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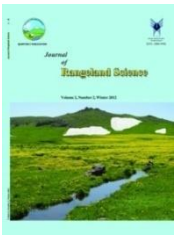

Full Length Article:

Assessment and Comparison of Different Methods for Estimating Forage Production (Case Study: Rangeland of Kurdistan Province)

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Abstract. Today, in the rangeland management science and determination of range capacity, accurate and true information about range production is crucial. In fact, range production is considered as a basis for range management. The aim of this study was to compare different methods for the estimation of forage production with four sampling methods in the rangelands of Kurdistan province, Iran. The sampling methods were Adelaide technique, double sampling, estimating method, clipping and weighting method (control). A two-way analysis of variance was made to compare the methods and vegetation types. The estimating methods and plant vegetation types were considered as treatments and blocks, respectively. The results showed that Adelaide method had no significant difference with control method and was selected as the best method for estimating the plant production in the rangelands of study area with dominant shrub plants. A significant difference was obtained between control and estimation methods. Therefore, this method had lower accuracy for estimating the production of range plants. The results showed that the composition of range plants was an effective factor on the accuracy of estimating methods and also paying attention to ecosystem variability was an important key to achieve a suitable method in order to estimate the range production. A significant difference was obtained between double sampling method and clipping and weighting method (control). It was due to various plant combinations of the study area. Therefore, the double sampling had lower efficiency than clipping and weighting method to estimate various plant species such as grasses, shrub and herbaceous plants.

Key words: Estimation of forage production, Vegetation types, Clipping and wighting, Adelaide, Double sampling.

Introduction

Rangeland is defined as a land that naturally produces suitable forage plants for grazing but where rainfall is too low or erratic for forage growing. There are unreliable estimations of total rangeland production in Iran. The country lands as rangelands were accounted for approximately 106 million hectares by Sheidaei and Nemati (1978). Despite rangeland degradation in the recent decades, significant parts of fodder and subsequent meat production are still provided by the rangelands. The amount of forage consumption varies depending on the production system of the rangeland. According to Fazilati and Hosseini Eraghi (1984), rangelands with 10 million tones of annual dry matter production produce 31% of the country's meat and 11% of milk production. Also, rangelands had been used as a source of medicinal plants. Plant production estimation in rangelands can be determined using a variety of methods or a combination of methods including estimating, harvesting or by estimating and harvesting (double-sampling). A wareness of control rangeland degradation through the regulation of livestock numbers based on the carrying capacity of rangelands is created and needs to be examined for verification. Production of rangeland plants is the vegetation growth during few years including stems, flower-bearing branches, clusters or flowers and seeds or fruit (Mesdaghi, 1998). For estimating the forage production in the rangeland, we need a standard and reliable method that is able to save time, costs and resources and estimate the production with reasonable accuracy. Adelaide method was used in Australia for the first time in 1979. This method was used in Isfahan province, Iran and efficiency of this method was proven (Shahr ashoob and Mikaeili, 1996). Javadi *et al.*, (2011) to estimate the forage production in *Atriplex canescens* and *Haloxylon ammodendron* studied the relationship between forage production as an independent variable and some factors including small diameter, large diameter, height, canopy cover, volume, average diameter height as dependent variables. Their results showed that volume in *A. canescens* and height in *H. ammodendron* were the most effective factors for estimating the forage production. The most important factors in the estimation of production are selecting the suitable method. The aim of this study was to compare different methods and to select a suitable method for estimating the forage production in rangelands with vegetation types of grass and forb combined with shrubbery in Kurdistan province of Iran.

Materials and Methods

The study area was bounded by 46°25' to 46°50'E and 35°35' to 35°56'N and located in the 10 km of Southwestern city, Sanandaj (Rangeland Research Station of Kurdistan University). The total area of region is 5000 ha. Medium altitude in the region is 1850m above see level and its species belong to Umbelliferae, Poaceae, Cyperaceae and Fabaceae families that are subjected to moderate grazing. The mean precipitation is 480mm/year that maximum and minimum of precipitation occur in February and July, respectively. The mean of annual temperature is 13°C. All plants in this region belong to the families of Fabaceae, Poaceae, Brassicaceae, Umbelliferae, Chenopodiaceae, Polygonaceae, Ranunculaceae, Papaveraceae, Euphorbiaceae, Geraniaceae, Rosaceae, Lamiaceae, Convolvulaceae, Boraginaceae, Campanulaceae, and Asteraceae. Liliaceae, Iridaceae. Plant community in the study area was dominated by shrubs, forbs and occasionally with high density of grass plants classified in 4 types as follow: *Astragalus gossypinus-Gundelia tournefortii, Astragalus bukanensis-Bromus tomentellus, Prangos ferulacea-*

Psathyrostachys fragilis and *Astragalus nervistipulus- Prangos ferulacea*.

