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THE BEHAVIOUR OF FARM RABBIT DOES AROUND PARTURITION AND DURING LACTATION

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Abstract: The effects of parturition and lactation were assessed on eleven multiparous rabbit does caged under farm conditions. Frequency and time for different activities (*drinking, eating, caecotrophy, nesting, grooming, chewing*, attention to *neighbour* and *resting*) were studied for the day of parturition, and days 1, 10 and 28 of lactation. Parturition: Does spent most time during the dark period in *drinking* (85%) and *eating* (63%). Conversely, 79% of the time spent in caecotrophy and 55% in *resting* were recorded during the light period. *Eating* time was 104 minutes per day, being higher during the dark period and after delivery. Females rested 33 minutes per hour and started one of the observed activities 39 times per hour. A general tendency to reduce main activities was observed around parturition with the exception of time spent *nesting*. Lactation: Does spent most time during the dark period in *drinking* (59%), *eating* (59%), *grooming* (55%) and *neighbour* (72%) while they spent less time *resting* (46%). The level of activity in parturition seems to be maintained or increased on the following day and reduced afterwards. Does were resting 31, 35 and 41 minutes per hour, and started one activity 67, 27 and 24 times per hour during 1st, 10th and 28th lactation days, respectively.

Key words: rabbits, behaviour, parturition, lactation.

INTRODUCTION

Knowledge of the behaviour of breeding does on commercial farms seems to be the first step in developing alternative “welfare” systems. Only six works have been found that analyse the general behaviour of adult rabbits over a minimum one-day period in commercial farm conditions, which in the western world means being housed in cages. Few of these works have used a system of continuous observation, many

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of them have considered a small number of animals and no work has studied both the frequency and time of a reasonable number of activities throughout an entire day. Moreover, no specific work on the behaviour of does around parturition or lactation has been produced up to date.

The present work will study the effect of parturition and the effect of lactation day on the behaviour of multiparous does by continuous video recording. It is expected that the action of giving birth alters the standard nocturnal behaviour, interferes with some activities and promotes others, for instance the well known behaviour of nest building. In commercial farms, each lactating doe rabbit and her litter remain in the same cage until weaning time, which usually takes place on the 28th day of lactation; kits are increasingly active, being out of the nest most of the time from 21st days of age, where the activities they perform and the limited area available for a numerous litter would affect the behaviour of the mother. Recording the behaviour of reproducing rabbit does will help to establish the pattern of behaviour on those crucial days of the rabbit's life.

MATERIAL AND METHODS

Housing

The research work was carried out at the experimental rabbit farm of the Animal Nutrition Unit at the Polytechnic University of Valencia (UPV). The experiment took place between January and March 2003, with a daily mean temperature between 16 and 20º C. The light:dark cycle was 15:9 (light interval from 06.00 am to 21.00 pm and dark interval from 21.00 pm to 06.00 am). Cages were flat-deck type, dimensions 49 × 72 × 32 cm with a hopper-type feeder and a teat-type water dispenser and a plastic resting slat. Nests were of plastic material, dimensions 40 × 25.7 × 23.5 cm with a 17 cm diameter entrance.

Animals

Eleven multiparous pregnant rabbit does (*Oryctolagus cuniculus*) were used, resulting from New Zealand × Californian cross (V × A cross, V and A being maternal lines developed in the UPV) of about the same age and 4 kg live weight and between their second and fourth reproducing cycle. On the 20th day of pregnancy, does were allocated to the experimental cages in an isolated room and in visual contact with other does, also pregnant. A nest-cage was installed at the beginning of the 4th week of pregnancy and coarse wool was provided. Only minimal-distant routine work was carried out on the days when observation occurred and the experiment was carried out in two consecutive periods. The does were fed with a commercial diet, usually once a week and had access to water *ad libitum*. After parturition the litters were equalised to 8 kits. Lactation followed a free-suckling regime.

Video technique

Images were transmitted by video camera focussed on 6 cages using an infrared lamp during the dark period. Images were captured as AVI type files and stored in MPEG format on 700MB CD-R disks, so that the activities usually considered in studies of this type, within the requirements of our case, could be more accurately identified in the films recorded, and greater reliability in recording measurements could be expected.

Records

Sampling methods using observations at certain times, intervals or periods are simpler and faster but they need to be validated with a continuous observation method, otherwise the error involved in their utilisation is unknown. In the present work, continuous data of recorded behaviour was used to examine the activities of the animals. Start and finish times (hh:mm:ss), which included the initial reaction to cessation, were registered, selecting the twelve hours prior to and post-partum (parturition) and for the 24 hours of days 1, 10 and 28 post-partum (lactation).

For the analysis of parturition, records were grouped by hours, and means of frequency and time of the activities were considered for each hour, from 12 hours before parturition up to 12 hours after. This means that when positive an hour (H) includes the activities observed between H and (H-1) hours, and when negative an hour (H) includes the activities observed between H and (H+1). “0-hour” was not included, as it was considered to be the period in which delivery took place.

For the analysis of lactation, activities on days 1 (the day following parturition), 10 and 28 of lactation were registered. Records for day 1 were started for each rabbit at least 14 hours after delivery; days 10 and 28 were chosen for their particular significance: day 10 is often the day before insemination and the kits are still in the nest; and day 28 is the weaning day of the litter in many farms. Records were grouped and means were considered for each 2 hours, from 0 to 24; which means that hour (H) included the activities observed between H and (H+2) hours.

