* and isamong low-gradepastures. This type includes 1510 hectares inthearea and includes 0.02% ofpastures in the province. Sheep and goat are the dominant livestock.

Methodology

At first, a reference area in each site was selected. Next, sampling was carried out by a randomized systematic method in the reference areas. In steppe regions, 60 plots (2 m^2) were totally established along four transects of 400 m length and 100 m intervals. But in semi-steppe regions, 60 plots (1 m^2) were totally established along four transects of 200 m length and 20 m intervals.

Canopy cover percent of the species was measured in each plot. Production was measured by clip and weigh method for 25% of randomly selected plots. Production was also estimated for the other plots by a regression equation between canopy cover (percent) and production (kg ha^{-1}).It was estimated only for the species used by livestock.

To determine the grazing capacity of each rangeland, the following equation is applied:

$$A.U = \frac{\text{Available forage in site} \times \text{Area (ha)}}{\text{Daily forageneed} \times \text{length of grazing period}} \quad (1)$$

To calculate the amount of livestock available forage, the following equationis utilized.

Available forage= allowable use or palatability × production (2)

In above equation,by comparing the coefficient of allowable use and palatability, the smaller coefficient is used in the calculations (Holechek *et al.*, 2004). Length of grazing period in each site was considered as 120 days according to Range Management Plan of each study area.To determine the metabolic energy requirements of livestock,the method suggested by Maff (1984) was used.

A corrected coefficient is added to the calculated energy value according to the vegetation distribution and distance travelled by the livestock from the rangeland to trough and from fold to rangeland. In semi-steppe rangelands, this coefficient has been estimated as 30 and 40% for Vardasht, Pashmakan and Akhcheh, respectively whereas it was given as 50% for Nemati, Khoshkrood and Kachalu in steppe regions. With respect to daily need of livestock and average metabolic energy existing in 1 kg forage, the forage necessary for supplying the daily needs of livestock has been estimated.

All data collected from the sites were analyzed by SAS software followed by one-way analysis of variance (ANOVA) and mean comparisons were performed by Duncan Multiple Range Test.

Results

Allowable use

Usable forage (kg ha^{-1}) = Y*(AU or P)

WhereY is the forage production value (kgha^{-1}). AU and P are the allowable use and palatability, respectively. In above equation, smaller coefficient is regarded in the calculations by comparing the allowableuse and palatability. One of effective elements in range capacity is given as available production achieved by specifying the allowableuse in each region.Determination of allowable use is shown in table (1) according to the conditions, trends and the suitability of erosion for sheep.

Table 1. Determination of allowableutilization according to conditions, trends and suitability of erosion for sheep.

Namber of Type	type	Erosion class	Rangeland condition	Trend	Allowable use
Vardasht	*Sc.or-Br.to*	S3	medium	Fixed	20%
Pashmakan	*As.su-Br.to*	S2	medium	Fixed	25%
Akhcheh	*Sc.or-Co.cy*	S2	medium	Fixed	25%
Nemati	*Ar.si-St.ho*	S2	good	Positive	25%

Khoshkrud	*No.mu-Hu.pe*	S2	weak	Fixed	15%
Kachalu	*St.ba-Ar.si*	S3	weak	Negative	10%

Available production

Based on table (1), the highest production value can be related to semi-steppe rangelands. Total range production for every studied site has been presented as palatability classes of I, II and III in the mentioned table. As it has been seen already, the highest production value estimated as 330 kg ha^{-1} in semi-steppe regions can be attributed to Pashmakan site. Accordingly, the highest available forage value given as 80 kg ha^{-1} (regarding available forage related to all the plants with a variety of palatability classes) is attributed to the above-mentioned site.

Also, in table (1), total production of steppe rangelands for each studied habitat has been separately presented as palatability classes of I, II and III. The highest production value computed as 270kg ha^{-1}in steppe rangelands has been given for Nemati site. The highest available forage as 67kg ha^{-1} (regarding available forage related to all the plants with a variety of palatability classes) is attributed to the above-mentioned site.

