Determination of linear regression model to estimate the water requirements of sheep (case study: Pastures of northern Golestan province)

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Abstract

In areas where water is a scarce commodity, a strategy to determine water requirement of sheep to supply the amount of water, especially in droughts, are needed. The purpose of this paper is to offering a model to determine water requirement of sheep in winter pastures. This study was conducted in four commercial flocks of sheep in winter pastures of north of Golestan province (Gomishan and Aq-Qala) during the grazing season at December 2010 to April 2011. Among factors affecting on water requirement of sheep, the factors of ambient temperature, rainfall, wind speed, relative humidity, forage moisture and level of activity of sheep has been studied. Stepwise regression analysis is used to determine the factors that have most influence on water consumption of sheep during the grazing. Variables of Ambient temperature ($t = 12.532$, $p < 0.01$), forage moisture ($t = - 6.124$, $p < 0.01$) and rainfall ($t = 4.011$, $p < 0.01$), respectively, were selected in Stepwise regression analysis. A linear formula ($r^2 = 0.87$, $p < 0.01$) to determine the water requirement of sheep is obtained from this study.

Key words

Water requirement, sheep, winter pasture, linear formula, Golestan, Iran

Introduction

Livestock require the proper balance of water, carbohydrates (energy), protein, vitamins and minerals for optimal levels of performance. Of these nutrients, water is the most critical for all classes of livestock (Gadberry, 2000). The water intake of livestock varies greatly between species and between animals of the same Species, depending on their environment, age, type of feed and production environment (Dennis, 2008). Cattle water requirements and consumption depend on a number of factors, including air temperature, humidity level, water temperature, milk production, pregnancy status, physical activity, growth rate, animal size, breed, diet type, moisture level in the diet, salt intake, and dry matter intake (Parish and Rhinehart, 2008). The amount of water a cow drinks depends on her size and milk yield, quantity of dry matter consumed, temperature and relative humidity of the environment, temperature of the water, quality and availability of the water, and amount of moisture in her feed (Looper and Waldner, 2002). Many factors has affected on water consumption of sheep. In this research climatic factors including air temperature, rainfall, relative humidity, wind speed, and moisture of forage consumptions of sheep and level activity has been studied. The factors that have the greatest impact on water consumption of sheep, to make a linear regression model of water requirements of sheep have been used in this study.

Materials and methods

Study area

The study area was located in north of Golestan province that included winter pastures and are used for livestock in autumn and winter seasons. Four flocks of sheep have been selected in 2 stations having pastures 1-2 km away from each other. The climatic factors having effect on water consumption in each station were not different but activities and forage moistures factors were different in each station. The animals were similar in age, breed, weight (40 kg) and sex (male) in all flocks to neutralize the biological effects. The Bakhtyari sheep selected for study is dominant in this area. The Bakhtyari breed is one of the Fat-tailed breed and the goal of foster is production of meat.

Estimation of factors

The grazing season started in December and ended at the end of the April. Data were collected each month at three consecutive days in all stations. Ten sheep with same age and weight were chosen to estimate water consumption by drinking water out of the trough and then averaged in sampling days.

The green forage which was available during this study and used by sheep was *Halocnemum strobilaceum*. This is a succulent shrub, found in steppe and desert areas (Vali, 2006) and often used as forage in fall and winter pastures of wet and salty areas of Iran (Rasoli and Amiri, 2010). Twenty plant samples of forage were cut daily from the plants which were partly used by sheep for measurement of moisture. The fresh samples were weighed, then dried overnight in an oven at 100 ºC and weighed again after cooling to calculate the moisture content.

Activity was calculated by the movement of sheep with GPS during the grazing at each sampling in pastures. GPS was placed in a waist bag and was tied close to the back of sheep at start of grazing and opened up after grazing in end of day. So the amount of sheep movements was recorded at km-scale. Data on climatically factors were obtained from nearby meteorological stations (Mazraeh Nemone and Bandar Turkaman stations)

Statistical analysis

Simple and multiple linear regression procedures (selection/ stepwise) were used in the validation of the importance of the factors in the prediction of water requirement of sheep. Only those parameters significant at $P< 0.01$ for at least three variables were retained in the correlation and regression analyses. All data analyses were performed using SPSS 18 (SPSS, 2009). Significance level was sets at $P < 0.05$ and $P < 0.01$.

