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Effect of animal species and supplementary feeding on digestion and energy utilization by sheep and goats grazing arid-area rangelands

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Abstract. Fifty-two non-productive females, 26 Balady goats and 26 Abu-duleik sheep, were employed in a 2.5-month experiment to study the effects of animal species and supplementation level on intake, digestion and energy utilization. Animals of each species were divided into two treatments. They all were grazing arid-area rangelands with a limited amount of concentrate supplement, low (1% BW) or high (2% BW). Total energy expenditure (EE) was estimated by heart rate monitors for 48h after individual calibration by oxygen consumption with a face mask open-circuit respiratory system. Acid insoluble ash (AIA), as an internal marker, was used to estimate the individual intake and digestibility for 6 animals per treatment, while bags were used for total fecal collection. Increasing the concentrate supplement level had negative effects on forage intake and digestibility of grazing goats, while the contrary was observed in sheep. The reduction in goat's digestibility was mainly attributed to the reduction in fiber fraction digestibility. However, grazing sheep supplemented with a high concentrate level consumed more forage and had a higher digestibility, including fiber fraction digestibility. Total EE was similar between animal species at a low supplementation level and significantly increased with a high level in sheep, but not in goats. Energy balance (EB) was negative and similar between animal species at a low supplementation level, while sheep reported positive and better EB than goats with a high level. In conclusion, supplementary feeding is essential to maintain the animals without deterioration while grazing arid-area rangelands but its effects varied between sheep and goats when supplied at a high level (2% BW).

Keywords. Grazing – Arid-area rangelands – Supplementation – Digestion – Energy utilization – Sheep and goats.

Effet de l'espèce animale et la supplémentation alimentaire sur la digestion et l'utilisation de l'énergie par les ovins et les caprins conduits sur parcours en zones arides

Résumé. *Cinquante-deux femelles taries et non gravides, 26 chèvres de race Balady et 26 brebis de race Abu-duleik ont été utilisées, dans un essai d'une durée de 2,5 mois, pour étudier l'effet de l'espèce animale et la supplémentation alimentaire sur l'ingestion, la digestion et l'utilisation de l'énergie. Les animaux de chaque espèce ont été divisés en deux traitements. Tous les animaux pâturaient sur des parcours des zones arides avec une quantité limitée de supplément de concentré niveau faible (1% de poids vif) ou niveau élevé (2% de poids vif)). La dépense énergétique totale (EE) a été estimée en utilisant un moniteur de fréquence cardiaque (HR) pendant 48h après un étalonnage individuel de la consommation d'oxygène avec un masque respiratoire facial ayant un système de circuit ouvert. Les quantités ingérées individuelles, de six animaux de chaque traitement, ont été déterminées en estimant la digestibilité (en utilisant les cendres insolubles dans l'acide (AIA) comme marqueur interne) et mesurant la production totale de fèces (sacs de collecte fécale). L'augmentation du niveau de supplémentation a eu des effets négatifs sur la consommation de fourrage et la digestibilité chez les chèvres au pâturage, alors que chez les brebis, le contraire a été observé. La diminution de la digestibilité chez chèvres est due principalement à la réduction de la digestibilité des fractions de fibres. Cependant, les brebis au pâturage et supplémentées avec le niveau élevé de concentré ont consommé plus de fourrage et ont eu une digestibilité supérieure (y compris la digestibilité de la fraction de fibres). L'EE totale a été similaire entre les ovins et les caprins avec le faible niveau de supplémentation, par contre, elle a augmenté significativement avec le niveau élevé de supplémentation chez les ovins en comparaison avec les chèvres. Le bilan énergétique (EB) a été négatif et similaire entre les deux espèces animales avec le faible niveau de supplémentation, tandis que les brebis ont eu un EB positif et meilleur que les chèvres avec le niveau élevé de supplémentation. En conclusion, la supplémentation alimentaire est essentielle pour maintenir les animaux sur parcours en zone aride sans détérioration, mais ses effets varient entre les ovins et les caprins avec le niveau élevé (2% PV) de concentré.*

