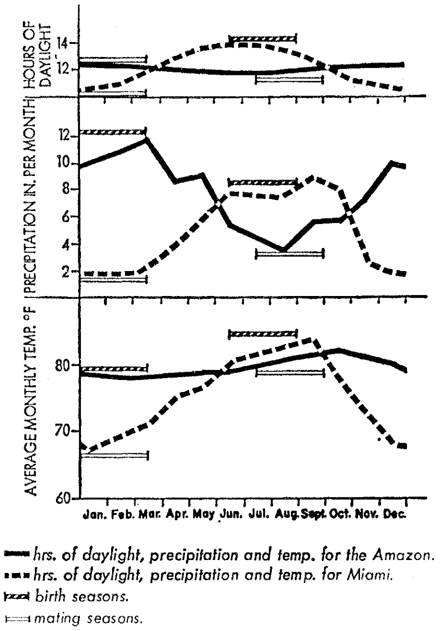

Fig. 3. Climatological comparison of the Western Amazon Basin with the local Miami environment, showing in both environments the correlations of birth season with periods of maximum rainfall and of mating seasons with periods of minimum rainfall.

the cycle for Iquitos is only ± 11 minutes, and it is difficult to seriously consider this as a triggering or controlling factor.

The precipitation cycles in the two environments occur 6 months out of phase. In both environments the mating seasons occur during the dry periods, whereas the birth seasons occur during the rainy ones. Thorington (*8*) reports that a birth season occurs during February, March, and April in San Martin, Colombia, which is 4° north of the equator and in the same, though greatly attenuated, light-dark cycle as Miami. However, the rainy season for the area is March, April, and May. Again the correlation is evident. There was no apparent relationship between the temperature cycles of the two environments and reproduction.

Mating seasons occur in the valleys of the precipitation curves for all three environments reported. There must be present in the early dry season some factor that causes hormone production to begin. Two possible ones are (i) the wavelength quality of solar radiation as influenced by atmospheric moisture, and (ii) a nutritional factor possibly associated with the forest flowering sequence, which in turn is usually associated with nonvegetative phases during dry periods.

More and more primates are being described as seasonally reproductive and, although ours, we believe, is the first report of such a phenomenon in a New World primate, others may also exhibit some form of seasonal reproduction. What may be unique in the *Saimiri* is the extent to which this sexual periodicity influences the whole animal, causing in the males significant physiological, morphological, and behavioral changes that have not been observed in the Old World primates reported to date.

Our findings suggest that mating phases of both sexes must be in synchrony before reproduction can occur. Reproduction asynchrony may result from random pairings of animals in various stages of the shift in the cycle from feral environment to the laboratory environment. These factors, which probably have not been considered by investigators attempting to establish breeding groups, may be associated with the history of poor reproduction among squirrel monkeys in laboratories. Groups composed of animals simultaneously imported during the feral mating season, or in which permanent membership has been maintained over several years, would probably be in reproductive synchrony.

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References and Notes

1. S. B. Lancaster and R. B. Lee, in *Primate Behavior: Field Studies of Monkeys and Apes*, I. DeVore, Ed. (Holt, Rinehart, and Winston, New York, 1965), pp. 496–513.
2. C. R. Carpenter, *Comp. Psychol. Monogr.* **10**, serial No. 48 (1934); *J. Mammol.* **16**, 171 (1935).
3. F. V. Du Mond and R. W. Cooper, *Lab. Primate Newsletter* **4**, 1 (1965).
4. C. H. Conaway and D. S. Sade, *Folia. Primatologica* **3**, 1 (1965).
5. P. D. MacLean, *Science* **146**, 950 (1964).
6. A more detailed description of the unique environment may be found by F. V. Du Mond, in *The Squirrel Monkey*, L. Rosenbloom and R. W. Cooper, Eds. (Academic Press, New York, in press).
7. W. G. Kendrew, in *Climate of the Continents* (Oxford Univ. Press, New York, 1953); *World Weather Records 1941–50* (U.S. Department of Commerce, Washington, D.C., 1951; *World Weather Records 1951–60* (U.S. Department of Commerce, Washington, D.C., 1961).
8. R. W. Thorington, Jr., in *The Squirrel Monkey*, L. Rosenbloom and R. W. Cooper, Eds. (Academic Press, New York, in press).
9. Supported by FDA contract No. 67-54, NIH grant 2R01 HD02743-02, and Monkey Jungle, Inc., Miami, Florida. We thank Reinaldo Ramos for his assistance in tissue preparation.

