ANALYSIS OF BIOMASS BALANCE AND STOCKING RATE IN CATTLE AND SHEEP PRODUCTION SYSTEMS IN MEDITERRANEAN AREAS

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Abstract

The breeding of cattle and sheep is the most important in Mediterranean areas both for its numerical importance and for its spread on the territory. The practise of irrational zootechnical activities, associated with excessive stocking rate, is likely to contribute to soil degradation and desertification. In order to carry out informations about the biomass removed by animals and the trading on soil, a virtually experiment has been carried out using simulated sheep and cattle production systems. The results of this simulation can be profitably utilised for the definition of the system variables of the model MEDRUSH II.

Résumé

L'élevage bovin et ovin a une place dominante dans les régions méditerranéennes tant pour son importance numérique que pour sa diffusion sur le territoire. Une activité zootechnique irrationnelle associée à un taux de charge excessif, vont probablement contribuer à la degradation du sol et à la désertification. Afin d'obtenir des informations sur la biomasse absorbée par le bétail et le chargement du sol, une expérience virtuelle a été menée à travers la simulation des systèmes de production des bovins et des ovins. Les résultats de cette simulation ont été utilisés avec profit pour la définition des variables du système du modèle MEDRUSH II.

The breeding of herbivores is the main agricultural activity in Mediterranean areas both for its numerical importance and also because of its spread on the territory. The total amount of herbivores is about 100 millions of mature conventional heads (MCH) (**table 1**), 53.8% of which is bred in European countries, 23.2% is bred in African countries and 23.0% is bread in Asiatic countries (FAO, 1993). The majority of this amount (90.2%) is composed by ruminants (cattle, sheep and goat) and we think that

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Table 1 ***Stocks of principals herbivores in Mediterranean Countries (HEAD*1000) (FAO - Yearbook production 1992).***

Country	cattle	sheep	goats	horses	camels	MCH (*)
EUROPE	42157	75709	13761	2707		53811
Albania	502	1000	800	176		858
Bulgaria	1336	6703	553	459		2521
France	20928	10579	1221	377		22485
Greece	616	9694	5832	305		2474
Italy	8087	10435	1314	384		9646
Malta	23	6	5	2		26
Portugal	1370	5847	862	275		2316
Spain	4924	24625	3000	470		8157
Ex Yug.	4371	6820	174	259		5329
AFRICA	11543	51950	15350	4159	758	23190
Algeria	1420	18600	2500	531	130	4191
Egypt	6052	4350	4800	1560	210	8737
Libya	135	5600	1250	91	155	1066
Marocco	3300	17000	5500	1610	33	7193
Tunisia	636	6400	1300	367	230	2003
ASIA	13582	59115	13131	1983	157	22947
Cyprus	57	310	205	8		117
Israel	349	360	111	11	10	417
Jordan	32	2000	600	24	18	334
Lebanon	72	230	465	41	1	184
Syria	763	15782	986	235	6	2681
Turkey	12309	40433	10764	1664	122	19215
TOTAL	67282	186774	42242	8849	915	99948

(*) MCH = Mature Conventional Head = 1 cattle, 1 horse, 1 camel, 10 sheep, 10 goats = 0.4 tons of body weight.

Table 2 ***Annual dry matter balance (t*1000) by grazers in Mediterranean Countries.***

Countries	intake	faeces + urine	losses
European	236768.4	94707.0	142061.0
African	102036.0	51018.0	51018.0
Asian	100966.8	45435.0	55532.0
Mediterranean	439771.2	191160.0	248611.0

Hypotheses:
a) Average dygestibility of dry matter: Europe, 0.6; Asia, 0.55; Africa, 0.5 (INRA 1988; Butterworth 1967).
b) Average annual intake = 11 times the body weight (corresponding at 3 % of body weight per day).

more than 90% of these is bred using directly natural or cultivated forage resources by grazing. Both, irrational grazing and excessive stocking rate, probably are the most important causes of soil degradation and desertification (Savory, 1992), mainly where rainfalls are meagre and not well distributed, or where there are high slope and soil instability (Harrington, 1981; Margaris & Grove, 1993); this is particularly true in some Mediterranean areas, like Spain, Crete, and North Africa, where excessive grazing and the use to fire in order to improve pastures have caused a great reduction of soil fertility and, in some cases, their sterility (Novikoff, 1992; Margaris & Grove, 1993).

The negative action of grazing on soil fertility is due to: a) trampling, which decreases its porosity and consequently water percolation (Speeding, 1971; Valentine, 1990); b) reduction of LAI, which allows water to have a bigger strength of impact and runoff (Larin, 1962; Valentine, 1990; Kirby et al., 1993); c) organic matter remotion, because organic matter is essential to help soil to maintain a good structure favourable on contrasting the erosive action of water and wind.

