

MOTHER-INFANT INTERACTIONS IN THE ALBINO MICE (*Mus musculus*)

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ABSTRACT

The infant is, at birth, very dependent on maternal behavior and its survival is very difficult in the absence of either the mother or a conspecific adult which could care for it. In order to analyse maternal behavior of mice, 12 females and their litters were observed from the birth of infants to the 25<sup>th</sup> day **postpartum**. In relation to mothers, it has been noted that 1) both mother-infant contact and nest building time decrease during the first week; 2) maternal grooming of infant also decreases after the 14<sup>th</sup> day; 3) locomotion and self-grooming (head, paws, ventral and dorsal regions) were very irregular and not showing significant alterations during the lactation period. As far as the infants are concerned, it has been observed that 1) locomotion and self-grooming start at the 7<sup>th</sup> day and increase with age; 2) nest material manipulation and social-grooming (the infants groom or are groomed by other infants) start approximately at the 11<sup>th</sup> day

of age; 3) ingestive behavior (eating and drinking) - which reveals physical independence from the mother - begins around the 16<sup>th</sup> day **postpartum** and coincides with increased locomotor activity. It has been concluded that mother-infant interactions in mice are very dynamic and the maintenance of this link depends on the behavior of both mother and infant alike.

**KEY WORDS:** Maternal Behavior, Physical Contact, Locomotion, Grooming, Nest Building, Ingestive Behavior, Mouse.

### RESUMO

O filhote roedor é, ao nascer, extremamente dependente de cuidados maternos e seguramente teria a sua sobrevivência dificultada na ausência da mãe ou de um conspecifico adulto que lhe despendesse algum cuidado parental. Com o objetivo de analisar o comportamento materno do camundongo, 12 fêmeas, com seus respectivos filhotes, foram observadas desde o parto até o 25º dia **postpartum**. Em relação às mães, observou-se que 1) os tempos despendidos em contato físico com os filhotes e na arrumação do ninho decaíram logo na primeira semana; 2) a limpeza materna dos filhotes decaiu após o 14º dia; 3) os números de locomoções e de auto-limpeza (cabeça, patas e regiões ventral e dorsal) não sofreram alterações significativas durante o período de lactação. Em relação aos filhotes, observou-se que 1) a locomoção e a auto-limpeza surgiram por volta do 7º dia e aumentaram com a idade; 2) a arrumação do ninho e a limpeza social (limpar e ser limpado por um outro filhote) surgiram por volta do 11º dia; 3) os comportamentos ingestivos (comer e beber), que indicam independência física dos filhotes, surgiram em torno do 16º dia, período em que também ocorreu um aumento na atividade locomotora dos filhotes. Concluímos que a alteração mãe-filhote no camundongo é bastante dinâmica e a manutenção do vínculo depende tanto do comportamento do filhote quanto da própria mãe.

**UNITERMOS:** Comportamento Materno, Contato Físico, Locomoção, Limpeza, Arrumação do Ninho, Comportamento Ingestivo, Camundongo.

## MOTHER-INFANT INTERACTIONS

### INTRODUCTION

The infant rodent is, at birth, very immature and dependent on mother care. In most cases, the infants are born without fur and with closed eyes. The infant needs food, warmth and protection against predators. The survival of infants is very unlikely in the absence of the mother.

The infant attracts the mother's attention and this strategy is important for its survival. However, as the infant grows older, there is a gradual decrease in the mother responsiveness to the infant. This change in maternal behavior has been correlated with differences in the hormonal state of the mother and the development of its infant. However, the presence of infants is essential to maintain the mother responsiveness at a high level during the lactation period. The non-hormonal basis of maternal behavior in nonpregnants intact, ovariectomized and hypophysectomized females, as well as in intact and castrated rats, has been analysed only by exposures to young infants. When continuously exposed to young pups, these subjects exhibit maternal behavior (retrieving, crouching posture, licking and nest building) at high level (Rosenblatt, 1967). Males of California mice also show some care for the infants at the same level as that displayed by females (Gubernick and Alberts, 1986). Depending on the test conditions, paternal care could be elicited in infanticide male rats (Brown, 1986).

Pups are a strong stimulus which maintains the mother-infant link. During suckling, infant mice emit low-frequency calls. The wriggling calls maintain the mother responsiveness at a high level and bring about licking of the pups, changes in the suckling position, and increase in the nest building activity of the mother (Ehret and Bernecker, 1986).