Some errors were unavoidable in the frequency data, as when one activity took place in two consecutive intervals of time, this activity could only be assigned to one of them. When examining the light:dark cycle the appropriate correction was made, taking into account the single hourly records for the 20^{th} hour.

Activities

The following activities were considered:

- *Drinking*: the doe contacts the water nipple. It keeps its head motionless.
- *Eating*: the doe approaches the hopper. This includes the time with the head in the feeder, masticating and swallowing.
- *Caecotrophy*: the rabbit touches the anus with its mouth. This is distinguished from grooming by the fact that when cleaning itself, the doe does not move its head to lick the fur.
- *Fur pulling*: in this activity the doe pulls out its own fur to prepare the nest prior to partum. Only the 4 hours prior to partum were recorded, in accordance with the study made by XU (1996), who described how the doe pulls out fur and places it in the nest between 3 and 5 hours before delivery.
- *Nesting*: time spent from the moment when the doe puts its head into the entrance of the nest until it comes out. Suckling or its specific behaviour was not studied.
- *Grooming*: licking, scratching or nibbling the body or the hair.
- *Chewing*: gnawing, biting, pulling, nibbling the bars, plastic jug, corners or food hopper. The time spent by the doe sniffing cage corners or even the nest but without entering was included here.

- *Neighbour*: registered when the doe stares at her neighbours, or tries to touch or attack them. Gauging this behaviour is not usual, but we included it here because it may give us an indication of the social behaviour of adult animals isolated in cages.
- *Resting*: sitting, lying and stretching positions, irrespective of whether the animal is alert or not.

Statistical Analyses

Statistical analyses of frequency and time of activities were carried out with the SAS program (Statistical Analysis System Institute, 1990). Data were analysed using a mixed procedure (PROC MIXED) and according to a repeated measure design that took into account the variation and co-variation between animals, the values being expressed in LSM (least square means). The correlation between the frequency and time for each activity, and the correlation between the frequency and time of several different activities, were also calculated.

Parturition: of the eleven does monitored, seven gave birth during the light period, and four in the dark. Therefore, although most activities already mentioned could be linked to delivery of the litter *per se*, they may also be related to the fact that the rabbit is essentially a nocturnal animal. Thus we have examined the analyses of frequency and time spent on each activity, using a model which considered the hour (each hour from 12 h pre-partum to 12 post-partum), the period (light or dark) and their interaction as main factors.

Lactation: as in the case of parturition, for the analyses of frequency and time spent on each activity, a model was used considering the hour of day (each 2 h from 0 to 24), the day of lactation (day 1, 10 and 28) and their interaction as main factors. Although the effect of the period of the day is implicit in the results deduced for hour (the light period in the farm was from 6 to 21 h), it was considered useful to specifically analyse this effect when it helped to give a better understanding of the situation.

RESULTS

Parturition

The activities measured on day of partum (see Table 1 and Table 2) added up to 3538 s/h, leaving a margin of 62 s/h for other activities not included in the study. Does had pulled out a quantity of fur and taken it into the nest 3.5 times/h and 65 s/h during the 4 hours before delivery; time spent in this activity was neither affected by hour nor by the period, which was observed more often during the dark period than in the light (4.4 *vs.* 2.7 times per hour, $P<0.1$).

The does remained in the nest while giving birth, so it is not actually possible to say how long the delivery itself took, lasting from as little as 182 and reaching up to 3154 s. It was not linked to the corresponding period (light or dark) of the day; in fact, delivery took place at all hours of the day.

The frequencies and time for the different activities varied from 0.6 times and 7 s per hour in attention to neighbour up to 13.9 and 1988 in resting posture, respectively. Hour only clearly had a significant effect on frequency ($P<0.001$) and time ($P<0.05$) spent in resting. In most cases, the frequency and/or time of all the activities were clearly related to the light:dark period. Only attention to neighbours was unrelated to this factor.

Almost no significant interactions were registered between period and time, either for frequency or for time in the activities analysed, the exception being the frequency of *resting.*

It was found that the correlations between frequency and time of the same activity were significant ($P<0.001$), with the Pearson coefficient (r) between 0.6 and 0.8, except for *nesting* and *resting*, which had a very low correlation value. The correlations for time among the activities were in general not statistically significant; however there were two relevant exceptions: the positive correlation between *drinking* and *eating* (r = 0.5), and the negative correlations found between *resting* and *nesting*, *grooming* and *chewing* (r values varying between -0.4 and -0.6).

Lactation

The activities measured on days 1, 10 and 28 amounted to 7009 s/2 h, leaving a margin of 191 s/2 h for other activities not studied in this work, or possibly some slight error when listing the variables. The frequency and time of the different activities, measured in 2-hour intervals, are shown in Table 3 and Table 4, where it may be seen that in general they were significantly affected by hour and day. In ascending order, *grooming, eating* and *resting* were the main activities: animals groomed 176 min daily; feeding behaviour represented 20% in total (*eating* took up 16% and *drinking* 4% of the total time), with a mean of 294 min/24 h, and *resting* occupied 849 min.

Frequency and time spent on many of the activities were significantly different on day 1 than on days 10 and 28, between which, in general, no significant differences were detected. Many activities were performed more frequently on the first day post-partum, declining the following days. Frequency of *drinking, eating, caecotrophy, nesting, grooming, chewing* and *neighbour* activities was greater during day 1; time spent in the last five activities was also longer during day 1, and this fact determined the proportional change in daily time spent in *resting*.

