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GRASS PRODUCTIVITY AND CARRYING CAPACITY OF THE CHOLISTAN DESERT RANGELANDS

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Abstract

Cholistan desert is hot and an arid rangeland located in the southern Punjab, Pakistan. The wet season lasts from June to September, whereas dry season falls from October to January with seasonal and annual variation in rainfall and temperature. The monthly sampling over 2 year's period was carried to determine the grass productivity from 20 sites during 2010-12. The average dry biomass production of grasses was 263.22 Kg/ha during the dry season, whereas the same was 370.22 kg/ha in wet season. The maximum carrying capacity (17.25 ha/AU/year) was observed in the wet season, while the same was the lowest (24.2 ha/AU/year) during the dry season. Based on the results, it is concluded that the Cholistan rangeland is degraded due to overgrazing resulting into reduction in biomass production especially during the dry season coupled with the removal of palatable species from the whole rangeland. There is need to manage proper stocking rate during the growing season along with the introduction of high yielding livestock breeds that may help to reduce grazing pressure and improve productivity.

Key words: Grass productivity, Carrying capacity, Biomass production, palatable species, Cholistan desert, Livestock breed.

Introduction

Pakistan has a wealth of 135 million heads of livestock which account for 10.8% of the GDP. Nutritional requirements of these animals are mainly met through fodder crops and agro-industrial wastes. The sustainable use of rangelands is vital for the development of national economy. Overgrazing of rangelands, depletion of vegetation cover, shortage of forage and fodder resources and poor livelihood of pastoral communities as influenced by the fragile environment are some of the major issues and for the food security in the country (Anon., 2005)**.**

Biomass means the total quantity or weight of organisms in a volume or given area. According to Bonham (1989), composition of vegetation based on dry weight is the best indicators of species importance within a floral community. Biomass production is influenced by major factors like temperature, microbial activity, moisture content, photosynthesis and available nutrients. Biomass measurements are of great importance to rangeland managers as it presents a quantitative evaluation of production of dry matter over a period of time (Scholes & Baker, 1993). Measurements of biomass in all seasons are very helpful for range managers to know about the forage availability in the different seasons and this information is compulsory for estimating the carrying capacity of any area. Measuring the biomass also provides insights about forage utilization by grazing animals (Alemayehu, 2006).

Livestock production in the rangelands of desert regions depends entirely on rangeland forages whose quality and productivity varies tremendously, with wet or rainy season being characterized by high abundance of herbage as compared to scarce feeds during dry seasons (Otsyina *et al*., 1997). Rangeland quality largely dictates animal productivity response and thus it becomes vital to match sustainable feed resources from rangelands without deterioration of the ecosystems through appropriate rangeland management schemes. In most sub-tropical regions, ruminant production is mostly limited by lack of fodder availability in the dry season (Rubanza, 1999).

The Cholistan rangelands are also under severe threat of degradation due to overgrazing and extreme climatic conditions. Due to continuous grazing, the desirable palatable species are disappearing at an alarming rate and relatively non-palatable species are dominating and spreading the entire desert. The extent of problem can be seen from the fact that highly desirable grass species have vanished from most part of the Cholistan rangelands (Arshad *et al*., 1999; Akhtar & Arshad, 2006). No other reference especially on the productivity of grass species from Cholistan rangeland is available. It is obvious that any future management planning definitely requires a baseline data about the existing rangeland productivity (Farooq *et al*., 2008). The present study was therefore, aimed to assess the existing grass productivity to help range managers and ecologists in their future studies and management of this and other similar rangelands.

Material and Methods

Study site: The current study was carried out in the Cholistan desert that is located in South-West of Punjab province (Pakistan). This desert is an extension of Great Indian Desert and lies between latitudes 27º 42' and 29º 45' North and longitudes 69º 52' and 75º 24' east (Baig *et al*., 1980). The total land area of Cholistan desert is about 2.6 million hectares (Anon., 1993), and has a length of about 480 km and width differ from 32 to 192 km (Khan, 1987). Based on parent material, topography, soil and vegetation, the whole desert can be separated into two geomorphic regions. Lesser Cholistan or northern region bordered by canal irrigated areas and covers about 7,770 km^2 and Greater Cholistan or southern region is comprised of 18,130 km^2 (Chaudhry, 1992).

