Rodent Management – Session 2

Enabling effective rodent pest research in African smallholder farming systems

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A meta-analysis of published research between the years 1910 to 2015 on rodent pest damage and management was carried out for the Afro-Malagasy region. Using a defined set of criteria, 162 publications were identified with a focus on rodent pest research in agricultural contexts. Although this showed relevant research activities have taken place in 32 African countries, more than half of the research has been focussed in four countries only: Tanzania [25%], Nigeria [9%], Ethiopia [9%] and Kenya [8%]. Data extracted from these publications strongly suggest pest rodents have a significant negative effect on Afro-Malagasy smallholder farming communities. Crop losses varied between cropping stages, storage and crops and the highest losses occurred during early cropping stages (46% median loss during seedling stage) and the mature stage (15% median loss). There was a scarcity of studies investigating the effectiveness of various management actions on rodent pest damage and population abundance. We argue that there has been inadequate empirical research focused on developing sustainable control methods for rodent pests, with the situation further exacerbated by a lack of communication pathways for appropriate knowledge extension. We carried out stakeholder analyses in six countries which indicated rodent pests were considered to be a serious problem among smallholder farming communities. However, these views were not shared by government authorities and rodent control businesses who were generally not aware of the importance smallholder communities attributed to rodent pests. Our analysis suggests blockages in information flow from communities to government and industry are preventing the recognition and resolution of rodent pest problems affecting smallholder farmers across the Afro-Malagasy region. A new research project funded by the African Union involving researchers from seven countries aims to increase empirical research on sustainable rodent control methods as well as unblock communication pathways between service providers and smallholder communities.

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Effect of synthetic hormones on reproduction in *Mastomys natalensis*

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Rodent pest management traditionally relies on some form of lethal control. Developing effective fertility control for pest rodent species could be a major breakthrough particularly in the context of managing rodent population outbreaks. This laboratory-based study is the first to report on the effects of using fertility compounds on an out breaking rodent pest species found throughout sub-Saharan Africa. *Mastomys natalensis* were fed bait containing the synthetic steroid hormones quinestrol and levonorgestrel, both singly and in combination, at three concentrations (10, 50, 100 ppm) for 7 days. Consumption of the bait and animal body mass was mostly the same between treatments when analysed by sex, day and treatment. However, a repeated measures ANOVA indicated that quinestrol and quinestrol/levonorgestrel treatments reduced consumption by up to 45%, particularly at the higher concentrations of 50 and 100 ppm. Although there was no clear concentration effect on animal body mass, quinestrol and quinestrol/ levonorgestrel lowered body mass by up to 20% compared to the untreated and levo- norgestrel treatments. Quinestrol and quinestrol/ levonorgestrel reduced the weight of male rat tested, epididymis and seminal vesicles by 60–80%, and sperm concentration and motility were reduced by more than 95%. No weight changes were observed to uterine and ovarian tissue. However, high uterine oedema was observed among all female rats consuming treated bait at 8 and 40 days from trial start. Trials with mate pairing showed there were significant differences in the pregnancy rate with all treatments when compared to the untreated control group of rodents.

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An Africa Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development (ACE IRPM&BTD) in sub-Saharan Africa