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Behavior Development in the Dog: An Interspecific Analysis

Abstract. *Young dogs were maintained in isolation from other dogs and under varying degrees of exposure to an alien species (mature rabbits). Parametric observations indicate that an interspecific social attachment develops during the initial hours of cohabitation. The later social interaction patterns of the dogs were influenced, but not irrevocably fixed, by the early cross-specific rearing experience.*

Immature animals that have been isolated from their own kind and reared with another species generally demonstrate a strong affinity for the "alien" animals (*1*). Despite the relevance of this curious phenomenon for the processes of species-identification and attachment behavior, it has been infrequently studied under laboratory conditions (*2*). Virtually no information is available with respect to the time-course of the process in mammals, or the extent to which the effects of early exposure to an alien species are enduring. To obtain parametric data on these issues, we reared young canines under various conditions of interaction with mature lagomorphs. We found that interspecific attachments develop with great rapidity in young dogs, an outcome which is in accord with the stimulus pattern theory of mammalian attachment behavior (*2*)

In our first experiment, 30 purebred dogs from the Jackson Laboratory were placed at 29 ± 2 days of age in individual compartments (1.2 by 0.8 by 1.2 m high) enclosed on four sides by opaque walls and open at the top. The rearing conditions permitted neither physical nor visual contact with other dogs. Ten animals were assigned to each of three conditions: (i) interaction, in which a dog was permitted continuous physical contact with a rabbit cohabitant; (ii) noninteraction, in which a dog and rabbit were separated by a double wire fence (2.5 by 5.1 cm interstices) down the midline of the compartment, which permitted visual and olfactory stimulation but no physical contact; and (iii) isolation, in which a dog was reared alone. The rearing conditions were comparable for all conditions save the varying degree of contact permitted with the alien cohabitant. Five pure breeds of dogs were used: basenjis ($N = 7$), beagles ($N = 4$), cocker spaniels ($N = 2$), Shetland sheepdogs ($N = 8$), and Telomians ($N = 9$). Within each sex-breed category, animals were assigned at random to the three experimental conditions. The cohabitants were mature rabbits obtained from the stocks of the Jackson Laboratory.

At the start of the experiment, the pups were placed alone in the compartment for 2 hours, after which the rabbit cohabitant was introduced. To investigate the development of attachment formation, a series of cohabitant removal-replacement tests was conducted. Each test ran for 18 minutes and involved six alternating periods in which the rabbit cohabitant was in the compartment for 3 minutes and then removed for 3 minutes. The indices of disturbance recorded were the number of vocalizations emitted by the young dog and the amount of locomotion shown by the dog in the cohabitant-absent periods relative to the cohabitant-present periods. For dogs reared alone in the isolation condition, these indices were recorded during the same time periods with no removal-replacement introduced. Removal-replacement tests were conducted with every animal after 0, 1, 2, 4, 8, 24, 48, 96, and 168 hours, and thereafter at weekly intervals.

The vocalization results over the first week of cohabitation are given in Fig. 1. By the end of the first day, animals in the interaction condition whined and yelped at high rates during those occasions when the rabbit was removed. Vocalization was accompanied frequently by the dogs' moving about the compartment and scratching at its walls. Similarly, a significant but less pronounced effect was observed after 1 week of experimental confinement for dogs in the noninteraction condition. Subsequent weekly tests indicated decreasing levels of vocal and motor disruption during the absence of the rabbit cohabitant, a finding which is consistent with the report of Elliot and Scott (*3*). However, the interaction group after 8 weeks of cohabitation continued to vocalize at a significantly elevated rate indicating a lack of habituation to this separation. Comparable results in terms of curve form and levels of statistical significance were obtained in the analysis of general activity (that is, locomotion). The results obtained in the noninteraction condition indicated that physical contact facilitates, but is not necessary for, the separation-disruption phenomena (*4*).

