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Promoting Grass in Horse Diets and Implementing Sustainable Deworming: 'Équipâture' Programme

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Abstract

The Équipâture programme examined the grazing regimes and parasite statuses of horses on 12 study farms. Its research yielded useful results. Rotational grazing of mares, foals, and school riding horses allowed animals to meet their nutritional needs without any supplements (50 ares/LU in the spring; 80 ares/LU in the summer). During the winter, haylage met the high demands of mares and foals. Late-cut hay could not, and there was a risk of P, Cu, and Zn deficiencies when horses were given a 100% hay diet. A sustainable approach to deworming was implemented on the farms. Based on faecal analysis, animals were assigned a parasite excretion status. As a result of this categorisation, only half of the animals were dewormed. This method helped limit deworming costs and the development of parasite resistance to dewormers.

Keywords: horse grazing, stocking rate, hay, haylage grass analysis, deworming, faecal egg count

1. Introduction

Grass, although being the most adapted food and considered as the least costly for herbivores, is nevertheless not always duly promoted in equine diets. The lack of data on equine pasture management and systematic deworming practices are recorded as factors hampering the efficient and sustainable management of grazing horses [1]. Systematic and frequent deworming of horses encourages the development of parasite resistance to dewormers. Three active dewormer families against cyathostomins, the most prevalent parasite in adult horses, are currently available on the market in France. Among the said three families, cyathostomins are known to resist two of them. In order to counteract the development of such resistances, it is important to change deworming practices by adopting faecal egg count as a determining element whether or not to worm. Sustainable deworming could also include the implementation of management measures in order to reduce the parasitic pressure on pastures [2]. Nevertheless, literature provides very little data

in this regard. In this context, the 'équipâtur' programme was initiated through the monitoring of 12 equine study farms located in the regions of Centre Val de Loire, Limousin and Normandy (France) between 2016 and 2017, with the aim of analysing pasture management, promotion of forage intake, and implementation of sustainable deworming. In collaboration with Agricultural Chambers, local Horse Councils, and the French Horse and Equestrian Institute (IFCE), this study has permitted the compilation of data on horse grazing and pasture management. This summary illustrates the technical results of feed and pasture management, as well as the monitoring of animal infection.

2. Material and methods

At the national level, 12 study farms were monitored for over 2 years—2016 and 2017 (grazing seasons and in the winter). The selected equine farms were chosen according to the different breeds (draft horses, racehorses, sport and leisure horses, and cattle-combined) and the category of horses at grass (breeding stock and adult horses at rest or for schooling). The idea was to study and monitor a panel of structures with different production targets, using all grass surfaces for equine feeding and wishing to engage in more sustainable parasitic management practices. The 12 farms were located in 3 abundant grass regions [Centre-Val de Loire (4), Limousin (4), and Normandy (4)] and were comprised of 7 stud farms (2 draft horse + suckling-cow farmers, 1 pony breeder + crop farmer, 1 thoroughbred stud, 1 French Trotter stud, and 2 sport-horse breeders) and 5 riding establishments (1 riding school + sport-horse breeder, 2 riding schools + livery + breeder, 1 trail-riding centre, and 1 'active stall').

Batches of 10 to 25 adults (aged 3 years or more in 2016) per farm, i.e., 204 horses in total, were monitored by the study team (2 persons) with the aim of defining their parasitic status, measuring their body condition score (BCS), and analysing their feed pattern and grazing during the two 2016–2017 seasons. Since it has been illustrated that acquired immunity against cyathostomins is reached at age 3, adults can be grouped according to their strongyle egg excretion level. It is considered that 15 to 30% of horses over the age of 3 are responsible for excreting approximately 80% of all eggs [2].

2.1 Monitoring animals

For each animal over the two-year period, faeces were collected individually and their body condition score (BCS) and weight were recorded at three intervals (May, August, and November). Faecal sample, upon individual identification, was despatched within 24–48 hours after refrigeration to the same county veterinary analysis laboratory for faecal egg count [quantitative numeration of the number of strongyle and tapeworm eggs per gram of faeces (epg)]. For each visit, the INRA 1997 [3] grid was used to evaluate the body condition score of each monitored horse (score ranging from 0 to 5, 3 being the optimum score). The faecal egg count (FEC) results and BCS figures were regularly transmitted to the farmers, along with personal advice per animal as to whether or not to worm, in addition to guidance on feed and grazing.

In spring and summer, only horses whose faecal egg count resulted in an egg count exceeding 200 epg were dewormed with, respectively, ivermectin in spring and pyrantel in summer (such threshold being traditionally recommended in literature, according to [2]). All of the horses, regardless of the faecal egg count results, were dewormed at the end of autumn using a molecule association (moxidectin and praziquantel), thus enabling to eliminate strongyles, whether adult or larvae, as well as tapeworm.

At each farm visit, some horses were absent or gone definitely (sold, owners changed, died, etc.); that is why, 6 (FEC + BCS) data/horse were not possible to collect over the 2 years.

