# Eliminative behaviour of free-ranging horses: do they show latrine behaviour or do they defecate where they graze?

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**Abstract**

In contrast to horses in pastures, it is thought that free-ranging horses do not perform latrine behaviour, i.e. a behavioural pattern whereby the animals graze and defecate in separate areas. However, few studies deal with this particular subject, reporting contrasting conclusions. We hypothesize that horses free-ranging in large heterogeneous areas do not perform latrine behaviour. Thus, we believe that grazing and elimination behaviour are spatially related: where horses graze, they will also defecate. Behavioural data were collected from Konik horses, Haflinger horses, Shetland ponies and donkeys, grazing in different nature reserves (54–80 ha). Data for the different equids were analyzed separately, as well as data for mares and stallions (Konik and donkey stallions only). We investigated the proportion of the number of defecations/urinations while grazing on the total number of defecations/urinations; furthermore, we searched for the sequence of behaviours representing latrine behaviour in the strict sense. Additionally, we analyzed the correlation between grazing behaviour and eliminative behaviour on both vegetation type level and patch level. All the female equids often continued grazing while defecating. During urination, grazing ceases in the majority of instances. Cases where a mare terminated grazing in a certain vegetation type and sward height to eliminate in another vegetation type or in another sward height within the same vegetation type were rarely observed. On the vegetation type level as well as on the patch level, there was a highly significant ($P < 0.001$) positive correlation between grazing time and number of eliminations (or eliminating time). The high values of the correlation coefficients (in case of the defecation variables $r$ ranges between 0.553 and 0.955; in case of the urination variables $r$ ranges between 0.370 and 0.839) illustrate that the spatial

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distribution of the eliminative behaviour can be explained to a high degree by the spatial distribution of the grazing behaviour. Results in the case of the stallions are preliminary, but indicate the same pattern. Horses, free-ranging in large heterogeneous areas, do not perform latrine behaviour, but defecate where they graze. Possibly, animal density is of major importance to explain this behavioural difference with horses in pastures. We suggest that also spatial vegetation heterogeneity and plant productivity of the grazed area, as well as parasite status of the grazing animals could play a role.


*Keywords:* Equids; Faeces avoidance; Grazing behaviour; Spatial differentiation; Urine; Horse marking

## 1. Introduction

Free-ranging herbivores have to make many foraging decisions at different resolution levels (Senft et al., 1987; Stuth, 1991), resulting in a foraging strategy that meets the large herbivores' nutrient and energy requirements. These decisions are primarily made in relation to forage availability and quality, which are in turn determined by environmental conditions. On the other hand, large herbivores themselves have an impact on their environment as well. Grazing animals affect the plants they utilize for forage in an enhancing or a degrading way (Vallentine, 1990; Briske, 1991). Furthermore, large herbivores have an impact on a higher level of ecological resolution. Herbivores can influence diversity, density and productivity of a plant community (Vallentine, 1990; Archer and Smeins, 1991; Duncan, 1992; Bakker, 1998), mainly through their selective grazing, but also through other behaviour like trampling and rolling. Also the eliminative behaviour of large herbivores is brought up as a potential factor playing a role in both vegetation development (Archer, 1973; Steinauer and Collins, 1995; Bokdam et al., 2001) and foraging strategy (Marten and Donker, 1964; Ödberg and Francis-Smith, 1976; Archer, 1978; Hutchings et al., 1998). Captive horses in pastures are known to establish a pattern of shortly grazed patches, relatively free of faecal droppings, and ungrazed taller patches, where horses preferably defecate and urinate (Archer, 1972, 1973; Ödberg and Francis-Smith, 1976). This pattern is caused by the avoidance of grazing near faecal droppings (Ödberg and Francis-Smith, 1977; Archer, 1978), and not through an initial difference in palatability of the vegetation of the grazed and ungrazed patches (Ödberg and Francis-Smith, 1977). It is suggested that this behaviour is a result of diminishing the chances of helminthic reinfestation (Taylor, 1954; Arnold and Dudzinski, 1978). Recently, this hypothesis is experimentally tested and confirmed in the case of sheep (Hutchings et al., 1998, 2002). Studies on the behaviour and/or habitat use of free-ranging or feral horses rarely discuss the horses' eliminative behaviour. Tyler (1972) reported some aspects of the eliminative behaviour of ponies in the New Forest. One conclusion was that there was no evidence that the ponies grazed and defecated in separate areas. Several authors (Tyler, 1972; Boyd, 1998; Klingel, 1998; Moehlman, 1998) mentioned specific eliminative behaviour of stallions as part of scent marking behaviour. Moehlman (1998) stated that, in contrast with donkey stallions, female donkeys of all ages showed little interest in dung and simply defecated where they stood. Only Edwards and Hollis (1982) dealt with the subject of the eliminative behaviour of free-ranging horses in particular. They concluded that the establishment of distinct latrine areas by horses is not merely a result of captivity, but does occur with free-ranging animals.

In several coastal nature reserves, close to the French–Belgian border, several different equids are free-ranging for nature management reasons. An initial investigation of the areas did not provide any visual cue to suppose that the above-mentioned latrine behaviour induced patterns were created. There were some faecal concentrations on paths and on frequently used resting places or grazing spots. We supposed that the faecal piles on paths were the result of the marking behaviour of the stallions. Other concentrations of defecations were believed to be the result of a concentration of animals in space and time. Between 1998 and 2001 we conducted several behavioural observations on the different free-ranging equids in these nature reserves. Based on these observations we hypothesized that horses grazing in large heterogeneous areas do not perform "latrine behaviour". We defined "latrine behaviour" as follows: a horse stops grazing and walks to an "eliminative" or "latrine" area to defecate or urinate, afterwards the horse walks back to a "nutritive" area (as described by Ödberg and Francis-Smith (1976)), or sometimes grazes in the "latrine" area for a while, and then gradually moves back to the "non-latrine" area (as described by Edwards and Hollis (1982)). A more indirect way to examine the occurrence of latrine behaviour was to investigate the spatial relation between grazing and defecating/urinating. A strong positive relationship between grazing and eliminative behaviour would indicate that latrine areas are not formed.

