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Estimating Plant Biomass by Using Non-Destructive Parameters in Arid Regions (Case Study: Inche-Broun Winter Rangelands, Golestan, Iran)

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Abstract. Plant biomass is an important factor for determining arid and semi-arid rangelands capacity. Due to the lack of proper and annual sampling of rangelands, there are no suitable data to determine biomass, range condition and proper range management operations. Plant biomass is one of the measurable attributes that can be assessed in rangeland studies. Since the clip and weight method is destructive and time-consuming, green biomass was estimated by using dimensional parameters (Plant Allometry) including canopy cover, length and width of diameters. Field sampling was done using seventy 2×2 m quadrats along five 100 m transects. The data were analyzed by stepwise regression. The results showed that the fresh and dry biomass showed significant positive correlations with canopy cover, the length and width of diameters of *Halocnemum strobilaceum* shrub (p<0.05). The results of stepwise regression showed that just canopy cover and diameter length were remained in the final model, so that 80.2% of biomass variations were explained by canopy cover and diameter length.

Introduction

Rangelands are one of the valuable renewable resources that have important role in the national development plans of many countries. Iran with a rangeland area of 90 million ha has special position in Middle East countries. Unfortunately, due to improper range usage and management, these valuable resources deteriorated. Biomass as a measure of rangeland carrying capacity has an important role in arid and semi-arid rangelands (Al-Bakri and Taylor, 2003; Palmer and Yunusa, 2011). Potential capacity is reduces by long-term exploitation of rangeland biomass. Estimation of plant biomass in annual range management or inventory plans are time consuming and expensive. So due to the lack of annual and proper rangeland samplings, there is no suitable information for estimating biomass, range condition and proper management operations (Benkobi *et al.,* 2000).

It is obvious that a method of measuring production is acceptable that has higher accuracy and validity. Asad pour *et al.* (2011) in assessing relationship between dry biomass of *Sphaerocoma aucheri* Boiss (Caryophyllaceae) and its vegetative characteristics showed that 77% biomass variation explained by plant cover percentage. There was similar relationship between these two variables in Patagonian steppe for *Stipa speciosa*, *Stipa humilis* and *Poa ligularis* (Flombaum and Sala, 2007) but the case was different for shrub species. Arzani *et al.* (2008) assessed the relationship between foliage cover and biomass in three different vegetation types including grassland, grass-shrub land and shrub land. They concluded that canopy cover in all species and foliage cover in most of the species had close, rational and acceptable relationship with biomass. Plant species produce different amounts of forage in the various environments. Since clipping and

weighting method is time consuming and destructive, so some indirect methods of estimation may be employed, e.g. double sampling (Mesdaghi and Ajami, 1997; Whelan, 2001).

The *Halocnemum strobilaceum* as dominant vegetation species uniformly distributed on Inche-Broun winter rangelands, Golestan province, Iran. *Halocnemum strobilaceum* is used as forage in winter and its protein is about 14 to 15 percent (Sabeti, 1994). Its preference value in vegetative growth stage is lower than *Puccinella distance* and *Aeluropus littoralis* (Hosseini, 2008; Abarsaji, 1996; Khatirnameni, 1996). This species is distributed at Europe, Turkey, Iran, Caucasus, Central Asia, Afghanistan, Pakistan, Iraq, and the Arabian Peninsula. *Halocnemum strobilaceum* also grows in Irano-Turanian, Mediterranean, Euro-Siberian, and Sahara-Sindian Chorotypes. In Iran, this species grows in the North-West, Central, South and South East of Iran that includes cities like Gorgan, Azerbaijan, Isfahan, Yazd, Fars, Hormozgan, Boshehr, Khuzestan, Baluchistan, Khorasan, Semnan, Tehran, Qom, and Arak (Asadi, 2001).

Halocnemum strobilaceum is an important forage species for livestock feeding in winter, soil conservation and carbon sequestration. Therefore, it is needed to conserve this species and using non-destructive method in evaluating its biomass (Hosseini, 2008; Hosseini *et al.,* 2007).

The aim of this study was to determine the relationship between the biomass and canopy cover of *Halocnemum strobilaceum*, so in this way, the feasibility of providing appropriate statistical models as a way to estimate the biomass indirectly, becomes possible.

