

Social Behavior, Range and Territoriality in Domestic Mice

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Recent advances in biosociology have emphasized the fact that the tendency for an animal to stay in one particular locality is directly connected with the social behavior and organization of the species. In the case of birds, fighting appears to be one of the major factors which causes the division of breeding territory and limits the density of population in the species. It is in this latter connection that territory appears to have its greatest significance, as a determinant of the numbers and dispersion of a species.

In the case of the house mouse the density of population may become an important commercial problem as well as an interesting theoretical one (Elton, 1942). The following observations concerning territoriality in domestic strains were made partly in large pens where the mice were left as undisturbed as possible, and partly in connection with experimental situations involving fighting and social dominance, whose result has been reported elsewhere (Scott, 1943). While the behavior of domestic and wild mice is not identical, it was expected that the behavior of one would throw some light on that of the other.

Materials and Methods. The mice used came from two inbred stocks, the C-57 black, subline 10, and the C3H agouti. Both strains are very nearly genetically pure, and there is a high degree of resemblance between individuals in the same strain, both in appearance and behavior, provided they have been raised in the same environment. At the Jackson Laboratory at which these mice were originally studied (Scott, 1942) there is a decided difference between the fighting behavior of the males in the two strains.

The ordinary small breeding boxes do not give much scope for behavior, and mice were put into two multiple escape pens of the type illustrated in the figure. These are 5 feet in greatest diameter, and in a later experiment a side alley 10 feet long with two additional nest boxes was added. The mice roamed through all parts almost immediately, indicating that the limit of wandering had not been reached.

The pens were kept in a cellar in which there was very little light and whose temperature stayed fairly constant between 70 and 80 degrees F. except in the cold winter months, when it usually stayed between 60 and 70. An attempt was made to reverse the day-night cycle of behavior by lighting each pen with a 75 Watt lamp for 8 hours during the night, the light being turned on again for observations some time during the day. Observations extended from November 21 to May 14 in one series, and from March 8 to July 15 in the other. In each series a single pair of young mice was put into a pen, a second pair saved from the first litter, and all other young mice removed before 30 days of age. Bedding

of cotton and excelsior was provided in each nest box, together with a small amount of sawdust, and a constant supply of feed and water was kept in the center box. The pens were not cleaned out during the entire period of observations.

Behavior, the conditions of nests, and the position of mice in the pens were especially noted.

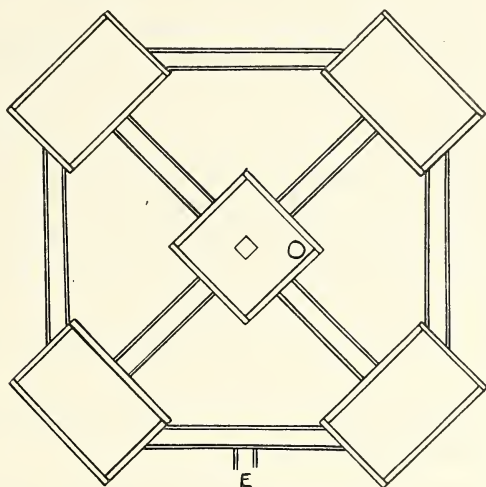


Fig. 1. Plan of multiple escape pen. At the start of the observations equal amounts of bedding were placed in the corner boxes, the center box containing a food hopper and water bottle. E indicates the spot at which an extension was attached in the second series of observations.

Effects of Changes in the Physical Environment. An attempt was made to keep the physical environment as constant as possible, so that all behavior might be attributed to changes in the social milieu. However, this was not entirely successful. A lowering of temperature was accompanied by greater general activity and seems to have been a contributing cause of one fight which got started in the longer series of observations. Such a change was also followed by a period in which solid, well-roofed nests were built and passages from them plugged with debris.

The change from dark to light was also followed by a period of greater activity, mostly investigation.