Mots-clés. *Pâturage – Parcours de zone aride – Supplémentation – Digestion – Utilisation d'énergie – Ovin-caprin.*

I – Introduction

Sheep and goats are very important to the world's food security and supply because of their ability to utilize fibrous materials not of immediate nutritional value of people. They also affect the social and economic status of people inhabiting arid and semi-arid regions. The efficiency of forage utilization is affected by many factors such as animal species and supplementary feeding (NRC, 2007). Feeding supplementation may be necessary to cover the nutrient requirements of grazing animals, particularly in the dry season. Supplementation may also affect the forage intake and digestibility (Askar *et al*., 2014). It decreases time spent grazing and associated energy cost for grazing activity (Beker *et al*., 2009), improving the efficiency of nutrient utilization. The objective of this study was to determine the effect of supplementary feeding on energy utilization by sheep and goats grazing arid rangelands and supplemented with two concentrate supplement levels.

II – Material and methods

The study was carried out in the Ras Hederba Valley region at the Shalateen research station of the Desert Research Center, some 1300 km south east of Cairo, the capital of Egypt. The full description of the area is mentioned in Askar *et al*. (2014).

Animals and treatments: Fifty-two non-productive females, 26 Balady goats and 26 Abu-duleik sheep (hair coat breed), were employed in a 2.5-month experiment to study the effects of animal species and supplementary feeding level on intake, digestion and energy utilization. Animals of each species were divided into two treatments, 13 per each. They were grazing arid rangelands with a limited amount of concentrate supplement, low (1% BW) or high (2% BW).

Experimental procedures: The experiment started in July 2013 and lasted for 2.5 months, including a 2-week final period for the measurements of feed intake, digestibility and energy utilization. Concentrate supplement was given in the morning (before grazing). Water was available free choice twice daily, at 08:00 and 14:00 h. The acid insoluble ash (AIA), as an internal marker, was used to estimate the individual intake and digestibility for 6 animals per each treatment, while bags were used for total fecal collection.

Energy expenditure: The calorimetry system and its usage were described previously by Askar (2016). Animals were fitted with a face mask facilitating open-circuit respiratory system for measuring O2 consumption (Sable Systems, Las Vegas, NV). Heart rate (HR) was simultaneously measured to determine the individual energy expenditure (EE)/HR ratio. Energy expenditure was estimated assuming a constant thermal equivalent of 20.47 kJ per liter O2. Human S610 HR (Polar, Lake Success, NY) monitors with infrared connections to the transmitters were used to collect HR data at a 1-min interval. Heart rate data were analyzed using Polar Precision Performance SW software provided by Polar. Heart rate was measured for each animal while grazing for at least 48h. The daily EE was determined from the EE: HR ratio of each animal. Furthermore, Gross energy (GE) of feed, orts and feces were estimated by bomb calorimeter (IKA, model C 200, Staufen, Germany), using benzoic acid as standard. Metabolizable energy (ME) was estimated as 82% of digestible energy (DE) intake (NRC, 2007). Energy balance (EB) was calculated as the difference between ME intake (MEI) and EE.

Statistical analyses: Data were analyzed by the GLM procedure of the SAS statistical package. The model included the effects of animal species, supplementation level, and their interaction. The least significant difference (LSD) was used to compare the means, and differences with $P<0.05$ were accepted as statistically significant.