Materials and Methods
Study area

The research was conducted in arid rangeland of Inche-Broun which situated in north-eastern of Golestan province (54° 43' E, 37° 25' N). This area shares borders with Turkmenistan in the north, Aghala and Gomishan farm land in the south, Caspian Sea in the west, and Dashley Boroun-Gonbad road in the east. The area is topographically flat without any up and down. The elevation ranges from 24 to 11m below sea level (Fig. 1).

Based on the region meteorological stations, precipitation is varying between 365 mm (Ghale Jigh, southeastern of area) and 205 mm (Inche-Broun, northeastern of the area). Most of the precipitations occur during fall and winter. The most and the least precipitation fall in November and June respectively (Hosseini *et al.,* 2007). According to Domartan method semi-arid and arid climate prevails in the study area.
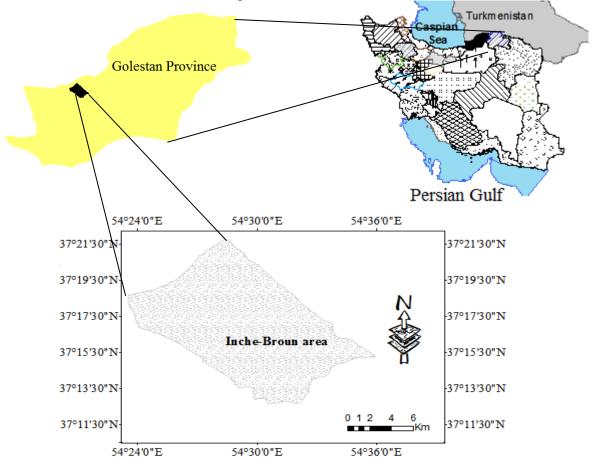

Fig. 1. Location of study area

Vegetation sampling

To estimate the green yield of *Halocnemum strobilaceum* clipping and weighing method was employed. Five transects were sampled, each containing seventy 2m x 2m quadrates which were located 100 m apart.

In each plot, vegetation attributes (canopy cover, length and wide of diameter and plant height of *Halocnemum strobilaceum* were recorded. In this technique, plants were harvested, weighted, and recorded in the quadrats in terms of growth forms. To determine the amount of current yield, the aerial part of plants were harvested. To save time, from

each 12 plots, five plots were clipped and weighed. To obtain accurate and acceptable data, 100 g samples with 3 replicates were dried in 60°C oven for 24 hours. Then the dried samples were weighted again.

Data analysis

At first, data were tested for normality using Kolmogorov-Smirnova method in R software (P<0.05). After testing normality, it was transformed by log10 for removing outlines. Then data were analyzed by using stepwise regression and the amount of biomass as the dependent variable and canopy cover, plant height, canopy diameters length and wide, as independent variables considered. The correlation coefficient between traits were estimated and tested for significance. The best regression model was introduced based on the determination coefficient and lower standard error. In this study, statistical analyses were done using SPSS 17 and MS Excel 2010.

Results and Discussion

The correlations between traits are shown in (Table 1). There was positive and significant correlation between green and dry biomass and canopy cover and pant diameter. The correlation between canopy cover and plant height was negative; indicating that plants with bigger diameter has lower height. There was strong positive correlation between diameter width and diameter length and between dry and green biomass. As shown in (Table 2), the canopy cover percentage and diameter length were selected in final model and they had significant relationship with green biomass, so that 98.2% green biomass variation can be explained by canopy cover percentage and diameter length. Regression equation is as follows (Equation 1):

$$Y=-31.9+0.645X_1+0.13X_2 \quad \text{(Equation 1)}$$

Where
Y, X1, and X2 are biomass, canopy cover percentage, and diameter length respectively. Using the model, it's possible to estimate similar region biomass. The results showed that to estimate the plant biomass without cutting, canopy cover and diameter length data can be useful. The results are consistent with studies of Wilson and Tupper (1982) who declared that canopy cover due to easy and rapid measurement can be used as an indicator of biomass. Saeidfar (1994) found the best relationship between biomass and canopy cover for *Artemisia sieberi* and *Eurotia ceratoides*.

