14. Rodents

14.1 Efficacy testing

14.1.1 Bromadiolone

The efficacy and palatability of an 0.005% bromadiolone wax block formulation were tested on brown rats (*Rattus norvegicus*) in two room tests and two single-cage choice tests. The single-cage tests revealed neophobic reactions, a low acceptance and a mortality of 50-80% only. The room tests, however, showed a good acceptance and a mortality of 90-100%. This compensates for the low acceptance in single cages and this formulation could therefore be approved for control.

M. Carlsen, H. Leirs, and J. Lodal

14.1.2 Difenacoum

The efficacy and palatability of an 0.01% difenacoum paste formulation were tested on brown rats (*Rattus norvegicus*) in two room tests and one single-cage choice test. The paste was generally well accepted but there was a high individual variation. Although the results of the two room tests were very different, mortality was high. This paste formulation was approved for rat control.

H. Leirs and J. Lodal

14.1.3 Difenacoum, LD_{50}

At the request of a foreign company, the acute LD_{50} for difenacoum was determined in roof rats (*Rattus rattus*) by oral intubation.

J. Lodal

14.1.4 Plaster baits as rodenticides

In mid-1997, articles and letters in the popular press in Denmark claimed that rats could effectively be controlled by applying baits based on plaster (powdered gypsum, $CaSO_4.2H_2O$), and DPIL received questions about this issue. Although the product is or has been available as a commercial rodenticide in some countries, there is no scientific literature about its effectiveness. Therefore, it was decided to test this in the laboratory.

A bait was prepared by the mixing of 50% plaster powder, 1% sugar and 49% rolled oats, corresponding to a commercial formulation. Ten adult *Rattus norvegicus* (5 males, 5 females) from DPIL's own laboratory strain of anticoagulant susceptible rats were caged singly. The animals were allowed to acclimatize for one week during which they received rye bread and water ad lib. At the start of the test period, each animal was offered 30 g of the experimental bait. Consumption was monitored by weighing the remaining bait daily (except on Sunday) for a one week period. Every day, the amount of bait was replenished to 30 g per cage, on Saturday 40 g. Water was available ad lib. throughout the test period. The condition of the animals was checked daily. After the experiment, the animals were placed in observation for 16 more days, during which they received rye bread as food. At the end of the experiment, the animals were killed.

All animals ate considerable amounts of the experimental bait: total individual uptake during the test period (mean ± st.dev) reached 89.54 ± 39.57 g bait, or 120.65 ± 59.97 g plaster/kg body weight. During the experiment, they produced hard and white excrements, showing that the plaster was indeed ingested. Small traces of blood could be seen in the excrements after day 4. Three animals learned to efficiently separate the oats and the plaster in the bait; from day 4 onwards, the bait dish in their cages contained loose left-over plaster and their excrements did no longer show the white colour. Water consumption was normal. None of the animals died, and none showed any signs of distress or bad condition during the test.

It was concluded that a plaster bait is accepted by the rats, but it does not cause any mortality within a week of non-choice feeding. This bait formulation is not suitable as a rodenticide.

H. Leirs and J. Lodal

14.2 Palatability testing

14.2.1 Bromadiolone liquid poisons

At the request of a Danish company eight different formulations of a bromadiolone liquid poison were screened as to how well they were accepted by brown rats (*R. norvegicus*). All formulations contained 0.01% bromadiolone and to seven of them had been added different flavourings which were expected to increase the palatability. The rats did not clearly prefer one of the formulations to the others. Another important aspect was a low mortality in one test over three days in spite of a theoretically sufficient amount of bromadiolone consumed.

Two room tests with 0.01% bromadiolone liquid poison against brown rats (*R. norvegicus*) were conducted after the above-mentioned tests. The morta-lity was 0/10 and 1/10, respectively, after a four-day test period with a choice between the bromadiolone poison and non-poisonous tap water. A higher mortality might have been expected in both tests based on the calculated theoretical amounts of bromadiolone consumed per kg body weight.

J. Lodal

14.3 Resistance to anticoagulants

14.3.1 Resistance in the brown rat

During 1997, 496 brown rats (*R. norvegicus*) were received for anticoagulant resistance testing. New municipalities where resistance has been found are: coumatetralyl in Brøndby, Sorø, Vordingborg, Fredericia and Rødding; and bromadiolone in Vordingborg, Fredericia and Rødding. Decreased susceptibility to bromadiolone was found in Sorø and to difenacoum in Vordingborg and Rødding.

J. Lodal

14.4 Other works on rodents and rodent management

14.4.1 Rat trap

At the request of a Danish inventor a special trap was tested in the laboratory. This special trap is a killing trap constructed to take several rats before emptying. The aim of the test series was to find the most optimal solution to some construction details of the trap. Therefore, different prototypes were presented to groups of rats in order to analyse the effect of different materials, shape of entrance and some other factors. After having entered the trap, rats are automatically killed with CO_2. It was found that the concentration of CO_2 should not be lower than 60% by volume in order to kill the rats.

J. Lodal

14.4.2 Mammals crossing Øresund

At the request of one of the contractors involved in the construction of the Fixed Link over Øresund the risks associated with mammals crossing the bridge and tunnel between Denmark and Sweden have been evaluated. The main concern is the risk of direct damage to the construction and its installations that may be caused by the mammals and how to reduce it. Another aspect is a possible transmission of diseases by the animals.

H. Leirs and J. Lodal

14.4.3 Field voles *Microtus agrestis* and predation

Throughout 1997 the Ph.D. project "The importance of predation for populations of *Microtus agrestis* in fragmented habitats" (initiated in 1995) has been dominated by intensive field work. The gathered data still await thorough analysis. This will mainly be done in 1998.

