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National Agri-Environmental Standards Initiative (NAESI)

Report No. 2-43

Developing Risk-Based Rankings for Pesticides in Support of Standard Development at Environment Canada: Preliminary Terrestrial Rankings

Technical Series 2006

Photos:
Bottom Left- clockwise

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**NATIONAL AGRI-ENVIRONMENTAL STANDARDS INITIATIVE
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DEVELOPING RISK-BASED RANKINGS FOR PESTICIDES IN SUPPORT OF STANDARD DEVELOPMENT AT ENVIRONMENT CANADA: PRELIMINARY TERRESTRIAL RANKINGS

REPORT NO. 2-43

NOTE TO READERS

The National Agri-Environmental Standards Initiative (NAESI) is a four-year (2004-2008) project between Environment Canada (EC) and Agriculture and Agri-Food Canada (AAFC) and is one of many initiatives under AAFC's Agriculture Policy Framework (APF). The goals of the National Agri-Environmental Standards Initiative include:

- Establishing non-regulatory national environmental performance standards (with regional application) that support common EC and AAFC goals for the environment
- Evaluating standards attainable by environmentally-beneficial agricultural production and management practices; and
- Increasing understanding of relationships between agriculture and the environment.

Under NAESI, agri-environmental performance standards (i.e., outcome-based standards) will be established that identify both desired levels of environmental condition and levels considered achievable based on available technology and practice. These standards will be integrated by AAFC into beneficial agricultural management systems and practices to help reduce environmental risks. Additionally, these will provide benefits to the health and supply of water, health of soils, health of air and the atmosphere; and ensure compatibility between biodiversity and agriculture. Standards are being developed in four thematic areas: Air, Biodiversity, Pesticides, and Water. Outcomes from NAESI will contribute to the APF goals of improved stewardship by agricultural producers of land, water, air and biodiversity and increased Canadian and international confidence that food from the Canadian agriculture and food sector is being produced in a safe and environmentally sound manner.

The development of agri-environmental performance standards involves science-based assessments of relative risk and the determination of desired environmental quality. As such, the National Agri-Environmental Standards Initiative (NAESI) Technical Series is dedicated to the consolidation and dissemination of the scientific knowledge, information, and tools produced through this program that will be used by Environment Canada as the scientific basis for the development and delivery of environmental performance standards. Reports in the Technical Series are available in the language (English or French) in which they were originally prepared and represent theme-specific deliverables. As the intention of this series is to provide an easily navigable and consolidated means of reporting on NAESI's yearly activities and progress, the detailed findings summarized in this series may, in fact, be published elsewhere, for example, as scientific papers in peer-reviewed journals.

This report provides scientific information to partially fulfill deliverables under the Pesticide Theme of NAESI. This report was written by M. Whiteside, P. Mineau, C. Morrison, and K. Harding of Environment Canada. The report was edited and formatted by Denise Davy to meet the criteria of the NAESI Technical Series. The information in this document is current as of when the document was originally prepared. For additional information regarding this publication, please contact:

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NOTE À L'INTENTION DES LECTEURS

L'Initiative nationale d'élaboration de normes agroenvironnementales (INENA) est un projet de quatre ans (2004-2008) mené conjointement par Environnement Canada (EC) et Agriculture et Agroalimentaire Canada (AAC) et l'une des nombreuses initiatives qui s'inscrit dans le Cadre stratégique pour l'agriculture (CSA) d'AAC. Elle a notamment comme objectifs :

- d'établir des normes nationales de rendement environnemental non réglementaires (applicables dans les régions) qui soutiennent les objectifs communs d'EC et d'AAC en ce qui concerne l'environnement;
- d'évaluer des normes qui sont réalisables par des pratiques de production et de gestion agricoles avantageuses pour l'environnement;
- de faire mieux comprendre les liens entre l'agriculture et l'environnement.

Dans le cadre de l'INENA, des normes de rendement agroenvironnementales (c.-à-d. des normes axées sur les résultats) seront établies pour déterminer les niveaux de qualité environnementale souhaités et les niveaux considérés comme réalisables au moyen des meilleures technologies et pratiques disponibles. AAC intégrera ces normes dans des systèmes et pratiques de gestion bénéfiques en agriculture afin d'aider à réduire les risques pour l'environnement. De plus, elles amélioreront l'approvisionnement en eau et la qualité de celle-ci, la qualité des sols et celle de l'air et de l'atmosphère, et assureront la compatibilité entre la biodiversité et l'agriculture. Des normes sont en voie d'être élaborées dans quatre domaines thématiques : l'air, la biodiversité, les pesticides et l'eau. Les résultats de l'INENA contribueront aux objectifs du CSA, soit d'améliorer la gérance des terres, de l'eau, de l'air et de la biodiversité par les producteurs agricoles et d'accroître la confiance du Canada et d'autres pays dans le fait que les aliments produits par les agriculteurs et le secteur de l'alimentation du Canada le sont d'une manière sécuritaire et soucieuse de l'environnement.

L'élaboration de normes de rendement agroenvironnementales comporte des évaluations scientifiques des risques relatifs et la détermination de la qualité environnementale souhaitée. Comme telle, la Série technique de l'INENA vise à regrouper et diffuser les connaissances, les informations et les outils scientifiques qui sont produits grâce à ce programme et dont Environnement Canada se servira comme fondement scientifique afin d'élaborer et de transmettre des normes de rendement environnemental. Les rapports compris dans la Série technique sont disponibles dans la langue (français ou anglais) dans laquelle ils ont été rédigés au départ et constituent des réalisations attendues propres à un thème en particulier. Comme cette série a pour objectif de fournir un moyen intégré et facile à consulter de faire rapport sur les activités et les progrès réalisés durant l'année dans le cadre de l'INENA, les conclusions détaillées qui sont résumées dans la série peuvent, en fait, être publiées ailleurs comme sous forme d'articles scientifiques de journaux soumis à l'évaluation par les pairs.

