in the amount of retinal illumination required to achieve threshold. The greatest separation occurs at 7.5 minutes, when there is approximately 1 log troland difference.

In one analysis of the data we shifted the curve formed by the control threshold values laterally to 3 minutes earlier (Fig. 2). The shapes of these curves are identical, and the curves essentially are not different. The effect was demonstrated by three of the four subjects. The woman who failed the stereopsis test did not exhibit any effect at all; apparently normal binocular vision is necessary for it (*4*).

We conducted brief experiments on one subject to determine some of the limits of the effect. We found that light adaptation in the contralateral eye, not only for the 5 minutes of light adaptation but also for the entire 40 minutes of the dark-adaptation period, had no effect on the dark-adaptation curves; this light adaptation was the same as the control.

Since there had been a difference in size and intensity for the light-adapting fields for the left and right eyes in the original study, we determined what, if any, effect equal adaptation states for the two eyes would have. Before dark adaptation, the eyes were simultaneously exposed together for 5 minutes to an adapting field outside the adaptometer. The threshold determinations made under the control and experimental conditions were not significantly different.

Finally, when the inducing field of the contralateral eye was made much brighter (by 1.2 log units) the interocular effect vanished. When the inducing field was dimmed by 0.3 log unit, the time shift appeared unchanged.

The last findings may provide a clue to the nature of the effect. With both of the light-adapting fields similar in luminance but different in size and retinal location, both are clearly seen simultaneously; this is also true when the inducing field was made slightly dimmer. Making the inducing field brighter by 1.2 log units caused rivalry between the fields, and during adaptation to light the subject could see only with one or the other eye alternately. On the other hand, when both dissimilar patterns can be seen superimposed, there is strong local suppression of each light-adapting field by the other. The region where the stimulus will appear is clearly dimmed during light adaptation by local suppression from the inducing field. Dark adaptation is but a special case of light adaptation—an adjustment to lowered levels of luminance. A light-adapting effect which is directly related to the subjective brightness of the adapting field may be superimposed upon the well-known peripheral light-adaptation processes.

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4. Since the original study was completed, four other subjects have been tested for the facilitating effect. One male subject who had stereopsis did not demonstrate binocular facilitation.
5. We thank Bonnie Lawrence, D. Peeples, and B. Hurley for their assistance. This study was supported by NSF-RPCT GY-2378.

7 March 1969

Communal Nursing in Mice: Influence of Multiple Mothers on the Growth of the Young

Abstract. *Female mice will combine their litters into a communal nest. The young raised in a communal nest show faster rates of growth during the first 20 days than young raised by single females, even when the ratio of mothers to young is the same.*

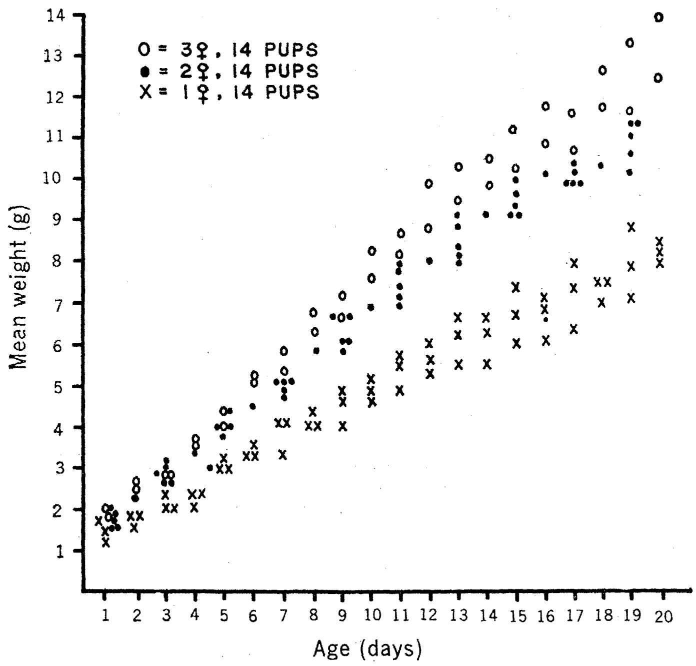
In certain species of feral rodents (*Mus, Peromyscus*), more than one female in a local population may achieve pregnancy at the same time. Under these circumstances, the females may combine their young in a communal nest, which they continue to share for several consecutive litters and often share with the litters of their daughters (*1*). Findings on albino mice raised in the laboratory have confirmed these observations. On parturition, pregnant mice housed in the same cage would build one nest, combine their litters, and nurse them simultaneously. This phenomenon occurred even when there was a discrepancy of up to 12 days in the age of the young or when the area of the cage was increased several times (*2*). Because this "socialized" form of maternal behavior occurs so consistently but has not been experimentally analyzed, we determined in what ways communal nursing influences the development of the young. The results show that the growth rate of mice is enhanced by the presence of more than one mother, even when the ratio of mothers to young is constant.

