THE NEED OF SURFACE SPRAYS FOR THE CONTROL OF MICROTINE RODENTS

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ABSTRACT: Four Microtine species, the field vole (Microtus agrestis), the continental vole (Microtus arvalis), the water vole (Arvicola terrestris) and the bank vole (Clethrionomys glareolus) are the most harmful rodents in forests, fields, orchards and gardens in Northern and Central Europe. Except for the latter they are all herbivorous, their food consisting to a very low degree of seeds and grain. As a consequence dry poison baits are not well accepted most of the year. The only economic and effective control method until now has been surface spraying with the chlorinated hydrocarbons endrin and toxaphene. As these chemicals are now black-listed in many European countries, and their use severely restricted in other countries, no effective means for controlling these rodents exist for the time being.

New surface sprays without the persistence of endrin, but with a more long-lasting effect than parathion, are severely needed if the extensive damage to trees and crops shall be reduced.

Leaving out of consideration the brown rat and the house mouse, both of which can be coped with if reasonable economical and organizational efforts are taken, only five rodent species can be considered major pests in Europe. They all belong to the subfamily Microtinae. The largest species being the muskrat (Ondatra zibethica) which constitutes a special problem discussed by Dr. Becker, Germany. First, I shall give you a short description of the other four important species, their food habits and the typical damage for which they are responsible.

The water vole or black water rat (Arvicola terrestris) is the size of a young brown rat with a somewhat shorter tail and ears hidden in the black-brownish fur. It is found all over Scandinavia, Denmark, Germany, Central Europe, Holland, and Belgium. Westwards, in England, France, Spain, and Portugal it is replaced by other subspecies, not always of the same importance. Being a true vegetarian, it prefers grasses and herbs in the summer, and the storage organs of various plants, as well as roots of trees and shrubs in winter-time, when it is mainly subterranean. All habitats with grass-cover are suitable for the water vole, which - in spite of its name - is not bound to water and streams as is its harmless close relative in Britain. The water vole is feared by fruitgrowers, foresters, private garden-owners, farmers and telephone companies. Except for the last group mentioned the most important damage occurs in the winter when roots of all sorts of trees and ornamental shrubs are severely gnawed. Fruit trees are preferred, and certain kinds as Cox orange apples are selectively chosen. Bulbs of various plants, potatoes, carrots, and other plant storage organs are collected in autumn in the extensive burrow system. Beets, clover, luzerne, and other field crops are damaged in the summer season. Telephone cables are of course endangered the whole year.

The field vole (Microtus agrestis) is a much smaller animal, but in some countries, such as Norway, Sweden and Finland, it is considered a much more important forest and orchard pest. As a real herbivorous rodent, it is strictly bound to areas with a permanent grass-cover. When the caloric value of this food is at a minimum in late winter the voles often turn over to feed on the bark of trees. As it cannot climb, the damage is confined to the lower 15-20 cm of the stem, but most often the effect is fatal to the trees. Old abandoned fields turned into forests by large-scale plantation programs all over Scandinavia, and to some degree in Central Europe, are ideal habitats for the field vole and are particularly susceptible when peak densities occur almost every four years.

The continental vole (Microtus arvalis) is very similar to the field vole and can only be distinguished by experts. It is an open land species not dependant on trees, but just as much bound to grass cover and herbs. In West Germany, Central Europe, France, Belgium, and Holland, it is more abundant than M. agrestis and causes heavy losses to clover and luzerne fields, grass-seed fields, beets and other field crops. In most of its areas, it reveals a rhythm in population densities with a peak every three years.

The bank vole (Clethrionomys glareolus) with a reddish color on the back and the size of a field vole, differs in some important respects from the other voles mentioned. It prefers a habitat of mixed deciduous trees with high bottom vegetation of scrubs and is not dependant on grass as food or cover. It is more granivorous, the diet consisting for a large part of seeds, leaves of trees, animal food, and bark. As it is an excellent climber the damage to the trees is generally not concentrated to the lower part of the stem, but still it can be quite severe and in some parts of Central Europe (e.g. Romania) it is considered the most important pest in deciduous forests.

THE DAMAGE AND ECONOMIC IMPORTANCE OF THE MICROTINES

In few countries only, data are available on the economical importance of the damage caused by the voles. Most often very subjective estimates are given. More accurate estimates seem to be confined to Scandinavia, West Germany and part of France, mostly based on enquiries to foresters and orchardmen; some, however, were verified by direct investigations. To give an idea of the significance of Microtine damage, I find it more adequate to present examples from various European countries instead of treating each species separately.