The present results, however, indicate that predator exclusion does have an effect. In the exclosures the voles have a slightly better survival, but above all, they are in better condition, i.e. their weight development is more positive leading to higher mean weights and earlier reproduction. Also numbers are more stable and at their highest in exclosures. The predator-enriched areas have the lowest numbers, but the difference between these areas and the controls is more vague than the difference between controls and exclosures.

M. Carlsen

14.4.4 Population ecology of the African field rat *Mastomys natalensis*

Based on earlier capture-recapture data collected in Tanzania and the use of advanced statistical analysis, the demography of Afrcan field rats *Mastomys natalensis* was analyzed. These rodents are common agricultural pests and carriers of diseases in subsaharan Africa. The results showed simultaneous occurrence of density-dependent and density-independent (rainfall-related) variations in survival and maturation parameters in this species. Incorporation of the obtained estimates of demographic rates in a population dynamics model showed that the observed dynamics are affected by stabilizing non-linear density-dependent components coupled with strong deterministic and stochastic seasonal components. The obtained model can be used to predict future development of a *Mastomys* population, given a number of rainfall and density conditions, and this is useful in the forecasting of outbreaks or the simulation of possible management strategies. Currently, work is in progress to test the practical applicability of such approaches.

In an earlier and more simple formulation of the population dynamics model, it was already claimed that early rainfall played a major role in initiating reproduction and through this affected the population size. Analysis of capture data from four different localities in Tanzania showed that this was indeed the case, but not in areas where early rains were commonly abundant. Similar work is going on in grassland and maize fields in central Ethiopia, and suggests that rodent population dynamics also in this area are linked to rainfall patterns. Experiments in Tanzania also showed that a single control action undertaken at planting time does not persist long enough to protect seedlings, probably due to quick reinvasion of the treated fields by rodents from the surroundings.

Data from another 3-year (1994-1997) capture-recapture study with *M. natalensis* in a small scale maize field-fallow land mosaic in Tanzania were used to investigate habitat effects on population dynamics. The seasonal evolution of rodent presence was the same in both habitat types and it was not affected by agricultural activities in the fields. About one week after planting, there was a short increase of rodent captures in the maize fields, but this disappeared again after a few days. Recolonization of fields was achieved very fast after a rodent control operation. Radiotelemetry indicated that many individuals were active in the maize field as well as in the fallow land. In conclusion, the field and fallow land rodent populations in a small-scale setup are not separated. This renders several rodent control approaches unsuitable. In order to investigate the spatial components of *Mastomys* population dynamics in more detail, in particular also the differences between monoculture and mosaic farming systems, as well as the problem of recolonization of fields after rodent control, further data are now being collected.

Several observations indicate that predation may be a major cause of death in *Mastomys* populations. This suggests that biological control of these rodents could be a possible management strategy. In a six-month pilot study in Morogoro, Tanzania, populations were followed on experimental fields with decreased control and increased predation pressure. The data showed an increased survival on a field where avian predators were excluded but no effects of placing perches. This study is now being expanded in a large replicated setup where fields are manipulated for predation pressure and controlled for compensatory dispersal effects.

H. Leirs

14.4.5 Search for the vertebrate reservoir of Ebola virus

During the 1995 outbreak of Ebola Haemorrhagic Fever in Kikwit, Democratic Republic of the Congo, an international team under auspices of the WHO collected 3066 vertebrates, mainly small mammals, in the surroundings of the site, where the putative primary case probably became infected. All collected samples were tested for Ebola virus isolation or serology at the Centers for Disease Control in Atlanta, USA, but all were negative. The identification of the different specimens happened in the laboratories of relevant taxonomists but all data were afterwards grouped and analysed at DPIL. Several explanations were identified for the negative result despite the large field efforts: the investigation was hampered by lack of information beyond the daily activities of the primary case, lack of information on Ebola virus ecology, which precluded the detailed study of select groups of animals, and sample size limitations for rare species. Furthermore, the epidemiology of Ebola hemorrhagic fever suggests that humans have only intermittent contact with the virus, which complicates selection of target species. Nevertheless, making a large and diverse collection remains an appropriate approach during future Ebola outbreaks.

H. Leirs

14.4.6 Alternatives to methyl bromide. Control of rodents on ship and aircraft

A report describing the current use of methyl bromide as a pesticide in the Nordic countries for on-board ship and aircraft fumigation was commissioned by the Nordic Council of Ministers/The Chemical Group.

Methyl bromide is the fumigant currently allowed for quarantine treatments on ships and aircraft in the Nordic countries. Methyl bromide is not used in Iceland. Its use was terminated in Denmark, Sweden and Finland by January 1, 1998. Norway has adopted the Nordic Strategy and is at present working on regulations of import and consumption of methyl bromide.

In the years 1992-1996 methyl bromide was used for on board ship fumigation 1-2 times per year in the Nordic countries, and 2 aircraft fumigations were performed. The low incidence of methyl bromide strongly questions the need of sustaining this pest control technique, since control can be performed by other measures.

There is no single alternative fumigant which meets the specifications wanted: fast and efficient with high penetration at low temperatures and under humid conditions, not causing damage to the vessel and to be used on food or feed products.

Sulfuryl fluoride is the single compound closest to meeting the wanted specifications, but it is not registered for use on food or feed crops.

Hydrogen cyanide and phosphine are good alternatives in dry and hot conditions, but cause many different problems in cold and humid conditions. In general they do not meet the specifications defined for an alternative fumigant in the Nordic countries.

Controlled atmospheres, carbonyl sulfide, and recovery of methyl bromide, are not applicable alternatives for on-board ship or aboard aircraft fumigation.
The most obvious alternative for ships is traditional rodent control performed by professional pest control operators. This is the way most rodent infestations are treated at present in the Nordic countries. The problem of this is time, which might be overcome by (1) preventive