Daily livestock need

Daily need of livestock in the studied sites has been estimated by the means of daily required metabolic energy and the equation suggested by Maff (1984) (table 2).A corrected coefficient is added to the calculated energy value according to the vegetation distribution and distance travelled by the livestock from the rangeland to trough and from fold to rangeland.In semi-steppe rangelands, this coefficient has been estimated as 30 and 40% for Vardasht, Pashmakan and Akhcheh, respectively whereas it was given as 50% for Nemati, Khoshkrood and Kachalu in steppe regions. With respect to daily need of livestock and average metabolic energy existing in 1 kg forage (table 9-4), the forage necessary for supplying the daily needs of livestock has been estimated (table 2).

Table 2. Comparison of metabolic energy estimation and daily need of sheep in steppe and semi-steppe rangelands.

Area	Mean weight of animal (kg)	Daily metabolic energy (MJ)	energy in 1 kg forage (Mj)	Dailyforage need (kg)
Vardasht	32.49	84.8	6.54	1.35
Pashmakan	32.49	52.9	6.84	1.4
Akhcheh	50	52.9	6.2	1.53
Nemati	45	45.9	5.87	1.75
Khoshkrood	55.44	2.10	4.99	2.04
Kachalu	55.44	2.10	5.82	2.5

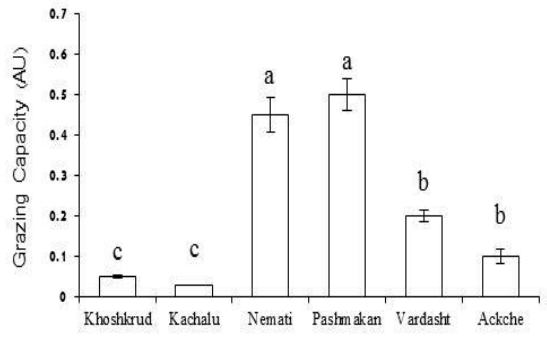

Fig. 1. Comparison of short-term capacity of steppe and semi-steppe sites (steppe rangelands: Khoshkrood, Kachalu and Nemati and semi-steppe ones: Pashmakan, Vardasht and Akhcheh).

Results of above table show that daily need of livestock in steppe rangelands is more than semi-steppe ones and it has lower values of plants existing in semi-steppe rangelands with regard to the forage quality and metabolic energy existing in the forage so that mean daily need of livestock may be reported as

2.09 and 1.42kg ha^{-1} for steppe and semi-steppe rangelands, respectively.

Grazing capacity

In order to calculate the grazing capacity, the capacity of studied rangelands have been computed as 0.3, 0.5 and 0.3 livestock concerning the grazing period and range area in a 4 month grazing period. The highest and lowest values are related to Pashmakan and Vardasht along with Akhcheh, respectively. Regarding climatic characteristics of each region and better plant composition, the areas necessary for grazing one livestock in a grazing season are given as 3.55, 2.02 and 5.38 ha forVardasht, Pashmakan andAkhcheh, respectively. The area of Pashmakan is less than Vardasht and Akhcheh (table 3).

Table 3. Short-term grazing capacity of steppe and semi-steppe rangelands (Isfahan and Markazi provinces).

Region	Site	Area (ha)	Allowable utilization	Production	Production (ha)			Available forage (kg ha^{-1})			Metabolic energy in 1 kg forage			Available metabolic energy	Daily livestock need	Grazing capacity / number of livestock	Area for grazing one livestock
					Class I	Class II	Class III	Class I	Class II	Class III	Class I	Class II	Class III				
Semi-steppe	Vardasht	4590	20	232.99	110.48	71.81	53.7	22.09	11.7	12.74	7.55	5.87	6.29	315.93	8.84	0.2	3.55
	Pashmakan	40500	25	331.81	220.28	42.71	68.82	55.07	10.67	17.2	7.47	6.2	6.67	592.24	9.52	0.5	2.02
	Akhcheh	1510	25	137.05	85.42	6.18	44.82	21.35	1.54	11.2	7.59	6.18	5.88	237.4	9.52	0.1	5.38
Steppe	Nemati	4500	25	270.83	-	227.82	43.01	-	56.95	10.75	-	7.61	5.42	491.64	9.45	0.45	1.94
	Khoshkrood	330.6	15	71.95	-	16.93	55.02	-	2.53	8.25	-	5.33	4.93	54.15	10.2	0.05	17
	Kachalu	813.2	10	66.42	-	51.32	15.1	-	5.13	1.51	-	5.87	5.12	37.84	10.2	0.03	30

