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REVIEW OF THE ECOLOGICAL EFFECTS OF POISONING ON MIGRATORY BIRDS

EXECUTIVE SUMMARY

Convention on the Conservation of Migratory Species of Wild Animals

Secretariat provided by the United Nations Environment Programme

UNEP/CMS Minimising Poisoning Working Group

Review of the ecological effects of poisoning on migratory birds

UNEP/Convention on Migratory Species
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Executive Summary

1. Introduction and scope

The project objectives, as defined by UNEP/CMS Resolution 10.26 (agreed at the 2011 Conference of the Parties), are to undertake a detailed assessment of:

1. the scope and severity of poisoning for migratory bird species globally and how this varies geographically and across taxa;
2. significant knowledge gaps,[1] either across range states, or in specific areas; and
3. where sufficient evidence exists, to recommend suitable responses to address the problems, potentially including:
    i. areas where enhanced legislation may be required;
    ii. features of effective regulatory regimes; and
    iii. understanding of socio-economic drivers of poisoning.

This project, including the technical background review and guidelines with recommendations for adoption at the Conference of the Parties in 2014, will focus on migratory bird species. The priority categories of poisoning addressed by this study are those most likely to affect migratory bird populations in line with UNEP/CMS Resolution 10.26.[2]

These were selected by the working group at the workshop held in Tunisia in May 2013 using the criteria in the Toxins Matrix (Table 1) as well as identifying the socio-economic drivers of poisoning (Table 4). These are poison-baits, lead ammunition/shot, veterinary pharmaceuticals, agricultural insecticides and rodenticides. There are other potentially significant poisons that, while not covered in this initial review, could be covered in the next triennial period, subject to Scientific Council agreeing the remit and appropriate funding being found.

This review analyses direct lethal and sub-lethal poisoning with the potential to lead to population decline, (e.g., egg shell thinning resulting in reduced breeding success) to migratory birds through both deliberate poisoning and incidental/accidental poisoning. Direct lethal and sub-lethal effects can occur through *primary poisoning* (direct ingestion of poison) and *secondary poisoning* (when predators are exposed to physiologically damaging concentrations of poisons by eating contaminated prey, insects or worms).

Whether lethal and sub-lethal effects of poisoning are likely to lead to population declines is a function of (1) the likelihood that migratory birds will be exposed to poison; and (2) the toxicity of the poison to migratory birds. A global assessment on the scale and severity (likelihood of population effects) of each of the priority categories of poisoning on migratory birds is included in this review. A summary of the findings are discussed below.

[1] Significant knowledge gaps will include identification of (1) the extent of impacts; and (2) the range of different types of effects of poisons on migratory birds.

[2] http://www.cms.int/sites/default/files/document/10_26_poisoning_e_0_0.pdf.

2. Poison-baits

Predator control using poison-baits occurs on a global scale, particularly in areas with game management and livestock farming. Predator and scavenger bird species are at risk of poisoning from poison-baits targeting them directly, and also from baits targeting mammalian species (with birds becoming by-catch through secondary poisoning). The effects on species, other than birds of prey, is largely unknown and further research is needed to understand this.

The risk of poisoning from harvesting for human consumption and traditional medicine appears to be much more isolated. Using poisons to harvest migratory bird species for consumption and/or traditional medicine may be limited to particular areas in Africa and Asia.

Due to the indiscriminate nature of many of the substances used in poison-baits, any birds are at risk of poisoning if they come into contact with poison-baits. The most common substances are rodenticides and insecticides, usually those that are known to farmers in the area as highly toxic. Carbofuran appears to be used in poison-baits in many areas around the world.

Many birds of prey populations are in decline as a result of illegal poison-baits, particularly vultures. This suggests that further work needs to be developed to understand why poison-baits continue to be used and create effective solutions.

3. Lead ammunition/shot

Lead is highly toxic to birds causing, at higher concentrations mortality and at lower concentrations a range of sub-lethal impacts. Wherever there is anthropogenic use of lead which is available to migratory birds, poisoning can potentially occur. Thus, it should be noted that although surveillance and research reports on lead poisoning from most sources are mainly from North America and Europe, this is unlikely to reflect distribution of the problem.

Lead poisoning, whether primary or secondary, through ingestion of shot and bullets has been recorded in at least 20 countries with greatest reporting in North America and Europe. However, lead poisoning in migratory birds can be expected to occur wherever lead ammunition is used for hunting. It follows that wherever lead shot is used, it will accumulate within the environment and the degree of contamination will be directly proportional to the intensity of use.

