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## THE BIOLOGY AND PSYCHOLOGY OF CROWDING IN MAN AND ANIMALS<sup>1, 2</sup>

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### ABSTRACT

Crowding is an ecologic and psychologic aspect of population density which produces a significant impact upon the behavior and physiology both of individuals and of social groups. In animal populations, an optimal level of crowding is often necessary for favorable social interactions, reproduction, and normal group organization. Beyond optimal levels, however, crowding may become a detrimental influence on the well-being of individuals within the population.

Crowded animal populations often show a breakdown of normal social behavior, with increased aggression and violence, aberrant sexual activity, improper parental care, and abnormal states of activity, aggregation, or social withdrawal. A variety of stress-related diseases and mortality patterns may ensue.

The human populations of the world are rapidly becoming more crowded through excessive rates of population growth, urbanization, and increased social and communicative contact. Many urban areas throughout the world are showing classic symptoms of crowded animal populations. We cannot, however, attribute all such symptoms to crowding *per se*, nor can we adequately distinguish all of the multiple interactions of social, economic, political, and biological factors in producing the "inner-city syndrome." In viewing the complex problems of urban ecology and social behavior, it is important to maintain ecologic perspective and to work toward understanding the interactional relationships between man's physical, social, and biologic environments.

### INTRODUCTION

Of the great myriad of problems which man and the world face today, there are three significant trends which stand above all others in importance: (1) the unprecedented population growth throughout the world—a net increase of 1,400,000 people per week—and all of its associations and consequences; (2) the increasing urbanization of these people, so that more and more of them are rushing into cities and urban areas of the world; and (3) the tremendous explosion of communication and social contact throughout the world, so that every part of the world is now aware of every other part. All of these trends are producing increased crowding and the perception of crowding.

It is important to emphasize at the outset that crowding and density are not necessarily the same. Density is the number of individuals per unit area or unit space. It is a simple physical measurement. Crowding is a product of density, communication, contact, and activity. It implies a pressure, a force, and a psychological reaction. It may occur at widely different densities. The frontiersman may have felt crowded when someone built a homestead a mile away. The

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suburbanite may feel relatively uncrowded in a small house on a half-acre lot if it is surrounded by trees, bushes, and a hedgerow, even though he lives under much higher physical density than did the frontiersman. I have seen populations of white-footed mice (*Peromyscus leucopus*) showing severe crowding symptoms at a density of 1 mouse per 50 square feet, whereas others were uncrowded, in the behavioral sense, at a density of 2 mice for each square foot. The important difference was the social history and behavioral response of the mice, not the density *per se*. Hence, crowding is very much a psychological and ecological phenomenon, and not just a physical condition.

In human terms, not only is man getting packed into higher density, but he is also getting psychologically crowded at an accelerating rate. Much of the world's population is now directly aware of all other parts of the world community. This awareness may be based on very limited knowledge, often inaccurate knowledge, but this does not necessarily diminish the force of that awareness. It may, in fact, exaggerate it, or make it dangerously inappropriate. We are all, in a sense, spectators at every major critical event. A crisis in any one of the world's cities, or in any of the world's countries, may be witnessed by tens of millions of people around the world. It has often been said that the Vietnamese war is the first war to come visually in full living color into the living room of American homes, and the armed conflicts of the Middle East are vividly familiar to people throughout the world. Similarly, the U.S. urban riots of 1968 and the campus riots of 1970 were viewed and experienced in millions of homes far away from their original location. This may be good or bad, but in any case it spreads the influence of these events around the world, and tremendously alters the impact they might otherwise have.

Thus, I think we could agree that the dramatic multimedia approach of our communications networks affects the sense of crowding and crisis that individuals and social groups perceive. I am suggesting, then, that crowding is becoming one of the predominant social and ecological forces of our times, and that it will most certainly increase in the future. It behooves us to learn as much about it as we can.

The scientific study of crowding has interested biologists, ecologists, and psychologists for many years. Professor W. C. Allee of the University of Chicago was one of the first to emphasize that most animals have optimal levels of crowding, above which and below which biological and behavioral functions are impaired (Allee, 1931). He showed that many aquatic animals, from crustacea to fishes, have enhanced survival and reproduction in social groups at certain densities. At low densities or high densities, survival is often reduced and reproduction impaired. This was found to be attributable to both chemical and behavioral aspects of optimal densities. A certain population level conditioned the environment through metabolites and pheromones for the most favorable physiological function, and a certain frequency of social contact provided the most favorable stimulation for optimal behavioral function. Above or below these optimal levels, both physical and behavioral impairments became apparent. The remainder of this paper will concentrate on consequences of exceeding these levels, that is, the behavioral and physiological consequences of excessive crowding.