## 2. Materials and methods

### *2.1. Study sites*

We performed our study at three nature reserves ("Westhoek", "Houtsaegerduinen" and "Ghyvelde"). The first two are located in the coastal dunes of Belgium, near the French border. The latter is an old dune area in France close to the northern French coastline and bordering an equally old dune ridge in Belgium. All these reserves are relatively nutrient-poor systems with a spatially heterogeneous vegetation pattern. Domesticated grazers were released as a nature management tool, in the entire reserve or in parts of it.

The "Westhoek" reserve (total area: 340 ha) offers a diverse landscape consisting of a fore dune ridge and two dune slack zones that are separated by a large mobile dune. A fenced area in the north of the reserve ("Westhoek-North", 54 ha) is grazed by a herd of Konik horses and a small group of Highland cattle. Scrubs of *Hippophae rhamnoides* L. (Sea Buckthorn), *Ligustrum vulgare* L. (Wild Privet) and to some lesser extent *Salix repens* L. (Creeping Willow) occupy the largest part of the area. Before the start of the grazing project 12% of the original 79% scrub layer was cut down and removed, resulting in an area of ruderal vegetation composed of a low, grass-dominated layer (main species are *Holcus lanatus* L. (Yorkshire-fog) and *Calamagrostis epigejos* Roth (Wood Small-reed)) and patches of tall herbs *Eupatorium cannabinum* L. (Hemp-agrimony), *Lythrum salicaria* L. (Purple Loosestrife) and *Cirsium arvense* Scop. (Creeping Thistle). The remaining area is covered by species-poor grassland, dominated by *C. epigejos* or *C. canescens* Roth (Purple Small-reed); species-rich dune grassland with *Poa pratensis* L. (Smooth Meadow-grass), *Avenula pubescens* (Huds.) Dum. (Downy Oat-grass), *Veronica chamaedrys* L. (Germander Speedwell), *Galium verum* L. (Lady's Bedstraw); young dune slack and moss dune.

"Westhoek-South" (ca. 60 ha), a fenced area in the south of the "Westhoek", is grazed by a herd of Shetland ponies and a group of Highland cattle. The area encompasses a dune slack zone and an inner dune ridge. Two-thirds of this area is covered by more or less closed scrub vegetation: main shrub species are *H. rhamnoides*, *L. vulgare*, *Crataegus monogyna* Jacq. (Hawthorn) and *Prunus spinosa* L. (Blackthorn); tree species are several Poplar species (*Populus* × *canadensis* Moench, *Populus tremula* L., *Populus canescens* Smith), *Ulmus minor* Mill. (Small-leaved Elm) and *Alnus glutinosa* Gaertn (Alder). The other third of the fenced area is occupied by grasslands and herbaceous vegetations: species-rich dune grasslands with *P. pratensis, A. pubescens*, *V. chamaedrys* and *G. verum*; tall herb vegetation with *C. arvense*, *E. cannabinum, Lysimachia vulgaris* L. (Yellow Loosestrife), *L. salicaria* or *Iris pseudacorus* L. (Yellow Iris); patches of species-poor grassland enclosed by scrub, dominated by *C. epigejos*; moss dune and some marram dune (*Ammophila arenaria* Link) vegetation.

In the "Houtsaegerduinen" a herd of donkeys graze all over the reserve (total area: 80 ha). The site is mainly occupied by *H. rhamnoides*/*L. vulgare* scrub, with relatively small and scattered patches of dune grassland and moss dune (*Cladonio-Koelerietalia*). Old, deteriorating *Hippophae* scrub is generally replaced by species-poor grassland dominated by *C. epigejos*. Part of the area has been planted with *A. glutinosa* and several non-native tree species (*Populus* div. spp.).

In "Ghyvelde" (ca. 60 ha) a herd of Haflinger horses is grazing the entire area. Two-thirds of this area is open habitat formed by *Carex arenaria* L.-dominated grassland (Sand sedge), alternated with moss dunes. One central forest and several dispersed, small congregations of trees shape the woodland at the site, which is mostly afforested. Additionally, the closed vegetation is also formed by natural scrub of *H. rhamnoides*, *L. vulgare*, *S. repens* and *Sambucus nigra* (Elder).

### *2.2. Animals*

In all study areas, the animals are free-ranging and remain in the area year round. They receive no additional food. Nonetheless the herds are managed to avoid inbreeding and overgrazing. Each year all equids in the Belgian nature reserves were treated with 'Horseminth' (Pfizer), an anthelminthic active against a broad spectrum of gastrointestinal parasites. Within the observation periods Konik horses were treated once and Shetland ponies and donkeys thrice.

Grazing by Konik horses in "Westhoek-North" started in 1998 with 2 mares and 2 stallions. During the study period the herd was enlarged with 1 foal.

In "Westhoek-South" grazing started in April 1997, with 7 Shetland pony mares and 1 stallion. The herd enlarged mainly naturally and at the end of the study period, in spring 2001, there were 17 adult ponies, 2 colt yearlings and 10 foals. The adult group was formed by 1 dominant stallion, 12 mares and 4 bachelor stallions (three geldings).

