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# SURVIVAL RATES OF PINE VOLES IN NORTH CAROLINA ORCHARDS

by

Don W. Hayne
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## INTRODUCTION

There are a number of definitions of control of a pest. One of the competing definitions, and probably the most common even if not accepted in advanced circles, is to kill off the pest. Translated, this says: to increase the mortality rate, preferably to an extreme degree.

I am going to talk here about survival rates. A survival rate is just the complement of the mortality rate - if survival is 80 percent, then mortality is 20 percent. It happens to be more generally useful in studying populations to deal with survival rates, so I hope I may be excused not having translated everything to mortality rates as I might have done.

All animals are mortal, so left to themselves their populations would dwindle to nothing except for their rates of reproduction. It is necessary to know what the natural rates of survival are in order to avoid confusing the natural decline of populations during periods of low reproduction with the supposed effect of some control measure.

The trials described here are simple in concept. We have measured survival both with and without control measures with the primary purpose of comparing rates under the two conditions and then judging the efficacy of treatment from the changes in survival rates.

## METHODS

Survival rates as calculated here are based on capture - recapture records obtained from live-trapping. Animals were taken in Sherman live traps (3 x 3 x 10 inches; galvanized sheet steel) set under cover of a piece of composition roofing, often in a shallow trench dug to place the trap at the level of the burrow. Traps were tended twice daily; each animal was marked by toe clip with a unique serial number and released where caught. Records were made routinely of sex, age and breeding condition at each capture. Some individuals were taken as many as 20 times in a 43-day study period (25 days of trapping).

In each experiment, trapping was carried on for about 5 days immediately before the rodenticide application, 10 days later and at two later times separated by intervals of about 10 days. In addition, in the more recent studies, trapping was carried on at an earlier time, about 10 days before the pre-treatment trapping, to measure natural survival rate (i.e., when voles were not exposed to rodenticide treatments). Traps remained on the site but closed between trapping sessions so that animals would not be captured.

Different types of accessory information were obtained depending on the nature of the trial. With endrin ground sprays, specimens for residue analyses were obtained both before and after the spraying. With tests of anticoagulant materials the blood clotting time of animals was measured both before and after treatment.

Survival rates were estimated here through use of a paired-record modification of the Ricker method. This general method was developed for use in fisheries but has been applied in other population studies. It compares the recovery rate of animals handled previously before some time interval, with the recovery rate of those handled in the immediate past. In such a comparison the recovery rate is higher for the more recently handled animals than it is for those animals handled some time ago because in the interval a greater proportion of the latter group have died (or moved elsewhere). The paired record feature was introduced here in order to more precisely associate the elapsed period of time with the change in the recovery rate. This exact association becomes necessary here where we are attempting to measure survival rates over short time periods. Were we concerned with periods of several months then the several days difference in elapsed time from beginning to end of a trapping period would be unimportant. But when measuring survival over a 10-day period with trapping periods of 4 or 5 days, the question becomes important.

One disadvantage of this paired-record modification is that it tends to weight heavily the contribution to the overall data made by those animals which repeat more often in the traps, day after day.

In results reported here, the records are combined without reference to age or sex class. This compositing of records was made because in some trials the data were inadequate to support separate analyses by age-sex class, and also for lack of any clear evidence of differences in survival rates for these classes. All estimates of survival have been calculated to the 10-day basis to provide for making comparisons between trials that extended for longer or shorter periods.

## RESULTS

Natural survival rate was determined in 12 tests with results summarized in Table 1. Values as calculated ranged 0.605 to 1.000 as calculated for 10-day survival, with an average value of 0.871. Using this 10-day average value, I have calculated the survival to be expected over a period of several months (Table 1). This shows that over a 4-month span, say from mid-November to mid-March we may expect about 20 percent survival, or 80 percent mortality due to natural factors only.

Table 1. Determinations of 10-day survival rate in orchards under natural conditions and estimated survival for periods of 1-5 months at the mean 10-day rate of 0.871

| Study no. | 10-day survival | Study no. | 10-day survival | Study no. | 10-day survival |
|---|---|---|---|---|---|
| 6 | 0.953 | 10 | 1.000 | 19-22 | 0.913 |
| 7 | 0.848 | 17 | 0.874 | " | 0.648 |
| 8 | 0.794 | 18 | 0.605 | " | 1.000 |
| 9 | 1.000 | 23 | 0.833 | 24 | 0.988 |
| | | | mean | | 0.871 |
| | | | standard deviation | | ± .135 |

Calculated survival for longer periods

| | |
|---|---|
| 1 month | .661 |
| 2 months | .437 |
| 3 months | .288 |
| 4 months | .191 |
| 5 months | .126 |