A tendency for the activities to decrease in the middle of the day may be noted in Table 3 and Table 4, suggesting that the light cycle had some effect on the activities of the does. This fact was consequently borne out by an independent analysis that found that period (light or dark) significantly affected the results. As a consequence, it was shown that does spend much more time during the dark hours in *drinking, eating, grooming* and *neighbour.*

The evolution of frequency and time throughout days 1, 10 and 28 had a very similar pattern but values for day 1 were significantly higher, occasional markedly so: the ordinates of the maximum and minimum points of the curve were more pronounced and graphs for days 10 and 28 were flatter, with the maximum and minimum values being hardly distinguishable. A representative example is given in Figure 1 for the frequency of *nesting*.

Table 1: Parturition. Effect of hour (− 12 to 12) and period (light or dark) on frequency (F, No./h) and time spent (T, s/h) in each activity.

	drinking		eating		caecotrophy		nesting		grooming		chewing		neighbour		resting	
	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T
Significance																
Hour (H)	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	+	NS	NS	***	*
Period (P)	**	**	NS	*	*	*	*	NS	*	NS	**	NS	NS	NS	***	+
H × P	NS	NS	NS	NS	NS	NS	+	NS	NS	NS	+	NS	NS	NS	*	NS
Mean	1.6	101	2.1	261	0.9	13	4.1	441	9.0	477	7.1	250	0.6	7	13.9	1988
MSE	1.70	182	2.30	293	1.48	32	4.57	768	5.71	440	5.06	30	0.99	19	7.30	849
CV	65	88	59	91	60	70	53	92	28	17	47	68	76	76	32	11
Period																
Light	1.1	35	1.7	209	1.2	23	3.2	428	8.7	469	5.9	190	0.6	9	12.1	2141
Dark	2.5	191	2.5	359	0.6	6	5.4	420	11.3	497	9.4	257	0.5	4	19.6	1774

Significance: +P<0.1, *P<0.05, **P<0.01, ***P<0.001. MSE: mean square error. CV: coefficient of variation (%)

Table 2: Parturition. Effect of hour (-12 to 12) on frequency (F, No./h) and time spent (T, s/h) in each activity.

	drinking		eating		caecotrophy		nesting		grooming		chewing		neighbour		resting	
Hour	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T
-12	2.5	242	2.8	357	0.4	4	7.4	137	7.3	402	9.6	187	0.0	0	16.2	1956
-11	4.7	269	2.3	311	2.8	55	2.9	81	13.0	401	6.7	155	0.2	4	15.3	2293
-10	1.7	81	2.3	312	3.1	43	4.1	83	14.3	385	8.4	210	0.7	9	24.2	2284
-9	2.2	169	2.8	387	2.1	50	2.9	116	14.1	593	6.3	130	2.0	14	22.1	2141
-8	2.6	125	1.2	227	1.6	15	6.8	137	13.1	469	9.8	149	0.8	9	28.3	2229
-7	2.3	85	3.7	479	0.5	7	7.5	170	12.5	483	15.3	158	0.4	1	32.6	1885
-6	2.2	138	1.4	355	0.7	8	5.8	80	13.0	561	9.6	182	0.1	0	18.9	2103
-5	1.2	93	1.1	135	0.4	6	3.8	65	12.1	441	6.5	142	0.2	10	18.1	2661
-4	0.5	19	1.2	98	0.4	8	3.5	75	8.2	570	3.4	98	0.0	0	12.6	2611
-3	1.0	40	1.2	81	1.5	25	5.5	137	7.6	628	4.4	64	0.0	0	14.2	2555
-2	0.8	55	0.6	69	1.0	16	8.4	498	10.1	589	5.7	110	0.1	3	17.2	2114
-1	2.2	165	0.9	108	0.2	2	5.0	671	9.0	572	6.5	210	0.2	7	15.2	1928
1	2.3	171	1.4	103	0.3	3	3.6	851	10.1	630	7.5	655	0.3	4	10.4	1137
2	1.1	68	2.4	212	0.1	1	3.9	908	7.3	365	7.4	410	0.7	11	8.2	1619
3	1.1	30	2.4	178	0.1	1	5.0	864	7.8	541	9.7	577	0.7	11	11.2	1247
4	1.7	61	2.6	289	0.9	16	5.5	754	10.6	464	6.3	262	0.2	1	15.6	1591
5	1.2	85	2.5	338	0.4	9	3.7	864	7.9	354	6.7	340	0.5	14	11.1	1578
6	2.2	133	3.3	357	0.7	12	4.4	471	7.6	332	8.9	353	1.0	16	11.8	2021
7	2.5	170	2.1	286	0.4	7	2.5	778	8.2	447	6.9	184	0.7	5	10.1	1927
8	1.5	101	3.4	476	1.7	18	2.0	284	9.1	460	6.6	140	0.7	4	12.6	1880
9	2.2	186	2.9	453	1.0	9	2.0	381	9.7	496	8.5	161	1.4	14	13.6	1857
10	1.2	135	2.1	293	0.2	18	2.6	464	10.2	743	8.5	223	0.5	11	14.3	1320
11	1.3	40	2.5	461	1.5	14	2.8	618	9.3	356	7.9	157	1.0	7	16.4	1858
12	0.9	44	1.8	348	0.3	6	1.9	692	7.2	306	6.0	107	1.1	8	10.5	2178

Table 3: Lactation. Effect of hour and day of lactation on the frequency (F, No./2h) and time spent (T, s/2h) in each activity.

