

## The 24-Hour Time Budget of Przewalski Horses

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### ABSTRACT

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A herd of 8 Przewalski horses were observed on pasture in summer. Fifteen-minute focal animal samples were used to determine the time budget of the horses during the periods 00.00-04.00, 04.00-08.00, 08.00-12.00, 12.00-16.00, 16.00-20.00 and 20.00-24.00 h EDT. The behavioral states recorded were feeding (grazing and eating grain), nursing, drinking, standing, stand-resting, self-grooming, mutual grooming, locomoting, playing, and lying laterally and sternally. The average number of behavioral states occurring per hour, and the defecation, urination, aggression and vocalization rates were also determined.

Overall, the horses spent  $46.4 \pm 5.9\%$  of their time feeding,  $1.3 \pm 0.1\%$  nursing,  $0.5 \pm 0.1\%$  drinking,  $20.6 \pm 5.4\%$  standing,  $15.7 \pm 3.2\%$  stand-resting,  $1.7 \pm 0.2\%$  self-grooming,  $2.2 \pm 0.7\%$  mutual grooming,  $7.4 \pm 1.0\%$  locomoting,  $1.2 \pm 0.3\%$  playing,  $1.2 \pm 0.5\%$  lying laterally and  $4.1 \pm 3.0\%$  lying sternally. The horses averaged  $45.2 \pm 5.8$  behavioral states per hour, and  $0.2 \pm 0.0$  defecations,  $0.3 \pm 0.0$  urinations,  $1.5 \pm 0.3$  aggressions and  $0.7 \pm 0.1$  vocalizations per hour. The horses spent the greatest amount of time foraging between 20.00 and 04.00 h, when the temperatures were lower. They spent  $68.2 \pm 2.2\%$  of their time between 20.00 and 24.00 h feeding, but only  $31.2 \pm 2.1\%$  of their time feeding between 08.00 and 12.00 h. Recumbent rest was most common between 00.00 and 04.00 h. As temperatures rose during the daylight hours, the horses spent more time drinking and standing, rather than grazing. Stand-resting was the most common form of rest during the day. The horses exhibited the greatest number of activities per hour from 08.00 to 20.00 h. While standing in close proximity to one another during these hours, the horses exhibited the highest number of aggressions per hour (1.9-2.4).

### INTRODUCTION

The Przewalski horse (*Equus przewalskii*) is an endangered species. The world population of 660 animals exists wholly in zoos (Wolf, 1986). The closest living relatives of Przewalski horses are domestic and feral horses (*E. caballus*) (Benirschke et al., 1965; Ryder et al., 1978). Little is known about the behavior of Przewalski horses in their native Mongolian habitat, except that they had a harem social organization similar to that of domestic and feral horses (Mohr,

1971). This study was undertaken to compare the 24-h time budgets of captive Przewalski horses with time budgets reported in the literature from previous studies of both domestic and Przewalski horses.

Diurnal studies of the time budgets of domestic horses on pasture, and of free-ranging feral horses, have been conducted by Schoen et al. (1976), Salter and Hudson (1979), Crowell-Davis (1983), Kaseda (1983) and Rifa (1985). However, only Misaki horses (Kaseda, 1983), Assateague Island ponies (Keiper et al., 1980; Keiper and Keenan, 1980), Camargue horses (Boy and Duncan, 1979; Duncan, 1980, 1985) and Polish primitive horses (Kownacki et al., 1978) have been studied for a 24-h time period. Of these studies, only the results from the Assateague Island ponies were analyzed by time of day. The Assateague Island ponies' time budgets were found to vary with the time of day. For this reason we decided to study the 24-h time budget of Przewalski horses.

Two previous studies of the 24-h time budget of Przewalski horses have been conducted. Bubenik (1961) observed a total of 12 animals in 2 herds at the Prague Zoo. Each herd was studied for 3 consecutive days. Griffiths (1985) studied a herd of 5 Przewalski horses at the Denver Zoo for 3 months. During this time nocturnal observations of 4 horses were made on 13 nights. Results from Bubenik's and Griffiths' studies were presented by time of day. A third study of 8-12 Przewalski horses at the Bronx Zoo was conducted during a 2-month period, and an overall time budget for the hours between 08.00 and 17.00 Eastern Daylight Time (EDT) was reported (Popolow, 1984). The herds in all three of the above studies occupied grass-less enclosures that were less than 0.4 ha in size (Volf, 1975; Griffiths, 1985; Rosenthal, 1986). This is the first study to investigate the 24-h time budgets of Przewalski horses in a large grassy pasture.