RESULTS AND DISCUSSION

The results revealed that during grazing season value of water consumption of sheep was different. Daily water requirement of sheep varied in different months and seasons. It fluctuated during the grazing season, was least during winter months and was less in wet than dry season.

The least water consumption was 0.63 liters per day in the humid and rainy season in February, with average consumption of 0.97 liters per day in this month. Similar amount (0.75-1 liters per day) of water consumption in the wet grazing season is reported earlier (Stoddart and Smith, 1955). The maximum water consumption was in December and April, which coincided with the warmest and most dry seasons. Average water consumption in these months was 5.7 liters per day. Similar consumption (4-6.5 litre per day) was also reported by previous workers (Ward and Mckague, 2007). The highest water consumption in dry season during present study was 8.08 liters per day whereas 8.5 litres per day was reported to be the peak consumption during dry season in a previous study (ANZECC, 2000). The average water consumption in the present study varied from 0.97-5.7 liters per day during different seasons.

F value and correlation coefficient between variables and water consumption are given, respectively, in Table 1 and 2. In the stepwise regression output (Table 3) among the factors examined variables temperature, forage moisture and rainfall, respectively, are excluded from the model. Air temperature was found to have a direct impact on water consumptions ($F = 157.062$, $p < 0.01$) and very strong correlation with water consumption of sheep ($r = 0.85$, $p < 0.01$). During the grazing season, with increasing temperature, the amount of water also increased. The water consumptions was least in February when air temperature was at its lowest (Fig. 1). Water consumptions of sheep increased with increase of air temperature. In hot weather, animals use more water for evaporative cooling (Winchester and Moris, 1956). For example, shearing increases the heat load on sheep in summer because the insulation formerly provided by the fleece is lost. The sheep adjust to this heat load by increasing evaporative cooling through panting. Water consumption can increase by 78 percent under extreme conditions (Markwick, 2007). Normally two third of water requirement of grazing animals in summer comes from drinking water, but in winter up to 90% of its requirements may come from pasture. Therefore the amount of drinking water required by an animal depends on what type of feed it is eating and the ambient temperature (Dennis, 2008). Water consumption of livestock depends up on combination of factors, of which air temperature is the most important, especially for outdoor livestock. Hot days increases water consumption (Brown, 2006).

Forage moisture was found to have negative effect on water consumption of sheep ($F=191.062$, $p < 0.01$). The correlation between moisture content of forage and water consumption was also very strong ($r = - 0.85$, $p < 0.01$). The highest forage moisture occurred in February, resulting into reduction in the amount of water consumption of sheep. The reduced forage moisture resulted into increasing water consumption during dry months of grazing season (Fig. 2). When high moisture feeds such as silage or fresh forages are used, water intake as drinking water is reduced. Because of the need to excrete more urine, high levels of salt or protein in the feed increase water needs (Gadberry, 2000). Sheep grazing in cold seasons require relatively less water because succulent feed is available. But in hot dry weather, however, the need for water increases (NAS, 1973). Feeds that are high in moisture such as green chop, silage or pasture provide part of the requirement, while feeds such as grain and hay offer very little moisture (Landefeld and Bettinger, 2000).

Rainfall has a negative effect on the water consumption ($F = 26.764$, $p < 0.01$). Correlation between rainfall and water consumption was negative and moderate ($r = - 0.45$, $p < 0.01$). Most rainfall occurred in winter. With increase in rainfall the amount of water requirement of sheep decreased due to increased relative humidity, lower temperatures, high forage humidity and reduced evaporation from the surface of the body. The highest rainfall occurred in February and coincided with the highest moisture content of forage and lowest temperatures. At this time the water consumption of sheep was at its lowest (Fig. 3). Sheep can be without water for several days to several weeks, one of the factors influencing this ability is abundance of rainfall and dew (Arthur and Sampson, 1952). In areas with high rainfall and humidity due to less evaporation livestock require less water (Gadberry, 2000).