2.2 Monitoring the feed pattern and grazing

Three to four visits over the two-year period, from March to September, were conducted in order to draw up a grazing programme, evaluate pasture management, and carry out grass and fodder sampling. At the beginning of the season, the grazing forecast was estimated using the 'prév'Her' application (tool devised by the Creuse Chamber of Agriculture and adapted to take account of French equine LU references: one saddle mare and its foal = 1.2 LU [4–6]). The grazing base area for each batch was calculated for horses under rotational grazing. Forage, hay, and haylage samples over the 2 years, in addition to fresh grass samples in 2017, were taken from the grazing plots at various intervals, and they were tested using near-infrared spectrophotometry at the LANO 50 agronomy laboratory in order to determine their nutritive values [HFU/kg DM (net energy horse feed units), INRA 2011, (g HDGP) horse digestible crude proteins g/kgDM, Ca, P, K, Na in g/kg DM and Mg, Cu, Zn, Mn, Fe in mg/kg DM (XLStat statistics' analysis, Student Test)]. From 2 to 11 dried forage samples (2016 and 2017) were collected depending on the numbers of hay or haylage harvests per farm. From 2 to 6 fresh grass samples per farm (2017) depending on the numbers of grazing cycle exploited were taken across the various seasons from the grazed areas (rough areas excluded) on the same plots of permanent pastures, free of nitrogen fertiliser. Winter diets for the different equine categories were calculated with INRA system according to the nutritional values collected from the analysis of forage harvested in 2016.

2.3 Influence of stud management and the age of the horses on parasite excretion

Only the results of the faecal egg counts gathered in spring and summer of 2016 and 2017 were used. Indeed, studies have shown that parasites lay fewer eggs outside the grazing season, i.e., when the climate is less favourable to parasitological transmission [7]. Nevertheless, any such faecal egg count in November remains interesting in practice, in order to give an overall picture of the farm's parasitological situation at the end of the grazing season.

Five explanatory variables were retained in relation to stud management and to the age of the horses:

- Foals (< 1 year) on site: two criteria—present or absent
- Accommodation type: two criteria—horses living out at pasture 24/7 or horses turned out daily (stable/pasture combined)
- Annual stocking rates: three criteria—low (less than 0.6 LU/ha), medium (between 0.6 and 1.0 LU/ha), and high (more than 1 LU/ha), (LU: livestock unit)
- Age of horses: three criteria—young (under 10 years), medium (between 10 and 15 years), and old (over 15 years)
- Significant movement on site: two criteria—few or many new arrivals

Among the 204 horses monitored, data from 83 horses were used for the analysis, the result range of the others being incomplete. For the horses used, five explanatory variables were applied in addition to the 2016 and 2017 spring and summer faecal egg count results. The five explanatory variables underwent a multiple correspondence analysis (R software), followed by agglomerative clustering (AHC), in order to compile groups of variable criteria. The clusters derived from the AHC are those that maximise the difference of one group in relation to another, while ensuring the best homogeneity among individuals within the same group. The best division singles out four groups:

- Group 1: stud farms with a high turnover (many new arrivals, high stocking rate, presence of foals, living out 24/7, and horses mostly aged between 10 and 15 years)
- Group 2: horses over the age of 16
- Group 3: riding establishments with a low turnover (absence of foals, few new arrivals, living out 24/7, and horses aged under 10)
- Group 4: stud farms with a low turnover (horses turned out daily, presence of foals, low or medium stocking rate, and few new arrivals)

A principal component analysis (PCA) was conducted in order to observe a possible influence of the explanatory variables on parasite excretion in the spring and summer of 2016 and 2017.

3. Results of the feed patterns and pasture management

3.1 Stud farm stocking rates

The indicator retained for evaluating the stocking rate is calculated according to the number of LU (livestock units) per equine equivalent (one saddle mare and its foal = 1.2 LU, INRA 2012) in relation to the volume of the breed main forage areas (MFAs) in hectares. The 12 stud farms monitored are characterised by a medium to low stocking rate (from 1.05 to 0.6 LU/ha of MFA), on par with the data of equine farms monitored in the context of the REFErences' network (7). The most intensive systems can be found in multi-production farms, comprising horse breeding alongside another production (beef cattle or crop farming). The most extensive farms (<0.5 LU/ha of MFA) breed exclusively top pedigree horses (2/12). For such farms, the productivity of grassland is not a priority when considering the real economic value of the animals [8].

3.2 Stocking rate and conditions of pasture management

Pasture management for the 33 batches of animals was duly monitored on the 12 study farms. Grazing rotations were recorded by noting the number of animals present per cycle.

Pasture management was split into three different types (**Table 1**).

Seven batches of horses monitored out of 33 (21%) were reared in rotational pastures with a stocking rate comprised between 40 and 60 ares/LU in spring and 80 ares/LU in summer. Sixty per cent of the farms mulched the herbage rejected by the animals.

Stocking rate observed	No. of batches of horses observed and overall %	Horse types	Feed pattern and pasture management
<20 ares/LU in spring/ summer	4/33 (12%)	Stabled horses Horses at rest	The so-called paddock void of feeding role several hours/day for exercise 24/7 for overweight horses with restricted forage rations
40–60 ares/LU in spring 80 ares/LU in summer	7/33 (21%)	Broodmares and foals School horses	Rotational grazing
> 100 ares/LU in spring and summer	22/33 (67%)	Horses at rest Broodmares	Grazing 24/7

Table 1.
Stocking rate observed and management conditions on the 12 study farms.

For example: 14 thoroughbred yearlings and 10 cows with calf at foot were taken in the spring to a 9-ha pasture divided into 5 separate plots of 1.5 to 2 ha. This combined batch then grazed 18 ha in the summer.

Among 2/3 of the batches (67%), grazing 24/7 is generally conducted at low intensity (>100 ares/LU) across large areas, with small batches of horses (2 to 3) given extra fodder in summer and/or autumn [9]. Rough was mulched several times during the grazing season.

To end, for 12% of the batches, small surface areas (<0.2 ha), mainly located near the farm buildings, were used as ‘exercise paddocks’ for stabled horses. Such paddocks may also serve to accommodate horses that should have limited grazing (overweight horses and ponies at rest or retired). These paddocks are not considered as a nutritional source for the animals.