## METHODS

A herd of Przewalski horses at the National Zoological Park's Conservation and Research Center in Front Royal, Virginia, was studied. This group was chosen because it was the largest herd in the U.S.A. that was housed on pasture, and the animals were quite habituated to human contact, which greatly facilitated night observations. The herd was observed from 12 June to 13 August 1984 and from 6 June to 6 August 1985. In 1984, the herd consisted of a 2-year-old stallion (1065 Bektair<sup>1</sup>), two 3-year-old mares (948 Tasha, 952 Misha), two 2-year-old mares (1028 Marge, 1035 Tracy), 2 yearling mares (1125 Tara, 1155 Misty), and one filly born on 27 May 1984 (1240 Nicola). The horses were housed in a grassy 4-ha pasture. In 1985 the same individuals were present, and they were housed in a 12-ha pasture adjacent to their former location. In both pastures the horses had free access to a barn, automatic water

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<sup>1</sup>Studbook number and house name.

dispensers and salt blocks. Twenty-three kg of Purina Herbivore Zoo Chow, a cubed complete diet, was provided to the herd once daily in a hayrack outside the barn, usually between 08.00 and 12.00 h EDT. The 3 youngest females were the offspring of the 2 oldest mares, and they were suckling in both 1984 and 1985 (Tasha nursed both Tara and Nicola). In contrast to most other Przewalski horses, these animals were not on exhibit. Except for the presence of the observer, they received less than 1 h of human contact a day. Human contact occurred primarily during presentation of their feed, occasional pasture mowing, and restraint for hoof-trimming and immunizations.

Fifteen-minute focal-animal samples were used to collect the data (Altmann, 1974). The next focal animal to be observed was drawn randomly without replacement from the list of herd members until all members of the herd had been observed. This sampling process was then repeated. The horses were habituated to the presence of an observer, and it was possible to approach within 5 m, although observations were usually conducted from a distance of 20 m to avoid influencing the horses' behavior. Two observers collected the data. One observer collected most of the 1984 data, while the other observer collected some of the 1984 data and all of the 1985 data. Both observers used the same protocol, and 1.5 h of inter-observer accuracy tests where both observers scored the same horse for 15 min showed an 80% agreement on behaviors and an agreement of transition times between behaviors of 3.6 s. The discrepancies arose when a behavior of long duration, such as grazing, was interrupted by another behavior of a few seconds duration. One observer might record this as 2 bouts of grazing, while the other ignored the short interruption and considered all to be one bout. Such discrepancies would have little effect on the calculations of total time spent in each behavior.

The day was divided into 6 periods: 00.00–04.00; 04.00–08.00; 08.00–12.00; 12.00–16.00; 16.00–20.00; 20.00–24.00 h EDT. These intervals were chosen as they were large enough to allow all 8 members of the herd to be observed once within an interval. Also, since sunrise occurred at approximately 05.30 h and sunset at 20.00 h, these intervals divided the day into 2 night observation periods, 2 midday observation periods, and an early morning and a late afternoon period. Night observations were facilitated by use of a headlamp.

Since horses could be followed closely, they rarely went out of sight. In the event that a focal animal disappeared from view for more than 30 s, the sample was discarded. If the animal disappeared for less than 30 s it was assumed to be continuing the behavior that was occurring when it disappeared (Lehner, 1979). Ten mutually exclusive behavior states were recorded. These were feeding, nursing, drinking, self-grooming, mutual grooming, standing, locomoting, playing, lying sternally and lying laterally. In 1985, a distinction was made between standing awake and standing resting. Reproductive behavior, such as courting and mounting, was rare, but was also noted. Defecations, urinations, aggressions and vocalizations were treated as events because of their short

duration, and were also recorded. All behaviors were recorded directly onto data sheets. At the end of each 15-min observation, the ambient temperature was recorded from a thermometer, since temperature has been shown to affect the time budget of domestic horses (Crowell-Davis, 1983). One hundred and twelve hours of focal-animal observations were made in 1984, and 95.75 h were collected in 1985.

