Simulation Model for a Nomadic Animal Production System in Southern Iran

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Abstract. The first motive for the determination and evaluation of an energy production system is the need to change. Such system is dynamic in nature and is influenced by many factors such as age and physiological status of individual sheep or goat, quantity and quality of available feed and environment including the management systems. Traditional pastoral resource assessments do not always account for the complex, interrelated nature of land, forage and livestock. Modeling may overcome the limitations of traditional methods by improving the understanding of complex pastoral systems, and makes fast repetitive analyses, spanning time, incorporating variability and representing more realistically complex interactions possible within the system. The estimated values of metabolisable energy for maintenance and production in this study are based on the results of two feeding systems linked together by grazing the energy intake in the Nomadic Production System (NPS) and the dynamic system modeling used to study the assessment of these complex systems. In this study, validation of model relied on the observations of Torki Ghashghaii (TG) sheep (like those in Bakkan) under pen-fed and integrated rangeland-cropland feeding systems, and was carried out mainly by studying the body weight gain of growing animals and also body weight changes of ewes due to pregnancy and lactation. After validation, the study indicated that the mean value of actual data of male and female lambs (weaners) and ewes were in close agreement with the simulated data. These results validate the generalized structure of energy utilization models of grazing sheep under production sub- systems of NPS. These results will enable the prediction of carrying capacities in any given situation under conditions similar to those in Bakkan.

Keywords: Model, Nutritional Management, Nomadic, Sustainable Livestock Production System, Simulation, and Southern Iran.

Introduction

Nomads represent less than two percentages (1.9%) of total population of Iran (61million), but they control 23% of livestock (Emadi, 1995). Pastoral nomadism is a form of living that is ecologically adjusted at a particular technological level for utilization of marginal resources (Emadi, 1995). Research on traditional nomadic pastoralism so far has mainly focused on the relationship between animal husbandry and range ecology. Rapid increases in human and livestock populations this century along with conversion of grazing land to other land uses have contributed to increase the grazing pressures, especially in the arid and semi-arid environments. A "universal" methodology or prescribed procedure for analyzing the grassland-based pastoral resources is not practical. While there are general similarities between grassland-based systems, each has its own unique characteristics and resources which include environmental features, social and cultural factors, markets and political structures (Emadi, 1995).

Managing the livestock and forage resources to accommodate seasonality of forage supply is a major issue in livestock production. The issues supporting either a conservative or an opportunistic stocking policy for grazing the lands are complex. Traditional pastoralists often use a combination of conservative and opportunistic stocking policies. Consequently, there is a very integrated relationship between the major components of nomadic life namely nomads, pastures and herds. Information on the spatial patterns of livestock used in the study area is essential for identifying the efficiency of grazing use, constraints within the forage production system, and for interpreting the status of forage resource.

The overall objective of research was to study the nomads as the major Nomadic Production System (NPS) in the Bakkan region and to identify their sub-systems and components. Nomads and their belongings are the main part of highland range production system (hRPS) and cropland production system (CPS) as sub-systems, and system dynamics and modeling were used to assess these complex systems. The main contributing factor for integrating the livestock production system is the availability of herbage in rangeland that is directly grazed by animals and availability of forage in a cropland production system that directly (grazing on crop residues) and indirectly (by gathering the crop residues) provides the animal feed. The output of NPS or energy consumption is measured by animal production such as live body weight (meat production). In this study, validation of some components in these feeding sub-systems was carried out based on the observations of Torki sheep, the main breed raised in Bakkan, Iran (Badjian, 2005).

Materials and methods

To achieve the results and answers to some questions based on the objective, a district located on the northwest of Fars province in the southwest of country, namely Bakkan as the first governmental site for nomads' settlement and as NPS was selected. The NPS covers four tribes namely Igdir with 126 families, Ghottelo with 89 families, Safikhani with 126 families and Ardkapan with 144 families that were established in four new villages during the governmental plan for nomadic settlement in Bakkan. The NPS has two major sub-systems, namely a CPS and hRPS with other supplements (such as concentrates) and acts as the NPS inputs. These sub-systems are linked together by grazing the energy intake models of sheep and goats. Each system has its own feed quality and feeding system which can influence the feed and energy intake of sheep and goats. The environment, management system and socio/economic living of nomads also affect the NPS (Badjian, 2005). The output of the NPS or energy consumption is measured by animal production such as live body weight (meat production). General information on seasonal grazing patterns was obtained from institutions and specific information during field interviews. Grazing lands were sub-divided according to the grazing land status (e.g. natural or improved), season of usage and form of pastoralism (e.g. nomadic, transhumant or sedentary). The principal factors governing the grazing distribution should be identified. They include topography, seasonal differences in availability of forage and palatability of different plant communities, seasonal flooding or weather characteristics.

