A Perspective on Rat Control

By DAVID E. DAVIS, Ph.D.

Rat control is clearly a problem in the management of a species so that the numbers will be reduced. Management in general implies altering the abundance of a species according to our desires. For example, management of cattle suggests a planned increase in numbers or size; management of a fish pond implies increase of some fish and decrease of others. Since rat control is merely a specific case of management, a perspective on rat control probably can be obtained by examining the field of wildlife management as a whole and by placing the management of rats in relation to the knowledge about other species.

The abundance of every species is regulated by a variety of factors. The inherent physiological and psychological capacities of a species are affected by such factors as temperature, food, disease, and others. But at a specific time and place some particular factor limits the population by its scarcity or excess. In winter an inadequate food supply may limit the deer population by starvation. In southern States the temperature may be too high during the incubation period of pheasants for survival of the embryos. The regulatory factor which governs the population at a specific time and place is called the limiting factor. It is essential for an understanding of the management of populations to remember that the limiting factor may be one thing in one place and another thing in another place. For example, a quail population may be limited by food supply in one field, by shelter in another field, and by disease in still another field. The bewildering complexity of the interactions of limiting factors is both a challenge and an annoyance to the investigator.

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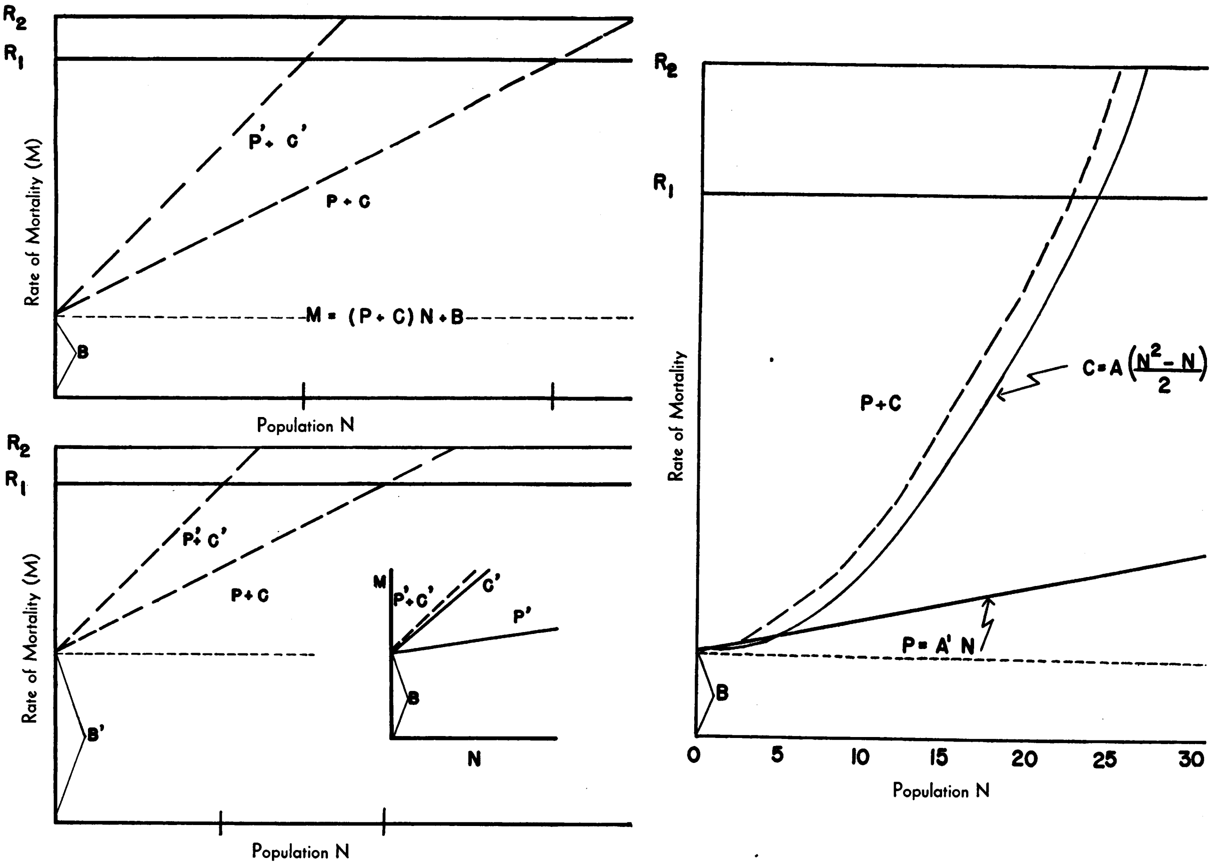
The Regulatory Factors