Average temperatures were calculated for each of the 6 time intervals of the day. The percentage of time spent in each of the behavior states was calculated for each horse in each of the 6 time intervals. The number of transitions between behavior states was calculated on a per hour basis for each horse in each interval to give an index of the level of activity. A very active horse might be expected to have a high number of transitions per hour. (Theoretically, a horse might walk during the entire observation and so be very active, but have few transitions per hour. This was rare, however, as the duration of the observation (15 min) was long in relation to the duration of most behaviors). Similarly, an individual's frequency of being involved in aggression (either initiating or receiving it), and number of vocalizations, were calculated on a per hour basis in each interval. Each of the behavior states, as well as defecations per hour, urinations per hour, transitions per hour, aggressions per hour and vocalizations per hour, were examined by use of the Kruskal–Wallis test to discover whether there were any time-of-day effects.

If homogeneity was not found, multiple comparisons were used to determine which time intervals differed (Conover, 1980). Values for all 8 individuals for all behaviors were then averaged to obtain a mean time budget for the herd in each of the 6 time intervals of the day. The time budgets from these 6 intervals were then averaged to produce an overall 24-h time budget for purposes of comparison with other studies where the data were not presented by time of day.

## RESULTS

Table 1 gives the average time budget of the herd for each of the 6 intervals of the day. The Kruskal–Wallis test indicated homogeneity throughout the day in the distribution functions of the percentage time spent nursing, self-grooming and lying laterally (all  $P > 0.05$ ). The number of urinations and vocalizations per hour were also uniformly distributed throughout the day ( $P > 0.05$ ). All other behaviors showed time-of-day effects. Percentage of time spent feeding and lying sternally were higher at night than during the day (Fig. 1). Eating grain accounted for 13.3% of all feeding behavior observed; the rest of the time horses were grazing or browsing. The lowest percentage of feeding time spent eating grain was 1% between 00.00 and 04.00 h with a high of 39% of the foraging time spent eating grain between 08.00 and 12.00 h, when the manger was refilled.

