INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 11, p. 20-27, 2013

RESEARCH PAPER OPEN ACCESS

Monthly and annual changes of forage production and consumption of *Cymbopogon olivieri* (Boiss) Bor., Case study: Jevengane Genou-Hormozgan Province, Iran

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Key words: Production, consumption, range species, *Cymbopogon olivieri*, Bandar Abbas.

doi: http://dx.doi.org/10.12692/ijb/3.11.20-27 Article published on November 02, 2013

Abstract

Forage production in rangelands differs at different times of the grazing season and also in the same months of different years. In the present, 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 in to 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, therefore, it is necessary to measure it during the months of grazing season in a few years and, based on it, the long-term grazing capacity of key range species could be calculated. The aim of this study was to determine the seasonal changes of forage production and consumption of *Cymbopogon olivieri* during the growing season in different years. This research was performed for four years in the vegetation type of *Gymnocarpos decander-Euphorbia larica*, in Jevengane region of Genou, located at an altitude of 265 meters above sea level and 40 km From Bandar Abbas in south of Iran. For this purpose, the production of this species was measured in a one-hectare exclosure with one month intervals until the growth dormancy. The rest of production was measured outside the exclosure, and the amount of consumption was calculated by subtracting it from the production of inside the exclosure. The amount of forage production and consumption, after air-drying, were analyzed by SAS software. Results showed that, due to the high variability of monthly and annual rainfall in the region, forage production and consumption of *Cymbopogon olivieri* showed significant differences at the 1% level.

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Introduction

Forage production in rangelands differs at different times of the grazing season and also in the same months of different years. In the present, 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. Therefore, it is necessary to measure it during the months of grazing season in a few years and, based on it, the long-term grazing capacity of key range species could be calculated. forage production is measured accurately in a few years during the months of grazing season and the curve of average monthly production is drawn, then we can estimate the average amount of forage production in the other months of the grazing season by measurement of forage in one month of grazing season and applying a correction factor.

Sanadgol (2002) investigated the forage production of *Bromus tomentellus* and grazing behaviour of Sangsari sheep under two grazing systems and three grazing intensities, at Homand Absard research station. He concluded that much of the production of *Bromus tomentellus* was occurred in the beginning of the grazing season and only in the first two months of growth this species was used by sheep.

Arzani (1994) investigated the changes in production, palatability and forage quality of five vegetation types and concluded that the production of species varied in different years and in different periods of the grazing season; therefore, grazing capacity should be determined on the basis of the production of each grazing season. Moghadam (1998) stated that to determine the grazing capacity, production assessment coincided with maximum growth of desirable and dominant range species. He also noted that specific rainfall regime in the area was the cause of fluctuations of production. In a study at Roode Shoor exclosure, the production of grazed and ungrazed areas was reported to be 200.2 and 516.5 Kg ha^{-1}, respectively (Akbarzadeh, 2005).

Generally, forage production on rangeland depends on the distribution of rainfall, soil type, range species and range management. Sharrow (2007) concluded that 60% of the dry matter production of most of the species in grasslands was produced in the months of April, May and June. In these rangelands in the months of July and September, this rate is declining with a relatively gentle slope and depending on weather conditions.

Climate change in different years is among the significant factors influencing the annual forage production at each site, and estimated data of production in a specified year are not sufficient for long-term plannings in rangeland (Arzani, 1984). He also reported that the fluctuations of production were different in the arid rangelands. Annual rainfall fluctuations in steppe rangelands of the country are high and their distribution throughout the year is very irregular. This climatic characteristic severely affect the forage production in these areas during different years. Basically, drought and wet years influence differently the production of species, and perennial grases will face further loss of production compared to the deep-rooted species (Humphrey, 1962). Karimi *et al.,* (2008) studied the effect of exclosure on rangeland production of Nodoushan in Yazd province and reported significant differences in the total production in different years. Baghestani *et al.*, (2006) investigated the fluctuations of forage production in Nir rangelands of Yazd province and reported taht the production of each species significantly differed in different years. Forage production of perennial species increased 2.3 times in a good year in comparison with normal year. With the incidence of severe droughts, the range of these changes reached to 18.2 times. Krueger and Roath (1982) studied the effect of distance of water resources and concluded that being far or close to the water resources had positive and negative effects on forage consumption. If this distance is much shorter, forage consumption will increase and further pressure is occurred on the rangeland. Reezer *et al.,* (2006) studied the effects of drought on forage production and livestock nutrition in southern

Mongolia and reported an increased production in mountainous areas due to receiving more rainfall in comparison with semi-arid regions.