3.3 Estimation of a horse’s body condition

A body condition score (BCS) was recorded for 132 adult horses at three separate intervals (May, August, and November) over the 2 years.

The BCS of the school horses was >3.6 for 48% of them in spring and 39% in summer. In autumn, they gained weight with 16% becoming quite overweight (BCS > 4.1). In such a case, forage supplementation in winter was delayed. Eighty-three per cent of the horses at rest were overweight (BCS > 3.6) in summer, 37% of which showed a BCS > 4.1. Grass restrictions were imposed on certain horses (BCS > 4.6 in summer) by placing them in drylots in order to limit the risk of laminitis. Fifty per cent of the retired horses with a BCS < 2.4 in summer were at least supplemented in forage. Twenty-nine per cent of the thoroughbred broodmares, some of which being supplemented with concentrates, became overweight in autumn (BCS > 3.6). Eighty-eight per cent of draft horse broodmares that attained a BCS > 4.6 in autumn were not given extra fodder during that period, nor even in winter.

3.4 Grass analysis

3.4.1 HFU content and digestible crude proteins/kg fresh grass DM

The mean HFU energy value of grass was exactly the same in April and in May (0.718 vs. 0.72 HFU/kg DM). In June, the mean energy value significantly dropped

to 0.67 HFU/kg DM ($p < 0.01$), proving to be more heterogeneous, and then increased again in July to 0.71 HFU/kg DM ($p < 0.01$). The higher energy values in July were due to regrowth following a more prominent period of rain than in June 2017 (**Figure 1**). Hence, other mean grass HFU comparisons in April and May among the three regions illustrated superior energy values in Normandy by +0.04 ($p < 0.01$) and +0.06 ($p < 0.01$) HFU points, respectively, in relation to the HFU value of grass in the Limousin and the region of Centre Val de Loire.

Concerning the protein values in gr HDCP/kg DM (**Figure 2**), the averages observed during the grazing season hardly differed ($p > 0.5$) on a monthly scale. Hence, the protein value comparisons among the three regions failed to show any difference ($p > 0.5$).

When grass was abundant and could be compared with a minimal to maximal *ad lib* intake level of DM/kg, the nutritional needs (in intake HFU and gr HDCP/kg DM) of the broodmare during the 1st month of suckling and of the 18-month yearling are basically covered between April and June across the three regions.

3.5 Analysis of the harvested dry forage and the consequences on winter diets (HFU and g HDCP/kg DM)

3.5.1 Energy and protein

The harvesting conditions in 2016 (late first cut in July) resulted in slightly lower energy and crude protein values by, respectively, 0.04 points HFU and 8 g HDCP/kg of DM in relation to the values of forage harvested in 2017 (early to mid-June cut) (**Table 2**).

The HFU and HDCP nutritive values of 62 hay and 10 haylage samples were compared with the recommended dietary needs [4] for three categories of animals receiving essentially forage-based rations in winter (**Table 3**).

Haylage harvested at the end of May or as second cut seems better adapted than hay for animals with high nutritional needs (broodmares and foals). For horses at rest or having light exercise, hay seems more adapted despite a 5- to 15-gr HDCP/kg DM crude protein deficiency in relation to dietary needs (**Table 3**).

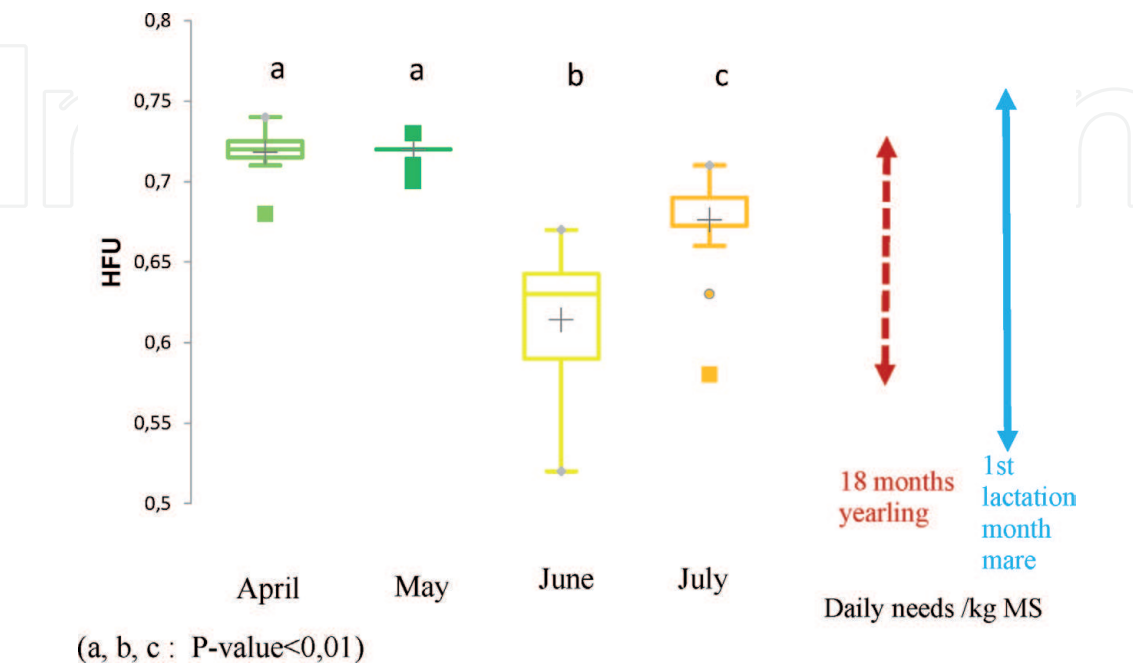


Figure 1. Net energy values (net energy horse feed units: HFU/kg DM) of grass samples depending on grazing period (2017 season, $n = 52$).

