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Nursing and feeding behaviour of confined red deer (*Cervus elaphus scoticus*) in the Mexican highlands*

C. G. VÁSQUEZ[1]
L. OLVERA[2]
Y. SIQUEIROS[3]
M. L. KURI[2]
V. A. NAVARRO[2]
A. E. ROVELO[2]
A. SHIMADA[4,5]

[1]Coordinación de la Investigación Científica
Facultad de Medicina Veterinaria y Zootecnia
Universidad Nacional Autónoma de México
Ciudad Universitaria, D.F., México

[2]Student
Facultad de Ciencias Naturales
Universidad Autónoma de Querétaro
Centro Universitario, Qro., México

[3]Student
Facultad de Ciencias
Universidad Nacional Autónoma de México
Ciudad Universitaria, D.F., México

[4]Laboratorio de Rumiología y Metabolismo Nutricional
Coordinación General de Estudios de Posgrado e Investigación
Facultad de Estudios Superiores-Cuautitlán
Universidad Nacional Autónoma de México
Juriquilla, Qro., México

[5]Centro Nacional de Investigación en Fisiología y Mejoramiento Animal
Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias
Ajuchitlán, Qro., México

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Abstract Red deer (*Cervus elaphus scoticus*) hinds were confined before parturition in 20 × 30 m earth-floored pens and offered freshly cut legume-grass mixed pasture (Experiment 1) or lucerne hay (Experiment 2). In Experiment 1, four hinds were placed in a single pen; all parturitions took place within 24 h. Animals were monitored by a single observer for 24-h periods twice weekly for 10 weeks. Number of daily suckling episodes increased with age while their duration decreased. Consumption of forage started around the fourth week and, by weaning, calves had spent an average of 105.5 min eating forage and 44.2 min ruminating daily, compared with hinds, which consumed forage for 6.05 h and ruminated for 1.77 h per day. In Experiment 2, 24 hinds and their calves were confined in four pens for 12 weeks. Four observers each monitored the activities of a randomly chosen calf from 0800 to 1330 h and from 1430 to 2000 h. Activities were analysed as proportions of total activity using linear and quadratic regressions. Time spent suckling increased until Day 26 (110 seconds, in a total of three bouts), decreasing to 13 seconds (in a total of eight bouts) by Day 73. Most of the hinds (70%) allonursed (nursing a calf other than its own), some as soon as 2 days post-partum. Forage consumption by the calves decreased from 37.1 s at 8 days to 12.6 and 17.1 s at 59 and 73 days, respectively. The regression equation for time spent suckling (proportion of total activity) against calf age (days) showed a quadratic effect: $y = 0.76 – 0.026$ day $+ 0.00023$ day^2 ($R^2 = 0.797$), whilst time spent eating forage showed an opposite quadratic trend: $y = –0.17 + 0.28$ day $– 0.0002$ day^2 ($R^2 = 0.761$).

Keywords red deer; *Cervus elaphus*; calves; nursing; allosuckling; behaviour; feeding

INTRODUCTION

Of the members of the family *Cervidae*, a subspecies of elk (*Cervus elaphus merriami*) was endemic to northern Mexico until the early 1900s, when

poaching caused its eventual extinction (Weber & Galindo-Leal 1998). The other native *Cervidae* species are *Odocoileus virginianus*, *O. hemionus*, and *Mazama* spp. (Weber 1993; González 1998; Bryant & Brown 1999; Reardon et al. 1999).

In 1994 the Federal Government, in a controversial decision (Weber 1993), introduced a herd of about 900 European red deer (*Cervus elaphus scoticus*) from New Zealand, with the intention of promoting deer farming as an alternative form of livestock production. There is very little published data on the production characteristics, feeding patterns, management, and behaviour of *Cervus elaphus scoticus* introduced to the region lying between the Tropic of Cancer and the Equator (Shimada 1997; Siqueiros et al. 1998). The objective of this study was to observe the feeding patterns of newborn red deer calves and their respective dams, in the central Mexican highlands.

MATERIALS AND METHODS

The animals studied were part of the imported herd that had been assigned to the Mexican Forestry, Agricultural and Livestock Research Institute (INIFAP), to be finally settled at the Animal Physiology and Breeding Research Centre (CeNIFyMA). The site is located in the state of Querétaro at 20°47′N and 100°03′W, 1990 m a.s.l., with semi-arid climate, 15°C average daily temperature and 460–630 mm annual rainfall, mainly in the summer months (INEGI 2000).