After 5 weeks of cohabitation, the dogs' "social" preferences were assessed in a series of learning trials in a Y maze with a noncorrective procedure. In this apparatus, the dogs could learn to choose either their rabbit cohabitant (or, in the case of dogs assigned to the isolation condition, a rabbit which had cohabited with another pup) or an empty goal area. Tests were conducted over a 5-day period, with two sets of three trials each day. For a given dog, the placement of his rabbit cohabitant was constant and he was required to learn a position response. If the dog did not enter one of the two goal areas within 6 minutes of the first day or within 3 minutes of succeeding days, he was placed in either the right or the left goal area. In all instances, the animals were permitted to remain in the goal area for 60 seconds prior to the beginning of the next trial. The index of preference obtained was the number of trials that the dog freely selected the rabbit minus the number of trials that he ran to the empty goal compartment.

No dog (0/10) in the interaction condition, 20 percent (2/10) in the noninteraction condition, and 60 percent (6/10) in the isolation condition selected the empty compartment more frequently than the compartment containing the rabbit. Furthermore, the amount of behavioral disruption (as assessed by amount of vocalization) observed among dogs in the interaction condition during the 5th-week removal-replacement test provided a remarkably reliable gauge of the pups' choice behavior. Thus the more disrupted the dog was by rabbit-cohabitant separation, the greater was the likelihood that he would approach the rabbit ($\rho = .81$, $P < .01$). A significant correlation was found only for the dogs in the interaction condition.

A final test series was conducted after 8 weeks of cohabitation. Over four test trials given daily, the dogs were permitted to approach a rabbit in a neutral 1.8 by 1.8m test chamber. On two trials, the test animal was the dog's cohabitant, or, in the case of isolated dogs, a rabbit that had cohabited with another pup. In the remaining trials, the test animal was a rabbit which had not been maintained in interspecific cohabitation. The latency recorded was the time elapsed from the dog's entry into the compartment to the point at which it made physical contact with the test animal. If the dog