Table 1. Body weights of individual *Mus* pups taken at 9 and 19 days of age (mean ± S.E.).

Group (female: young)	Pups (No.)	Body weights (g) 9 days*	Body weights (g) 19 days†
1 : 14	35	4.59 ± 0.14	7.98 ± 0.19
1 : 7	42	5.55 ± 0.14	10.81 ± 0.17
2 : 14	70	6.36 ± 0.10	11.15 ± 0.10
3 : 21	83	6.77 ± 0.28	11.96 ± 0.10
3 : 14	28	7.04 ± 0.18	12.77 ± 0.19

* All groups differed significantly ($P < .005$, two-tailed *t*-tests) except for the following: 3:21 and 2:14; and 3:14 and 3:21. † All groups differ significantly from one another ($P < .025$, two-tailed *t*-tests).

Nulliparous pregnant mice (inbred strain BALB/c) were removed from community cages 5 to 7 days before parturition and placed in separate cages. On the day of parturition, mothers and their young were combined randomly in various groupings. These consisted of the following ratios of mothers to young: eight litters of one mother with seven pups (1:7); six litters of two mothers with 14 pups (2:14); six litters of three mothers with 21 pups (3:21); six litters of one mother with 14 pups (1:14); and four litters of three mothers with 14 pups (3:14). Seven was chosen as the standard litter size because it approximated the average number of young produced by our primiparous females. The cages (20.5 by 36 by 15.5 cm) contained bedding (Sanicel) and were devoid of any nesting materials (*3*). The mice were given free access to breeding chow and water. The females and their young were simultaneously introduced into each cage, and the young of each female were placed in separate piles. By the end of their first day together, the females combined their litters into one pile in a corner of the cage. The young in each cage were weighed as a group every other day. The day following parturition was regarded as day 1. Most of the litters were weighed on