The deer research farm had four 2.5-ha paddocks planted with irrigated lucerne (*Medicago sativa*), ryegrass (*Lolium perenne*) and orchard grass (*Dactylis glomerata*) pasture, and 12 partially shaded 30×20 m earth-floored confinement pens, provided with several secluded nesting areas made out of reeds. Each pen was surrounded by a meshed wire fence. Water was always freely available.

The hinds spent most of the year in the pasture. To better monitor the behaviour and the health of parturient hinds and their calves, in the days prior to parturition they were confined in groups of 12–15 females and remained in the penned areas throughout lactation and the rut.

All animals in the farm were habituated to the frequent presence of personnel. Therefore, the animals were not disturbed by the observers. The observation sites were adapted in partially protected areas, contiguous to the pens.

Experiment 1 (1977)

During the summer (July and August), four hinds were confined in a single pen, where freshly cut pasture was offered *ad libitum* daily. All parturitions took place within a 24-h period. After delivery, the calves (two males, two females) were weighed and tagged. Dam-offspring behaviour was observed for 24-h periods twice weekly (from 19:30 to 19:30 h; Monday/Tuesday and Thursday/Friday) for 10 weeks until weaning. The area was lit during the dark hours by means of a single 100 watt light bulb. All 20 observations were performed by the same person, using binoculars and a stopwatch.

The information obtained included date, calf's tag number and age, the hind's identification, the hour of any given event, the time spent suckling, the identification of the nursing hind, unsuccessful attempts to suckle, and times spent eating soil, eating forage, ruminating and drinking.

Experiment 2 (1999)

A group of 24 hinds (7 years old) was confined in four pens ($n = 6$ per pen). All animals had access to liberal amounts of pasture hay, which was offered twice daily (at 07:00 and 15:00 h). At birth, calves were identified and handled as described above.

Four observers (one for each pen), using binoculars and stopwatches, simultaneously recorded the behaviour of a randomly chosen calf and its dam for 11 h (from 08:00 to 13:30 h and from 14:30 to 20:00 h) once a week. To avoid a confounding pen-observer effect, all observers were rotated weekly in such a way that by the end of the study, each person had observed each pen three times. The observations were performed in the summer of 1999 (26 July–4 September) for a 73-day period.

Calculation of data and statistical analysis

Behavioural patterns from birth to weaning (Experiment 1), for time suckling, failed attempts to suckle, time eating soil or forage, ruminating and

Table 1 Experiment 1. Least square means and standard errors for single and multiple suckling behaviour of confined red deer (*Cervus elaphus scoticus*) calves. Data are the averages for each animal from birth to weaning.

Dams	Single	Multiple
Episodes/24 h	8.1 ± 7.0	11.1 ± 4.1
Minutes/24 h	8.7 ± 10.5	10.4 ± 4.4
Seconds/episode	51.3 ± 29.8	54.5 ± 16.2

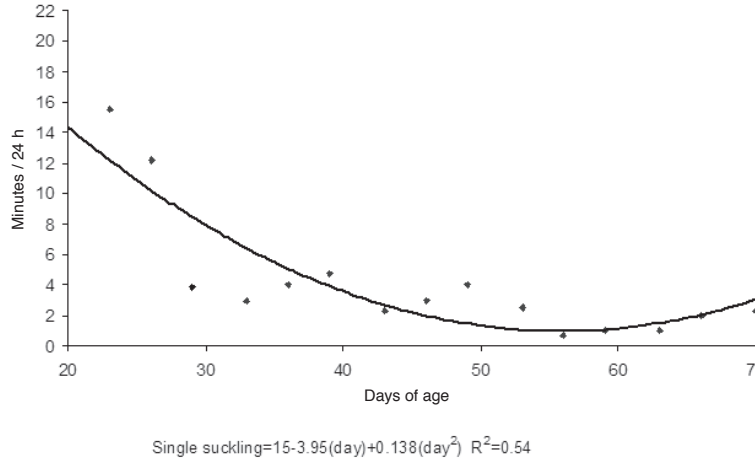


Fig. 1A Experiment 1. Suckling time (min/24 h) behaviour of red deer (*Cervus elaphus*) fawns.