Figure 1 shows a conceptual model of NPS. In this conceptual model, the system starts with the availability of forage from hRPS for about 3 months of year. Each tribe of nomads has its own grazing calendar for the hRPS during wet and drought years. The animals use a lowland range production system (lRPS) before coming to the hRPS which is far from the hRPS. The grazing duration in the lRPS accompanied with supplementary feeding is about 2.5-4 months depending on whether it is a wet or drought year. Supplementary feed consists of barley grain, alfalfa hay, barley and bean straw that most of the nomads have gathered and carried from their cropland (during their stay in Bakkan) to the lowland. Animals start grazing on barley and bean crop residues from July to August for about 2-4.5 months. Then, the energy requirement of grazing animals of the NPS will conceptually depend on the energy of dry matter from hRPS, lRPS, CPS, residue and supplementary during drought and wet years. Energy flow in this conceptual model is shown in (Fig. 1). In an optimum situation, the grazing animal will utilize the available metabolizable energy in this system which comes from the grazing intake.

Since the present models rely on so many different sub-systems and components, it is practically impossible to obtain enough data to specify a particular system in sufficient details. Model predictions of system can be accurately compared with the actual outputs of system. For example, recorded data on integrated range-cropland-pen-fed systems for sheep and goats are always incomplete and usually only consist of information such as composition of herds, animal number in the herds, death number, number sale and occasionally animal weights at the time of sales. Other more detailed information such as proper use factor (PUF) is difficult to obtain under this mixed system.

Furthermore, there are no recorded data available in the literature regarding the performance of sheep and goat herds under such a system. Thus, in this study, validation of the model relied on the observations of Torki Ghashghaii (TG) sheep (like those in Bakkan) under pen-fed and integrated rangeland-cropland feeding systems, and was carried out mainly by studying the body weight gain of growing animals and also body weight changes of ewes due to

pregnancy and lactation. In 1996, 150 ewes and 15 rams were bought as a herd and kept in Neyriz research station (55º, 19´E - 29º, 21´N) for three years.
Data on TG sheep from this station were used for validation purposes. With the services of a local herder, the herd grazed daily on the rangeland. The herd composition consisted of two-year old (30%), three-year old (30%), four-year old (25%), and five-year old animals (15%). The herd was weighed monthly and data such as feeding calendar for ewes, rams and lambs, monthly body weights, pregnancy rate, lambing rate, body characteristics of lambs, ewes and rams, and mortality are available (Eilami, 1999).
The data show the same feeding calendar of TG sheep herd components that rural inhabitants or nomads use for their grazing animals. Three main feeds and feeding systems were studied for TG sheep herds in this project, namely highland range, cropland residues and hand feeding. The highland range and croplands for this project were close to the research station and needed only a small energy cost for walking.
The average daily gain (ADG) of lambs below 5 months of age reached its highest value at the age of 3 months for male and females. After the age of 5 months, the ADG started to decrease due to the changes in feeding and physiological status. At 4 months of age (110-120 days), male lambs (95 heads) and female lambs (70 head) were separated from the herds for 8-month period for the purposes of fattening, studying carcass characteristics and other experiments.
Parameter values used for the simulation of grazing sheep growth (Badjian, 2005) were as follows: The initial weights used in the simulation are presented in Tables 1 and 2.

- Dry matter digestibility (DMD) of 70.7%, 62.6%, and 61.7% for hand feeding, cropland residues and rangeland herbage respectively.
- Metabolizability (q-value) of 0.55 for both hand feeding and cropland residues feeding, and 0.52 for rangeland herbage.
- Efficiency with which ME is converted into energy for BW gain is 0.44(kg) for both hand feeding and cropland residues and 0.41 for rangeland herbage.
- Efficiency with which ME is converted into energy for BW maintenance is 0.7 (km) for both hand feeding and cropland residues and 0.69 for rangeland herbage.
- Animal age in years, i.e. A = 0.8
- Energy for grazing (E-graze) required for walking is 40% of metabolizable energy for maintenance for rangeland grazing and 20% for grazing on cropland residues. E-graze for hand feeding is taken as zero.