Lactating female rats exhibit **postpartum** aggression toward an adult intruder. This phenomenon is dependent on the presence of the pups since maternal aggression decreases when

the pups are removed or placed inside a glass flask, while remaining in the nest (Ferreira and Hansen, 1986). In mice, lactating females also show **postpartum** aggression toward a female or a male intruder. Maternal aggression disappears after the 14<sup>th</sup> day of lactation or 5 hours after the removal of the infants (Galdelman, 1972). It has been concluded that olfactory cues of the infant and intruders are a critical element for maintenance of mother aggression (Gandelman, 1972; Ferreira and Hansen, 1986; Ferreira et al., 1987; Cohen-Salmon et al., 1986; Flannelly and Kemble, 1987).

Alterations in the mother-infant relationship cause serious problems for the development of the infant. Infant mice of prenatally-stressed (heat and restraint) female exhibit deficiencies in birth weight and body weight gain during lactation (Kinsley and Svare, 1988). Infant rats prematurely separated from their mothers show a high level of defecation and locomotor activity in open-field situations (Janus, 1987), or exhibit a great susceptibility to immobilization-induced gastric erosions (Ackerman et al., 1975). The early weaned rats die at faster rate, show a great cumulative ulcer length and are more active in activity-wheel cages (Glavin and Pare, 1985).

The infants are dependent on mothers for their survival and mothers are dependent on their infants for maintenance of maternal responsiveness. As the infant grows older, the mother-infant relationship is modified. In fact, the infant rodent, during the first weeks of life, exhibits several changes including body temperature control, ingestive behavior and increase in motor activity (see Rosenblatt et al., 1979; Rosenblatt, 1987; Rosenblatt et al., 1988).

The main purpose of the present work is to analyse some behavioral aspects of mother-infant relationship of albino mice (*M. musculus*), from the first day of life up to the 25<sup>th</sup> day **postpartum**.

## MOTHER-INFANT INTERACTIONS

### MATERIAL AND METHODS

Twelve females of albino mice (*Mus musculus*) and their infants have been used as subjects. Each female, in the beginning of the experiment, had approximately 100 days of age and was obtained from the stock of the Laboratório de Psicologia Experimental at the Universidade Federal de Santa Catarina.

Two chronometers (Technos, with cumulative record) and standard sheet notes have been used during observations. The subjects were housed in 40 x 30 x 17 cm polipropilene home-cages, with natural light/dark cycles.

Couples remained together for 10 days. After parturition, litters were artificially limited to 3 infants on the 5<sup>th</sup> day **postpartum**. For a better observation of infant behavior, one infant (focal-infant or FI) was randomly selected and marked with a short incision in its right ear.

Experimental 15 minute-sessions were routinely carried out from 4:00 to 9:00 p.m. and sleeping animals were gently awakened by slowly removing the home-cage. The pups were observed from birth up to 25 days of age. Infant and mother behaviors were separately recorded by two different observers.

Home-cages contained a standard quantity of wood shavings and food and water were provided **ad libitum**.

The following behaviors of mother and infant were recorded: **Mother-infant contact time**: Physical contact time with FI involving mutual touch of any part of the body, except tail and whiskers. In most cases, the mother assumes a crouching posture towards its infant.

**Mother and infant locomotion**: Dislocation either of the mother or the FI by voluntary movements of paws from one place to another.

**Nest building and nest material manipulation:** Nest building involving transport, putting together and biting of wood shavings that may result in a clear modification of nest structure by mother. On the other hand, nest material manipulation involving only biting of nest material by FI and not resulting in modification of nest structure.

**Grooming behavior:** Mother or FI lick any part of its own body (self-grooming). The following behaviors have been observed: a) maternal grooming of the FI - the mother licks any body part, usually the anogenital region, of its infant -, b) social-grooming - the infant either grooms or is groomed by another infant of the litter.

**Ingestive behavior:** The ingestive behavior of infant may be divided in: a) eating - the infant bites and eats food pellets, and b) drinking - the infant touches and licks the water tube. Each bite of food pellet has been considered as one episode of eating, and each contact of the mouth with the water tube as one episode of drinking.

## RESULTS, DISCUSSION, AND GENERAL CONCLUSIONS

### 1. Physical contact between mother and infant

After parturition, the mother and its infants remain in a close physical contact in the nest. The mother-infant contact time is very high during the first days after parturition (fig. 1). Thereafter, this time decreases and remains very irregular up to the 25<sup>th</sup> day **postpartum**.

