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journal or publication title	Tohoku journal of agricultural research
volume	24
number	3
page range	117-122
year	1974-02-15
URL	http://hdl.handle.net/10097/29659

Studies on the Reproductive Phenomena in the Post-Partum Rat

I. Time of Delivery and Post-Partum Ovulation in Rat

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(Received August 21, 1973)

Summary

The time of delivery and the interval from delivery to post-partum ovulation in rats were investigated under two different conditions—natural and artificial lighting (light on 6:00 hr and off 18:00 hr). Deliveries began at 11:00 hr on day 22 of pregnancy (day 1 of delivery) under both conditions. The majority of pregnant rats delivered by 20:00 hr on day 23 of pregnancy.

In the rats delivered from 11:00 to 20:00 hr, ovulations began at 12 hours after delivery and the majority of these rats ovulated at 14 hours after delivery. But, animals delivered between 20:00 and 23:00 hr did not ovulate within 24 hours after delivery.

This results suggest that the post-partum ovulation in rats occurs between 12 and 30 hours after delivery, and that the time of ovulation is closely related to the end of delivery in individual post-partum rats.

The time of delivery in the rats had been observed by several workers (1-5). It has been generally known that the delivery in the rats occurred during night. But Kirkham and Burr (2) have reported that the delivery usually took place during late afternoon or early evening. Blandau and Soderwall (3) have also shown that the largest number of pregnant rats delivered their young during the afternoon. The results of these authors were obtained from rats kept under natural conditions, and there was a discrepancy between these results. On the other hand, Ying *et al* (5) have reported that the majority of Sprague-dawley rats have delivered between 6:00 and 16:00 hr on the 23th day of pregnancy. It remains unknown whether the disagreement in the results from these authors depend on the experimental conditions or the strain.

It has been well known that the post-partum ovulation in rat occurs soon after delivery (1-7). According to Long and Evans (1), post-partum ovulation

in rat occurred between 16 and 24 hours after delivery. Blandau and Soderwall (3) have also found that the ovulation in the delivered rat began within 7 hours after the beginning of heat, and that the ovulation was completed within 11 hours in most animals.

Hoffman and Schwartz (4) have described that the rats delivered after 16:00 hr had not ovulated by the following morning, but ovulated at 10:00 hr of day 3 of delivery. However, they only observed the ovulation two times every day (10:00 and 16:00 hr). The exact relationship between the time of delivery and that of ovulation has not yet been obtained. Thus this experiment was undertaken to examine the time of delivery under two different conditions — natural and constant period lighting, and to know the exact interval between delivery and post-partum ovulation in rat.

Materials and Methods

The animals used in the experiment were mature virgin female rats of the Wistar strain weighing 160–230 g, which had been inbred in our laboratory. The rats were kept under natural or constant illumination conditions (light on 6:00 hr and off 18:00 hr). They were fed on a basic diet and tap water *ad libitum*.

At least three consecutive 4-day oestrous cycle were followed before the experiment was began. The females in proestrus were caged with fertile males overnight and mating was determined by the presence of sperm in vaginal smears on the next morning. This day was designated as day 1 of pregnancy. Pregnant rats were checked for the occurrence of delivery from 8:00 hr on 22 days of pregnancy. After that delivery was observed every hour. The end of parturition was determined by palpation of the abdomen. For the examination of ovulation, ovaries and oviducts were removed from the end of the delivery to 30 hours following it, and the oviducts were examined by desecting microscopy.

Results

1) *Distribution of Time of Delivery (Fig. 1)*

Delivery began 11:00 hr on 22 days of pregnancy under both conditions of natural and constant lighting, and the majority of pregnant rats delivered by 20:00 hr on day 23 of pregnancy. The animals delivered during daytime or light period were about 75 percent, and the rest delivered during the night or dark period.

2) *The Relationship between the Time of Delivery and That of Ovulation*

a) *Natural Conditioning Group (Table 1)*; The animals delivered between 11:00 hr on day 22 of pregnancy (day 1 of delivery) and 20:00 hr (day 1) did not ovulate within 11 hours after delivery, 8 out of 15 animals, ovulated by 12 hours and all animals (8/8) had ovulated by 14 hours following delivery. However, the