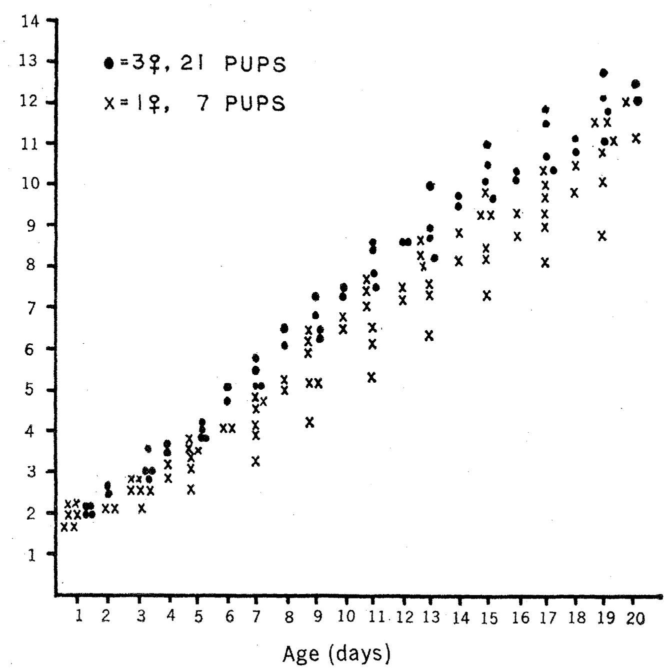


Fig. 1 (left). Growth rates of litters of 14 pups during the first 20 days when provided with one, two, and three mothers. Fig. 2 (right). Growth rates of two different litter sizes when the ratios of mothers to young are constant.

odd days, but a few litters of each group were weighed on even days to obtain weight values for each day. Each pup was weighed at 9 and 19 days of age. The differences in weights among the 9- and 19-day groups were compared by a one-way analysis of variance. Significant F values were obtained for both the 9-day group ($F_{4;253} = 73.9$, $P < .001$, d.f. $= 257$) and the 19-day group ($F_{4;253} = 93.8$, $P < .001$, d.f. $= 257$); t-tests were consequently run on these data (Table 1). In a few cases pups died before the end of the experimental period. For this reason some of the sample sizes given in Table 1 are not exact multiples of the litter size (*4*).

When additional mothers were present, and litter size was held constant at 14 young, growth rates of the young were accelerated (Fig. 1). These differences were apparent when the young were weighed individually at 9 days of age and were even more exaggerated at 19 days of age (Table 1). The differences in body weight are most likely related to the nutritional benefit of additional milk provided by more than one mother. When an increase in litter size was accompanied by additional lactating females, but the ratio of mothers to young held constant, differences were also evident (Figs. 1 and 2) (*5*). In these groups (1:7, 2:14, and 3:21) all the young presumably had an equivalent access to milk. Although there were no statistically significant differences between the body weights of the 2:14 and 3:21 groups at 9 days, all of these young weighed significantly more than the 1:7 group (Table 1). By 19 days of age, differences between each of the groups were more obvious and all differed significantly from one another.

Differences in rates of growth by pups are affected not only by possible nutritional factors provided by extra mothers, but also by other influences associated with additional mothers and littermates. There are three categories of stimuli that could act to promote faster growth rates in our communal groupings: tactile, thermal, and nutritional. In rats, tactile stimuli associated with handling of the pups during the first 10 days of life resulted in higher individual body weights at a later age, but this effect was not apparent until 69 days of age (*6*). The same phenomenon may occur in mice, with tactile stimuli emanating from additional mothers and young in some unknown way promoting an increased body weight during the first 20 days. Murid rodent pups regulate their temperature poorly during the early neonatal period. The presence of additional littermates and mothers could serve to insulate the pups, so that more metabolic energy could be devoted to growth. Finally, we have noticed that communally nursing females will simultaneously nurse during the first few days postpartum, but as the pups grow older and their milk demands increase, the mothers tend to nurse alone and relieve one another at nursing duty quite frequently. This arrangement may allow the pups an increased amount of uninterrupted feeding time and permit the females to furnish more milk of a higher quality.

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3. In other tests, with paper or cotton present in the cages, the females would still build one nest and deposit their young in this area. In the present experiment, nesting material was eliminated to keep the cage environment of all groups as similar as possible.
4. Most of the deaths occurred in the 1:14 group. In two of these litters, 13 young survived the 20-day experimental period and in one litter only nine pups survived. Few deaths occurred in the other groups. In the 1:7, 2:14, and 3:14 groups, all young survived. One pup was lost from one of the 3:21 litters.
5. Comparison between regression lines computed from both the litter groupings of Fig. 2 showed that the growth rates of the 1:7 ($y = 0.52x + 1.02$) and 3:21 groups ($y = 0.56x + 1.55$) differed significantly ($t = 2.190$, $P < .025$, d.f. $=$ 136, one-tailed test).
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