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Vertebrate pest management: research for science-based solutions

Vertebrate species are diverse and widespread in Europe. They are vital components of aquatic and terrestrial ecosystems, where they participate in manifold interactions. Vertebrates are important for ecosystem integrity, function, and services. Some are resources for humans, (hunting) and some are valued because of their appealing nature (iconic species, bird watching). However, there are species that can pose considerable problems to humans because of their role in the transmission of zoonotic diseases, (e.g. hantavirus infection, tularaemia) or livestock disease (e.g. leptospirosis). Due to competition with native fauna and livestock, some species have also had adverse effects on native flora, pre-harvest crop damage, and have caused damage to stored produce and infrastructure.

Problem species – or, more often, problematic overabundant populations of particular vertebrate species – require human intervention to minimise adverse effects. In the case of invasive alien species, European regulation requires eradication or control of the most harmful invasive species.[1] The possible problems and management approaches are as diverse as vertebrate (pest) species are.[2] Care needs to be taken so that management action is suitable for all interest groups affected. This is one of the major challenges in vertebrate management and requires sound knowledge of the system to be navigated. Awareness of the potential consequences of management for target, and non-target, populations including environmental, social, ecological, and economical aspects is another key challenge for those involved.

This In-Focus section of *Pest Management Science* is dedicated to science-based solutions in vertebrate pest management in several taxa and across several continents. The 13 papers in the In-Focus section are drawn from contributions to the 10th European Vertebrate Pest Management Conference, held in September 2015 in Seville, Spain, which was attended by 182 participants from 34 countries. Topics covered included: biological control of rodent pests by promoting increased raptor predation pressure, urban pest management, control methods and alternatives, agricultural and silvicultural pest management, ecologically based pest management, invasive vertebrates, zoonoses and parasites, and the consequences of control for non-target species. Summaries of all conference abstracts are available at the conference website www.evpmc.org. They clearly demonstrate the science-based adaptation of vertebrate pest management in a changing world, looking towards integrating multiple management approaches.

Three contributions cover the topic of how to deal with invasive bird species. Feral pigeons (*Columba livia*) are an important risk for human health, and a nuisance in building conservation in many cities. Senar et al. showed how educating the public on reducing the food availability to birds resulted in a 40% reduction in the population size of pigeons.[3] The common myna (*Acridotheres tristis*) is a serious threat to the conservation of native endemic avifauna in many islands. Eradication of common myna from small islands is possible but requires a combination of different control methods.[4] As with the feral pigeons, food shortage may greatly facilitate the control/eradication of the species. A third study describes the quick growth of monk parakeet populations (*Myiopsitta monachus*) in Israel.[5] Since 1995 the population has exponentially increased in size, and distribution, in urban and agricultural areas. The authors highlight the potential damage to agriculture and the need to initiate eradication campaigns as soon as possible.

Aside from birds there are also several mammalian species that can interfere with human interests. Rodents are an important threat for public health, native wildlife, and crops in many countries. A survey of Norway rats (*Rattus norvegicus*) in five European countries found *Leptospira* and *Rickettsia* spp. both as separate, and as co-infections, especially in adult rats from rural habitats.[6] Grey squirrels (*Sciurus carolinensis*) endanger native red squirrels (*Sciurus vulgaris*), however, grey squirrels are aesthetically appealing to the general public, adding a social dimension to the management of this species. Through a Bayesian decision network mode, La Morgia et al.[7] identified the priority areas for population control and concluded that citizen attitude towards the project significantly modifies the optimal strategy of control. Understanding habitat use can greatly help to improve control programs, increasing efficiency and reducing cost. This is also the case in invasive brushtail possums (*Trichosurus vulpecula*) in New Zealand, where habitat use and home range size is varied in response to population abundance.[8] When new invasive species appear, rapid response is recommended as the best strategy to reduce the environmental, financial, and welfare cost of eradication/control programs. Of the large-scale alien mammal removal programs conducted in northern Europe, reviewed by Robertson et al.,[9] 80% were successful.

Worldwide, one of the main tools for rodent management are anticoagulant rodenticides.[10] However, there are disadvantages in using these compounds including environmental persistence and resistance. The former was demonstrated by Martínez-Padilla et al.[11] who revealed the presence of residues of the common anticoagulant active ingredient, bromadiolone, in nestlings of common kestrels (*Falco tinnunculus*). The latter was validated by Goulois et al.[12] in house mice (*Mus musculus*), where anticoagulant efficiency is severely hampered for some anticoagulant compounds by an introgressed mutation acquired from the Algerian mouse (*Mus spretus*). An alternative to the use of rodenticidal bait, based on an anticoagulant compound, may be the application of a mix of an anticoagulant active ingredient with other compounds such as cholecalciferol (vitamin D_3), which seems to be sufficiently effective in rodenticide resistant Norway rats.[13]

Some of the most obvious rodent damage is caused pre-harvest in agriculture and forestry and in storage facilities. Rodent damage to rice in Myanmar occurs pre-harvest when *Bandicota* species remove rice grains from the fields and store them in their burrows, with additional damage being caused by *Rattus* species that consume rice in storage facilities.[14] The rice eaten by rodents is equivalent to the amount needed to feed a household in Myanmar for up to four months, which can severely affect food security.[14]

Rodent damage in German forestry is related to outbreaks of common *Microtus* and *Myodes* species, indicating density dependent damage patterns.[15] Time-series analyses show that outbreaks occur largely synchronous in both species, most likely driven by mast of beech trees the year before the outbreak.[15] Van Loon et al. used historical information about trap success and trap efforts to assess the effectiveness of muskrat (*Ondatra zibethicus*) removal in the Netherlands.[16] They identified effort thresholds required to make invasive muskrats decline, which will guide future management approaches.

The work presented at the 10th European Vertebrate Pest Management Conference demonstrates that the scientific community strives to create, and use, robust scientific data, to develop and test suitable vertebrate pest management approaches. This includes a better understanding of invasion processes, patterns, the species implicated, and management options. Previous information about the effect of predators, in the cyclic population dynamics, of some rodent species, provides the opportunity to design systematic and robust experiments to identify potential application in pest management. New molecular approaches presented at this conference have provided details about the mechanism of resistance to rodenticides in commensal rodent species. Also, the overlap between pest management and conservation has become evident. In many cases, the knowledge and tools developed to control pests have been important to promote conservation measures. The contributions clearly show that scientific findings can further vertebrate pest management regarding effectiveness, conservation, animal welfare, and public opinion.

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