Le présent rapport fournit des données scientifiques afin de produire en partie les réalisations attendues pour le thème des pesticides dans le cadre de l'INENA. Ce rapport a été rédigé par M. Whiteside, P. Mineau, C. Morrison et K. Harding d'Environnement Canada. De plus, il a été révisé et formaté par Denise Davy selon les critères établis pour la Série technique de l'INENA. L'information contenue dans ce document était à jour au moment de sa rédaction. Pour plus de renseignements sur cette publication, veuillez communiquer avec l'organisme suivant :

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1 INTRODUCTION

Environment Canada has been tasked with developing environmental standards for implementation in Agriculture and Agri-Food Canada's Agricultural Policy Framework (AAFC; APF). The Wildlife Toxicology Division of the Wildlife and Landscape Science Directorate of EC's Science and Technology Branch was tasked specifically with developing comparative environmental risk assessment tools for pesticides in support of standard development. The development of standardised pesticide assessment tools has already enabled Environment Canada to prioritise in-use pesticides for the development of concentration-based Ideal Performance Standards for aquatic protection (Whiteside et al. 2006). This will also provide environmentally-oriented advice to AAFC under the APF, allowing for the promotion of reduced risk pest management strategies. Furthermore, standardised pesticide assessment tools will enable EC to objectively assess the environmental impact of alternative pesticide products and prioritize them for research and monitoring.

In parallel with our efforts to rank objectively the aquatic environmental impact of all active ingredients used in Canadian agriculture (Whiteside et al. 2006), we used a number of measures to rank the impact of those same active ingredients on terrestrial vertebrates (birds and mammals at least). The ground work for this was explained in our year 1 scoping document (Mineau and Whiteside 2005), parts of which are repeated here for greater clarity.

In that document, some twenty-nine risk assessment systems described in the published or gray literature from 1992 to current were reviewed in detail. Regardless of their respective approaches, they all failed in one important consideration: none were validated against real-world outcomes. In order for risk assessment measures to be given some credibility and have any chance of

modifying day to day product choice decisions, it is essential to attempt validation wherever possible – even if the risk index is only validated partially.

With acute risk in birds, we showed how field data could be used to derive an empirically-based risk index which, by definition, was already validated against real-world outcomes. A similar approach was taken here for defining population risk in small mammals. Where field validation was not yet possible, we opted to follow procedures and assumptions gleaned from pesticide regulatory bodies, principally EU harmonised procedures and those of the USEPA, in order to make our rankings compatible with -- but not necessarily identical to -- regulatory assessments.

As discussed in Mineau and Whiteside (2005), we kept different risk measures separate rather than combine them into a single index. Finally, we favoured risk measures that assessed the risk of individual applications without regard for product popularity. This was done with NAESI objectives in mind, giving us the flexibility to prioritize products based on their inherent risk or, alternatively, to compile risk based on whatever geographic area is required assuming the availability of pesticide use information.

2 METHODS

2.1 Pesticide List

The starting point was the same as for the aquatic ranking effort (Whiteside et al. 2006) and included a list of 286 active ingredients currently registered in Canada for commercial, agricultural or restricted use in agriculture, but not applied directly to bodies of water. We relied on pesticide labels for information on application methods. In line with the above definition of candidate active ingredients, we considered only labels recommended for commercial, agricultural or restricted use. Also, we retrieved only information regarding applications on crops

grown out-of-doors, thus excluding applications in greenhouses, on ornamentals, in or around buildings, on machinery, on harvested produce, livestock, etc. Some active ingredients were excluded because of missing information and six were not included because they are used as fumigants. This gave us a subset of 207 active ingredients to rank (see Appendix A).

All label rates for crop applications were converted to kg of active ingredient per hectare. In the absence of any pesticide use information, the highest application rate only was retained. In most cases, the conversion from the product rate was straightforward and relied on the product guarantee, product density or specific gravity (based on proprietary information obtained from the PMRA), as well as simple unit conversions. The application volume per hectare was also required for application rates which were reported as a quantity of product per volume. When available, we used the application volume suggested on the label. If it was not reported however, we estimated the application volume to be 1000 L/ha for orchard crops and other fruit crops such as grapes and berries. For vegetable and other field crops, we used an estimated application volume of 300 L/ha. These estimated volumes were found on many labels and are therefore believed to be realistic. For seed treatments, rates are typically reported as an amount of product per weight of seeds which is the most useful for the risk measures reported here.

2.2 Avian acute risk

2.2.1 Liquid applications

Whereas it is customary to have some form of TER (Toxicity/Exposure Ratio) or RQ (Risk Quotient) at the core of most indicators, we have relied instead on the logistic models developed in the course of previous analyses of avian field studies (Mineau 2002) in order to derive a likelihood that a given pesticide application will result in observable avian mortality.

So, in essence, the avian risk index has already been validated against real field outcomes – unlike most calculated ratios of exposure and toxicity. The process can be summarized as follows: As a first step, a measure of acute pesticide toxicity for birds ranging from 20 to 1,000 grams (a weight range that covers most bird species found dead in farm fields) is obtained by applying species sensitivity distribution techniques (Mineau et al. 2001b). A value called the HD5 ('Hazardous Dose at the 5% tail of the species distribution') is derived. The HD5 is the amount of pesticide in mg of chemical per kg of body weight estimated to lead to 50% mortality in a species more sensitive than 95% of all bird species, calculated with a 50 percent probability of over- or underestimation. The HD5 can be calculated mathematically where several toxicity values exist, or extrapolation factors can be applied to single (or even multiple combinations of species specific toxicity values – see Table 1 in Mineau et al. 2001b). The choice of acute toxicity rather than the dietary 5 day test as the most relevant for ranking purposes was discussed at length in the scoping document as well as the references herein.

A probability of kill is then derived from a model that uses logistic multiple

regression with the finding of bird carcasses in fields as the endpoint of interest. Note that this index does not incorporate other toxic effects on birds, or indirect effects. (The latter would probably best be captured in a terrestrial invertebrate index.) Aside from the HD5 values, the model makes use of application rate, as well as physico-chemical constants such as octanol-water partition coefficient, molecular weight and size as well as the ratio of rat oral to dermal data, if available. The physicochemical and rat data are combined in a linear

regression model to estimate the ability of pesticides to penetrate avian skin. This ability has been found to significantly affect field outcome. One of the three models outlined in Mineau (2002)

was run for each pesticide application, depending on the availability of model parameters. The simplest model used HD5 and application rate only. Independent validation of the model for a sample of studies in field crops indicate that better than 81% of studies were correctly classified – as to whether they gave rise to mortality or not. These models are currently being revised and the rankings are therefore preliminary in nature.