For the implementation of this study, different types of plants were identified using a combination of vegetation cover and percentage of dominant plant cover methods (Gracz, 2005). The name of each vegetation type was chosen based on two dominant plant species. These species are *Astragalus gossypinus-Gundelia tournefortii, Astragalus bukanensis-Bromus tomentellus, Prangos ferulacea-Psathyrostachys fragilis* and *Astragalus nervistipulus- Prangos ferulacea* allocated to the highest percent of vegetation cover (Table 1).

For sampling the vegetation types, the study area was initially determined on 1:50000 topographic map scale. After determining the plant types, sampling was carried out based on random-systematic method (Ghanbarian *et al.*, 2009). Transects of 100 m long (Ghelichnia *et al*., 2009; Jafari *et al*., 2010) were selected according to the type, composition, density of vegetation and ecological conditions. The plot area was obtained on the basis of minimal area method. The area of plots was determined as $1m^2$ and $2m^2$ for grasses/forbs and shrubs, respectively (Coulloudon *et al*., 1999). To determine the number of samples, it was necessary to determine the sample variance. To determine the minimum number of samples, statistical methods were used as follows (Mesdaghi, 1998).

$$N = \frac{t^2 S^2 x}{p^2}$$

Where

N is the plot number,

t is student's t-test;

p is an approximate value of error (0.05) and S_x is standard error for all plots, four methods given in below are used for estimating the forage production.

Adelaide method

The method includes the selecting of a branch from each species which is taken from outside of the study area. This branch is called the reference unit (Andrew *et al.*, 1979; Andrew *et al.*, 1981 and Cabral and West, 1986). It should represent the form and foliar density of the branches for each species. Then, using this reference unit, the number of branch units for each sampled shrub was estimated. The shrub was harvested at the end of measurement period to determine its leaf biomass. Afterwards, the regression equation which fits the relationship between leaf dry matter and the number of units was chosen to predict the leaf biomass as forage on site for other individual shrubs of same species (Froughbakhch *et al.*, 2005).

Double-Sampling Method

Although the harvesting method is highly accurate, it is also very time and labor consuming. In contrast, the estimation method is more rapid but not as accurate. By combining the harvest and estimation methods, the Double-Sampling Method can reduce the time that it takes to sample and is still fairly accurate. This procedure basically requires that the observer estimates the weight of several plots and then clips a few more plots to determine the accuracy of estimations. It can be much more efficient than direct sampling of primary variable if the secondary variable can be measured quickly and it is highly correlated with the primary variable (Reid *et al*., 1990). The formulas for data analysis and sample size estimation are much more complex than those of other methods.

Clipping and weighing

Clipping vegetation to ground level and then weighing are the most direct and objective ways to measure the herbaceous biomass (Van Dyne *et al.*, 1963). Before clipping, the field technician must clarify which plants will be clipped with a plot. Clipping and weighting of vegetation are expensive and tedious. Though "clip-and-weigh" methods are highly accurate, they

are very time consuming (Van Dyne *et al.*, 1963). Therefore, harvest techniques are usually combined with indirect estimation techniques in methods known as "double sampling". In this study, this method was examined as a control factor for being compared with other methods.

Estimating Method

The estimating method is the most rapid method among four production ones listed above since it takes much less time to estimate the weight in a quadrate as compared with clipping a plot (Schoop and McIlvain, 1963). However, it is not as accurate as the harvesting method or double sampling method due to the personal error in the estimation of utilization levels. Extensive training is required to perform this method which involves the weighing of representative plant units and training the observers' "eye" for the weight categories.

Considering different numbers of samples in different methods, we used an unbalanced randomized complete block design to do a comparison between methods. Production estimation methods were considered as treatments and different plant types were considered as blocks. Unbalanced randomized complete block design was appropriate due to the increasing degree of freedom and creating of a homogenous environment for testing. The Least Significant Difference (LSD) was used for a comparison among methods (Goeble, 1955). The collected data were analyzed using $SPPS_{15}$.

Results

The collected data were analyzed for determining the best method for estimating the plant production in Kurdistan rangeland with various plant combinations leading to a special result that comes in following. As it has been seen, the first part of study was focused on the number and size of plot for data collecting in various types that are presented in (Table 1). The regression analysis between estimated and clipping and weighing rates (g/m^2) are shown in (Fig. 1).

There was very close accordance between Adelaide and double sampling methods for estimating the production in the field, but their ability was different from the plant combinations. In our study, field plant species were so high and over time, grass species with high density was dominant in the field. Therefore, the efficiency of double sampling method in this situation was more than Adelaide method which is suitable for shrubs; however, our data collecting shows that due to high frequency of grass plants, double sampling is more suitable and since the result shows this approach, we can explain this various significance.

Results of variance analysis are presented in (Table 2). The comparisons among the means of treatments (different methods) and blocks (different types of plant) are shown in (Table 3). Results showed that average values of double sampling and theory estimating method had significant differences with control and the average of Adelaide method showed no difference with control method.