Cholistan is one of the hottest deserts in Pakistan. The climate of the study area is hot arid with rainfall being the major factor influencing the life of local people as well as livestock. Temperatures are high in summer and mild in winter with no frost. In summer, temperature may reach to more than 51ºC and in winter it drops down below freezing point (Hameed *et al*., 2002; Arshad *et al*., 2008). May and June are the hottest months with mean temperature 34ºC. Average annual rainfall varies from 100 mm to 200 mm. Most of the rainfall is received during monsoon (July-September) but winter rains (January-March) are also common (Arshad *et al*., 2006). Due to scanty and unpredictable rainfall along with long spells of droughts, water is a limited factor in Cholistan desert. Aridity is the most striking characteristic of the area with dry and wet years occurring in clusters (Akhter & Arshad, 2006). The vegetation of Cholistan desert comprises of wide variety of xerophytes. These drought tolerant species are well adapted to severe seasonal temperature, moisture instability and large variety of edaphic conditions. The soil physio-chemical composition is playing a significant role in vegetation distribution in the area (Chaudhary, 1992; Arshad & Akbar, 2002). Fortunately, a wide range of nutritious species of grasses, shrubs and trees occupy the entire desert. Even these plant species are slow growing but respond very well under favorable climatic conditions and provide abundant biomass for livestock consumption. Significant genera of grasses include *Cenchrus*, *Panicum* and *Lasiurus* while important genera of browses include *Calligonum*, *Haloxylon*, *Prosopis*, *Zizyphus* and *Acacia*. The same species are reported from the Nara Desert, Pakistan (Qureshi, 2008; Qureshi & Bhatti, 2005; 2008; Qureshi *et al.*, 2009). Each site is represented by typical plant species based on availability of soil moisture, salinity and plant characteristics (Naz, 2011).

Biomass production of range grasses: Several reconnaissance surveys of Cholistan desert were conducted on a Suzuki jeep during 2009-2010. Twenty sites were selected on the basis of visual homogeneity of vegetation and physiognomic features of the studied areas. For the measurement of standing phytomass production of grasses, 1×1 m^2 square quadrate was systematically placed at regular interval of 10 m. The data was collected during the wet season and dry season. The vegetation found inside each quadrate was clipped, and the unpalatable plants were discarded. The samples were packed in the labeled bags and fresh biomass was calculated at the spot. Further, the oven dry weight was calculated after drying the samples at 65ºC for 72 hours in the laboratory. The total phytomass of grasses in the study area was obtained by summing up the dry matter production from all the study sites, then averaged and converted in to kg/ha (Bonham, 1989). Grazing status at each range site was noted by direct observations in the field, confirmed by grazers and nomadic people of particular area and categorized into slightly grazed, moderately grazed and over-grazed sites.

Carrying capacity: A straight forward approach to determine the number of animals the management unit can support over a period of time is to divide the total forage biomass (i.e., forage supply) by the total amount of forage consumed by a grazing animal during the grazing period (i.e., forage demand) (Workman & MacPherson, 1973). Calculations based on long-term average forage production provide an appraisal of carrying capacity, whereas existing forage levels give an estimate of shorter term stocking rates. Carrying capacity was calculated on the basis of 40% allowable grazing material. The one animal unit (AU) was taken as, a cow having 350 kg weight, demanding 7 kg dry matter forage per day, 2555 kg/year (Bonham, 1989). Carrying capacity was measured by using following formula.

$$\text{Carrying capacity (ha/AU/y)} = \frac{\text{Animal forage requirement kg /year}}{\text{Available forage kg /ha}}$$