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Rodents are some of the most serious mammalian pests in sub-Saharan Africa. The economic, health and social impact of rodents is not adequately quantified, species identity is not well known and the ecology and dynamism of populations are understudied in sub-Saharan Africa. An Africa Centre of Excellence for Innovative Rodent Pest Management and Biosensor Technology Development (ACE IRPM&BTD) was established in 2016/2017, based in Tanzania. The ACEIRPM&BTD shall enhance scientific knowledge (taxonomy, ecology, zoonotic diseases, pest management, biosensor using rats), technology and innovations (STI) on rodent pest management in Africa. ACEIRPM&BTD is currently focusing on two major activities (i) Postgraduate training (16 registered PhD candidates undertaking studies in Tanzania, Uganda and Ethiopia). Ten MSc. candidates will embark on research activities in 2018/2019 (ii) Curriculum development for MSc. programmes to train potential candidates for PhD studies on rodents. About 35 PhD and 80 MSc candidates will enrol in the next five years. Studies already being undertaken include: (i) Landscape ecology and population dynamics of rodents in Afro-alpine ecosystems, Ethiopia (ii) Diversity and population dynamics of rodents and associated ectoparasites in Mt. Elgon ecosystem, Uganda. (iii) Prevalence and diversity of haemoflagelates and filarial worms in rodents and shrews in Uganda (iv) Habitat disturbance, population dynamics and community structure of rodents in forest reserves, Uganda. (v) Ectoparasites and gastrointestinal helminthes diversity in rodents and shrews in Siemens Mountains, Ethiopia. (vi) Prevalence of Leptospira in rodents, shrews and humans in Uganda (vii) Community ecology of rodents in the Selous ecosystem, Tanzania (viii) Ecology of rodents and flea ectoparasites in plague endemic foci in the Rift Valley, Tanzania. (ix) Biosensor technology development using the African giant pouched rats, *Cricetomys gambianus* (5 studies in pipeline). The ACEIRPM&BTD will support high impact research on rodents in Africa and welcomes collaboration with scientists from all over the world.

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Population dynamics and breeding patterns of *Mastomys natalensis* (Smith 1834) in three different agricultural practices

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The multimammate mouse, *Mastomys natalensis* (Smith, 1834), is an important agricultural pest in sub-Saharan Africa where it can cause severe crop losses. The eruptive nature of this rodent species has been linked before to abundant rainfall leading to population outbreaks. The aim of this study was to examine and describe the population dynamics and breeding patterns of *Mastomys natalensis* in three locations in Tanzania with different cropping system, crop calendars and water availability: rainfed maize/single crop, rainfed maize/double crop, and irrigated rice/double crop. In these locations *Mastomys natalensis* was the dominant rodent pest species, contributing more than 95% of animals captured in the study sites. Rodent population densities were higher in an irrigated rice/double crop fields than in either the rainfed maize/single crop or rainfed maize/double crop fields. *Mastomys natalensis* showed almost continuous breeding in irrigated rice/double crop fields, and extended breeding was observed in rainfed maize/double crop fields. The nearly constant supply of water in the irrigated rice/double crop fields allows for an almost continuous availability of young green vegetation with germinating crop and weed seeds. This provides good conditions for the maturation of *Mastomys natalensis* and hence allows continuous breeding. Forecasting models based on rainfall should take into account differences in rainfall pattern or alternative provision of water from irrigation.

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A large-scale experiment to evaluate the effects of trapping on muskrat (*Ondatra zibethicus*) population development in The Netherlands

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Muskrats are considered a pest species in The Netherlands and are being harvested in a year-round control-program. Supported by the man-power and registration system in this control-program, a unique large scale management experiment took place from 2013 till 2015 (3 years) to study the effect of manipulating Muskrat harvest intensity (time invested in trapping) on catch rate. The experiment took place in 117 atlas squares of 5*5 km, selected in a stratified random way. The experimental results were analysed with mixed-effects models, with appropriate spatio-temporal covariance structures to avoid biases or inflation of significance. There was a strongly positive relation between time spent trapping and number of animals caught, substantiating that catch is determined by effort. Catch rates did furthermore vary substantially between seasons, being higher in autumn than in spring, were correlated across years, and did exhibit a marked spatial auto-correlation up to distances of 10 to 15 km on average. The development of catch rate over time differed between experimental atlas squares, but could not be related to experimental treatments or any other known environmental variable of relevance. This experiment thus did not provide evidence for the role of quantity of effort on Muskrat population dynamics. We identified several mechanisms that may have attenuated differences in trapping effort on local Muskrat populations studied. We suggest that the spatial context and spatial scale, as well as the effectiveness of time spent trapping, are more important than previously thought. The experimentally assigned change in effort was presumably not sufficient to provide an experimental evidence for the hypothesised effects, given the spatial scale of the plots. New research efforts should therefore focus on disentangling the role of quality of effort invested versus its quantity, and also find ways to accurately document aspects of quality in the trap recording system.

