Relationship between cover and yield of some range species in steppic region of Yazd province

N. Baghestani Maybodi[1*], H.Arzani[2] and M. T. Zare[3]
1. Assistant Prof., Yazd Agricultural and Natural resources Research Center, Yazd, Iran
2. Prof., Faculty of Natural resources, University of Tehran
3. Senior Expert of Range Management, Yazd Agricultural and Natural resources Research Center, Yazd,

(Received 3 Sept. 2005, Accepted 28 Dec. 2006)

Abstract

Sustainable range management needs the accurate estimation yield and determining of grazing capacity in rangelands. It is easy to obtain yield estimation with indirect methods.

For this purpose, the relation between cover and forage yield of range species were studied in steppic rangelands of Yazd. Measurements of cover and forage yield were carried out with plot area and clipping and weighting methods, respectively. Every year, one hundred and twenty quadrate plots were systematically assessed from 2000 until 2004 in mid-May. In addition to mentioned measurement, four sampling was done until early November in 2004. Data were analyzed in regression and correlation programs (SPSS 10.0).

Results showed that there was significant relation ($p<0.01$) between cover and forage yield of studied species during 4 years (2001-2004), but 3 species out of 7 studied species had significant relation in 2000-drought year ($p<0.05$). Obtained relations and also fitted models were varied in different years and stages. Therefore, the yield estimation is possible by using cover, but in dry years. These characteristics are applied for annual yield estimation of steppic range species by double sampling model with cover.

Key words: cover, forage yield, clipping and weighting, Yazd, Iran

[*] Corresponding author: Tel: +98 351 7222261, E-mail: n_baghestani@yahoo.com

Introduction

Sound management of vegetation communities of rangelands requires accurate estimation of production for grazing capacity determination. Among several methods of yield estimation, clipping and weighting method is more accurate. However, it is more time-consuming and expensive method. Therefore, selecting an accurate, fast and applicable method is essential. Estimating yield from cover measurement was first suggested by Dauben Mire.

Payne (1974) studied relationship between cover and yield of 48 plant species observed in 160 quadrats, in various vegetation communities of Beaverhead National Forest located in south western of Montana. He reported that the relationship between canopy cover and yield of 12 species had not been significant, for 36 species correlation coefficient was significant and for 16 species correlation coefficient was higher than 0.9. Amount of cover as a most important factor for determination of quantity and quality of available forage has been recognized in Australian arid areas (Arzani, 1994). Cook and Stubbendieck (1986) believed that it is possible to estimate dry matter yield of rangeland using cover data. Evans and Jones (1958) referred to relationships existing between cover and yield. Pasto et al (1957) reported a significant correlation between cover percentage and weight in two grasses *Bouteloua gracilis* and *Dactylis glomerata* were 0.278 and 0.735, respectively.

Ludwig et al. (1975) found that it is possible to apply calculated equations based on relationship between cover and yield of one time for other times. However, many scientists emphasis that because of climate and grazing effects on forage, usage of such equation should be done carefully (e.g. Hughes et al, 1987). Payne (1974) suggested that similar investigation is required in each region to test relationship between cover and yield and calculate suitable equation for estimating yield from cover data. Andariese and Covington (1986) believed that effects of over story on under story vegetation cover and local condition should be taken into account for increasing precision of this method.

Due to variation in conditions of communities and type of grazing management, calculated equations are only valuable for production estimation of same location and time of calculation. Many scientists including Payne (1974), Harinss and Murray (1976), Hughes et al (1987) and Arzani (1989) emphasis on this point.

In the present study, relationship between canopy cover and yield of some important range species in Yazd's rangeland were investigated.

Materials and Methods

The project was conducted in Nir station located in Posht-kouh region of Yazd province. This area is represented of range areas with high elevation in steppic zones (Baghestani, 2003). Average annual precipitation for 38 years period of 1966 to 2004 has been 132 mm. Annual precipitation from 2000 to 2004 has been recorded 27,108, 210,141and 208 mm, respectively in the station. These were represented severe drought, drought, wet, normal and wet conditions. Climate based on Amberjeh classification is dry-cold and based on Iranian climatic classification has been classified as steppic region. The soil was light with high infiltration and low erosion.