TABLE 1

Time budget of Przewalski horses by time of day<sup>1</sup>

	EDT						Overall
	00.00-04.00	04.00-08.00	08.00-12.00	12.00-16.00	16.00-20.00	20.00-24.00	
Observation time (h)	20.25	24.25	51.00	52.50	32.00	26.50	206.50
Mean percentage time spent							
Feeding	60.3 <sup>a</sup> (5.2)	40.1 <sup>b</sup> (3.4)	31.2 <sup>c</sup> (2.1)	38.2 <sup>bcd</sup> (3.2)	40.6 <sup>bd</sup> (2.4)	68.2 <sup>a</sup> (2.2)	46.4 (5.9)
Nursing	1.1 <sup>a</sup> (0.5)	0.9 <sup>a</sup> (0.5)	1.4 <sup>a</sup> (0.3)	1.2 <sup>a</sup> (0.5)	1.8 <sup>a</sup> (0.6)	1.3 <sup>a</sup> (0.6)	1.3 (0.1)
Drinking	0.06 <sup>a</sup> (0.04)	0.13 <sup>a</sup> (0.06)	0.76 <sup>bc</sup> (0.26)	0.67 <sup>bc</sup> (0.15)	0.81 <sup>b</sup> (0.18)	0.36 <sup>c</sup> (0.10)	0.47 (0.13)
Standing (both years)	9.9 <sup>a</sup> (2.1)	44.5 <sup>b</sup> (3.4)	50.8 <sup>b</sup> (3.5)	43.9 <sup>b</sup> (2.1)	43.8 <sup>b</sup> (3.0)	10.3 <sup>a</sup> (2.2)	33.9 (7.6)
Standing awake (1985)	2.3 <sup>a</sup> (0.9)	33.4 <sup>b</sup> (2.7)	32.5 <sup>b</sup> (3.4)	24.5 <sup>c</sup> (1.9)	24.6 <sup>c</sup> (2.3)	6.42 <sup>c</sup> (1.7)	20.6 (5.4)
Stand-resting (1985)	8.9 <sup>ac</sup> (3.8)	19.4 <sup>ab</sup> (5.4)	18.1 <sup>ab</sup> (3.6)	25.0 <sup>b</sup> (2.2)	19.4 <sup>ab</sup> (3.8)	3.5 <sup>c</sup> (2.4)	15.7 (3.2)
Self-groom	0.9 <sup>a</sup> (0.2)	1.8 <sup>a</sup> (0.4)	1.3 <sup>a</sup> (0.1)	1.8 <sup>a</sup> (0.5)	2.1 <sup>a</sup> (0.8)	2.1 <sup>a</sup> (0.4)	1.7 (0.2)
Mutual groom	0.5 <sup>a</sup> (0.2)	2.5 <sup>bd</sup> (0.4)	1.1 <sup>a</sup> (0.4)	2.4 <sup>bd</sup> (0.6)	1.3 <sup>ac</sup> (0.4)	5.1 <sup>d</sup> (0.9)	2.2 (0.7)
Locomotion	3.6 <sup>a</sup> (0.9)	6.5 <sup>ac</sup> (1.3)	10.1 <sup>b</sup> (1.3)	9.3 <sup>b</sup> (0.7)	8.6 <sup>bc</sup> (0.7)	6.4 <sup>c</sup> (0.9)	7.4 (1.0)
Play	0.0 <sup>a</sup> (0.0)	1.3 <sup>b</sup> (0.9)	2.3 <sup>c</sup> (0.7)	1.4 <sup>bc</sup> (0.6)	1.4 <sup>bc</sup> (0.4)	0.6 <sup>bc</sup> (0.3)	1.2 (0.3)
Lie lateral	3.2 <sup>a</sup> (2.0)	0.3 <sup>a</sup> (0.3)	0.8 <sup>a</sup> (0.5)	1.0 <sup>a</sup> (0.5)	0.0 <sup>a</sup> (0.0)	1.9 <sup>a</sup> (1.0)	1.2 (0.5)
Lie sternal	19.2 <sup>a</sup> (4.3)	1.5 <sup>bc</sup> (1.5)	0.3 <sup>bc</sup> (0.9)	0.5 <sup>bd</sup> (0.1)	0.1 <sup>c</sup> (0.1)	3.3 <sup>d</sup> (1.0)	4.1 (3.0)
Mean trans. h <sup>-1</sup>	20.1 <sup>a</sup> (3.1)	45.1 <sup>b</sup> (3.0)	52.9 <sup>c</sup> (2.1)	56.3 <sup>c</sup> (2.7)	57.9 <sup>c</sup> (3.2)	39.1 <sup>b</sup> (3.2)	45.2 (5.8)
Mean def. h <sup>-1</sup>	0.05 <sup>ac</sup> (0.05)	0.25 <sup>abc</sup> (0.13)	0.24 <sup>b</sup> (0.03)	0.06 <sup>c</sup> (0.03)	0.28 <sup>b</sup> (0.07)	0.08 <sup>abc</sup> (0.05)	0.16 (0.03)
Mean urin. h <sup>-1</sup>	0.52 <sup>a</sup> (0.15)	0.24 <sup>a</sup> (0.11)	0.23 <sup>a</sup> (0.06)	0.31 <sup>a</sup> (0.10)	0.32 <sup>a</sup> (0.10)	0.35 <sup>a</sup> (0.12)	0.33 (0.04)
Mean aggress. h <sup>-1</sup>	0.4 <sup>a</sup> (0.2)	1.4 <sup>bcd</sup> (0.5)	1.9 <sup>bcd</sup> (0.3)	2.4 <sup>c</sup> (0.4)	2.2 <sup>bc</sup> (0.8)	0.8 <sup>ac</sup> (0.8)	1.5 (0.3)
Mean vocal. h <sup>-1</sup>	0.9 <sup>a</sup> (0.3)	0.3 <sup>a</sup> (0.2)	0.6 <sup>a</sup> (0.2)	0.9 <sup>a</sup> (0.2)	0.6 <sup>a</sup> (0.2)	0.7 <sup>a</sup> (0.1)	0.7 (0.1)

<sup>1</sup>Values given are means for 8 horses, except for nursing where  $n=5$ . Numbers in parentheses are the standard error of the mean. (Reproductive behavior was too rare to compare.) Values within the same row which share a superscript letter are not significantly different from one another ( $P>0.05$ ).