Because of the posture of mothers during suckling, the contact of infant with mother nipple is very seldom directly observed. Therefore, the decrease in mother-infant contact time is a good indicator of infant weaning. The mother-infant contact which occurs during rest and sleep periods is very high in the first days **postpartum** and decreases as the infant grows older (Bolles and Woods, 1964). This decrease could be

## MOTHER-INFANT INTERACTIONS

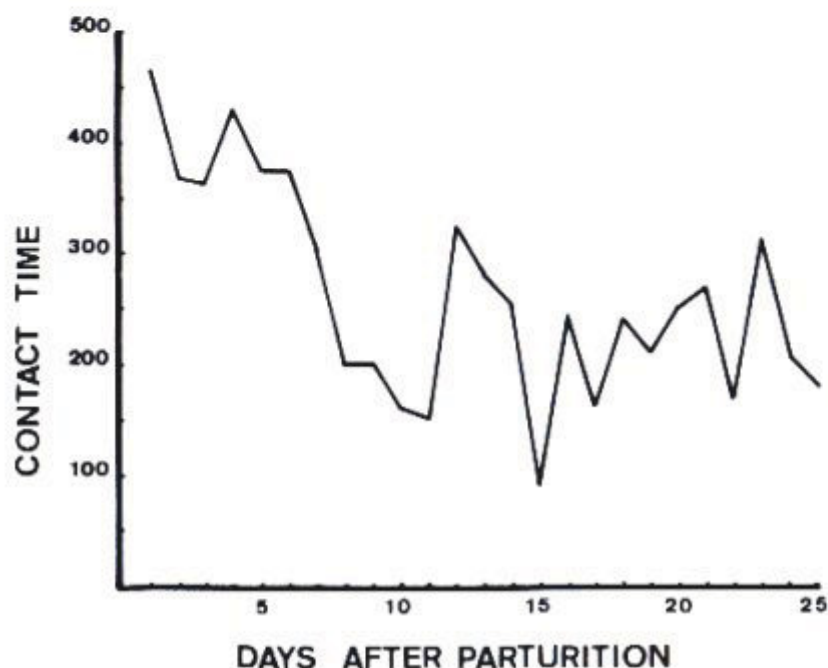


FIG. 1 - Mean contact time (seconds) between mother and infant as a function of increasing age of the infant.

related to litter, size, because female rats with litters of 12 infants show a faster decrease in contact time than those with litters of 4 infants (Grota and Ader, 1969). On the other hand, female gerbils of smaller litters expend greater level of nest building than those with bigger litters (Elwood and Broom, 1978). Males of California mice exhibit some parental care towards their infants. The physical contact time of males and females is identical and decreases, in some cases, as the infant grows older (Gubernick and Alberts, 1987).

The physical contact time could be analysed in a thermodynamic perspective. During lactation period mothers

are more sensitive to the infant's temperature. The physical contact stimulates an acute hyperthermia in the mother and limits the duration of intervals between contacts. In fact, some manipulations which affects the mother's ability to dissipate heat - by elevating room and litter temperatures or by removing the tail of the mother - decrease the duration of mother-infant contact time (Leon et al., 1978). An acute hyperthermia causes withdrawal of the mother. As time goes on, the infants are cooled and emit ultrasonic vocalizations which may stimulate the mother to go back to the nest (Jans and Leon, 1983). Infant rats play an active role in maintaining the mother-infant contact. The infants stimulate the mother to release both prolactin and ACTH, which increase progesterone and corticosterone levels, respectively. Progesterone may increase the thermal set point of the mother and corticosterone may be necessary to elevate the heat production and retention (Adels and Leon, 1986).

## 2. Locomotion

Mothers usually show an irregular frequency of locomotion. On the other hand, the infant locomotions gradually increase from the 8<sup>th</sup> day **postpartum** (fig. 2).

Initially, infant locomotions were very rare - something like a creeping behavior - and usually occurred only inside the nest. After the 16<sup>th</sup> day **postpartum**, a sudden increase occurs in the locomotion frequency, which seems related to the infant's opening of the eyes, which has been noted after the 15<sup>th</sup> day. Thereafter, infant locomotions increase with age and are more frequent near the nest. It has been noted that mothers exhibit higher levels of locomotion than infants.

The locomotion of infant rats emerges, in the same manner, up to the 8<sup>th</sup> day of age and begins its development through a crawling motion inside the nest. As the infant grows older, the crawling behavior disappears and the normal locomotion (walking, running, and jumping) becomes more