#### *Effects of Crowding in Animal Populations*

About 20 years ago, there were a number of studies by ecologists (such as John Calhoun (1962a, 1962b), Jack Christian (1961 and, with Davis, 1964), Robert Brown (1953), Dennis Chitty (1960), and others) on populations of rats and mice which demonstrated the occurrence of a variety of events as populations became crowded. Rodent populations, like those of most living organisms, have a great capacity for reproductive increase. Theoretically, one pair of Norway rats can produce 250 progeny in one year, and in the same period, one pair of house mice

can produce 4,000 mice if all of their offspring survive and breed (Southwick, 1966). Thus populations of these animals can increase exponentially under favorable circumstances and can achieve conditions of crowding very quickly.

As rodent populations become crowded, a variety of changes occur, both behaviorally and physiologically. Crowding is often accompanied by a break-

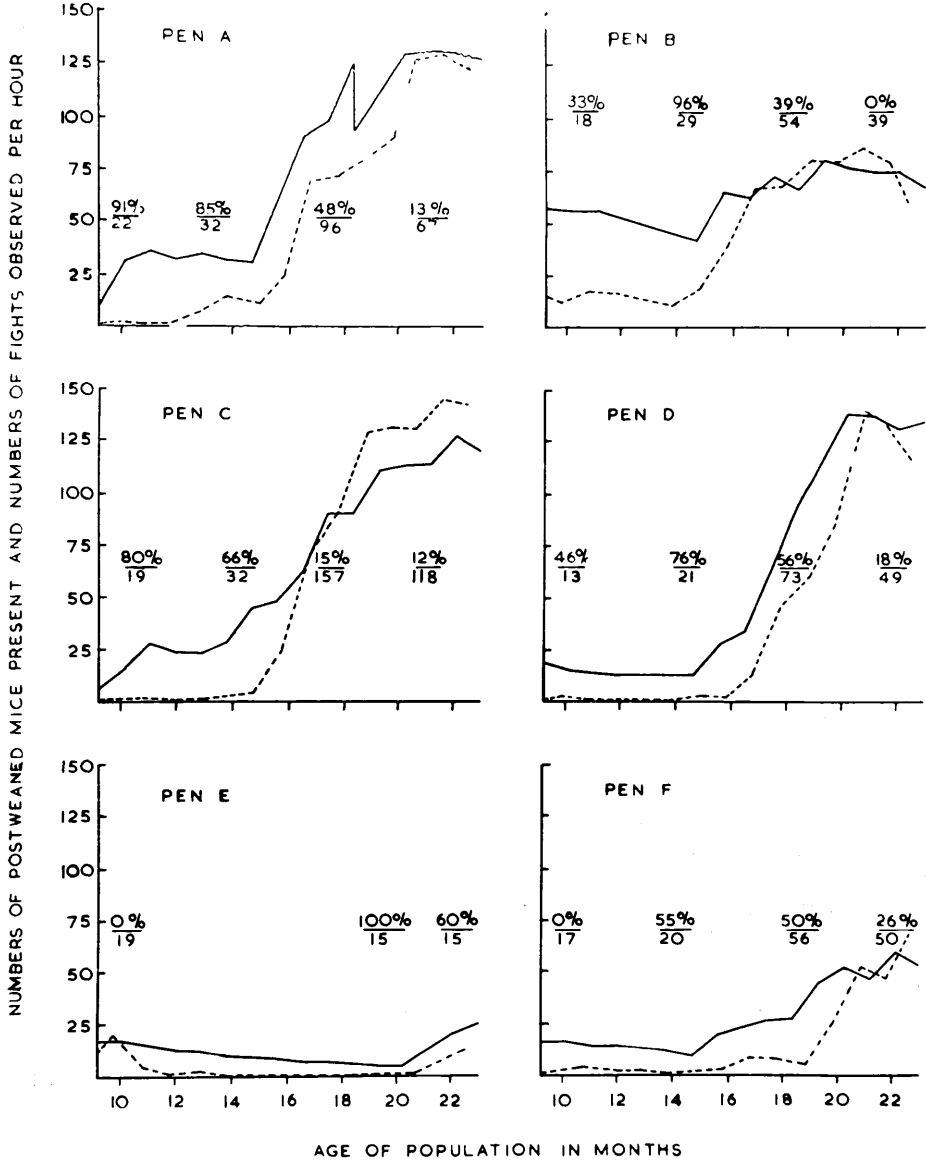


FIGURE 1. Population growth, aggressive behavior, and litter survival in seminatural populations of wild house mice, *Mus musculus* (from Southwick, 1955).  
 solid line—numbers of postweaned mice  
 dashed line—numbers of fights observed per hour