In "Houtsaegerduinen" a stallion and 5 donkey mares were introduced in 1997. Two more stallions and a mare were introduced later and 15 foals were born so that in spring 2001 there were 9 mares, 5 stallions, 3 colt yearlings and 7 foals.

Table 1
Animal density in different areas

| Area | Surface area (ha) | Equid breed | Initial density | Final density | Other large herbivores | Total density |
|---|---|---|---|---|---|---|
| Westhoek-North | 54 | Konik horse | 0.7 | 0.9 | Highland cattle | 1.3 |
| Westhoek-South | 60 | Shetland pony | 1.3 | 3.2 | Highland cattle | 3.8 |
| Houtsaegerduinen | 80 | Donkey | 0.7 | 2.1 | – | 2.1 |
| Ghyvelde | 60 | Haflinger horse | 2.0 | 1.6 | – | 1.6 |

Initial and final densities: equid density at the start and at the end of the observation periods, respectively; total density: animal density (equids and cattle) at the end of the observations. Densities are expressed as the number of adult individuals per 10 ha.

At the initiation of the observations in "Ghyvelde" (May 2000) the herd of Haflinger horses was composed by 4 stallions, 11 mares and 3 foals. Composition of the herd changed twice, but during most of the observations 12 adult horses (3 stallions, 9 mares) and 2 foals were grazing the area. An overview of the animal density during the observation periods in the different areas is given in Table 1.

### *2.3. Behavioural observations*

All observations took place between August 1998 and August 200l. Different periods of observations should be distinguished. Six observers (the first six authors of the paper) were involved in the data collection. Donkeys were observed: August 1998–March 1999 (00:00–24:00 h), August 1999–March 2000 (06:00–24:00 h), May 2000–July 2001 (daylight hours) (in total 1061 observation hours). Shetland ponies were observed during August 1998–March 1999 (00:00–24:00 h) and May 2000–July 2001 (daylight hours) (in total 706 observation hours). Observations of Konik horses were carried out from August 1999–March 2000 (06:00–24:00 h) (in total 297 observation hours). Observations of Haflinger horses were performed from May 2000–April 2001 (daylight hours) (in total 185 observation hours).

Data were collected through continuous focal animal observation (Altmann, 1974). During a 6 h period we continuously monitored the behaviour of 1 focal animal, chosen at random from a pool of possible study animals. Observational data are from 6 donkey mares and 1 donkey stallion (born in the reserve on April 1998; subordinate, but competing with his father for the dominant position), 10 Shetland pony mares, 2 Konik mares and 2 Konik stallions (1 dominant and 1 subordinate), and 3 Haflinger mares. The same individuals were repeatedly observed (for donkeys, Shetland ponies, Konik horses and Haflinger horses the mean number of observation periods per individual is 25, 12, 12 and 10, respectively). The observed individuals were habituated to the presence of humans and could be approached closely (1 m) without visible influence on their behaviour. The duration (accuracy: 1 s) of the observed behaviours and the vegetation type in which the behaviours were performed were recorded on a protocol form. From May 2000 onwards, we noted also height of the vegetation in which the behaviour was performed. Therefore, we used a scale related to the animal's physiognomy: 'no height' (in case of no vegetation), 'shortly grazed', 'hoof', 'knee', 'belly', 'spine' and 'higher'. We considered the behaviours grazing, resting up, laying down, walking, standing alert, grooming, mutual grooming, drinking, defecating, urinating, defecating while grazing, urinating while grazing, nursing, nursing while grazing, rolling, sniffling, pawing, flehming, aggressive behaviour, sexual activity and other interactions. From the moment a grazing animal has put its head upwards and simultaneous it was not chewing, then this was recorded as the stop of the grazing activity and the start of a subsequent behaviour, e.g. standing alert.

### *2.4. Data analysis*

Data from the different equid groups (in the different areas) were analyzed separately. The different observation periods were analyzed together. Data from mares and data from stallions were handled separately, as the eliminative behaviour of stallions could be influenced by marking behaviour. As we only had data from 2 Konik stallions and 1 donkey stallions, the results concerning stallions are only indicative.

#### *2.4.1. Eliminative behaviour*

First potential evidence for our hypothesis came from the observation that the horses often did not stop grazing to defecate and to a lesser degree even to urinate. To analyze this we retained the behaviours defecating, urinating, defecating while grazing and urinating while grazing. We calculated the proportion of the number of defecations while grazing over the total number of defecations (sum of the number of defecations and the number of defecations while grazing). The same procedure is followed for the number of urinations.

Furthermore, we investigated whether the event of “latrine behaviour” did occur, by looking for the following sequence of behaviours: animal is grazing in a certain vegetation type with a certain height; animal stops grazing, doing other behaviours while moving to another vegetation type or to another sward height within the same vegetation type; animal defecates or urinates in that other vegetation type or sward height; animal performs another activity. We considered a maximum time of 60 s between the grazing stop and the start of the elimination, because we assumed that a horse would not walk for more than 60 s to a certain place to eliminate there. We retained also the two following behaviours, occurring after the eliminative behaviour, to see if the horse started grazing in the patch (with a certain vegetation type and sward height) where it has been eliminating.

#### *2.4.2. Spatial relation between grazing and eliminative behaviour*

It could very well be that the mares did not perform latrine behaviour as described above, but that they concentrated their faecal droppings anyway in places where they grazed less, with the consequence that their favourite grazing places were less contaminated with faeces than the places where they spent less time grazing. Therefore, we investigated the spatial relation between grazing behaviour and eliminative behaviour. We supposed that the number of defecations (urinations) in a given vegetation type is a good measure for the quantity of faeces (urine) that this vegetation type receives. It is also possible that defecation time (urination time) is a better measure for the quantity of faeces (urine); therefore, we analyzed the questions below by two alternative approaches using either number of defecations (number of urinations) or defecation time (urination time) as dependent variables.