In Finland the field vole is the most harmful rodent damaging afforested areas and orchards. Apple trees are the favorite objects for the rodents in winter. In the peak year of voles, 1958, more than 18% of the apple trees in Finnish orchards were severely damaged and in the period 1954-1958, 90,000 young apple plants were killed (Myllymäki 1959).

Based on questionnaires a minimum estimate of the damage caused by field voles to horticultural plants in the 1950's and 1960's is given by the Agricultural Research Centre (Kanervo et al. 1970). For the 13 years covered by the survey the verified damage to apple trees and other horticultural plants was calculated to about 2 million dollars. In the second largest Finnish orchard in the winter of 1965-66, 13,500 apple trees in their best yielding years were killed by the voles. The entire damage to horticulture in Finland is estimated at a total of 3.143 million dollars per year.

In Finnish spruce nurseries the percentage of 2-3 year-old seedlings, damaged by the voles in the period 1962-66, varied from 12.2 to 77.5 with an average of 52.5%, and the mortality was 13.4-64.6%, with an average of 41.9% (Myllymäki 1970b).

The economic losses by vole damage to forestry in the 1960's were at a minimum $120,000, when only verified cases are included, and the following figures give an indication of the importance of the vole damage to seedlings of forest trees in nurseries in 1966 (Kanervo et al. 1970): 28.3% of 848,000 pine plants damaged, 8.8% of 1,329,000 spruce plants damaged, 50.0% of 10,000 birch plants damaged, and in 1968-69, 22,500 grafts were destroyed, or almost 4% of the entire number of grafts in the seed orchards of the Finnish State Board of Forestry.

Besides this, field voles damage various crops as barley, oats, and wheat by eating the green plants - as well as peas, sugar beets, and mangel. No estimates of the economic importance of this damage are given.

In the northern parts of Finland (and Sweden) severe losses on stored hay, caused by voles were recorded in the winter 1966-67 followed by epidemics of tularemia, among the local inhabitants.

In Norway the field vole is also by far the most important rodent. In the peak year 1965-66 spruce plantations were severely damaged, about 3,243 ha of young spruce were destroyed and 6,269 ha more or less damaged. The losses have been estimated at about 1.434 million No.Kr. (appr. $200,000) as an absolute minimum (Wegge 1967), private foresters and nurseries not being included. In a single nursery 22,400 spruce plants had to be renewed in 1965, and 23,500 the following winter, at a cost of about 36,000 No.Kr. (appr. $5,000), not considering the waste of time and experimental data.

As a rule the more severe losses occurred in areas where old grass-covered fields were afforested, like in Finland.

In Sweden up to 1 million ha of abandoned fields were made available for afforestation in the 1960's and damages from field voles have been of great significance for this project. A preliminary planting experiment in 1959-60 was heavily influenced by voles, as about 16%

of all young plants were killed and 46% more or less damaged in 1962 (Bärring 1963). The losses were estimated at about $36,700 during this period (Stenmark 1967).

The verified damage to horticulture in 1962 was about 70,000-140,000 dollars, and the total estimated damage to fruit trees about 4-8 million dollars in the same year (Stenmark 1963).

For the water vole very few data exist, but for the period 1957-62 approximately 42,000 ha of forest plantations were damaged, a loss of about 1,650,000 Sv.Kr. (0.3 million dollars). In the same period 207.220 young fruit trees were killed in orchards, the value of each tree ranging from 1.70-3.50 Sv.Kr. (0.35-0.82 dollars) (Giege 1965).

In West Germany field voles and bank voles are serious pests in forests, and continental voles in the open fields, with peak occurrences roughly every three years.

In large-scale project for the renewal of destroyed forests after the world war was sabotaged by new enemies--the field voles. The losses in the two periods 1949-50 and 1952-53 were estimated at "several million DM" (Schindler 1955). In Lower Saxony alone a more accurate estimate for the two periods was 500,000 DM (appr. $150,000). When changing grass fields into forests, field voles and continental voles may occur side by side, both gnawing the bark of the young trees and the water vole gnawing the roots making the situation very serious (Schindler 1954).

The damage to field crops by continental voles is in the Wesermarsch (NW Germany) alone estimated at 300 DM/ha (appr. $100) and on grass fields about 95 DM/ha (appr. $30), which on average is 20% of the total yield in this area (Lange 1960). When only infested fields are considered, the part of the yield taken by the voles varies from 24% in hay producing meadows to 90% in winter crops (wheat and rye). In the year of mass occurrence of 1952, estimated losses to field crops in just the southern part of Wesermarsch were about 2.7 million DM (0.7 million dollars).

German Democratic Republic (DDR). Little information is available, but it is indicated that the intensified and specialized forestry methods in the latest decades have been very vulnerable to attacks from particularly water voles. In the years 1960-66 about 2,000 ha of forest plantations were destroyed, consisting for the major part of 10-15 year-old broadleaf trees. The economic losses are estimated at 2 million MDN (appr. $578,000) (Kulicke 1967).