Certain taxa, namely wildfowl and raptors, including threatened species, are more greatly affected than other groups of birds and losses can be high. Population effects are difficult to quantify for a number of reasons, including, lack of robust surveillance and gaps in knowledge of ingestion rates and subsequent survival. Sub-lethal impacts are particularly difficult to quantify. In most countries there are also gaps in knowledge of the efficacy of restrictive regulations.

The effects of lead poisoning from fishing weights on migratory birds are restricted to certain susceptible species and to certain geographical areas where discarded and lost weights are available. A number of migratory species are known to suffer from lead poisoning following the ingestion of discarded or lost lead fishing weights. In principle, most birds feeding in currently or historically fished water bodies or near-shore soils and sediments are at risk of being exposed to and ingesting lead. Species likely to feed in areas exposed to lead fishing weights and that have physiological mechanisms that assist lead absorption, are therefore, most at risk of suffering from lead ingestion and poisoning. For these reasons, lead weight related poisoning has been widely reported in waterbirds. Although it is difficult to assess population-level effects of lead poisoning from fishing weights, there is some evidence that such effects can occur in species particularly sensitive to lead poisoning such as the mute swan and the common loon. Furthermore, significant mortality of threatened species from lead poisoning is a cause for concern.

4. Pesticides

Most bird species that use agricultural landscapes are in decline in Europe and North America as a result of the direct and indirect effects of land use intensification, habitat modification, pesticides, and other factors.[3] Often, these declines are related to intensification of management practices associated with the modernisation of agriculture.

Three quarters of all pesticides used are in agriculture.[4] The pesticide use often associated with modern agriculture can threaten ecosystem viability through a reduction in biodiversity (flora and fauna) and pollution of natural resources, such as groundwater, that impact human health and communities, as well as the natural environment. Indirect effects of pesticides on birds, such as the loss of habitat/cover and invertebrates, which lead to reduced feeding opportunities and breeding success, are well documented,[5] but will not be considered in detail here, as indirect effects are beyond the focus of this review. This study seeks to understand the scale and severity of the direct effects of pesticides on migratory birds.

Effects on birds arising unintentionally from the legal use of pesticides in agriculture are inherently variable.[6] However, insecticides and rodenticides are the main agricultural pesticides likely to result in direct lethal or sub-lethal poisoning of migratory birds (see Introduction and Scope).

4.1. Insecticides

Insecticides account for less than 20 per cent of pesticide use generally (in North America), but are more prevalent in developing countries.[7] Bird species that inhabit farmland or use farmland during migration are at risk of exposure to insecticides. Waterfowl and some gamebirds which feed on agricultural foliage are at potential risk. Granivorous passerines are attracted to pesticide-treated seeds. Birds that feed on agricultural pests, such as grasshoppers and earthworms, are at risk if

[3] Mineau, P., & Whiteside, M. (2006). Lethal risk to birds from insecticide use in the United States—a spatial and temporal analysis. *Environmental toxicology and chemistry*, *25*(5), 1214-1222 and Guerrero, I., Morales, M. B., Oñate, J. J., Geiger, F., Berendse, F., Snoo, G. D., ... & Tscharntke, T. (2012). Response of ground-nesting farmland birds to agricultural intensification across Europe: Landscape and field level management factors. *Biological Conservation*, *152*, 74-80.

[4] Sánchez-Bayo, F. (2011). Impacts of agricultural pesticides on terrestrial ecosystems. *Ecological Impacts of Toxic Chemicals. Bentham Science Publishers, Online*, 63-87.

[5] Devine, G. J., & Furlong, M. J. (2007). Insecticide use: contexts and ecological consequences. *Agriculture and Human Values*, *24*(3), 281-306.

[6] Hart, A. D. M. (2008). The assessment of pesticide hazards to birds: the problem of variable effects. *Ibis*, *132*(2), 192-204.

[7] Herbicides account for nearly half of the pesticides used in North America, insecticides 19%, fungicides 13%, with the remaining 22% including a variety of other products. Gianessi LP, Silvers CS. Trends in crop pesticide use: comparing 1992 and 1997: Office of Pest Management Policy, U.S. Department of Agriculture; 2000.

feeding on contaminated insects.[8] Scavengers and predators are poisoned when they consume contaminated prey.[9]

The likelihood of exposure to insecticides is influenced by a number of factors, including cultivation practices, pest types, crop types, pesticide form, and migratory bird ecology (diet and habitat preferences). Exposure may be reduced by using particular forms of pesticides, e.g., liquid forms over granular forms, and changing application periods for when migratory birds are not likely to be present (which can be effective given the low persistence of many of the second generation pesticides).

