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Author

Whisson, Desley A.

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The Dynamics of Vertebrate Pest Management and Research

Desley A. Whisson

School of Life and Environmental Sciences, Deakin University, Victoria, Australia

ABSTRACT: Papers presented at two long-running conferences, the *Australasian Vertebrate Pest Conference* and the *USA Vertebrate Pest Conference*, were reviewed to examine changes in the field of vertebrate pest management over the last few decades. At both conferences, there has been a shift in focus from pest impacts on production (crop, livestock, forestry etc.) to impacts on conservation values. Papers have also become more focussed with a decrease in papers on pest problem overviews. There were surprisingly few papers focussing on the human dimensions of vertebrate pest management, despite general acknowledgment that the public have become more involved in pest management decision-making. The number of papers presented and number of pest species addressed has also increased, indicating the importance of these conferences to pest management professionals for sharing information and ideas.

KEY WORDS: Australasia, control methods, impacts, pesticides, topics, trends, USA, vertebrate pest conference

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INTRODUCTION

It is generally acknowledged that over the last few decades there has been an increase in human-wildlife conflicts resulting from increasing urbanisation and other changes in land use, increasing fragmentation of wildlife habitat, recovery of many native species in response to conservation programs, heightened awareness and interest in wildlife by the general public, and continued introductions of exotic species (Berryman 1994, Clay 2007, Fall and Jackson 2002, Messmer 2000, 2009, Miller 2007). Improved understanding of the high economic and social cost of problem wildlife has also resulted in more attention being given to the management of such wildlife (Fall and Jackson 2002). At the same time, challenges facing wildlife managers have increased as a result of a shift in public attitudes regarding the welfare of animals, increased scrutiny of methods used to manage wildlife problems, and increasing public interest and participation in resource management decision-making (Clay 2007, Curnow 2000, Fall and Jackson 2002, Messmer 2009, Miller 2007).

Papers presented at two long-running conferences, the *USA Vertebrate Pest Conference* (California) and the *Australasian Vertebrate Pest Conference* (Australia and New Zealand), document the changes over the last few decades in the field of vertebrate pest management including pest species, their impacts, and associated research and management.

The *USA Vertebrate Pest Conference*, first held in 1962, is a biennial conference that is overseen by the Vertebrate Pest Council, comprised of professionals (academic, government, private) working in the field of vertebrate pest management. A primary objective of the Council is to facilitate the exchange of information on vertebrate pest management through conferences and workshops. Marsh (2008) documents the history of this conference and its organization.

The *Australasian Vertebrate Pest Conference* has occurred roughly triennially since 1957. Originally named the '*Vermin Control Conference*' (1957 and 1960), it has

occurred under several other titles including the '*Australian Vermin Control Conference*' (1964 - 1973), the '*Australian Vertebrate Pest Control Conference*' (1978 - 1994), and the '*Australian Vertebrate Pest Conference*' (1998). The conference is overseen by The Vertebrate Pests Committee (VPC) which is a government-appointed committee with the role of providing coordinated policy and planning solutions to pest animal issues. Each state and territory and the Australian Commonwealth Government have membership on the VPC, and currently the Invasive Animals CRC, Bureau of Rural Sciences, and others have Official Observer status (Department of Agriculture, Fisheries and Forestry 2010).

The objective of this paper was to document the major trends in the field of vertebrate pest management including changes in species and impacts, topics, and control methods as reflected by the content of papers presented at each of these conferences.

METHODS

A total of 1,264 and 839 papers or abstracts published in the *Proceedings* of the USA and Australasian Vertebrate Pest Conferences, respectively, were considered. Papers authored by international attendees at either conference were excluded.

Papers were primarily classified based on the title or abstract with the following recorded for each paper (Table 1):

- Animal (taxonomic group, genus or species if only one species was involved)
- Topic
- Control method (if specified)
- Impact (if specified) – This was recorded only for those papers that described an impact or where a pest was being controlled for a specific purpose; for example, a paper addressing fox control for protection of an endangered species would be classified as a 'conservation' impact, whereas a paper discussing fox control methods in general would not be classified under any impact.

