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SUMMARY – This experiment aimed to examine the effect of stocking rate (SR) on selectivity, dry matter (DM) intake and milk production of Girgentana goats grazing on a sward of ryegrass (RG) and berseem clover (BC) mixture. The experiment involved 21 goats at 130±6 d of lactation divided into 3 homogeneous groups. From 9th April, for 87 d, each group grazed (9.00 am to 4.00 pm) on a sward plot with a different surface (972, 1458, 1944 m^2), according to a high (HSR, 72 goats/ha), medium (MSR, 48 goats/ha) and low SR (LSR, 36 goats/ha). All the goats were fed 500 g head/d of barley meal. Weekly, sward biomass, herbage selected by goats and individual milk yield were measured and sampled. The DM intake and digestibility and diet botanic composition of grazing goats were assessed by the *n*-alkane method. Grazing at HSR was suspended 25 d before MSR and LSR (62 *vs* 87 d), due to the low biomass availability. During the 62 d of contemporary grazing, biomass availability was lower at HSR (P≤0.001). The BC was the dominant species in each plot, while the HSR led to a low presence of RG (P≤0.001). SR affected botanic composition of selected herbage: the incidence of the more palatable RG decreased (P≤0.001) with SR increase. DM intake and digestibility of forage at pasture increased (P≤0.001) from HSR to LSR, resulting in an improved milk yield (P≤0.001), without any changes in milk composition. Whereas the HSR gave the lowest total milk yield *per* goat, grazing at MSR produced the highest milk amount per ha during the whole grazing period.

Keywords: Goats, Girgentana, grazing, stocking rate, herbage intake, milk.

RESUME – *"Effet du taux de chargement sur le comportement sélectif et la production laitière de chèvres Girgentana sur un pâturage de mélange de raygrass et de bersim". On a étudié les effets du chargement (SR) sur la sélectivité, la consommation de matière sèche (DM) et la production laitière de chèvres de race Girgentana pâturant une prairie de* Lolium multiflorum *(RG) et* Trifolium alexandrinum *(BC). 21 chèvres à 130±6 j de lactation ont été réparties en 3 lots homogènes. A partir du 9 avril, pendant 87 j, chaque groupe a pâturé de 9h00 à 16h00 sur des parcelles de différente surface (972, 1458, 1944 m^2), selon un chargement élevé (HSR, 72 chèvres/ha), moyen (MSR, 48 chèvres/ha) et bas (LSR, 36 chèvres/ha). Tous les animaux recevaient 500 g/j de farine d'orge. La biomasse des parcelles, l'herbe sélectionnée par les chèvres et la production individuelle de lait ont été mesurées et échantillonnées une fois par semaine. La consommation de DM, la digestibilité et la composition botanique de la ration au pâturage ont été évaluées par la méthode des n-alcanes. Pour le lot HSR le pâturage a été arrêté 25 j avant les autres (62* vs *87 j), en raison de la basse disponibilité de biomasse. Pendant ces 62 j de pâturage, la disponibilité de biomasse a été plus limitée pour le lot HSR (P≤0,001). Le BC a été l'espèce dominante dans toutes les parcelles. Le HSR a conduit à une présence réduite de RG (P≤0,001). Le SR a influencé la composition botanique de l'herbe sélectionnée : l'incidence du RG a diminué (P≤0,001) en augmentant le SR. La consommation de DM et la digestibilité du fourrage au pâturage ont augmenté (P≤0,001) du HSR au LSR; cela a causé une augmentation de la production laitière (P≤0,001), sans modifier la composition du lait. Le lot HSR a donné la plus basse production de lait par chèvre et le lot MSR a eu la production la plus élevée par ha pendant toute la période de pâturage.*

Mots-clés: *Chèvres, Girgentana, pâturage, chargement, consommation d'herbe, lait.*

Introduction

In the Mediterranean area, the goat rearing system is mainly based on extensive native pastures,

where often tree and shrub species are predominant over the herbaceous vegetation. Nevertheless, in the last few years, intensive systems have spread in favourable environments, where productive goat breeds are grazing on forage crops, such as an integration of feeding resources from natural pasture. Mixed sward has often been shown to be an alternative to pure stands, allowing improvements in forage and animal production. In a recent study (Bonanno *et al.*, 2004), a grass and clover mixture, grazed by goats at a low stocking rate (16 heads/ha), ensured a superior herbage availability than the separate and sequential utilization of the relative monocultures, favouring an increase in dry matter (DM) intake and milk yield.