Baghestani and Zare (2006) studied the relationship between annual rainfall and forage production in steppe rangelands of Poshtkooh of Yazd province and reported that rainfall in winter and autumn seasons had no significant effects on the production of perennial plant species. October and spring rainfall affected the production of forage species differently. Fetcher and Trlica (1980) investigated the impact of climate on annual forage production of 7 species in cold deserts, and concluded that there was no significant relationship between the amount of forage production of *Artemisia arbusculia*, *Oryzopsis hymenoides*, and *Sitanion hystrix* with rainfall and temperature while a positive and significant correlation was found between the amount of forage production of *Artemisia tridentate, Ceratoides lanata* and *Atriplex confertifolia* and rainfall during the growing season. They reported that the response of species to rainfall and other environmental factors also depended on morphological and physiological characteristics of the species because some species are deep-rooted to use the groundwater in years of low rainfall whereas annual species and species with shallow roots just use the surface and spring water and suffer serious injuries in times of drought. Durrani *et al.,* (2005) reported that annual and seasonal rainfall strongly affected the forage production of rangelands. Ehsani *et al.,* (2007) studied the impact of climate on forage production in steppe rangelands of Akhtar Abad-Saveh during 8 years and concluded that among important climatic factors, rainfall during the grazing season and highly affected the production of forage and showed a positive and significant correlation with forage production. In arid and semi-arid regions, daily, monthly, and annual rainfall and rainfall distribution fluctuate from year to year. Accordingly, the amount of forage production is not a steady state. Depending on the vegetative form and root system and also the time and quality of rainfall, the vegetation response to rainfall will be different. Zadbar *et al.,* (2009) studied the relationship of production and rangeland vegetation with annual rainfall in the North East of Iran and concluded that rainfall during the growing season had a great impact on increasing production. Filehkesh *et al.*, (2009) investigated the forage production in desert rangelands of Sabzevar and concluded that it was heavily dependent on seasonal rainfall. In other words, a reduction in rainfall greatly reduced the amount of forage production that influenced the consumption rate.

This research was aimed to investigate the changes in production and consumption of *C.olivieri* as one of the most important species in South of Iran. By knowing the changes in production of this key species, it is possible to estimate the forage production in the other months through measuring the production of only one month of the year.

Materials and methods

Characteristics of the study area

The study area is located at coast of Persian Gulf and Omman Sea, in an enclosed area of one hectare between latitude 27° 29′ 5″ N and longtitude 56° 15′ 28″ E, 265 m above sea level. It is in Jevengane Genou region, 40 km far from Bandar Abbas. This region is located in foothills with a coarse soil texture and a normal salinity. The method of rangeland utilization is rural and goats are the dominant livestock of the region.Monthly and annual changes in rainfall during the project period and also 1992-2010 are shown in Table 1. In 2006-2007, a rainfall of 39 mm was recorded for June and because of the high heat, it had no availability for the species or, in other words, it was not an effective rainfall. In this year, effective rainfall for the species were distributed in the months of December, January and February. In (2007-2008), a total of only 56 mm of rainfall was recorded and generally, if the effective rainfall is assumed to be at least 10 mm, only about 45 mm of rainfall occurred in January and February in this year.

The Cymbopogon genus from Andropogonae race, Panicoidaea sub-family and Poaceae family, has two

perennial genera in Iran (*Cymbopogon olivieri* and *C. parkeri*), distributed in tropical and subtropical regions of Asia (Mozffarian, 1996). The genus of *C. olivieri* was selected for the study.

Methods

To determine the monthly forage production and consumption of *C. olivieri*, a key range species in the region, forage production of this species was measured from the beginning of the growing season every year, for 4 years, inside a one-hectare exclosure with one month intervals until the growth dormancy. The rest of production was measured outside the exclosure, and the amount of consumption was calculated by subtracting it from the production inside the exclosure. Each Month, for each species inside and outside the exclosure, the harvested forage was placed in separate bags and after air drying and weighing the samples, dry weight was calculated. The amount of forage production and consumption, after air-drying, was analyzed by SAS software. Total production and total amount of forage consumption were calculated at specified intervals using the average of production and density of the species in rangeland.