Fortunately, it is possible to group the regulatory factors into three classes—environment, predation, and competition—to facilitate analysis. Environment includes food, shelter, temperature and soil type. Predation includes foxes, traps, and diseases, and competition is the fighting for the limited supply of the environmental necessities.

Although these three groups are all regulatory factors, there is a difference between environment and the latter two types. Environment is considered to be density-independent. This phrase means that an environmental factor affects the same proportion of the species irrespective of the size of the population. For example, low temperature may kill 10 percent of the mosquitoes whether there are 100, 1,000, or 10,000 present. In contrast, predation and competition are considered to be density-dependent and to affect a changing percentage of the population according to its size. Interspecific competition is density-dependent and for simplicity may be classed as predation or competition according to circumstances.

The contrast between the environmental and the predation and competition factors is illustrated by figure 1, modified from Smith (*12*). The horizontal axis represents the population and the vertical axis the rate (percentage) of

Figure 1. Theoretical scheme for clarifying interaction of environment, predation, and competition.



mortality. In the upper left-hand chart the environmental factors (density-independent) account for a constant percentage of mortality given by B (dotted horizontal line). We assume that the reproductive rate is fixed at some value (R_1 or R_2) and is constant at all sizes of population. Predation and competition together (density-dependent) account for an increasing percentage of mortality as given by the two examples (P+C, P′+C′; dashed lines). Where these dashed lines reach the upper horizontal lines (reproductive rate), the population will be stationary because the rate of mortality equals the rate of reproduction. In this example, the environmental factors are responsible for a small proportion (B) of the mortality, but in the lower left-hand chart the environment (B′) is responsible for a much larger proportion. Although the slopes of the predation and competition (P+C) lines are the same as in the upper chart, the population at equilibrium of mortality and reproduction is much lower.

Now we need to introduce a theoretical refinement into the predation and competition term. It is probable that predation is proportional to the population ($P=A'N$), but competition is probably proportional to some power of the population. One relation is $C=AN^2$ since this expresses the number of collisions. Another relation is $C=A\left(\frac{N^2-N}{2}\right)$ where the term $\frac{N^2-N}{2}$ gives the number of interactions of N objects moving at random. If we use the latter equation for C, we get the rapidly ascending heavy line in the right-hand diagram. Adding P to it gives the ascending dashed line.

This scheme obviously is a simplification of natural conditions and cannot be translated into wildlife in detail, but it clarifies the relationships of the regulatory factors. A change in any of the three groups of factors will change the population number at equilibrium of mortality and reproduction. Control of a species

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thus becomes a question of the feasibility of changing the factors, or, in its simplest terms, of how much it costs in time and money to change B or the slopes of P or C. This cost is determined by local conditions for each species and is naturally extremely variable. It is hard to change the slope of C, because this implies changing the inherent psychology of the species. Therefore, only environment (B) and predation (P) remain to work with.