England has an exceptional position, as no vole outbreaks of "any noticeable extent" have occurred since 1960 (Davis 1970), but still small-scale damage occurs in forest plantations.

Telephone cables, however, are often damaged by voles and 12-18% of cable defects in some years were caused by field voles (Davis 1959).

In Czechoslovakia the bank vole is the most common forest mammal and a particular threat whenever coniferous monocultures are replaced by mixed forests, which is now often the case. Deciduous trees are heavily damaged by bark gnawing when planted in spruce or pine forests (Zejda 1970).

In Poland the root vole (Microtus oeconomus), a close relative to the field vole is considered a serious pest to all deciduous tree species, but not to spruce and pine. Bark as well as roots are eaten by the voles in late autumn and early spring, when herbs and grasses have a low nutritional value. In peak years (every three years) about 48-67% of the trees are damaged, only 6-7%, however, so severely that they die (Buchalczyk et al. 1970).

In Holland the continental vole almost every three years causes considerable damages in orchards, grass-seed parcels, and beet-seed fields. Approximately 1,000-3,000 ha are regularly affected by the voles (Jobsen 1972).

France. The continental vole is the most important species which attacks almost all field crops, particularly cereals, luzerne and clover fields, and sugar beets. Now and then also potatoes, fruit orchards and nurseries are damaged. In peak years with population densities of 500-1200 voles/ha about 300,000 ha are affected, and the yield losses are estimated at 100 million fr. (appr. $200 million) (Bouyx 1967).

Denmark. No estimates available due to the great variety of damages caused by voles to relatively small areas.

The field vole and bank vole regularly damage young beech, pine, and spruce plantations and a preference is shown for more rare species of coniferous trees, used for decoration at Christmas time, and of particular economic importance to the forester.

The continental vole is restricted to a minor part of the country. In peak years, however, they damage especially grass-seed fields, luzerne and clover fields. The grass-covered dikes in the southern and western parts of Denmark, facing the North Sea, are always ideal habitats for voles, and their burrow systems weaken the resistance of the dike surface during floods and storms.

The water vole has increased very much in numbers since the war, coinciding with the giving up of much farming, so that large, undisturbed reproduction areas constantly deliver water voles as a compensation for those killed by desperate fruit growers or garden-owners surrounding these areas. A rather new, strange habitat for water voles are the grass-covered shoulders of our numerous motor ways, and they also function as reservations, from where the voles invade the neighboring gardens, fields and orchards in late summer and autumn.

METHODS OF CONTROL

When considering the direct control of the microtine rodents discussed, some basic difficulties already mentioned must be stressed: Two of the most harmful species, the field vole and the water vole are strictly herbivorous, the first eating only negligible amounts of seed in late summer and autumn (Hansson 1971), and the latter species supplementing its other food sources with seed only in winter, when it is subterranean. The continental vole may keep less rigorously to herbs and grasses and take seed and cereals if other food is scarce. The bank vole, however, may be termed half granivorous and half herbivorous. This means that poison baits based on cereals or other dry material are 1) as a rule refused by field voles and water voles, regardless of the particular poison, 2) that continental voles may accept the baits under certain conditions, and 3) that only bank voles are readily killed by poison baits.

Another basic point is that these rodents regularly occur in high densities over large areas, the individual home-ranges being small, so that bait stations have to be very numerous if the bait is not simply distributed all over the area by hand, machine or aeroplane--a procedure not recommended in most European countries.

Putting down the bait by spoon in open holes and burrows may be practiced in gardens, but not on large afforested areas. This method must be classified as old-fashioned, ineffective and labor-wasting. As a matter of fact, this has also been stated at a meeting of EPPO in 1965, and it is agreed upon by many European countries (e.g. Schindler 1970a; Myllymäki 1970a; Giban 1967; Jobsen 1972). A different point of view is, however, expressed by a few experts. In France dry baits containing 0.0075% chlorophacinone are now considered to give a mortality of 75-85% in populations of continental voles (15-20 kg bait/ha) (Giban 1970). In England 0.025% warfarin baits (oatmeal), protected in drainage pipes, are claimed to have an effect on small-scale outbreaks of field voles (25-30 kg bait/ha) (Davis 1970).

Whereas damages by microtine rodents were very serious after the world war and in the early fifties, the situation was suddenly changed, and a period of optimism in rodent control lasted about 10 years in many countries. This was the period of the chlorinated hydrocarbons, especially endrin, which was used for vole control as a surface spray. It was soon established that for the first time in the history of vole control a 100% kill could be obtained for certain species over large areas with relatively small costs and little labor. An area could be sprayed, as soon as the first sign of damage was detected and the crops or trees could be saved for that season due to the long lasting effect of endrin.