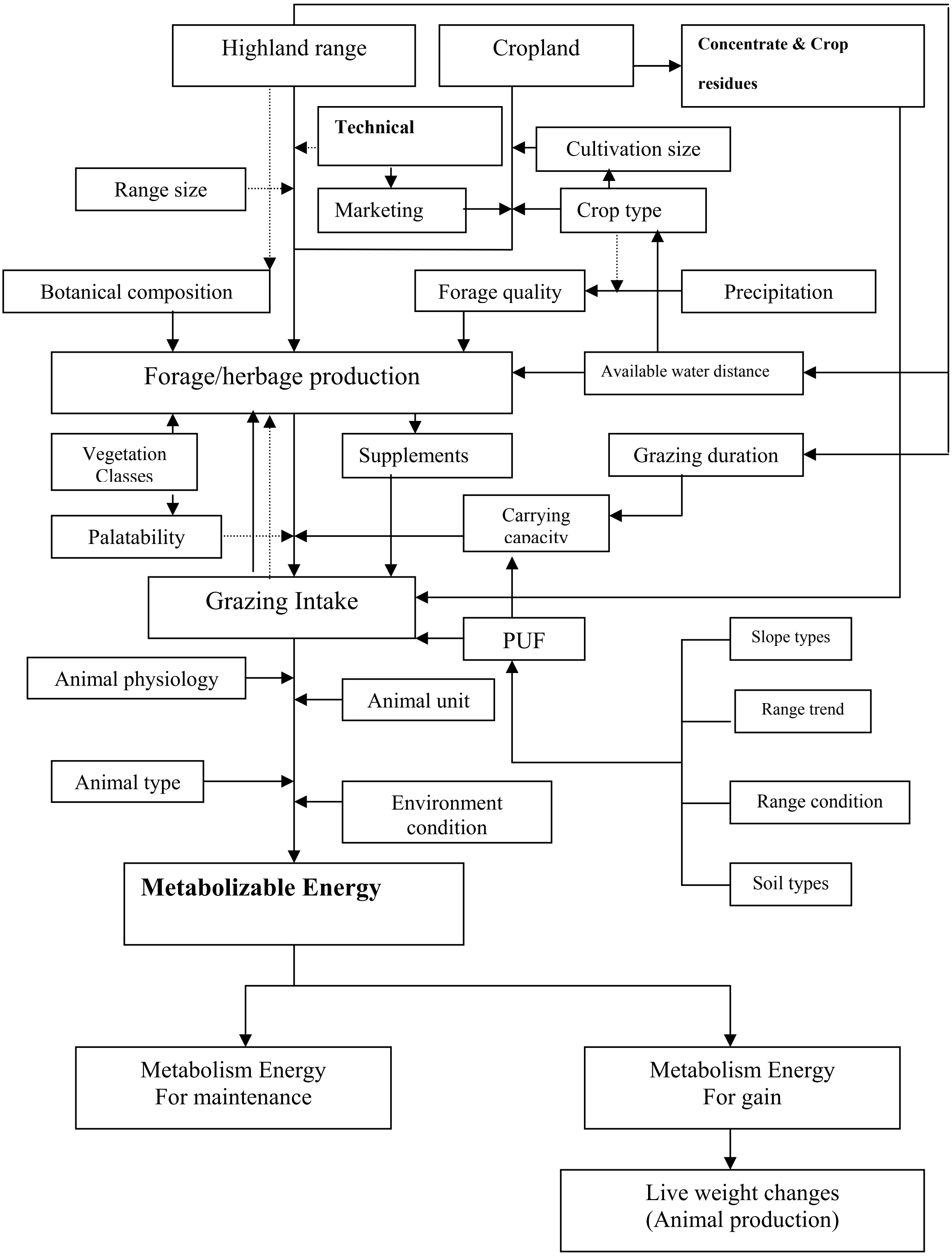

Fig. 1. Conceptual Model of Nomadic Production System (NPS)

The voluntary intake (VIg) of weaners in this validation study was simulated according to the following model (Badjian, 2005):

VIg= DMI*BW% (1)

Where BW is body weight and DMI is dry matter intake calculated from the following equation:

DMI = 0.0537DMD – 0.5027 (2)

Where DMD is dry matter digestibility.