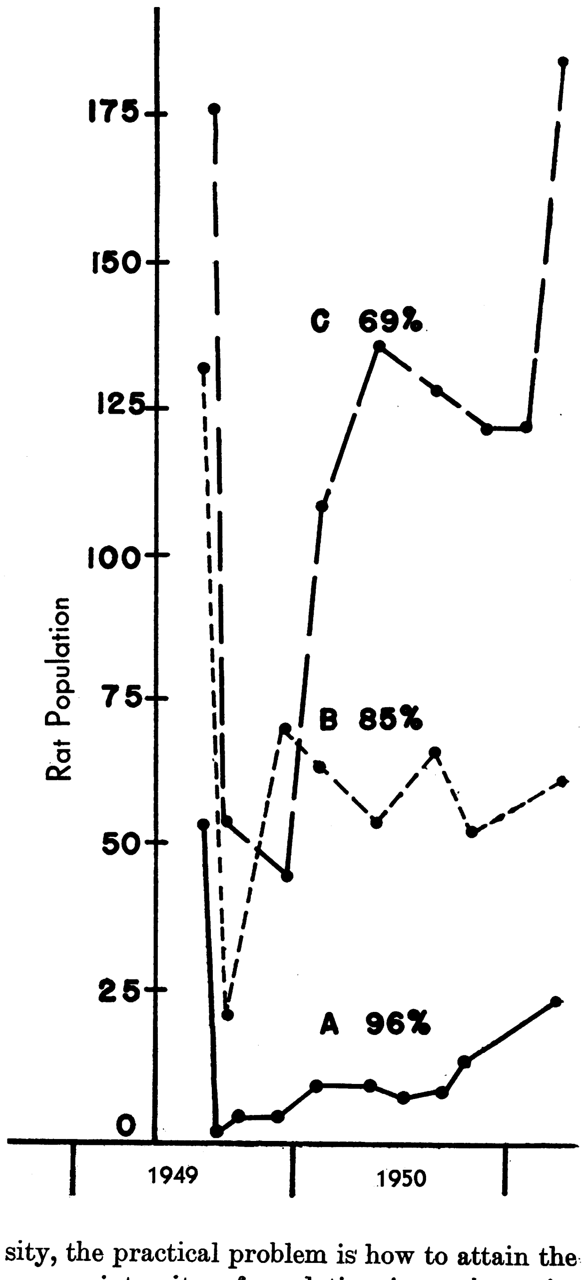
Predation Intensity

Clearly, a sufficient increase of rate of predation will reduce the population. Existing data help to indicate how much increase in predation is sufficient. For insects there is considerable evidence that predation can be increased under some conditions (*13*), but for vertebrates there is little evidence that natural predators or disease hold a population below the level determined by density-independent factors. For example, Errington (*4*) found no increase in rate of mortality from predation in many species. These data show that under usual conditions the predators are well adjusted to their prey and have little effect on the numbers. Indeed, even intensive hunting did not reduce pheasants in Michigan (*1*). But these cases are at one end of a scale of intensities. The slope of the predation rate can be any value from 0 to 1—no predation to complete predation (right-hand diagram, fig. 1). Krumholz (*5*) found that *Gambusia* clearly limit the population of mosquito larvae. Russell (*11*) summarized the obvious effects of excessive fishing on supplies of commercial fish. Rothschild (*9*) quotes many cases of extermination of birds by cats, dogs, and rats on islands.

Thus, there is a continuous series of examples from no effect to complete extermination. It is even possible that predation is not intense enough for maximum population. Swingle and Smith (*14*) showed that increased fishing was desirable to increase the yield from farm ponds in Alabama, while Lynch and associates (*8*) found that intensive trapping of muskrats was necessary to prevent the muskrats from increasing so greatly that they destroy their habitat.