$$\frac{91\%}{22} = \frac{\text{Percent survival to weaning of young born in a two-month period}}{\text{Number of young born in a two-month period}}$$

down of normal territorial behavior and an upset of dominance hierarchies which were formerly stable. These changes in turn lead to increased social contact and irritation. Aggressive behavior becomes more frequent and more intense, and it often changes from threat display to injurious fighting and violence. Under these circumstances, females are no longer able to maintain good nests, nest construction breaks down, and young are poorly cared for, often trampled, and eventually deserted. Sometimes there is a flurry of unusual activity in which young are carried from nest to nest, some of whom are dropped and abandoned between nests. Occasionally, the young are viciously attacked, bitten, and partially cannibalized. Infant survival falls sharply, and few young reach the age of weaning. Figure 1 shows data from experimental populations of wild house mice (*Mus musculus*) on population growth, the increase of aggression, and the decline of infant survival in crowded populations. Violence, if defined as destructive aggressive behavior, became more prevalent as the populations became crowded, and was expressed in terms of increased aggression between adults and increased cannibalism by adults on infants.

The precise density levels at which pathological behavior of this type occurs are highly variable for different populations. These density levels relate to the tolerance of individuals and of groups to crowding. This, in turn, is a function of the behavioral differences of individuals, the history of social groups, and the nature of environment.

Other behavioral changes which occur in crowded rodent populations often involve abnormal clusterings of individuals. Though the individuals may already be crowded, they seem to seek and to exaggerate this crowding. Thus, they may group together in a few nest sites or at a few feeding spaces by the dozens, even though other sites and spaces are empty. There seems to be a loss of normal individual distances and social spacing characteristic of stable societies. Calhoun (1962b) has called this "pathological togetherness," or a "behavioral sink" phenomenon. We have no satisfactory explanation for this phenomenon, but it is a conspicuous feature of crowded rodent populations. One theory states that crowded animals become conditioned or habituated to crowding in early life, and so they seek further crowding as adults. Many students of animal behavior have emphasized the importance of primary socialization and early experience in influencing adult behavior (Denenberg, 1962; Levine, 1961; Scott, 1962, 1967). Another theory suggests that, in crowded and disrupted populations, it is increasingly important for members to be able to predict crises and danger, which requires that each individual keep all other members of the population in view. Altmann (1967) has pointed out that the survival of social animals often depends upon instant recognition of, and correct response to, the social signals emanating from other individuals in the group. Thus, in critical social situations it may become necessary to crowd together to increase the probability of receiving important social signals as rapidly as possible. In other words, the individual who is not constantly in touch with the group may miss some essential social cue. It is at least reasonable to expect, therefore, that crowding may stimulate more crowding.

Still other types of deviant behavior found in crowded rodent populations include inappropriate sexual behavior, often misdirected in regard to sex and age, and social withdrawal, in which some individuals avoid contact and fail to display normal activity. Thus, Calhoun's study of wild Norway rat populations (1962a) showed deviant sexual behavior by some individuals which he called "pansexuals." Their sexual behavior was indiscriminate in regard to the sex and age of the other individuals which they approached and mounted. He also observed the withdrawn individual or "social dropout"—one who entered a state of inactivity and depression and went into a spiral of deteriorating health.

The physical consequences of crowding and of social stress are often profound and widespread. They clearly affect physical health and well being. Increased

aggression often leads to wounding, and the wounds in rats and mice can become sites of infection of bacteria or ectoparasites. Acarinar dermatitis (a skin disease caused by a small mite) is a common occurrence in rodent populations which show high levels of fighting. Christian and Davis (1964) further believe that increased social contact and fighting cause endocrine changes in individuals through the mechanism of the Selye Stress Syndrome, often known as the General Adaptation Syndrome, or G.A.S.

