Ecology of Foxes and Rabies Control

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A 5-year study of fox populations in the southeastern United States was undertaken to provide information applicable to the prevention of rabies. The research was designed to accomplish at least six objectives: to estimate numbers of foxes, to determine reproduction and death rates, to examine the extent of movement, to determine the prevalence of rabies in a random sample of foxes, to evaluate procedures for controlling their numbers, and to suggest possible trends in fox populations in the future. Results of the investigation, presented in detail in a series of papers in specialized journals (*1–6*), are here summarized and interpreted from the public health point of view.

The research was conducted in Georgia, Florida, and South Carolina, with Thomasville and Newton, Ga., as bases. This area was chosen for several reasons. First, rabies has occurred in these States for many years. Second, vegetation is typical of a great region from Virginia to Texas and thus findings should have wide applicability. Third, the Communicable Disease Center of the Public Health Service had in this area a laboratory which would provide certain services.

The basic philosophy of the research was that foxes are an integral part of the biological economy and should not be exterminated even if this were feasible. It was believed, however, that their numbers should be held below a density at which rabies will occur and that control activities should keep the population below this threshold.

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Census and Vital Data

The first step was to estimate numbers of foxes. A standard procedure of setting traps which permitted calculation of a simple relative census was developed (*1*). A number of traps were set according to specific rules. The traps were placed along dirt roads at intervals of 0.2 mile and examined each morning for 7 days. The proportion of stations that caught 1 or more foxes in 7 days was calculated (*2*). Thus, one trapping area might have a value of 0.15 and another of 0.30. These proportions are only relative measures. They simply indicate differences in number of foxes caught; they do not reveal absolute numbers of foxes. To determine absolute numbers of foxes, rather elaborate and expensive procedures are necessary (*3*). Fortunately, in most practical work a relative method is sufficient to indicate changes.

Since the number of foxes caught depends on movement as well as abundance, the trapping proportions can be used for comparisons of abundance only during periods when movements are constant (as measured by tracking patterns) or between areas of similar habitat. From several lines of evidence it seems clear that greatest movement occurs in the fall in this region. In six areas foxes were trapped in summer after the young were at large and again in the fall. The proportion of stations catching foxes was 0.09 in the summer and 0.18 in the fall, but most of the increase in the index was due to increased travels of the foxes within their home range (*3,5*). In three large areas where movements were known as a result of capturing, marking, and releasing foxes, an increase in the number caught occurred in October and November.

The rate of increase of a population must be known in order to appreciate the efficacy of a reduction procedure or the recovery of a population after a natural calamity. Our research found that gray foxes averaged 4.5 embryos per female, that 96 percent of the females bred successfully, and that parturition occurred primarily in March and April (*4*). From these results we estimate that a population of 100 foxes in March will produce about 215 pups at birth. (We found no intra-uterine mortality.)

The rate of decrease of a population is equally important in evaluating numerical changes. To determine the mortality rate of foxes, a method of estimating age by tooth wear was developed (*4*). This permitted calculation of probability of dying from the age composition of various samples, using certain well-known assumptions. From these results it was found that the annual probability of dying is about 0.5 (annual death rate per fox=1.3). The life expectancy of an adult fox is 1.5 and that of a pup is about 0.9 years.

These mortality rates are surprisingly high, but they are coupled with a high rate of reproduction to produce a high proportion of young foxes in the population. In five areas in Georgia, Florida, and South Carolina, in which foxes were trapped in the winter, the percentage of foxes less than 1 year old varied from 48 to 61, and only 4 percent were more than 3 years old. The important conclusion here is that the fox population is essentially an annual crop. Control procedures and conclusions about prevalence of virus must recognize this situation.

Precise data on movement of foxes are difficult to obtain, but the question was explored by trapping foxes, tattooing a number in their ear, and releasing them in the expectation that some would be caught again and thus reveal some information about their movements. From the results it was clear that some foxes avoided recapture, but 56 were captured again. More than half of these were recaptured within a mile of the point of release. An aspect of considerable importance is the tendency of foxes to remain together in groups, presumably familial (*3*). These groups disperse in early fall, and this dispersal apparently sets the stage for high mortality of pups.