Table 1. Key words used for classifying papers presented at vertebrate pest conferences.

Animal	Topic/Focus	Control Method (development, testing, etc.)	Impact
Bird Mammal Amphibian Fish Reptile	Disease Ecology Research technique Impact Economics Human dimensions Information / Resources Communication / Education Government plans/policies Organisation Biosecurity Management approach Management program Control method Nontarget impacts Ethics / Welfare Overview of a pest problem and control methods General – e.g., this paper	Pesticides Repellents Trapping Hazing Exclusion Habitat manipulation Fertility control Biological control Mechanical control Shooting Bounties Commercial use	<u>Conservation</u> Biodiversity / natural resources Non-target risks <u>Health</u> Aircraft Human <u>Production</u> Agriculture Aquaculture Apiculture Crop Fisheries Forestry / Plantation Livestock Rangeland / Pasture <u>Urban</u> Nuisance Structure

Figure 1. Number of papers presented at the USA (solid squares) and Australasian Vertebrate Pest Conferences (open circles) from 1957 to 2009.

Papers were grouped into four time periods (<1970, 1970 - 1989, 1990 - 2000, 2000 - 2008) for analysis. The small number of papers presented at conferences between 1970 and 1989 precluded further subdivision of this time period. Chi-squared goodness-of-fit tests were applied to detect significant changes between time periods.

RESULTS

Number of Papers Presented

The number of papers presented at each conference generally increased from around 20 to over 100 in some years post-2000 (Figure 1).

USA Vertebrate Pest Conference

Pest Species/Groups

Papers on mammalian and avian pests comprised 73% and 24% respectively of all papers presented. Commensal rodents were the predominant pest group (13% of all papers), but other mammalian pests were primarily native species. Blackbirds (several species), starlings (*Sturnus vulgaris*), and Canada geese (*Branta canadensis*) were the predominant avian pests (Table 2).

Table 2. Predominant species addressed in each conference (all years combined). The percentage of all papers on each species or group of species is given in brackets.

Pest Group	USA VPC	Australasian VPC
Mammals	<i>n</i> = 746 Commensal rodents (13%) Squirrels (10%) Coyote (8%) Pocket gopher (6%) Pig (4%) Deer (4%) Meadow vole (2%)	<i>n</i> = 583 European rabbit (35%) European red fox (13%) Dingo / wild dog (11%) Common brush-tailed possum (7%) Feral pig (5%) House mouse (5%)
Birds	<i>n</i> = 250 Blackbird (24%) Starling (15%) Canada goose (11%)	<i>n</i> = 37 Parrots (33%) Emu (19%) Wedge-tailed eagle (11%)

There was some variation in mammalian pest groups addressed from the 1962 - 1970 period to the 2000 - 2009 period, with an increase (9% to 20%) in the frequency of

Table 3. Percentage of papers on each major focus/topic presented at the USA and Australasian Vertebrate Pest Conferences.

Topic	<1970	1970 - 1989	1990 - 1999	2000 - 2009	χ^2_3
USA					
Control method	41	47	51	44	2.4 ($P = 0.49$)
Overview	23	12	10	7	16.8 ($P < 0.001$)
Impact	4	13	8	8	8.3 ($P = 0.04$)
Management programs	0	4	4	7	10.1 ($P = 0.02$)
Human dimensions	3	1	2	4	8.9 ($P = 0.03$)
Australasia					
Control method	37	31	40	29	5.9 ($P = 0.11$)
Ecology	10	28	9	12	22.9 ($P < 0.001$)
Overview	37	12	8	8	70.7 ($P < 0.001$)
Management programs	2	4	6	9	8.2 ($P = 0.04$)
Human dimensions	2	0	4	4	5.0 ($P = 0.17$)

Table 4. Pesticides discussed in papers from the USA and Australasian Vertebrate Pest Conferences. The percentage of papers addressing each specific pesticide or group of pesticides is given in brackets.