The benefits of mixed sward, as of every pasture, depend greatly on grazing management, which must aim to ensure selective behaviour for the goats, the maximum herbage intake and the satisfaction of the nutritional requirements for optimizing production. Among the practices employed to develop an appropriate grazing management, the major determinant of animal and forage productivity is the stocking rate (SR), i.e. the "number of animals to graze per unit area of land for a specific amount of time" (Malecheck, 1982). Both overstocking and understocking have adverse effects on the botanical composition and quality of the biomass and the diet selected by the animals at pasture. Overgrazing can reduce the herbage allowance and the herbage intake of animals. Undergrazing reduces forage yield and quality, and causes forage loss for tissue ageing. Several studies suggest that a moderate grazing intensity has a positive impact on quantity and quality of forage resources and animal performance (Hart *et al.*, 1988).

The studies into the effect of SR mainly regard the goats grazing on shrubby and woody lands (Njwe *et al.*, 1995; Tsiouvaras *et al.*, 1999; Abbadessa *et al.*, 2000), whereas there are few investigations into goats grazing on herbaceous forage crops, especially with regard to milk yield and quality. Therefore, this experiment aimed to examine the effect of SR on the selective behaviour, herbage intake and milk production of Girgentana goats grazing on a sward of ryegrass and berseem clover mixture.

Materials and methods

The field experiment, carried out in a hilly semi-arid area of Sicily (Pietranera farm, Agrigento, 37°37'N; 13°29'E; 178 m a.s.l.), lasted 87 d from 9th April 2004, and involved 21 Girgentana goats at 130±6 d of lactation, homogeneously divided into 3 groups on the basis of milk yield, body weight and BCS. During the daytime (9.00 am to 4.00 pm), the goats were allowed to continuously graze a mixed sward of ryegrass (RG) (*Lolium multiflorum* Lam. subsp. *Westerwoldicum, var.* Elunaria*)* and berseem clover (BC) (*Trifolium alexandrinum* L., var. Lilibeo), divided into 3 fenced areas, one for each group, of different surface (1947, 1462 and 976 m^2). In this way, low, medium and high SR were compared, corresponding to 36 (LSR), 48 (MSR) and 72 (HSR) goats/ha. Grazing at HSR was suspended at day 62 of experiment, as consequence of the low biomass availability. Each goat was fed 500 g/d of barley meal (15.0% CP on a DM basis).

The measurements were taken weekly. The sward surface height was measured by sward stick. Herbage mass was determined by clipping at ground level 6, 5 or 4 square areas of 0.72 m^2, for LSR, MSR and HSR respectively. Samples of each square were divided into green matter from RG and BC, weeds and dead matter. The herbage DM intake and the *in vivo* DM digestibility of grazing goats were assessed by the *n*-alkane method (Mayes *et al.*, 1986): goats were continuously dosed twice daily with pure cellulose stoppers including 30 mg of the alkane C_{32}; faeces samples were taken by grap-sampling the goats twice daily during a 4-day period within each week. Hand-plucked samples of herbage intake were collected after observing the selective behaviour of goats during grazing. Individual daily milk yield was recorded and sampled. Live weight and BCS of goats were measured at the start and at day 62 of the experiment.

Analysis for DM, crude protein (CP) and NDF was carried out on forage and barley. Selected herbage and faeces were processed for *n*-alkane analysis by gas-chromatograph. Diet composition was estimated using herbage and faeces concentration of the alkanes C_{27}, C_{29}, C_{31} and C_{33}, adjusted for the recovery rate (Mayes *et al.*, 1986). Milk samples were analysed for: lactose, fat, protein and somatic cells (Combifoss 5200); total N, non-casein N, non-protein N; urea (differential pH-metry); pH and clotting parameters (r, k_{20}, a_{30}).

Experimental data for the period during which the groups were grazing contemporarily (62 d) was statistically analysed by GLM procedure of SAS 6.12; the model included the effects of two factors, experimental period (8 levels) and SR. Differences between treatment means were tested by Student "*t*" test.