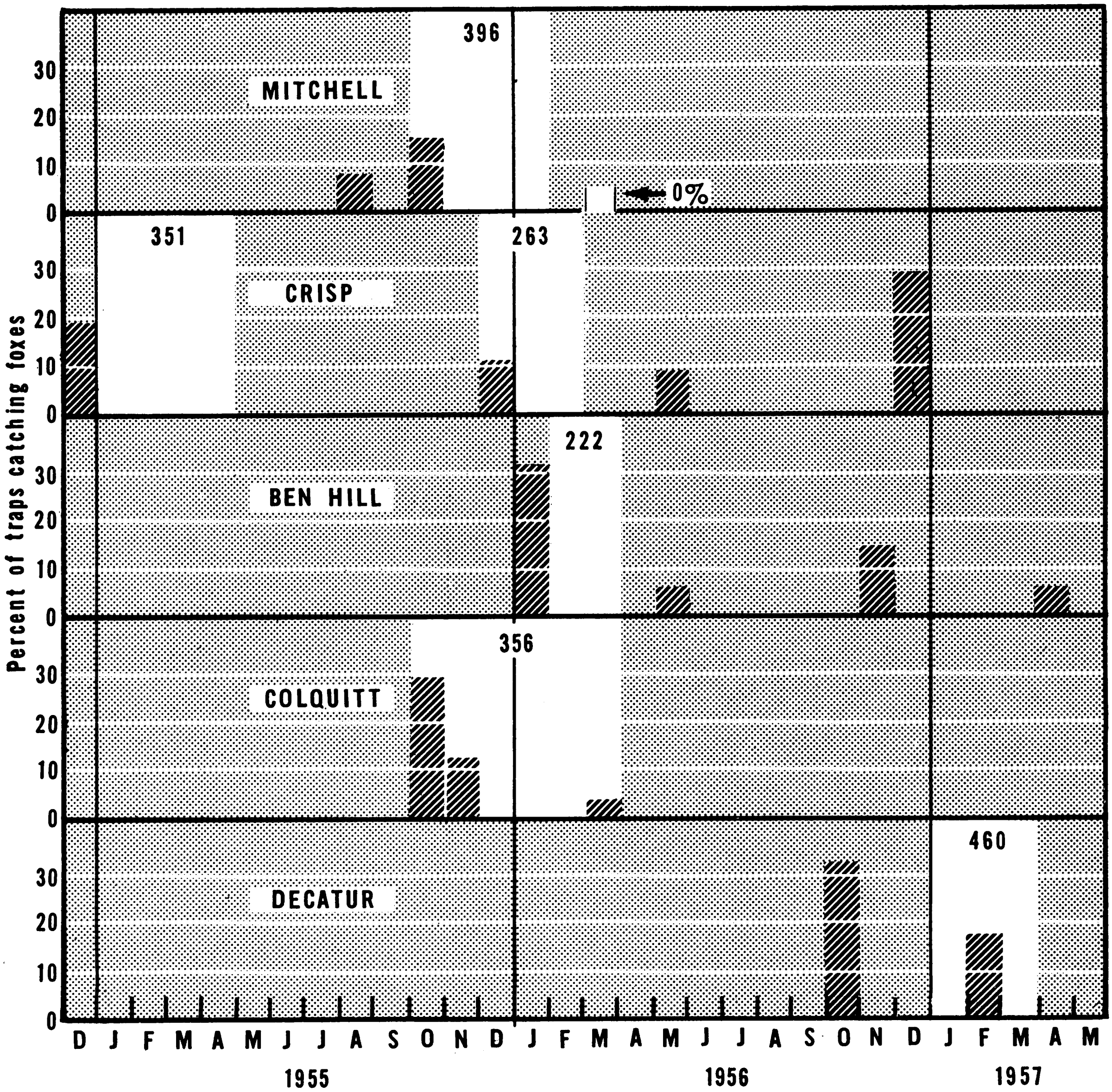
The relation of abundance of foxes to type of habitat is crucial to understanding current distribution and predicting future trends. Detailed analysis of trapping results shows clearly that foxes are most abundant in areas supporting cultivation (*2*). The population indexes were: cultivated areas, 0.22; savannah pine, 0.15; woods, 0.06. The agricultural trend in recent years has been from cultivated areas to woods (for pulp and timber) and pasture. This change greatly reduces the suitability of the area for foxes and should result in a decline in numbers.