One recognized weakness of the approach is that the empirical models relating

mortality to HD5 and to the other independent variables were derived entirely from foliar applications of pesticides. Use pattern adjustment factors (UPAFs) based on the best available expert opinion were obtained to integrate the avian exposure-related consequences of alternative pesticide formulations (e.g. granular, seed treatment), methods of application (ground sprayer, airblast, aerial), and timing of application (see Appendix in Mineau and Whiteside 2005). These factors estimate the risk associated with a given type of pesticide application relative to the risk posed by a foliar spray. For example, an adjustment factor of 2 means that the risk of avian mortality from a given type of application is roughly twice what it would be if the same a.i. was foliar applied by ground rig at the same rate per hectare.

In this preliminary ranking exercise, we have not used UPAFs because product-specific attributes (such as the nature of the granular bases and type of application) were not available for a complete ranking of a.i.s. Instead, we ranked all liquid applications together, whether foliar or soil applied and then, ranked granular and seed treatments (particulates) together.

2.2.2 Granular or seed treatment applications

The chosen risk measure for these two types of applications is the number of particles (whether granule or seed) that a 15 g bird can ingest before reaching a median lethal dose; assuming that

the bird is at the median estimate of the 5% tail of the scaled distribution of LD_{50}s as defined above.

2.3 Avian chronic risk

2.3.1 Liquid applications

Two measures form the basis of our assessment of chronic (or reproductive) pesticide risk in birds. (See Mineau 2005 for a discussion of chronic vs. long term vs. reproductive risk in current risk assessment procedures.) The first is the standard ratio of residue intake calculated immediately after pesticide application relative to the critical daily residue intake deemed to be reproductively toxic. This measure best represents the risk of deposit of peak pesticide residues into the egg or the risk of rapid parental toxicity resulting in the cessation of an on-going breeding effort. It is customary for the EPA and PMRA to compare reproductively toxic intake rates with peak residue concentrations; EU assessors calculate a time weighted average over a 3 week period, assuming a fixed half life of 10 days (European Commission 2002).

The second, and more novel, measure of risk is the number of days that residues in the environment remain above the threshold concentration for reproductive effects. This concept was initially introduced in a Society of Environmental Toxicology and Chemistry-sponsored workshop entitled: 'Harmonised Approaches to Avian Effects Assessment' held in Woudshoten, The Netherlands in September of 1999 (Mineau et al. 2001a). More recently, the idea of using time as a currency in risk assessment measures gained acceptance at another workshop convened under the auspices of the British Department of Environment, Food and Rural Affairs in York, UK (e.g. Bennett et al. 2005, Mineau 2005, Shore et al. 2005). The rationale is that, the longer the pesticide remains in the environment at levels at which reproductive toxicity is possible, the greater the probability that birds will be exposed at a critical stage of their reproductive cycle.

Note that the York workshop recommended distinct and separate treatment of the various endpoints measured in a standard reproduction study. Unfortunately, this was not possible here since the studies themselves were not available to us.

The model species for this assessment was a 15 g insectivorous songbird. The threshold concentration was based on the available reproductive evidence adjusted to reflect inter-specific (acute) sensitivity to the pesticide. Again, this is a concept that was introduced at the 1999 Woudschoten workshop and which gained acceptance at the York meeting (Luttik et al. 2005). Two or three species at most are ever tested for reproductive effects. This does not provide a good basis of estimating inter-species differences. It has been proposed therefore to use acute data as an indication of inter-specific variation in chronic toxicity. Luttik and colleagues (op. cit.) argued that chronic toxicity is no less variable than acute toxicity given the wealth of possible mechanisms through which this toxicity can be manifested, and provided support for this with a comparison of acute and chronic toxicity interspecies variance. We applied the extrapolation factor to the geometric mean of reproductive NOAELs determined for the Mallard and Bobwhite. In order to estimate time for residues to fall below a critical level, exposure was assumed to be entirely through the alimentary route (unlike acute exposure which has been shown to have an important dermal component) and residues in insect prey were assumed to have a rate of decline given by the foliar half-life of the pesticide. Foliar half lives were obtained from a USDA compilation. Where they were not available, they were estimated from a model based on soil half lives (see details in Appendix B). Detailed calculations for the risk measures are provided in Appendix C. A tabulation of all the indices is given in Appendix D.

2.3.2 Granular applications and seed treatments

Toxicity data are treated as for liquid applications and the critical reproductive effect concentration Ic is derived for a model 15g bird at the 5% lower tail of the estimated bird distribution. At this point, the ranking of these particulates is left at its simplest – namely the number of particles needing to be ingested daily to arrive at the criterion dose. We have to assume no active avoidance of any of the particles by birds.

Therefore, risk is expressed as …

…. Ic (µg/bird/day) / ug pesticide per particle

A thorough search of pesticide label information on the PMRA's ELSE system, for the 207 active ingredients used on crops in Canada, was conducted to assess which active ingredients are used as seed treatments and which are used as a granular formulation. For the purpose of this ranking exercise, we considered only seed treatment information for three crop groupings: corn, oilseeds (canola) and cereals (wheat, barley, oats, and rye). We did not consider active ingredients that are used to coat potato seed pieces at planting.

This resulted in 13/207 (carbaryl, terbufos, dazomet, chlorpyrifos, ethalfluralin, EPTC, metalaxyl-m, metalaxyl, trifluralin, triallate, diazinon, napropamide and tefluthrin) active ingredients that are used in a granular formulation, and 18/207 (captan, clothianidin, difenoconazole, diazinon, fludioxonil, imidacloprid, iprodione, maneb, metalaxyl-m, metalaxyl, acetamiprid, tebuconazole, thiamethoxam, thiram, triadimenol, thiophanate-methyl, triticonazole and carbathiin) active ingredients that are used as seed treatments. Eight of these active ingredients are used exclusively as a granular or seed treatment and therefore do not appear in the rankings of liquid pesticides (clothianidin, dazomet, difenconazole, metalaxyl, tefluthrin, thiamethoxam, triadimenol and

carbathiin).