Eighty-seven perennial and annual species were observed during study. Presence of annuals and perennial forbs was affected by rainfall. The perennial shrubs were present even in severe drought of 2000. Three indicator species including *Salsola rigida, Artemisia sieberi, Stipa barbata* and 3 accompany species including *Scariola orientalis, Launaea acanthodes* and *Noaea mucronata* were studied in this research.

The 22.6-hectare exclosure site was selected in the mentioned research station area and twenty 300m transects with 50 m spaces were determined in it. In the first year, data were collected from ten $2m^{-1}$ quadrate plots in each transects systematically (120 plots in the studied area). Clipping and weighting affected on the vegetation normal regrowth in the surface plots. Therefore, plot locations were changed continuously around of the first plot locations in the studied years. Measurements of cover and forage yield were carried out with plot area and clipping and weighting methods, respectively. Cover of indicator perennial plants and accompany species were measured separately in every plot. Cover and annual yield of the rest perennial plants were low. Annual species were not separable and analyzed totality. Growth of clipped plants and their dried weight were analyzed and calculated based on kilogram per hectare. The research was started on the mid-May (range readiness time) in 2000 and continued on the same time until 2004. Meanwhile, data collection on 4 other stages was done in the research final year to determine the main species phonological stages. The cover and yield data of every species in the studied periods was recorded in the Excel 2000. The correlations between cover and yield data were studied by person correlation method in Spss.10. For introducing suitable model between them, regression analysis program was used and four types of regression models including linear, logarithmic, power and exponential were compared. Cover percentage was considered as independent variable (X and yield (kg/ha) as dependent variable (Y). Correlation of coefficient, coefficient of determination (R^2) and higher significant level were taken to account for selecting the best model for each species (Baghestani, 1999). According to these results, the importance of cover measurement for yield estimation of main species of rangelands in the region and the way of usage were indicated.

Results

The phenological records of species have been shown in table 1 for year 2004. Correlation coefficient between yield and cover percentage, coefficient of determination, significant levels and calculated equation for each species during 2000-2004 have been presented in table 2 and in 5 stages during year 2004 in table 3.

Table 1: Time of sampling and phenological calendar of main and accompanied species in Nir Range station (2004)

Stage	Date	Phenology condition						
		Salsola rigida	***Artemisia sieberi***	***Stipa barbata***	***Noaea mucronata***	***Scariola orientalis***	***Launaea acanthodes***	***Annuals***
1	Third decade of May	Vegetative stage	Vegetative stage	Flowering and seed formation	Vegetative stage	Vegetative stage	Vegetative stage	Maturity
2	First decade of July	Beginning of flowering	Bloom stage	Seed falling	Beginning of flowering	Beginning of flowering	Beginning of flowering	Fall
3	Third decade of August	Full flowering	Beginning of flowering	Summer Dormancy	Full flowering	Full flowering	Full Seed formation	Fall
4	Third decade of September	Beginning of Seed formation	Full flowering	First of Regrowth	Beginning of Seed formation	Seed falling	Seed falling	Fall
5	First decade of November	Full Seed formation	Beginning of Seed formation	Regrowth	Seed falling	Seed falling	Seed falling	Fall

Table2: Relationship between cover (%) and yield (kg/ha) of species during 2000-2004 in Nir Range Research Station