Rabies Virus Prevalence

The prevalence of the rabies virus in the fox population was determined by examination of all fox heads from certain areas. This work was done at the Communicable Disease Center laboratory at Newton, Ga., under the general direction of Dr. Ernest Tierkel. Of 1,026 foxes, 32, or 3.1 percent, were found positive for rabies by virus isolation techniques (*6*). No statistical difference in prevalence between gray and red foxes was apparent, for 2 of the 117 red foxes were positive. None of the 299 raccoons or 215 opossums trapped was positive, but 1 of 89 bobcats and 1 of 144 skunks were positive.

The prevalence of the rabies virus differed, of course, from place to place. The data were analyzed to see whether the results could be useful in predicting an outbreak of rabies. The only practical geographic unit for this analysis was the county. In 5 counties that had not reported rabies in either man or animals for many years, none of the 133 foxes was positive. In 2 counties 2 rabid foxes were reported after an absence of reported rabies for 5 years, but examination of 93 foxes in these counties caught in 9 periods revealed no positive foxes. Ten counties had regularly reported rabies in humans or livestock for several years, but in

Population index (proportion of trap stations catching foxes) before, during, and after a specified number of foxes were removed by trapping, five counties in Georgia.



WHITE AREAS: Periods during which foxes were removed by trapping. FIGURES IN WHITE AREAS: Number of foxes removed.

7 of these no positive fox was found in one trapping period when samples of from 9 to 83 foxes per county were examined. In the other 3 counties, 3.5 percent of 28, 11.3 percent of 62, and 8.8 percent of 147 foxes were positive for rabies.

These results demonstrate clearly that the detection of rabies in foxes by trapping on a sampling basis is not a sufficiently sensitive technique to be useful in predicting a rabies outbreak. The basic problem, of course, is that rabies occurs at a high prevalence in a few small areas. Thus, while in a large area only 3 percent of the trapped animals may have detectable virus, there may be many positive foxes localized in a few small habitats. Detection of rabies in foxes is very difficult under these circumstances.

The next step in the search for an indicator of future epidemics was to examine the density of foxes in relation to prevalence of rabies virus. The results in 24 locations showed no obvious relation between our measure of fox abundance and prevalence of rabies in the foxes. In 11 places where the prevalence varied from 2 to 33 percent, the abundance index (proportion of trap stations catching foxes) varied from 0.10 to 0.51. In 13 locations where no virus was demonstrated, the index varied from 0.06 to 0.40. Actually, there were significantly more captures in localities with recently reported rabies (0.29) than in those without recently reported rabies (0.22).

From this examination we conclude that neither the detection of virus in foxes nor the density of population of foxes is practical as a predictive measure. We thus accept the reporting of cases of rabies in animals and humans as the most promising method of maintaining surveillance of rabies, and we suggest greater emphasis on completeness and accuracy of reporting.

Evaluation of Control Methods

The next question for our research was, what are the most practical and most effective means of reducing fox populations? It is generally recognized that the best way ecologically to control a population is by manipulation of the habitat. Data summarized above suggest that the trend in the southeastern United States from small fields to forests or pasture will produce a reduction in foxes. Fortunately, this trend is expected to continue, but no other feasible habitat change is apparent.

The only alternative to habitat manipulation is killing foxes. Use of poisons should be rejected at once because it is nonselective. Trapping is feasible, and this method has been used for many years. Its effectiveness, however, needs more examination.

Records are available in five counties for the fox population before, during, or after a reduction program by conventional trapping methods (see chart). In four counties (Mitchell, Ben Hill, Colquitt, and Decatur) reduction in the fox population was substantial. In the fifth county, some reduction was obtained, but the population increased subsequently.

Summary and Conclusions

In summarizing the data on fox populations applicable to the prevention of rabies, these points deserve emphasis.

Because of high birth and death rates, fox populations are essentially an annual crop. Thus, there are many new, susceptible foxes each year, and increase in numbers, even after a reduction, may be rapid.

Examination of prevalence of rabies virus in foxes or of abundance of foxes when conducted on the small scale that seems feasible is not sufficiently sensitive for predicting rabies outbreaks. Thus, the reporting of human and animal cases is still the best method of warning that preventive measures are desirable.

Trapping foxes will reduce their numbers, but the effect of such reductions on prevalence of rabies in the fox populations is yet to be determined. The agricultural trend in the southeastern United States from small farms to large tracts of timber or pasture should reduce fox numbers and consequently the amount of rabies.

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