

10. Rodents

10.1 Efficacy and palatability testing

A pelleted formulation of a rodenticide with cellulose as the main active ingredient was tested on four adult male Norway rats (*Rattus norvegicus*), two in a no-choice test and the two others in a choice test. All rats were caged singly and had access to the product for 11 days. Both rats in the no-choice test consumed only small amounts of the product on the two first days whereupon the daily consumption increased and on day 11 it made up 18-22% of the body weight. Apart from a weight loss of 10.8-14.4% during the test period the animals seemed normal and unaffected and they did not die. The two rats in the choice test were offered crushed organic wheat as non-poisonous alternative food. The cellulose-containing product was not very well accepted, making up no more than 2.2% and 2.9%, respectively, of the total consumption by the two rats during the 11-day test period. Both rats had a weight gain during the test period of 2.2%-2.5%, they survived and seemed rather unaffected by the cellulose-containing product. With a very low acceptability of the test product and no rats dying in these preliminary tests it was decided to discontinue the tests.

J. Lodal

10.2 Resistance to anticoagulants

10.2.1 Resistance in the Norway rat

During 2001, a total of 87 Norway rats (*Rattus norvegicus*) from 16 municipalities were received for anticoagulant resisting testing. In addition to confirming resistance levels found in a number of municipalities previously, difenacoum resistance was found in the municipality of Nordborg, and resistance to warfarin was found in the municipality of Tønder. Both municipalities are situated in the southern part of Jutland.

J. Lodal

10.2.2 Population effects of anticoagulant rodenticide resistance in Norway rats

A Ph.D. project is investigating the individual negative consequences related to anticoagulant resistance in the Norway rat (*Rattus norvegicus*).

Under laboratory facilities wild free-ranging rats were maintained in four breeding colonies in order to monitor the level of anticoagulant resistance when anticoagulant selection was present or absent. The experimental populations have been followed for a period of two years.

The data collection was finished in early June 2001 followed by the final data-analysis and writing of papers. The Ph.D. thesis is expected to be handed in in January 2002.

A.-C. Heiberg

10.2.3 Vitamin K requirement in Danish anticoagulant-resistant Norway rats

An increase in dietary vitamin K requirement is known to be a consequence of anticoagulant resistance. However, the vitamin K requirement of wild Danish resistant rats (*Rattus norvegicus*) is unknown. From other studies conducted in the United Kingdom, different resistant strains have been identified, based on the increase in vitamin K requirement. In order to verify if Danish resistant rats experienced such an increase and if more resistant strains could be identified, a project was initiated in the summer of 2000 as a master project. The laboratory experiment was carried out until the autumn of 2001 and is expected to be finished in the spring 2002.

10.3 Other work on rodents and rodent management

10.3.1 Genetic diversity in population of wild rats

A master study on genetic diversity within and between Danish populations of Norway rats (*Rattus norvegicus*) was finished in July 2001.

Based on collection of tissue samples from rats from a total of 15 populations representing 6 different geographic regions a large, geographic isolation with restricted gene flow between adjacent populations was found.

H. Martin-Legène & A.-C. Heiberg

10.3.2 Pest problems in organic pig production

Within the framework of the Research Programme for Organic Agriculture (FØJO) a collaborative research project entitled "Management in relation to health and food safety in organic pig production" has been started. Researchers from the Danish Institute of Agricultural Sciences and the Royal Veterinary and Agricultural University and DPIL make up the project group. DPIL has a work package "Development of strategies for pest management in selected production systems", and the first step in 2001 was identification of pest-supporting factors. For this purpose a questionnaire was sent to more than 400 farmers. Among respondents 153 had outdoor pig production and problems with rats and/or mice occurred regularly on up to 22% of these farms. This part of the project will be analysed further. In December two study farms were selected for more direct ecological studies of the rodents with the aim of defining the key factors which may be limiting for the size of the pest population. The project will continue in 2002.

J. Lodal, H. Leirs and M. Knorr

10.3.3 Rodents and *Salmonella*

A collaborative research project involving researchers from the Danish Veterinary Institute, Zoological Museum and DPIL entitled "Wildlife as a source of salmonella infection in food-animal production" was initiated in 2000. Farms with pig, cattle or poultry have been selected as study farms. As part of the project rats, mice and voles have been trapped, or faeces from the rodents have been collected, for the purpose of being analysed for the presence of *Salmonella*. The project will continue in 2002, and results will be published elsewhere.