Species	Year	Epuation	Standared eror	Correlation coefficient	Coefficient of determination	Probability level
Salsola rigida	2000	$Y= 4.304 X^{0.533}$	0.40	0.82	0.67	0.007
	2001	$Y=19.975 X^{0.537}$	0.21	0.89	0.80	0.000
	2002	$Y=42.815 X^{0.836}$	0.15	0.95	0.91	0.000
	2003	$Y= 18.373 X^{0.825}$	0.51	0.78	0.61	0.002
	2004	$Y= 22.679 X^{1.042}$	0.24	0.92	0.85	0.000
Artemisia sieberi	2000	Y= 0.244 + 0.681 X	0.84	0.65	0.43	0.057
	2001	$Y= 6.858 X^{0.953}$	0.62	0.88	0.77	0.000
	2002	$Y= 12.587 X^{1.217}$	0.19	0.95	0.91	0.000
	2003	Y= -6.395 + 15.113 X	6.05	0.94	0.89	0.000
	2004	$Y= 10.745 X^{1.131}$	0.28	0.96	0.91	0.000
Stipa barbata	2000	Y= 0.425 + 3.368 X	0.55	0.87	0.76	0.002
	2001	$Y= 19.975 X^{0.537}$	0.21	0.89	0.80	0.000
	2002	$Y= 17.032 X^{1.183}$	0.33	0.92	0.85	0.000
	2003	$Y= 26.106 X^{0.979}$	0.32	0.75	0.56	0.005
	2004	Y= 0.212 + 29.587 X	11.93	0.93	0.86	0.000
Noaea mucronata	2000	Y= 2.961 + 5.726 X	2.21	0.23	0.05	0.559
	2001	Y= -1.296 + 16.196 X	3.36	0.76	0.58	0.004
	2002	Y= - 4.289 + 22.086 X	3.58	0.93	0.86	0.000
	2003	Y= - 2.307 + 18.826 X	2.40	0.87	0.75	0.000
	2004	Y= -0.657 + 10.107X	1.64	0.86	0.74	0.000
Scariola orientalis	2000	Y= 1.452 + 4.505 X	1.28	0.55	0.31	0.122
	2001	Y= 0.829 + 16.323 X	4.00	0.91	0.83	0.000
	2002	$Y= 18.840 X^{1.118}$	0.24	0.97	0.94	0.000
	2003	Y= 1.885 + 17.206 X	8.26	0.92	0.84	0.000
	2004	Y= -5.930 + 16.606 X	10.57	0.93	0.86	0.000
Launaea acanthodes	2000	Y= 0.352 + 32.931 X	5.70	0.78	0.60	0.014
	2001	Y= 0.524 + 11.604 X	1.67	0.85	0.72	0.000
	2002	Y= 0.128 + 12.047 X	2.85	0.82	0.67	0.001
	2003	Y= -0.665 + 10.290 X	2.24	0.95	0.90	0.000
	2004	Y= - 0.060 + 8.407 X	1.36	0.95	0.91	0.000
Annuals	2000	-	-	-	-	-
	2001	Y= 6.502 + 9.913 X	16.33	0.65	0.42	0.022
	2002	Y= -2.837 + 19.064 X	8.52	0.74	0.54	0.006
	2003	Y= 18.962 + 6.258 X	9.52	0.47	0.22	0.124
	2004	$Y= 42.352 X^{0.230}$	0.26	0.33	0.11	0.234
Other prennial Plants	2000	Y= 0.249 + 6.092 X	2.74	0.59	0.35	0.096
	2001	Y= -2.168 + 9.400 X	7.37	0.75	0.56	0.005
	2002	Y= 0.679 + 16.122X	8.45	0.88	0.78	0.000
	2003	$Y= 14.031 X^{0.812}$	0.56	0.54	0.29	0.069
	2004	$Y= 10.927 e^{0.617 X}$	0.49	0.80	0.63	0.004

Table 3: Relation ships between vegetation cover (%) and yield (kg/ha) in different phenological stages in Range Research station of Nir (2004)