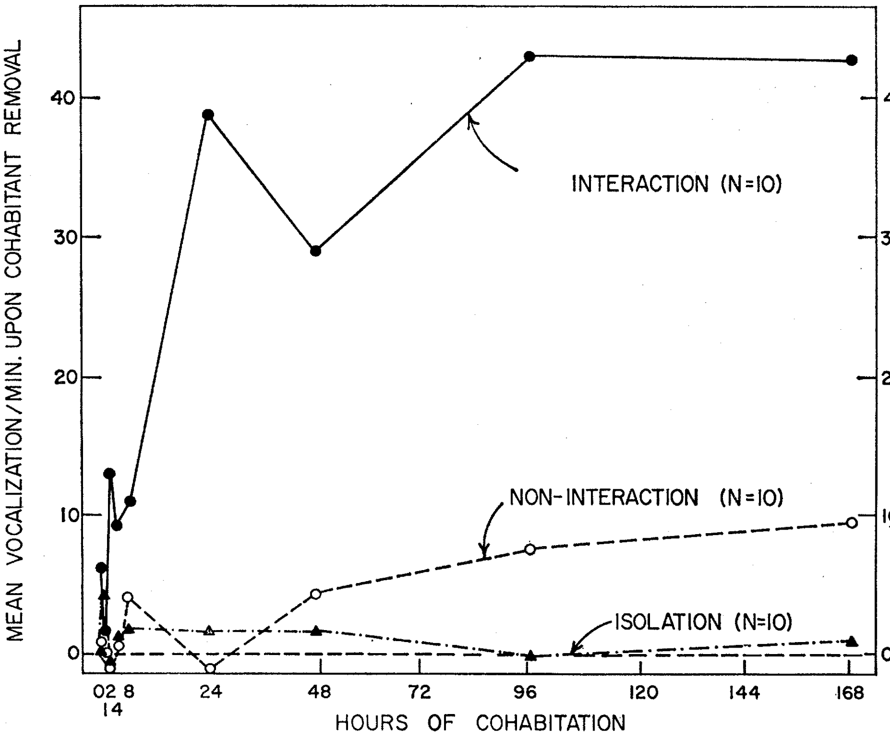

Fig. 1. Amount of vocalization, plotted as a function of number of hours of cohabitation for the three experimental conditions. These data represent the mean vocalization difference scores (vocalization when rabbit was removed minus vocalization when rabbit was present). Analysis by the *L* test (*13*) indicates that both the interaction ($P < .001$) and noninteraction ($P < .01$) conditions show increase in discriminative vocalization during the first week of cohabitation.

Table 1. Median latency (in seconds) for dogs to approach cohabitant and noncohabitant rabbits. Separate analyses of variance upon the scores obtained in a logarithmic transformation of the prime data indicate that the three groups of dogs differed in their latency in approaching both the familiar ($F = 6.61$, df $= 2/27$, $P < .01$) and unfamiliar ($F = 6.21$, df $= 2/27$, $P < .01$) test animals.

Condition	Test animal	
	Cohabitant	Noncohabitant
Interaction	4.0	9.0
Noninteraction	8.0	52.5
Isolation	128.0	193.0

did not approach the test animal within 5 minutes, the test was terminated. Again, the groups differed markedly in their approach behavior. Median latencies are presented in Table 1. Animals in the interaction condition had the shortest latencies, while animals in the isolation condition had the longest latencies, with the latter dogs frequently failing to contact the test rabbit in the entire 5-minute period (*5*). Apparently the essential phenomenon is trans-situational, and not restricted to a given test arrangement or limited to the particular rabbit with which the pup had cohabited.

These data are consistent in showing that interspecific rearing conditions have a pervasive influence on the young dog's response to another species to which it has been exposed. One of the more remarkable features of these results was the rapidity of formation of the interspecific attachment. Subsequent experiments confirmed that the phenomenon was not an artifact of the test procedures adopted nor of the response index employed. Independent removal-replacement results were obtained from a new group of 31 dogs maintained in an interaction condition similar to that of the first experiment, but tested only after 88 hours of cohabitation (*6*). These results, which were free of the influence of repeated testing, were not significantly different from those obtained after 96 hours of interaction-cohabitation in the first experiment. Nor were the effects restricted to the vocalization-disruption measure. After 4 days in the interaction condition, a significant shift was obtained in the preference of the experimental dogs for the rabbits. These data strongly suggest that significant changes in social preference occur over relatively short periods. A recently completed study by Fleener (*7*) indicates that human infants share this capacity for the rapid establishment of social preferences.

Observations of the animals in the first week of cohabitation yielded data which were consistent with the quantitative results. After an initial period of mutual avoidance, a considerable portion of the young dog's time was spent in grooming, lying upon, and gnawing at the extremities of his cohabitant. Such behavior continued throughout the duration of the experiment. As the dogs grew older and more capable of inflicting physical damage through grooming and "play" activities, the outcomes became increasingly more noxious to the rabbit cohabitant. By the 8th week of cohabitation, six of the ten rabbits in the interaction condition were severely injured and the pairings were discontinued. Contrary to the earlier reports of Kuo (*8*), continued cohabitation is not necessarily associated with the development and maintenance of peaceful relationships between species.

Preliminary information was obtained on the post-experimental sexual adaptation of dogs that had cohabitated with rabbits. A follow-up study of the subgroup of six female beagles used in the two experiments indicated that alien cohabitation does not necessarily inhibit the development of species-appropriate reproductive activities. Of the six animals observed in maturity, four were successfully mated and produced litters in their first heat. Parallel data on male dogs unfortunately were not obtained.