## MOTHER-INFANT INTERACTIONS

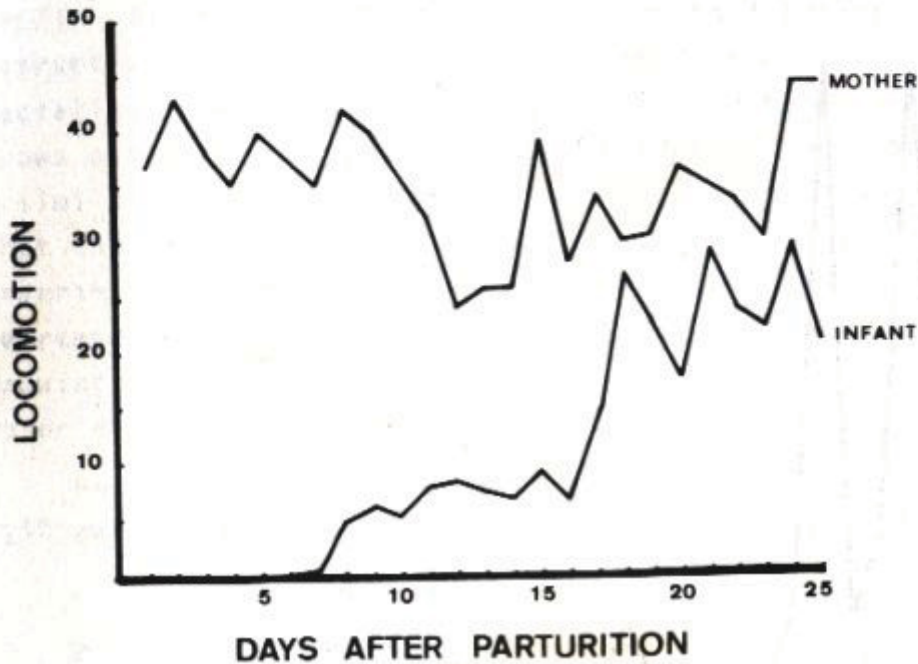


FIG. 2 - Mean number of mother and infant locomotion as a function of days after parturition.

frequent (Bolles and Woods, 1964). Infant rats submitted to an isolation period show a high level of exploratory locomotion and attentive immobility (Baenninger, 1967).

### 3. Nest building and nest material manipulation

The nest building time spent by the mother was very high during the first week after parturition. Thereafter, there is a sudden decrease in this activity, which lasts until the 25<sup>th</sup> day postpartum (fig. 3).

Nest building is an important activity for lactating females. In fact, the nest structure allows a better retention of heat, protects the infants against predators and

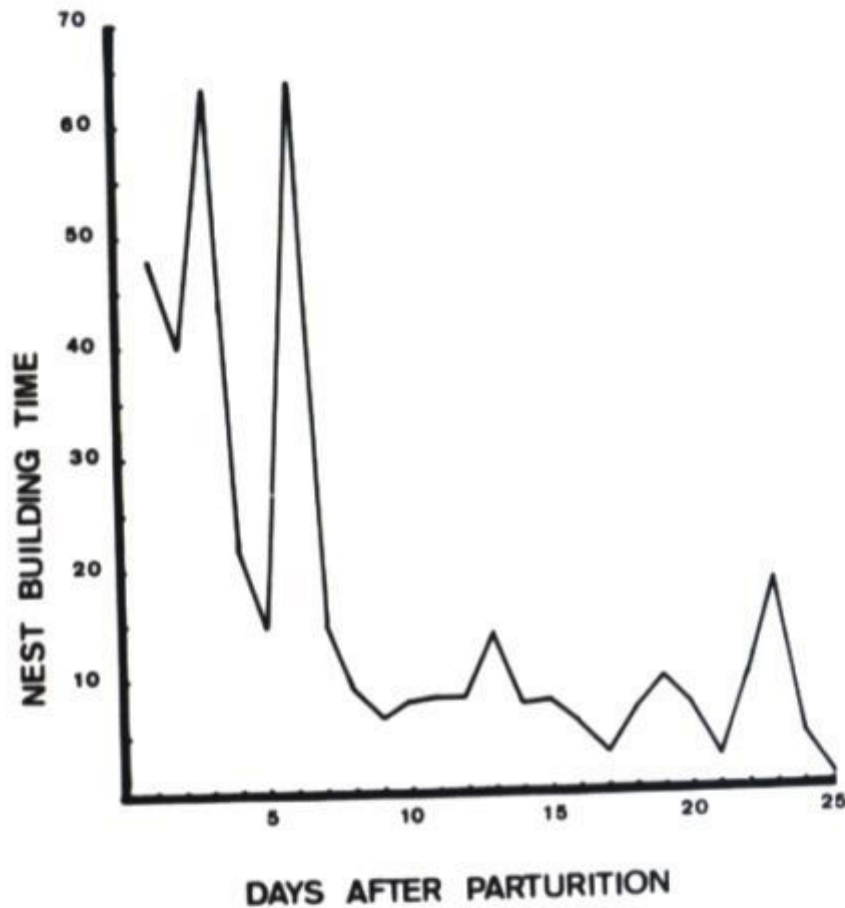


FIG. 3 - Mean time (seconds) spent by the mother in nest building activity as a function of days after parturition.

simultaneously provides comfort for the mothers and their infants. Therefore, nest building is essential during the first days after parturition, since infants are more vulnerable, and the decrease in this activity could be related to infant development. In fact, the lactating female rats exhibit a visible decrease in nest building activity after the first week postpartum (Grota and Ader, 1969). This behavior

