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Rustcomfort

Changes in the environment (for example diet and sensory input) of an animal cause changes in the animal's circadian rhythms and sleep patterns (Dallaire and Ruckebusch, 1974a, b). In particular, the immediate effect of changes in the environment is to reduce the daily duration of paradoxical sleep, and thus an animal's adaptation to its environment is reflected in the duration of paradoxical sleep. Horses lie down in either sternal or lateral recumbency, spending approximately 11.5% of the day recumbent (Steinhart, 1937).

Pedersen et al., 2004: Electroencephalographic (EEG) studies in cats have demonstrated that sleep can be divided into two stages of differing electrocorticographic (EcoG) patterns, ie, slowwave-sleep (SWS) and paradoxical sleep (PS) (Jouvet, 1967). During PS, bursts of rapid eye movements (REM) can be seen at irregular intervals (Dallaire, 1986). In humans, dreaming occurs during this stage (Aserinsky & Kleitman, 1953; Dement, 1960). Horses are able to sleep while standing, (Steinhart, 1937) but in this position they only go into SWS (Ruckebusch, 1970; Dallaire & Ruckebusch, 1974b). During PS there is a complete abolition of muscular tone of antigravity muscles and of neck muscles, as shown in cats (Jouvet et al., 1959). In horses, there is a gradual loss of muscular tone until the middle of the recorded SWS period, whence it decreases to a negligible amount during PS (Ruckebusch, 1972). Consequently, muscular tone disappears entirely at the onset of PS (Dallaire & Ruckebusch, 1974a). Horses are unable to complete a sleeping cycle without lying down to enter PS (Dallaire, 1986; Ruckebusch et al., 1970; Hale & Huggins, 1980). They normally fall asleep while standing and, when they feel confident about their environment, lie down in sternocostal recumbency (Dallaire, 1986). Thereafter, they proceed to lateral recumbency and enter PS (Ruckebusch, 1970; Ruckebusch et al., 1970). Dallaire and Ruckebusch (1974a) demonstrated that the SWS state was infrequent in the standing animal and most often occurred during sternocostal recumbency with the head resting or not on the ground. PS occurred in both sternocostal and lateral recumbency, although the animal frequently had to readjust its position into sternocostal recumbency due to the disappearance of neck muscular tone.
The sleep pattern of horses depends on many circumstances, such as age, (Duncan, 1980; Crowell-Davis, 1994) diet (Dallaire & Ruckebusch, 1974b) and familiarity with the environment. If one horse that is familiar with the environment lies down, the others usually follow (Dallaire, 1986; Ruckebusch, 1975). Dallaire and Ruckebusch (1974a) subjected three horses to a four-day period of perceptual (visual and auditive) deprivation. After this period total sleep time increased due to an augmentation of both SWS and PS. Finally, there is large individual variation between horses in the time they spend recumbent and sleeping (Ruckebusch, 1972). Horses spend 11% to 20% of the total time in recumbency (Steinhart, 1937; Ruckebusch, 1972). Lateral recumbency represents about 20% of total recumbency time, and uninterrupted periods of lateral recumbency vary from 1 to 12 minutes (mean, 4.6 min) (Dallaire & Ruckebusch, 1974b). Total sleeping time in the stabled horse averages 3 to 5 hours per day or 15% of the total time (Dallaire, 1986). Keiper and Keenan (1980) found similar time budgets in feral horses that were recumbent approximately 26,6% of the night. Paradoxical Sleep (PS) is about 17% to 25% of total sleeping time, and the mean length of a single PS period is 4 to 4.8 minutes (Ruckebusch, 1975; Dallaire & Ruckebusch, 1974a).
The mean total time the horses spent recumbent did not differ between the two groups (166.8 min for horses on straw, and 133.8 min for horses on shavings, $P > .1$). The mean time spent in sternal recumbency was the same for the two groups (5.6 min). The time spent in lateral recumbency was almost three times longer for the horses on straw (mean, 57.5 min) than for those on shavings (mean, 19.3 min) ($P < .001$). There were consistent individual differences between the 16 horses in

time spent recumbent, but there was no significant difference between the first and the second night of recording. The results showed that horses on straw were lying in lateral recumbency three times longer than horses on shavings ($P < .001$), whereas the time horses spent in sternal recumbency did not differ. The longest period of noninterrupted lateral recumbency was longer for horses on straw than for those on shavings. Because horses must lie down, preferably in lateral recumbency, to achieve paradoxical sleep, the reduced time spent in lateral recumbency in horses on wood shavings may affect their welfare and performance. The time budget of recumbency of the horses in this study was very similar to that described by other authors (Dallaire, 1986; Dallaire & Ruckebusch, 1974a, b; Keiper & Keenan, 1980). The fact that most recumbency occurred between midnight and early morning explains why some horse owners are convinced that their horse never lies down, as they have never seen it doing so.