Most reproductive behavior occurred at dawn (04.00–08.00 h). Standing, and standing awake and standing resting in 1985 were higher during daylight hours, as were locomotion, play, transitions per hour (Fig. 2) and aggressions per hour. Most drinking occurred during the midday and early evening hours.

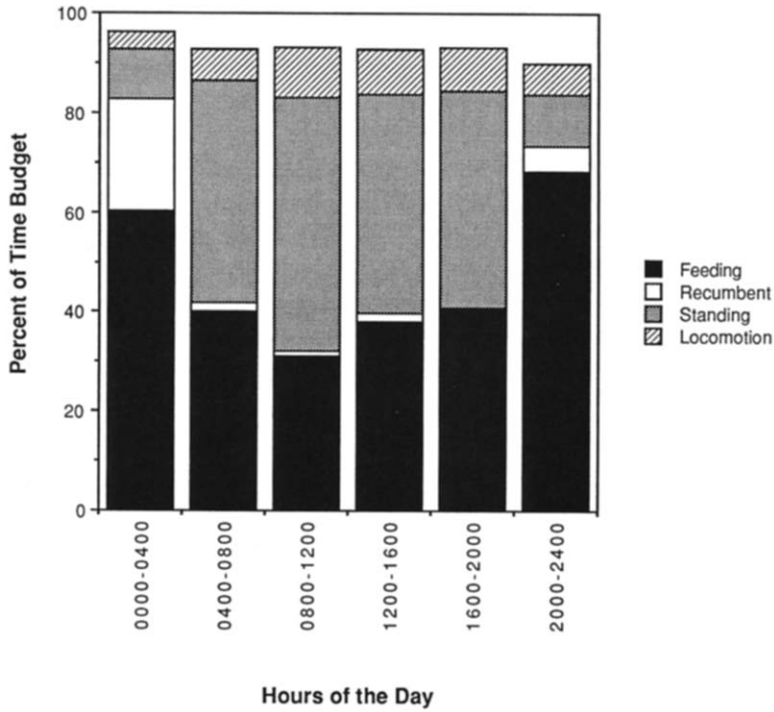


Fig. 1. Percentage of time spent in 4 behaviors throughout the day. The value presented for each behavior at each time of day is the mean of data from 8 Przewalski horses in one herd.

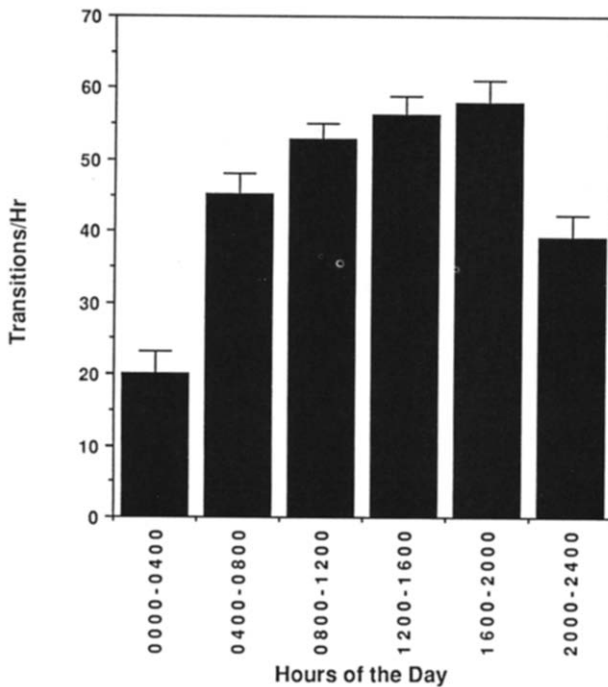


Fig. 2. The number of behavioral states per hour by time of day. The values presented are the mean of 8 horses. Standard error of the mean is indicated by the vertical bar.

Percentage of time spent mutual grooming and defecations per hour varied in a cyclical pattern throughout the day, with several peaks of activity.