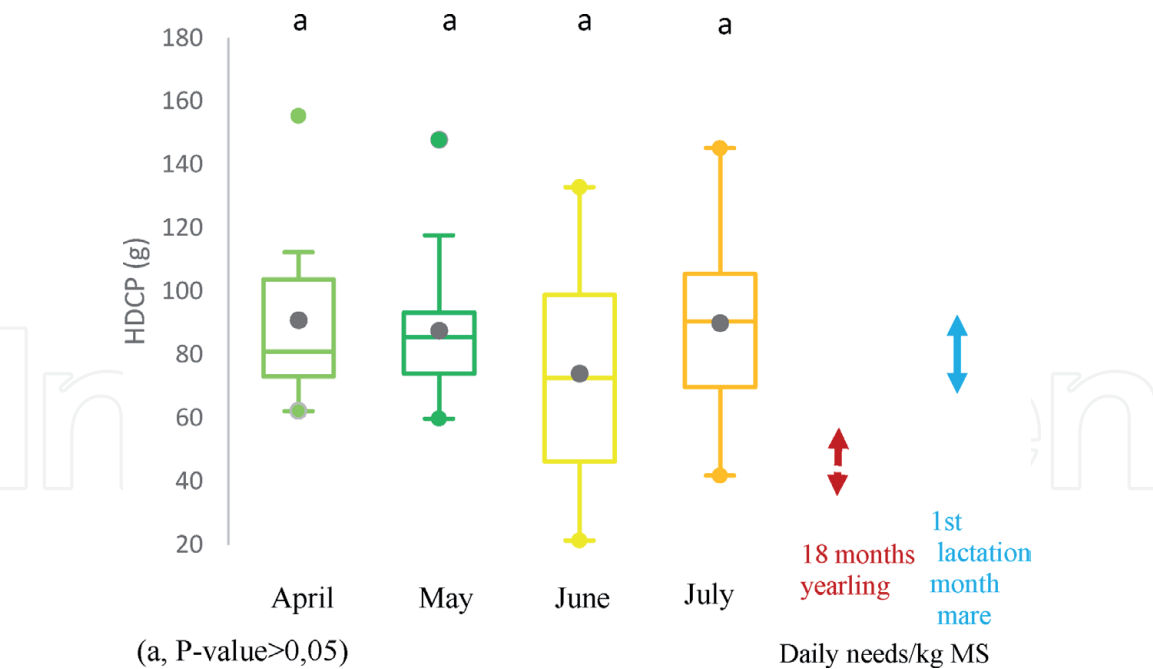


Figure 2.
Horse digestible crude protein values (g HDCP/kg DM) of grass samples depending on grazing period (2017 season, n = 52).

2016 (n = 40), 2017 (n = 22)	HFU/kg DM		g HDCP/kg DM	
	2016	2017	2016	2017
Minimum	0.33	0.38	12	16
Maximum	0.65	0.62	76	73
Averages	0.48	0.52	25	33
Standard deviation	0.07	0.06	13	14
	+ 0.04 p < 0.1		+8 p < 0.1	

Table 2.
Nutritional values (HFU and g HDCP) of hay depending on harvest year.

For each stud farm, a report on the winter rations was drawn up based on the forage analysis.

If the net energy and digestible crude protein needs of animals with high nutritional needs (broodmares) are covered by haylage-based rations, those based on hay harvested in 2016 (with or without concentrates) fail to cover such needs (**Table 4**).

For animals with minimal needs (horse at rest or in light exercise), a winter ration of 100% hay, or 90% hay +10% cereals, based on forage analysed in 2016, failed to cover the digestible crude protein needs. A 100% haylage ration for a horse at rest was far too rich (**Table 4**).

3.5.2 Minerals

The Ca and Mg content of the three forage types (grass, haylage, and hay) (**Table 5**) covered the overall daily needs for the three animal types (broodmare, 18-month foal, and horse at rest or in light exercise). The mean phosphorus content of the hay (Me = 1.8 g/kg DM) was deficient for animals with high nutritional needs (broodmare: 3.2–4.3 g/kg DM; 18-month foal: 2.7–3.4 g/kg DM). The Ca/P calcium-phosphate ratio showed an average of 2 instead of 1.5 (mean reference of all horse categories [4]). The potassium content was in excess in relation to needs (**Table 5**).

		HFU/kg DM		g HDCP/kg DM	
		Haylage	Hay	Haylage	Hay
Energy and protein values/kg DM of hays (n = 62) and haylage (n = 10)	Minimum	0.62	0.33	35.2	11.8
	Maximum	0.73	0.65	76.8	75.9
	Averages	0.67	0.49	55	28
	Standard deviation	0.04	0.07	12	13
		P-value		+0.18 (p < 0.01)	
Daily needs/kg DM according to horse's low and high intake	9th month pregnant mare	0.55–0.67		43–54	
	18–24 month yearling	0.58–0.73		33–41	
	Adults at rest or having light exercise	0.46–0.60		33–43	

Table 3.
Nutritional values (HFU and g HDCP) of hay and haylage compared with the animals' dietary needs.

% of net energy and protein needs covered by the four ration types observed (/kg DM)	Ninth month pregnant mare		Adult at rest or in light exercise	
	in HFU	in g HDCP	in HFU	in g HDCP
100% hay	80	50	98	70
Hay (90%) + cereals (10%)	110	50	133	70
100% haylage			174	194
Haylage (87%) + industrial concentrates (13%)	92	120		

Table 4.
Winter rations calculated according to the nutritional values of forage harvested in 2016.