Ruckebusch, 1970: lateral recumbency periods of 2-15 minutes, average of one latency period 4-5 minutes.

Duncan, 1980: Time-budgets of adult and weaned sub-adult horses were studied in a small population of Camargue horses living in semi-liberty. The categories of activities used were: Standing resting, Lying flat, Lying up, Standing alert, Walking, Trotting, Galloping, Rolling and Foraging. The main differences in time-budgets were related to age and to sex : young horses spent more time lying (sleeping), males spent more time standing alert and in rapid movements (trot, gallop), while usually foraging less than did the adult females. During the three years of the study the population increased from 20 to 54 horses and there were considerable changes in social structure as the number of adult males increased. Associated with these developments there were some changes between years in the time-budgets: the most striking of which was a general trend for all horses to spend less time lying. Nonetheless the time-budgets showed a considerable constancy across years and age/sex-classes, especially with regard to time spent foraging. This conclusion may provide a clue as to why horses have an unusual social system based on long term relationships between a male and the females of his harem.

Ruckebusch, 1975: ***Distraction and disturbance.*** Total sleep time was consistently increased during the weekend in all four species studied. This was mainly due to the occurrence of additional SWS and PS episodes during the daytime and coincided with reduced laboratory activity. This point is interesting because it is observed in animals well-adapted to laboratory conditions and which already show the high level or “luxury” form of sleep associated with a stalled environment. Furthermore, it indicates that the level recorded during the week is not the ceiling for total sleep time. ***Increased environmental pressure.*** Stalled horses tethered outside showed, as expected, a marked decrease from the “luxury” level of sleep. During the first 3 days, sleep duration was strongly decreased but subsequently a stable level of sleep was established. This was less than was observed outdoors and involved only a decrease in number of sleep episodes and not any change in their duration.
Horses assume recumbency only in wellknown surroundings and experience SWS whilst standing (Ruckebusch et al., 1970).

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TABLE I

Characteristics of behaviour and hypnogram of three ponies when stalled (inside) and when tethered outside (mean value ± SD from 20.00 h to 08.00 h)

	Inside	Outside	
		1st—3rd night	4th—30th night
Recumbency	238 ± 71	142 ± 77	174 ± 55
Drowsiness (% of waking time)	15 ± 3	11 ± 1	8 ± 2*
Total sleep time (min)	218 ± 26	101 ± 28	156 ± 28*
SWS			
Number of episodes	18 ± 3	14 ± 3	12 ± 3
Mean duration (min)	9.0 ± 1.8	7.8 ± 1.8	9.4 ± 2.5*
PS			
Total duration (min)	37 ± 3	10 ± 11	25 ± 3**
Mean duration (min)	4.8 ± 1.6	4.5 ± 2.1	4.5 ± 1.4

Data outside grouped (1st—30th night) are significantly different at $P < 0.01$ from those inside except for the mean duration of SWS and PS episodes.
*$P < 0.05$;
**$P < 0.01$ for comparisons between the initial 3 nights and the following 27 nights studied outside.

Ruckebusch, 1972:

Table I. Mean Values of Comparative Data of Sleep-Wakefulness States and Attitudes in Four Species of Farm Animals (Three Subjects of Each Species)

Species and time period	Duration and percentage					
	Wakefulness		Sleep		Attitude	
	AW	DR	SWS	PS	Standing	Recumbent
HORSE						
24-hr period	19hr 13min 80·8%	1hr 55min 8·0%	2hr 05min 8·7%	47min 3·3%	22hr 01min 91·8%	1hr 59min 8·2%
Night-time (10 hr)	5hr 14min 52·4%	1hr 54min 19·0%	2hr 05min 20·8%	47min 7·8%	8hr 01min 80·1%	1hr 59min 19·9%

Dallaire & Ruckebusch, 1974a: The mean length of a sleep epoch was 41.0 min although some periods of uninterrupted sleep were as long as 90 min. Total sleep was clearly distributed in two periods one occurring between 21:00-23:00 and the other between 02:00-04:00. On rare occasions (1-2%) sleep was observed at 12:00. Sleep cycle duration was calculated from the end of one PS period to the end of the next. Only cycles uninterrupted by awaking were used for compilations of data. The observed mean value was 13.5 rain. The amount of PS expressed as a percentage of total sleep time (TST) was about 25% and the mean length of a single period was 4 min (Table I).