Effects of Changes in the Biological Environment. In the second series of observations one pen became infested with lice, with a consequent increase in the amount of grooming and scratching.

Under the conditions described, the observer also acted as a stimulus. The reactions varied from running away through investigation and even attempted attack. (One old male mouse came regularly to the part of the cage nearest the observer and ran up and down, occasionally stopping to bite on the wire.)

Classification of Reactions Observed. The following sorts of behavior are listed in order of greatest frequency.

Investigation. This appears to be the predominant type of behavior in the mouse. Anything new in the physical, biological or social environment is immediately investigated, chiefly with the nose and whiskers, but also with the eyes and ears. A typical bit of behavior is for a mouse to creep slowly down a new passage, sniffing and feeling every inch of the way, and occasionally running back to familiar ground. Once this is done he may dash back through it at top speed, if frightened. The reaction to a new mouse is to smell it all over, including the genital region.

Epimeletic Behavior. This type of behavior, consisting principally of the care of others, is next most commonly observed. It includes grooming, nest-building and digging, and nursing the young. As a social reaction it is most prominent in pregnant and lactating females, which build nests for the young and spend much time in grooming them. Male mice usually build nests and groom themselves in a solitary fashion but have been observed to groom other adults of either sex, especially in the C-57 stock.

Because of the construction of the pens, digging was infrequently observed.

Feeding of other animals is confined to nursing the young. No cases of carrying or hoarding food were seen, in spite of the fact that it was provided in convenient small pellets.

Eating. This type of behavior occurs at fairly frequent intervals. As a social reaction it is important to the young mice before weaning.

Shelter-seeking. Under the conditions described, mice show two forms of this behavior: attempts to get into dark spots when frightened, and attempts to get warm. Either may result in aggregation and thus become a variety of social behavior.

Sexual behavior. Inasmuch as the female mouse comes into heat only once in every 5 days and not at all during pregnancy, sexual behavior of the female was not frequently observed. In the male it was more common, usually expressed as a tendency to nose the genital region of other mice, and to follow the females. Greater activity was seen only when females were in heat.

Fighting. Infrequent cases of fighting between the adult males were seen, these being more violent in the observations carried on in the winter. Small amounts of aggression were also seen in C3H females, directed at males and young which had been weaned.

Et-epimeletic Behavior. This type of behavior, defined as calling or signalling for epimeletic behavior, is of importance only to the small mice in the nest, from which squeaks are often heard. The squeaking of adult mice when hurt may be a form of this behavior.

Allelomimetic Behavior. No indication of any sort of imitation was observed.

Range and Territoriality. In cold weather a female mouse constructs a solidly built and roofed-over nest a short time before her young are born. During the first few days she spends a great deal of time in the nest, suckling and grooming the young. If she is disturbed, squeaks are heard in the nest. In unusual cases she may move them to a different nest, carrying them in her mouth. The young mice may occasionally leave the nest as early as fifteen days, and by twenty days they are usually found scattered around the pen, while the nest is flattened and in bad repair. However, they tend to return to it for a few days. Since the female may have become pregnant immediately after giving birth, a new litter may be born about this time. She usually builds a new nest in a different part of the pen.

The males have never been seen in nests with very young litters. They are likely to join the litter about the time the nest begins to break down, and when the nests are open, as in warm weather, the male has been seen with the young as early as eight days. Males are also seen huddled together, either in nests or out of them, sleeping and occasionally grooming themselves or each other. A male and female will usually form this type of group up till the time the young are born, and the same thing may be observed between two females or among immature mice.

While the female is in estrus, a male and female keep in close contact, running around a great deal as well as showing actual sexual behavior. When the female is not in heat she shows little response to the male, and he usually reacts only with a slight sniff in passing.