If a migratory bird is likely to be exposed, the toxicity of the pesticide is significant. The broad spectrum nature of organophosphates and carbamates (the most common insecticides) makes any bird at risk of lethal or sub-lethal effects if they happen to be in the vicinity at the time of application, or shortly thereafter, or if they come into contact with exposed prey.

Many of the highly toxic insecticides to birds, such as carbofuran, have been removed from the market in developed countries as a result of population declines in some bird species. Much of the effects, both sub-lethal and lethal, recorded in the literature are related to the use of these now highly regulated compounds. This could indicate that the situation has improved in areas where these highly toxic compounds are no longer used or that other substances have not yet been studied.

The implications of sub-lethal effects from exposure to second generation agricultural insecticides are little understood and are difficult to study in the field. Migratory birds may be particularly susceptible to sub-lethal effects from insecticides, which may cause reduced movement and affect migratory orientation. Further research should focus on assessing these effects on populations.

4.2. Rodenticides

Rodenticides are most commonly used for agricultural purposes, such as the protection of crops and grain storage from rodent pests. Anticoagulant rodenticides (ARs) are the most widely used rodenticide to control rodent pests worldwide.[10] They are also an integral component of modern agriculture for the control of rodent populations.[11]

Migratory birds are exposed to ARs through the consumption of contaminated baits (primary) or by the consumption of contaminated prey (secondary). Widespread exposure in birds to rodenticides has been detected through wildlife monitoring programmes in Europe and North America. For example, high detection rates of anticoagulant rodenticides have been reported in birds of prey collected through wildlife monitoring programmes in New York (49 per cent of 265 raptors between 1998-2001),[12] France (73 per cent of 30 raptors, 2003),[13] Great Britain (37 per cent of 351 owls and

[8] Szabo, J. K., Davy, P. J., Hooper, M. J., & Astheimer, L. B. (2009). Predicting avian distributions to evaluate spatiotemporal overlap with locust control operations in eastern Australia. *Ecological Applications*, *19*(8), 2026-2037.

[9] Mineau, P. (2009). Birds and pesticides: is the threat of a silent spring really behind us? *Pesticides News*, (86), 12-18.

[10] Sánchez-Barbudo, I. S., Camarero, P. R., & Mateo, R. (2012). Primary and secondary poisoning by anticoagulant rodenticides of non-target animals in Spain. Science of the Total Environment, 420, 280-288.

[11] Tosh, D. G., Shore, R. F., Jess, S., Withers, A., Bearhop, S., Ian Montgomery, W., & McDonald, R. A. (2011). User behaviour, best practice and the risks of non-target exposure associated with anticoagulant rodenticide use. Journal of environmental management, 92(6), 1503-1508.

[12] Stone, W. B., Okoniewski, J. C., & Stedelin, J. R. (2003). Anticoagulant rodenticides and raptors: recent findings from New York, 1998–2001. *Bulletin of environmental contamination and toxicology*, *70*(1), 0034-0040.

kestrels, 2003-2005),[14] and Western Canada (70 per cent of 164 owls, 1988-2003).[15] However, birds submitted to monitoring programmes (e.g., dead birds found by members of the public) are unlikely to accurately represent the prevalence of exposure in the wild, as the sampling will be biased towards sick and dead individuals, and it is therefore difficult to estimate exposure rates for populations of migratory birds.

Birds that forage in agricultural landscapes are most likely to be exposed to anticoagulant rodenticides, as use of these products is primarily in agricultural areas. However, some species' ecology will make them more likely to be exposed than others within these areas. Many raptor species are especially likely to be exposed to rodenticides due to a regular diet of rodents. Scavenging species may be especially at risk because they feed on carcasses that could be contaminated with rodenticides. The red kite, for example, may be particularly susceptible to secondary poisoning because of the high proportion of carrion in its diet, including rat carcasses.[16]