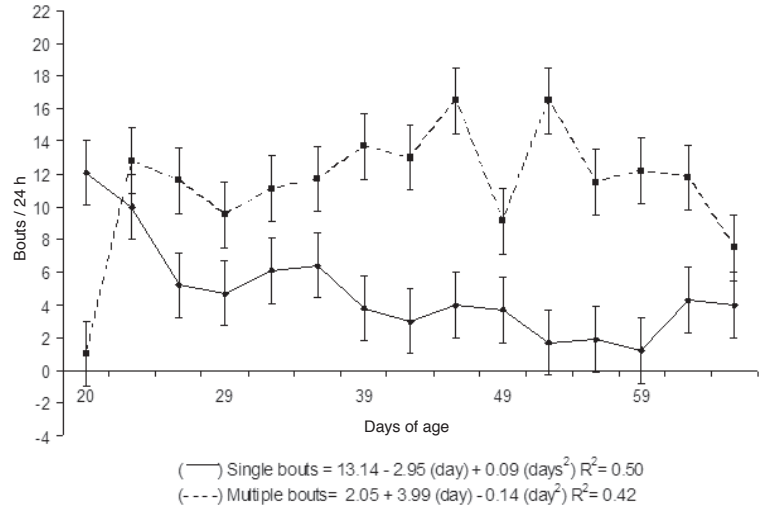


Fig. 1B Experiment 1. Suckling bouts (bouts/24 h) behaviour of red deer (*Cervus elaphus*) fawns.

drinking, and calf behaviour from birth to 10 weeks of age (Experiment 2), for time suckling, eating forage, ruminating and drinking water, were all analysed as a proportion of the total of these activities. The statistical analysis used for both experiments was a regression approach (SAS 1990), with time being the independent variable. In Experiment 1, the analysis for bouts and time behaviour for suckling, foraging, and feeding data were regressed on time in their actual units; for Experiment 2, the behaviour as a proportion of the total activity was transformed to the arc-sine square root of the proportion for the regression analysis. Linear correlation coefficients were also calculated.

RESULTS

Experiment 1 (1977)

The suckling behaviour for time suckling and number of suckling bouts of calves is shown in Table 1 and Fig. 1A and B, respectively. During the first 3 weeks, calves mainly suckled their dams an average of seven times in 24 h, with each bout lasting about 2 min. Although the number of suckling bouts tended to increase with age to up to a maximum of 19.2 times daily at 49 days, the duration of suckling decreased down to 53 s for each bout by 70 days.

Suckling behaviour showed a quadratic trend from the 20th to the 70th day of age (suckling =

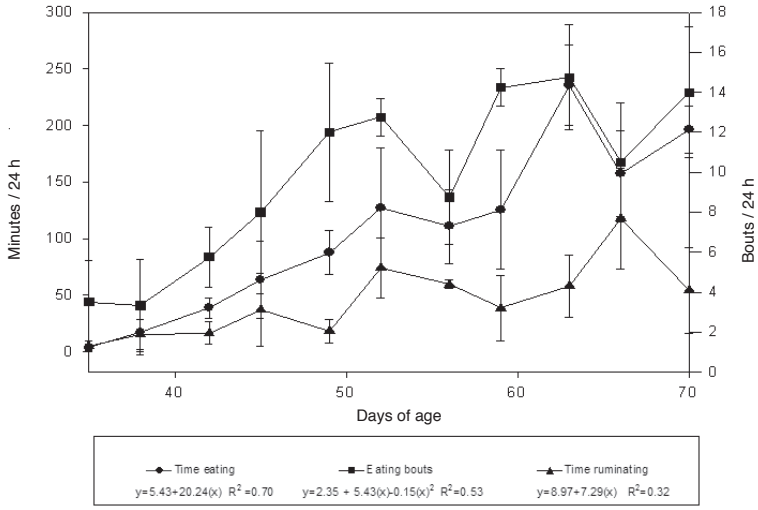


Fig. 2 Experiment 1. Foraging behaviour of suckling red deer (*Cervus elaphus*) fawns.