Results and Discussion

The grass biomass yield and grazing status of 20 selected sites is presented in Table 1. Maximum dry biomass production was recorded from Chahbariwala toba (384 kg/ha) and the lowest from Qila derawer (207 kg/ha). In the investigated area, three range habitats viz., sand dune, interdunal area and flat land (clayey saline) have been recognized. During the dry season, mean maximum biomass production was recorded from interdunal range sites (304.5kg/ha), followed by sand dune (259 kg/ha) and flat land (226.2 kg/ha) with a mean of 263.2 kg/ha (Table 2). From the interdunal sites, maximum dry biomass production was recorded from Chahbari wala toba (384 kg/ha), while the lowest one from Bari wala (234 kg/ha). In the flat range sites, maximum biomass production was recorded in Kora khu (258 kg/ha), followed by Chanan pir (228 kg/ha), Mansoora (212 kg/ha) and Qila derawer (207 kg/ha). On the other hand, maximum dry biomass production from the sand dune sites was recorded from Khanser (300 kg/ha), followed by Khirsar (269 kg/ha), Qila derawer (253 kg/ha) and Qemma wala toba (214 kg/ha). During the dry season, 13 (65%) studied sites were observed as overgrazed, followed by moderately grazed (6 sites, 30%), while only1 site (5%) was slightly grazed (Table 1.

During the wet season, maximum dry biomass production was recorded from Dhori (543 kg/ha) and the lowest one from Chanan pir (236 kg/ha). The mean maximum biomass production was recorded from interdunal range sites (453.16 kg/ha), followed by sand dune (354.75 kg/ha) and flat land (302.75 kg/ha). The mean biomass production from all 20 sites during wet season (370.22 kg/ha) was much higher than that of dry season (i.e. 263.2 kg/ha). The maximum dry biomass production of grasses among the interdunal sites was recorded in Dhori (543 kg/ha) and minimum was recorded from Toba Sawan wala (376 kg/ha). Maximum dry biomass production among sandunal sites was recorded in Qemma wala toba (380kg/ha), followed by Qila derawer (356 kg/ha), Khanser (347 kg/ha) and Khirsar (336 kg/ha). From the flatland areas, maximum biomass production was recorded in Kora khu (338 kg/ha), followed by Qila derawer (329 kg/ha), Mansoora (308 kg/ha) and Chanan pir (236 kg/ha). During the wet season, 10 (50%) stands were observed to be of moderately grazed, followed by overgrazed stands (30%) and then slightly grazed stands (20%) as shown in Table 1.

The evaluation of carrying capacity is a vital part of rangeland inventory and monitoring studies because it is the most important management tool to ensure the sustainable use of natural resources. It provides the number of grazing animals as a management unit that is able to support rangeland vegetation and soil resources without depletion (Quraishi *et al.*, 1993). Since, the Cholistan desert is a degraded rangeland, so the studies on the productive potential of its rangelands are essential in order to make a plan for its sustainable development. The aim of this study was to analyze the effect of seasonal changes on grazing capacity from three different range habitats of Cholistan desert. In present study, carrying capacity was calculated in both dry and wet season based on grass biomass production. The average carrying capacity in dry season was calculated as 24.2 ha/AU/y. The highest carrying capacity was reported from interdunal habitat (20.98 ha/AU/y), followed by sand dune habitat (24.66 ha/AU/y) and flatland habitat (28.2 ha/AU/y) as shown in Table 2. The interdunal areas showed good potential for biomass production and hence there was the highest stocking rate as compared to other two range sites. The stocking rate during dry season was calculated as 0.041 AU/ha/year. The total land area of Cholistan desert is 2.6 million hectare, out of which 1300000 ha is considered as rangelands. Hence, Cholistan rangelands can support various animal units such as63193 cow, 315968 sheep, 210645 goats and 35107 camels during the dry season. The average carrying capacity during wet season was recorded 17.25 ha/AU/y. The average carrying capacity was 14.1 ha/AU/y in interdunal area, 18 ha/AU/y in sand dune and 21.1 ha/AU/y in flatland area as shown in Table 2. The interdunal areas showed good potential for biomass production and hence there was highest stocking rate in this range as compared to other two range sites. During the wet season, stocking rate was calculated as 0.057 AU/ha/year. Moreover in this season, these rangelands can support 91178 animal units of cow, 455890 sheep, 303926 goats and 50654 camels.