## MOTHER-INFANT INTERACTIONS

could be elicited by prolonged exposure of the young to nonpregnant intact, hypophysectomized and ovariectomized females as well as intact and castrated males (Rosenblatt, 1967). On the other hand, septal-forebrain lesions produce a disruption in nest building and other maternal activities in lactating female rats (Flanelly *et al.*, 1986). As the infant grows older, primiparous and multiparous mother hamsters show a similar decrease in the nest building level, suggesting that the emergence of this activity may not dependent on experience (Swanson and Campbell, 1979). On the whole, the decrease in mother nest building time, as a function of infant growing, is expected since infant temperature control and motor development increase with age.

Nest material manipulation by the infant begins on the 12<sup>th</sup> day postpartum (fig. 4). At first, the infant bites the

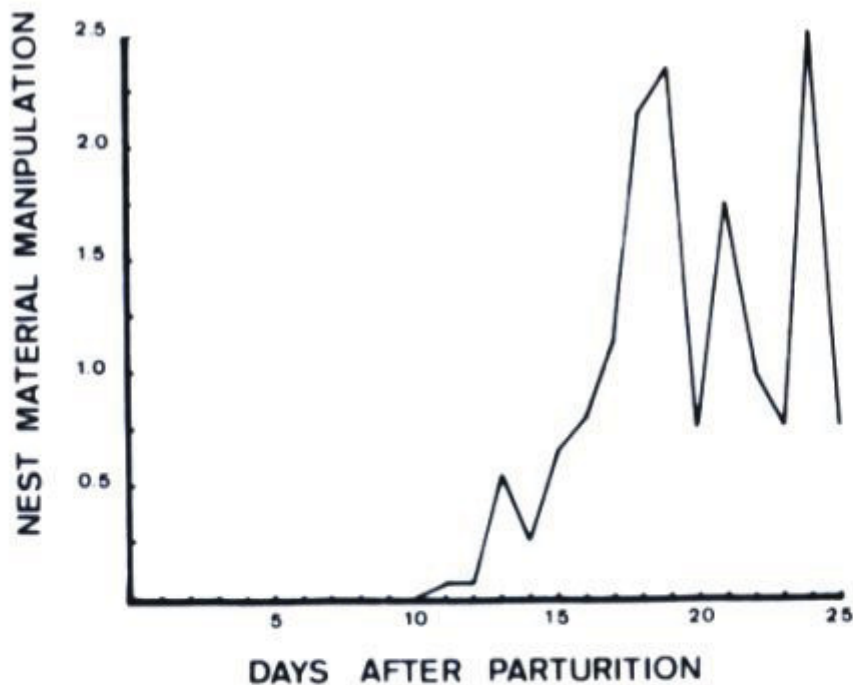


FIG. 4 - Mean number of nest material manipulation by the infant as a function of days after parturition.

wood shavings and very seldom transports the nest material to the center of the nest. This behavior never causes an effective transformation in the nest structure. From the 14th day on nest material manipulation becomes suddenly more frequent.

**4. Grooming by mother, self-grooming and social grooming**

It has been noted that the number of mother self-grooming was very irregular (fig. 5). It is clear, however, that grooming of the head and dorsal region was considerably higher than grooming of the paws and ventral region.