Seed treatment information from the label typically refers to a quantity of the formulated product per 25 or 100 kg of seed. Representative seed weights were obtained from a compilation of the PMRA based on a number of different sources (Chris Fraser, PMRA, pers. comm.). Values used in our calculations were as follows: canola = 0.003g, cereals = 0.035g, and corn = 0.38g. For granules, in the absence of specific information on granule base and weight, we assumed that most were clay-based and have an individual weight of 200µg which is the average weight of diazinon 14 G (Hill and Camardese 1984).

For liquid formulations, specific density measures were also obtained where possible (PMRA, pers. comm.). Otherwise, a specific density of 1 was assumed.

Once the amount of active ingredient per seed for each crop, and per granule, was calculated for each of the separate label rates, the highest amount was selected for each active ingredient per granule and per seed treatment (one for each crop: cereals, corn and canola where applicable) and these values were used to determine the risk. The risks were then ranked to attain a risk based ranking of pesticides to terrestrial life.

The seed treatment calculations will eventually be improved along the lines of Smith (2006) with actual bird consumption data. Similarly, various correction factors could be applied to granular products if we had information on the granule base. These rankings are therefore preliminary.

2.4 Mammalian Acute Risk

2.4.1 Liquid applications

Knowing that the field information available to validate an assessment was more limited for

mammals than it was for birds, we initially turned to a typical hazard quotient as used by regulatory agencies. However, we also scoured the field literature and attempted some validation of these quotients. See section 4 for our field validation attempts.

For the acute index, we compared a day's worth of ingestion of contaminated cereal foliage by a small 25 g mammal (e.g. a vole) following the scenario proposed by the EU in their last guidance document. The ingestion rate was compared to a median lethal dose at the median estimate of the 5% tail of the acute toxicity distribution for mammals. Integrating ingestion over a 24 hour exposure period in order to compare to an acute toxicity endpoint is common practice although it does penalise pesticides for which metabolism and/or recovery from intoxication is extremely rapid – e.g. carbamate pesticides.

At this point, we were unable to incorporate dermal toxicity into our measured assessment. In light of the avian models that were developed (Mineau 2002), this may be a serious limitation.

A compilation of acute toxicity data was made from a number of different sources and values were chosen in a manner analogous to those used by Mineau et al. (2001b) for birds. Only toxicity data for technical active ingredients with a high percentage of active ingredient (>80%) were used and geometric mean values were calculated for each species-pesticide combination. Male and female data were similarly averaged. Because the same test values were extracted from multiple references, we used unique values only in the compilation of geometric species means. Limit values were treated as described in Mineau et al. (2001b). Because limit tests were not always identified in all published sources, we treated all 'large round numbers' of 1000 mg/kg or greater (e.g. 1000, 1500, 2000, 5000 etc…) as limit values.

We derived HD5 (hazardous dose) values, using the ETX 2.0 software (van Vlaargingen et al.

2004). ETX 2.0 is a program used to calculate the hazardous concentrations and fraction affected, based on normally distributed toxicity data, to derive environmental risk limits for chemical substances.

For all datasets with more than 5 data points (17 pesticides only), visual inspection of the data was critical. If the sample was considered normal based on a cumulative probability plot and the Anderson – Darling test, we generated the SSD (species sensitivity distribution). If on the other hand normality was not met, we used the small sample method as detailed below.

For the majority of pesticides, we used the small sample procedure of ETX based on the work of Aldenberg and Luttik (2002). This consists in estimating the HD5 on the basis of a mean LD50 and pooled variance estimate of 0.36 (for the log10 LD50 values) calculated for a large group of pesticides at large. Because data were frequently available for 2-4 species, we considered that this method of assessing mammalian toxicity was preferable to relying only on a single test species, e.g. typically the rat. We used the median estimate of the HD5 in order not to bias the data for data availability. Limit values were used to generate an overall mean to which we applied the pooled mammalian variance. This means that toxicity will be overestimated for the least toxic pesticides. However, we expect this to be without consequence because these products are not expected to rate as being very hazardous regardless of the exact values we calculate.

2.4.2 Granular applications and seed treatments

This is scored as it was for birds – as the number of particles ingested daily to arrive at the critical daily intake.

For the purpose of the acute hazard calculation, we calculated the number of particles a 25 g small mammal could ingest before reaching a median lethal dose assuming that the small

mammal is at the median estimate of the 5% tail of sensitivity distribution for mammals as described above.

$$\frac{\text{Risk}}{\mu\text{g/particle}} = \frac{\text{Ic } (\mu\text{g/day})}{}$$

2.5 Mammalian Chronic Risk

2.5.1 Liquid applications

EPA and other jurisdictions report on chronic Reference Doses – cRfD. This is typically the lowest chronic NOEL (in mg/kg bw/day) to which a safety factor has been assessed – typically 100 in order to account for both inter-individual and inter-species extrapolation error. (Note that, unlike the situation in birds, we are not using compound-specific variance in order to assess inter-species differences in susceptibility. It is rare to have a sufficient number of species tested to generate a robust variance term.) Following the Food Quality Protection Act of 1996, an extra factor of 3X or 10X were applied to reflect certain toxic modes of action (e.g. neurotoxins, endocrine disruptors…) as well as the higher susceptibility of certain sub-groups, notably children. The resulting reference dose is known as the cPAD or chronic Population Adjusted Dose. The cPAD is taken as the daily allowable intake for any and all human population sub-groups.

The general availability of the cPAD in USEPA review documents makes it an attractive endpoint against which to compare exposure levels. (In many cases, the cPAD is identical to the pre-FQPA cRFD.) The first risk index was therefore the extent to which the cPAD was exceeded after a 24 hour feeding period immediately after application. Of course, the highly protective nature of cPADs means that exceedance in the case of wildlife may not be of concern. However, in a

relative risk context, the amount of time required to bring daily exposure to a level below the cPAD (an analogous measure to that used for the bird assessment) offers an interesting second measure of the chronic risk from pesticides. A compilation of cPAD values from EPA review documents was provided to us by Benbrook Consulting Services (K. Benbrook, pers. comm.).