USA ($n = 186$)	Australia ($n = 77$)
Anticoagulants – multiple (19%)	1080 (68%)
Rodenticides – multiple (15%)	Zinc phosphide (5%)
1080 (11%)	Pindone (5%)
Strychnine (7%)	Sodium cyanide (5%)
Zinc phosphide (7%)	Anticoagulants – multiple (4%)
DRC1339 (5%)	Strychnine (3%)
Sodium cyanide (5%)	
Brodifacoum (5%)	Others ($\leq 2\%$ each)
Warfarin (4%)	Cyanide
Diphacinone (3%)	Brodifacoum
	Cholecalciferol
Others ($< 2\%$ each)	Thallium sulphate
Chlorophacinone	Bromocriptine
CPT/CPH	
Bromethalin	
Cholecalciferol	
Difethialone	
Flocoumafen	
Bromadiolone	
Aluminum phosphide	
Difenacoum	
Gophacide	
Molexit	
Pindone	
Red squill	
Avicide (general)	

papers on predators (e.g., coyotes, *Canis latrans*; and mountain lions, *Felis concolor*) ($\chi^2_3 = 8.3$, $P = 0.04$), and a decrease (18% to 6%) in the frequency of papers on commensal rodents ($\chi^2_3 = 8.8$, $P = 0.03$). Field rodents (e.g., pocket gophers, *Thomomys* spp.; voles, *Microtus* spp.; and prairie dogs, *Cynomys* spp.) consistently comprised 16% of all mammalian pests addressed ($\chi^2_3 = 4.1$, $P = 0.25$).

Topics

Papers on control methods consistently comprised 46% of papers across all time periods (Table 3). Overview papers and papers describing impacts each comprised 10% of all papers, with other topics each comprising less than 10% of papers.

The frequency of ‘overview’ papers declined from 23% of papers in the 1962 - 1970 period to 7% of papers in the 2000 - 2009 period (Table 3). The frequency of

papers focussing on impacts caused by vertebrate pests also varied, with a higher than expected proportion of papers on this topic in 1970 - 1989 (Table 3). The frequency of papers discussing management programs also increased from 0% in the 1962 - 1970 period to 7% of papers in the 2000 - 2009 period (Table 3). There was a slight increase in the frequency of papers addressing the human dimensions of vertebrate pest control in the 2000 - 2009 period (Table 3).

Control Methods

Pesticides (Table 4) were the primary control tool in 58% of all papers on control methods, and this was consistent across time periods ($\chi^2_3 = 5.6$, $P = 0.13$). Repellents comprised 12% of control method papers, and all other methods comprised less than 10% of papers.

Impacts

The frequency of different impacts varied between time periods ($\chi^2_3 = 47.6$, $P < 0.001$). Vertebrate pest impacts on ‘production’ was the most frequent impact addressed (between 43% and 71% in any time period), but decreased in frequency from 1970 - 1989 with corresponding increases in frequencies of papers addressing ‘conservation’ and ‘health’ impacts. ‘Urban’ impacts remained relatively constant (Figure 2).

Figure 2. Change over time in the impacts addressed at the USA Vertebrate Pest Conference. Impacts are ‘conservation’ (solid black), ‘production’ (dark grey), ‘urban’ (hollow), and ‘health’ (light grey).

The Australasian Vertebrate Pest Conference Pest Species/Groups

Papers on mammalian and avian pests comprised 89% and 7% of all papers. Mammalian pests were primarily

introduced species, while avian pests comprised mostly native species (Table 2). European rabbits (*Oryctolagus cuniculus*) were the most common pest species addressed during the 1957 - 1970 period, but they declined in frequency in subsequent time periods, with an increase in the frequency of papers on the European red fox (*Vulpes vulpes*) and a diversity of other introduced species including feral pigs (*Sus scrofa*), camels (*Camelus dromedarius*), goats (*Capra hircus*), deer (Family *Cervidae*), common brush-tailed possums (*Trichosurus vulpecula*) (introduced in New Zealand), canetoads (*Bufo marinus*), and carp (*Cyprinus carpio*) (Figure 3). The latter two species have only been addressed since 2001.