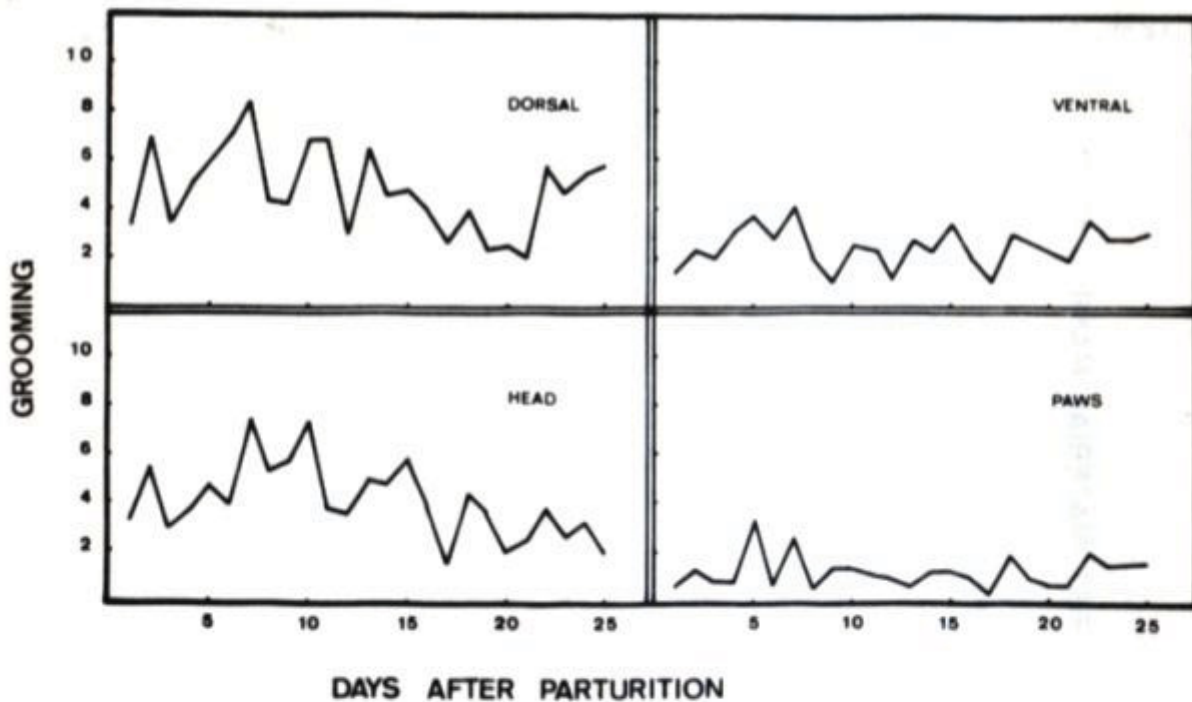


FIG. 5 - Mean number of episodes of self-grooming (paws, head, ventral, and dorsal regions) by the mother as a function of days after parturition.

## MOTHER-INFANT INTERACTIONS

At the end of pregnancy, grooming level of "critical regions" (pelvic region, nipples and anogenital area) increases in female rats. At parturition, mother self-grooming decreases and maternal grooming of infant becomes more frequent (Rosenblatt and Lehrman, 1963).

Infant self-grooming was non-existent during the first days of life (fig. 6). Thereafter, around the 7th day **postpartum** the infant shows a gradual increase in the activity. Grooming of the infant rat is very similar and also occurs during the first week of age. In fact, self-grooming changes as the infant grows older. In the beginning, facial grooming is more frequent and, a few days later, an increase in the frequency of social-grooming occurs (Bolles and Woods, 1964).

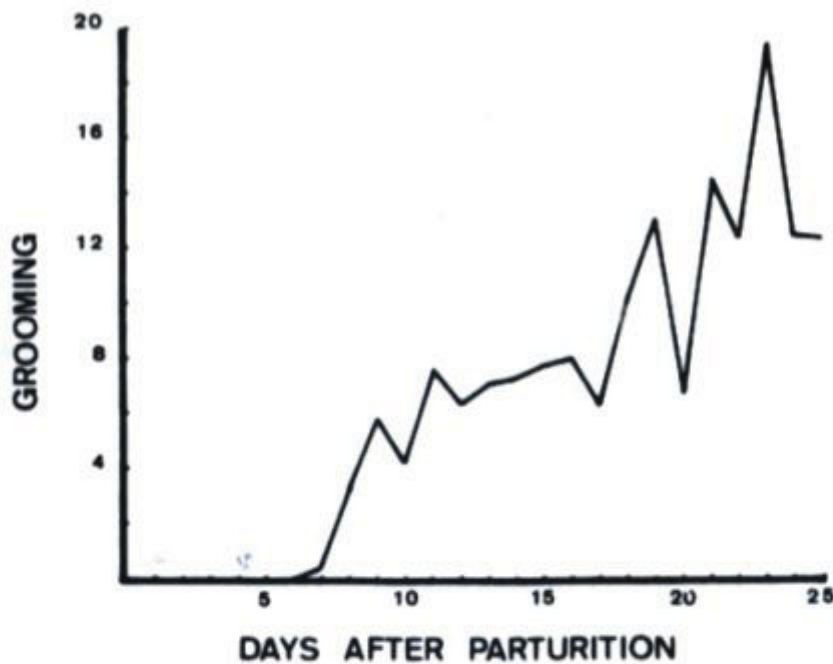


FIG. 6 - Mean number of episodes of self-grooming by the infant as a function of days after parturition.

Similarly, social-grooming of infant mice occurs immediately after the occurrence of self-grooming (fig. 7). Shortly after the 12<sup>th</sup> day postpartum a visible increase in this activity has been noted. The infant grooms (active) or is groomed (passive) by another infant at same time and shows a similar gradual increase as far as self-grooming is concerned.