III – Results and discussion

Intake and digestibility: Although a similar forage intake was observed in grazing sheep and goats receiving a low supplementation level, a significant reduction in forage intake was observed in goats *vs* sheep receiving a high level. Roughage to concentrate ratio in the diet was similar (67.6%) for sheep and goats at a low supplementation level, while this ratio was significantly varied and dropped to be 43.8 vs. 53.9%, respectively, at a high level. However, lower forage intake in goats was associated with a significant reduction in nutrient digestibility, particularly for those related to fiber fraction digestibility (Table 1). Results are in agreement with Allam *et al*. (2007) who worked on the same goat breed supplemented with two concentrate levels, 25 and 50% of ME, and grazing similar arid-area rangelands. It was expected that increasing concentrate supplement intake might negatively affect forage intake and digestibility (Garcés-Yépez *et al*., 1997). This would be attributed to its negative effects on rumen pH and cellulolytic bacteria (Mann and Ørskov, 1975). Increasing concentrate supplement in diet might also negatively affect protozoa population, sometimes leads to their disappearance in the rumen (McAllister and Cheng, 1996), and the efficiency of microbial protein synthesis. On the other hand, this is not the case with sheep in which forage intake was increased by increasing the concentrate supplement level. Our results also showed that increasing the supplementation level improved the forage intake and digestibility in sheep. The findings are in agreement with our previous results with the same sheep breed and under similar grazing condition (Askar *et al*., 2014). Moreover, concentrate supplement was reported to increase forage intake and utilization as a result of increasing dry matter digestibility (Gekara *et al*., 2005). It was reported that the effects of concentrate supplement on forage intake vary depending on the forage quality and supplement composition (Moore *et al*., 1999). In agreement with the current findings in sheep, supplementary feeding was not observed to affect forage intake when the forage quality was high (Kartchner, 1980; Smith *et al*., 2006), while supplementation was reported to positively affect the intake of low quality forage (Kartchner, 1980).

On the other hand, faster fractional rates of passage of digesta from the rumen were reported in goats vs. sheep when they grazed in semiarid-area rangelands (García *et al*., 1995). This might negatively affect rumen retention time and consequently fiber fraction digestibility in goats. Moreover, in the current study, increasing concentrate level, which was accompanied by increasing total feed intake, may accelerate the rate of passage from rumen and increase the associated negative effects in goats.

Table 1. Feed intake and digestibility in sheep and goats grazing arid-area rangelands with different concentrate supplement levels, low (1% of BW) or high (2% of BW)

	Goats		Sheep		SEM	Significant		
	Concentrate supplement							
	Low	High	Low	High		Species	Treat	S*T
DM intake, g/ kg $BW^{0.75}$/ day								
Forage	47.0^{b}	36.0^{c}	51.8^{ab}	58.8^{a}	2.92	***	ns	**
Total	69.6^{c}	82.2^{b}	76.5^{bc}	109.2^{a}	2.67	***	***	***
Digestibility, %								
DM	58.2^{ab}	54.5^{b}	54.5^{b}	60.3^{a}	2.01	ns	ns	*
Energy	59.1^{a}	56.0^{b}	57.9^{ab}	62.3^{a}	1.74	ns	ns	*
NDF	54.6^{a}	44.1^{b}	51.3^{a}	54.4^{a}	2.40	ns	ns	**
ADF	49.9^{a}	36.5^{b}	45.5^{a}	48.3^{a}	2.89	ns	ns	**

$^{a, b, c}$ Means without a common superscript letter in the row are different (P < 0.05) among species x treatments. ns = non-significant; * = P < 0.05; ** = P < 0.01 *** = P < 0.001; SEM = Standard error of means.

Energy utilization: The GE, DE, and ME intake (kJ/ kg MBW, Table 2) are following the same trend of total dry matter intake. However, the EE (kJ/ kg MBW) was similar between sheep and goats when receiving a low supplementation level, while it was significantly (P<0.001) greater for sheep vs. goats when receiving a high level (Table 2). The differences between sheep and goats received different concentrate levels in the estimated EE were consistent throughout the day as shown by the evolution of daily records illustrated in Fig. 1. A higher intake of grazing sheep supplemented with high concentrate level was associated with a higher EE. In this regard, a positive relationship between feed intake level and EE was previously reported (Askar 2016; Askar *et al*., 2016).