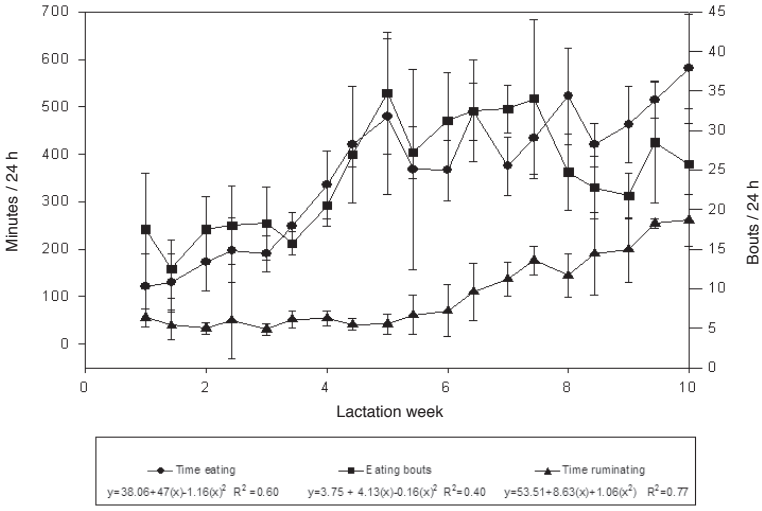


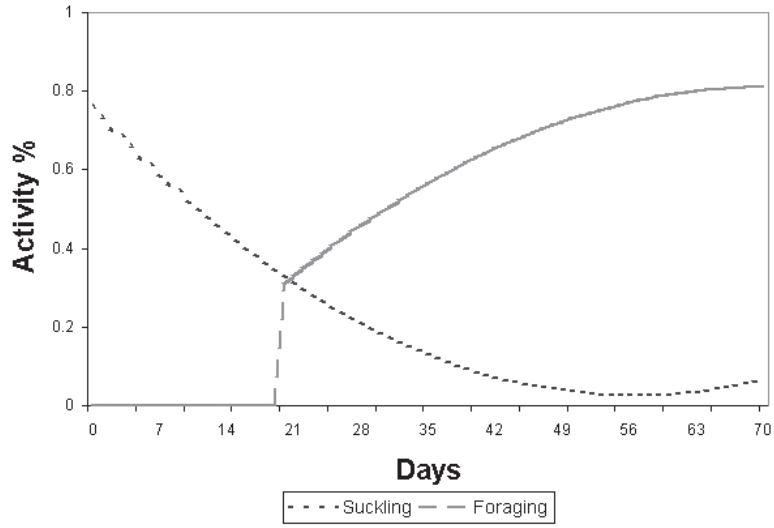
Fig. 3 Experiment 1. Feeding behaviour of lactating red deer (*Cervus elaphus*) hinds.

Table 2 Experiment 1. Least square means and standard errors for forage eating behaviour of confined red deer (*Cervus elaphus scoticus*) calves. Data are the averages for each animal from birth to weaning.

Eating time (min/24 h)	105.5 ± 76.4
Eating episodes/24 h	9.7 ± 4.7
Minutes/episode	9.6 ± 5.2
Ruminating time (min/24 h)	44.2 ± 38.5

Table 3 Experiment 1. Least square means and standard errors for foraging behaviour of confined lactating red deer (*Cervus elaphus scoticus*) hinds. Data are the averages for each animal from birth to weaning.

Eating time (min/24 h)	363.2 ± 157.6
Eating episodes/24 h	24.4 ± 8.0
Minutes/episode	14.9 ± 5.5
Ruminating time (min/24 h)	106.4 ± 84.7



Time spent suckling = 0.76–0.026 day+0.00023 day^2 (R^2=0.797).
Time spent foraging = –0.17+0.28 day–0.0002 day^2 (R^2=0.761).

Fig. 4 Experiment 2. Time suckling and ruminating as a proportion of the total diurnal activity for confined red deer (*Cervus elaphus scoticus*) calves from birth to weaning.

15.05 – 3.95 day + 0.138 day^2, R^2 = 0.54). We also observed that allosuckling (i.e., suckling from a hind other than their dam) occurred in 42% of the observations and calves were normally accepted by the foster mother; on occasion all four calves suckled the same hind simultaneously.

The forage eating behaviour of suckling calves is summarised in Table 2 and graphically presented in Fig. 2. Consumption of forage started around the fourth week of age, and ruminating commenced around the same time. Consumption of forage and ruminating times increased linearly throughout the weeks of observation (foraging = 5.43 + 20.24 (week), R^2 = 0.70 and ruminating time = 8.97 + 7.29 (week), R^2 = 0.30), while the number of foraging episodes could be expressed by a quadratic equation (foraging = 2.35 + 5.43 (day) – 0.15 (day)^2, R^2 = 0.53). From birth to weaning, individual calves spent an average of 105.5 min eating forage (9.7 episodes) and 44.2 min ruminating per day.

The forage eating behaviour of lactating hinds is presented in Table 3 and Fig. 3. On average, hinds consumed forage for 6 h daily in 14.9 bouts per day and ruminated for about 2 h.