Quantifying organic matter removed by ruminants through the balance between the dry matter eaten by animals and restitution by mean of urine and faeces on the animal-soil-climate system (Snaydon, 1981), is particularly useful for the construction of models about soil degradation as MEDRUSH (Kirby et al., 1993); these remotions are made of CO_2, which comes from breathing and rumen fermentations (CH_4/CO_2 molar ratio is approximately 1/1; Rhode, 1990), and commodities (meat, milk and wool). Organic matter removed by grazing animals in Mediterranean countries, has been estimated to be about $249*10^6$ t, $212*10^6$ of which are made of CO_2 ; $12*10^6$ are made of CH_4 and $25*10^6$ are made of commodities. It has been estimated that CH_4 production is about 2.7% of the weight of eaten organic matter (5.4% of C eaten) because of the fact that we consider the ration of grazing animals made mainly of grass with high content of cell walls (INRA, 1978; Johnson et al., 1991; Succi et al., 1992). The study of ruminants CH_4 production is an important subject for researches; this is due to the fact that it has been estimated that it contributes to the green-house effect - which long term consequences will probably exalt the negative characteristics of Mediterranean climate (increase of ratio winter-to-summer precipitations; Karl et al., 1991) - fifteen times more than CO_2 does. Being ruminants contribution to total CH_4 production about 14% (Johnson et al., 1991), it can be told that CO_2 from ruminants reared in Mediterranean areas amounts to 8% of the whole of the CO_2 produced by grazing animals, which is only 1.1% of the total production of CH_4; however, the grazing animals' contribution to the production of gases responsible for the green-house effect (CO_2+CH_4) is not very high (Van Soest, 1994), and it is absolutely not important the one caused by Mediterranean grazing animals (not more than 0.1% of the total production).

The effect of organic matter restitution is worth to be studied with great attention: it is effective only during the damp season, when soft faeces (caused by intake of fresh grass) can easily be absorbed by the soil, whereas in the dry season faeces (drier because of the diet is composed of stubble and there are some defences of the animal bodies against water waste) are likely to be oxidised because of their long permanence over the soil; from this point of view, coprophagus insects are very important because they are able to spread and earth faeces up, mainly during the summer. A further effect of grazing animals regards the pollution of grazing grass with faeces and urine, which may cover till about 15% of grazed surfaces, and may decrease dry matter potential intake till about 50% (Larin, 1962; McLusky, 1960; cit. by Brockington, 1972); the influence of this feature on the utilisation of pastures, has been analysed through a mathematic model by Brockington (1972). Due to the importance of the organic matter in the dynamics of degradation of the Mediterranean soils, this study is aimed to evaluate in the details organic matter remotion in standard breeding situations of sheep and cattle in Mediterranean countries.

Table 3 ***Sheep hypotheses (referred to standard flock: 100 mature sheep + 2.5 ram).***

Breeding systems	External imputs (1)	Reproductive parameters		Productive parameters			Fodder production (t/ha of DM)		
		Fertility	Prolif.	FCM (2)	Lambs to sold (3)	Replacement (4)	Pasture	Grass (5)	Cereals
semi-int.	0	A=0.80	1.00	A=140					
	15	B=0.95	1.40	B=250	96	15	2.4	5.0	2.5
	30			SF=185					
semi-ext.	0	A=0.70	1.00	A=110					
	15	B=0.90	1.25	B=220	78	15	1.8	3.5	2.0
	30			SF=155					
extensive	0	A=0.60	1.00	A=90					
	15	B=0.85	1.10	B=190	62	15	1.2	0.0	1.5
	30			SF=125					

(1) % of DM eaten. (2) kg of 6.5% Fat Corrected Milk. (3) 9 kg of body weight. (4) 42 kg of body weight. (5) Cultivated
A= ewes lamb (150 days of lactation)
B= mature ewes (250 days of lactation)
SF= Standard Flock
Hypotheses: replacement 20%; lambing death 5%; mature death 5%; reproductive sex ratio 1ram/40ewes; principal lambing season, autumn (65% of ewes)

Experimental contribution

Two virtual experimentats have been carried out utilising sheep and cattle production systems which have been simulated by computer. The two models refer to the breeding of a cattle herd for the meat production and of a sheep flock for the milk production (Masala et al.,1994; Pulina, 1994). The dimension of husbandries has been standardised (100 mature females + replacing + males) and the relative stocking rate has been referred to a standard farm; the breeding techniques analysed are those normally carried out in Sardinia, which can be considered a representative Mediterranean zootecnic area (in the island there are 0.33 MCH/hectare of surface; Brandano et al., 1988). As what regard to sheep, three production systems (semi-intensive; semi-extensive and extensive) have been analysed , while as regards cattle only semi-extensive system has been considered.