Although predation may occur at any intensity, the practical problem is how to attain the proper intensity of predation in a given circumstance. Whether the result is a trivial effect or extermination depends upon the effort expended. In actual practice the effort ex-

Figure 2. Changes in rat population in blocks in Baltimore after poisoning with compound 42 (warfarin). In the smallest block (A) the greatest decline (96 percent) was obtained and the slowest subsequent increase. In block B a good reduction (85 percent) resulted. In the largest block (C) a fair reduction (69 percent) was followed by a rapid return to the original number.



pended is rarely enough to reduce the population to a satisfactory level. Poisoning and trapping, for instance, have as yet been unable to reduce rats to the low level desired by the health officer. Poisons and traps can reduce rats enough to satisfy the farmer and some householders, but that is a question of sanitation standards.

Change in Reproduction

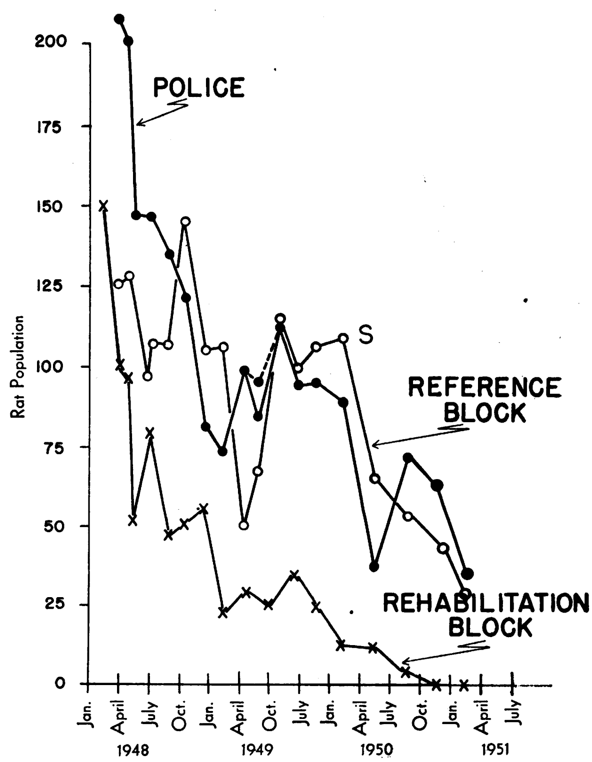
The converse of a change in mortality is, of course, a change in reproduction. The upper horizontal line in figure 1 represents rate of reproduction, which is assumed to be constant, although it probably is concave downwards. If reproduction is increased from R_1 to R_2 and the slopes of the predation and competition lines are not changed, the population will obviously increase. Reproduction can be increased in several ways: (*a*) some heredity mechanism; (*b*) increased food and shelter; and (*c*) artificial introductions of young or adult individuals. The first is outside the scope of this discussion since we are assuming a given species. The second is obvious: more food and shelter mean more reproduction. The third is a favorite panacea of sportsmen for all hunting troubles. Although it is possible to raise game or fish and release them in areas where sportsmen can get them, this system soon degenerates into the notorious "put-and-take" scheme in which the game commission dumps trout into the stream a few yards away from the fishermen who catch them.

The problem of stocking fish and game, like predation, is a question of intensity. Examples can be cited for the whole gamut of results from trivial effect to satisfactory solution. But as a practical problem of dollars and cents, stocking rarely is effective at a level that the sportsmen will support by taxes or fees. Buechner (*3*) showed that success was seldom attained with quail. Fish hatcheries have limited value for the improvement of fishing (*10*). But stocking has a place. Baumgartner (*2*) showed that the stocking of quail was beneficial in low populations but not in high populations. Krumholz (*6*) discusses the obvious conclusion that stocking newly constructed farm ponds is beneficial. Unfortunately, for higher vertebrates the predation + competition line rises very steeply at high populations, and hence great expense is required to increase the population by stocking methods. Thus, as in predation, a problem of practicability confronts the investigator.

Predation Results

What are the practical means at our disposal for changing the population? It is clear that an increase in predation (the slope of line P, fig. 1) will reduce the population. This increase can be obtained for a sum of money that may or may not be available, depending upon conditions. But increase of predation also reduces competition and thereby makes conditions better for the survivors. Thus, the increase of predation is partially opposed by a reduction in competition.