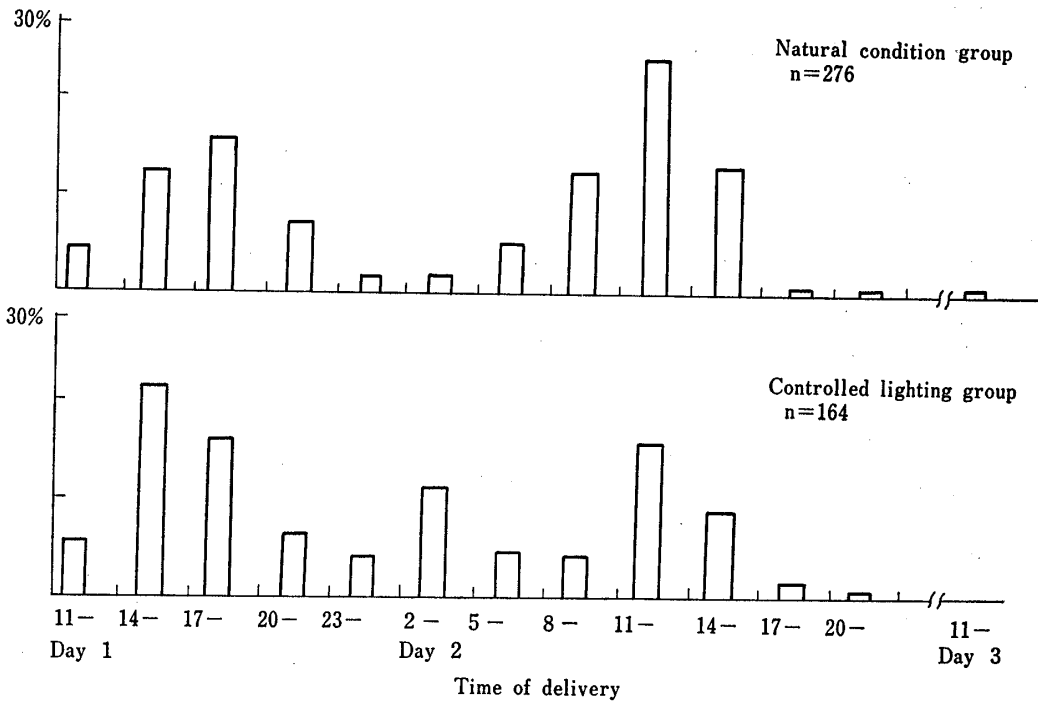


FIG. 1. Distribution of time of delivery.

TABLE I. *Relation between Delivery and Ovulation (Natural)*

Interval from delivery to ovulation (hrs.)	Time of delivery											
	Day 1					Day 2						
	11-	14-	17-	20-	23-	2-	5-	8-	11-	14-	17-	20-
0			0/2	0/1			0/2	0/1	0/1	0/1		
6	0/1	0/1	0/3	0/2	0/1			0/1	0/1	0/1		
10								0/1	0/1	0/4		
11		0/1								0/3		
12	1/2	2/5	5/8	0/2				0/6	0/8	1/5		
14		2/2	6/6	0/1			0/3	0/8	8/9	3/3		
16		4/4	4/6	0/2			0/1	3/4	4/4	2/2	1/1	0/1
18	1/1	3/3	3/3	0/3	0/1	0/1	1/1	3/4	7/7	4/4		
20				0/1					2/2	1/1		
21						0/1	1/1					
22							1/1	1/1				
23						1/1						
24		1/1	2/2	0/1	1/1		2/2	1/1	3/3			

animals delivered between 20:00 hr (day 1) and 23:00 hr (day 1) did not ovulate within 24 hours though the majority of them had ovulated by 30 hours after delivery. In the animals delivered from 23:00 (day 1) to the next morning 11:00 hr, (day 2), the ovulation occurred in shorter times following delivery than that of the animals delivered between 20:00 (day 1) and 23:00 hr (day 1). The animals

delivered from 11:00 (day 2) to 17:00 hr (day 2) had partly ovulated at 12 hours (1/13), and on the other hand, almost all had ovulated by 14 hours after delivery (11/12). There is a highly significant difference (X^2) in occurrence of ovulation at 12 hours after delivery between the animals delivered before 20:00 hr (day 1) and those delivered from 20:00 (day 1) to 10:00 hr (day 2). But, there is no significant difference in occurrence of ovulation ratio at 14 hours after delivery, in which the animals delivered from 11:00 to 20:00 hr between day 1 of delivery and days 2 of delivery. The number of the shed ova in the rats delivered from 11:00 to 20:00 hr and killed after 12 hours was 9 and their number increased to 14 at 16 hours after delivery and thereafter the number reached to plateau (Fig. 2).

b) *Controlled Lighting Group (Table 2)*; 3 out of 6 animals which delivered between 11:00 (day 1) and 20:00 hr (day 1) had ovulated after 12 hours, and 4 out of 6 animals had ova at 14 hours after delivery. But the majority of the animals delivered from 20:00 (day 1) to 23:00 hr (day 1) did not ovulate within 24 hours after delivery. Also, ovulation occurred in 4 out of 6 animals delivered between 11:00 (day 2) and 20:00 hr (day 2) at 14 hours following delivery. The relationship between the time of delivery and that of ovulation was almostly the same as to that in natural conditions. The number of shed ova in the animals delivered from 11:00 to 20:00 hr and killed after 12 hours was 8. Their number increased to 13 at 16 hours after delivery and thereafter the number reached to plateau (Fig. 2).