3.5.3 Trace minerals

If the Cu and Zn content was deficient for all forages, the manganese and iron content was significantly in excess (**Table 5**). Among the stud farms monitored, some administered mineral and vitamin supplementation to the winter diet (5/12) or make it available in the grazing period (3/12).

4. Results of parasite excretion monitoring

Throughout the grazing season (spring and summer 2016 and 2017; **Figure 3**), the results of the faecal egg counts carried out on the 83 adult horses (**Table 6**) aged over 3 enabled, on average, to simply worm 50% of the horses, i.e., those excreting more than 200 epɡ. Such horses are nevertheless responsible for excreting 94 to 99% of the eggs, depending on the period concerned, thus significantly contributing to pasture contamination.

4.1 Definition of the excretory status

Three excretory statuses of horses were defined:

- 23% of the horses have a low excretory status: horses excreting less than 200 epɡ in all faecal egg count analysed in spring and summer of 2016/2017.

Mineral g/kg DM and trace minerals mg/kg DM from forages	Grass (n = 53)		Haylage (n = 10)		Hay (n = 62)		Early pregnant mare, 18–24 month yearling and light exercise adult average needs [4], per g or mg per kg DM intake
	Median	σ	Median	σ	Median	σ	
Ca (g)	6.2	1.9	6.4	1.4	4.0	1.1	2 at 5 g
P (g)	2.9	0.6	2.9	0.3	1.8	0.5	1.7 at 4.3 g
Ca/P ratio	2.2	0.9	2.1	0.6	2.2	0.9	1.35 at 1.8
Mg (g)	1.7	0.4	1.5	0.5	1.3	0.3	0.7 at 1.1 g
K (g)	23.8	5.5	25.1	6.5	14.6	4.6	2.5 at 5.5 g
Na (g)	0.8	0.8	0.7	1.4	1.2	1.5	0.9 at 2 g
Cu (mg)	5.5	1.6	4.9	1.3	3.2	1.1	10 mg
Zn (mg)	23.9	7.6	25.0	6.2	17.9	5.2	50 mg
Cu/Zn ratio	0.2	0.1	0.2	0.1	0.2	0.1	0.2
Mn (mg)	155.2	120.1	195.3	86.6	158.1	150.6	40 mg
Fe (mg)	147.6	215.3	152.5	94.8	116.6	507.0	50 at 80 mg

Table 5.
Mineral content in gr or mg/kg DM of forage (grass, haylage, and hay) for the 2 years 2016 and 2017. Data over or under the average needs.

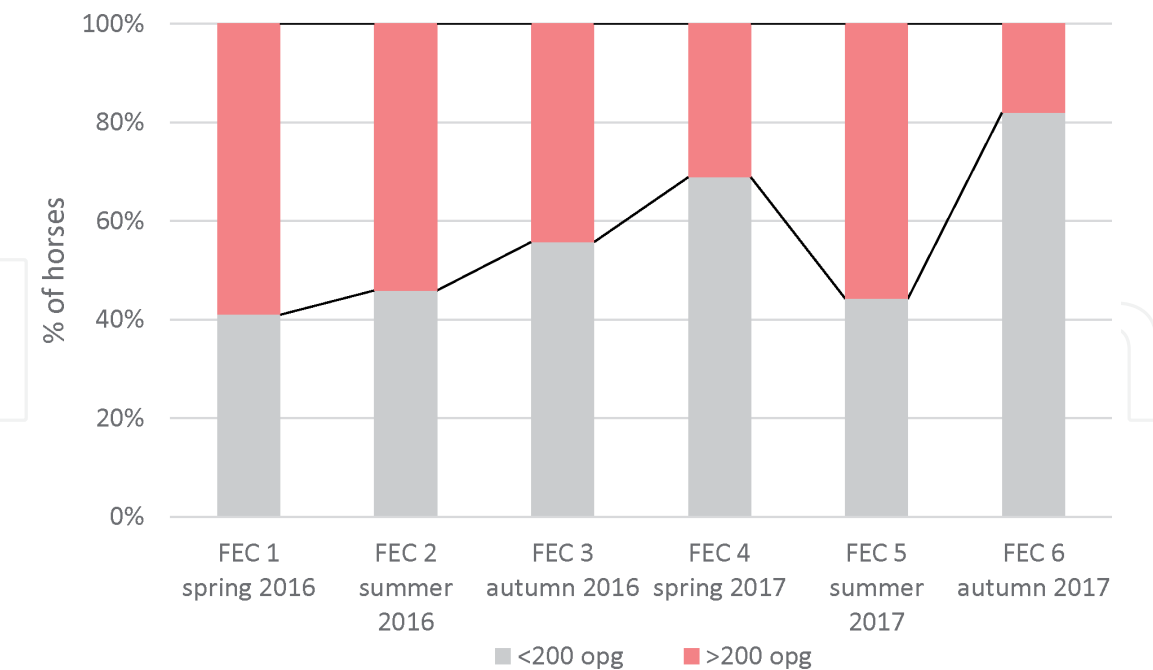


Figure 3.
Percentage of the 83 horses excreting more or less 200 strongyle epg at each faecal egg count (FEC).

- 13% of the horses have a high excretory status: horses excreting more than 200 epg in all faecal egg count analysed in spring and summer of 2016/2017.
- 64% of the horses have an unstable excretory status: horses excreting alternatively more than 200 epg or less than 200 epg.