Net energy for gain (NERg) was simulated according to the following model:

NERg = (MEVI– MERm) * kg (3)

Where MERm is the ME for maintenance and MEVI is the ME intake which are both calculated from the following equations:

$MERm = (0.26 * BW^{0.75} * e^{-0.03 A}) / k_m$ (4)

MEVI=14.58*VIg*DMD (5)

The kg and km are the efficiency of ME utilization for gain and maintenance respectively, and are determined by $k_g = 0.78q + 0.006$ and $k_m = 0.35q + 0.503$.

The live weight gain (Dg) of weaners was simulated based on the following equation:

Dg = NERg / (6.28 + 0.0188 BW + 0.3 NERg) (6)

The increment of live weight of weaners was computed according to the following model:

TBW= BWi + (Dg*Delt) (7)

Where Delt = 1 day (for monthly weight increments, multiplied by 30).

Energy costs for activities such as walking, physiological status such as pregnancy and lactation, and the feed source are the most important factors of variation in body weight changes and energy requirements of Torki sheep. These variations should be considered in the process of simulating the body weight changes of grazing sheep. For validation purposes, the initial body weights of individual ewes need to be specified for each physiological status. In this study, for the simulation of weight changes of individual ewes (3.5 years of age), the initial weights at e three stages were considered, namely 1) Lactation period (early and late lactation), 2) Dry period and 3) Pregnancy period after a parturition cycle of one year (365 days) (Table 3). The feeding systems in these stages were different and the energy requirements of the ewe within feeding systems were mainly for maintenance, activity, and physiological status.

Table 1. Mean of Body Weight Changes of Male/Female Lambs (1996-99) at Different Ages

Month	n		Mean BW (/kg)		S.d.*		Maximum (kg)		Minimum (kg)	
	Ewe	Ram	Ewe	Ram	Ewe	Ram	Ewe	Ram	Ewe	Ram
March-April	284	28	43.31	69.67	6.23	10.61	28.5	59.5	58.4	101.5
April-May	279	27	43.87	71.73	5.82	9.40	28.8	50.8	57.0	98.0
May-June	283	27	45.79	65.91	5.94	8.50	30	51.0	58.5	97.3
June-July	283	27	49.48	69.77	6.10	6.77	33	47.2	63.5	86.0
July-August	282	27	49.55	66.48	6.28	6.43	31.5	54.5	65.0	89.0
August-Sep.	282	24	45.35	70.22	6.63	8.47	30.8	56.0	63.0	82.5
Sep.-Oct.	280	27	42.84	67.44	6.61	7.34	30	56.5	58.8	93.0
Oct.-Nov.	279	27	43.57	65.44	5.78	7.17	33.1	54.1	59.0	86.5
Nov.-Dec.	280	27	44.66	65.52	5.68	7.49	33.7	50.0	61.5	85.0
Dec.-Jan.	280	27	44.70	65.88	5.22	7.85	34.5	51.5	59.5	85.5
Jan.-Feb	279	26	45.10	65.42	4.94	7.73	33.6	52.4	61.0	87.5
Feb.-March	249	26	47.29	69.63	4.75	8.48	34	52.4	60.0	87.5

* S.d = Standard deviation

Table 2. Actual (A) and Simulated (S) Body Weight Changes of Male and Female Lambs within Different Feeding Systems

Age (month)	Months	Feeding	M. Lambs BW (kg)		F. Lamb BW (kg)	
			A*	S*	A	S
6	February	Rangeland grazing + Hand feeding	30.63	30.63	27.04	27.04
7	March	Rangeland grazing + Hand feeding	31.41	31.52	26.55	27.52
8	April	Rangeland grazing + Hand feeding	33.85	32.7	27.47	28.08
9	May	Rangeland grazing	35.07	33.88	28.95	28.72
10	June	Grazing on cropland residues	35.37	35.73	30.01	29.87
11	July	Grazing on cropland residues	36.85	37.6	31.02	31.36
12	August	Grazing on cropland residues	34.62	36.76	28.93	30.47

A: actual live body weight (kg); S: simulated body weight (kg)

In stage 1, the ewe is considered to be in lactation (early and late) for 111 days after parturition. This stage occurs while the ewes are on hand feeding and rangeland grazing systems and the ME intake is utilized for maintenance, activity and lactation. The following equation is used:

MERl=MERm+MER+E-graze (8)