Discussion and Conclusion

The results showed that Adelaide method is accurate for the production measuring in shrub lands. Measuring of rangeland production should not be destructive for plant conservation. Clipping and weighing method is harmful, so Adelaide method can be used as a suitable method in such rangelands. Table 3 showed that estimating method had the least accurate, so it cannot be offered as a suitable method for the production measuring. The significant difference between double sampling method and clipping and weighing method (control) is due to various plant combinations of the study area because double sampling efficiency

can be lower than clipping and weighing method to estimate various plant species such as grasses, shrub and herbaceous plants. According to (Table 3), the mean difference between double sampling and control (crippling and weighing) methods are significant, therefore, this method is one of the methods having an error for measuring in this region and use of it in these rangelands is not reasonable. Mentioned method depends on the estimations to create a regression correlation and in the length of transect, there are more shrub plants that will cause fatigue for the expert and make a great variance. LSD comparison in Table 3 showed lower mean values for estimating method and it had a significant difference with control. In other words, this method has a little accuracy for measuring the production of rangelands in Kurdistan and we do not offer this method for the production measuring in the project and design in Kurdistan province. The results showed that Adelaide method was the best method in shrub lands and confirmed the results of Sadeghinia *et al.*, (2003). Due to variation in the conditions of communities and type of grazing management, calculated equations are valuable just for the production estimation in the same location and same time of calculation. Many scientists including Payne (1974), Harinss and Murray (1976), Hughes *et al.*, (1987) and Arzani (1994) emphasize on this point. Adelaide method is the accurate method due to the use of reference shrub in it. The results of this study showed that regarding the composition of plants in rangeland ecosystem of Kurdistan, the Adelaide method is logically a reasonable method due to its least variance. To use different methods in measuring production in rangelands, an expert has a duty to select the method that has the most accuracy. So, by noticing the applying Adelaide method in shrub lands of Australia, it can be used in such case study as shrub lands of Kurdistan province.

Table 1. Number and area of plots in different types

Type Name	Needed Plot Number	Plot Area (m^2)
Astragalus gossypinus-Gundelia tournefortii	15	2
Astragalus bukanensis-Bromus tomentellus	12	1
Prangos ferulacea-Psathyrostachys fragilis	10	1
Astragalus nervistipulus- Prangos ferulacea	10	2

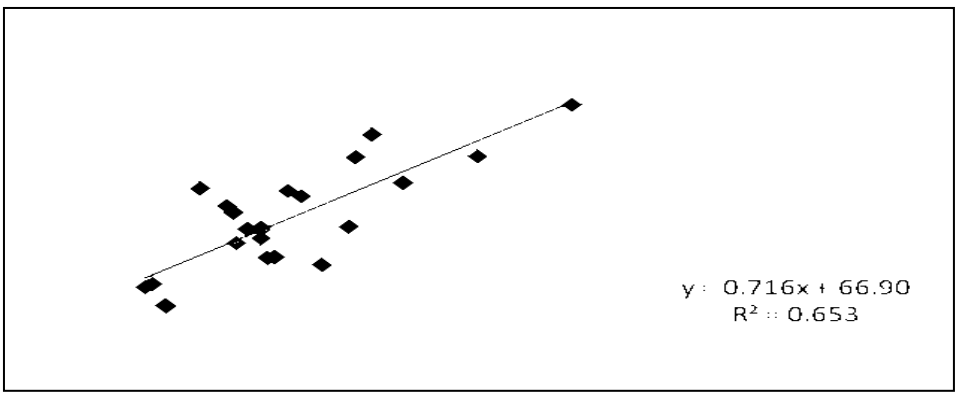

Fig. 1. Regression analysis between estimated and clipping and weighing rates (g/m^2) (number of sample: 25)

Table 2. Two way analysis of variance among blocks (different types of plant) and treatments (estimation method)

Source of variation	DF	SS	MS	F
Blocks (Vegetation types)	3	148.7	49.6	15.03**
Treatments (Estimation methods)	3	48.4	16.2	4.9*
Error	9	30.1	3.3	

*, **= significant at 5 and 1%, respectively.

Table 3. Comparison between means of treatments (different method) and blocks (different types of plant) regarding interactions of estimation methods

Block number / Type of plant	Estimation methods				Blocks Means
	Clipping and Weighing Method (control)	Theory Estimating Method	Double Sampling Method	Adelaide Method	
1	4.29	2.00	1.35	3.99	2.91 a
2	2.10	1.00	0.99	1.98	1.52 b
3	2.24	1.00	1.54	2.34	1.78 b
4	0.85	2.50	2.15	0.75	1.56 b
Means of treatments	2.37	1.63	1.50	2.27	
Total	9.49 a	6.50 b	6.02 b	9.06 a	

The means of blocks (type of plant) with the same letter had no differences based on LSD method (P<0.05)
Total of treatments (last rows) with the same letter had no differences based on LSD method (P<0.05)

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