TABLE 1

SLEEP PATTERN CHARACTERISTICS (MEAN ± SE) IN THE PONY FED ON HAY AD LIB (FROM 20:00 to 08:00)

Animals	Total sleep time (min) (TST)	PS/TST (%)	Length of SWS period (min)	Length of PS period (min)	Sleep cycle length (min)	Sleep epoch length (min)	Number of sleep epochs (per day)
A	178.5 ± 11.4	24.6	5.3 ± 0.51	3.6 ± 0.22	13.0 ± 1.3	33.7 ± 3.7	7
B	237.0 ± 2.6	22.3	7.7 ± 0.22	3.9 ± 0.40	13.9 ± 1.4	49.9 ± 4.5	5
C	193.9 ± 9.1	21.5	6.5 ± 0.50	4.6 ± 0.11	11.4 ± 1.1	35.9 ± 5.5	5
D	188.6 ± 29.6	27.9	6.4 ± 1.30	4.3 ± 0.45	15.6 ± 2.1	43.6 ± 4.4	5

Dallaire & Ruckebusch, 1974b: For several weeks, three ponies kept in an environment with controlled light and temperature, were studied for behaviour (time spent in recumbency and time required to consume hay or oats) and for electrical activity of the brain (cortical and sub-cortical) during the night phase of the circadian rhythm. Recumbency was adopted by all the ponies for six or seven periods during the night. With a regimen of hay ad libitum, about four hours were cumulated in sternal recumbency and only one hour in complete lateral recumbency. Various degree of sleep, as identified by cortical and hippocampal electrical activities, accounted for 30% of the circadian cycle. Paradoxical sleep was calculated to occur during 7% of the 24 hours. When oats were substituted for hay or during fasting for two to five days, the total recumbency time and the total sleep time (slow wave sleep and paradoxical sleep) increased. The time in lateral recumbency did not change.

Rose-Meierhöfer et al., 2010: Field studies have shown that the time adult horses spend recumbent is between 3% and 11% of the day, which equals 45 minutes to 2.5 hours (Duncan, 1980; Boyd et al., 1988). During these lying periods horses prefer a dry and soft ground (Zeitler-Feicht & Prantner, 2000; Fader & Sambraus, 2004). Systematic observation of lying behavior in horses is necessary to ensure that horses are able to perform normal sleeping behavior in individual and group housing systems (Raabymagle & Ladewig, 2006).

Werhahn et al., 2011: The observed total duration that the horses spent lying was almost exactly the same as that observed by Werhahn et al. (2010) for the riding horses in their group (between 2.5 and 3.0 hours). Similar results (between 2.5 and 3.5 hours spent lying) were shown by Kiley-Worthington (1990) in freeranging and stalled horses in different housing systems.

Werhahn et al., 2010: Because occupation is one of the important functions that bedding material is supposed to fulfill, we concluded that in regard to horse behavior, straw bedding was the best among the three materials analyzed.
Complex problems arise with the provision of physical and thermal comfort, since horses have been shown to exert bedding preferences in experimental situations which may be a risk to their physical health (Mills *et al.*, 2000). Mills *et al.* (2000) found that straw bedding was preferred over wood shavings and both of these were preferred to shredded paper. Whilst straw bedding is associated with fewer behaviours of welfare concern (McGreevy *et al.*, 1995a), it is also associated with an increased risk of respiratory disease.

Greening et al., 2012: Their results indicate that straw bedding facilitates the display of ingestive and sleep behaviors, whereas horses bedded on shavings spent a greater proportion of their nocturnal time budget engaged in "other" behaviors. The horses spent 12% of the night time (7-7) recumbent in the shavings condition, whereas the horses in the straw condition spent 29% of the night recumbent. Overall, horses bedded on straw spent, on average, 56.9% engaged in sleep behaviors compared with 49.2% for horses bedded on shavings.

Benhajali et al., 2008: Restriction of the behavioural repertoire involved an absence of maintenance behaviour such as lying down and rolling. Lying down has been observed from 0.4 to 5% of the time in wild and domestic conditions during the day (Boyd, 1988: ~0.4%). The absence of lying down and rolling might be due to bedding preferences of individual horses (Houpt, 2005; Hunter & Houpt, 1989). It has also been shown that horses do not perform this behaviour in stressful situations (Houpt, 2005), similar to sheep (Kim et al., 1994) and cattle (Raussi et al., 2005).