Results and discussion

SR influenced the length of the grazing period: grazing at HSR was suspended 25 d before MSR and LSR (62 *vs* 87 d), due to the faster deterioration and reduction of the available vegetation (Fig. 1). In fact, the residual biomass under HSR, even though close to 3 t DM/ha, consisted of 45% dead matter.

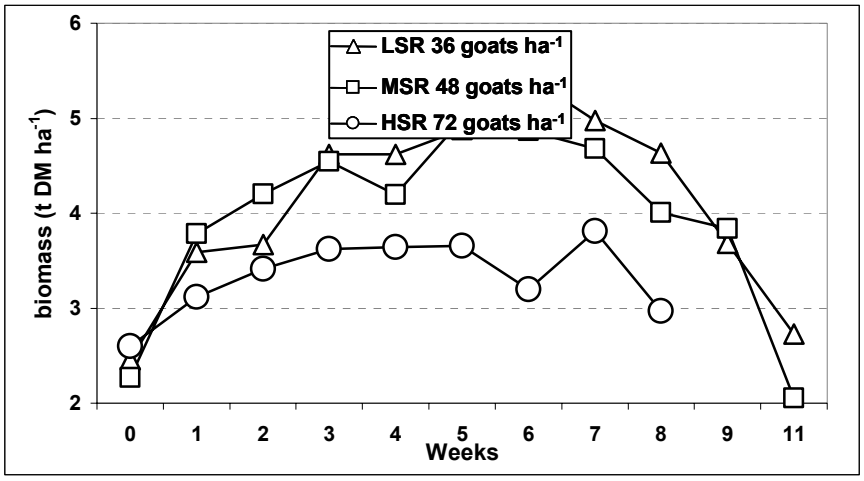

Fig. 1. Effect of stocking rate on variation of biomass during the grazing period.

On average (Table 1), during the 62 d of contemporary grazing, height and biomass of sward were lower under HSR (P≤0.001). The HSR influenced botanic composition, determining a lower presence of RG (P≤0.001), more palatable than BC, this latter being constantly the dominant species in each plot. A superior incidence of dead matter (P≤0.01), as well as the mass percentages of DM and NDF (P≤0.01), emerged under LSR and HSR, whereas the protein content was slightly lower at LSR (P≤0.01). It was also observed (Fig. 2) that the increase in SR led to the reduction in forage yield, due to the slower herbage growth; thus, at HSR the daily herbage allowance per goat was lower and the utilization pressure was higher.

Herbage intake of goats at pasture decreased, passing from LSR to HSR in terms of DM, protein and NDF (P≤0.001) (Table 2), and under HSR it was constantly lower during the entire grazing period. The botanic composition of selected herbage shows that RG decreased and BC increased with high grazing pressure, indicating how the goats, under superior SR, were obliged to reduce their intake of RG (P≤0.001), which being more palatable, was gradually less present, and to increase the incidence of BC, which was more available but less favoured. Therefore, the selective index over RG increased from LSR to HSR (2.4, 3.0 and 3.7 for LSR, MSR and HSR; P≤0.001). The goats' preference for grass, explained by higher digestibility and content in non-structural carbohydrate (Fedele *et al*., 1993), and their refusal of leguminous species, containing secondary compounds responsible of lower digestibility and palatability (Provenza, 1995), are well known. Other findings indicate that, in the presence of a low incidence of palatable species at pasture, the goats tend to reduce their grazing time and DM intake, rather than consume species for which they show no liking (Penning *et al.*, 1997).

At each SR, the goats selected forage of a better quality than the available vegetation (Table 2), confirming that they tend to select the more proteinic and less fibrous parts of plants (Pizzillo *et al.*, 1988), and reduce the herbage intake if the biomass availability or quality do not allow this selective

behaviour. In the selected herbage under HSR, the protein content was higher (P≤0.001) and digestibility was lower (P≤0.001), linked to the higher incidence of BC, having superior protein and lignin contents than RG, whereas the NDF did not differ between the groups. Also Tsiouvaras *et al.* (1999) observed the reduction of palatable species, forage yield and DM intake of goats on shrublands at higher grazing intensity.