In relation to each system these features have been taken into consideration:
a) three levels (0%, 15%, 30%, of eaten dry matter) of external feed supplement (hay and concentrate);
b) three productive and reproductive levels (only for sheep)
c) three fodder production levels for three sheep classes, and only one for cattle (the same one of the corresponding sheep class).
The study considers the Sarda cattle breed

Table 4 ***Cattle hypotheses (referred to standard herd: 100 mature cows + 2.5 bulls).***

Breeding System	External imputs (1)	Fertility	Fodder production (t/ha of DM)		
			Pasture	Cultivated grass	Cereals
	0				
semi-extensive	15	0.8	1.8	3.5	2
	30				

(1) % of DM eaten
Hypotheses: replacement 12%; calving death 0%; cows death 4%; bulls death 0%; distribution of calving during the year 50% Jan., 50% Feb..

Table 5 ***Sheep hypotheses: material balance (referred to standard flock: 100 mature sheep + 2.5 ram).***

Breeding systems	Intake (1)	Ext imputs (2)	Restitutions (1) Faeces	Urine (3)	Total F + U	Remotions (1) Milk (4)	Meat (5)	Wool	Others (6)	Total	R/B (7)	Surface (8)	Rem. (9)
		0								39.510	42.16		
semi-int	60.919	15	19.363	2.046	21.409	3.330	0.592	0.15	35.438	30.372	32.41	22.74	1.738
		30								21.234	22.66		
		0								36.788	41.32		
semi-ext	57.878	15	19.074	2.016	21.090	2.790	0.538	0.15	33.310	28.106	31.57	28.38	1.296
		30								19.424	21.81		
		0								34.347	40.50		
extensive	55.121	15	18.788	1.985	20.774	2.250	0.490	0.15	31.457	26.079	30.75	33.82	1.015
		30								17.811	21.00		

(1) t of DM/year.
(2) % of DM eaten.
(3) 1 liter/day (5.0% of DM) (Bortolami et al., 1985).
(4) milk with 18% of DM.
(5) body weight with 30% (lambs) and of 45% (ewes) of DM.
(6) mainly CO2 (85.5%) and CH4 (4.2%).
(7) ratio Remotions/Biomass produced in % (Biomass = DM eaten/Utilizzation ratio of 0.65 (Lucifero et al., 1973)).
(8) ha.
(9) Remotions t/ha per year.

Table 6 ***Cattle hypotheses: material balance (referred to a standard herd: 100 mature cows + 2.5 bulls).***

Breeding systems	Intake (1)	Ext imputs (2)	Restitutions (1) Faeces	Urine (3)	Total F + U	Remotions (1) Meat (4)	CH_4	CO_2	Total	R/B (5)	Surface (6)	Rem. (7)
		0							272.766	39.049	220	1.240
semi-ext	454.037	15	156.662	24.608	181.27	6.776	12.259	253.731	113.165	16.201	194	0.538
		30							45.060	6.451	177	0.255

(1) t of DM/year.
(2) % of DM eaten.
(3) 8 liter/day (5.0% of DM) (Bortolami et al., 1985).
(4) live weight with 35% of DM (calf) and of 45% (cattle) of DM.
(5) ratio Remotions/Biomass produced in % (Biomass = DM eaten/Utilizzation ratio of 0.65 (Lucifero et al., 1973)).
(6) ha.
(7) Remotions t/ha per year.

