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Daily intake and the selection of feeding sites by horses in heterogeneous wet grasslands

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Abstract — In spite of the importance of grazed forage in horse nutrition, little information is available on their daily intake at pasture. We determined the intake of 4 non-breeding mares of a heavy breed (average body weight = 674 kg), grazing during the summer in heterogeneous natural grasslands of the Marais Poitevin (France), an internationally important wetland where grazing is an essential process which maintains biodiversity. The mares ate large quantities of forage (21.9 ± 2.4 kg of organic matter per day, i.e. 166.2 ± 20.8 g of organic matter per kg $LW^{0.75}$ per day) in comparison with previous published values and with the estimated requirements of these horses. The use of the vegetation was very selective, the mares spent about 70% of their feeding time on short grass lawns (sward surface ≤ 4 cm, biomass < 100 $g \cdot m^{-2}$), that represented only 10% of the area. This behaviour maintained the plants at young growing stages which are of better quality than ungrazed plants. These results are discussed in relation to the dynamics of the plant communities.

horse / intake /grassland / heterogeneity / wetland

Résumé — Quantités ingérées et sélection alimentaire réalisées par des chevaux en prairies humides hétérogènes. Malgré l'importance de l'herbe dans l'alimentation du cheval, peu de données sont disponibles concernant les quantités ingérées au pâturage. En juillet-août 1997, nous avons déterminé les niveaux d'ingestion de 4 juments de race lourde à l'entretien (poids moyen : 674 kg) pâturant au sein de prairies naturelles hétérogènes du Marais Poitevin (France), un marais d'importance internationale où le pâturage est un processus essentiel au maintien de la biodiversité. Les juments ingéraient d'importantes quantités d'herbe (21,9 ± 2,4 kg de matière organique par jour, i.e. 166,2 ± 20,8 g de matière organique par kg $PV^{0,75}$ par jour) en comparaison des résultats publiés antérieurement et des besoins estimés pour ces animaux. Les juments utilisaient la végétation de manière très sélective, passant environ 70 % de leur temps d'alimentation sur des zones d'herbes rases (hauteur ≤ 4 cm, biomasse < 100 $g \cdot m^{-2}$) qui couvraient 10 % de la surface totale. Ce comportement

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maintenait les plantes dans de jeunes stades de croissance, de meilleure qualité que celle d'une végétation non pâturée. Les résultats sont discutés en rapport aux dynamiques des groupements végétaux présents sur le site.

cheval / ingestion / prairie / hétérogénéité / zone humide

1. INTRODUCTION

Intake rates by horses of green or dried forages distributed ad libitum are well documented [2, 4, 5, 18]. In spite of the importance of grazed forages in horse nutrition (these can represent more than 70% of the annual food, [17]), little information is available on intake at pasture [17], principally because in the field it is difficult to estimate faecal output and diet digestibility accurately. Rittenhouse et al. [24], using neutral detergent fiber (NDF) as an external marker for non productive and lactating mares in a natural grassland, measured intakes of 113 and 138 g $DM \cdot LW^{-0.75} \cdot d^{-1}$ respectively. Nonetheless, the reliability of this method, and of others based on external markers such as chromic oxid (e.g. in yearling horses, 80 g $DM \cdot LW^{-0.75} \cdot d^{-1}$) [14] is debatable [13, 15, 26]. Mesochina et al. [18], in a recent study, demonstrated that fecal crude protein is a good predictor of the digestibility of forages by horses (dry matter digestibility: rsd: 0.038; $r^2 = 0.65$; organic matter digestibility: rsd: 0.036, $r^2 = 0.74$). Duncan [8] used this approach to determine the intake of lactating mares of the Camargue breed (intake: 170 g $DM \cdot LW^{-0.75} \cdot d^{-1}$).

This study was part of a long term programme of research on the effects of different herbivores on the dynamics of the vegetation in a wetland of international importance, the Marais Poitevin. The site was in natural wet grasslands of the Communal des Magnils-Reigniers, which is of importance for the conservation of wetland plants (e.g. *Ranunculus ophioglossus*), birds (e.g. breeding *Tringa totanus*) and mammals (e.g. otters, *Lutra lutra*), and has traditionally been grazed by cattle. The experimental set-up consisted of 10 plots of 1–2 ha which were grazed by cattle, horses or both species. Under cattle at densities comprised between 341 and 1246 $kg \cdot ha^{-1}$, the plant community dynamics depended on the biomass density of the animals [1]: with high densities there are many rosette plants (hemicryptophytes), while at low animal densities these plants are replaced by competitive species (sensu Grime [12], mainly perennial graminoids). Horse grazing lead heterogeneous plant communities, as the two dynamics were observed whatever the density of the animals (345 to 900 $kg \cdot ha^{-1}$). Tall grasses appear in patches of lightly grazed plants, where the animals deposit faeces. This leads to a loss of plant species diversity in the tall grass patches, but an increase in structural diversity. Elsewhere, in heavily grazed lawns, halophytes and hemicryptophytes appear.