Species	stage	Equation	Standard eror	Correlation coefficient	Coefficient of determination	Probability level
Salsola rigida	1	$Y= 22.679\ X^{1.042}$	0.24	0.92	0.85	0.000
	2	$Y= 39.998\ X^{0.872}$	0.29	0.89	0.79	0.000
	3	$Y= 3.559 + 30.543\ X$	22.37	0.94	0.89	0.000
	4	$Y= 32.471\ X^{0.958}$	0.33	0.91	0.82	0.000
	5	$Y= 34.456\ X^{1.105}$	0.29	0.94	0.87	0.000
Artemisia sieberi	1	$Y= 10.745\ X^{1.131}$	0.28	0.96	0.91	0.000
	2	$Y= 15.268\ X^{1.266}$	0.19	0.97	0.95	0.000
	3	$Y= 11.199\ X^{1.422}$	0.25	0.93	0.87	0.000
	4	$Y= -21.033 + 26.763\ X$	24.47	0.89	0.80	0.000
	5	$Y= -17.050 + 29.713\ X$	13.86	0.98	0.96	0.000
Stipa barbata	1	$Y= 0.212 + 29.587\ X$	11.93	0.92	0.86	0.000
	2	$Y= 41.527\ X^{1.144}$	0.24	0.93	0.87	0.000
	3	$Y= -1.813 + 49.441\ X$	12.32	0.90	0.81	0.000
	4	$Y= 19.018 + 28.044\ X$	15.67	0.68	0.46	0.005
	5	$Y= 8.341 + 44.38\ X$	21.15	0.83	0.69	0.000
Noaea mucronata	1	$Y= -0.657 + 10.107\ X$	1.64	0.86	0.74	0.000
	2	$Y= 24.473\ X^{1.461}$	0.34	0.95	0.91	0.000
	3	$Y= 0.922 + 26.066\ X$	3.76	0.87	0.76	0.000
	4	$Y= 2.141\ e^{3.260\ X}$	0.45	0.92	0.84	0.000
	5	$Y= -2.438 + 34.857\ X$	4.96	0.94	0.88	0.000
Scariola orientalis	1	$Y= -5.930 + 16.606\ X$	10.57	0.92	0.86	0.000
	2	$Y= 27.125\ X^{1.125}$	0.21	0.97	0.94	0.000
	3	$Y= 28.837\ X^{1.010}$	0.17	0.95	0.90	0.000
	4	$Y= -8.925 + 31.917\ X$	14.36	0.96	0.92	0.000
	5	$Y= 22.560\ X^{1.125}$	0.18	0.97	0.93	0.000
Launaea acanthodes	1	$Y= -0.060 + 8.407\ X$	1.36	0.95	0.91	0.000
	2	$Y= -1.407 + 20.972\ X$	12.99	0.88	0.77	0.000
	3	$Y= -4.368 + 27.270\ X$	12.61	0.84	0.71	0.000
	4	$Y= 2.204 + 22.969\ X$	9.73	0.96	0.91	0.000
	5	$Y= -0.732 + 22.499\ X$	12.71	0.82	0.68	0.000
Annuals	1	$Y= 42.353\ X^{0.230}$	0.26	0.33	0.11	0.234
	2	$Y= 8.334\ e^{0.450\ x}$	0.58	0.33	0.11	0.234
	3	$Y= 11.422\ X^{0.659}$	0.48	0.50	0.25	0.060
	4	$Y= 14.972 + 1.974\ \log X$	7.92	0.12	0.01	0.671
	5	$Y= 15.533\ X^{1.103}$	0.43	0.78	0.61	0.001
Other prennial Plants	1	$Y= 10.927\ e^{0.617\ x}$	0.49	0.80	0.63	0.000
	2	$Y= 11.201 + 17.503\ X$	26.23	0.43	0.18	0.111
	3	$Y= 10.040 + 18.840\ X$	18.91	0.58	0.34	0.022
	4	$Y= 46.587 + 21.221\ \log X$	39.07	0.37	0.14	0.176
	5	$Y= 18.688 + 22.772\ X$	38.92	0.48	0.23	0.070

Based on the results gained in years 2001-2004, high robust correlations ($p<0.01$) were seen between cover and yield of studied species. The lowest correlation during these years for *Salsola rigida*, *Artemisia sieberi*, *Stipa barbata* and three accompanied species *Scariola orientalis*, *Noaea mucronata* and *Launaea acanthodes* were 0.78, 0.88, 0.75, 0.76, 0.91and 0.82, respectively. For each species linear or power equations with high (R2) is applicable (Table 2). In all sampling stages in 2004 a significant correlation between cover and yield was observed ($p<0.01$). Due to occurring of drought in year 2000 correlation coefficient for *Salsola rigida and Stipa barbata* ($p<0.01$) and *Launaea acanthodes* ($p<0.05$) were 0.82, 0.87 and 0.78, respectively and non-significant correlations were observed for other species.