*2.4.2.1. At the vegetation type level.* Per vegetation type we calculated the total time spent grazing and the total number of defecations (or urinations), and analyzed correlations between these variables. Sample size (*n*) is the number of vegetation types. We did the same with total time spent defecating or urinating in a vegetation type.

*2.4.2.2. At the patch level in the most grazed vegetation types.* Possibly, the pattern of latrine areas and non-latrine areas did not occur at the scale of the vegetation types, but rather at the scale of patches (combinations of vegetation types and sward heights). Therefore, we "zoomed in" to this more detailed scale. Avoidance of grazing near faeces would lie at the basis of the formation of latrine areas (Ödberg and Francis-Smith, 1977; Archer, 1978). We assumed that if the animals avoided places where faeces occurred, this would be most detectable in the vegetation types with highest grazing times, which we analyzed consequently. We calculated total time spent grazing and total number of defecations (or urinations) per height class per vegetation type, and we again analyzed the correlations. We did the same with total time spent defecating or urinating per height class per vegetation type. Since data on sward height were collected from May 2000 onwards, these analyses could only be done for donkeys, Shetland ponies and Haflinger horses.

*2.4.2.3. At the patch level in a grassland entity.* In "Westhoek-South" a pasture-like area of 6.6 ha is intensively used by the ponies. We assume this situation comparable to the one studied by Edwards and Hollis (1982) in the New Forest. Within this grassland entity several vegetation types and several sward heights within these vegetation types could be distinguished. We calculated the total time spent grazing and the total number of defecations (or urinations) per height class per vegetation type, and we analyzed again the correlations between these variables. The same is done with total time spent defecating or urinating per height class per vegetation type.

Square root transformations were performed on all variables to achieve normal distributions. When transformed data had a truly normal distribution, Pearsons correlations were calculated, if not so, we used Spearman correlations. All analyses were performed using SPSS 11.0 for Windows.

## 3. Results

### *3.1. Eliminative behaviour*

Defecating occurred more frequently than urinating in all equids (Table 2). All the female equids defecated often while grazing, i.e. 46–60% of all performed defecations (Table 2). In the other cases they were standing or walking while defecating. The 2 Konik stallions and the 1 donkey stallion mostly ceased grazing to defecate. We also found that in most

Table 2
Features of the eliminative behaviour of the equids

| | Obs, *n* | Defecations | | Urinations | |
|---|---|---|---|---|---|
| | | Mean no. per 6 h | Grazing (%) | Mean no. per 6 h | Grazing (%) |
| Mares | | | | | |
| Konik horse | 18 | 5.0 ± 0.3 | 45.6 | 2.4 ± 0.3 | 18.2 |
| Shetland pony | 119 | 3.5 ± 0.2 | 57.3 | 2.5 ± 0.2 | 6.0 |
| Donkey | 169 | 3.6 ± 0.1 | 55.0 | 1.5 ± 0.1 | 1.2 |
| Haflinger horse | 31 | 4.2 ± 0.3 | 59.5 | 2.9 ± 0.3 | 23.3 |
| Stallions | | | | | |
| Konik horse | 33 | 4.9 ± 0.3 | 19.8 | 2.6 ± 0.2 | 3.5 |
| Donkey | 14 | 4.9 ± 0.4 | 7.3 | 2.3 ± 0.3 | 0.0 |

Obs, *n*: number of observation sessions of 6 h; mean no. per 6 h: mean number of defecations/urinations per 6 h ± standard error; grazing (%): the proportion of number of defecations/urinations while grazing over the total number of defecations/urinations. (Note that the different equids were observed for a different amount of 6 h sessions.)