The aim of this work was first to provide data on the rates of daily food intake in the horses on these pastures and then to contribute to this programme by describing the use of these grasslands by horses. We measured the time-budgets of the horses and their selective use of structural types (lawns and patches of tall grasses) and of the plant communities.

2. MATERIALS AND METHODS

2.1. Study site

The Magnils-Reigniers common is part of an area of brackish grasslands where the topography leads to a specific pattern of plant communities [1]. The shallow natural drainage channels, which are flooded from late autumn to early spring, are characterized by hygrophile vegetation with subaquatic species (Tab. I). The top of the catena is occupied by graminoids, forming the mesophile community. The slopes, whose soils are saline, are favourable for sub-halophile species, forming the meso-hygrophile community.

We defined two structural vegetation types, which were represented in all communities, lawns (sward surface ≤ 4 cm) and taller grasses (mostly at the reproductive stage during the study) where the horses deposited all their faeces.

2.2. The animals

We studied 4 non-reproductive mares (*Mulassier Poitevin* breed), 2 to 7 years old. They were distributed in 2 sets, homogeneous for weight, each grazing a 2 ha pasture (E2D or E2) from April to October 1997. The mean weight of the animals was 674 kg during July and August.

2.3. Measurements

2.3.1. Daily food intake

The daily food intake was measured as OMI = F/(1-OMD) where OMI is the organic matter intake, F is the weight of faeces produced over 24 h (g) and OMD is the organic matter digestibility estimated by the crude protein (CP) content of the faeces [18]. The results are expressed in organic matter (OM) in order to avoid inaccuracies due to contamination by soil. Faecal output was measured by collecting the total amount of faeces produced 3 times a day over 4 successive days (29.VII.97 to 01.VIII.97) [15]. Faecal dry and organic matter content were measured in one sample per plot per day, dried at 80 °C to constant weight and by mineralization at 550 °C. Nitrogen was determined by the Kjeldahl method. The results were corrected for the mean weight of the animals, expressed as live or metabolic weight.

2.3.2. Spatio-temporal organization of the feeding behaviour

The mares were observed for a total of 48 h, between 21.VII-08.VIII.97. Individual behaviours were recorded using scan sampling during periods of 3 h by day and by night in order to cover the 24 h in 4 days. The 4 mares, previously accustomed to the presence of the observer in the pasture and to the use of a lamp, were checked successively by the same person at 5 minute intervals.

An animal was recorded in feeding activity if one of these actions was observed: searching (sorting or gripping food with the upper-lip), cutting, chewing or swallowing. The structural type and the community grazed were noted. In each plot, 100 measures of the sward surface were made (50 on each diagonal, with a measure every 4 m, on 21.VII.97, 28.VII.97, 06.VIII.97) using a 50 × 50 cm sward stick. At each measure, the structural type and the community were recorded. The mean of the 3 measurements enabled us to determine the area covered by each community and structural type in each plot, and to calculate for each plot a selection index S for the 2 mares of the pasture (the ratio of the percentage of the feeding time passed on the particular structural type or community, and the percentage of the area covered by that structural type or community). The null hypothesis was that the animals used the vegetation types evenly, i.e. S = 1.0.

2.3.3. Above-ground plant biomass, and forage quality

In each plot, samples (Tab. I) were clipped with shears in a rectangle (50 × 25 cm) placed at random in each structual type of each community (mesophile, meso-hygrophile, hygrophile). The samples were dried at 60 °C to constant weight to calculate the plant biomass (dry weight/area clipped). Some samples were analyzed for nitrogen (Kjeldahl method), cellulose (Weende

Table I. (a) Comparison of the mean aerial biomasses between communities and between lawns and patches of tall grasses; (b) and (c) comparison of crude protein (CP), cellulose and Neutral Detergent Fiber (NDF) contents between communities and between lawns and patches of tall grass, across both plots.