Again, a 25 g herbivore was modeled and foliar half lives used to calculate the time (in days) from initial application to intake below the cPAD. In reality, residue degradation is often biphasic with a prolonged persistence of very low levels for a long time. However, these residues are often inextricably bound to the foodstuff. These added complexities will be ignored here.

2.5.2 Granular applications and seed treatments

Again, the number of particles to critical intake (cPAD here) for a 25 g small mammal was calculated. Because of the large residue concentration on seeds and granules, we expect this number to be very small indeed – often a fraction of a particle. Interpretation of actual field effects is likely to be difficult here and the rankings are meant to reflect relative risk only. We have to assume no active avoidance of treated seed. Any differential avoidance (something which is likely) would undoubtedly change our rankings.

3 RESULTS

3.1 Acute risk from liquid applications

There were a total of 198 active ingredients applied as a liquid (spray) in agriculture.

Based on the original risk models of Mineau (2002), a number of pesticides present a risk of mortality, in some cases severe, to birds. Those pesticides registering a greater than 10% probability of kill (i.e. 1 in 10 fields approximately) are listed in Table 1. A number of herbicides

appear at the lower end of the risk estimates (e.g. 10-20% probability of mortality). In part, this is due to very high application rates from some of the older products as well as physico-chemical characteristics that promote dermal uptake. There is a great deal of uncertainty attached to those estimates because the acute models were developed with cholinesterase-inhibiting pesticides only. The importance of dermal uptake in the case of intoxication with a herbicide having a totally different mode of action is uncertain. Nevertheless, at the top of the list come the 'usual suspects', those compounds well known to kill or incapacitate birds quite reliably and, often, unavoidably: carbofuran, diazinon, chlorpyrifos etc….. However, there are some surprise entries such as thiram, captan and glyphosate that bear scrutiny. As a preliminary cut-off value, we should be concerned with pesticides showing a probability of mortality of 50% or more. However, it will be part of our cycle 3 activities to explore some of these compounds in more detail and try to improve on the risk models.

Table 1: Risk of mortality in birds from acute exposure to pesticides. All pesticides registered in Canada for use on outdoor crops with a probability of mortality exceeding 10% at the maximum label rate are listed.

PMRA AI Code	AI Accepted Name	Risk of mortality at maximum application rate
NAL	Naled	1.00
PHR	Phorate	1.00
DIA	Diazinon	1.00
PRT	Phosmet	0.99
COY	Terbufos	0.98
DUB	Chlorpyrifos	0.98
OXB	Oxamyl	0.96
ESF	Endosulfan	0.95
GOO	Azinphos-methyl	0.94
CAF	Carbofuran	0.93
TRI	Trichlorfon	0.92
THI	Thiram	0.80
CAP	Captan	0.79

Table 1: Risk of mortality in birds from acute exposure to pesticides. All pesticides registered in Canada for use on outdoor crops with a probability of mortality exceeding 10% at the maximum label rate are listed.

PMRA AI Code	AI Accepted Name	Risk of mortality at maximum application rate
MOM	Methamidophos	0.77
DIM	Dimethoate	0.76
ACP	Acephate	0.73
ZIR	Ziram	0.71
GPS	Glyphosate (acid)	0.70
FOM	Formetanate (form not specified)	0.62
DIK	Dichloran	0.56
KRS	Kresoxim-methyl	0.51
DCB	Dichlobenil	0.20
CUY	Copper (copper oxychloride)	0.18
DXB	2,4-D (unspecified amine salt)	0.16
MAS	MCPA (potassium salt)	0.13
LUN	Linuron	0.13
DIQ	Diquat (form not specified)	0.12
MML	Methomyl	0.12
ENT	Endothall (form not specified)	0.11
DIC	Dicamba (form not specified)	0.11
MBS	MCPB (sodium salt)	0.10
CHL	Chlorthal (form not specified)	0.10
DXF	2,4-D (unspecified ester)	0.10

Mammalian acute toxicity data were not available to us for all pesticides. Those for which we are still seeking data are given in Table 2.

Table 2: List of pesticides requiring acute mammalian toxicity data.

CHH	Boscalid
CUS	Copper (copper sulphate)
DFF	Diflufenzopyr (form not specified)
DIH	Dichlorprop (form not specified)
DIN	Dinocap
DXB	2,4-D (unspecified amine salt)

Table 2: List of pesticides requiring acute mammalian toxicity data.

FAB	N-Octanol
FBZ	Fenbuconazole
GPM	Glyphosate (mono-ammonium salt)
GPP	Glyphosate (potassium salt)
MAE	MCPA (unspecified ester)
MEA	Mecoprop (potassium salt)
MEC	Mecoprop (form not specified)
MEW	Mecoprop d-isomer (potassium salt)
MEZ	Mecoprop d-isomer (amine salt)
TCM	2-(Thiocyanomethylthio)benzothiazole

For those where we do have acute mammalian data, we listed the acute risk quotients 0.1 and higher. This cut-off, although completely arbitrary, is one in common use in regulatory circles. Certainly, because the risk quotient is calculated from a mortality endpoint, any ratio above one is indicative of a potentially serious problem. This is especially so since the risk model only factors alimentary risk and does not include other possible routes of exposure such as the dermal and inhalation route.

Table 3: Acute mammalian risk quotients 0.1 and higher.

PMRA a.i. code	Common name	Risk quotient (Initial 24 hour exposure / HD5
OXB	Oxamyl	383.2
ESF	Endosulfan	317.8
FOM	Formetanate (form not specified)	167.6
ETS	Ethofumesate	130.1
GOO	Azinphos-methyl	79.1
CAF	Carbofuran	77.6
DIA	Diazinon	45.6
MML	Methomyl	44.6
THI	Thiram	41.5
MOM	Methamidophos	36.9
CCC	Chlormequat (form not specified)	25.5

Table 3: Acute mammalian risk quotients 0.1 and higher.