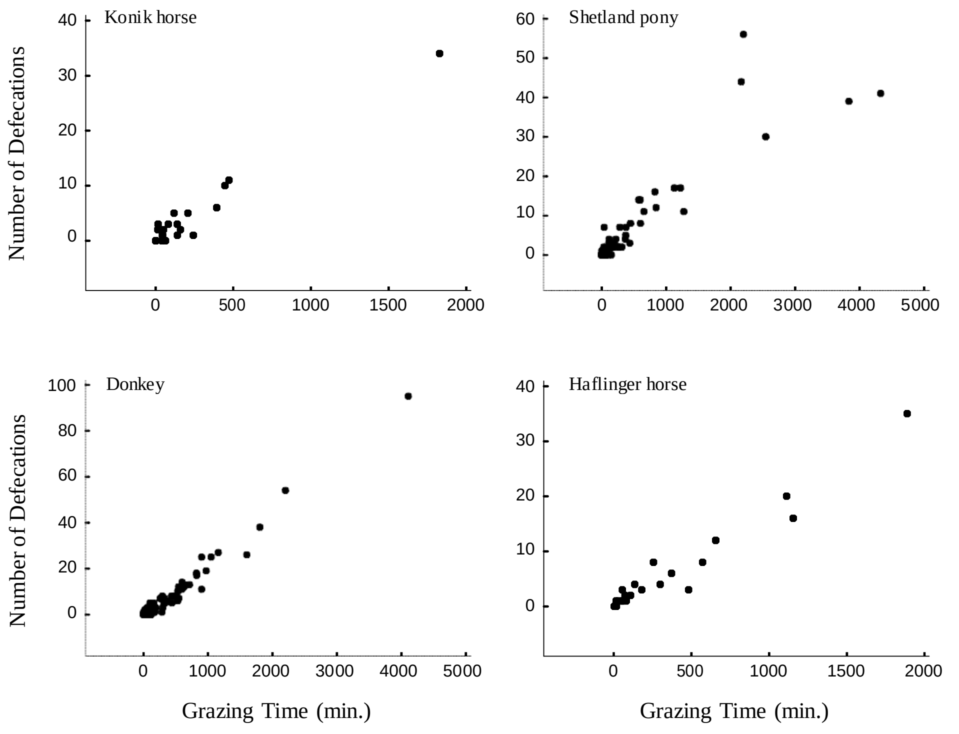


Fig. 1. Correlation at the vegetation type level for the four mare groups. The total number of defecations in relation to the total grazing time (min). Each dot represents a vegetation type.

cases grazing was stopped during urinating. Donkeys urinated very rarely while grazing, but Haflinger and Konik mares did so more frequently (Table 2).

Shetland pony mares terminated grazing in a certain vegetation type and moved within 60 s towards another vegetation type and defecated there in only 6 of the 419 defecations. If they behaved this way, in two out of six times the pony mares subsequently started grazing in the vegetation type in which they defecated. Only 1 out of 299 times a pony mare changed vegetation type before urinating; though started grazing there subsequently. Donkey mares changed vegetation type 4 out of 609 times to defecate and 6 out of 259 times to urinate. In one of the four defecations and in three of the six urinations they started grazing in the vegetation type where they had eliminated. The donkey stallion changed 6 out of 68 times of vegetation type to defecate. In one of these six events the donkey stallion started grazing within the fouled vegetation type. In the case of the Haflinger horses a mare

Table 3
Spatial relation between grazing and eliminative behaviour at the vegetation type level

| | No. of defecations | Defecation time | No. of urinations | Urination time |
|---|---|---|---|---|
| Mares | | | | |
| Konik | | | | |
| Grazing time ($n$ = 21) | | | | |
| Pearson $r$ | 0.901 | 0.864 | 0.836 | 0.839 |
| $P$ | 0.000 | 0.000 | 0.000 | 0.000 |
| Shetland pony | | | | |
| Grazing time ($n$ = 92) | | | | |
| Spearman $r$ | 0.806 | 0.797 | 0.821 | 0.806 |
| $P$ | 0.000 | 0.000 | 0.000 | 0.000 |
| Donkey | | | | |
| Grazing time ($n$ = 115) | | | | |
| Spearman $r$ | 0.835 | 0.825 | 0.719 | 0.705 |
| $P$ | 0.000 | 0.000 | 0.000 | 0.000 |
| Haflinger horse | | | | |
| Grazing time ($n$ = 22) | | | | |
| Pearson $r$ | 0.955 | 0.934 | 0.829 | 0.773 |
| $P$ | 0.000 | 0.000 | 0.000 | 0.000 |
| Stallions | | | | |
| Konik | | | | |
| Grazing time ($n$ = 22) | | | | |
| Pearson $r$ | 0.957 | 0.951 | 0.884 | 0.871 |
| $P$ | 0.000 | 0.000 | 0.000 | 0.000 |
| Donkey | | | | |
| Grazing time ($n$ = 83) | | | | |
| Spearman $r$ | 0.460 | 0.457 | 0.500 | 0.511 |
| $P$ | 0.000 | 0.000 | 0.000 | 0.000 |

Correlations between total grazing time in a vegetation type and total number of defecations/urinations or total defecation/urination time in that vegetation type. All variables were square-root-transformed. $n$: number of vegetation types. If data were normally distributed the Pearson correlation coefficient was used. If not, we used the Spearman correlation coefficient.

changed the vegetation type to urinate only once. In the case of the Konik horses we found none. One pony mare moved to another sward height, within the same vegetation type, to eliminate there. This was the only case of movement to another sward height within the same vegetation type for all the equids studied this way (Shetland ponies, donkeys and Haflinger horses).

This minimal amount of movements to another vegetation type or to another sward height within the same vegetation type to defecate or urinate is considered rather to be coincidental than as evidence of latrine behaviour.

### *3.2. Spatial relation between grazing and eliminative behaviour*

#### *3.2.1. At the vegetation type level*

For donkeys and the three other equid breeds we analyzed the correlation between total grazing time in a vegetation type on the one hand and total number of defecations (urinations) and total defecation (urination) time in that vegetation type on the other hand. For the mares, we found a highly significant ($P < 0.001$) positive correlation for both defecating and urinating behaviour (Table 3; Figs. 1 and 2). This means that vegetation types with a low grazing time encounter a low elimination activity, while vegetation types with