		Top of the catena *Mesophile community* *Hordeum secalinum,* *Agrostis stolonifera,* *Elymus repens,* *Cynosurus cristatus,* *Bromus commutatus,* *Lolium perenne...*	Slopes *Meso-hygrophile community* *Carex divisa,* *Hordeum marinum,* *Juncus gerardii,* *Hordeum secalinum,* *Alopecurus bulbosus* *Agrostis stolonifera...*	Drainage channels *Hygrophile community* *Agrostis stolonifera,* *Glyceria fluitans,* *Alopecurus geniculatus,* *Eleocharis palustris,* *Oenanthe fistulosa...*	*p*	Lawns	Tall grasses	*p*
(a) Biomass	E2D	199.4 ± 141.6 (*n* = 4)	25.6 ± 1.6 (*n* = 2)	459.8 ± 271.8 (*n* = 4)	0.073	91.1 ± 71.4 (*n* = 6)	535.4 ± 196.7 (*n* = 4)	0.011
(g DM·m^{-2})	E2	293.0 ± 116.7 (*n* = 4)	97.1 ± 65.6 (*n* = 3)	319.2 ± 272.2 (*n* = 4)	0.176	86.1 ± 36.3 (*n* = 5)	403.2 ± 200.2 (*n* = 5)	0.018
	mean	246.2 ± 137.9 (*n* = 8)	68.5 ± 61.7 (*n* = 5)	389.5 ± 281.0 (*n* = 8)	0.023 M-MH: 0.028 MH-H: 0.013 M-H: 0.401	88.8 ± 58.2 (*n* = 11)	461.9 ± 209.2 (*n* = 9)	0.000
(b) CP (% DM)		10.1 ± 1.7 (*n* = 4)	12.2 ± 1.9 (*n* = 2)	10.7 ± 2.1 (*n* = 10[1])	0.596	12.8 ± 1.3 (*n* = 6)	9.3 ± 1.2 (*n* = 9)	0.009
(c) Cellulose (% DM)		32.1 ± 1.7 (*n* = 4)	27.1 ± 2.3 (*n* = 2)	28.2 ± 2.0 (*n* = 10[1])	0.153	26.7 ± 2.2 (*n* = 6)	30.8 ± 1.6 (*n* = 9)	0.056
NDF (% DM)		70.5 ± 2.1 (*n* = 4)	62.1 ± 3.2 (*n* = 2)	62.7 ± 2.6 (*n* = 10[1])	0.106	62.1 ± 2.8 (*n* = 6)	67.1 ± 2.9 (*n* = 9)	0.059

[1] 8 samples from biomass measurements + 2 at random; DM: dry matter.

method) and cell walls: Neutral Detergent Fiber (NDF) [28].

2.4. Statistics

The significance of selection for vegetation types was determined by chi-square tests, by comparing the numbers of feeding observations with the values expected if the animals used the vegetation types evenly. Kruskal-Wallis and Mann-Whitney tests were used to compare plant biomass and grass quality respectively, between plant communities (across structural types) and between structural types (across plant communities).

Statistical tests were bilateral, for $p < 0.05$ using Statistica [25].

3. RESULTS

3.1. Daily food intake at pasture

The mares in both pastures selected diet of good quality (estimated organic matter digestibility: 61.8 ± 0.8%) with little variability. Intake was on average 21.9 kg OM·kg $LW^{-0.75} \cdot d^{-1}$, i.e. 3.3% of liveweight, i.e. 166.2 ± 20.8 g OM·kg $LW^{-0.75} \cdot d^{-1}$. The mean value in terms of dry matter was 172.5 ± 23.1g DM·kg $LW^{-0.75} \cdot d^{-1}$. The digestible organic matter intake (nutrient assimilation) was 102.8 ± 13.8 g DOM·kg $LW^{-0.75} \cdot d^{-1}$.

3.2. Spatio-temporal organization of the feeding behaviour

The mares fed on average 60 ± 1% of the 24 h. This activity occupied about 3/4 of the night (74 ± 4%) and half of the daylight (54 ± 1%). The use of vegetation communities was not homogeneous (chi-square test, $p < 0.01$). The mares selected the meso-hygrophile community, using this 2.5 times as much as expected from the hypothesis of even use and they avoided the mesophile community (Tab. II).

At the time of the study, the structural heterogeneity of the cover was not very pronounced in the pasture E2, with small patches of lawns beginning to appear. The use of the structural types by the mares was measured only in the E2D pasture. Here the mares fed on both the structural types, but the use of the lawns was 7 times as much as expected (chi-square test, $p < 0.01$), their

Table II. Use of the plant communities, lawns and patches of tall grasses and the values of the selection index.

Community	Pasture	% of the feeding time	% of the total area	Selection index
Top of the catena	E2	8.1 ± 1.2 (n = 2)	39.1	0.21
Mesophile community	E2D	17.8 ± 0.3 (n = 2)	59.8	0.30
	mean			0.26
Slopes	E2	30.6 ± 0.8 (n = 2)	10.1	3.03
Meso-hygrophile community	E2D	8.6 ± 0.8 (n = 2)	5.4	1.59
	mean			2.53
Drainage channels	E2	61.3 ± 0.0 (n = 2)	50.8	1.21
Hygrophile community	E2D	73.6 ± 0.7 (n = 2)	34.8	2.11
	mean			1.58
Structural type				
Lawns	E2D	69.5 ± 2.8 (n = 2)	9.8	7.09
Tall grass	E2D	30.5 ± 2.8 (n = 2)	90.2	0.34

selectivity index being 20 times that on the taller grass. The preference for the lawns is verified in each community (M, MH, H), where the percentage of the area covered by the lawns were respectively: 9.4%, 37.5%, 10.7% and the selection index were 6.24, 2.58, 7.15 for the lawns and 0.36, 0.05, 0.36 for the tall grasses (chi-square test, $p < 0.01$).