Results

Changes of production

ANOVA table of the changes in production of *C. olivieri* (Table 2) showed that the production of this species in different years and months as well as the interaction effect of year and month were significant at 1%. Mean comparison of the production of this species (Table 3) showed that the production of the months of January, February, March and May did not have significant differences with each other, but production of this species in mentioned monthes showed significant differences with April. Meanwhile, the lowest and the highest production were related to January and April, respectively. Also, the production of this species was statistically different during the study years (Table 4). According to the results, the highest and the lowest production were recorded in the fourth year (2009-2010) and the third year (2008-2009), respectively; so that in the year of high production, it was two times more than that of the year of low production. The production period of each year varied from three to four months, which occurred in different months.

Table 1. Monthly and annual changes in rainfall (mm) during the project period and also1992-2010.

Period	2006 -2007	2007-2008	2008-2009	2009 -2010	Mean(1992-2010)
December	50	6	5	86	34
January	3	32	10	0	68
February	38	13	19	2	43
March	29	0	0	18	35
April	0	0	84	1	13
May	0	0	0	0	5
June	39	0	0	0	3
Annual precipitation	168	56	118	119	224

Table 2. Analysis of variance of the production and changes of consumption of C. *olivieri*.

Source of variations	Degree of freedom	Mean squares (Production)	F	Mean squares (Consumption)	F
year	3	17.33	17.2**	15.7	12.5**
Error I	16	0.15	0.15n	0.36	0.29
Month	4	285.77	284.1**	86.03	68.6**
Interaction effect (year*month)	12	29.14	28.9**	25.89	20.7**
Error II	64	1.005	-	1.25	-

** and *: Significant at 1% and 5%, respectively ; n: not significant.

Changes of consumption

ANOVA table of the changes in forage consumption of *C. olivieri* showed that the consumption of this species in different years and months was significant at 1% as well as the interaction effect of year and month (Table 2). According to the results (Table 3),

the consumption of this species in different months showed significant differences from each other. The highest consumption was related to April while the lowest was recorded in January. This amount in the month of high consumption was 16.8 times more than that of the month of low consumption. Meanwhile, the amount of consumption in February and March had no significant difference with each other but a significant difference was found for the other months. According to the results (table 4), the highest amount of forage consumption was related to the second and fourth years, and the lowest was recorded in the first and second years, respectively. This amount in the year of high consumption was 3.3 times more than that of the year of low consumption. Generally, the changes in consumption should be attributed to the changes in species production and annual and monthly rainfall distribution. The utilization of this species depends on the composition of the herd, the time of livestock entry to the rangeland, stop time for grazing, species composition, abundance or scarcity of forage in grazing time, phenological stages, and vitality which is a function of rainfall fluctuations. In other words, the amount of forage consumption depends on a number of different factors as the separation of these factors and understanding of the interaction effects among them are not simply posible.

Table 2

Table 3

Table 4

Figure1

Table 3. Mean comparison of the monthly production and changes of consumption of *C. olivieri.*

Month	Mean Production	Mean Consumption
January	0.66^{b}	0.32^{c}
February	1.26^{b}	0.88^{bc}
March	1.31^{b}	0.77^{bc}
April	9.55^{a}	5.37^{a}
May	1.24^{b}	1.14^{b}

Different letters indicate significant differences and common letters indicate non- significant differences.

Table 4. Mean comparison of the annual production and changes of consumption of C. olivieri.

Year	Mean Production	Mean Consumption
2006-2007	3.27ab	0.79d
2007-2008	3.06b	2.64a
2008-2009	1.57c	1.38c
2009-2010	3.32a	1.97b

Different letters indicate significant differences and common letters indicate non- significant differences.

Discussion

Production period of this species varied in different years. During the years of (2006-2007) and (2008-2009), the production period was 4 months, which began in February and continued until May. Although during 2009-2010 the production period was 4 months, it started from January and ended in March. During (2007-2008), the production period of this species reduced to three months and lasted from February to April.

Analysis of variance table of production changes and mean comparisons of production showed significant differences for forage production of this species (Tables 2, 3 and 4). In average, the highest and lowest production percentage were recorded in April (70%) and January (4/7%), respectively (Figure 1). Generally, this study showed that the production period and the amount of forage production had monthly and annual changes that it must be due to changes in the amount of rainfall and especially annual and monthly rainfall distribution. The results