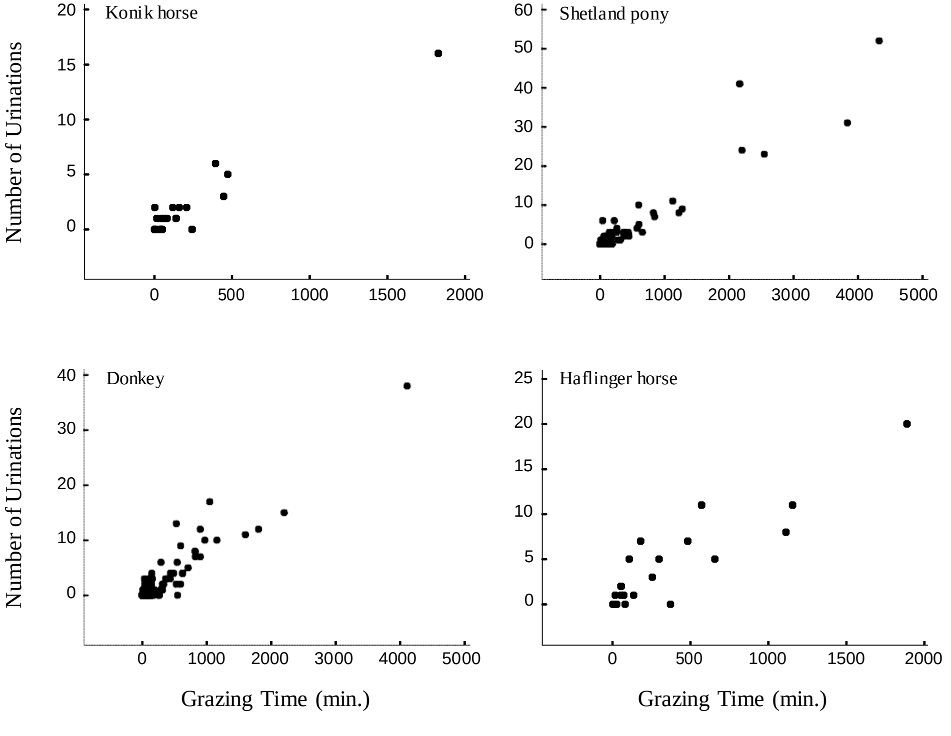


Fig. 2. Correlation at the vegetation type level for the four mare groups. The total number of urinations in relation to the total grazing time (min). Each dot represents a vegetation type.

a higher grazing time receive a higher number of defecations and urinations (and show a higher defecation time and urination time). Results of the Konik stallions were very similar compared to the results of the Konik mares (Table 3). In the case of the donkey stallion we also found highly significant positive correlations, though smaller values for the correlation coefficients (Table 3). In most cases, for both mares and stallions, the correlation coefficients were higher for the defecations than for the urinations. We conclude that the equids eliminated most in the vegetation types where they grazed most, and eliminated less in less grazed vegetation types.

### *3.2.2. At the patch level in the most grazed vegetation types*

When considering different patches within the most frequently grazed and hence most frequently fouled vegetation types, the highly significant positive correlations remained (Table 4). Patches with a small grazing time showed a small number of eliminations and

Table 4
Spatial relation between grazing and eliminative behaviour at the patch level

| | No. of defecations | Defecation time | No. of urinations | Urination time |
|---|---|---|---|---|
| In most grazed vegetation types[a] | | | | |
| Mares | | | | |
| Shetland pony | | | | |
| Grazing time ($n = 73$) | | | | |
| Spearman *r* | 0.780 | 0.789 | 0.710 | 0.703 |
| *P* | 0.000 | 0.000 | 0.000 | 0.000 |
| Donkey | | | | |
| Grazing time ($n = 87$) | | | | |
| Spearman *r* | 0.655 | 0.636 | 0.457 | 0.439 |
| *P* | 0.000 | 0.000 | 0.000 | 0.000 |
| Haflinger horse | | | | |
| Grazing time ($n = 37$) | | | | |
| Pearson *r* | 0.909 | 0.884 | 0.797 | 0.774 |
| *P* | 0.000 | 0.000 | 0.000 | 0.000 |
| Stallions | | | | |
| Donkey | | | | |
| Grazing time ($n = 42$) | | | | |
| Spearman *r* | 0.566 | 0.553 | 0.370 | 0.371 |
| *P* | 0.000 | 0.000 | 0.016 | 0.015 |
| In a vegetational entity | | | | |
| Mares | | | | |
| Shetland pony | | | | |
| Grazing time ($n = 60$) | | | | |
| Spearman *r* | 0.781 | 0.772 | 0.648 | 0.633 |
| *P* | 0.000 | 0.000 | 0.000 | 0.000 |

Correlations between total grazing time in a patch (vegetation type–sward height combination) and the total number of defecations/urinations or the total defecation/urination time in that patch. All variables were square-root-transformed. *n*: number of patches. If data were normally distributed the Pearson correlation coefficient was used. If not, we used the Spearman correlation coefficient.

[a] Only the vegetation types with highest grazing times were considered.

patches with higher grazing times received a higher number of eliminations. Again, we found for the donkey stallion lower values for the correlation coefficients in comparison with the donkey mares.

*3.2.3. At the patch level in a grassland entity*

In “Westhoek-South” we analyzed how the Shetland ponies used the “Pasture”, an intensively grazed part of the terrain. In this area different grass-dominated vegetation types could be distinguished. Within these vegetation types, different sward heights could be discriminated. Again we found highly significant positive correlations. Total grazing time in a vegetation type–sward height combination was positively correlated to total number of defecations/urinations and to total defecation/urination time in this vegetation type–sward height combination (Table 4).

## 4. Discussion

In the present study we hypothesized that free-ranging horses do not perform latrine behaviour. Thus, these horses do not concentrate their eliminations in certain areas, where they avoid grazing. Our results confirm this hypothesis.

The mares often defecated while grazing, i.e. 46–60% of all performed defecations. This proportion was smaller for the observed stallions (7–20%). On the other hand, mares and stallions mostly stopped grazing to urinate. Stalled ponies moved to another place before they defecated or urinated in 50% of the occasions (Sweeting et al., 1985). The differences in both eliminative behaviours can be due to the processes of the two eliminative behaviours themselves. Waring (2003) describes that a horse about to urinate assumes a basic posture, where the neck is slightly lowered, the tail is raised, and the hindlegs are spread apart and stretched posteriorly. He reports also that during urination, grazing ceases in the majority of instances and no particular site is sought. Our findings are in line with this. The process of defecation occurs without any specific posture except that the tail is raised and often held to one side (Waring, 2003). If the horse does not have to take up a specific posture it can proceed to graze without interruption.