In steppe rangelands, the grazing capacity of Nemati, Khoshkrood and Kachalu is 0.5, 0.05 and 0.03 livestock per hectare, respectively. The highest and lowest ones are attributed to Nemati and Kachalu.Accordingly, the area necessary for grazing one livestock in a grazing season are given as1.94, 17 and 30 ha for Nemati, Khoshkrood and Kachalu.

Comparison of short-term capacity of steppe and semi-steppe sites

Results achieved by analysis of variance indicated that there is a significant difference between the habitats of steppe and semi-steppe regions regarding short-term capacity. Based on the results, the highest grazing capacity value as 0.5 livestock per hectare can be given for Pashmakan and Nemati rangelands. The lowest one is related to Kachalu and Khoshkrood.

Discussion

Range grazing capacity is influenced by many factors including available production (regarding the allowed utilization and forage quality), grazing period, daily livestock need and range types area (Holechek, 2001).

Given these factors, function of climate and the other factors that are changing, the calculation of grazing capacity in a one year grazing period is not advisable for the coming years (Pouzesh, 2012).

It has been shown that such elements as available production is to be affected by the allowable use and also, daily livestock need is more likely to influence the grazing capacity. Voorthuizen (1978) reported that production may be regarded as one of the grazing capacity determinants.

Results demonstrate that in semi-steppe rangelands, grazing capacity is affected by the range production due to the fixed elements of range area, grazing period and daily livestock need. As the range production increases, the grazing capacity is enhanced. More precipitation and vegetation, especially grasses result in the increase of production. Mean production values are 230 and 110 kg ha^{-1} in semi-steppe and steppe rangelands, respectively. SharifiJelodar (2009) has mentioned the positive effects of precipitation on the production variations. In this respect, Arzani (2007) studied the relationship between production and canopy cover in three shrubbery and meadow habitats and observed a close relationship between the canopy cover of all species and production.

Production and grazing capacity variations in semi-steppe rangelands can be more than steppe ones. In these regions, range plant composition is usually composed of forbs and grasses but in steppe regions, bushes with deep roots and the capability of underground humidity consumption in the droughts are the dominant in the plant composition. Thus, production variations in steppe regions may be less than semi-steppe and humid ones so that the control and determination of their capacity is of lower sensitivity. Accordingly, it is suggested that in semi-steppe rangelands, range capacity is to be determined on the basis of long-term range production (Moghadam, 2008).

Studying the production in 2011 (short-term) in steppe regions demonstrated that production and vegetation in Nemati rangeland are better than Khoshkrood and Kachalu due to appropriate and accurate management plans. In Nemati site, implementing a suitable grazing program (delayed periodic grazing system with moderate grazing) led to a better situation for different species so that *Salsolalaricina* species was of considerable production.

Therefore, appropriate or inappropriate range management and climatic changes are important elements which are able to affect the plant composition, production and vegetation considerably.

Arzani (1994) reviewed the short-term and long-term estimations of grazing capacity and reported that using statistics and climatic data, long-term productionmay be estimated.

Diaz- Soils *et al.* (2006) achieved the sustainable balance between livestock production and rangeland health while number of livestock should be dynamic.

Although data and graphs have presented the grazing capacity of each region, number of livestock existing in the rangeland is calculated more than the grazing capacity in the studied rangelands, especially steppe rangelands (Khoshkrood and Kachalu); in other words, it leads to the instability of ecosystem in a long-term period.

Arzani *et al.* (2006) stated that low productivity, early grazing, out-of-season and over- grazing of rangeland, abundance of poisonous plants and invading of nearby villages and water resources resulted in the reduced forage production and suitability.