Where MERl and MERm is ME for lactation and maintenance respectively, and E-graze is for activity. Energy for foraging is taken to be 40% of MERm while grazing on rangeland in stage 1 (Abbott *et al.*, 2002). In stage 11, the ewe is considered to be in the dry period for 103 days and the energy requirement is mainly for maintenance. This stage occurs while grazing on rangeland and within a hand feeding system, and the ewe is not assumed to be pregnant. The amount of ME for maintenance (MERm) can be expressed as:

MERm = (NERm / k_m) + E-graze (9)

Where NERm is the net energy requirement for maintenance (MJ/day) and (k_m) is the efficiency of metabolizable energy utilization for maintenance.

In stage 111, the ewe is considered to be in the pregnancy period. Thus, the ME requirement was based on the energy needed for pregnancy, maintenance and activities for 151 days. This stage occurs within hand feeding, rangeland grazing and cropland residue grazing systems. The following equation expresses these requirements:

MERmp=MERm+MERp + E-graze(10)

Where MERp is ME for pregnancy.

During this stage, the lactating ewe usually loses weight. Assuming that the feed availability is unlimited, losing weight is mainly due to the low quality of the feed consumed and the higher demand for energy during the early lactation period. Thus, extra energy is needed to maintain body functions, and this condition will lead to occurrence of tissue mobilization in the animal (MAFF, 1975; Dahlan *et al.*, 1991).E-graze for grazing on cropland residues is taken to be 20% of total MER for maintenance. The parameters used for the stages and related equations are provided in Table 4. The ME intake (MEVI) for ewes is shown in equations 5 and 6. Starting from the initial weight of the ewe at a specific stage, the changes in body weight can be simulated with the differences between MEVI and MER as follows:

LW (i+1) = LWi + WC * 30 (11)

WC = (MEVI – MER) * kg /16.4 (12)

LWi is the initial body weight or previous weight of the ewe, and LW (i+1) is the ewe's body weight after the increment of time has passed (increment = 30 days). WC is the body weight change. The constant 16.4 describes tissue mobilization. (MAFF 1975; Dahlan *et al.*, 1991) suggested 20 MJ/kg (ME) for body tissue and a coefficient of 0.82 for its utilization.

Results and Discussions

Table 1 shows the body weight changes of lambs (male and female) from 1996 to 1999. The birth weight of male and female lambs was 4.4 kg and 4.2 kg, respectively showing no difference ($P<0.05$) although female lambs showed lower body weight than male lambs in monthly measurements for every age group.

After validation, the study indicated that the mean value of actual data of male and female lambs (weaners) and ewes were in close agreement with the simulated data (Tables 4 and 5).

Monthly body weight data over the age range of 6 to 12 months for the herd during the three year trial period were used to compare with simulated data. Table 3 compares the same quantities for female lambs. The results show that the simulated growths of male and female lambs are in close agreement with the actual growth of Torki lambs used for comparison. The simulated ADG of male lamb was 0.03 kg/day whereas the actual ADG mean of Torki male lambs at ages between 6-12 months old was 0.02 kg/day. Table 2 shows the monthly body weight of TG ewes and rams during the research project (1996-99). The body weight mean of ewes and rams at mating time were 45.55 and 71.89 kg, respectively. Comparisons of monthly body weight mean shows higher BW mean for rams than ewes ($P<0.05$). The ADG of ewes and rams was higher during June and July. After these months, the ADG started decreasing due

to changes in the feeding system and physiological status. The ratio of rams to ewes in this herd was 1:13. The mortality rate was for ewes and lambs3.0% and 4.6%, respectively. This information was used in the validation processes to compare the real system data with the simulated results.
In order to simulate the lamb growth or body weight changes, initial body weight, time increment and the parameters of lamb energy intake models for each feeding system need to be specified. Male and female lambs (weaners) were not assumed to have similar growth rates during 7 months (6-12 months of age) after a special hand feeding program (pre-weaners) for 4 months.