Table 4 Experiment 2. Times suckling, eating forage, ruminating, and drinking water as proportions of the total diurnal activity of confined red deer (*Cervus elaphus scoticus*) calves, during three age periods.[a,b,c]Significant differences within a row $P < 0.05$. [w,x,y,z]Significant differences within a column $P < 0.05$.

	Age of calf		
Activity	0–20 days	20–40 days	40 days–weaning
Suckling (%)	55.58^{a,x}	10.86^{b,x}	2.58^{c,x}
Eating forage (%)	38.11^{a,y}	23.68^{b,y}	27.36^{b,y}
Ruminating	0.0	62.14^{a,z}	68.09^{a,z}
Drinking water	0.06^{b,z}	0.03^{a,w}	1.97^{c,x}

Experiment 2 (1999)

In Experiment 2, association between some activities with age were estimated; time spent suckling gradually increased to reach the highest level on Day 26 after birth with 110 s (in three episodes); afterwards it decreased to 13 s (in eight episodes) at 73 days of age with negative correlation in this segment ($R = –0.439$, $P < 0.01$). As in 1997, calves suckled different hinds and were generally allowed to do so. Calves started to eat forage at 8 days of age (showing a linear correlation $R = 0.739$, $P < 0.01$) and to ruminate at 23 days of age, with the correlation being $R = 0.799$, $P < 0.01$ (with one and two daily episodes, respectively). Time spent drinking water was minimal compared with that spent suckling or foraging, and started at 8 days of age with 14 s split over three episodes, ($R = 0.489$, $P < 0.01$). In most cases, the longest drinking times coincided with the highest foraging times ($R = 0.430$, $P < 0.05$). This study showed a negative correlation between suckling time and time foraging ($R = –0.392$, $P < 0.01$) and time ruminating ($R = –0.350$, $P < 0.01$); however, no significant correlation was found between time suckling and time drinking ($R = –0.111$, $P > 0.05$). On the other hand, significant correlations ($P < 0.01$) were found between time foraging and time ruminating ($R = 0.735$) and time drinking ($R = 0.596$).

Table 4 shows the times spent suckling, foraging, ruminating, and drinking water as a proportion of the total activity divided into three periods: 0–20, 21–40, and 40–73 days of age. The results show decreased suckling activity as age increases, from 55.58% in the first 20 days of age to 2.58% at the end of the study ($P < 0.05$). Eating activity decreased from 38.11 to 27.36% ($P < 0.05$); forage eating activity started rapidly and increased up to 68.09% of the total activity; meanwhile drinking activity increased from 0.06% up to 1.97% ($P < 0.05$) of total activity time.

During the first 20 days of life, suckling was the most prevalent activity of the calves ($P < 0.05$), while eating and foraging became more important from Day 20 until weaning. In the first 20 days of life, the activity recorded as "eating", was more like ingesting soil, playing with the feed and nibbling it, rather than actual eating.

The regression equation for time spent suckling as a proportion of the total activity (y) shows a quadratic effect, $y = 0.76 – 0.026\ \text{day} + 0.00023\ \text{day}^2$ ($R^2 = 0.797$); meanwhile, time spent foraging as a proportion of the total activity (y) also showed a quadratic trend but in the opposite direction, the equation being $y = –0.17 + 0.28\ \text{day} – 0.0002\ \text{day}^2$ ($R^2 = 0.761$). The relationship between these two equations is presented in Fig. 4. Regression equations for foraging and drinking activity did not show a significant trend.

DISCUSSION

Young *Cervus elaphus* calves (3–4 weeks old) have been reported to suckle six times in 24 h; by 2 months of age this had reduced to three times a day (Lent 1974). In the case of free-roaming *C. elaphus* (Clutton-Brock et al. 1982) and *Ovis canadensis* (Berger 1979), there is a time-related gradual decrease in number of suckling episodes, counterbalanced by longer durations. However, under confinement, calves might suckle more frequently, although for less time, as reported for *C. elaphus* (Ekvall 1998) and *Dama dama* (Lent 1974). The latter reports the highest frequencies with longest duration at the onset of lactation, both gradually decreasing as the calves get older. He also reports on the existence of different rhythms of nursing episodes in *O. hemionus*, with some occurring at dawn and some at dusk.

Although we did not observe differences in suckling behaviour between light and dark hours in Experiment 1, in Experiment 2 it was noted that, even considering the fact that wild ungulates have to nurse very quickly, the time spent suckling seemed too short, especially when taking into account the fact that the daily milk intake is estimated to be up to approximately 2 litres (Arman et al. 1974; Haigh & Hudson 1993; Landete-Castillejos et al. 2000).