Conclusion

Results indicate that in semi-steppe regions, grazing capacity has been affected by the range production due to the fixed range area elements, grazing period and daily livestock needs. As the range production increases, grazing capacity is enhanced. High precipitation and vegetation of these rangelands, especially grasses lead to the increase of production. Production and grazing capacity variations in semi-steppe rangelands can be more than steppe ones. In these regions, range plant composition is mainly consisted of forbs and grasses but in steppe regions, shrub which have deep roots and are able to consume the underground moisture in the droughts are dominant in the plant composition. Therefore, production variation in steppe regions is lower than steppe and humid ones so that their control and capacity determination are of lower sensitivity. Studying the production in steppe regions shows that range production and vegetation in Nemati rangeland are of more appropriate conditions due to its correct management plans as compared to Khoshkrood and Kachalu. Thus, suitable or unsuitable range management and climatic variations are regarded as important elements which can considerably affect the plant composition, production and vegetation.

Acknowledgements

The authors would like toacknowledge from AlirezaEftekhari and SedighehZarekia for their assistance in field surveys.

References

Pouzesh H. 2012. Comparing of two methods and assessment of short-term grazing capacity in

Taleghan summer rangelands,Annals of Biological Research, **3 (10),** 4865-4873

Arzani H, Nourian B, Tavili A, Alikhani S. 2012. Sustainable Sheep Grazing Based On Range Suitability Classes *OIDA*. International Journal of Sustainable Development 05: 01

Holechek JL, Pieper RD, Herbel CH. 2004. Range management: principles and practices. 5th ed. Upper Saddle River, NJ: Printice-Hall. Inc.607p.

Moghadam M. 2008. Range & range management, 5 Th Edition, Uiniversity of Tehran press, p 470.

NajafiK, Zandi E, Ramezani M. 2013. Monthly and annual changes of forage production and consumption of Cymbopogonolivieri (Boiss) Bor., Case study: Genou-Hormozgan Province, Iran. International Journal of Biosciences. **3(11),** 20-27

Diaz-Solis H, Kothmann M.M, Grant WE, De Luna-Villarreal R.2006. Agricultural Systems, **88,** 514–527.

Arzani H, Jankju M, Shams H, Mohtashamnia S. 2006. Journal of sciences and techniques of agricultural and natural resources, **10(1),** 273-289.

Steven H. 2009. Sheep Grazing Management. Virginia Cooperative Extension.Umberger, Animal Scientist, Sheep, Virginia Tech, Produced by Communication and Marketing, College of Agriculture and Life Sciences, Polytechnic Institute and State University, Publication, 410-366.

Randall B, Boon. 2005. Quantifying Changes in Vegetation in Shrinking Grazing Areas in Africa, Conservation and Society, **3(1),** 150-173.

Kothmann MM, Hinnant RT. 1992. A carrying capacity model for grazing management (Appendix II), Forecasting carrying capacity: an approach to drought management (Appendix III), Relative to: Grazing Management Stock Adjustments

Maff. 1984. Energy Allowances and Food system for Ruminants. ADAS Reference Book 433. HMSO, London.

Arzani H. 1994. Some aspects of estimating short term and long term rangeland carrying capacity in the western division of New South Wals. Ph.D. Thesis, University of New South Wals, Australia, 379p.

Galt D, Molinar F, Navarro J, Joseph J, Holechek J. 2000. Grazing Capacity and Stocking Rate. Rangelands, **22(6)**, 7-11.

Hacker R, Beurle D, Gardiner G. 1992. Monitoring Western Australia's Rangelands, in "Rangeland Management in Western Australia", Department of Agriculture, Western Australia, and Miscellaneous publication 8/92, pp. 15-20.

Holechek JL, Galt D, Navarro J. 2001. What s the trend? Rangeland, **23(3),** 10-13.

Voorthuizen EG. 1978. Global desertification and rang management: an appraisal. Journal of Rangeland Management **31,** 378-380.

Perry LJ, chapman. 1975. Effects of clipping on dry matter yields of Basin wildrye. Journal of Range Management, **28(4),**271-274.