The endrin was generally applied in late autumn at a dosage level of 1.0-1.7 l/ha of a 20% emulsion for field voles and continental voles, and 2.0 l/ha for water voles. The amount of water varied according to the height of vegetation and the application methods from 50-600 l/ha. The method of poisoning the entire environment and food supply of the voles might seem to be too dangerous for other, not harmful, species, but in spite of its

high toxicity, endrin had a remarkable specific effect in practice, killing only about 20-30% of the Apodemus spp., 0-20% of the Clethrionomys glareolus, and 0-30% of the Sorex spp. (Schindler 1957).

This seems to be due to the different food habits of these animals--the strictly herbivorous species being far the most exposed.

The endrin spray was first introduced in West Germany and already in 1955-56 it was used in many areas with mass occurrences of voles. The reports of non-treated areas being totally damaged, while endrin-treated areas were saved (Schindler 1960), soon had their effect in many other European countries which in the following years took up this control method at an increasing rate. In the early 1960's, however, endrin was very much criticized from sound and well-supported environmental and toxicological points of view. The well-known consequences were that in 1963-65 endrin was totally banned in some countries, and the use very much restricted in others (EPPO 1967).

For some years another spray, the chlorinated camphene, toxaphene, took over the place of endrin in some countries. But even at doses far beyond that used for endrin, e.g. 2-10 l/ha of a 50% emulsion, poorer results were obtained with Microtus agrestis and arvalis (EPPO 1967; Giban 1967; Gandschau 1958), but still the effect was much better than the one obtained with poison baits. Arvicola terrestris, however, could not be effectively controlled by toxaphene (P. Bang et al. 1964).

During the following two or three years, toxaphene was also black-listed in most European countries. Still it is used in West Germany even for regular prophylactic treatments on about 10,000 ha per year. This procedure is claimed to have saved 10 million DM (appr. 3 million dollars) annually in reduced damage (Schindler 1970a). In Romania toxaphene is also still used against continental voles, with somewhat less enthusiasm, however, as the toxic effect was only claimed to last 4-5 days (Hamar et al. 1970).

ALTERNATIVE METHODS

Repellents and mechanical protection.

A variety of chemical repellents have been investigated for the protection of young trees in plantations and orchards against field vole damage (Myllymäki 1970a). Most often the effect, if any, disappeared as soon as the material dried up, and in large areas the method was rather expensive when repeated every season. Furthermore, in natural reafforestation areas in Central Europe the method cannot be applied in practice (Schindler 1956).

A prophylactic method widely used, particularly in Finnish horticulture, is the protection by aluminium collars on the stems of fruit trees and young plants in seed orchards of forest trees. Somewhere the method has proved useful, but in countries with a deep snow layer the effect is highly reduced, and much labor is needed in forestry for shifting the collars on growing plants (Myllymäki 1970a). The costs per hectar in fruit orchards are considered the same as three endrin sprayings.

Application of ecological control measures such as making the habitats unfavorable for the voles by removing the grass cover, either mechanically or by means of weed-killers, seems to be a theoretical rather than a practical solution to the problem. In fruit orchards this method certainly can be, and has to be, applied, but not so in larger afforestation areas.

If areas surrounding orchards and plantations are not treated in the same way, water voles will immigrate in autumn, and carry out their subterranean, root-killing work during the winter.

In recent years other attempts have been made to find a new method of vole control. Instead of spreading poison baits on the ground, an investigation was made to see if the poison (crimidin) could be applied directly to the stems of the trees as a paste or dye (Myllymäki 1970a). No effect could be obtained, apparently because the voles gnawed off the outer poisonous bark-layer without eating it.

Alternative surface sprays have been investigated too. A German compound, ethamphention (Muritan) had promising effects on field voles (Myllymäki 1970a; Lund 1969) in preliminary tests, but unfortunately the material was withdrawn by the producer for toxicological reasons, before tests were completed.

Parathion, too, has been tested lately as a spray against voles (Lund 1971), but even a dosage of 6 l/ha of parathion 35 had no marked effect on a population of water voles.

CONCLUSIONS

After the almost complete banning of endrin and toxaphene sprays, we are now back to the situation of the early 1950's. We must face the situation that at present we have no practical and effective means for the control of two or three of the most harmful rodent species in Europe.

Accordingly there is an obvious and urgent need for a new surface spray with the effectiveness of endrin, but without its ecological long-term side effects.

For the reasons mentioned, it must be considered more important to search for new surface sprays than for improved bait methods, which will never be more than moderate in effect, whatever the poison used.

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