Thus in the large multiple escape pens range appears to be directly connected with the nests. In the vast majority of cases, mice when first observed were found either in nests or in the boxes which contained nests. This was even more true of the females than the males, presumably because of the attraction of the young. For example, in one series of 60 observations, the female was found either in the nest or in the same box 54 times, while the male was found 50 times. The male was found 5 times in the box containing feed, and the female only once. During most of this period there were nests in three out of the seven boxes and it is unlikely that the other four boxes would be avoided so many times merely by chance. But even within such a pen, nests are frequently changed. The females usually move when bearing a new litter, and nests are rebuilt and moved with fluctuations in temperature.

When experiments on fighting were performed in the pens a different set of factors was introduced. The passages were blocked off, and two males were isolated in adjoining pens with nesting material for at least a week while being trained to fight. When the passage between the two pens was opened the mice investigated it and the other pen, usually within less than five minutes. As soon as the fight started both mice would rush through both pens at top speed, the mouse which had investigated it only once running as efficiently as the one which had known it for a week. A mouse apparently becomes familiar with a new passage after one thorough investigation, and it may be concluded that familiarity and habit are of little importance in determining the range of mice.

Fighting itself is apparently an unimportant factor, even in the division of territory. Mice have never been seen fighting for the possession of a nest, although a beaten mouse may hide in one. Female mice may fight to keep the males out of nests where there are young, but this has not been actually observed. In situations where two males are kept in adjoining pens and taught to fight (Scott, 1943) the combat usually starts when one mouse finds the way blocked to its own pen, or after one mouse has made a sexual attempt on another, and not when a strange mouse enters the pen. Furthermore, males which habitually fight each other have been found sleeping in the same nest, or huddled together in the same box.

A distinction has been made by Burt between range, which includes the area over which a given animal may roam, and territory, which may be defined as a range occupied only by a particular individual or group. In order to have range, there must be the sort of behavior which will cause an animal to remain in a particular locality. In the mouse, a combination of epimeletic, et-epimeletic and shelter-seeking behavior has this effect, resulting in the group of a female and her young occupying a definite nest. Epimeletic behavior and shelter-seeking are also present in the males, though in a different degree, and lead to the same result. However, neither of these types of behavior are constantly present, and both investigation and fighting have a definitely dispersive effect, so that range in the mouse appears to be a temporary and variable affair.

This in itself would make any stable division of territory impossible. In addition, the strong tendency toward investigation makes division of territory on the basis of familiarity and habit impossible, leaving only fighting as a basis for such division, and there are at least two possible reasons why the latter does not give a clear result. There appears to be no tendency to fight over the nests, which are the most definite spots in the range, and since mice are nocturnal, it would be impossible for a mouse to effectively patrol a territory as large as that which investigation apparently leads them to cover. Fighting in the mouse leads more to simple dispersion than to division of territory. It may be concluded that territory in mice is either temporary and variable as in the case of the nest of the lactating female, or, if it exists at all in males, extremely nebulous.

Probable Organization in Wild Mice. The differences between the C3H and C-57 strains appear to be matters of degree rather than of fundamental type of social behavior. Similarly, the few wild mice observed in this laboratory seem to differ from the domestic strains chiefly in degree of activity or "wildness," especially in those reactions involving fighting or escape. One female killed two domestic males before it was finally mated to a third.

Assuming that wild mice possess the same types of social behavior as the domestic strains but intensified, and allowing for the possibilities of digging holes, of wandering unrestrained by artificial barriers, and the presence of a fluctuating food supply, the following conclusions regarding the probable territorial organization of wild mice may be drawn.

In temperate climates a sharp difference between summer and winter behavior would be expected. In the winter mice would tend to collect in heated buildings where food is stored, showing a greater tendency toward the formation of shelter-seeking aggregations in the nests. In summer they would occupy a far wider range because of the dispersive effects of investigation, fighting and a more plentiful and widely distributed food supply.

As to territory, the heated building would form a boundary limiting the favorable environment during the winter, a situation comparable to the experimental one described above. Given an unlimited supply of food, such a building would probably contain a large number of mice before the winter was over, though the numbers might be somewhat checked by fighting between the males and by the limits of available nesting sites.