Region	Centre Val de Loire				Normandie				Limousin			
Farm No.	1	2	3	4	5	6	7	8	9	10	11	12
Nb of followed animals with full FEC results in spring and summer 2016/2017	14	18	0*	5	4	0*	14	11	0*	8	0*	9

*Horses with less than 6 FEC/2 years.

Table 6.
Followed animals per farm distribution.

4.2 Study of the influence of stud management and horse’s age on the level of equine parasitic excretion

In the principal component analysis, four groups were identified:

- Group 1: stud farms with a high turnover (many new arrivals, high stocking rate, presence of foals, living out 24/7, and horses mostly aged between 10 and 15 years), 20 horses
- Group 2: horses over the age of 16, 18 horses
- Group 3: riding establishments with a low turnover (absence of foals, few new arrivals, living out 24/7, and horses aged under 10), 18 horses
- Group 4: stud farms with a low turnover (horses turned out daily, presence of foals, low or medium stocking rate, and few new arrivals), 27 horses

The first and second axes of the PCA are those that best resume the data contained in the five variables; they are thus retained for the analysis. Axis 1 represents the general tendency of the faecal egg count (FEC) for an individual: on the left, an individual shows basically low results, while on the right, the results are generally high. Axis 2 represents the results from spring and summer 2016: at the top, the individuals show high results in spring 2016, while in summer 2016, the results are low. **Figure 4** thus enables to distinguish a high excretory profile in spring 2016 and a low excretory profile in summer 2016 (in the direction of ‘FEC 1’), a high excretory profile in summer 2016 and a low excretory profile in spring 2016 (in the direction of ‘FEC 2’), and a high excretory profile in 2016 and in 2017 (in the direction of ‘FEC 4’ and ‘FEC 5’).

Figure 5, on its part, enables to identify certain individuals belonging to one of the profiles highlighted in the graph of the variables. The individuals (grey dots) surrounded by a continuous line illustrate high FEC in spring 2016, though with low results in summer 2016. The individuals surrounded by a dotted line illustrate high FEC in summer 2016, though with low FEC in spring 2016. The individuals surrounded by dashes illustrate high FEC for all FEC. These different ellipses were hand drawn for educational purposes. All other individuals illustrate low or average FEC. The four groups of horses (black boxes), identified in accordance with their management type, appear in the box in the centre of the graph. None of these groups particularly stand out in relation to the four axes. No significant difference can be observed among the faecal egg count results for the different groups.

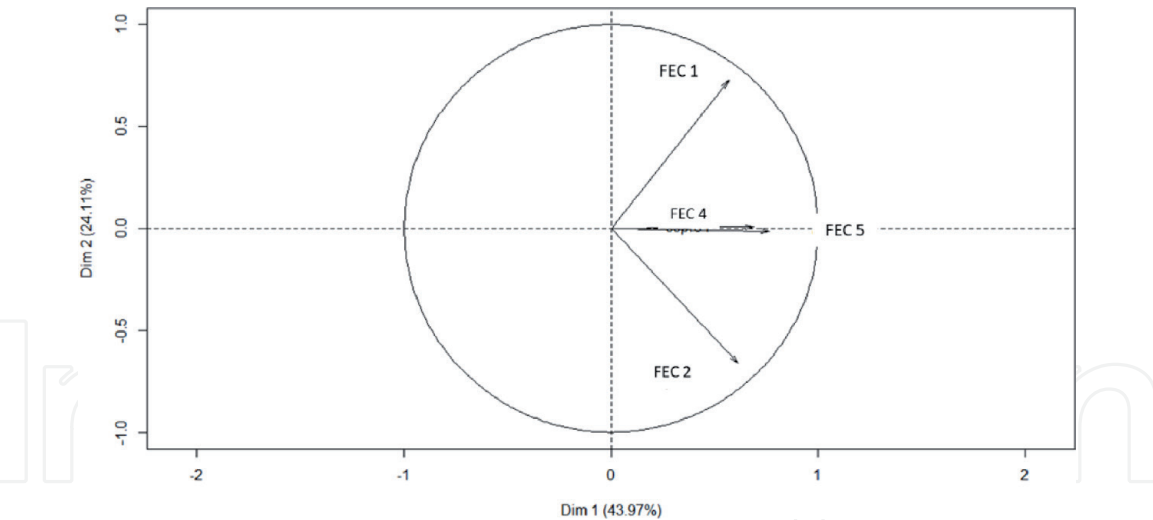


Figure 4.
Principal component analysis on the effect of the five explanatory variables on the results of spring and summer 2016 and 2017 faecal egg count (FEC).