With regards to strong correlation between the biomass and the canopy cover, this potential in general can help to estimate rangelands biomass and capacity as a non-destructive method. Due to the low cost, high accuracy and speed, measuring canopy biomass can be an important and effective step in Rangelands. Realization of this fact can fill other gaps in range management on biomass measurement. It is suggested that the relationship between dry biomass and canopy cover be performed in dry years because of the role of environmental factors in growth form and change in various phonological stages.

The results of this study indicated that using convenient and non-destructive method is best way to achieve the correct values with considering special climate and topography (lower field work) of each region and to less cut and damage plants (Muukkonen *et al.,* 2006). The results are consistent with Asadpour *et al.* (2011) and Mokhtari Asl and Mesdaghi (2007) while studying on two species *Salsola dendroides* and *Atriplex verrciferum*, stated that in both species canopy cover was appropriate criterion to estimate yield. The results are also somewhat in consistence with the findings of Hosseini *et al.* (2010) that founded a linear relationship between

production as dependent variable and volume, canopy cover, and canopy height as independent variables. But the results of Guevara *et al.* (2002) and Akbarlou *et al.* (2012) are contrary which implies that there is a strong relationship between

production and plant height. It is also suggested that this method can be checked at other sites to achieve the native patterns.

Table 1. Correlation between traits

Traits Name	Height	Short Diameter	Long Diameter	Dry Weight	Fresh Weight
Diameter width	-0.224				
Diameter length	-0.164	0.762**			
Dry weight	-0.445	0.631*	0.503		
Fresh weight	-0.422	0.588*	0.465	0.851**	
Canopy cover%	-0.525*	0.750**	0.767**	0.701**	0.665**

*, **= Significant at 5% and 1% probability levels, respectively

Table 2. results of stepwise regression in final step for biomass as dependent variable and other traits as independent variables

Model	Regression Coefficient	MSE	T Test	Coefficient of Determination
Intercept	-31.9	78.8	2.65**	
Canopy cover%	0.654	2.953	5.83 **	R^2=80.2%
Diameter length	0.130	2.312	4.06*	

*, **= Significant at 5% and 1% probability levels, respectively

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تعیین وزن زیتودهٔ تر با کمک پارامترهای غیر مخرب گیاه در مناطق خشک (مطالعه موردی: مراتع قشلاقی اینچه برون در استان گلستان)

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چکیده. زی‌تودهٔ گیاهی معیاری مهم برای تعیین قدرت و ظرفیت رشد مراتع خشک و نیمه‌خشک است. هرساله از مراتع به دلیل عدم نمونه‌برداری‌های درست، اطلاعات مناسبی برای برآورد زیتوده گیاهی، وضعیت مرتع و اعمال مدیریت مناسب وجود ندارد. اندازه‌گیری زیتوده گیاهی یکی از موارد قابل ارزیابی در مطالعات پوشش گیاهی است. با توجه به اینکه استفاده از روش قطع و توزین یک روش تخریبی و وقت‌گیر است، در این پژوهش تخمین زیتودهٔ گیاهی با توجه به یکسری از پارامترهای گیاهی (شامل سطح پوشش تاجی، قطر بزرگ و قطر کوچک تاج) انجام گرفت. برای نمونه‌برداری از واحدهای نمونه‌برداری ۲×۲ متر به تعداد ۷۰ پلات در امتداد ۵ ترانسکت ۱۰۰ متری استفاده شد. نتایج نشان داد که ضریب همبستگی مثبت و معنی‌داری بین بیوماس تر، خشک و با پارامترهای پوشش تاجی و قطر بزرگ در گونه *Halocnemum strobilaceum* وجود دارد ($p < 0/05$). در مدل رگرسیونی با استفاده از روش رگرسیون چند متغیر گام به گام، فقط درصد پوشش تاجی و قطر بزرگ با بیوماس‌تر رابطه معنی‌داری دارد. به‌طوری‌که ۸۰/۲٪ تغییرات زیتوده تر گیاهی توسط درصد پوشش تاجی و قطر بزرگ توجیه شد.

کلمات کلیدی: زی‌توده گیاهی، مراتع خشک، مراتع نیمه‌خشک، روش قطع و توزین، ابعاد غیرمخرب، ترانسکت، رگرسیون چند متغیره گام به گام