PMRA a.i. code	Common name	Risk quotient (Initial 24 hour exposure / HD5
ENT	Endothall (form not specified)	21.9
PAQ	Paraquat (form not specified)	21.2
DUB	Chlorpyrifos	17.8
PRT	Phosmet	17.5
ZIR	Ziram	15.3
CAB	Carbaryl	13.8
BET	Bensulide	12.3
DIK	Dichloran	11.3
DIQ	Diquat (form not specified)	7.2
NAL	Naled	7.1
CUZ	Copper (copper hydroxide)	6.3
TPR	Triclopyr	6.1
TRI	Trichlorfon	6.0
PIR	Pirimicarb	5.3
FOR	Formaldehyde	5.1
DIM	Dimethoate	5.0
AVG	Difenzoquat (methyl sulphate salt)	4.9
CUY	Copper (copper oxychloride)	4.8
NAP	Naptalam (form not specified)	4.3
DXA	2,4-D (acid)	4.2
ACP	Acephate	4.2
DCB	Dichlobenil	3.9
LUN	Linuron	3.9
GPT	Glyphosate (trimethylsulfonium salt)	3.4
DXF	2,4-D (unspecified ester)	3.3
DOD	Dodine (dodecylguanidine monoacetate)	3.0
MAS	MCPA (potassium salt)	2.8
SUL	Sulphur	2.8
PHS	Phosalone	2.7
MAB	MCPA (dimethylammine salt)	2.5
EPT	EPTC	2.4
BAX	Metribuzin	2.4
DYR	Anilazine	2.3
MBS	MCPB (sodium salt)	1.9
MAA	MCPA (acid)	1.8
MAL	Malathion	1.8

Table 3: Acute mammalian risk quotients 0.1 and higher.

PMRA a.i. code	Common name	Risk quotient (Initial 24 hour exposure / HD5
ATR	Atrazine	1.8
PYZ	Pyrazon (chloridazon)	1.7
DPA	Diphenylamine	1.7
DPB	2,4-DB (form not specified)	1.6
DIC	Dicamba (form not specified)	1.5
PRO	Prometryne	1.5
DCF	Dicofol	1.5
PFL	Permethrin	1.5
MFN	Metalaxyl-m (mefenoxam)	1.4
FER	Ferbam	1.4
VPR	Hexazinone	1.3
GLG	Glufosinate ammonium	1.3
TER	Terbacil	1.3
DUR	Diuron	1.2
AMZ	Amitraz	1.2
CAP	Captan	1.2
CYM	Cypermethrin	1.2
BRY	Bromoxynil (octanoate)	1.2
TRL	Triallate	1.2
AMI	Amitrole	1.1
SMZ	Simazine	1.0
PYD	Pyridaben	1.0
BZN	Bentazon (form not specified)	1.0
IMI	Imidacloprid	0.9
CHL	Chlorthal (form not specified)	0.9
NBP	Napropamide	0.9
MCZ	Mancozeb	0.9
DPP	Diclofop-methyl	0.8
ETF	Ethephon	0.7
FAL	Fosetyl-al	0.7
NXI	Acetamiprid	0.7
MTR	Metiram	0.6
TET	Chlorothalonil	0.6
GPS	Glyphosate (acid)	0.6
GPI	Glyphosate (isopropylamine salt)	0.6
FAA	N-Decanol	0.6

Table 3: Acute mammalian risk quotients 0.1 and higher.

PMRA a.i. code	Common name	Risk quotient (Initial 24 hour exposure / HD5
MEI	Dimethenamid	0.6
MTL	Metolachlor	0.6
MAH	Maleic hydrazide (form not specified)	0.5
CNQ	Clomazone	0.5
FLT	Flufenacet	0.5
CYH	Cyhalothrin-lambda	0.5
AME	S-Metolachlor	0.5
FOL	Folpet	0.4
ZIN	Zineb	0.4
TRF	Trifluralin	0.4
MAN	Maneb	0.4
PEN	Pendimethalin	0.3
PIC	Picloram (form not specified)	0.3
PHY	Propamocarb hydrochloride	0.3
TPM	Thiophanate-methyl	0.3
IPD	Iprodione	0.3
ACA	Acifluorfen (form not specified)	0.3
MOR	Chinomethionat	0.2
CYP	Cyprodinil	0.2
EFR	Ethalfluralin	0.2
TZL	Thiabendazole	0.2
KRB	Propyzamide	0.2
MMM	Thifensulfuron-methyl	0.2
TRA	Tralkoxydim	0.2
IMP	Imazethapyr	0.1
DBR	Deltamethrin	0.1
CYO	Cymoxanil	0.1
FEX	Fenhexamid	0.1
FOF	Fomesafen	0.1
QTZ	Quintozene	0.1
CYZ	Cyromazine	0.1
PON	Propiconazole	0.1
PMP	Phenmedipham	0.1
SOD	Sethoxydim	0.1
ASS	Imazamethabenz (form not specified)	0.1
TRR	Triforine	0.1

Table 3: Acute mammalian risk quotients 0.1 and higher.

PMRA a.i. code	Common name	Risk quotient (Initial 24 hour exposure / HD5
BTL	Desmedipham	0.1
MPR	(S)-Methoprene	0.1
CFZ	Clofentezine	0.1
VIL	Vinclozolin	0.1
TEU	Tebuconazole	0.1
OXR	Oxyfluorfen	0.1
FZA	Fluazifop-p-butyl	0.1

From the point of view of general protection of vertebrate wildlife, it could be argued that those compounds showing potential toxicity to both birds and mammals should be scrutinised more heavily. Table 4 lists those pesticides having both a probability of avian mortality > 10% and a mammalian acute risk ratio greater than 0.1 ranked by placing equal weight on both measures.

Table 4: Pesticides of high combined acute risk (birds and mammals) ranked starting with those with the worst combined rank.

Code	Pesticide name	Acute avian prob kill	Acute mammalian ratio	Combined rank starting with the worst
OXB	Oxamyl	0.96	383.2	1
ESF	Endosulfan	0.95	317.8	2
DIA	Diazinon	1	45.6	3
GOO	Azinphos-methyl	0.94	79.1	4
CAF	Carbofuran	0.93	77.6	5
DUB	Chlorpyrifos	0.98	17.8	6
PRT	Phosmet	0.99	17.5	7
NAL	Naled	1	7.1	8
THI	Thiram	0.8	41.5	9
FOM	Formetanate (form not specified)	0.62	167.6	10
MOM	Methamidophos	0.77	36.9	11
TRI	Trichlorfon	0.92	6	12
ZIR	Ziram	0.71	15.3	13

Table 4: Pesticides of high combined acute risk (birds and mammals) ranked starting with those with the worst combined rank.