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Aspects of good practice rodent control that affect exposure of non-target vertebrates to anticoagulant rodenticides

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Norway rats are frequently controlled with anticoagulant rodenticides in European livestock farming. Products are highly efficient but can pose environmental risks like primary exposure of non-target vertebrates and secondary exposure of predators and scavengers. Several features of good practice rodent control aim to reduce risk but often effects are not well known. On farms around Muenster, Northrhein-Westfalia, 1) We investigated the potential difference between using bait boxes only inside buildings in contrast to traditional bait box application in and around buildings regarding anticoagulant residues in liver tissue of non-target small mammals. First results suggested a lower exposure for some species if rodenticides are applied only inside buildings. 2) We also tested a new bait box design and observed small mammal behavior with camera traps. Non-toxic bait paste or bait blocks placed "above head", 200 mm up on the inner box wall, excluded all shrews and voles from the bait but not mice and the targeted rats. 3) We localized the places where Norway rats succumb to rodenticides by treating 53 live-trapped and radio tagged individuals with a lethal dose of the anticoagulant brodifacoum. Most rats died in hidden places inaccessible to avian or large mammalian predators. Some rats died in dense vegetation with limited access to predators or in open areas where they were exposed to predators. The latter can be easily removed and disposed to prevent consumption of poisoned rodents by predators or scavengers. The study showed that several aspects of good practice rodent control may reduce exposure of non-target species to anticoagulant rodenticides to further minimize non-target exposure.

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Dynamic of the invasive rodent ranges in Russia: facts and forecast

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A list of 100 invasive species of animals, plants and microorganisms (TOP-100 worst), witch are the most dangerous for ecosystems, native species and humans in the territory of Russia, is compiled. It contains 10 species of mammals, 6 of them are rodent species: *Castor canadensis* Kuhl, 1820; *Ondatra zibethicus* Linnaeus, 1766; *Apodemus agrarius* (Pallas, 1771), *Mus musculus* Linnaeus, 1758; *Rattus rattus* Linnaeus, 1758; *Rattus norvegicus* Berkenhout, 1769. The distribution of these rodents in the territory of Russia and in neighboring countries was analyzed on the basis of all available presence data from museums, monitoring and literature sources. We created geographical maps of the dynamics of the distribution range of invasive rodents using GIS-technologies and environmental niche modeling. We used the maximum entropy method (MaxEnt) for modeling the species' potential geographic distributions (Phillips et al., 2006 and other). An extensive literature review was conducted to select the important variables which are involved in determining the distribution of the rodent species. The selected environmental variables were: land cover/land use characteristics, climatic, topographic and location of anthropogenic objects. The native range and in time dynamics of rodent species range were identified. It is shown that regions of recent invasions of rodents are mainly located in the east part of Russia. The reduction of the *Rattus rattus* range was established in the last decades. A forecast of the changes in the rodent ranges under different scenarios of climate change is presented. According to preliminary data, climate change has only a small effect on the regions of rodent invasions. The anthropogenic transformation of landscapes, transport traffic intensity and land use changes have more significant impact for the range dynamics.

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The black rat (*Rattus rattus*) in Madagascar: threat to health and livelihoods

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Malagasy farmers face numerous risks to their agriculture, including frequent pest outbreaks. The black rat (*Rattus rattus*) is the primary rodent pest, and a key reservoir for a number of transmissible diseases including bubonic plague. Control using ecologically-based rodent management (EBRM) approaches has been shown to significantly reduce crop losses where it has been implemented in parts of Southeast Asia. EBRM is not presently practiced in Madagascar and there is an opportunity to develop strategies that improve both food security and human health. A good understanding of the breeding ecology and habitat use of the pest species is fundamental to the successful design and implementation of EBRM, as well as consideration of the specific agricultural production system. Experience in Southeast Asia has demonstrated the importance of integrating local knowledge and socio-cultural factors. Here, we present data on the size and breeding condition of *Rattus rattus* populations across Madagascar and discuss the implications of capture probability for the design of control programmes. As part of a wider study on the occurrence of rodent-borne illnesses, rodent trapping was conducted at paired rural and urban sites at twenty-eight locations across Madagascar between 2011 and 2013. Household questionnaire surveys were also conducted at the each site, and provide information on agricultural practices, local perceptions of the rodent problem, and control methods currently practiced.