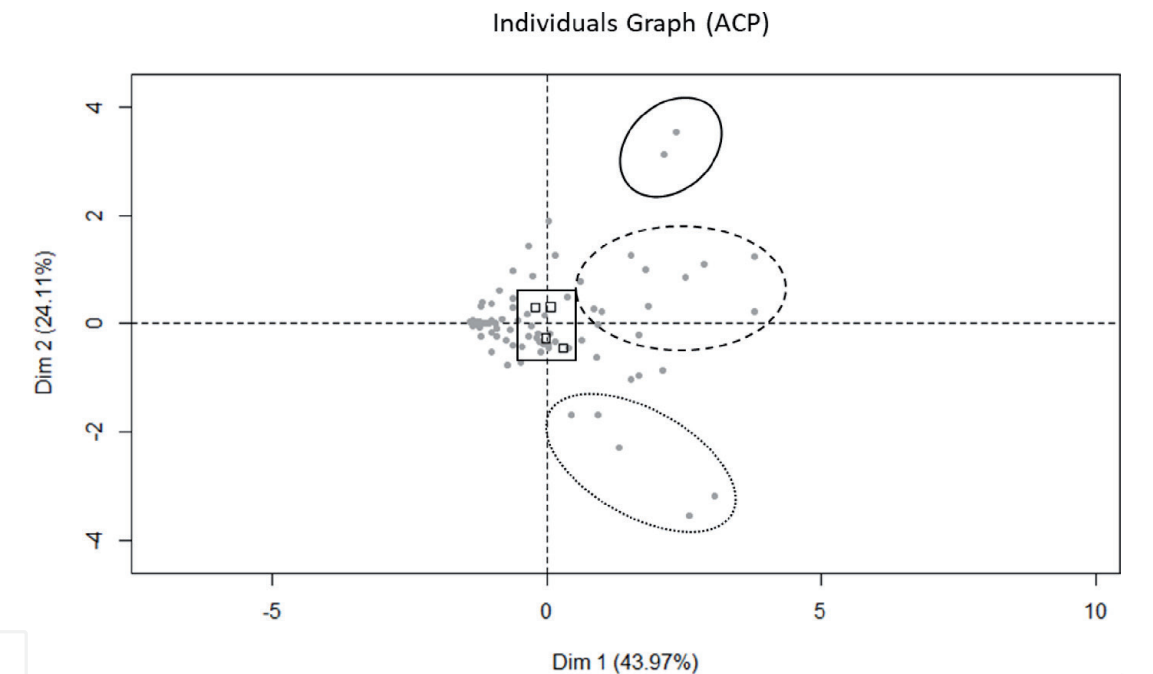


Figure 5.
Principal component analysis on the effect of the individuals on the results of spring and summer 2016 and 2017 faecal egg count (FEC).

5. Discussion

5.1 Stocking rate and pasture management

The stud managements observed illustrated a very low stocking rate in spring, thereby requiring regular mechanical maintenance in order to limit the development of roughs. The management of certain batches of animals (mares with foal at foot to be covered by a stallion and requiring individual attention and school horses exercised daily) and the need for shelters and secure fencing entail extensive pasture management and 24/7 grazing, where manipulation and care take priority in relation to a sustainable management of grassland. Such low stocking rate is, for some batches, linked to the use of pastures for wintering horses, thus reducing the available grass stocks early in the season and the productivity of grasslands [9].

When the stocking rate in the spring exceeds 100 ares/LU (22/33 of the batches studied), practices aiming to intensify the farming system, such as the sale of forage or taking on boarding cattle, were proposed to breeders. Nevertheless, the lack of human resources, the necessary investment in harvesting equipment, and additional infrastructures (fencing and wintering barn), as well as the lack of economic production attractiveness (suckling cows), are the main blockers exposed by the stud farms for developing other activities to enable optimum use of the grassland.

Since few references already exist on the interest of an equine-cattle grazing combination in grassy areas [6, 10], the French Horse and Equestrian Institute (IFCE) and the National Institute for Agricultural Research (INRA) are currently conducting studies in order to pinpoint its effects in relation to a farm's biotechnical, economic, and social (labour) performances [11].

Rotational grazing is considered as the most appropriate practice for providing an adequate energy and protein balance for animals requiring high nutritional needs (broodmares and foals), though without the necessity for concentrate supplementation and without body condition loss. The grass available must be of adequate quality (in leaf) and quantity (height between 5 and 20 cm) [12]. For those stud farms having thus invested, such practice should be long-lasting.

For horses at rest, their living conditions take priority over the optimum use of grassland. Pasture management thus becomes somewhat tricky when trying to prevent overweight and consequential metabolic illnesses (laminitis) in adult horses having little or no exercise. Indeed, as a monogastric herbivore, diets with a low starch and sugar content are more adapted to horses, who have the ability to continuously ingest vast quantities of rough forage in order to satisfy their nutritional needs and maintain a healthy digestive system [13]. When grass resources are abundant, ingestion increases beyond the normal capacity in terms of the nutritional needs for maintaining a 3/5 body condition score, and the lack of exercise results in weight gain. Restricting food in winter, in order to encourage weight loss and to limit overweight just prior to the grazing season, could be a solution. Nevertheless, such practice is scarcely applied by breeders, the latter generally offering *ad libitum* forage in winter.

In spring, the grass available in leaf can represent a far too rich food resource (in energy and proteins) with over 50% of the grass analysis attaining + 132% of the HDCP needs and + 110% of the HFU needs for such horses already in good condition (BCS > 3.6) at the end of winter.

Drylots are temporarily used for part of the day, or even 24/7, in order to restrict the food intake of overweight animals (horses and ponies) (body condition score corresponding to 4/5 at the end of winter). Low-protein fibrous forage is often administered in order to prevent metabolic illnesses (laminitis), notably when grass grows abundantly (spring, autumn). Such management raises the question of how to optimise the maintenance of such areas, not only in order to limit the propagation of weeds but also to maintain the weight-bearing ability of the ground in a manner not to damage the horses' hooves. An alternative, in order to prevent the degradation of drylots, sacrificed due to overgrazing, could be the creation of stabilised sandy areas where such horses could be parked during sensitive periods (spring, autumn).

5.2 Analysis of forage and winter rations

None of the stud farms monitored undertook forage analysis, nor calculated routine rations, despite the diet administered to their horses consisting of forage, for the most part. An essentially forage-predominant diet in terms of proportion

and quantity, thus enabling to further reduce the amount of concentrates, would not only control feed costs but also promote digestive health and the overall well-being of the horse [14, 15]. A simulation of the feed costs on a farm enabled to illustrate that a ration consisting of haylage + hay results in savings of up to 25% in relation to a standard ration of hay + concentrates.