Table 1. Seasonal biomass production (kg/ha) and grazing status of range sites of the Cholistan desert.

Sr. #	Name of site	Topography	Dry season		Grazing status	Wet season		Grazing status
			Fresh	Dry		Fresh	Dry	
1.	Mouj garh	Interdunal	537±1.55	274±0.15	Overgrazed	730±1.35	455±0.35	Moderately grazed
2.	Dingarh	Interdunal	610±0.38	310 ±0.43	Moderately grazed	900±0.30	491±0.48	Slightly grazed
3.	Chahnagra	Interdunal	425±0.12	259±1.37	Overgrazed	793±0.19	381±2.37	Moderately grazed
4.	Jinde wala toba	Interdunal	599±7.4	308±1.85	Moderately grazed	756±3.42	401±2.85	Moderately grazed
5.	Chabari wala toba	Interdunal	663±1.38	384±0.49	Moderately grazed	756±1.30	433±3.08	Moderately grazed
6.	Dhori	Interdunal	568±4.99	280±0.11	Moderately grazed	980±2.99	543±0.8	Slightly grazed
7.	Khokarawala toba	Interdunal	463±0.92	296±5.02	Overgrazed	856±1.92	457±3.0	Moderately grazed
8.	Bari wala	Interdunal	403 ±0.61	234±3.65	Overgrazed	755±1.61	389±2.05	Moderately grazed
9.	Toba sawan wala	Interdunal	675±0.02	373±2.65	Moderately grazed	704±1.02	376±2.5	Overgrazed
10.	Khavetal	Interdunal	669±0.03	356±0.88	Slightly grazed	877±1.03	563±1.88	Slightly grazed
11.	Thandi khoe	Interdunal	650±1.67	282±0.33	Moderately grazed	932±1.60	536±1.33	Slightly grazed
12.	Chanan pir	Interdunal	572 ±2.86	298±0.07	Overgrazed	731±1.80	413±1.05	Moderately grazed
	Average		**569.5**	**304.5**		**814.2**	**453.2**	
13.	Kora khu	Flat land	464±0.11	258 ±0.05	Overgrazed	587±0.18	338±1.05	Overgrazed
14.	Chanan pir	Flat land	338±0.05	228±2.36	Overgrazed	521.5±0.5	236±2.03	Overgrazed
15.	Qila derawer	Flat land	422±0.11	207±1.92	Overgrazed	617±0.15	329±1.72	Moderately grazed
16.	Mansoora	Flat land	489± 0.72	212±0.52	Overgrazed	601± 0.78	308±1.55	Moderately grazed
	Average		**523.5**	**277.4**		**748.0**	**411.8**	
17.	Qemawala Toba	Sand dune	397±0.58	214±0.18	Overgrazed	790±0.6	380±1.15	Overgrazed
18.	Qila derawer	Sand dune	458±3.90	253±4.99	Overgrazed	715±1.90	356±3.05	Moderately grazed
19.	Khirser	Sand dune	542±2.78	269±4.03	Overgrazed	778±1.78	336±2.03	Overgrazed
20.	Khanser	Sand dune	652±6.54	300±3.03	Overgrazed	690±2.52	347±3.07	Overgrazed
	Average		**506.4**	**258.6**		**710.4**	**370.3**	

Table 2. Seasonal carrying capacity from three range habitats of the Cholistan desert.

Range habitat	Dry season			Wet season		
	Biomass Kg/ha	Available biomass Kg/ha	CC ha/AU/y	Biomass kg/ha	Available biomass Kg/ha	CC ha/AU/y
Interdunal area	304.5	121.8	20.98	453.16	181.2	14.1
Sand dune	259	103.6	24.66	354.7	141.9	18
Flat land (Clayey)	226.2	90.48	28.2	302.7	121	21.1
Mean	263.23	105.2	24.2	370.18	148.07	17.25
±SE	± 2.3	± 2.03	± 1.98	± 3.05	± 2.75	± 1.95

Fig. 1. A. Grasses mostly found in stubble form due to overgrazing.