This theory states that any general stress agent, physical or behavioral, alters the function of the hypothalamus, a portion of the midbrain, and thereby changes the secretory activity of the pituitary gland, the master gland of the body located at the base of the mid-brain. As a result, there is decreased production of the gonadotropic hormones, FSH, LH, and LTH, hormones which maintain proper functioning of the reproductive system, and there is increased production of ACTH (adrenocorticotrophic hormone), which stimulates the adrenal glands to increased production of the adrenocorticosteroids. This enables the animal to maintain homeostatic conditions under chronic stress; blood-glucose levels and sodium and potassium balances are kept within normal limits, and other physiological demands are met. There is, however, a cost. The altered endocrine balances extract a cost in metabolic changes, some of which lead to what Selye (1950, 1955) calls the "Diseases of Adaptation." These involve adrenal enlargement or hypertrophy, lymphatic involution, declines in eosinophils and lymphocytes, hypertension or high blood pressure, increased susceptibility to infectious disease, and, in more severe forms, gastro-intestinal ulcers, sclerotic changes in the kidneys, and arterio-sclerosis.

If the stress continues, it may lead to adrenal exhaustion, chronic shock, Addison's disease, myasthenia, and eventually coma and death. Thus, long-term stresses may be cumulatively fatal, though no single episode is lethal in itself.

All of these pathologic changes have been documented in experimental animals, and Christian and Davis (1964) believe that they can occur in natural populations of wild animals as well. This is a controversial point, and the evidence for this is mixed. In some natural populations, pathologies of the stress syndrome have been shown to occur; in other populations, often very crowded with intense aggression, however, such physical changes have not been found. This certainly does not refute the validity of the concepts, though it may refute their universal application. It is also not too surprising—anyone who works with biological systems understands that variability is an intrinsic part of these systems. If you do precisely the same thing to two different mice, you do not invariably get the same result. If two different populations are subjected to the same stresses, they do not necessarily respond in the same way. Evidence relating to this point and to other aspects of the social stress theory has been reviewed by Barnett (1964) and by Myers (1965).

### *Crowding in Human Populations*

Having seen this impressive array of behavioral and physiological upsets which can occur in crowded animal populations, the leading question is, of course, whether similar processes occur in man. There is no doubt about the fact that human populations around the world are drastically out of balance, and in a dangerously unstable condition. Not only is there excessive population growth in sheer numbers, but these populations are becoming dramatically concentrated in and around major cities. In the United States in 1800, only 5% of the population lived in towns containing more than 2,500 people. In 1960, over 65% lived in towns of that size, and now 73% live in cities of over 100,000 people. By the year 2000, it is predicted that 80 to 90% of our populace will be living in urban areas. In construction and urban development, we are devouring 4,000 acres per day in the United States alone.

The story is similar throughout the world. Calcutta developed from less than

850,000 people in 1901 to 6.5 million by 1965. Los Angeles grew from 102,000 in 1900 to over 3 million in 1965. Mexico City tripled in size in one generation, from 1.4 million in 1940 to 5.2 million in 1965. These rapid growth rates have involved qualitative changes as well; cities throughout the world are on the verge of financial collapse as their wealthy tax base moves outward and poverty-stricken components of the population pour inward.

Obviously, these patterns, in both quantitative and qualitative terms, cannot continue. They must reach more stable conditions at some point, or experience many of the behavioral and physical pathologies which have been found so frequently in animal populations.

Or, one might ask, are they already exhibiting some of these characteristics? There seems to be substantial evidence that optimal size in human terms has already been exceeded in many cities. There is little doubt that our inner cities have become concentrations of both physical disease and behavioral pathology. The realities of ghetto life, with inadequate housing, poor sanitation, severe crowding, ill health, high crime rates, and a breakdown of social services, force us to realize that our giant cities have already become a "behavioral sink" of human despair.

Yet people continue to flock toward the cities of the world by the millions as if irresistibly drawn. Obviously urban centers have an attraction and fascination for many people that rural areas cannot provide. It is doubtful, however, if the main driving force of urban expansion lies in the cultural excitement of cities. Rather, it is more likely to be found in the realities of modern economics: the prospect of a job or a welfare payment. As such, the urban movement may be very close to the struggle for survival, and thus far more of an ecologic phenomenon than we realize. Even in Calcutta, where the resident population density already exceeds 75,000 people per square mile and where there are hundreds of thousands of homeless people barely clinging to existence, people continue to pour into the city. They come in hopes of a job, a handout, or a better life. Although they may be victims of mistaken perception and misplaced hopes, they at least feel that they can find food and some form of collective security within the city. The disillusionment is often massive and profound.