Table 2. Energy utilization by sheep and goats grazing arid-area rangelands with different concentrate supplement levels, low (1% of BW) or high (2% of BW)

	Goats		Sheep			Significant		
Energy utilization,	**Concentrate supplement**				**SEM**			
kJ/ kg $BW^{0.75}$/ day	**Low**	**High**	**Low**	**High**		**Species**	**Treat**	**S*T**
Gross energy	1048^{c}	1261^{b}	1151^{bc}	1662^{a}	38.9	***	***	***
Digestible energy	622^{c}	707^{b}	664^{bc}	1033^{a}	27.6	***	***	***
Metabolizable energy	510^{c}	580^{b}	545^{bc}	847^{a}	22.7	***	***	***
Energy expenditure	560^{b}	577^{b}	600^{b}	776^{a}	23.9	***	***	***
Energy balance	-50.0^{c}	2.6^{b}	-56.0^{c}	71.5^{a}	9.41	***	***	***

$^{a, b, c}$ Means without a common superscript letter in the row are differed (P < 0.05) among species x treatments.
*** = P < 0.001; SEM = Standard error of means.

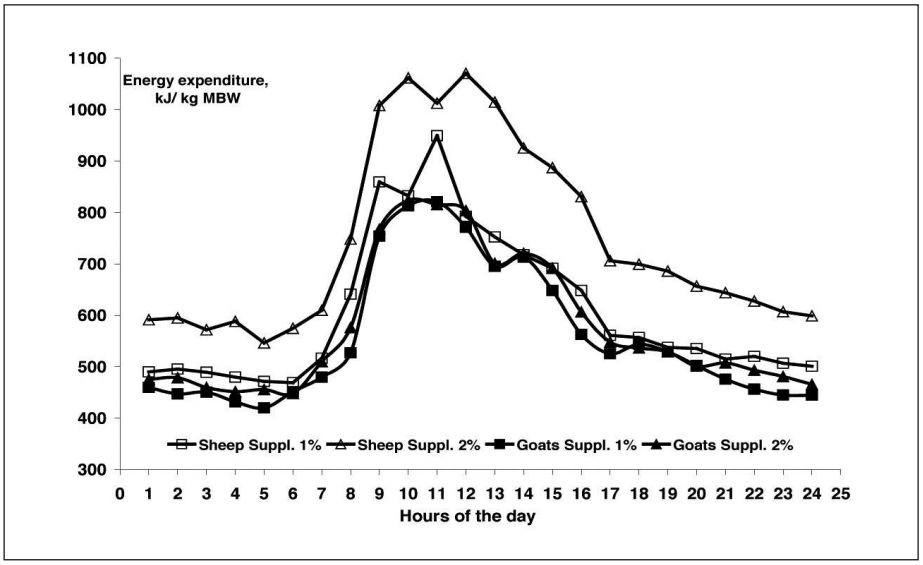

Fig. 1. Hourly energy expenditure (kJ/kg MBW) of sheep and goats grazing the arid-area rangelands with different concentrate supplement levels throughout 24-hour period.

On the other hand, a similar EE/ME intake ratio for sheep and goats receiving a low supplementation level (EE = 110% of ME intake), while a lower and an efficient ratio for sheep *vs* goats receiving a high level (EE = 92 *vs* 100% of ME intake, respectively) were observed. This indicated that sheep are in a better state than goats when supplemented with a high concentrate level. This is reflected on the EB that was negative and similar between animal species at a low supplementation

level, while sheep reported positive and better EB than goats with a high level, indicating that concentrate supplement is necessary to maintain animals while grazing arid-area rangelands as suggested by Askar *et al*. (2014), but its effects varied between sheep and goats at a high level.

IV – Conclusions

Supplementary feeding is essential to maintain animals without deterioration while grazing arid-area rangelands but its effects varied between sheep and goats when supplied at a high level (2% BW).

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