	drinking		eating		caecotrophy		nesting		grooming		chewing		neighbour		resting	
	F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T
Significance																
Hour	***	***	***	***	**	**	**	NS	***	***	***	***	**	**	***	***
Day	***	NS	***	**	***	***	***	***	***	***	***	***	***	***	***	***
H x D	NS	NS	NS	NS	**	*	**	***	*	*	***	NS	NS	NS	***	*
Mean	4.0	291	7.1	1181	1.9	17	4.2	71	19.4	880	14.4	310	1.6	16	28.9	4243
MSE	2.6	85	4.1	527	2.6	25	6.3	164	10.0	476	12.0	373	2.6	33	14.7	1055
CV	28	27	37	17	38	43	83	91	34	20	50	45	109	95	39	8
Period																
Significance	**	***	***	***	*	NS	NS	NS	NS	**	NS	NS	**	**	NS	**
Light	3.5	254	5.4	1001	2.7	19	4.7	53	18.1	854	14.2	343	1.1	9	27	4427
Dark	4.6	363	7.7	1435	1.5	16	4.4	79	20.2	1041	14.3	295	2.1	23	30	3827

Significance: *P<0.05, **P<0.01, ***P<0.001. MSE: mean square error. CV: coefficient of variation (%).

Table 4: Lactation. Effect of hour and day of lactation on the frequency (F, No./2h) and time spent (T, s/2h) in each activity.

		drinking		eating		caecotrophy		nesting		grooming		chewing		neighbour		resting	
		F	T	F	T	F	T	F	T	F	T	F	T	F	T	F	T
Hour	0	5.1	470	9.5	1573	2.2	18	5.1	99	25.8	1196	14.5	268	3.4	32	37.1	3399
	2	5.6	432	8.8	1548	1.5	12	4.4	77	20.8	1074	14.2	248	1.5	8	33.0	3873
	4	4.4	322	8.2	1541	0.8	6	5.4	61	20.3	1130	16.6	352	1.1	8	29.5	3696
	6	4.0	362	7.9	1522	0.9	6	7.6	82	22.8	956	21.2	481	1.7	14	33.7	3761
	8	5.8	422	7.6	1558	2.3	17	6.6	64	21.6	1305	19.8	511	1.7	12	30.8	3218
	10	4.1	309	3.8	842	3.1	18	2.7	52	18.3	1205	14.5	527	1.1	10	26.9	3826
	12	2.2	90	3.1	458	4.4	35	3.	43	18.2	597	13.3	258	1.0	7	28.0	5335
	14	1.1	39	2.6	451	3.9	34	2.9	36	11.8	418	8.7	175	0.8	6	20.2	5934
	16	1.8	169	3.4	612	2.8	23	2.3	33	13.2	523	7.6	130	0.6	5	17.9	5318
	18	3.3	209	6.2	1038	1.6	19	2.6	97	15.2	828	10.7	262	0.6	6	20.9	4584
	20	3.6	262	6.1	1190	1.4	15	1.8	18	13.4	790	9.9	235	2.1	30	16.5	4375
	22	4.0	298	8.1	1260	1.2	14	5.7	154	21.9	1018	18.3	407	2.6	41	31.4	3676
Day	1	4.8^{b}	247^{a}	8.3^{b}	943^{a}	3.4^{b}	29^{b}	9.7^{c}	141^{b}	29.6^{b}	1308^{c}	28.9^{b}	617^{b}	3.4^{b}	30^{b}	45.5^{b}	3686^{a}
	10	3.5^{a}	318^{b}	4.8^{a}	1315^{b}	1.8^{a}	15^{a}	2.5^{b}	42^{a}	13.3^{a}	899^{b}	8.7^{a}	221^{a}	0.7^{a}	7^{a}	17.8^{a}	4194^{b}
	28	3.1^{a}	279^{b}	5.8^{a}	1141^{c}	1.3^{a}	10^{a}	0.4^{a}	21^{a}	12.9^{a}	553^{a}	5.0^{a}	126^{a}	0.4^{a}	8^{a}	18.7^{a}	4868^{c}

Means within a row with different superscripts differ $P<0.05$.

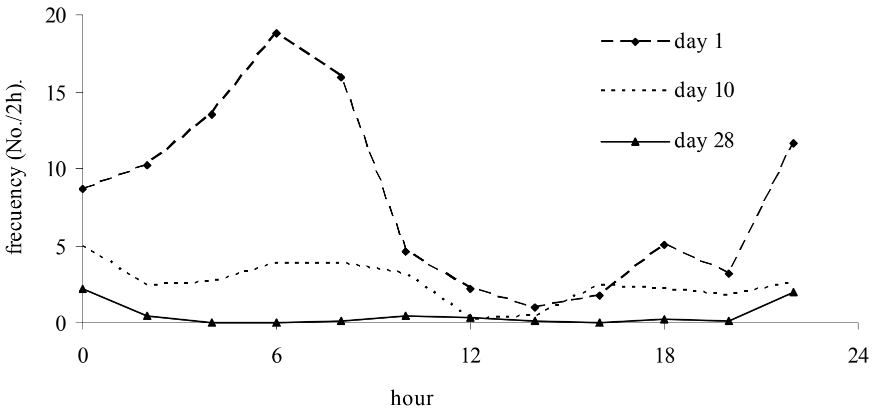

Figure 1: Lactation: frequency of nesting.

It was found that the correlations between frequency and time spent in the same activity were significant ($P<0.001$), with a correlation coefficient r between 0.4 for eating and 0.8 for chewing, being negative only for resting: the longer the time resting, the lower the frequency of this posture, which we have included as an activity.