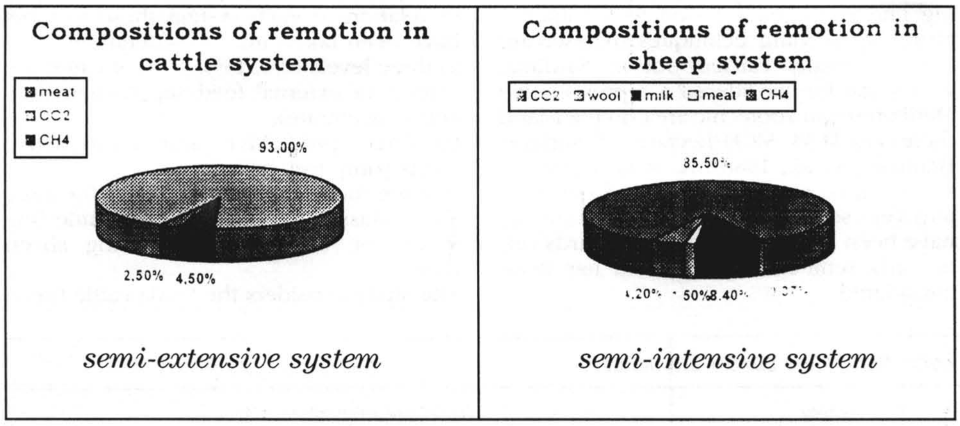

Figure 1

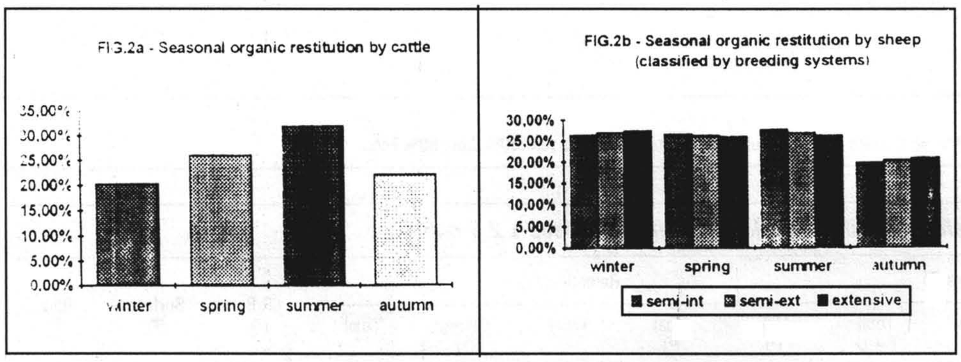

Figure 2

(body weight of mature female 350 kg; Brandano et al., 1988) and the Sarda sheep breed (body weight of mature female 42 kg; Piras 1986); their body weight could be considered typical and representative of cattle and sheep bred in Mediterranean countries (Bonadonna, 1976; Mason, 1967). The organic matter balance has been carried as follows.

a) Concerning the faeces amount has be considered as the indigestible part of eaten dry matter. The ration real digestibility, divided by month, has been estimated considering the energetic concentration of the ration (which results from the ratio between energetic requirements in Milk Forage Unit and dry matter intake in kg), using this equation which we obtained from INRA (1978) data:

$$\mathbf{y = 28.754 + 49.85x}$$

where **y** is dry matter digestibility (DMD) in % and **x** is concentration energetic ratio in MFU/kg of dry matter.

b) The amount of urine for head every day has been considered of 1 litre and of 8 litres respectively for sheep and cattle, with a dry matter content of 5% (Bortolami et al., 1985).

c) The CO_2 produced for kg of dry matter eaten, has been evaluated 150 g of C.

d) The CH_4 producted for kg of dry matter eaten has been evaluated of 20 g of C.

e) Concerning commodities, has been considered a dry matter content of 18% for sheep milk, of 30% for lambs, of 45% for mature sheep, of 100% for wool, of 35% for calves and of 45% for mature cattle.

Organic matter restitutions are those excreted by animals and we are not taking into account their evaporation and oxidation after their arrival on the soil. Remotions have been referred (in %) to the biomass produced from pasture (not taking into account roots), considering an average annual utilization rate of 65% (Lucifero et al., 1973).

The results are (**table 5** and **6**):

a) the organic matter given back to the soil averages out at 36.4% and 39.9% of the eaten respectively in sheep and cattle;

b) the high part of dry matter is lost like CO_2 (**figure 1**) and it can rise till 93% of the whole in cattle systems;

c) on sheep systems organic returns rise, in relative terms, from semi-intensive breeding systems to extensive breeding systems, due to the decreasing of the average ration digestibility;

d) the remotions, in the hypothesis in which there is no external integration, averages out at 40% of biomass produced by pasture;

e) the unitary remotion varies from a minimum of 0.25 t/ha in cattle system, where we give the maximum of external integration, till a maximum of 1.74 t/ha in the semi-intensive cattle systems with no external integration;

f) the seasonal distribution of returns (winter = dec-feb; spring = mar-may; summer = jun-aug; autumn = sept- nov) is concentrated in winter for sheep and in summer for cattle (**figure 2**); it means that probably 1/3-1/4 of the biomass given back to soil has been lost due to evaporation and oxidation.

Practical implications of this study, are such as to let us utilise the informations about dry matter returns, referred to unitary surface and to head, for the study of organic matter balance in zootecnic systems of Mediterranean areas. ●

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