The mean temperature for the 6 time intervals were as follows: 00.00–04.00 h EDT,  $19.1 \pm 0.3^\circ\text{C}$ ; 04.00–08.00 h,  $17.8 \pm 0.3^\circ\text{C}$ ; 08.00–12.00 h,  $23.8 \pm 0.3^\circ\text{C}$ ; 12.00–16.00 h,  $28.0 \pm 0.3^\circ\text{C}$ ; 16.00–20.00 h,  $25.1 \pm 0.5^\circ\text{C}$ ; 20.00–24.00 h,  $21.0 \pm 0.3^\circ\text{C}$ .

## DISCUSSION

The Przewalski horses at Front Royal spent 46% of their time feeding. There may be several reasons why the Front Royal Przewalski horses spent less time feeding than other populations studied (Table 2). For most of the Front Royal observations, the mares were in late lactation (nursing 1- and 2-year-old offspring), and none of them were pregnant, thus their energy requirements would be lower than those of the pregnant and lactating mares in the studies by Houpt et al. (1986), Crowell-Davis et al. (1985), Griffiths (1985), Popolow (1984) and the feral horse studies. The Front Royal herd also contained juvenile animals, and juvenile horses typically spend less time feeding than adults (Dun-

TABLE 2

Summary of time-budget literature for most commonly measured behaviors

Source	Season <sup>1</sup>	Time of day <sup>2</sup>	Time spent <sup>3</sup> (%)						
			Feed	Drink	Stand	Stand awake	Stand rest	Self-groom	Locomote
Domestic horses									
Sweeting et al. (1985)	—	D	70	2	18	11	7	1	3*
Crowell-Davis (1983)	Sp,Su	D	70	—	—	—	—	—	—
Houpt et al. (1986)	Su	N	62	—	28	—	—	—	4*
Sufit et al. (1985)	—	24	—	2	—	—	—	—	—
Duncan (1980)	Su	24	57	—	28	10	18	—	10
Kownacki et al. (1978)	Yr	24	70	—	23	—	—	—	4
Feral horses									
Salter and Hudson (1979)	Yr	D	75	—	—	—	—	—	—
Rifa (1985)	Yr	D	75	0.3	—	—	—	2	8**
Keiper and Keenan (1980)	Su	N	—	0.1	—	—	—	—	—
Kaseda (1983)	Yr	24	74	—	—	—	—	—	—
Przewalski horses									
Skiff (1982)	Su	D	63	—	—	—	—	—	—
Popolow (1984)	Su	D	55	0.7	25	—	—	2	13
Griffitts (1985)	Su	D	65	—	22	—	—	—	7
Griffitts (1985)	Su	N	36	—	51	—	—	—	2

<sup>1</sup>Spring (Sp); Summer (Su); Year-round (Yr).

<sup>2</sup>Day (D); Night (N); 24-h observations (24).

<sup>3</sup>Where a range was given, the median is presented.

\*Walking only; \*\*walking and trotting only.

can, 1980; Popolow, 1984; Griffiths, 1985). Additionally, the Front Royal herd was receiving 23 kg of complete cubed feed a day (approximately 3 kg per horse), which is twice the amount fed by most zoos that exhibit Przewalski horses. Although weights of the Front Royal horses were not available, the horses appeared to be in excellent condition. All animals were given the highest body condition score under Pollock's (1980) rating system. The horses may have received enough of their energy requirement in concentrated form so as to reduce their total foraging time. Willard et al. (1977) found that stabled horses fed concentrates spent less time eating and more time standing than horses fed hay.

The Front Royal horses usually received their concentrates between 08.00 and 12.00 h. However, this was the time of day when the lowest amount of feeding behavior was observed. The highest percentage of time spent feeding occurred at night when the temperature was lower. Over 60% of the time between 20.00 and 04.00 h was spent foraging; primarily by grazing. Time spent feeding declined to a low during the hottest hours of the day. The percentage time spent foraging in summer is also highest at night for Assateague Island ponies (Keiper and Keenan, 1980). Kaseda (1983) noted that Misaki feral horses grazed predominately from sunset to midnight as the temperature fell from the midday high, and another peak of grazing occurred at dawn. Bubenik (1961) found feeding peaks at 18.00 and 04.00 h during the summer in Przewalski horses fed ad libitum. Most of these time-budget studies have been conducted during the summer (Table 2), and the amount of time spent foraging and its distribution throughout the day may be different at other times of the year. For instance, Kaseda (1983) found much more diurnal grazing by Misaki horses in winter than in summer. During the summer, Rubenstein (1981) observed a decrease in percentage time spent feeding by Shackleford Island ponies during the midday hours, but this midday decrease did not occur in winter. Nutrient requirements of horses are probably higher in winter to support the higher metabolic rates needed to maintain core body temperature, necessitating more time spent foraging. During hot summer days the horses conserve energy by resting until it becomes cool enough for them to become active and graze without incurring thermal stress (Berger, 1986). The provision of concentrates during the day probably facilitates this summer pattern by permitting horses to obtain more calories per unit time with less effort than when grazing, so the horses can afford to rest until it becomes cooler.