Code	Pesticide name	Acute avian prob kill	Acute mammalian ratio	Combined rank starting with the worst
MML	Methomyl	0.12	44.6	14
DIM	Dimethoate	0.76	5	15
DIK	Dichloran	0.56	11.3	16
ACP	Acephate	0.73	4.2	17
ENT	Endothall (form not specified)	0.11	21.9	18
DIQ	Diquat (form not specified)	0.12	7.2	19
CAP	Captan	0.79	1.2	20
CUY	Copper (copper oxychloride)	0.18	4.8	21
DCB	Dichlobenil	0.2	3.9	22
LUN	Linuron	0.13	3.9	23
MAS	MCPA (potassium salt)	0.13	2.8	24
GPS	Glyphosate (acid)	0.7	0.6	25
DXF	2,4-D (unspecified ester)	0.1	3.3	26
MBS	MCPB (sodium salt)	0.1	1.9	27
DIC	Dicamba (form not specified)	0.11	1.5	28
CHL	Chlorthal (form not specified)	0.1	0.9	29

3.2 Acute risk from granular or seed treatment applications

Table 5 provides the relative acute risk of ingesting either a granule or treated seed for a 15g songbird at the 5% tail of avian sensitivity. It is noteworthy that the critical intake is less than one seed for at least 7 products, and 5 or less for another 7 products. This indicates that there is very high acute risk indeed associated with existing granular insecticides and seed treatments. Certainly, if a lethal dose is less than one seed, learned avoidance of the pesticide is not likely.

Table 5: Avian acute risk of granules and seed treatments measured as the number of particles required to reach HD5 in the case of a 15 g bird.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to HD5	Rank
DIA	Diazinon	Corn seed	0.06	1
COY	Terbufos	granule	0.08	2
IMI	Imidacloprid	Corn seed	0.13	3
CAP	Captan	Corn seed	0.17	4
VIT	Carbathiin	Corn seed	0.34	5
THI	Thiram	Corn seed	0.80	6
DIA	Diazinon	granule	0.89	7
COD	Clothianidin	Corn seed	1.04	8
VIT	Carbathiin	Cereal seed	1.07	9
MTA	Metalaxyl	Corn seed	1.69	10
DUB	Chlorpyrifos	granule	1.88	11
THE	Thiamethoxam	Corn seed	3.78	12
DAZ	Dazomet	granule	4.12	13
IMI	Imidacloprid	Canola seed	5.27	14
MCZ	Mancozeb	Corn	15.95	15
THI	Thiram	Cereal seed	22.73	16
TPM	Thiophanate-methyl	Corn seed	27.22	17
THI	Thiram	Canola seed	28.03	18
DFZ	Difenoconazole	Corn seed	33.93	19
EPT	EPTC	granule	37.98	20
MFN	Metalaxyl-m (mefenoxam)	Corn seed	38.30	21
NXI	Acetamiprid	Canola seed	41.49	22
CAB	Carbaryl	granule	45.15	23
VIT	Carbathiin	Canola seed	53.44	24
NBP	Napropamide	granule	58.52	25
COD	Clothianidin	Canola seed	64.92	26
MAN	Maneb	Cereal seed	69.76	27
TEU	Tebuconazole	Cereal seed	88.55	28
MTA	Metalaxyl	Cereal seed	103.30	29
THE	Thiamethoxam	Canola seed	121.89	30
THE	Thiamethoxam	Cereal seed	126.16	31
FLD	Fludioxonil	Corn seed	147.09	32
TRF	Trifluralin	granule	184.16	33
TRL	Triallate	granule	196.08	34
IPD	Iprodione	Canola seed	266.67	35
EFR	Ethalfluralin	granule	348.44	36

Table 5: Avian acute risk of granules and seed treatments measured as the number of particles required to reach HD5 in the case of a 15 g bird.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to HD5	Rank
DFZ	Difenoconazole	Cereal seed	368.41	37
MFN	Metalaxyl-m (mefenoxam)	Cereal seed	415.85	38
TEL	Tefluthrin	granule	446.58	39
MTA	Metalaxyl	granule	668.18	40
MFN	Metalaxyl-m (mefenoxam)	granule	1027.50	41
MTA	Metalaxyl	Canola seed	1205.15	42
TLL	Triadimenol	Cereal seed	1231.11	43
FLD	Fludioxonil	Cereal seed	1744.37	44
TRT	Triticonazole	Cereal seed	1860.79	45
MFN	Metalaxyl-m (mefenoxam)	Canola seed	4851.55	46
DFZ	Difenoconazole	Canola seed	5021.31	47
FLD	Fludioxonil	Canola seed	20350.99	48

Table 6 shows the same calculation for a putative 25 g small mammal. Far fewer products present an acute risk for small mammals with only 3 active ingredients having an HD5 contained in 5 particles or less.

Table 6: Mammalian acute risk of granules and seed treatments measured as the number of particles required to reach HD5 in the case of a 25 g small mammal.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to HD5 for 25g mammal	Rank
COY	Terbufos	granule	0.62	1
IMI	Imidacloprid	Corn	1.73	2
THI	Thiram	Corn	5.19	3
DIA	Diazinon	Corn	8.82	4
MTA	Metalaxyl	Corn	10.20	5
DAZ	Dazomet	granule	16.60	6
CAP	Captan	Corn	23.12	7
THE	Thiamethoxam	Corn	25.60	8
TEL	Tefluthrin	granule	39.98	9
DUB	Chlorpyrifos	granule	45.98	10
VIT	Carbathiin	Corn	46.39	11