The output of stepwise regression analysis consists of three stages for offering the final model. In the first stage of the stepwise regression variable temperatures were extracted for use in the final model ($t = 12.532$, $p < 0.01$). In second stage variable forage moisture was entered ($t = - 6.124$, $p < 0.01$). Variable rainfall was entered at three stage of stepwise regression analysis ($t = 4.011$, $p < 0.01$). The final model is as follows from the output of Stepwise regression analysis (Table 3):

$Y = 6.837 + 0.337\ x_1 - 0.097\ x_2 + 0.072\ x_3$ ($r^2 = 0.874$, $p < 0.01$) (Table 4)

x_1 = air temperature, x_2 = forage moisture, x_3 = rainfall.

According the results (Table 4 and Fig. 4) this model were suitable for determine of water requirement for sheep in these pasture.

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Table 1: F value of ANOVA table for factors examined

Variable	N	F	**Sig.**
Temperature	59	157.062	0
Rainfall	59	26.764	0
Relative humidity	59	40.693	0
Forage moisture	59	191.062	0
Activity	59	10.539	0.002
Wind speed	59	19.84	0

Table 2: Correlation coefficients between factors measurement and water consumption

Variable	Temperature	Rainfall	Relative humidity	Forage moisture	Activity	Wind speed
Water consumption	0.85**	-0.45**	-0.58**	-0.85**	0.44**	-0.49**

** P<0.01.

Table 3: Coefficient of dependent variable (wc)

Model		Unstandardized Coefficients		t	Sig.
		B	S. E.		
1	(Constant)	-1.537	0.429	-3.579	0.001
2	T	0.485	0.039	12.532	0
	(Constant)	6.613	1.373	4.818	0
3	T	0.283	0.045	6.296	0
	FM	-0.083	0.014	-6.124	0
	(Constant)	6.837	1.222	5.596	0
	T	0.337	0.042	7.992	0
	FM	-0.097	0.013	-7.719	0
	R	0.072	0.018	4.011	0

T-Temperature; FM- Forage Moisture; R-Rainfall

Table 4: Model summary of dependent variable (wc)

Model	R Square	Adjusted R Square	S. E. of the Estimate
1	.730 [a]	0.726	1.11751
2	.837 [b]	0.832	0.87545
3	.874 [c]	0.867	0.77848

a. Predictors: (Constant), T; b. Predictors: (Constant), T, Fm

c. Predictors: (Constant), T, Fm, R

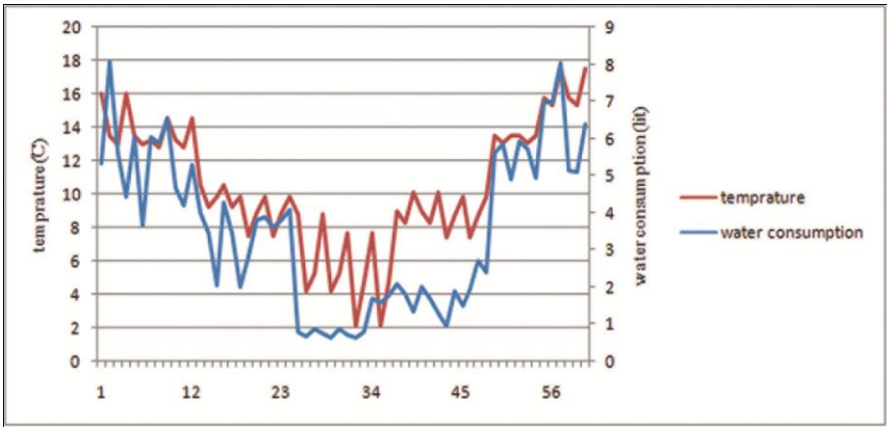

Figure 1 Water consumption of sheep vis-à-vis ambient temperature during the grazing season.