Table 3. Actual (A) and Simulated (S) Ewe Body Weight Changes within Different Feeding Systems and Stages

Stage	Months	Physiological status	Feeding	A	S
	October	Early lactation	Hand feeding	42.84	42.84
I	November	Late Lac./Dry period	Hand feeding + rangeland grazing	43.57	42.87
	December	Late Lac./Dry period	Hand feeding + rangeland grazing	44.66	43.7
	January	Dry period	Hand feeding + rangeland grazing	44.7	45.39
II	February	Dry period	Hand feeding + rangeland grazing	45.1	45.89
	March	Mating	Hand feeding	47.29	46.44
	April	Mating	Hand feeding	43.31	48.33
	May	Early gestation	Rangeland grazing	43.87	51.5
III	June	Early gestation	Rangeland grazing + grazing on cropland residues	45.79	49.05
	July	Late gestation	Grazing on cropland residues	49.48	46.43
	August	Late gestation	Grazing on cropland residues	49.55	44.36
	September	Early lactation	Hand feeding	45.35	51.5

The simulated ADG of female lambs was 0.02 kg/day whereas the actual ADG mean of Torki female lambs at a similar age was 0.01 kg/day. No differences were observed between the mean values of actual and simulated live weights of ewes and lambs (male and female) when tested with the Student *t*-Test showing that the used models are well fitted to the real conditions of system. Table 3 shows the actual and simulated body weight changes of ewes one day after parturition. Based on the actual data of Torki ewes at the age of 3.5 years, the initial body weights were considered at the beginning of three stages a) only lactation (111 days), b) dry period (103 days) and c) pregnancy (151 days). Although some variations between simulated body weight and actual body weight were found, the simulated ewe's weight was in close agreement with the respective actual Torki ewe weights. (Fig. 2), Shows that the weight variation was due to the differences in physiological cycle between the actual and simulated ewes, the beginning dates of each stage and the stage duration.

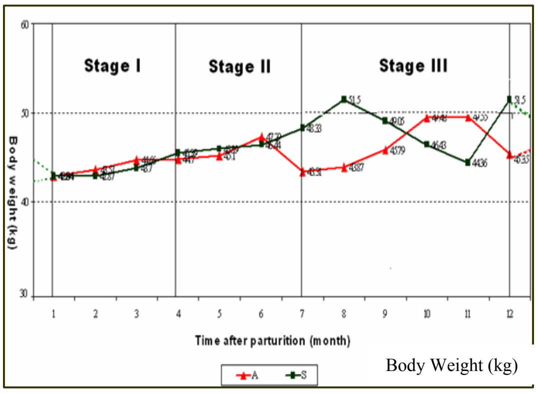

Fig. 2. Simulated (S) and (A) Body Weight Changes of Ewes after Parturition within three Different Stages of the Physiological Cycle.

Conclusions

The simulation of such system may still be possible if analysis is carefully conducted and the ultimate system requirements are known. Thus, the grazing intake on hRPS, CPS and the amount of supplementary feed determine the feed intake that is needed for the available metabolizable energy intake in NPS.

Torki sheep used to provide the actual data in this study is of the same breed and is used by nomads in their herds. The results showed no statistical difference between the actual and simulated data. Differences at specific points did occur, but the magnitude of differences was not large. More importantly, the simulations followed the trends of actual data describing the effects of various physiological stages of animals and the effects of different feeding systems.

These results validate the generalized structure of energy utilization models of grazing sheep under production sub-systems of NPS. These results will enable the prediction of carrying capacities in any given situation under conditions similar to those in Bakkan.

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References

Abbott, K. A. and Maxwell W. M. C. 2002. Sheep Health & Production. University of Sydney. Cited 03 May 2004, Available from: http://vein.library.usyd.edu.au

Badjian, G. R. 2005. Impact of Nomadic settlement on the ecology of Rangeland and Livestock in the Bakkan region of Southern Iran. Ph.D. Thesis, University Putra Malaysia.

Dahlan I. Shahar, M. Z. Yamada Y. & Mahyuddin M. D. 1991. The application of Modeling and Expert System for Livestock-Crop Integration. In: Recent Advances on the Nutrition of Herbivores, MSAD 1991. pp 253-267.

Eilami Bahman. 1999. Recognition of Torki Ghashghaii sheep in Fars province. Fars research center for natural resources and animal affairs. Iran (in Persian).

Emadi, M. H. 1995. Pastoralists, Participation and Policy: an action oriented, systemic and participatory approach to improve the relationships between Pastoralist Nomads, government and natural resources in Iran. Ph.D. Thesis, University of Western Sydney, Hawkesbury, Australia. pp 354.

Ministry of Agriculture, Fisheries, and Food (MAFF). 1975. Energy allowance and feeding systems for ruminants. Technical Bull. No.33. pp 79.