J. Lodal

10.3.4 *Leptospira pomona* and *Apodemus agrarius*

During 2000 some serious outbreaks of leptospirosis were noted in Danish sow herds with late abortions. The cases were studied and confirmed by the Danish Veterinary Institute. The first cases occurred on the island of Lolland in the southern part of the country, and strains of *Leptospira pomona* were obtained from two herds on the island. Rodents are known as reservoir hosts of *Leptospira*, and for *L. pomona* the striped mouse (*Apodemus agrarius*) has been shown to be such a host. Therefore it was decided in collaboration with the Danish Veterinary Institute to examine striped mice occurring in and around one of the farms with confirmed *L. pomona* infection. One of 40 trapped mice was found positive for *L. pomona*. It seems therefore reasonable to conclude that the striped mouse may be acting as a reservoir host for *L. pomona* in that part of the country. The results will be published in details in 2002.

10.3.5 A population dynamics model for rodent management in Africa

Rodent damage to field crops is an important agricultural problem in many regions in Africa. Average crop losses of around 15% are reported, and during outbreaks 80% or more of the potential harvest may be lost. Control with rodenticides is possible but costly, unsustainable and mostly initiated too late. In 2001, we finalized a project funded by the Danish Council for Development Research (Rådet for Ulandsforskning). The objective was to collate information about the population dynamics of the most common rodent pest in eastern Africa, the multimammate rat *Mastomys natalensis*. This knowledge was then formalized into a population model which can help us understand and predict changes in rodent numbers and evaluate management strategies.

The basic data material had been collected earlier during long-term capture-mark-recapture (CMR) studies in a maize fields landscape in Morogoro, Tanzania, between 1986-89 and again since 1994. Using state-of-the art CMR-analysis we obtained detailed estimates of survival and maturation which complemented the previous incomplete knowledge that we had about this species. The data confirmed that in all years, for both sexes, there is an interaction between density-dependent and density-independent effects, meaning that for example the survival of breeding females is affected by the number of rats in the population and by rainfall in the preceding months.

Data about the survival of newly born young rats are impossible to obtain in nature, but important if we want to predict how many rats will be present later in the year. In a laboratory study with 29 pairs of wild-born *Mastomys* rats, we documented litter size at birth, change of litter size with parity and survival of young from birth until weaning. Survival was very high with a median of 100%, indicating that juvenile survival is considerably higher than assumed so far. Work with several types of nest boxes in the field in Tanzania had no success but an experiment, in which pregnant females were caged and released with their young after they were marked, shows that there is a delay of 1-2 months before these young are recruited into the trappable population. This explains why earlier models always predicted an increase of population numbers that was too fast.

We combined all this demographic information into a numerical multi-stage population dynamics model. Such models are a way of representing our knowledge about processes which are too complex for intuitive predictions. Our model was shown to capture the essence of the population dynamics very well, and simulations of past population changes were generally close to field observations. The model is sensitive to starting values during the first time steps but converges later, while uncertainty about the values of the demographic parameters becomes important after several months in the model runs. For real-time forecasting, the model does not perform very well, due to the stochasticity of the rainfall over the period for which forecasts should be made. On the other hand, the model turned out to be very useful in the investigation of the nature of changes in population size and the effects of different management strategies.

In a last step, and partially under the framework of the EU-funded Staplerat project (see 10.3.6) the model was extended to also include a bio-economic component so that its output included not only rodent population size but also farmer income. The relevance of the model was further improved, and its user-interface developed, in close collaboration with extension officers in Tanzania. Analysis of this model showed complex interactions between ecology and economy, with the result that control strategies which seem optimal from a population ecological point of view (reducing number of rodents) are not necessarily interesting from an economic point of view (to maximize farmer income). The model allows planning officers to evaluate which management strategies would be best under given conditions of rainfall, fertilizer use and rodenticide efficiency and price. Work to incorporate alternative pest control methods is under way.

10.3.6 STAPLERAT: Protecting staple crops in eastern Africa: integrated approaches for ecologically-based field rodent pest management

Staple crops in eastern Africa are subject to serious pre- and post-harvest pest damage. Major losses can be attributed to rats, making them in several places the most important pre-harvest pest species. Indiscriminate use of rodenticides is neither efficient nor sustainable, and there is a need for ecologically-based management strategies. The STAPLERAT-project (supported by EU 5FP) is investigating the needed biological information and collecting data on the economic aspects of damage and controls. Based on these data, tools for the organization and evaluation of management strategies will be developed:

STAPLERAT is a collaborative project with different partners in Africa and Europe: DPIL, University of Antwerp, Belgium, University of Rome "La Sapienza", Italy, University of Oslo, Norway, Sokoine University of Agriculture, Morogoro, Tanzania, Rodent Control Center, Morogoro, Tanzania, Kenyatta University, Nairobi, Kenya, Addis Ababa University, Ethiopia and Mutanda Research Station, Solwezi, Zambia. DPIL co-ordinates the project. Although only a single year of the project has passed, a number of interesting results can be listed already. Briefly, achievements in the different work packages can be listed as follows.