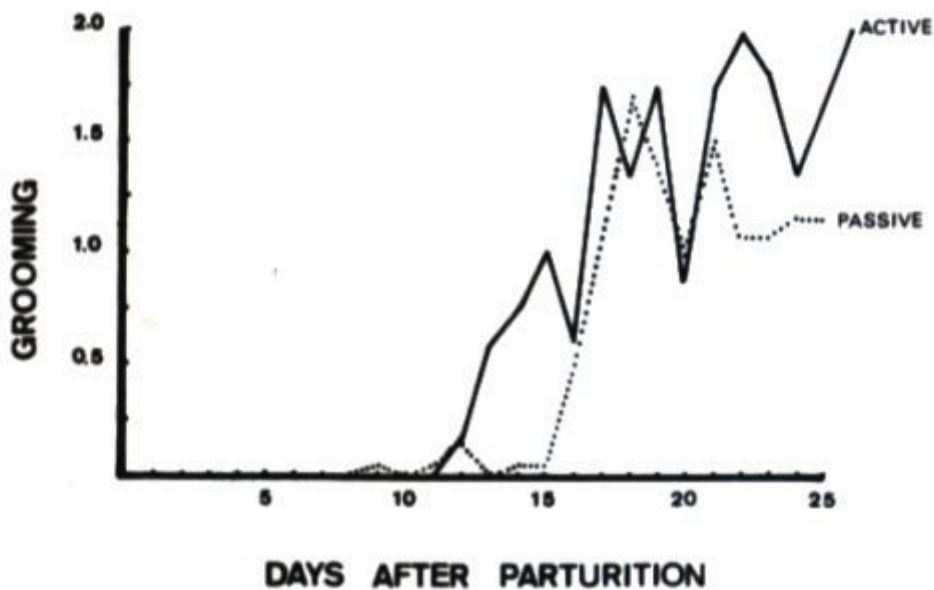


FIG. 7 - Mean number of social-grooming (the infant grooms, active, or is groomed, passive, by another infant) as a function of the increasing age of the infant.

During the observation period, infants were groomed by the mother at an irregular frequency (fig. 8). Furthermore, mother grooming of infant decreases after the 14<sup>th</sup> day postpartum and remains low until the 25<sup>th</sup> day.

Grooming of the infants by their mother is an important activity for the survival of the infants. At the birth, lactating female rats lick the anogenital region of the infants and this behavior stimulates both the reflexive urination by the infants and mother drinking of released urine

## MOTHER-INFANT INTERACTIONS

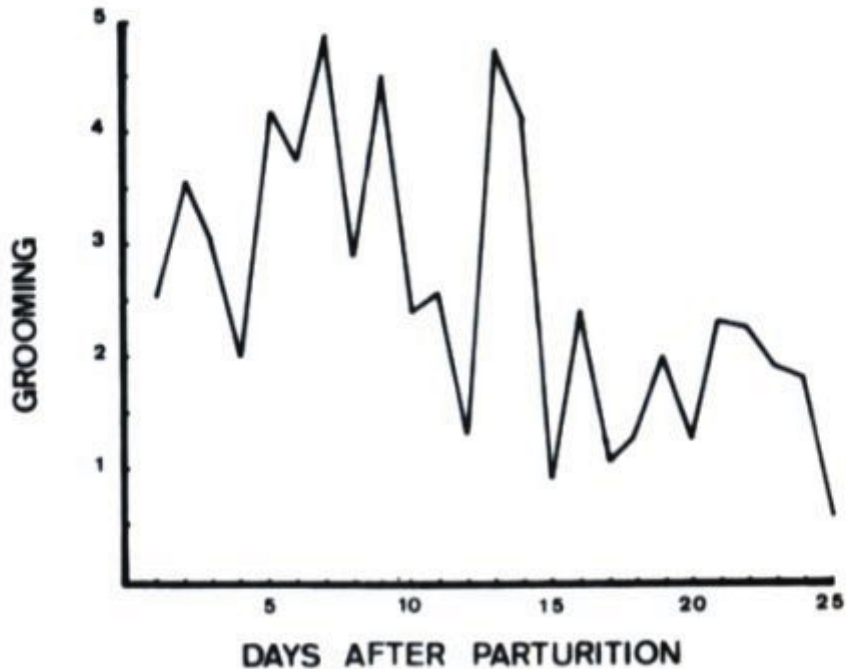


FIG. 8 - Mean number of episodes of infant grooming by the mother as a function of days after parturition.

(Friedman and Bruno, 1976; Friedman et al., 1981). The consumption of infant's urine could be partially explained by the increased water loss of mother during lactation and by a specific salt appetite. In fact, lactating female rats deprived of infant's urine show an increase in their consumption level of water and electrolytes, while mothers deprived only of water spend much more time liking the infant's anogenital area (Friedman et al., 1981). Mother anogenital licking of the infant could not be explained only by interchange of body fluids between them, since virgin female rats continuously exposed to newborn infants become "voracious consumers" of infant's urine and licks their anogenital region just as lactating females (Gubernick and Alberts, 1985). The consumption of infant's urine is an

important activity because it provides water and electrolytes to the mother, stimulates reflexive urination and eliminates the olfactory cues which attracts predator attention.