Fig. 1. B. Sheep grazing on grass stubbles

The Cholistan desert has hot and arid climate with low precipitation so the microbial activity is lower causing slow release of essential nutrients reducing plant growth. The inhabitants of Cholistan desert mostly keep migration from one place to another in search of grazing lands to feed their livestock. Especially in dry season, people depart from their villages in search of better grazing and migrate into irrigated areas in the periphery of the desert (Qureshi & Bhatti, 2005). In the wet season with onset of monsoon when forage is rich, they come back to their villages and leave their livestock free to graze in the whole desert (Anon., 1987; Umrani, 1996; Bhutto *et al*., 1993). Less biomass production of grass species in current study might be due to their short growth period, low erratic rainfall and severe climatic conditions in the rangelands of Cholistan desert (Arshad & Rao, 1994). Vegetation degradation and low forage production might also be due to illegal cutting over grazing and soil erosion (Gillman & Wright, 2006).

Our results revealed that in wet season maximum sites were moderately grazed, whereas in dry season maximum range sites were highly grazed (Fig. 1). It was due to better forage production during wet season that was ultimately dependent on availability of moisture (Arshad & Rao, 1994 Arshad *et al.,* 1999). The rainfall significantly enhanced the biomass productivity during the wet season. Our results are in line with findings of Shanmugavel & Ramarathinam (1993) who reported that biomass production was less during the dry season than the wet season. The decrease of dry biomass during dry season was due to long dry spell with less rainfall and high temperature. Taj *et al*. (2006) reported that biomass production in Cholistan desert is mostly limited to water availability. However, relationship between rainfall and biomass production is not regularly observed (Akbar & Arshad, 2000). Depletion of available nutrients, timing, duration, intensity of rainfall and changes in biomass distribution patterns may also negatively affect the grass productivity in Cholistan desert (Arshad *et al*., 2006). Similar, findings have been reported by some earlier scientists (Charley, 1972; Webb *et al*., 1978; Ahmad *et al*., 2009; Nordenstahl *et al*., 2011).

During the short wet season, grasses grow and mature rapidly, producing abundant biomass, but with the onset of dry season, both quantity and quality of the biomass starts declining and ultimately become unable to fulfill the minimum requirement of grazing animals (Scoones, 1992; Ahmad *et al*., 2006). Previous records showed that the range carrying capacity is imbalance with livestock feed requirements (Gammon, 1984). Hersom (2010) reported that dry matter intake of grazing ruminants is affected by several factors such as animal body weight, stage of production, forage quantity, quality and availability, and ecological conditions. According to the USA suggestions, range usage level is 30 to 40% of key species with 100 to 200 mm annual rainfall for desert regions (Holechek, 1999). It may reach up to 50% utilization of range during high productive year or wet season and reduced during dry season. Results (Table 2) showed that the Cholistan rangelands provide 148.07 Kg/ha available biomass during wet season. On the other hand stocking rate of 0.057 AU/ha/y was estimated during wet season when the biomass production was at peak level. Accordingly, Wahid (1990) estimated 0.89 AUM'S stocking rate in Tomagh and Zarchi rangeland where climate is dry temperate with overgrazing and severe deforestation that leads to less biomass production.

Grass species are slow growing in Cholistan desert due to extreme climatic conditions but respond very well to the suitable climatic conditions and provide plenty of biomass for utilization of livestock (Rao & Arshad, 1991; Arshad *et al*., 2006). The availability of water is key environmental factor which influence the survival, production of range vegetation, germination, wealth and successive growth **(**Noureen *et al*., 2008)**.** Water availability plays a vital role in the function and structure of several rangeland ecosystems (Ahrestani *et al*., 2011). Our findings are in agreement with the results of Mohammad (1989), Farooq (2008) and Hussain & Durrani (2007).

Conclusion

Based on the results, it can be concluded that the Cholistan desert is highly degraded due to heavy grazing that resulted in reduction of biomass production especially during the dry season. Moreover, there is rapid decline in populations of palatable species from the whole rangeland. There is need to manage proper stocking rate during the growing season along with the introduction of high yielding livestock breeds that may help to reduce grazing pressure and improve productivity.

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