Figure 3. Change over time in the frequency of papers on each species over time at the Australasian Vertebrate Pest Conference: rabbits (solid black), fox (clear), dog/dingo (light grey), other (dark grey).

Topics

Papers on control methods consistently comprised 34% of papers (Table 3). The frequency of 'ecology' papers varied, with a higher than expected frequency of these during the 1970 - 1989 period (Table 3). The frequency of 'overview' papers declined from 37% in the 1962 - 1970 period to 8% of papers from 2000 to 2009, and the frequency of papers on 'management programs' increased from 2% of papers prior to 1970 to 9% of papers in the 2000 - 2009 period (Table 3). The frequency of papers addressing the human dimensions of vertebrate pest control did not change, with an average of 3% of papers addressing this topic (Table 3).

Control Methods

Pesticides were the predominant control tool in control method papers in each time period, although the frequency of these papers decreased from 73% in the 1962 - 1970 period to 38% in the 2000 - 2009 period ($\chi^2_3 = 15.3$, $P = 0.002$). Papers on biological control methods (primarily diseases for rabbit control) were also frequent but varied between time periods ($\chi^2_3 = 12.4$, $P = 0.006$), with 26% of papers on this topic prior to 2000, and only 9% from 2000 to 2009. Papers specifically addressing fertility control methods first appeared in 1991 and have since represented 13% of control method papers. There has also been increased interest in commercial use of pest species, with a special session dedicated to this topic in the 2008 conference.

Impacts

Papers addressing 'production' and 'conservation' impacts predominated, although there was a significant change in the frequencies of papers on these impacts between time periods ($\chi^2_6 = 86.1$, $P < 0.001$). Conservation impacts increased, while production impacts decreased (Figure 4).

Figure 4. Change over time in the impacts addressed at the Australasian Vertebrate Pest Conference. Impacts are 'conservation' (solid black), 'production' (dark grey), 'urban' (hollow), and 'health' (light grey).

DISCUSSION

The increasing importance of the USA and Australasian Vertebrate Pest Conferences for sharing information and strategies for dealing with the many challenges faced by professionals working in this field was reflected by the increase in number of papers presented over the years. Corresponding to the increase in papers presented was a broadening of scope (i.e., more topics and pest species addressed) and audience, reflecting both the diversity of vertebrate pest issues encountered and approaches for effectively managing them.

Mammalian pest problems predominated in both the USA and Australasia. Mammalian pests in the USA were predominantly native species, although commensal rodents also received significant attention, especially in the early years of the conference. A slight increase in papers addressing predator problems (primarily coyotes and mountain lions) may have been due to the change in scope of the conference (Marsh 2008). Heightened awareness of the impact of predators on human safety and livestock production, and an increase in conflicts between predators and humans and their activities, may also have contributed to this increase.

In Australasia, mammalian pests comprised mostly introduced species. In the early years, conferences were dominated by papers on European rabbits, which is not surprising considering the significant negative impact this species has had, especially on pasture production, in both Australia and New Zealand. Despite the ongoing significance of rabbit impacts, which was recently estimated at A\$206 million p.a. in loss to total economic surplus in Australia (Gong et al. 2009), there has been a shift in interest to foxes, as well as a high diversity of other species including feral pigs, camels, deer, canetoads,

introduced fish species, and brush-tailed possums (an introduced pest in New Zealand). This partly reflects a broadening in scope of the conference as well as heightened awareness of the impacts of introduced species on both production and conservation values.