Correlations for time spent on the different activities were also significant ($P<0.001$) for most of them, although with low correlation coefficients (r = 0.4 to 0.7). Besides this weak relationship, the most interesting correlations were found to be negative for *resting,* with *drinking, eating, grooming* and *chewing* having varying r coefficients of between -0.5 and -0.7.

DISCUSSION

Two of these activities, *nesting* and *neighbour*, showed a high inter-animal variability (CV: 53-109%) at both parturition and lactation, which calls into question their suitability for this type of experiment. In fact, using the sample size of the present experiment (n = 11) as a reference, only changes of between 36 and 800 percent for these variables would be observed as significantly different ($P<0.05$).

For example, the time spent by the female in staring at its neighbour during the light period in parturition was 2.2 times greater than during darkness, but no significant differences were found.

In the case of *drinking, eating* and *caecotrophy*, the frequency and time spent in these activities by the female showed a high inter-animal variability at parturition (CV: 60-91%), but were clearly lower during lactation (CV: 17-43%). These differences could be due to the different parturition schedule for hour and physiological stage, as mentioned above.

As an example, the coefficients of variation for the time factor on day 28 of lactation oscillated between approximately 25% for *resting*, 60 to 80% for *drinking, eating* and *grooming*, 290% for *nesting* and 420% for *neighbour*. This means that the number of animals which in similar conditions to ours would be necessary to detect a difference of 20% between means would be 2, 11, 130 and 290 respectively. It appears that in the two latter cases the attempted observations would have to be excluded, even if we broaden the degree of tolerance, and on the other hand this points to the advisability of studying the admissible variation of a behaviour, which is linked to the effective decrease or increase in wellbeing. There is not much statistical data available on complete behavioural studies, but similar figures may be derived from several, which leads us to believe that in general the size of the sample has to be carefully chosen.

An examination of the standard deviations or standard error of the ratio time/frequency (seconds/number, equivalent to the "intensity" of the activities) would lead to similar conclusions as those above, since the variability of the data is extremely high and implied a high range for all activities in both parturition and lactation; for instance *nesting, grooming* and *chewing* in lactation varied from less than 5 s to around 200 s.

Comparing the results of this work with those of other studies is not easy, as the measuring conditions, observation method, physiological state of the animals and the activity considered may vary and sometimes are not compatible. Besides, there are no specific ethograms for these particular days, and, most importantly, no work was found that studied the complete behaviour on the day of parturition.

As a basis for discussion, we have generally chosen the time of the activities studied, as this is without doubt an easier datum to interpret and more often cited than frequency. The individual variation in the behaviour of different animals turned out to be very high, and so the representation of the values is sometimes confusing, although in general a reasonably defined trend was observed. These are represented in tendency lines that serve to suggest a common pattern of the time devoted to most of the activities, although the factors period, hour or day may have no significant effect on some of them.

Parturition

The overall results showed that, as mentioned above, the animals were more active during darkness, when they were in a resting posture 45% of the total daily time. This figure may define rabbits as relatively nocturnal animals, although time occupied in delivering and the activities closely related to it could interfere with the normal behaviour and alter this figure.

The attention paid to neighbours was extremely low and can thus be defined as a marginal activity, even considering that only very clear attitudes, such as facing or approaching neighbours were recorded.

Feeding behaviour (*drinking* and *eating* combined) occupied about 10% of the total time, taking up around 144 min daily. The animals drank considerable quantities one hour before and one hour after delivery and both activities followed a similar trend throughout the day. This value is exactly the same as that obtained in non-reproductive animals by GUNN AND MORTON (1995). Values published to date vary between 90 and 360 min/24h, e.g. highly variable data and in many cases lower than those observed in this work.

Feeding behaviour in wild rabbits occurs mainly during the night, but the behaviour of domestic animals is strongly affected by availability of food and the lighting regime. In our case, 60% of times and 63% of the time used in *eating* occurred during darkness. This value coincides with the conclusions reached by several other authors in conditions different to ours. This behaviour can be seen in more detail in Figure 2,which shows how in the hours following parturition, ingestion increases during both light and darkness. We can assume that does "prefer" to eat in darkness but "have to" eat after parturition, where the priority is to try to maintain their strength or recover from the effects of delivery. Farmers have often observed that, after delivery, rabbit does clean the litter and then go to eat and drink.

Caecotrophy occupied a very small portion of the total time (0.4 %). Although not affected by the hour of day, it tended to present a minimum after parturition (Figure 3), 83% of the time employed throughout the day in this activity was linked to the light period, coinciding with many works published elsewhere, which have described the precise circadian nature of this behaviour.

The does spent little time on *fur-pulling*; this activity had higher absolute values of time and frequency in the dark, but perhaps the significance was not detected due to the low number of measurements. The female would obviously prepare the nest irrespective of the light or other circumstances.

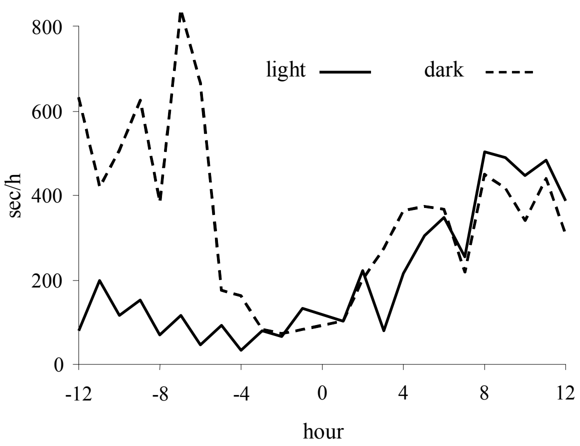

Figure 2: Parturition: eating time.