Discussion

According to Long and Evans (1), the delivery began from 20 days of pregnancy, and the majority of pregnant animals delivered at 21 or 22 days. The majority of pregnant rats delivered at 22 or 23 days of pregnancy in this experiment. But, day 1 of pregnancy in this experiment is corresponded to days 2 of pregnancy in their experiment, so the duration of pregnancy was the same in both experiments. The time of delivery was observed from 11:00 on day 22 to 12:00 hr on day 24 of pregnancy. The majority of animals delivered during the daytime or light period under both conditions. This results agreed with previous reports by Blandau and Soderwall (3) and Kirkham and Burr (2). Although, it has been said that the reproductive phenomena was closely related to the diurnal rhythm (8-10), there was no significant difference between the controlled lighting group and natural condition group in this observation.

It may be concluded that there is no difference in distribution of delivery between natural and controlled light conditions (12:12=light: dark period). Also, it may be suggested that the delivery time is different according to strain rather than light conditions. It had been generally stated that the post-partum ovulation occurred soon after delivery (1-7). In animals delivered from 11:00 to 20:00, the post-partum ovulation took place within 14 hours after delivery. In the case

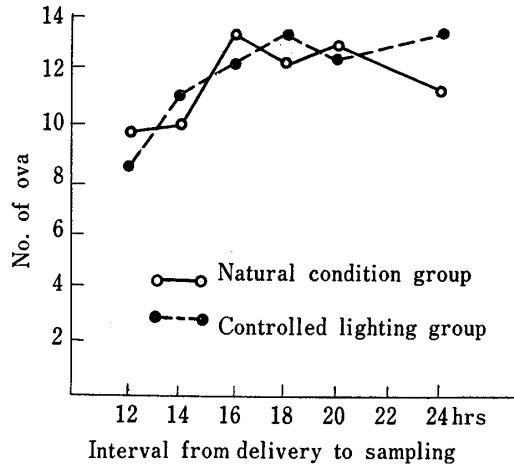


FIG. 2. Number of ovulation in postpartum.

TABLE 2. Relationship between Delivery and Ovulation Controlled.

Interval from delivery to ovulation (hrs)	Time of delivery										
	Day 1					Day 2					
	11-	14-	17-	20-	23-	2-	5-	8-	11-	14-	17-
0		0/1	0/1		0/1	0/2			0/1	0/1	
6	0/1			0/1	0/1	0/1			0/1	0/1	
12	0/1	2/3	1/2			0/2	0/1		0/5		0/1
14		3/3	1/3						3/3	1/2	0/1
16		1/2	2/2					1/1	1/1	1/2	
18	1/1	3/3	1/2	1/2	0/1	0/1			1/1		
20			1/1			1/1			1/1		
24		1/1	0/2	0/1		2/2			1/1		1/1

of the animals delivered between 20:00 and 11:00 hr (the next morning), the interval from the end of delivery to the post-partum ovulation is due to the time of delivery, especially in the animals which had delivered between 20:00 and 23:00 hr. They did not ovulate within 24 hours of post-partum. This means that post-partum ovulation is closely related to the end of delivery. The frontier reports (1-6) disagreed with each other, although the cause of this discrimination is not yet clarified, it must be thought that they had not given attention to the exact time delivery in each animal. So, it seems that the observation of delivery time in each animal is necessary in studies of post-partum events. The number of the shed ova in the rats delivered from 11:00 to 20:00 hr was 8-9 at 12 hours after delivery, and their number increased to 13-14 at 16 hours after delivery under both conditions, but these results disagree with the report of Ying *et al.* (5). However, it will be suggested that post-partum ovulation began about 12 hours after delivery and was completed at 16 hours after delivery. These results may suggest that ovulating hormone (OH) release of post-partum ovulation in the rats is closely related to the end of delivery, and the OH release of post-partum ovulation is

different to that in cyclic rats, assuming 12 hours to be the latent period from release of OH to ovulation (10, 11).

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