In this study, the lactating Przewalski horses and their offspring spent 1% of their time nursing. The time that a juvenile horse spends suckling decreases with age. Rifa (1985) found that Asturcon foals spent 6% of their time suckling, as opposed to 1% for yearlings. The data in the present study were obtained largely from yearling and 2-year-old animals, and were consistent with



Rifa's results from yearlings. No variations in percentage of time spent nursing were evident over the course of a day, as was also the case for the Przewalski horses at the Prague Zoo (Bubenik, 1961).

The Przewalski horses at Front Royal spent 0.5% of their time drinking. The amount of time spent drinking during the hottest part of the day was 6 times greater than during the early morning hours. In a study of Welsh pony mares and foals, Crowell-Davis et al. (1985) found fewer drinking bouts in the early morning hours, and a positive correlation between the number of drinking bouts and temperature. During the 1985 observations of the Front Royal Przewalski horses, the observer was aspirating the mares' urine off the ground as part of a study of ovarian activity. It was noted that the urination sites were far more difficult to locate between 00.00 and 06.00 h because of the presence of dew on the grass. This dew may have been an important source of water for the horses while grazing, and may explain why so little drinking was seen during these hours.

The Front Royal Przewalski horses spent 34% of their time standing. The highest percentage of time spent standing occurred during the daylight hours, when the temperature was higher and grazing time declined. When standing resting and standing awake were considered separately in 1985, both were highest during the daylight hours. The Front Royal horses average 16% of their time standing resting and 21% standing awake. Tyler (1972) found that New Forest ponies spent the majority of the time between 09.00 and 14.00 h resting during the summer.

The Przewalski horses at Front Royal spent nearly 2% of their time self-grooming. Popolow (1984) reported that a similar amount of time was spent self-grooming in a daytime study of Przewalski horses at the Bronx Zoo, and Rifa (1985) reported similar values in a daytime study of Asturcon feral ponies. Feral ponies on Assateague Island spent only 0.5% of their time grooming themselves, but like the Front Royal Przewalski horses, the time spent self-grooming was relatively constant throughout the night (Keiper and Keenan, 1980).

The Front Royal Przewalski horses spent 2% of their time mutual grooming. There was a cyclical pattern of mutual grooming, with peaks at 04.00–08.00, 12.00–16.00 and 20.00–24.00 h. Polish primitive horses groomed most frequently between 06.00 and 09.00 and between 12.00 and 18.00 h (Kownacki et al., 1978). The midday peak occurs during the hottest part of the day when the horses are not occupied with foraging and are resting standing near one another, creating opportunities for mutual grooming. The early morning and evening peak mutual grooming times are characterized by lower temperatures, and the horses are more active than in the intervening 00.00–04.00 h time-interval when recumbent rest is common. During their summertime study of Assateague Island ponies, Keiper and Keenan (1980) also found a peak of mutual grooming from 19.00 to 23.00 h, and an increase again at 04.00 h.

Locomotion took up 7% of the time budget of Front Royal Przewalski horses.

More time was spent in motion during the daylight hours than at night. Similarly, the Przewalski horses at the Denver Zoo spent 7% of their time locomoting during the day, but only 2% of their time locomoting at night (Griffitts, 1985). Assateague Island ponies also spent more time in motion during the day than at night (Keiper et al., 1980; Keiper and Keenan, 1980). During the night the Front Royal horses were usually feeding or in recumbent rest, so little time was spent walking other than as part of foraging.