Our results clearly indicate that the young dog's experience prior to the 3rd week of life does not preclude the rapid establishment of a "new" social bond with respect to a member of another species. Moreover, early exposure to an animal of another species does not insure against the subsequent development of antagonistic patterns of interaction with that species.

The present findings thus are consistent with recent reports which emphasize the role of contemporary events, both endogenous and exogenous, in the control of the social behavior (*9*). Specifically, studies of the post-emergence behavior of dogs reared in complete isolation have demonstrated that the intensity of the treatment effects can be greatly modified by varying the conditions of emergence (*10*). Similarly, our previous work indicates that the primary effects of interspecific rearing in sheep can be reversed (*11*). While some long-term effects of early experience on social and sexual behavior patterns cannot be gainsaid (*12*), our data indicate that a critical examination of the conditions required for the persistence of such effects is in order.

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References and Notes

1. V. H. Denenberg, G. A. Hudgens, M. X. Zarrow, *Science* **143**, 380 (1964); L. Hersher, J. B. Richmond, A. U. Moore, *Behaviour* **20**, 311 (1963); Z. Y. Kuo, *J. Comp. Physiol. Psychol.* **11**, 1 (1930); G. J. Romanes, *Nature* **12**, 553 (1875).
2. R. B. Cairns, *Psychol. Rev.* **73**, 409 (1966).
3. O. Elliot and J. P. Scott, *J. Genet. Psychol.* **99**, 3 (1961).
4. See also C. L. Pratt and G. P. Sackett, *Science* **155**, 1133 (1967); R. B. Cairns, *J. Comp. Physiol. Psychol.* **62**, 298 (1966).
5. It should also be noted that dogs maintained in isolation tended to approach rabbits which had previously cohabited with other dogs more rapidly than they approached rabbits that had not so cohabited (first and second columns, Table 1). This trend, of borderline significance ($.10 > P > .05$), suggests that the cohabitation experience modified the bebehavior of the rabbits as well as of the pups.
6. R. B. Cairns and J. Werboff, in preparation.
7. D. E. Fleener, thesis, Indiana University (1967).
8. Z. Y. Kuo, *J. Genet. Psychol.* **97**, 211 (1960). In this report Kuo indicated that attempts were made to inhibit fighting among dogs assigned to the experimental groups.
9. J. P. Scott, *Ann. Rev. Psychol.* **18**, 65 (1967).
10. J. L. Fuller and L. D. Clark, *J. Comp. Physiol. Psychol.* **61**, 251, 258 (1966).
11. R. B. Cairns, *ibid.* **62**, 298 (1966); R. B. Cairns and D. L. Johnson, *Psychon. Sci.* **2**, 337 (1965).
12. Including those effects related to the development of social preferences [see, for example, D. G. Freedman, J. A. King, O. Elliot, *Science* **133**, 1016 (1961)] and the sexual behaviors of dogs reared in isolation [see, for example, F. A. Beach in *Social Behavior and Organization among Vertebrates*, W. Etkin, Ed. (Univ. of Chicago Press, Chicago, 1964), p. 117].
13. E. B. Page, *J. Amer. Statist. Ass.* **58**, 216 (1963).
14. These experiments were conducted at the Jackson Laboratory while R.B.C. was on leave from Indiana University (PHS special fellowship 1-F3-NH-30, 205-10) and were supported in part by PHS research grants HD-01082 and GRS FR-05545-03-05 from NIH.

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Honeybees: Do They Use Direction and Distance Information Provided by Their Dancers?

My experiments on the language of the bees (*1*) received new impetus when I discovered that successful forager bees upon their return to the hive inform their hive mates of the location of the feeding place by wagging dances (*2*, *3*). The direction of the goal in relation to the sun's position and to the polarized light of the sky is indicated by means of the straight part in the wagging run. The distance to the feeding place is announced by