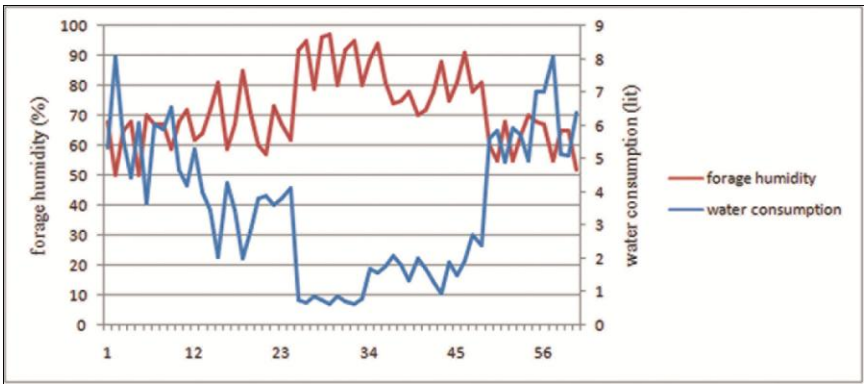

Figure 2 Water consumption by sheep vis-à-vis forage moisture during the grazing season.

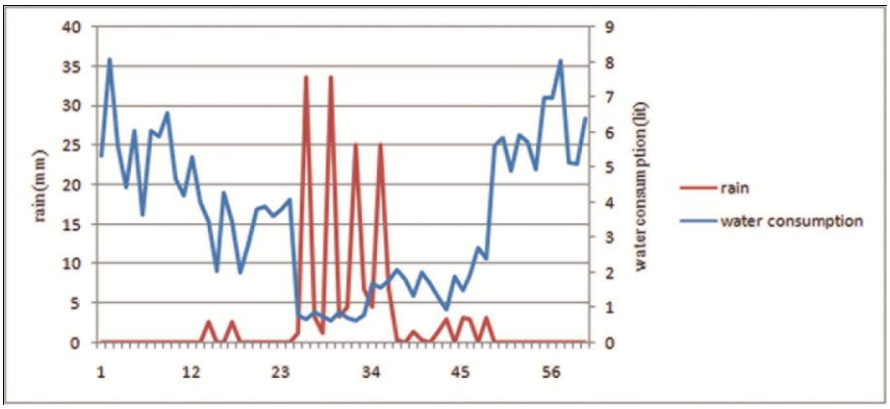

Figure 3 Water consumption of sheep vis-à-vis rainfall during the grazing season.

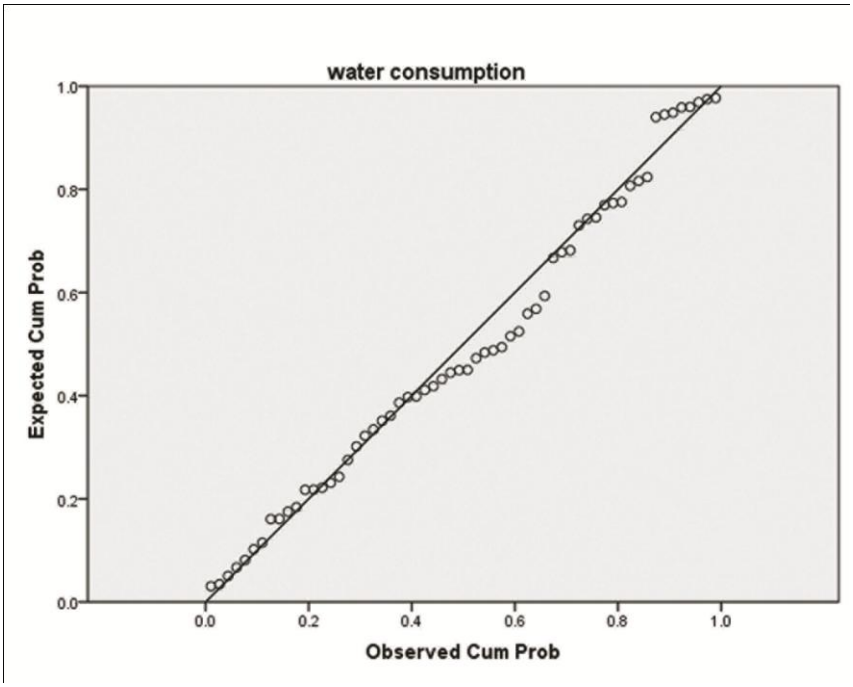

Figure 4 Normal plot of regression standardized residual.