Table1. Effect of stoking rate on height, biomass, botanic and chemical composition of sward (LSM)

	Stocking rate			Significance		Root MSE
	LSR	MSR	HSR	Period	SR	
Sward height (cm)	21.3^{A}	18.5^{B}	12.4^{C}	***	***	4.7
Biomass (t DM/ha)	4.3^{A}	4.2^{A}	3.3^{B}	***	***	0.79
Botanic composition (% DM)						
Berseem clover (BC)	46.0	45.3	51.1	**		14.9
Ryegrass (RG)	24.9^{A}	23.9^{A}	15.1^{B}	***	***	11.8
Weeds	6.7^{a}	11.4^{b}	8.3^{ab}		+	10.0
Dead matter	22.3^{ABc}	19.4^{Aa}	25.4^{Bb}	***	**	7.0
Chemical composition (% DM)						
Dry matter (DM)	20.4^{Aa}	18.4^{Bb}	19.8^{ABa}	***	**	2.9
Crude protein	16.0^{A}	17.0^{B}	17.0^{B}	***	**	1.6
NDF	49.8^{A}	47.7^{B}	50.3^{A}	***	**	2.5

+=P≤0.10; **=P≤0.01; ***=P≤0.001. A, B, C: P≤0.01; a, b, c: P≤0.05.

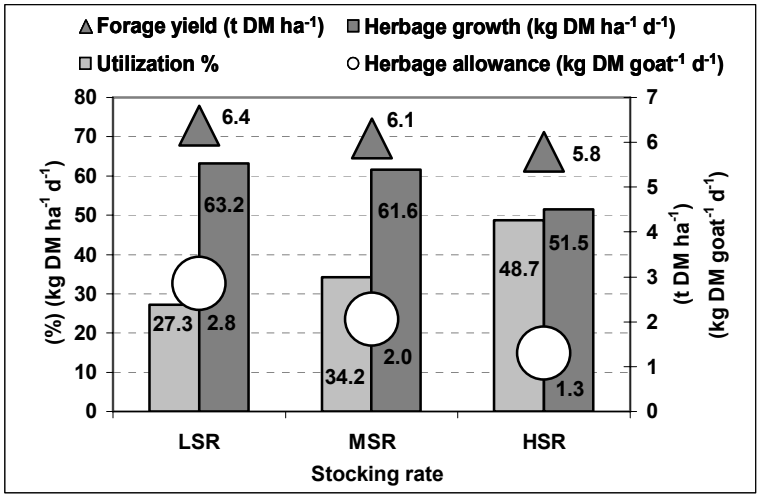

Fig. 2. Effect of stocking rate on forage yield, herbage growth, utilization and herbage allowance.

The effects of higher herbage intake and digestibility at LSR and MSR resulted in a corresponding improvement in milk production (P≤0.001) (Table 3), without relevant changes in milk quality. A lower level of somatic cells (P≤0.001) was noticed in the milk of MSR goats. Even though significant, variations in clotting parameters were moderate as a result of SR. Despite lower milk yield, goat grazing at HSR showed a more limited recovery in live weight (9.7, 8.6 and 4.3% for LSR, MSR and HSR; P≤0.01) at 62 d of experiment.

Table 2. Effect of stoking rate on DM intake, botanic and chemical composition of selected herbage (LSM)

	Stocking rate			Significance		Root MSE
	LSR	MSR	HSR	Period	SR	
Intake (g/goat/d)						
Herbage DM	806^{Aa}	716^{Bb}	635^{Bc}	***	***	171.7
Herbage crude protein	206^{Aa}	190^{ABb}	170^{Bb}	***	***	48.0
Herbage NDF	269^{A}	232^{B}	202^{C}	***	***	58.1
Botanic composition (% DM)						
Berseem clover (BC)	35.7^{A}	34.9^{A}	51.2^{B}	***	***	18.2
Ryegrass (RG)	54.7^{A}	45.8^{B}	36.8^{C}	***	***	16.7
Weeds	9.6^{Aa}	19.3^{Bb}	11.9^{ABa}	***	**	17.6
Chemical composition (% DM)						
Dry matter (DM)	18.7^{A}	19.1^{A}	16.5^{B}	***	***	2.3
Crude protein	25.6^{Aa}	26.4^{ABb}	26.8^{Bb}	***	***	1.7
NDF	33.0	32.7	31.7	***		3.6
Digestibility	70.1^{Aa}	69.8^{ABa}	67.1^{Bb}	***	*	6.0

*=P≤0.05; **=P≤0.01; ***=P≤0.001. A, B, C: P≤0.01; a, b, c: P≤0.05.