The Front Royal Przewalski horses spent 1% of their time in play. Adult Przewalski mares at the Bronx Zoo spent 0.2% of their time in play, while foals spent 1.5% of their time in this way (Popolow, 1984). Rifa (1985) observed no play in adult Asturcon ponies, while foals spent 0.6% of their time in play. The Front Royal herd is very young; the oldest horses were 4 years old in the last year of the study, and this may explain the relatively high amount of time spent in play. Most play occurred during daylight hours. Schoen et al. (1976) found foal play bouts to be most frequent between 06.00 and 08.00 h, whereas in this study the peak of playing occurred between 08.00 and 12.00 h.

Duncan (1980) found that adult Camargue mares spent 0.2–1.0% of their time lying laterally in the summer, and 1.0–6.0% of their time lying sternally. Rifa (1985) found that adult and juvenile Asturcon ponies spent 0.05–2.4% of their time lying laterally and 1.8–4.6% of their time lying sternally. Polish primitive mares spent 3.6% of their time lying down (Kownacki et al., 1978). The Front Royal Przewalski horses spent 2% of their time lying laterally and 4% lying sternally. Sternal recumbency was most common from 00.00 to 04.00 h, when it occupied 19% of the animals' time. Percentage time spent lying laterally also tended to be highest from 00.00 to 04.00 h, although statistically the time spent lying laterally was homogeneous throughout the day. Assateague Island ponies also showed a peak of recumbency between 00.00 and 04.00 h (Keiper and Keenan, 1980). Przewalski horses at the Prague Zoo also showed a peak in sleeping behavior between 00.00 and 06.00 h (Bubenik, 1961). Sternal recumbency seems to be more frequent than lateral recumbency, perhaps so that the horse can rise more quickly in response to danger.

No time-of-day differences in amount of time spent defecating were noted for the Przewalski horses at the Prague Zoo (Bubenik, 1961). The Front Royal horses showed two peaks in defecation rate. One peak occurred from 08.00 to 12.00 h, and since the horses received their concentrates during this time, this peak may be the result of the gastrocolic reflex. The second peak occurred from 16.00 to 20.00 h, which was 16–20 h after the peak of feeding behavior. Since Orton et al. (1985) found the highest rate of excretion of fluid and particulate digesta markers 16–20 h after the infusion of the marker into the horses' stomachs, it is likely that the second peak in time spent defecating by the Przewalski horses corresponds to the arrival in the rectum of material from the previous night's foraging.

These Przewalski horses urinated every 3 h on average. No difference in

urination rate was seen across the day; as was also true for Przewalski horses in the Prague Zoo (Bubenik, 1961).

Very little reproductive behavior was seen in the Front Royal herd. This is probably due to the immaturity of the stallion. The main reproductive behaviors observed were proceptive behavior, courting and mounting, and these occurred predominately at dawn (04.00–08.00 h). No reproductive behavior was seen from 16.00 to 04.00 h.

Transitions per hour were lowest from 00.00 to 04.00 h, indicating that the horses were spending this time in fewer behaviors of longer duration, such as foraging and recumbent rest. From 04.00 to 08.00 h the number of activities doubled, and continued to increase until 20.00 h, after which the number of transitions returned to pre-dawn levels. The number of aggressions per hour followed a similar pattern. Aggression rates were highest when the horses were standing near one another while resting in the midday heat. Overall, the horses averaged 1.5 aggressions per horse per hour, which is within the range reported for other Przewalski and domestic horses. The Bronx Przewalski horses averaged 0.6–2.0 aggressions per horse-hour (Popolow, 1984). Assateague Island ponies were found to have 0.2–0.7 aggressions per horse-hour (Haupt and Keiper, 1982), while Highland ponies exhibited 1.9 aggressions per horse-hour (Clutton-Brock et al., 1976).

The Front Royal Przewalski horses vocalized an average of 0.7 times per hour. The distribution of vocalizations was homogeneous over the course of a 24-h period.

In summary, the Przewalski horses on pasture in summer spent the highest amount of time foraging at night when the temperature was lower. Recumbent rest was also most common at night. As temperatures rose during the daylight hours, the horses spent more time drinking and standing, rather than grazing. While standing in close proximity at midday the horses interacted by mutual grooming and aggression against one another.

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