Table 2. History of survival during experimental trials of endrin and chlorophacinone ground sprays in North Carolina orchards; periods are of about 10 days starting immediately before spraying

| Study | Application Rate | | | | 10-day survival rates | | | |
|---|---|---|---|---|---|---|---|---|
| | per sprayed acre | | per orchard acre | | natural (pre-spray) | Period 1 | Period 2 | Period 3 |
| | lb. | gal. | lb. | gal. | | | | |
| Endrin ground spray | | | | | | | | |
| 1, 2 | 0.2 | 32 | 0.1 | 21 | | 0.952 | 0.818 | 0.834 |
| 3 | 3.9 | 647 | 1.7 | 284 | | 0.058* | -- | -- |
| 4 | 3.2 | 359 | 1.6 | 196 | | 0.215 | 0.899 | 0.688 |
| 5 | 2.3 | 286 | 1.6 | 96 | | 0.889 | 0.770 | 0.680 |
| 8 | 1.7 | 285 | 1.0 | 172 | 0.953 | 0.240 | 0.909 | 0.816 |
| 17 | 2.8 | 605 | 1.3 | 278 | 0.874 | 0.460 | 0.713 | 0.562 |
| 18 | 2.3 | 768 | 1.1 | 377 | 0.605 | 0.077 | 0.175 | 0.130 |
| Chlorophacinone ground spray | | | | | | | | |
| 9 | 0.21 | 624 | 0.10 | 304 | 0.848 | 0.433 | 0.801 | 0.914 |
| 23 | 0.34 | 682 | 0.15 | 298 | 0.833 | 0.359 | 0 | -- |

*Two animals captured alive after treatment.

Survival rates of pine voles in tests where ground sprays were used are shown in Table 2. The first point that is apparent is that in only one of the 7 tests was endrin completely and immediately effective. Several other tests probably achieved economic control, with 3 other trials reducing the population to about 20 percent of the initial population level in the first few days after the spray. That leaves 2 tests out of 7 with little if any effect and one test (no. 17) with a doubtful result.

Two tests were made of chlorophacinone ground spray; one of these showed a highly successful control and the other a more doubtful result. Neither the field notes nor records of precipitation made at Fletcher, N. C. show significant precipitation during the week following the spray application at the last test.

Tests of prepared bait treated with diphacinone showed successful control in 3 of 4 trials with the fourth trial showing a delayed response that may have been effective in reducing the resident population to a low level in about a month (Table 3).

Table 3. History of survival during experimental trials of diphacinone treated bait (Ramik Brown) in North Carolina orchards

| Study No. | Pounds per orchard acre | No. stations | 10-day survival rate natural (pre-spray) | Period 1 | Period 2 | Period 3 |
|---|---|---|---|---|---|---|
| 6 | 28 | broadcast | 1.000 | 0.103 | 0.428* | -- |
| 7 | 20 | 1 | 0.794 | 0.102 | 0.410* | -- |
| 10 | 10 | 2 | 1.000 | 0.047 | 0 | -- |
| 24 | 15 | 2 | 0.988 | 0.605 | 0.301 | 0.353 |

*Based on consolidated records, periods 2 and 3.

## DISCUSSION

These studies of survival rates of pine voles in orchards show, first, that endrin ground spray is not invariably efficient as a control measure, and as far as the tests have gone, that the chlorophacinone ground spray, and the bait prepared with diphacinone are at least as effective as endrin, and are probably better.

We have also drawn some other conclusions from these tests. The volume of spray used seems to be an important factor with endrin, with the tendency being to use too low a volume to thoroughly contaminate the runways. From other work it appears that when rain follows an application of the chlorophacinone ground spray, its effectiveness is much reduced.

This method of measuring survival is costly and furnishes variable results, but it measures survival as directly as possible, and survival is the important factor here. If we set as a standard of effective control the reduction of the 10-day survival rate to about 20 percent in the period following a control program, this implies an added mortality of 75 percent* beyond the 13 percent we may expect from natural factors.

The determinations of natural survival rate reported here were all made in fall and winter. A 10-day survival rate of 0.871, if assumed to apply over all seasons, suggests that a population would be virtually

*This figure is derived from the most simple model for competing risks which assumes independence of mortality factors, where survival to two factors (here 20 percent) is the product of survival to natural factors (87 percent) and survival to toxicant effect (calculated here as 25 percent).

eliminated (reduced to 1 percent of its size) in about 330 days, if there were no reproduction. A more realistic statement of this rate of natural mortality is that in 4 months the population would be reduced to 20 percent of its original level by natural causes only; thus some earlier reports of the over-winter reduction of vole numbers, credited to endrin treatment, may only reflect natural decrease.