In the summer the bounds of the range would be fixed only by fatigue and distance from the food and nests. As in the tame animals such ranges could not be effectively patrolled as territories, even if mice showed such tendencies. However, chance encounters would probably result in fights, with the losers tending to retreat into familiar areas. It would be expected that such "territories" would be large, overlapping, and constantly shifting, and that the territories of females would be smaller and less rapidly shifting, because of the attraction of the young.

One may think of mouse society as a whole as thinly dispersed and fluid, tending always to spread out and cover all suitable ranges, but occasionally accumulating in small groups around the nests, the most permanent being those of a mother and offspring. The division of territory is considerably less definite than that shown by some other vertebrates. This picture corresponds fairly accurately to that obtained by Burt (1940) from his trapping data of wild *Peromyscus* which have somewhat similar behavior to that of the house mouse.

In summary it may be said that while mice show intermittent tendencies to stick to one range including a nest or nests, they probably show very little tendency to divide the total range into definite territories.

Discussion

As mentioned in the introduction of this paper, territoriality is most important as a factor regulating the density of population. Considering the fluctuating range and the lack of definite territoriality in the domestic mouse, it may be concluded that the species has no regular social means of limiting numbers, and this is borne out by the accounts of epidemics and plagues of wild *Mus musculus* cited by Elton (1942).

This in turn has a bearing on the problem of mouse control. The mouse has such a low degree of social organization and interdependence that it is impossible to adversely affect the welfare of many by the destruction of a few individuals, and a single pregnant female can form the effective nucleus of a new population. Likewise, cleaning out mice from any one particular area by poison or trapping can have no perma-

nent effect; other mice will simply move in to take their place because of the dispersive effects of mouse behavior.

The observations in this paper do give one hint to the householder; mice should show more tendency to stick to one locality in cold weather than in warm, because of the cohesive effect of shelter-seeking, and if all the mice in a house are trapped or poisoned at the onset of cold weather, it is unlikely that more will return until spring. This does not apply, of course, to closely connected heated buildings.

Probably the only permanent and completely effective method of mouse control is to store all food in mouse-proof containers. Where this cannot be done they may be controlled only through constant trapping and poisoning, or by ecological means.

The natural controlling factors of mouse population appear to be chiefly ecological, consisting of disease and predators. The dispersive nature of their social behavior gives mice considerable protection against infectious disease until they accumulate in large numbers.

Either poisoning or artificial disease propagation are likely to be expensive, which throws the burden of control upon predators. If the average citizen will keep a cat (preferably a well-fed one which will not tend to bother birds) to keep down mice within his home, and will assist in the protection of small wild predators (particularly owls which are nocturnal like the mice) which will catch the mice en route from house to house, the numbers of mice may be kept down to a minimum. This is particularly important since Cable has reported that the plague flea, which may live on mice as well as rats, is now frequently found in Indiana.

Summary

1. Territoriality is chiefly important as a factor controlling population density.
2. Pairs of mice and their descendents from the C-57 and C3H strains were observed in large multiple escape pens for periods of six months and four months.
3. In order of importance, the following general types of behavior were observed: investigating, epimeletic, eating, shelter-seeking, sexual, fighting, and et-epimeletic. No form of imitation was observed.
4. Because of epimeletic and shelter-seeking behavior, the ranges of mice are closely connected with the nests.
5. Since these types of behavior appear intermittently and variably, the ranges are likewise variable.
6. Since the ranges shift frequently, fighting does not produce definite divisions of territory. No cases of fighting for the possession of nests have been observed.
7. It is concluded that the society formed by wild mice is probably fluid and dispersive in nature, with shifting ranges and unstable, badly defined territories.
8. In consequence the natural factors controlling population density should be chiefly ecological rather than social.

Literature Cited

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