Figure 3. Results of three levels of intensity of environmental control of rats in blocks in Baltimore. The "rehabilitation block" was greatly improved. The "police block" was partially improved. The "reference block" was not changed until January 1950 (S). The reduction in rat population is proportional to the intensity of rehabilitation.



In contrast, an increase of B (mortality due to environment) will reduce the population more effectively because B is increased by reducing the food and shelter. These measures, however, have additional effects. The rate of reproduction is decreased and the slope of the rate of predation is increased.

Conversely, a decrease of B will increase a species. These changes in turn also increase the rate of reproduction and decrease the rate of predation. Thus, this management procedure has three means of action.

The results of predation can be compared directly for rat populations in three blocks in Baltimore. Figure 2 shows the history of rat populations in three blocks in which compound 42 (warfarin) was used by a highly competent technician. The percentage reduction was greatest in the block with the smallest population, and also the increase was least in the block with the smallest population. These three populations show the points emphasized above. Predation can be intense enough to be satisfactory in some blocks (A), but it is often unsatisfactory (C). The question is simply how frequently the reduction in A can be accomplished. Unfortunately, budgets are a limiting factor in such accomplishments.

Housing Improvements Effective

Contrasted with poisoning is the rat reduction resulting from improved housing and sanitation in blocks rehabilitated by the Baltimore City Health Department (fig. 3). The "rehabilitation block" was inspected by the health department in April 1948, and the rat population was eventually exterminated. The "police block" was inspected by the police, who do less intensive work. The "reference block" was not affected until January 1950, when sanitation (S) was begun. The difference in results in the poisoning experiments needs no comment, but the costs do. The only cost of rehabilitation to the taxpayer was for inspection and enforcement. The actual sanitation was performed by the tenants and landlords. No figures on cost per premise are available, but the cost must be divided according to the benefits in all aspects of housing because the rehabilitation consisted of improving the construction, repairing the floors, cementing the cellar, correcting the plumbing, cleaning the yard, and similar improvements. If we assume the average cost is about $50 and that the actual rat work is one-fifth of the total, then the rat control is $10 divided between tenant and landlord. This multiple benefit aspect is extremely important. Few cities would advocate a rat control program at $50 a premise, but many would at $10 a premise.

Summary

This discussion has emphasized the problem of intensities and interrelations. Rat control is simply a problem of increasing the mortality rates. A perspective derived from comparison of other species shows clearly that a change in the environment gives the most results for the money spent. But in some cases, for economic or cultural reasons, the expenditure of even moderate sums is impossible. In these areas the cost of temporary poisoning jobs must be met until adequate improvements in conditions can do a real job.

The simple objective of getting rid of rats is too narrow to merit the attention of health officers. The worthy objective is to improve living conditions so that a variety of diseases and pests will disappear and a better community will result.

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New Aid For Venereal Disease Nursing

In response to inquiries by public health nursing educators about the nurse's responsibility in the changing pattern of venereal disease control, the Public Health Service, through the Division of Venereal Disease Control in the Bureau of State Services, cooperated with the Georgia State Department of Health in holding a 2-week work conference early in 1951 at the Alto Medical Center, Alto, Ga. Sixteen States and 23 universities were represented by faculty members attending the conference.

An outgrowth of the conference is the publication of a 28-page "Suggested Outline for the Teaching of Venereal Disease Control," by the National League of Nursing Education, 2 Park Avenue, New York 16, N. Y. Divided into three major units, the outline covers: medical aspects of venereal disease; venereal disease within the framework of nursing; and community education in venereal disease.

The outline is planned to serve as groundwork for revising courses of instruction for the student nurse in venereal disease control. Its use will depend on the individual instructor, the needs and interests of the students, available resources, the scope of the curriculum, and the area where the school of nursing is located. Methods and activities are suggested to the instructor for selecting realistic activities in the development of learning situations.