Mills et al., 2000: The preferences shown by eight Thoroughbred horses (6-16 years of age) for three commonly used bedding materials (paper, straw and shavings) were investigated. For each preference test two choices were presented in separate boxes joined by an unbedded corridor. Time spent in each compartment and associated behaviours were recorded over 6 h during the day and over 11 h at night. Despite a positional bias, horses clearly showed a preference for straw bedding (42.9%) over shavings (35.2%, $P<0.05$), straw (42.0%) over paper (29.3%, $P<0.05$) and shavings (41.6%) over paper (27.7%, $P<0.001$) based on percentage of observed time spent on the substrate. More bedding-related activities occurred in choices where straw was available ($P<0.001$) and in these choices the activities were preferentially expressed in the straw alternative ($P<0.001$). It is suggested that straw may be preferred as it allows the expression of a wider number of motivationally significant activities.

Dallaire 1986: Even during PS, which is the deepest sleep, the horse will be aroused easily by any strange noise and will stand up very quickly. Those familiar with horses know that they must be careful when approaching a recumbent subject to avoid any risk of being hurt while the animal stands up.

Ultradian rhythms

Murphy et al., 2009: This study determined the activity patterns of horses in their natural environment (Pasture) and under both a light/dark (LD) and constant dark (DD) stabled environment. In summary, mares display activity patterns that are weakly circadian and predominantly ultradian in nature.

Berger et al., 1999: Spectral analysis of activity and feeding in Przewalski horse showed a time pattern which was characterised by 24-h rhythmicity, but also by ultradian components with period lengths between 4.8 and 12 h, i.e., an activity pattern of up to five strong bouts per day.

Martin et al, 2010: Six healthy, untrained mares were studied to determine whether locomotor activity behavior and skeletal muscle gene expression reflect endogenous circadian regulation. Activity was recorded for three consecutive 48-h periods: as a group at pasture (P), and individually stabled under a light-dark (LD) cycle and in constant darkness (DD). The results revealed a predominantly ultradian (8.9 +- 0.7 bouts/24 h) and weakly circadian pattern of activity in all three conditions (P, LD, DD). A more robust circadian pattern was observed during LD and DD.

References

1. Aserinsky E, Kleitman N. (1953). Regularly occurring periods of eye motility, and concomitant phenomena, during sleep. Science;118:273-4.
2. Benhajali H, Richard-Yris M.-A., Leroux M., Ezzaouia M., Charfi F., Hausberger M. (2008). A note on the time budget and social behaviour of densely housed horses A case study in Arab breeding mares. Applied Animal Behaviour Science 112 196–200
3. Berger A., Scheibe K.-M., Eichhorn K., Scheibe A., Streich J. (1999). Diurnal and ultradian rhythms of behaviour in a mare group of Przewalski horse (*Equus ferus przewalskii*), measured through one year under semi-reserve conditions. Applied Animal Behaviour Science, 64, 1999, 1–17.
4. Boyd L.E., Carbonaro D.A., Houpt K.A. (1988). The 24-hour-time budget of przewalski horses Appl Anim Behav Sci, 21, pp. 5–17
5. Boyd, L.E., 1988. Time budgets of adult Przewalski horses: effects of sex, reproductive status and enclosure. Appl. Anim.Behav. Sci. 21, 19–39.
6. Crowell-Davis SL. (1994). Daytime rest behavior of the Welsh pony (*Equus caballus)* mare and foal. Appl Anim Behav Sci;40: 197-210.
7. Dallaire A. (1986). Rest behavior. Equine Pract; 2:591-607.
8. Dallaire, A. and Ruckebusch, Y. (1974a). Sleep patterns in the pony with observations on partial perceptual deprivation. Physiol. Behav., 12: 789-796.
9. Dallaire, A. and Ruckebusch, Y. (1974b). Sleep and wakefulness in the housed pony under different dietary conditions. Can. J. Comp. Med., 38: 65-71.
10. Dement W. (1960). The effect of dream deprivation. Science;131: 1705-7.
11. Duncan P. (1980). Time-budgets of Camargue horses: II. Time-budgets of adult horses and weaned sub-adults. Behaviour;72:26-49.
12. Fader C., Sambraus H.H. (2004). Das Ruheverhalten von Pferden in Offenlaufställen [The resting behaviour of horses in loose housing systems] Tieraerztl Umschau, 59, pp. 320–327
13. Greening, L., Shenton, V., Wilcockson, K., Swanson, J. (2012). Investigating duration of nocturnal ingestive and sleep behaviors of horses bedded on straw versus shavings Journal of Veterinary Behavior: Clinical Applications and Research, Available online 6 October 2012.
14. Hale LA, Huggins SE. (1980). The electroencephalogram of the normal “grade” pony in sleep and wakefulness. Comp Biochem Physiol;66:251-7.
15. Houpt, K.A. (2005). Maintenance Behaviours. The Domestic Horse; the Evolution, Development and Management of its Behaviour (ed. Mills & McDonnell). Cambridge University Press, pp. 94–108.
16. Hunter, L., & Houpt, K.A. (1989). Bedding material preferences of ponies. Journal of Animal Science, 67: 1986-91.
17. Jouvet M, Michel F, Courjon J. (1959). Sur un stade d´activité électrique cérébrale rapide au cours du sommeil physiologique. Compt Rend Seán Soc Biol Filiales;153:1024-8.
18. Jouvet M. (1967). Neurophysiology of the states of sleep. Physiol Rev;47:117-77.
19. Keiper RR, & Keenan MA. (1980). Nocturnal activity patterns of feral ponies. J Mammal;61:116-8.
20. Kiley-Worthington M. (1990). The behavior of horses in relation to management and training: towards ethologically sound environments. J Equine Vet Sci (USA);10:62-71.
21. Kim, F.B., Jackson, R.E., Gordon, G.D.H., Cockram, M.S., (1994). Resting behaviour of sheep in a slaughterhouse lairage. Appl. Anim. Behav. Sci. 40, 45–54.
22. Martin, A., Elliott, J.A., Duffy, P., Blake, C.M., Attia, S.B., Katz, L.M., Browne, J.A., Gath, V., McGivney, B.A., Hill, E.W., Murphy, B.A. (2010). Circadian regulation of locomotor activity and skeletal muscle gene expression inthe horse. J Appl Physiol 109: 1328–1336
23. McGreevy, P.D., Cripps, P.J., French, N.P., Green, L.E. and Nicol, C.J. (1995a). Management factors associated with stereotypic and redirected behaviour in the Thoroughbred horse. Equine Veterinary J. 27, 86–91.
24. Mills, D.S., Eckley, S. and Cooper, J.J. (2000). Thoroughbred bedding preferences, associated behaviour differences and their implications for equine welfare. *Animal Science* **70**, 95–106.