Hinds started allonursing (feeding calves other than their own) as early as 2 days post-partum and continued to do so thereafter. At one time or another, 14 out of 20 hinds nursed calves other than their own; however, the number of suckling episodes with a surrogate mother was always less frequent and for shorter times than with the calf's own dam. In both years, occasionally one hind was seen nursing four calves at once. The hind's position in the hierarchy and the sex of the calf did not seem to influence multiple nursing. Alloparental care has previously been reported in fallow deer (*Dama dama*) (Birgersson et al. 1991), and red deer (*Cervus elaphus*) (Kelly & Drew 1976; Siqueiros et al. 1998; Landete-Castillejos et al. 2000).

Allonursing seems to be a survival strategy that on one hand allows for a more standardised growth of all individuals within the herd, even in cases of

maternal death or lack of sufficient milk, and on the other it allows for greater social interaction between the members of the herd (Dwyer et al. 1998; Ekvall 1998). The latter factor could be important in intensive deer farming since the identification of a given fawn's dam and its maternal ability (milking and nursing) would be difficult to measure. The fact that fawns seem to be fed by the herd rather than by their individual dams would also minimise the need to hand-rear orphaned or rejected fawns (Semiadi et al. 1993a), a costly and time-consuming endeavour, in which a milk substitute is used (Arman et al. 1974; Napolitano et al. 1995).

Judging by the time calves spent suckling (both their own dams and the other hinds), milk intake appeared to be more or less constant during the entire 10- or 12-week observation periods. Suckling episodes usually seemed to be ended by the calf, although in most of *Cervidae*, as the calf gets older the mother would tend to terminate the episode with a forward movement, with or without lifting of the hind leg, as observed in *Capreolus capreolus* (Lent 1974).

In the wild, red deer calves are weaned at 6–7 months of age or with the arrival of the newborns. On commercial farms, calves can be weaned as early as 3 months of age (Guinness et al. 1979) or as late as 12 months. Ideally, the optimum weaning age of farmed ruminant animals should take into account the suckling, nursing, and foraging behaviour of the offspring and their respective dams (Bungo et al. 1998).

To detect the critical weaning period, when there is a conflict of interest between mother and calf, the latter's behaviour, including attempts to reach the udder and suckle (Berger 1979), the dam's rejection or aggression (Lent 1974), the calf's forage consumption, and both animals' body weight and body condition, should all be considered.

Another indication of weaning is the formation of small groups of calves, resulting in the offspring spending more time in activities away from their dams, including gradual changes in behaviour, anatomy, and physiology, both in the calves and the hinds. However, even after weaning, the bonds between dam and offspring can last for up to three generations, illustrated by the fact that hinds which have lost their calves have been observed to be suckled by their yearling daughters (Lent 1974).

The onset of allonursing seems to coincide with either a decreased availability of milk or an increased rejection from the dam. The calves are thus forced to look for milk elsewhere or to start eating forage as an alternative source of food (Semiadi et al. 1993a). Foraging time increases gradually from 37s at 8 days of age to 754 and 1028 s at 59 and 73 days of age, respectively.

Even after the onset of foraging, for the first few days the process of rumination is almost non-existent; but later on, rumen function seems to increase along with the higher intakes of solid feed. Of course the relative proportions of time spent foraging and ruminating depend on both the physical and the chemical characteristics of the forage consumed (Kusmartono et al. 1996; Tinworth et al. 1999).

Although in Experiment 2 diurnal foraging times appeared to be short, even in the oldest calves, in the case of adult *C. elaphus*, Semiadi et al. (1993b) have shown that the animals divide their foraging time evenly between light and dark hours.

The hinds' feeding patterns, as observed in Experiment 1, could be an indication of either a gradual increment in the capacity of the digestive tract and/or an increase in the animals' nutritional requirements as a response to milk production (Adam 1991). The provision of ample amounts of a high-quality forage at this stage ensures the optimal productive performance of both hinds and calves (Niezen et al. 1993).

The seemingly high ratio of foraging time to ruminating time (3.4:1) in hinds, observed in Experiment 1, could be due to the fact that the hinds were fed a freshly cut, highly digestible pasture that needed little rumination, as has been observed previously with other forages (Kusmartono et al. 1997).

Consumption of soil by calves was observed in both years. Semiadi et al. (1993a) report that in this way calves acquire their ruminal microbiota; however, it could also be an indication of some kind of mineral deficiency.

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