Nesting time was high (12% of the total), due to the preparation of the nest before parturition and the entrances into the nest post partum. This behaviour was affected significantly by the time of day, increasing progressively from a few hours prior to parturition, irrespective of light or darkness. Time *nesting* was always higher after parturition than before, although the number of visits to the nest decreased noticeably, the time increased to almost 200 s per visit, as a consequence of maternal behaviour. No other references are available for this behaviour throughout this particular day.

Our data reflect the fact that the time given over to *grooming* was 191 min/24 h, 13% of total time, whereas for Gunn and Morton (1995), the comparable figure was 19% and for Podberscek *et al*. (1991) 23%, both authors having observed non-reproducing does. These remarkable differences could be due to the condition of the doe, whose body volume is greater, thus having her movements restricted (Xu, 1996) or perhaps other activities that are more attractive to the animal around delivery.

Grooming time seems to be independent of the time or illumination period and to be fairly constant throughout the day, although it increased during the first hour post-partum. No data are available for this behaviour during the day of parturition, but its incidence could be related to the obvious need to clean the body when

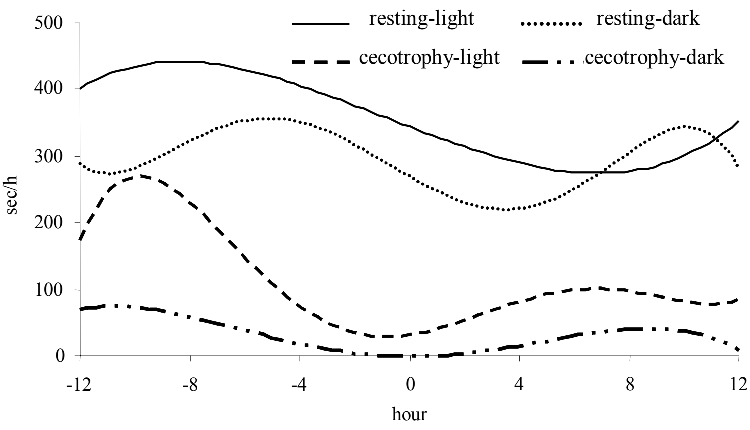

Figure 3: Parturition. Tendency lines for caecotrophy and resting. [Different vertical scale for resting (/6) and cecotrophy (×5)].

everything else had already been cleaned. This tendency is actually opposite to that exhibited by the *chewing* activity, which was linked to the partum surroundings and sharply increased in the previous hour and during the 6 following hours. The low significance found ($P<0.1$) was probably due to this fact. The significant effect of the period on the frequency of both activities gives some evidence for nocturnal behaviour.

There are no specific works concerning *resting* behaviour on the day of parturition with which to compare our results, although this figure for resting is similar to that obtained by other authors observing non-lactating does, such as GUNN and MORTON (1995) or HANSEN and BERTHELSEN (1999) who reported 56% and 59% of the total time, respectively. The time given over to resting was significantly different and depended on the light:dark period, since the does rested more during the day, a result that concurs with the observations made in all the works reviewed by VASTRADE (1985). In Figure 3, it can be seen that resting time was greater in the daylight hours prior to parturition, started to descend and eventually reached a similar minimum, regardless of the light:dark regime, which means that in both situations the doe spent more time on the remaining activities that we have recorded in Table 1. We could assume that resting time observed some hours before parturition is linked to darkness and the need to prepare the nest, whereas afterwards it is maintained independently of the illumination, since it is affected by the increment in the remaining activities.

As was foreseeable, the correlations between frequency and time employed in the same activity were mostly relatively high, but the ratio between both variables was far from being constant. This caused irregularity in the "intensity" of the activities, as has been mentioned previously, which was logically even higher when the correlation was low, as in the cases of *resting* and *nesting*. The negative correlation between the time spent in *resting* and the remaining activities merely indicates the contrast between them.

The high standard error of the means might have prevented some relevant differences from being statistically detected. This is the case for the interaction "period x hour" in *eating* and *resting*. In both cases (see Figures 2 and 3) the does' behaviour in light and dark was quite different before delivery and almost indistinguishable afterwards. This is in accordance with an interaction situation, but the analysis gave a non significant difference.

Lactation

Feeding was one of the main activities of the doe, and the data are close to the values consulted, although there is considerable variability, as mentioned in the section on parturition. Hoy (2000) observed a group of lactating does housed in cages and recorded the number of daily feeds at 63, with an average duration of 230 s each. These figures correspond to drinking 43 and 72 respectively; results similar to those of the present work, in which, taking day 10 as representative, the does drank 42 times with 91 s each time, and for eating 58 times, with an average of 274 s each time. Reyne *et al.* (1978) also found almost identical figures for lactating free suckling does, which went to the hopper 45 times per day in the first week and 54 in the third week.

All studies are unanimous in considering that ingestion happens mainly at night. Vastrade (1985) affirmed that, in domestic rabbits, results are more varied because there is probably a tendency in the animal to adopt daytime behaviour; for example Hoy (2000) did not detect any differences in the feeding frequency for lactating does housed in conventional cages during the hours of light and dark. Our results reflect the nocturnal character of this behaviour, but it was actually also appreciable during the light period, especially in the first three hours and in the three last hours of the light phase, a fact also reported by Reyne *et al.* (1978).