25. Murphy B. A., Martin A., Elliott J. A. (2009). Equine activity rhythms exhibit circadian and ultradian characteristics under different environmental conditions. Proc Physiol Soc 15, C7, Oral Communications.
26. Pedersen, G.R., Søndergaard, E., Ladewig, J. (2004). The influence of bedding on the time horses spend recumbent. Journal of Equine Veterinary Science, Volume 24, Issue 4, 153–158.
27. Raabymagle, P., & Ladewig, J. (2006). Lying behavior in horses in relation to box size. Journal of Equine Veterinary Science, Volume 26, Issue 1, Pages 11–17
28. Raussi, S., Boissy, A., Delval, E., Pradel, P., Kaihilahti, J., Veissier, I. (2005). Does repeated regrouping alter the social behaviour of heifers? Appl. Anim. Behav. Sci. 93, 1–12.
29. Ruckebusch Y. (1970). Un problème controversé: La perte de vigilance chez le cheval et la vache au cours de sommeil. Cahiers Méd Vét (Paris),39:210-25.
30. Ruckebusch Y. (1972). The relevance of drowsiness in the circadian cycle of farm animals. Anim Behav;20:637-43.
31. Ruckebusch Y. (1975). The hypnogram as an index of adaptation of farm animals to changes in their environment. Appl Anim Ethol; 2:3-18.
32. Ruckebusch Y., Barbey P, Guillemot P. (1970). Les états de sommeil chez le Cheval (*Equus caballus*). *Compt Rend Seán Soc Biol Filiales (Paris)*;164:658-65.
33. Steinhart, P. (1937). Der Schlaf des Pferdes, seine Dauer, Tiefe, Bedingungen. Z. Vetkde, 49: 145-232.
34. Werhahn, H., Hessel, E.F., Bachhausen, I., & Van den Weghe, H.F.A. (2010). Effects of Different Bedding Materials on the Behavior of Horses Housed in Single Stalls Journal of Equine Veterinary Science, Volume 30, Issue 8, 425–431.
35. Werhahn, H., Hessel, E.F., Schulze, H., Van den Weghe, H.F.A. (2011). Temporary Turnout for Free Exercise in Groups: Effects on the Behavior of Competition Horses Housed in Single Stalls. Journal of Equine Veterinary Science, Volume 31, Issue 7, 417–425
36. Zeitler-Feicht P., Prantner V. (2000). Liegeverhalten von Pferden in Gruppenauslaufhaltung [Lying behavior of horses in group discharge husbandry] Arch Tierz Dummerstorf, 43, pp. 327–335