A recent article by the psychologist Stanley Milgram (1970) pointed out that a resident of suburban Nassau county, outside of New York City, can meet a potential of 11,000 other people within a 10-minute radius of his office. In Newark, New Jersey, a moderate-sized city, he can meet 20,000 people within this radius, and in midtown Manhattan, he can meet fully 220,000. Thus the inner-city dweller has a potentially vast and oppressive number of social contacts with which to deal. City life, Dr. Milgram points out, constitutes a continuous set of encounters with sensory overload. As a result, the sensory input becomes unmanageable, unless some adaptation arises to cope with this overload. City dwellers characteristically have several common ways of doing this. One adaptive response is to ignore and filter out many of the inputs. Thus the city dweller disregards many social opportunities. He obviously does not greet or acknowledge each person he passes on the street; he does not become involved in arguments; he may even ignore crises, or may stand idly by when some other person is in danger or distress. He increasingly uses unlisted telephone numbers; he limits his availability and contributions to social organizations. Such patterns of behavior protect the individual from undue demands and responsibilities, but they also estrange the individual from his social environment. It is no coincidence that most social surveys in cities have found urbanites to be more suspicious of and less helpful to strangers, to express a greater sense of vulnerability and insecurity, to become less readily involved in social-betterment projects, and to have less sense of social community.

These are all reasonable adaptations to the social and psychological overload

conditions of crowded cities. They permit individuals to maintain themselves in socially stressful circumstances. But it is obvious that even these adaptations are not enough.

The records of inner cities in terms of physical and mental health are not good. Thirty years ago Faris and Dunham (1939) showed that, in Chicago, unusually high concentrations of schizophrenia occurred in the crowded populations around the loop of central Chicago. In the famous midtown Manhattan study of the 1950's, entitled "Mental Health in the Metropolis," Dr. Thomas Rennie and his colleagues showed that 80 percent of the people interviewed had detectable psychiatric disorders, and 25 percent of them had significant neuroses which made them indistinguishable from patients in mental hospitals (Srole, *et al.* 1962). More recently Myers and Bean (1968) showed a high prevalence of schizophrenia in the lower socioeconomic classes of several urban ghettos.

The extensive ecological studies on Philadelphia by Dr. Ian McHarg (1969) and his colleagues at the University of Pennsylvania have also shown the increased prevalence of behavioral pathologies in the inner-city environment. Not only mental illness, but various patterns of criminal assault, murder, rape, alcoholism, and drug abuse are also intensified in the inner-city ghettos. The prevalences of these are shown in a series of outline maps in McHarg's recent book on human ecology, "Design with Nature."

Many aspects of physical disease show similar concentrations in the inner city: tuberculosis, venereal disease, salmonellosis, dysentery, hypertension, and perinatal loss and infant mortality. Some of these are infectious diseases, clearly related to poor housing and unsanitary conditions; others, such as hypertension, are partially psychogenic in origin, and relate directly to the frequency and quality of social contacts.

It is, of course, not warranted to attribute all of these problems to crowding. There are so many variables in man which complicate inner-city disease patterns, such as socioeconomic status, vocation, malnutrition, poverty, race, education, family background, and the various environmental insults of pollution, that it is impossible to isolate crowding *per se* and to say that it alone is the cause of physical and behavioral pathology in man. The complexity of the problem has caused many scientists to despair of really understanding and sorting out the key variables. It is, in fact, a logical fallacy to seek a simple cause and effect in dealing with so complicated an issue. But this need not mask the essential significance of the syndrome—the reality of a package of related problems or a constellation of symptoms which seem to occur together in the recognizable form of what we might call the "inner-city syndrome."

The great challenge of our cities lies first in recognizing the interrelatedness of these problems, and secondly, in being able to mount some corrective attack on the predisposing factors. Thus, to the ecologist, planning for the future must direct itself to the basic issues of population and urbanization. The social, spatial, and behavioral needs of man must be more adequately understood and considered in urban planning. The quality of human life must be expressed in terms of all three components so often recognized by the ecologist, but readily forgotten in the pressure of modern economic growth; namely, that the physical, biological, and social environments of man compose an intensely interacting system structured in such a way that changes in any one component have major consequences for all.

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