Neighbour and *caecotrophy* took up a very small portion of the total time (0.2% each). The frequency and time devoted to caecotrophy, which was affected by both time and day factors, presented a maximum during midday and afternoon up to 18 hours. The classic observations of Jilge (1974), and Fioramonti and Ruckebusch (1976), established that, in an *ad libitum* feeding situation, the emission of caecotrophes takes place in the morning, with an average duration of 7 h and a maximum of approximately 12 h. Although biphasic patterns tend to appear when

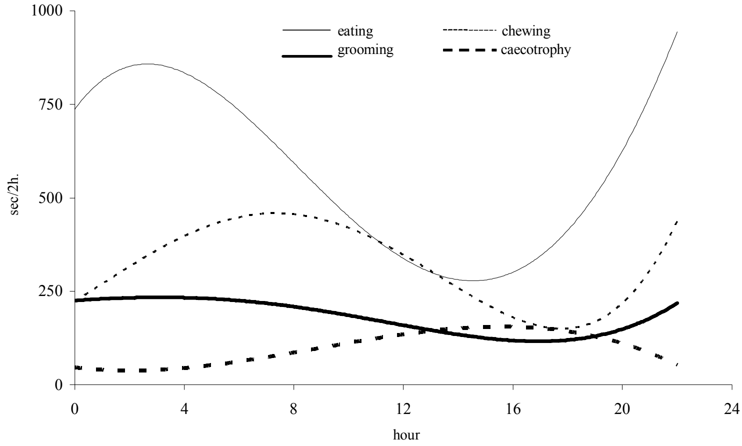

Figure 4: Lactation. Tendency lines for eating, chewing, grooming and caecotrophy [Different vertical scale for: eating (/2), grooming (/5), chewing (/1) and cecotrophy (×3)].

the light period is reduced from a schedule of 12 h, Figure 4 shows a monophasic pattern of excretion. Like other activities, the frequency and time dedicated to caecotrophy were 2-3 times greater on day 1. A series of high values, recorded on day 10 at 0, 2 and 22 h, probably led to the lack of significance of the light:dark period, and also the significant interaction detected between hour and day.

The activity termed *grooming* mainly occurred during nocturnal hours, with an average of 176 min per day, constituting 12% of the total time, similar to that published by GUNN and MORTON (1995), but much lower than the results of HANSEN and BERTHELSEN (1999), who, using the continuous observation technique, found 295 min devoted to this activity. Other much lower figures arise from the examination of semi-free colonies, which may suggest a lesser activity or a decrease proportional to the increase in another, such as social and exploratory behaviour. Some works on free or wild animals have found that it takes place in the early hours of the morning, but according to others, farm animals clean themselves mainly in the daytime (VASTRADE, 1985), more at night (GUNN and MORTON, 1995) or irregularly (KROHN *et al.*, 1999). The high values found on day 1 could respond to the pressing need for the doe to clean herself during the day after delivery, decreasing in subsequent days.

Chewing behaviour took up a small part of the day, especially compared with the more frequent *grooming*, reaching 4% of the total time, but this is a relevant rate. This activity increased appreciably in the first hours of light and dark. This increase was considerable, almost three times higher on day 1 than the others, when moreover the time employed was considerably shorter. If this is a response to a stress situation, it should also be taken into account that light and dark came about instantaneously in the farm.

The impossibility of differentiating between normal conduct, such as gnawing, and abnormal, such as biting the bars due to frustration or boredom, in the recorded film, prevents us from being able to consider this activity as a stereotype indicating discomfort. Gunn and Morton (1995) found that this possible stereotype took up 11% of the total time, although these authors include many other aspects which were either not taken into consideration or else were included in another activity, for example the fur biting behaviour, which we have considered as *grooming*; Hansen and Berthelsen (1999), reported that the does were gnawing 66 min/24 h (4.8% of the total time). Podberscek *et al*. (1991) reported that caged rabbits chew from the 9th to the 17th hour. Examination of Figure 4 indicates that it diminished appreciably during the light period, the initial hour fixed by Table 2 at 10 am, but the results were not significant.

In the present work, the trend observed for nesting (Figure 1) suggests a close relationship to the hour of the day, the highest frequency and time occurring at the beginning of the dark period, when mothers prefer to nurse their kits. This is in agreement with the observations of Hoy *et al*. (2000) on the frequency of nursing events; but the difference between the time used during the periods of light and dark was not significant when analysing the 3-day set of data. Our results on days 10 and 28 respond to the general notion that the number of visits to the nest was reduced to a great extent; and even on day 28 it is so small that it could lead one to think that the doe was not suckling its litter at all. Careful observation verified no suckling outside the nest, as sometimes happens at this age. The frequency of visits was very high during the morning of day 1, and this was the cause of the interaction registered between the hour and day in the statistical analysis.

The general idea is that the wild rabbit makes a very low number of visits to the nest. Our data are far removed from the conclusions of most authors, who affirm that the number of entries to the nest varies between 1 and 3 times a day, spending a total of between 180 and 240 s each time (Xu, 1996; Matics *et al*. 2001). Our data refer to visits, but the other studies preferred to focus on the number of times the doe suckles her litter, which means that the number of visits to the nest and suckling the kits are different issues which must be distinguished by direct observation or filming from very close to the nest.

All the time dedicated to *resting* constituted 59% of the total time, although it varied between 51 and 68% for days 1 and 28, respectively. This is not very far from that published by Gunn and Morton in 1995 (56%) but much further from that presented by Selzer *et al*. (2001), who concluded that for does with litters housed in conventional cages, there are minor differences between the rates of activity and repose not constituting more than 49% of the total time. These differences could have been due mainly to the method of measurement used, and the illumination periods on the farm.