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What the uninvited guests eat: dietary analysis of rodent pests present in the rural human dwellings of Pothwar, Pakistan

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Knowledge of what pest species are eating is very important to determine their impact on stored food products and it can help to develop more effective management strategies, such as targeted baits and lures. In this study, we investigated the food habits of two rodent species, *Rattus rattus\f "S"* (ship rat) and *Mus musculus* (house mouse) present in rural human dwellings of Pothwar, Pakistan. The trapping was conducted seasonally in village households, shops and farm houses from March 2012 through February 2014. We studied the dietary composition and seasonal variation in the food habits of the two rodent species. Overall, thirteen prey items were identified in gut contents of both *Rattus rattus* and *Mus musculus*. Among these items, cereal grains were the chief staple in the diet of both species. *Triticum aestivum* was the major cereal grain occurring in the gut content of both species across all the seasons. Among oil seeds, *Arachis hypogaea* consumption varied and it was best consumed in the autumn season. Arthropods (mainly insects) were consumed both the species and the intensity of consumption of arthropods was second to that of *Triticum aestivum*. No variation was detected in the food consumption across different trapping sites, seasons and trapping structures. Overall, the stomach content analysis showed that *Rattus rattus* and *Mus musculus* are omnivore, and mainly feeds on seeds, especially cereal grains and oilseeds. Our results indicated that the two rodent species were consistent pests of stored grains. This shows the potential negative impact of these pest species on people's health and the economy through consumption and contamination of their food products.

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Low frequency of warfarin resistance in Norway rats in China after 30 years usage of anticoagulant rodenticides

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The first generation anticoagulant rodenticides (FGARs), such as warfarin and diphacinone, have been widely used in rodent control in China for over 30 years and resistant Norway rats have been reported. The genetic basis of warfarin resistance has been studied in Norway rats in many European countries, but is an untouched area for Norway rats in China. Mutations in the vitamin K epoxide reductase complex subunit 1 (Vkorc1) gene confer anticoagulant resistance in rodents. In this study, we analyzed the Vkorc1 polymorphisms of 681 Norway rats collected in Zhanjiang and Harbin City in China from 2008 to 2015 and evaluated the warfarin resistance frequency. Analysis results revealed 4 mutations including 3 not previously reported. Two new synonymous mutations His68His and Leu105Leu are not associated with warfarin resistance. One new nonsynonymous mutation Ala140Thr was found in Zhanjiang rat samples collected in 3 different years with low frequencies (3.3%-4.0%) and is likely associated with warfarin resistance. No Vkorc1 mutation related to warfarin resistance was detected in rats in Harbin. Laboratory resistance tests suggested low warfarin resistance frequencies in rats from Zhanjiang (4.9%-17.1%) and Harbin City (0-2.5%). Therefore, both genetic analysis and laboratory resistance tests suggested low warfarin resistance frequencies in rats from Zhanjiang and Harbin City, which is likely owing to the absence of Vkorc1 mutations resistant to second generation anticoagulant rodenticides (SGARs), as well as different strategy of anticoagulant usage from Europe. The alternative usage of FGARs and SGARs might represent an effective strategy against the development of warfarin resistance in Norway rats in China.