### 5. Development of ingestive behavior

No ingestive behavior has been noted before the 16<sup>th</sup> day **postpartum**, apart from milk suckling (fig. 9). Thereafter, the infant begins to bite food pellets and, after the 17<sup>th</sup> day **postpartum**, this behavior evolves and becomes abruptly more frequent. On the other hand, drinking behavior is much lower than eating behavior and begins in the 18<sup>th</sup> day **postpartum**.

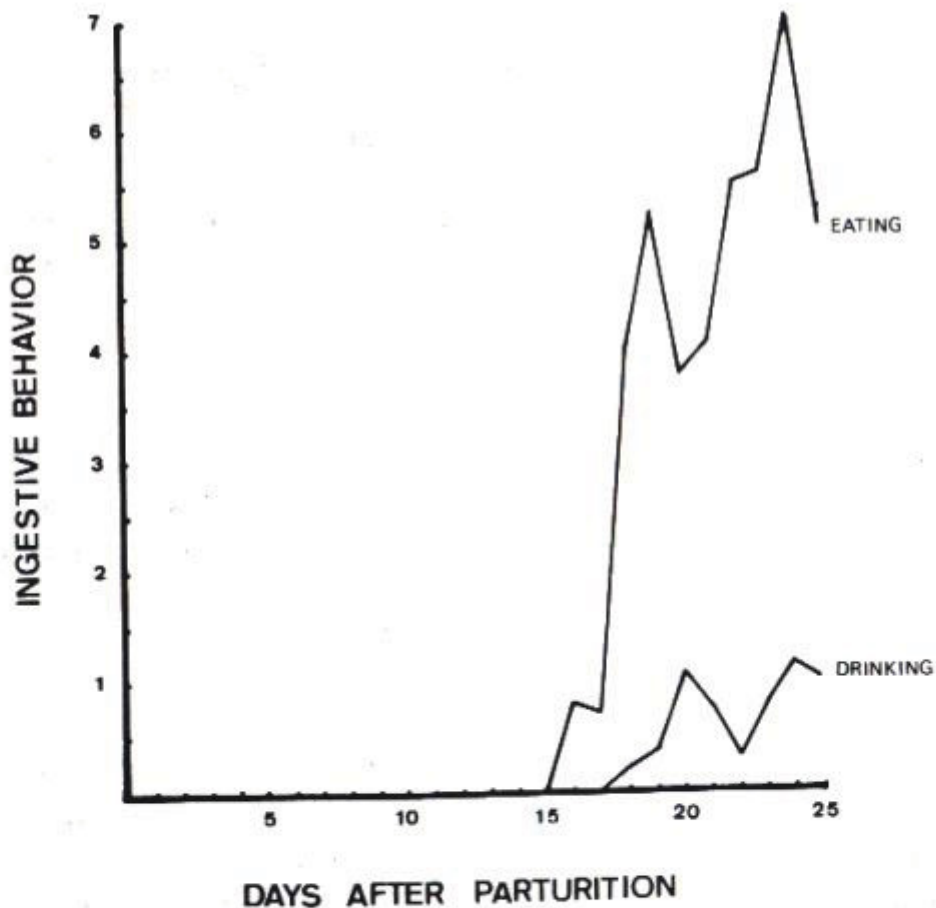


FIG. 9 - Mean number of ingestive behavior (drinking and eating) of the infant as a function of its increasing age.



## MOTHER-INFANT INTERACTIONS

The increase in ingestive behavior level indicates both the development of the infant and its independence from the mother. This phenomenon appears to be related to the opening of the eyes which occurs at about the same time.

### 6. General Conclusions

Mother-infant interaction in mice is a very important mechanism for the survival of the infants. Moreover, the mother depends on the infants in order to maintain its maternal responsiveness at a high level and the infants are greatly dependent on their mother for protection against predators and food provision.

The time spent by the mothers in contact with their infants and in nest building activity suddenly decreases after the first week **postpartum**. On the other hand, the infants simultaneously show a sudden increase in their locomotion level, nest material manipulation and social-grooming activity, which clearly indicates the beginning of the infant's social interactions. As the infant grows older, and becomes more independent, maternal care decreases. Around the 15th day **postpartum**, the infant opens its eyes, begins to eat solid food and spontaneously licks the water tube. In this period, the mother shows a lower level of infant grooming, and both contact time with their infants and nest building time decrease. It has been concluded that the decrease in the mother responsiveness is related to the physical development of infants.

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R. F. GUERRA AND M. L. VIEIRA

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