Diets consisting of just hay, or hay + cereals, are often less balanced (~40 HDCP/HFU ratio) compared with diets consisting of haylage (90 HDCP/HFU ratio, significantly more in line with the needs of the horse). Nevertheless, few stud farms (2/12) produce haylage. Eighty-three per cent of the stud farms monitored do not produce such forage, either because they have no knowledge of the harvest techniques (4/12) or because such forage constitutes too richer feed in relation to their animals' needs (at rest, light exercise, draft horse) (6/12).

Adding a vitamin-mineral supplement (VMS) to the ration is not systematic. Having said that, P, Cu, and Zn deficiencies were recorded on the forage analysed. A vitamin-mineral supplement is necessary not only in winter rations but also when out at grass.

5.3 Sustainable deworming

The implementation of targeted deworming above the threshold of 200 epg in such equestrian structures enabled to simply worm half of the adult horses present on site during the grazing season. Such 200 epg threshold thus enables to preserve a parasite population not subject to anthelmintic treatment, the so-called refuge population [2]. The larger the refuge population, the less rapidly resistances progress [16].

Having said that, these dewormed horses were responsible for excreting more than 94% of eggs across the pastures. Targeted deworming thus enables to rupture the cycle of most parasites and hence to safeguard the health of all the horses on site.

One of the main hindrances to implementing targeted deworming within a structure seems, aside from the time spent in collecting individual stools, to be its cost. Indeed, Sallé et al. [17] illustrated that such targeted deworming can be financially viable in relation to systematic deworming insofar as the cost of a faecal egg count is less than 5 Euros. In the stud farms monitored, approximately ¼ of the horses had a low excretory status. Literature shows that such low excretory status is stable from one grazing season to the next [18, 19], for a healthy horse accommodated in stable conditions. In this study, 90% of the horses with this status in 2016 had the same status in 2017. For such horses, deworming once or twice a year (in autumn and possibly in spring) was recommended, without annual faecal egg count testing; only one faecal egg count approximately every 2–3 years in order to verify that the on-site epidemiological situation has not evolved and that the horse has not changed status. Annual faecal egg count monitoring is moreover recommended in the case of suspicion of immune deficiency (senior horse over the age of 20 or illness affecting the immune system (e.g., Cushing's disease)).

The cost of sustainable deworming could thus be reduced over the seasons due to the stability of the low excretory status requiring less strict faecal egg count.

Having said that, the high excretory status was much less stable in between the two grazing seasons, since only 37% of the horses with such status in 2016 also had the same status in 2017, and the remaining 63% passed from a high excretory status to an unstable status. For such unstable and high excretory statuses, it was advised to continue faecal egg count in order to adapt the frequency of deworming.

In terms of faecal egg count results, the situations varied considerably among the stud farms, such as illustrated in the following two examples:

- The first structure is a French Trotter breed farm with significant breeding and foaling activity, taking in many broodmares during the breeding season, these outside mares being lodged with the home-based horses. We noted a very high proportion of the horses with an unstable excretory status (80%) with only 20% of the horses with a stable status, of which only half, i.e., 10% overall, had a low excretory status. In such structure, targeted deworming has little interest, since most of the horses need to be dewormed following the faecal egg count. We notably observe high excretion levels in summer (1000 epg per horse in 2016, compared with 272 epg in spring 2016). Prior to introducing targeted deworming, certain stud-management measures should be implemented, in order to reduce contamination of the plots and infestation of the horses in summer, notably by separating the outside mares from the rest of the herd.
- The second structure is an 'active stable', wherein the horses (essentially over the age of 15) benefit from mixed accommodation (a central stabilised area with rotational pastures during the grazing season, the dry areas being very regularly cleared of all dung). In this structure, $\frac{3}{4}$ of the horses had a stable status (54% with a low excretory status and 21% a high excretory status).

It is thus difficult to implement an appropriate and acceptable targeted deworming protocol for all equine structures. This programme should be adapted to each stud farm, not only in accordance with the objectives of each farm (protection of the environment, health safety, economic considerations, and breeder implication) but also according to the epidemiological situation, such as the presence of foals and youngsters, or the frequency of movement, among others [2]. Nevertheless, good practices of stud management, enabling to reduce parasitic pressure across pastures, have been the subject of few studies in relation to horses, with the exception of dung removal [20] or composting manure [21]. We have attempted, during this project, to highlight the influence of certain types of stud management (presence or not of foals, accommodation, 24/7 grazing VS mixed rotational grazing, stocking rates, and importance of movements) on parasite excretion; nevertheless, no correlation was able to be established. Perhaps this was due to the limited number of horses selected for the study, or maybe due to the age of the horses (3 years and over), for which parasite immunity is deemed as being established [2]. Additional studies are thus necessary in order to research such risk factors within farms and to preach good practices of stud management [11].

6. Conclusion

Monitoring feed and pasture management in horses on 12 study farms for 2 years highlighted the necessity to alert horse breeders on the regular recording of the body condition score in order to optimise the balance between the needs of the animals, notably those with low nutritional needs, and the grass available in the pastures. Forage analysis and the calculation of a ration need to be more commonly accepted in order to ensure dietary balance and more targeted grazing. The parasitic monitoring in horses illustrated very heterogeneous situations among the structures. It seems very difficult to propose a sustainable deworming protocol without first carrying out a parasitic audit and ensuring strict monitoring of the farm by the treating veterinarian.

Several pasture management studies are currently ongoing in order to optimise feed and cost controls and to limit equine parasitic pressure, with notably a combined cattle-equine grazing study.

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