Table 3. Effect of stoking rate on milk yield and quality(LSM)

	Stocking rate			Significance		Root MSE
	LSR	MSR	HSR	Period	SR	
Milk yield (g/goat/d)	1332^{A}	1328^{A}	1004^{B}	***	***	304.7
Normalized milk yield (3.5% fat) (g/goat/d)	1347^{A}	1350^{A}	1017^{B}	**	***	299.3
Fat (%)	3.6	3.7	3.7			0.46
Protein	3.6	3.6	3.6			0.34
Somatic cells (cells/ml)	756^{Aa}	181^{Bb}	513^{Ac}		***	0.42
Casein (%)	3.1	3.1	3.0			0.37
Non proteic nitrogen (mg/ml)	47.5	47.6	47.4	***		4.4
Urea (mg/dl)	54.0	55.1	53.4	***		7.5
pH	6.6	6.6	6.6	***		0.11
r (min)	10.9^{a}	11.1^{ab}	11.7^{b}	***	+	2.2
k_{20} (min)	1.6^{a}	1.9^{b}	1.6^{a}		*	0.62
a_{30} (mm)	53.4^{Aa}	50.2^{ABb}	48.8^{Bb}	+	**	7.2

+=P≤0.10; *=P≤0.05; **=P≤0.01; ***=P≤0.001. A, B: P≤0.01; a, b, c: P≤0.05.

The relationship between SR and milk produced during the entire grazing period (87 d) indicates that the increase in grazing pressure resulted in a gain of the daily normalized milk yield per ha (P≤0.001) (Fig. 3). Nevertheless, under the HSR the total milk yield per goat showed a drastic decline, whereas grazing at MSR produced the highest milk amount per ha. From the economic point of view (Hart *et al.*, 1988), the maximum profit of a system at pasture occurs at the point where the milk production per ha is maximum and the individual milk yield begins to decline, a condition that in this specific case also corresponds to the MSR.

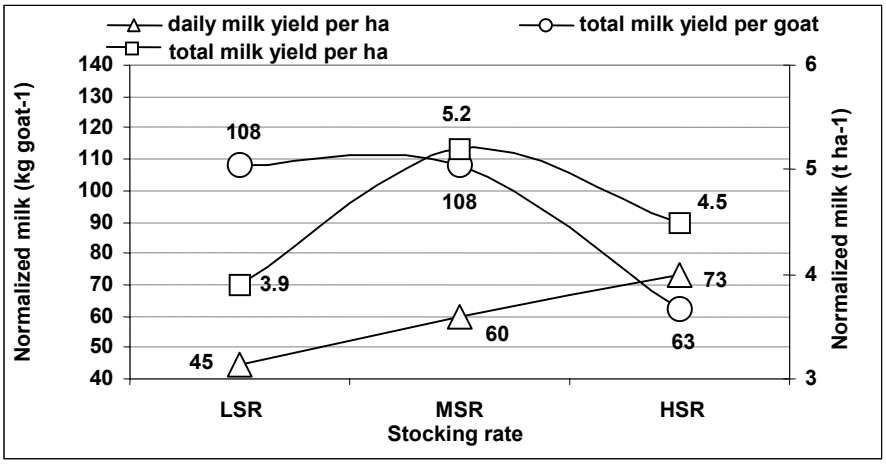

Fig. 3. Effect of stocking rate on total milk yield.

Conclusions

This experiment confirmed the SR to be an essential element in developing an appropriate grazing management, also for goats grazing on forage crops, greatly affecting forage and animal productivity. From a practical point of view, the results that emerged here suggest the adoption of a medium SR. The moderate grazing intensity, compared with lower or higher SR, enhanced the productive responses of the milking goats, ensuring for them higher forage availability and quality, the opportunity to fully express their selective behaviour, to optimize the level of herbage intake and to maintain a healthy condition.

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