As with other activities, the evolution of *resting* on day 1 was more pronounced than on subsequent days, where the curves are not so steep: there was less time resting in the dark and more in the light, causing the significant interaction found between hour and day. The time in repose was maximum between 12 and 18 h, a trend similar to that published elsewhere. One of the possible reasons for the greater resting time during day 28 is the reduction in space available in the cage for the doe, due to the constant presence of the litter outside the nest.

The activity designated as *neighbour* varied depending on the hour of the day, mainly taking place during night at well-defined hours, from 20 to 2 h in the morning and also occurred with greater frequency during day 1. It is a difficult activity to assess and even less related to the rest of the activities measured here. Domestic rabbits spend a considerable part of the time in social attitudes or behaviour, coming into physical contact if housed in natural or artificial warrens (Selzer and Hoy, 2003), and in our situation a trace of this behaviour has been detected, although the cage systems prevent this conduct. This activity would take in antagonistic behaviour, estimated at 2.5% in rabbits housed together (PODBERSCEK *et al*., 1991). Actually, we observed that neighbouring does attempted to attack each other, but in general it is considered that antagonistic behaviour is null in cages.

Correlations between frequency and time were low, significant and positive. This means that more time was spent on the most frequent activities but also means that a sound conclusion about this is not very reliable. For resting, the correlation obviously turned out to be negative, as could be deduced from its definition: if an activity is started many times in an hour this means less time in a sitting or stretching position. In the other set of correlations between activities, no relevant factors were found, apart from resting time being inversely correlated to the remaining time, an obvious fact.

Similarly to time, the interactions for frequency, detected in most activities, could be attributable to the different shape of the curve of day 1, which showed clear intervals for highest (2 to 8 h) and lowest (12 to 16 h) values, compared to those observed in the curves represented for the other days, where these differences can hardly be detected. Correlation coefficients of the regression lines for day 1 (R^2 about 0.8) and for days 10 and 28 (R^2 from 0.02 to 0.4) again suggest the difference between both sets of values.

A general conclusion from our results thus indicates that the does spent more time and/or higher frequency in darkness in *drinking, eating* and *grooming,* and significantly less in *resting* and *caecotrophy.* This seems to be related to the circadian rhythm of this species and is a direct consequence of the other activities, because it is evident that the process of re-ingesting faeces is linked to eating, and resting to the lack of activity. Some of these activities may be examined in Figure 4, where the tendency of the overall means of the three days so far studied is represented on a different scale.

The different significance assigned to hours of parturition and lactation prevents their being examined together, but certain interesting facts are readily observed and a comparison could be relevant in order to find the links between both physiological stages. The activities indicate very marked differences between certain hours and others on the day of parturition and day 1 of lactation, whereas on days 10 and 28 they were much less pronounced.

The frequency of total activities on the days studied, i.e. the number of times that the does initiated an activity, including a resting posture, was in the four days mentioned (Parturition, 1, 10 and 28) 39, 67, 26 and 24 times/h, respectively, which suggests a trend towards routine behaviour in lactation. The higher negative correlations between time resting and the other activities during lactation is also a sign of the return to normal behaviour, and the lower CV for the activities in lactation compared to those in parturition further indicates a somewhat less irregular behaviour.

The doe has eaten little on the day of parturition and on previous days, and will have to recover it in a few days post partum; accordingly, the time spent on eating and drinking was minimal on parturition day and increased afterwards, following a curvilinear response that resembles the well known curves of food intake or milk output during lactation.

Time spent in the nest on the day of parturition was much higher than on the other days studied and *resting* time, which was quite low then, on day 1 decreased even more, because almost all the activities increased at that time. This means that on day 1 the doe appears to compensate for the distortion of some activities that had not been carried out appropriately on the day of parturition (*drinking, eating* and *grooming*), and, on the other hand, the need to remain in the nest or suckle the litter decreases. On this day the doe may be extremely restless, since greater frequency and time were recorded in the activities *chewing* and *neighbour*, and the doe even made a large number of nest visits, which did not correspond to the time spent inside. Less time resting and shorter resting periods during days of parturition and 1 (143 and 81 s/resting event) than on days 10 and 28 (236 and 260 s/resting event) further characterise the stage of the animals on these days. On the course of lactation, the activities recovered “normal” values, *eating* time still adjusting to the milk output and *resting* time reaching 68% of the total time on day 28.

CONCLUSIONS

The does remained in a resting posture for a considerable part of the day, but the high number of activity – changes per hour, may define them as active animals; particularly on the first day of lactation this may be linked to a state of stress.

Although the time per hour performing most activities was significantly related to darkness, which defines rabbit does as nocturnal animals, a significant part of the activities, more than 40 %, was also carried out during the light period, leading to the conclusion that the caged rabbit does not have a marked nocturnal character. Considering that a schedule of 15 h of daily light was imposed on the farm, more time for activities was totalled during the light period than during the dark period.

On parturition day, the behaviour of the doe is affected by delivery: nocturnal behaviour is less pronounced than in lactation and the doe exhibits a peculiar behaviour, with considerable time spent inside the nest, apart from the delivery itself. The doe partially prolongs this behaviour on the following day, when it is far more active. Afterwards, the activities appear to recover normal values, with time and number of visits to the nest being very low and time spent on eating following the shape of the lactation curve.

The activities displayed a very high variability of frequency and time, and in many cases the number of animals that would be necessary in order to be able to appreciate significant differences between the variables studied would be too high for normal research studies.

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