of this study are in agreement with the results reported by Arzani (1994), Moghadam (1998) and Akbarzadeh(2005). Sharrow (2007) reported that forage production changed with seasonal fluctuations and Arzani (1994) showed the effects of climate change on annual forage production of plant species which corresponded with the results of this study. *Karimi et al.,* (2008) concluded that exclosure affected the annual changes of forage production. Fetcher and Trlica (1980) also concluded that there was a significant positive correlation between the amount of forage production of some species and rainfall. Our results also correspond with these conclusions. Durrani *et al.,* (2005) reported that annual and seasonal rainfall severely affect the forage production of rangelands. Generally, consumption changes should be attributed to the production changes, depending on monthly and annual changes of the amount and distribution of rainfall. The utilization rate of a species depends on herd composition, the time of livestock entry to the rangeland, stop time for grazing, species composition, abundance or scarcity of forage in grazing time, phenological stages, vitality, and the palatability of the species and companion species which is a function of rainfall fluctuations. In addition, monthly and annual production of this species are of the important factors affecting the amount of consumption. Generally, consumption of a species depends on a number of different factors that the possibility of the separation of these factors and understanding the interaction effects among them are not possible easily. Fluctuations of forage production and consumption of a species are strongly affected by the production and consumption of other species. The results of the current study are in agreement with the results reported by Torkan and Arzani (2002), concluding that forage quality of species differed significantly in different phenological stages. Gudmundson (1993) stated that in summer rangelands and in early spring, when the weather is cool feed consumption reaches its peak and at this time of the grazing season more forage is available to livestock. Filehkesh *et al.,* (2009) concluded that the amount of forage production was highly dependent on seasonal rainfall and due to reduced rainfall, the amount of forage production was greatly reduced, affecting the amount of consumption.Our results are also compatible with these findings.

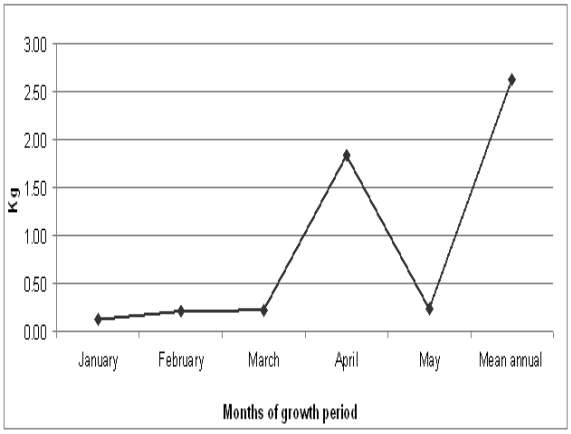

Fig. 1. Curve of the mean of the production changes at months of growth period.

According to the results, in arid and desert regions including the study area the possibility of production estimation based upon monthly and annual production in the short term is less credible. In addition, it should be emphasized that during the period of this study, the average annual rainfall was less than the statistical period of 1992-2010. It should be noted that forage production also depends on the amount of rainfall and its temporal distribution. According to the table of monthly and annual rainfall changes during 2008-2009 and 2009-2010 despite the annual rainfall was approximately equal during 2008-2009, most of the precipitation occurred in March whereas during 2009-2010 the main precipitation occurred in February and March, having an impact on forage production.Meanwhile, despite the fact that precipitation was revealed in June and December in some years, no available forage was found. However, if the rain falls in December as the beginning of the growth period, it will be possible to harvest the forage in January, otherwise, the first month with harvested forage, is January. Overall, regardless of differences in plant growth and production in different years, even the months effective on forage production were different in different years and this largely depends on the amount and especially distribution of precipitation.

Conclusion

Generally, according to the average production for this species during the period of plant growth (Figure 1), the production rate can be estimated during other years by measuring the production in each season.In the study area, due to the changes in rainfall during 4 years, the study species could be harvested only in December of 2009-2010 as the first time. For the second time, due to the severe drought in (2007-2008) unlike three other years the forage could only be harvested within three months of the year. Annual precipitation of 2007-2008 has been reported to be only 56 mm. According to the results (Figure 1), the amount of production in second and third year of the study was lower than that of the first and fourth year. In the third year of the study, although the amount of annual rainfall was approximately equal to the amount of annual precipitation of 2009-2010, in (2008-2009) the distribution of precipitation was highly inappropriate so that more rainfall was revealed in March. Meanwhile, the annual rainfall in all years of the study was less than the average of 1992-2010. In other words, the study area has faced drought during the duration of the study (table 3). Generally, it is concluded that due to the drought conditions prevailing in the region during the duration of the study, it is not possible to provide a useful model for estimating the range forage production. In such areas, statistical period should be increased so that a suitable model for estimating forage production could be more precisely provided.

Acknowledgments

It is with immense gratitude that we acknowledge the support and help of Forests, Rangelands and Watershed Management Organization and Research Institute of Forests and Rangelands.

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