Despite the differences in pest species, there were some marked similarities in the types of papers presented at the two conferences, which reflects global issues, challenges, and approaches in the field of vertebrate pest management. Papers on control methods dominated in both conferences, reflecting the ongoing need to evaluate control materials, and technological advances that result in the development of new materials. In both conferences, the majority of 'control method' papers addressed the use of pesticides. This is not surprising, given the cost-effectiveness of pesticides for reducing pest populations and their impacts. Heightened public concerns for animal welfare have also provided additional cause for the development of more humane and target-specific pesticides (Clay 2007, Fall and Jackson 2002). Some variation in the number and types of pesticides discussed at the two conferences reflects the differences in types of pest species addressed. The high frequency of papers on 1080 in Australasian conferences largely reflects the significance of fox and wild dog problems, and reliance on 1080 for controlling impacts of these pests. By contrast, pesticides addressed in the USA were predominantly those used for managing problems with commensal rodents or field rodent pests. In the USA, repellents were more commonly addressed than in Australasia, possibly reflecting a difference in type of herbivore problems and impacts. In Australasia, biological control was frequently addressed, reflecting the use of disease (myxomatosis and rabbit haemorrhagic disease) for controlling rabbits. The use of fertility control and commercial use of pest species has also gained popularity during the last decade, with symposia at Australasian conferences dedicated to these topics.

In both conferences, there was a decrease in the frequency of general overview papers describing problems and their control. This was coupled with increases in frequency of papers discussing management programs. Papers addressing the human dimension of vertebrate pest management have been included since the early years of both conferences. However, despite increasing involvement of the general public in wildlife management decision-making and impact on vertebrate pest management (Clay 2007, Curnow 2000, Messmer 2009, Miller 2007), there has only been a slight increase in the frequency of papers focussed on this issue, with papers only representing around 4% of papers presented at conferences in the last decade.

In the USA, there has been an ongoing emphasis on a diversity of 'production' impacts including crops, pasture, forestry, aquaculture, and livestock. However, since 1970 there has been an increase in attention to wildlife impacts on human health and safety, and conservation values. This change has been discussed by others (Clay 2007, Fall and Jackson 2002). Fall and Jackson (2002) suggested that the increased recognition of human health-related problems with wildlife may be due to human population growth and expansion into new areas, which

have resulted in more people and their domestic animals having contact with wildlife, resulting in an increased prevalence of vector-borne diseases, and an increase in wildlife-related incidents (e.g., vehicular collisions). They further suggested that improvements in surveillance and diagnostic techniques have brought the realisation that wildlife-vectored diseases are a growing problem. The shift in focus from impacts on production to impacts on endangered and threatened species have also been noted by others (Fall and Jackson 2002, Miller 2007). This has been partly attributed to the rise of interest in conservation biology and the negative impacts of pest species on reintroduction or recovery efforts (Fall and Jackson 2002).

In Australasia, the change in the type of impact addressed has been much more significant, with a decrease in papers on 'production' impacts and an increase in papers addressing 'conservation' impacts. This shift in focus reflects the growing awareness of the negative impacts of introduced species on native species and ecosystems, and implementation of a number of large-scale management programs (e.g., Western Shield in Western Australia, and the 'Ark' programs in Victoria) to reduce the impacts of invasive predators on native wildlife. The development of a national 'Pest Animal Strategy' by the Australian Government (Vertebrate Pests Committee 2007) also reflects the improved understanding of the negative impacts of pest animals in Australia, and the need for better coordination of pest management activities.

CONCLUSION

This simple review of papers presented at conferences has highlighted some of the major trends in vertebrate pest problems and the response of researchers and managers in addressing those problems. The increase in number and diversity of pest issues and impacts addressed reflects the importance and dynamic nature of vertebrate pest problems, and the diversity of backgrounds (e.g., economists, social scientists, ecologists, managers) of people involved in their management. Continued efforts to coordinate pest management activities, and to share information will be critical. Further consideration of the human dimension in vertebrate pest management will also be important.

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