We rarely observed an animal terminated grazing and started a subsequent behaviour while moving to another vegetation type or to another sward height within the same vegetation type, where it subsequently defecated or urinated. Therefore and because the horses, in particular the mares, often defecated while grazing, we conclude that the horses in the field situation of the present study did not perform latrine behaviour.

The only donkey stallion that has been observed changed vegetation type to defecate in 8.8% of the cases. We believe this was not the result of latrine behaviour, but was merely a result of marking behaviour. Several authors reported specific eliminative behaviour of stallions, in pastures as well as in more natural surroundings (Tyler, 1972; Ödberg and Francis-Smith, 1976; Boyd, 1998; Klingel, 1998; Moehlman, 1998). Marking behaviour is the behavioural pattern to deposit chemical signals on environmental objects or other animals of the same species (Ralls, 1971). Marking behaviour in stallions occurs mainly with faeces and urine and occurs as well on established faecal piles as on the fresh excrements of mares (Kimura, 2001; Waring, 2003). Different functions have been denoted to it (Klingel, 1998; Kimura, 2001). Although we did not perform research on the marking behaviour of the stallions in particular, at this point we think it is worth mentioning some situations observed. On several occasions we observed donkey stallions visiting established faecal piles. Dominant as well as subdominant stallions inspected such piles. Olfactory inspection occurred by smelling and sniffing, sometimes followed by flehming. Often the stallions then deposited fresh faecal material to the existing pile, and a second bout of olfactory investigation completed this process. Stallions also urinated on top of a faecal pile. On some occasions we observed that several donkey stallions investigated faecal piles all together, and consecutively defecated on top of it. The sequence of stallions defecating on the faecal pile could be related to the dominance order of the males, although literature does not provide an unambiguous view on this (Waring, 2003). Also the 2 Konik stallions in “Westhoek-North” eliminated on established piles or fresh excrements of mares. In the case of the Shetland ponies and the Haflinger horses this behaviour was only rarely seen, probably due to the composition of the herds.

On the vegetation type level as well as on the patch level there was a highly significant positive correlation between the time spent grazing and the number of defecations and urinations. This means that there was no spatial differentiation between grazing behaviour and eliminative behaviour. The high values of the correlation coefficients in the cases of the 4 mare groups and the Konik stallions illustrate that the spatial variation in the number of defecations can be explained to a high degree by the spatial variation in grazing time. For the donkey stallion we found smaller values for the correlation coefficients. However, the range of the values on both the *x*- and the *y*-axes is considerably larger in mares than in stallions. It is known that the values of correlation coefficients are influenced by the range of the *x*- and *y*-axes (Smith, 1984). The values of the correlation coefficients for the urination variables were in most cases smaller than for the defecation variables. This may be due to the smaller range of the *y*-axis and/or to the presence of more null values (since the horses urinated less frequently than that they defecated).

Results in the case of the stallions are preliminary, but indicate the same patterns as found in the case of the mares. We conclude that the free-ranging equids in the present study, both mares and stallions, simply defecate and urinate where they graze. Intensively grazed patches are more fouled compared to less grazed patches, which is in contrast with the patterns described in literature for horses in small pastures (Archer, 1972, 1973; Ödberg and Francis-Smith, 1976). Grazing and eliminating were not spatially separated in Camargue horses (Sereni, 1977). Similarly, Tyler (1972) found no evidence that free-ranging ponies in the New Forest grazed and defecated in separate areas. However, based on their study in unenclosed, improved grasslands in the New Forest, Edwards and Hollis (1982) stated that the establishment of distinct latrine areas by horses does occur in free-ranging animals.