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Comparative biological properties of the four stereoisomers of difethialone – a way to reduce the tissue persistence of difethialone

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Difethialone, a second generation anticoagulant rodenticide (SGAR) is highly potent to control rodent populations. However, its long persistence is responsible for secondary exposure or poisoning of predators and scavengers. A major pathway for improving difethialone has recently been proposed based on their stereoisomerism. In fact, the SGAR molecules, which all contain 2 asymmetric carbons, coexist in the form of 4 stereoisomers of configuration, the 1R/3R, 1S/3S, 1R/3S and 1S/3R stereoisomers. Stereoisomers 1R/3R and 1S/3S are enantiomers and have thus identical physicochemical properties in a symmetric environment, as stereoisomers 1R/3S and 1S/3R. The commercial forms contain the 4 stereoisomers in variable proportions and persistence and efficiency of the commercial form is the result of the persistence and efficiency of each stereoisomer. This study aims to evaluate the biological properties of each stereoisomer of difethialone as rodenticide. Separation of stereoisomers has been performed on chiral column. Pharmacokinetic properties of each stereoisomer has been determined by in vivo study in rats and efficiency has been evaluated in vitro by the determination of the efficiency to inhibit VKOR activity and in vivo by a no choice feeding test. Pharmacokinetic properties of the four stereoisomers are different with two stereoisomers systematically more persistent than the two other ones. The four stereoisomers are able to inhibit VKOR activity in warfarin-susceptible rats with the same efficiency. All the baits containing either 1R/3R or 1S/3S or 1R/3S or 1S/3R are able to induce more than 90% of mortality of rats in a no-choice feeding test. However, difethialone residues at the death of animals were comprised between 4 and 16% of the active substance ingested according to the stereoisomer. Modifying the proportion of stereoisomers of difethialone is thus a way to reduce ecotoxicity. This improvement may be major if pharmacokinetic properties observed in rats are similar in non-target species.

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Management of rodent pests in pig farming in North Rhine-Westphalia in Germany

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There is limited research focused on rodent control practices, usage of anticoagulant rodenticides and the acceptance of Pest Control Operators (PCOs) in domestic pig farming in Germany. In the present study, operation managers were offered the possibility to outsource rodent control to PCOs supported by a financial contribution of the North Rhine-Westphalian Animal Disease Fund (TSK) for two years. Data were collected from monitoring records of PCOs and personal interviews with farmers and PCOs. Of 47 farmers who were offered to participate, 33 joined the project. Despite the widespread opinion that the professional would not be worth it – we found that farmers financially profit from the work of the PCO, as calculated costs of pest control measures per operation on average did not greatly differ between costs incurred by employment of PCOs and costs that arise by farmers themselves. All PCOs used difenacoum and brodifacoum against pest infestations in each farm and the two anticoagulants, cumulatively accounted for 98 % of amounts of active ingredients of SGARs used within this study. By this, the infestation with rodents was reduced and most of the participating farmers assessed the project as success and employ the PCOs permanently. However, mapping the farm locations to resistance areas of the Rodenticide Resistance Action Committee (RRAC) shows that brodifacoum was frequently used in areas that are marked as areas that have no risk or rather are at low risk for resistance. If PCOs working in areas where resistances might occur, administer the highest potent anticoagulant available at present per se to avoid failure of pest control or if there are more today unknown resistance areas present in Germany, cannot be distinguished by the present data. Due to the alarmingly high quantities of brodifacoum used in the present study and the resulting risk for the environment, we highly recommend to further analyze the implementation practices of farmers and PCOs in livestock farming in Germany.

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Experimental evidence for the effects of muskrat control (*Ondatra zibethicus*) on abundance in The Netherlands.

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Unambiguous evidence for the effectiveness of Muskrat control in well-established populations in mainland Europe is still lacking. This is important given ongoing public debate on the need for Muskrat control and the political desire at the level of the European Union to eradicate Invasive Alien Species (IAS), amongst which the Muskrat. In this study, indices of Muskrat abundance have been collected using Capture Mark Recapture for multiple years in two study sites that were experimentally managed without Muskrat control for three years. The data were compared to those from six reference areas under permanent control by kill-trapping and one site in which control had been abandoned more than eight years ago. In the No-trapping area, the index of Muskrat abundance was variable, but consistently high. Meanwhile, the index was consistently low in the reference areas. In the temporary absence of kill-trapping in the experimental areas, the index of Muskrat abundance increased significantly. The results are interpreted as compelling experimental proof for an effect of Muskrat control on Muskrat numbers, a basic premise of the Muskrat control programme.