3.3. Aerial biomass and vegetation quality

The meso-hygrophile community, which was selected by the mares, had the least biomass ($p < 0.05$) (Tab. I), but the difference was not significant within pastures because the variances are high. The mean biomass of the patches of tall grasses was 5 times higher than the biomass of the lawns ($p < 0.01$, Tab. I).

There were no significant difference between the plant communities for crude protein, cellulose and NDF contents (Tab. I). Nonetheless, the lawns which were strongly selected by the mares were characterized by a crude protein content 38% higher than the tall grasses. The cellulose and NDF contents tended to be lower for lawns ($p < 0.06$) (Tab. I).

4. DISCUSSION

4.1. Daily intake

The daily food intake found here (172.5 ± 23.1 g $DM \cdot kg\ LW^{-0.75} \cdot d^{-1}$ or 166.2 ± 20.8 g $OM \cdot kg\ LW^{-0.75} \cdot d^{-1}$) is much higher than the few values available for non-productive horses at pasture (e.g. 113 g $DM \cdot kg\ LW^{-0.75} \cdot d^{-1}$ from Rittenhouse et al. [24]) and higher than those of Mesochina [19] and Ellis et Lawrence [10] for growing saddle horses (92 g $OM \cdot kg\ LW^{-0.75} \cdot d^{-1}$ and 80 g $DM \cdot kg\ LW^{-0.75} \cdot d^{-1}$). The values obtained in the Marais Poitevin are comparable to the values for breeding and growing wild equid species [2, 11, 21] and for lactating mares (e.g. in the Camargue, France [8]). Nonetheless, even if the needs for production seem to be the main determinant of food intake [2], Meyer [20] has shown that horses can have intakes higher than their needs, and maintain these for a long time. These intakes are also much higher than those of comparable beef cattle at pasture (3.3% of liveweight in horses compared with 2–3% in cattle (Dulphy et al. [7]).

In view of the fact that there are considerable inter-individual variations in intake in some herbivores [6, 23], and the small number of animals used in this study, the measures should be repeated. Nonetheless the slight variations between days on food intake (coefficient of variation: 12%) show that data from four days allow estimation of daily intake for horses on these pastures with reasonable accuracy. An obvious improvement would be to individualise the faeces with colored plastic marks.

4.2. Duration of feeding activity

The time spent feeding, 60 ± 1% (or 14 h 30) is consistent with previous published values (14 h–17 h, [8]) and the animals in the experimental plots appeared to have normal feeding behaviour. Nocturnal feeding comprised 38% of the total time spent feeding, which is typical for horses (20 to 50%, [16]), which is why it was necessary to conduct 24 h observations in this study of their feeding strategies.

4.3. Selection of vegetation types

The horses showed more marked selection for lawns than for any of the vegetation communities, as has been observed previously in dry grasslands [3, 9, 22]. The mares maintained lawns where the quality of the grass was high in comparison with the remainder of the pasture (38% higher crude protein, lower fibre). In this pasture, the horses choose their food plants principally on the basis of their structure (growth stage) rather than their botanical species.

In spite of the short period covered by this study, the feeding strategies of the mares described here clarify causes of the differences in the vegetation dynamics under cattle or horse grazing described by Amiaud [1]. The intense use of the meso-hygrophile community by horses explains the rejuvenation of sub-halophyte communities and the development of hemicryptophytes on the slopes. In the same way, the opening of the hygrophile community leads to the emergence of annual species (*Galium debile, Ranunculus sardous*) [1]. The development of highly competitive species at the top of the catena seems to be the result of low grazing pressure and perhaps favourable conditions of mineral and nitrogen availability brought by the faeces.

Finally, the high intake levels compared with cattle and strong selection for short grass lawns explain why the horses create and maintain structural diversity in such grasslands, whatever their stocking level.

The current hypothesis to explain the heterogeneous use of grasslands by horses proposes that the animals minimize their feeding time on patches of tall grasses where the faeces are deposited in order to minimize the intake of gastro-intestinal parasites [27]. The results of this study suggest another hypothesis: if the feeding strategy of these horses is to maximise daily nutrient assimilation, the maintenance of lawns of good quality could be a nutritional as well as an antiparasite tactic.

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