Why seem horses not to concentrate their faeces in non-grazed patches, when grazing in a large, spatially heterogeneous environment, and are consequently faced with faecal droppings in the grazed patches? We suggest that animal density, spatial vegetation heterogeneity and plant productivity of the grazed area could play a role. Also the parasite status of the grazing animals and the grazed areas could have an impact. Possibly, animal density, and thus consequently faecal density, is of major importance. Herbivores avoid grazing near faecal droppings (Ödberg and Francis-Smith, 1977; Archer, 1978; Hutchings et al., 1998), which is thought to be an adaptation to reduce infection by intestinal parasites (Taylor, 1954). Many studies of herbivores have shown that the animals select non-contaminated swards, when available, over faeces (from the own or another species)-contaminated swards (Marten and Donker, 1964; Forbes and Hodgson, 1985; Hutchings et al., 1998). Hutchings et al. (1998) found a threshold level of faecal contamination of swards for sheep: experimental sward trays with 15 g faeces and above were rejected by the sheep (this equated to 198 g faeces/m$^2$). In the four study areas the overall animal density is low (1 large herbivore per 2.7–7.7 ha). A low animal density implies a low parasite density. Therefore, it is possible that with the current defecating rate of the total herd the grazing animals are not faced regularly enough with faeces (and thus parasites) to establish a pattern potentially reducing the risk of parasitic infection. However, some areas are more intensively used than others, like the "Pasture" grazed by Shetland ponies and Highland cattle. According to our suggestion that latrine behaviour is related to animal density, we would expect that on this particular site the horses would use separate patches to graze and to defecate. However, in this case we also did not find evidence for latrine behaviour. The reduction in herbage intake associated with the fouling from dung appears greatest at intermediate grazing pressures but minimal at either very low or very high grazing pressure (Wilkins and Garwood, 1986). It is difficult to know the animal density on an unenclosed area like the "Pasture", but it could be that grazing pressure was here above a potential upper limit. We assumed the "grazing situation" at the "Pasture", to be similar to the point of departure in the study of Edwards and Hollis (1982). However, they reported that the studied lawns showed a mosaic of latrine areas with taller vegetation and non-latrine areas with shorter vegetation. The ponies grazed mostly in the non-latrine areas, though there was seasonal variation, and the highest levels of dunging were in latrine areas. Edwards and Hollis (1982) suggested that the formation of latrine areas is related to high animal densities, which should explain the discrepancies with previous conclusions of Tyler (1972) in the New Forest. However, according to the difference between the results at the "Pasture" and the results at the New Forest grasslands, we assume that also other factors have to be taken in mind. We suggest that the level of heterogeneity of the grazed area plays a role. The grasslands considered in the New Forest were rather homogeneous. The above-ground biomass of herbage was higher in the latrine areas and the proportion of some species present varied between latrine and non-latrine areas; however, species composition showed rather few differences between the two areas (Edwards and Hollis, 1982). Our study site "The Pasture" forms a clear spatial entity within its surroundings but is still heterogeneous on lower spatial levels. Overall the area is "grassy", with several patches of rough vegetation. Within the grassy environment and within the rough vegetation different vegetation types, with specific species composition, can be distinguished. Herbivores foraging in heterogeneous surroundings are expected to be faced with more foraging decisions than when foraging in homogeneous areas. In such situation the avoidance of parasites and thus of faeces may become of minor importance to the decision on grazing where and what. Furthermore, the present study was conducted in nutrient-poor systems. It could be that the grazing animals were nutrient-stressed and consequently became less selective, since being selective is time-consuming and thus costly. This latter factor of forage quality can also contribute to the observed differences in eliminative behaviour between horses in pastures and the free-ranging horses of the present study. Domestic animals are mostly 'parked' in pastures with a vegetation cover of a higher nutrient quality compared to the grazed dune areas. Moreover, many domestic horses are fed additional concentrate rations. Thus, the more nutrient-comfort situation of horses in pastures may enable them to display a more selective grazing as well as eliminative behaviour.

An additional explanation for the dissimilarity between our results and those of Edwards and Hollis (1982) lays in the 'grazing history'. Ponies have been grazing the New Forest hundreds of years and parasite levels of the intensively grazed lawns may be much higher compared to the parasite levels of the dune reserves with a much younger grazing history. Besides the parasite levels of the grazed area the parasite status of the horses themselves may play a role in the explanation of the lack of appearance of latrine areas. The parasite status and immune status of sheep affects the degree of avoidance of grazing near faeces (Hutchings et al., 1998, 2001a,b, 2002). Immune sheep took higher parasitic risks, while parasitized animals reduced parasitic risk through increased rejection of faeces-contaminated swards and/or changing foraging behaviour. Exposure to internal parasites may lead to a certain degree of immunity in adult horses. They can live with a certain internal parasite load without being harmed seriously. Treatment with an anthelminthic allows an increase in immunity. The equids of the present study could have reached a certain degree of immunity and in addition with the supposed low parasite levels of the grazed areas, the horses may behave like the immune sheep, taking higher parasitic risks. Since no veterinary control of the effective degree of intestinal parasitic infection or of a possible immunity is performed, it is difficult to estimate the possible impact of this factor on the grazing and eliminating behaviour of the studied equids.

Mixed grazing seems to result in a reduced avoidance of faeces-contaminated swards (Forbes and Hodgson, 1985). Horses, grazing in combination with other large herbivores, did not perform latrine behaviour (Carson and Wood-Gush, 1983). In the present study two areas were grazed only by equids, in the other two areas the equids were accompanied by Scottish Highland cattle. Since we found similar results in the four cases, we believe that the impact of mixed grazing on the eliminative behaviour of free-ranging equids is of minor importance. We want to indicate also that herd composition, moreover the sex ratio of the herd, can have far-reaching influences on the behaviour and habitat use of equids.

Our conclusion that horses, grazing in large heterogeneous areas, simply defecate where they graze, has important consequences for nature management. Some studies (Bakker et al., 1983; Putman, 1986; Bokdam and Gleichman, 2000; Bokdam et al., 2001) suggest that there exists a transfer of nutrients in grazed systems, and even more pronounced so in nutrient-poor systems. They assume that a depletion of nutrients will occur in the preferred grazing sites, whereas areas with faeces concentration will show an accumulation of nutrients. At this point we can state that this process is not likely to occur on a large scale in nature reserves grazed by equids. Vegetation types with highest grazing times receive also the highest number of defecations. Thus, nutrients taken by the grazing equids have a great chance to return to these grazed areas, although not necessarily (most probably not) at the very same location.

Another consequence of our findings is that the distribution of faecal pellets in an area gives a fairly good picture of the habitat use of the horses. The faecal count method is an indirect method available for trying to assess the patterns of habitat occupancy by secretive wild herbivores (Putman, 1990). According to our results this technique can be used for free-ranging equids in nature reserves.

## 5. Conclusions

In the present study, we conclude that horses, free-ranging in large heterogeneous areas, do not perform latrine behaviour, as described for horses in pastures. The spatial distribution of the eliminative behaviour could be explained to a high degree by the spatial distribution of the grazing behaviour: horses defecate where they graze. We suggested possible reasons why this behaviour is different with the eliminative behaviour of horses in pastures. Further research is required to investigate the impact of the suggested explanations. Especially experimental setups can help to find the answers related to the issue grazing in relation to faecal distribution.

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