Discussion

Strong relationships between cover and yield were obtained during normal and wet years in terms of precipitation. However there were some fluctuations in drought conditions. In drought conditions cover form and yield were varied depending on species. Therefore, except serious drought condition, it is possible to estimate main and accompanying species production using their cover data. Significant correlations for *Artemisia sieberi* and *Stipa barbata* have also been reported by Saeedfar (1994) and Bigdeli (1997) in Isfhan province, for *Artemisia sieberi* and *Salsola rigida* by sadeghinia et al (2003) and three mentioned species and *Noaea mucronata* in Yazd and Isfahan provinces by Arzani (1989). They have also reported significant correlation between cover and yield of other species in steppic and semi steppic regions. Dauben Mire reported relationship between cover and yield for first time. Many papers have been published in other countries, however there no paper for species studied in the present project. The key point is that correlation rates and regression equations have been influenced by years and phenological stages. Even under relatively same rainfall condition in two years of 2002 and 2004, there were differences in each species equations .For example, the yield of *Salsola rigida* based on equation calculated for year 2001 with 4.5% vegetation cover, was estimated about 150.4 kg/ha. However, based on equation of 2004 for the same vegetation cover, yield was equal 180.6 kg/ha that shows the difference as 28%. Difference in yield estimation for *Artemisia sieberi* was 38%. Some parts of difference are related to variation in time of precipitation and its distribution during these two years that have caused different effect on plant growth. Meanwhile, Arzani (1989) reported different kinds of linear regression equation in various regions of Isfahan and Yazd provinces for two species of *Artemisia sieberi* and *Stipa barbata* in

1988. Therefore, application of equation for each species in a vegetation community in specific year and special time is possible, but for other times or location would involve with large error. Variation of rainfall in different years in a region and diversity ecologic characteristics of studied species limits applicability of obtained equation for wide areas. This finding is different from Ludwig et al. (1975) one. They believed that equation calculated in a certain time could be used in other times. However, most scientists emphasized that equation should be used by care (Harniss and Murray, 1976, Hughes et al, 1987, Payne, 1974). For instance Payne (1974) suggests the effect of location and Andariese and Covington (1986) the effects of vegetation composition and local condition for rising up accuracy should be taken into account. Arzani (1989) reported that calculated equations for each kind of vegetation that are suitable for yield estimation belong to specific condition and time of data collection .He suggested that calculating other equations would be required if condition changed. Similar finding was reported by Sadeghi Nia (1999). According to the results in the present study except in severe drought and different times and location robust correlation generally exist between cover and yield of studied species. So this is possible to estimate yield from cover data in the steppic regions using a double sampling procedure. This method was reported by Arzani and King (1994) for estimating forage production in the Australian rangelands, too. Clipping and weighing of shrub species is time consuming and expensive, in contrast using double sampling procedure which has been introduced by Wilm et al. (1944) is continually used in range inventory, but it needs experience of user in terms of ocular estimation of yield. So, double sampling procedure suggested in this paper is more applicable. Determination of ratio of direct and indirect sampling for double samples is important (Ahmed and Bonham 1982, Ahmed et al 1983, Arzani 1997).

Plants with small percentage especially with non-homogenous distribution will appear less in quadrates and it is not possible to calculate equation for each. Therefore, in the present study such species have been classified to other perennial plants. A general equation for estimating of yield from cover was calculated in the mentioned group (Table2). In year 2004, rate of correlation was lower (Table3). The variations in climatic condition during different years and different phenological characteristics during a year are main causes of changes. However, ratio of yield of such species to total yield is small. So, application of their equation is acceptable and related error is not important. Ahmed et al. (1983) also classified rare species to a group in their study. Correlation between cover and yield of annual species during different years and even for a year was changed (Tables 2, 3). Their low percentage and their non-homogeneous distribution are added to involved error. So this error should be taking to account while using equations for estimating their production.

Shape and canopy cover are generally changed by severe grazing (Holechek et al 1995, Moghaddam 1998, Vallentine 1990), but result of this study and review of other works (Arzani 1989, Begdeli 1997, Sadeghi Nia et al 2001) were based on data collected from exclousers. So, it is important to investigate more on correlation between cover and yield at different conditions.

References

1- Ahmed, J. and G. D. Bonham, 1982. Optimum allocation in multivariate double sampling for biomass estimation. J. Range Management, 35(6): 777- 779.

2- Ahmed, J., G. D. Bonham and W .A. Laycock, 1983. Comparison of techniques used for adjusting biomass estimates by double sampling. J. Range Management. 36(2): 217-221.

3- Andariese, S. W. and W. W. Covington. 1986. Biomass estimation for four common grass species in Northern Arizona ponderosa pine. J. Range Management. 39(5): 472 – 473.

4- Arzani, H., 1989. Relationship between canopy cover, foliage cover and basal cover with range production. MSc thesis, University of Tehran. 313pp.