If exposure to anticoagulant rodenticides is likely to occur, the toxicity level of the AR will greatly influence the corresponding effect – whether lethal or sub-lethal. The effects, particularly sub-lethal effects, of exposure to ARs on species at both the individual and population level remain poorly understood.[17] Sub-lethal exposure to second generation ARs (which are more commonly used and more toxic to birds than first generation ARs) may hinder the recovery of birds from non-fatal collisions or accidents. They may also impair hunting ability through behavioural changes, such as lethargy, thus increasing the probability of starvation. However, there is limited evidence of these effects occurring in the field. [18]

There is wide-spread exposure of raptors to rodenticides where second-generation anticoagulant rodenticides are used in agriculture, but the ecologically-significant effects (both lethal and sub-lethal) from exposure are largely unknown. Additionally, it is unknown whether there are any population level effects from exposure. There is also scant knowledge of SGAR exposure rates in birds outside Europe, North America and Australasia.

In addition to research needed to determine whether there are population effects resulting from widespread exposure in some species, further research is also needed to identify the exposure rate of rodenticides in species other than raptors as some evidence indicates that grain-based baits could result in exposure of granivorous bird species.

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13 Lambert, O., Pouliquen, H., Larhantec, M., Thorin, C., & L'Hostis, M. (2007). Exposure of raptors and waterbirds to anticoagulant rodenticides (difenacoum, bromadiolone, coumatetralyl, coumafen, brodifacoum): epidemiological survey in Loire Atlantique (France). *Bulletin of environmental contamination and toxicology*, *79*(1), 91-94.

14 Walker, L. A., Turk, A., Long, S. M., Wienburg, C. L., Best, J., & Shore, R. F. (2008). Second generation anticoagulant rodenticides in tawny owls (Strix aluco) from Great Britain. *Science of the Total Environment*, *392*(1), 93-98.

15 Albert, C. A., Wilson, L. K., Mineau, P., Trudeau, S., & Elliott, J. E. (2010). Anticoagulant rodenticides in three owl species from western Canada, 1988–2003. *Archives of environmental contamination and toxicology*, *58*(2), 451-459.

16 Carter, I., & Burn, A. (2000). Problems with rodenticides: the threat to red kites and other wildlife. British Wildlife, 11(3), 192-197.

17 Burn, A. J., Carter, I., & Shore, R. F. (2002). The threats to birds of prey in the UK from second-generation rodenticides. *Aspects of Applied Biology*, *67*, 203-212; Knopper, L. D., Mineau, P., Walker, L. A., & Shore, R. F. (2007). Bone density and breaking strength in UK raptors exposed to second generation anticoagulant rodenticides. *Bulletin of environmental contamination and toxicology*, *78*(3), 249-251.

18 Thomas, P. J., Mineau, P., Shore, R. F., Champoux, L., Martin, P. A., Wilson, L. K., ... & Elliott, J. E. (2011). Second generation anticoagulant rodenticides in predatory birds: probabilistic characterisation of toxic liver concentrations and implications for predatory bird populations in Canada. *Environment international*, *37*(5), 914-920.

5. Veterinary pharmaceuticals (NSAIDs)

Non-steroidal anti-inflammatories (NSAIDs) are used to treat domestic livestock for inflammation and pain relief. Diclofenac, a previously popular NSAID for veterinary care of cattle in India, Pakistan, Bangladesh, and Nepal, is toxic to a number of vulture species. It resulted in the poisoning of scavenging vultures throughout India, Pakistan, Bangladesh and Nepal by contaminating domestic livestock carcasses traditionally fed on by vultures. Prior to the ban of diclofenac in these countries, it was prevalent in livestock carcasses and caused substantial population declines of three Gyps vulture species in South Asia. Research is ongoing to determine the effectiveness of the ban.

The use of diclofenac in regions outside South Asia may pose a risk of poisoning to other vultures. For example, the promotion of diclofenac on the African continent could pose a risk to vultures in this region, including the African white-backed vulture (*Gyps africanus*) and the endangered Cape Griffon vulture (*Gyps coprotheres*) due to these species' sensitivity to diclofenac. Although, exposure levels may be different in Africa, through, for example, the removal of cattle carcasses from open areas and variation in vulture diet.

The next steps are to (1) evaluate the effects of other NSAIDs on vultures; (2) identify vulture-safe alternatives (so far only meloxicam has been shown to have low toxicity to *Gyps* vultures); (3) determine whether diclofenac/NSAIDs are toxic to other vultures and birds of prey; and (4) assess the effects of diclofenac/NSAIDs on vultures in areas outside South Asia, especially in areas where domestic ungulate carcasses are likely to be available for scavenging.