Identifying the pest rodents. Taxonomic collections of rodents present in staple crop fields in Ethiopia, Kenya, Tanzania and Zambia have started and a considerable number of animals has been brought together already. The most common rodents everywhere belong to the genus *Mastomys*, as expected, but species identification need further karyologic and molecular work which is now going on. Seasonal variation in rodent fauna composition is studied by repeat of the work in different seasons, and expeditions to different localities will provide information about the geographical variation. The presence of a rodent in or near a field is not an indication of pest activity as such, therefore work is started in the second year to analyse the rodents' diet.

Damage characteristics. By the use of a farmer participatory research approach, information was obtained about the nature and extent of rodent damage, farmers' perception of the problems and their attitude towards the management of these problems. Preliminary results show that farmers are well aware of the rodent problem and consider it very important in particular in maize. There is a strong reliance on the use of acute rodenticides, but the awareness about the phenology of rodent damage may allow focused actions, provided a strong extension service can be provided. A quantitative analysis of damage and yield loss has started.

Economics and effects of control. A very detailed description of the damage function (i.e. the relation between rodent population size and damage) has been obtained for the planting season, showing a quickly increasing and then flattening curve. Similar data are available for damage at pre-harvest and will now be analysed.

Rodent population dynamics. Capture-recapture studies have started timely in all study areas, and data are collected monthly. It is far too early for any demographic or population dynamics analyses but the data clearly show the expected seasonal variation and a good congruence between replicates, laying a basis for robust analysis later.

Population models and early warning systems. The location of historical outbreaks in a systematic way has been very difficult and not very successful. Therefore, this work package has not come very far in the first year. Extra efforts will be made here during the second year.

Bioeconomics in rodent management. A very extensive bio-economics has been developed, much earlier than expected. The model is based on a well-documented population model for *Mastomys natalensis*, complete with a simple maize growth model (as a function of rainfall and fertilizer) and the observed damage functions. The economic components are the costs of planting, maintaining and harvesting the maize, the costs of rodent control and the benefits of selling the harvested maize. So far, the pest control methods built in the model are limited to the on/off use of rodenticide control in any given month. The first simulations

show a very important and non-trivial difference between control strategies which are most effective in an ecological way and those which are most efficient from an economical viewpoint. Analysis of different control calendars suggest optimal timing and period of rodenticide application.

Protecting seed with repellents. A number of potential seed repellents has been identified and tested for phytotoxic effects. Their effects on palatability of treated seeds have been tested in laboratory conditions in a number of tests and on this basis, three products are selected for further work, including field tests.

Biological control with predators. The setup of perches and nest boxes for raptors and owls has initially caused an unexpected negative reaction from local communities, due to cultural beliefs about the presence of owls as a bad omen. In Kenya this problem has been solved by involving the farmers more actively in the programme, and in Tanzania this is now being done. The nest boxes in Kenya are very successful in attracting breeding owls - raptor monitoring is on its way. Monitoring of the rodent population is in place in the study areas but of course it is still premature to present results.

Agroforestry as a rodent management tool. *Tephrosia vogellii* bushes have been planted either dispersed or as fences in fields with enset (Ethiopia) or cassava (Zambia) to investigate whether they can be used to keep out mole rats from these fields. In Ethiopia growth is slow, probably due to the high altitude. In Zambia, growth of the bushes is very fast. Preliminary data on mole rat activity show a very strong protective effect of *Tephrosia* bushes.

H. Leirs, S. Vibe-Petersen and J. Lodal

10.3.7 Effects of grazing on small mammals in wet meadows

Differences in vegetation structure affect the living conditions for small mammals with respect to food quality and quantity, cover against predators, etc. In the framework of a large project to investigate the different grazing systems as a nature management strategy, DPIIL and the Royal Veterinary and Agricultural University (Copenhagen) have investigated the population ecology and behaviour of rodents under different grazing pressure from 1998-2000. The experimental areas were situated in Fussingø, Jutland, and subject to different grazing and/or mowing intensity by sheep or cattle. The data analysis was finalized in 2001.