5- Arzani, H. 1994. Some aspects of estimation short-term and long-term range carrying capacity in the western Division & New South Wales, PHD Thesis, University of N.S.W,

6- Arzani, H. 1997. Project manual of range evaluation in different climatic regions of Iran. Research Institute of Forests and Rangelands. 30 pp.

7- Arzani, H. and G.W. King, 1994. A double sampling method for estimating forage production from cover measurement. In proceeding of 8th biennial Australian Rangelands Conference. pp. 201-202.

8- Baghestani Maybodi, N., 1999. Correlation and regression models in SPSS software. Scientific report, organization of research and education, Ministry of Jahad-e- Sazandegi. 58pp.

9- Baghestani Maybodi, N., 2003. Study of short – term effects of different Goat's grazing intensities on some aspects of vegetation and animal performance in Yazd steppic rangelands. Thesis of PhD. University of Tehran. 214pp

10- Begdeli, M. 1997, Determining of suitable yield estimation method for shrub plants in Iranian's arid and semi arid zones. J. Pajohesh & Sazandegi. 37: 72-75.

11- Cook, C.W. and J.Stubbendieck. 1986. Range research: Basic problems and techniques. Society for Range Management.

12- Evans, R.A and M.B. Jones. 1958. Plant height times ground cover versus clipped samples for estimating forage production. Agronomy Journal. 50:504 – 506.

13- F. A. O., 1967. Pasture development and range improvement through botanical and ecological studies. UNDP. NO. TA. 2311 Rome.

14- Gholinejad, S. 1998. Determining of suitable plot numbers for direct and indirect methods in yield double sampling method. Thesis of M.S. Tarbeat-e- Modarres University. 115pp

15- Harniss, R.O. and R. B. Murray. 1976. Reducing bias in dry leaf weight estimates of big sagebrush. J. Range Management. 29(5): 430-432.

16- Holechek, J. L., R.D. Pieper, and C. H. Herbel, 1995. Range management, principles and practices (second edition). Prentice Hall Upper Saddle River, New Jersey 526pp.

17- Hughes, H.G., L. W. Varner and L.H. Blackenship. 1987. Estimating shrub production from plant dimensions. J. Range Mansgement. 40(4): 367-369.

18- Ludwig, J. A., J. F. Reynolds and P.D. Whitson, 1975. Size- biomass relationships of several chihahuan desert shrubs. The American Midland Naturalist. 94(2): 451-461.

19- Mesdaghi, M., Management of Iranian's rangelands. Astan-e- ghods Publication. Meshad. 215pp.

20- Moghaddam, M. R., 1998, Range and Range management, Tehran University Publication. Tehran. 470pp.

21- Pasto, J.K., J.R. Allision and J. B. Washko. 1957. Ground cover and height of sward as a means of estimating pasture production. Agronomy Journal. 49: 407-409.

22- Payne, G.F. 1974. Cover- weight relationships. J. Range management. 27(5): 403-404.

23- Pickup, G., V.H. Chewings and D. J. Nelson, 1993. Estimating changes in vegetation cover over time in arid rangeland using land sat Mss data. Remote Sensing Environment. 43:243-263.

24- Reich, R. M., C.D. Bonham and K. K. Remington. 1993. Technical notes: Double sampling revisited. J. Range Management, 46(1): 88-90.

25- Sadeghi Nia, M., 1999. Evaluation of Adelaide and cover technique for estimation of shrub production in range land of Yazd province. Thesis of M.S. Tarbeat Modarres University. 91pp

26- Sadeghi Nia, M., H. Arzani and N. Baghestani, 2001. Comparison of different yield estimation methods for some important shrub plants (the case study in Yazd and Isfahan provinces). J. Pajohesh & Sazandegi 61: 28-32

27- Saeedfar.M.1994. Forage estimation in some rangeland species by statistical models in Isfahan rangelands. Thesis of M.S. Tehran University. 214pp.

28- Vallentine J. F, 1990. Grazing management, Academic Press, INC., New York, 533pp.

29- Wilm, H. G., D. F. Coslello and G. E. Klipple, 1944. Estimating forage yield by the double sampling method. J. of American Society of Agronomy. 36: 194 - 203.