Generally, grazing livestock had a negative effect on the peak biomass of small mammals, and the negative effect increased with grazing intensity, irrespective whether pens were grazed by cattle or by sheep. The more detailed analyses, however, revealed that an intermediate grazing intensity actually seemed to benefit small mammals. Additionally, field voles on intermediary grazing intensity were on average larger and had more foetuses compared to field voles.

Additional data on the movements of field voles under different grazing pressure were collected by radio-telemetry in the same areas. Analysis is under way.

H. Leirs

10.3.8 Behavioural effects in *Mastomys natalensis* rats under exposure to predator odour

Observed effects of predation pressure in populations of rodents can be due to direct effects of predation on survival, but also due to indirect effects caused by the rodents' individual behaviour responses to different levels of predation risk. In order to investigate whether differences in predation pressure are apparent to the individual rodents living in an area, a number of experiments was carried out in 1999 in Tanzania in fields with manipulated predation pressure. The rodents' feeding decisions were measured by means of a method

known as the “giving-up-density” method, and their foraging was recorded on video. Analysis was finalized in 2001. We concluded that *M. natalensis* can assess the ambient predation pressure and adapt its behaviour.

K. Mohr

10.3.9 Feeding decisions as an anti-predation strategy in *Mastomys natalensis* rats

In 2000 an M.Sc. project was started to investigate changes in the explorative behaviour of *Mastomys natalensis* rat in relation to predator odour. The odour medium was introduced in an arena, and the reaction of the *Mastomys* rat was video-recorded for 24 hours in a photo-regulated room. The tested odour media were faeces from cats that had been fed on either dead *Mastomys* rats or fish, and a control experiment in which no odour was used. The experiment will be completed with a neutral odour (rabbit faeces). In 2001 the data were analysed. In the spring of 2002 a report and an article manuscript will be prepared.

H. H. Petersen

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

S. Vibe-Petersen continued the data analysing of her Ph.D. project “Predation pressure and population dynamics in African *Mastomys* rats: possibilities for integrated pest management?” until April 1 and again from December 1, 2001. The study began in November 1997 and evaluates the effects of different avian predation pressures on populations of the agricultural pest species *Mastomys natalensis* in Sub-Saharan Africa (see also Danish Pest Infestation Laboratory, Annual Report 1998 (for explanations on the setup), Annual Report 1999 (for preliminary data results) and Annual Report 2000 (for results on rodent population dynamics patterns, crop yield and damage).

Predators may indirectly affect their prey by influencing their body weight through changes in foraging activity and/or stress levels. Preliminary statistical analysis of the relative individual body weight change in *M. natalensis* indicates at first sight that predation does not affect the relative growth of the rodents in the period of October to December when birds of prey are abundant. A significant interaction of predation level and dispersal level (i.e. between control fields, predator exclusion fields, control enclosures and predator exclusion enclosures) and pair-wise comparisons of the treatments, however, reveals that predation probably does act indirectly to affect the relative body weight change of the rodents. The explanation may be found in an unattended indirect predation factor effect on rodents of perching birds of prey on construction poles in both predator exclusion fields and predator exclusion enclosures. This indirect predation factor seems to affect rodents in predator exclusion fields but is counteracted by rodents in predator exclusion enclosures, probably because enclosed rodents are forced to stay in the field plots thus learning that perching raptors should not be accounted for a potential danger. Further data analyses are ongoing on the effects of predation on rodent body weight (as well as on reproduction, survival and other important demographic factors).

S. Vibe-Petersen

10.3.11 STEPICA: The plague of Central Asia - epidemiological study focusing on space-time dynamics

Bubonic plague remains a concern in many places in the world, where the bacterium circulates in wild rodents. In Central-Asia, the disease is enzootic in populations of gerbils. In Kazakhstan and other former Soviet Republics, country-wide monitoring schemes used to be in place and control operations were organized as soon as an outbreak of plague was imminent. Such extensive (but also very expensive) monitoring is no more feasible, and the EU is therefore supporting a research project to use the data-sets from previous monitoring to elucidate the epidemiological processes of plague dynamics in Central Asia, and to develop models that can be used as early-warning systems. DPIL participates in this project together with partners from Norway, France, United Kingdom and Finland in Europe and Kazakstan, Uzbekistan and Kyrgyzstan in Central Asia. The project started in 2001 with computerization and analysis of the existing

data-sets, but the role of DPIL is mainly in a later phase of the project when population models are to be developed.

H. Leirs