Table 6: Mammalian acute risk of granules and seed treatments measured as the number of particles required to reach HD5 in the case of a 25 g small mammal.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to HD5 for 25g mammal	Rank
COD	Clothianidin	Corn	53.29	12
MCZ	Mancozeb	Corn	61.25	13
IMI	Imidacloprid	Canola	68.47	14
MFN	Metalaxyl-m (mefenoxam)	Corn	73.90	15
TPM	Thiophanate-methyl	Corn	92.09	16
DFZ	Difenoconazole	Corn	119.05	17
DIA	Diazinon	granule	125.32	18
VIT	Carbathiin	Cereal	145.69	19
THI	Thiram	Cereal	146.72	20
TEU	Tebuconazole	Cereal	153.72	21
NXI	Acetamiprid	Canola	155.90	22
THI	Thiram	Canola	180.91	23
CAB	Carbaryl	granule	349.12	24
TRL	Triallate	granule	462.73	25
MAN	Maneb	Cereal	475.84	26
TLL	Triadimenol	Cereal	609.57	27
MTA	Metalaxyl	Cereal	624.28	28
MFN	Metalaxyl-m (mefenoxam)	Cereal	802.29	29
THE	Thiamethoxam	Canola	825.33	30
THE	Thiamethoxam	Cereal	854.22	31
TRF	Trifluralin	granule	1271.30	32
DFZ	Difenoconazole	Cereal	1292.52	33
EPT	EPTC	granule	1399.55	34
FLD	Fludioxonil	Corn	1506.42	35
NBP	Napropamide	granule	1829.94	36
MFN	Metalaxyl-m (mefenoxam)	granule	1982.35	37
IPD	Iprodione	Canola	2685.22	38
EFR	Ethalfluralin	granule	3197.16	39
COD	Clothianidin	Canola	3334.06	40
MTA	Metalaxyl	granule	4038.10	41
TRT	Triticonazole	Cereal	6829.71	42
MTA	Metalaxyl	Canola	7283.30	43
VIT	Carbathiin	Canola	7306.67	44
MFN	Metalaxyl-m (mefenoxam)	Canola	9360.07	45
DFZ	Difenoconazole	Canola	17616.78	46
FLD	Fludioxonil	Cereal	17864.78	47

Table 6: Mammalian acute risk of granules and seed treatments measured as the number of particles required to reach HD5 in the case of a 25 g small mammal.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to HD5 for 25g mammal	Rank
FLD	Fludioxonil	Canola	208422.47	48

3.3 Chronic risk from liquid formulations

3.3.1 Comparison between the two risk measures

As we suspected, the two indices of reproductive toxicity are correlated but clearly not identical. For those compounds where the reproductive threshold was exceeded after application, we plotted the extent of this exceedance with the time needed for residues to drop below this chronic threshold. The indices were log-transformed to normalize them. The avian and mammalian data are shown in Figures 1 and 2 respectively; the regression is better with the avian data.

Figure 1: Log-log plot (and 95% prediction interval) of avian chronic threshold exceedance against time (in days) that the residues remain above this threshold.

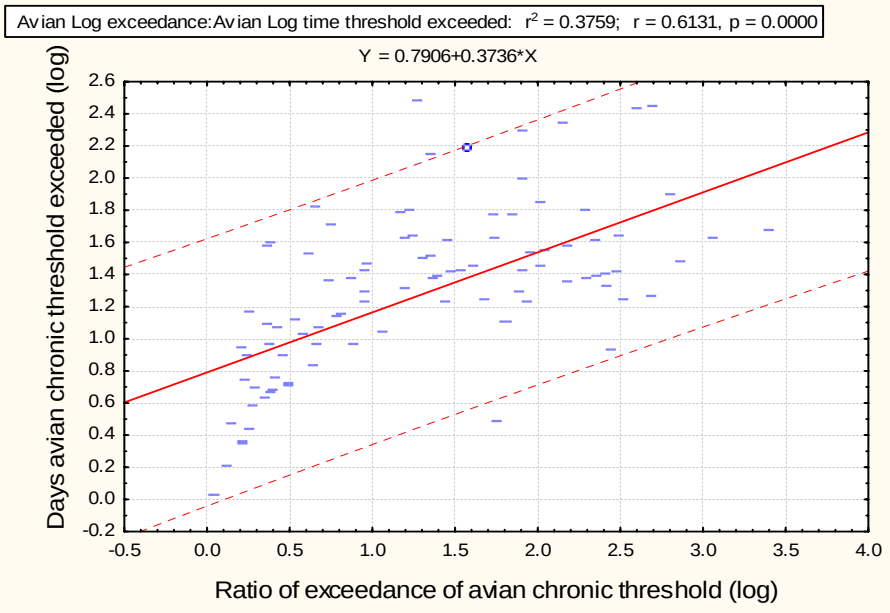
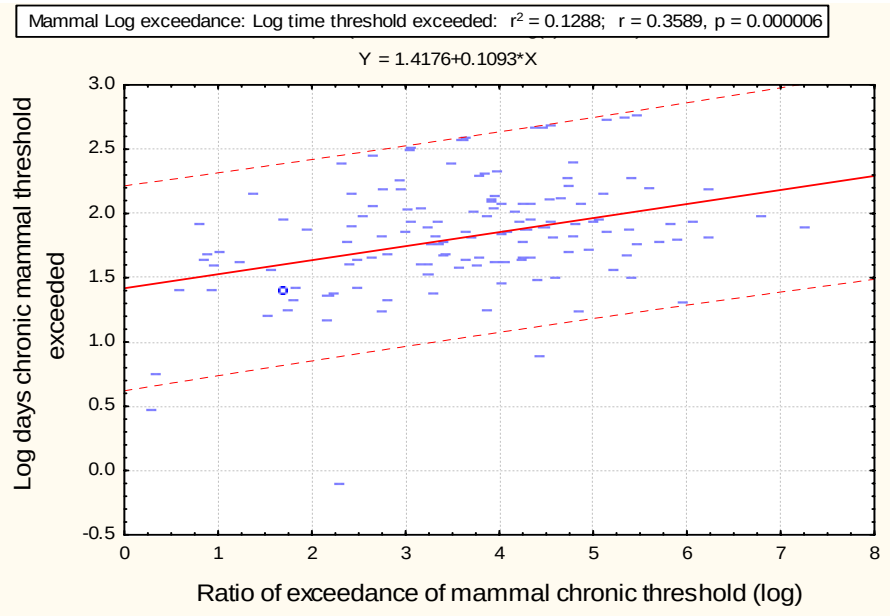


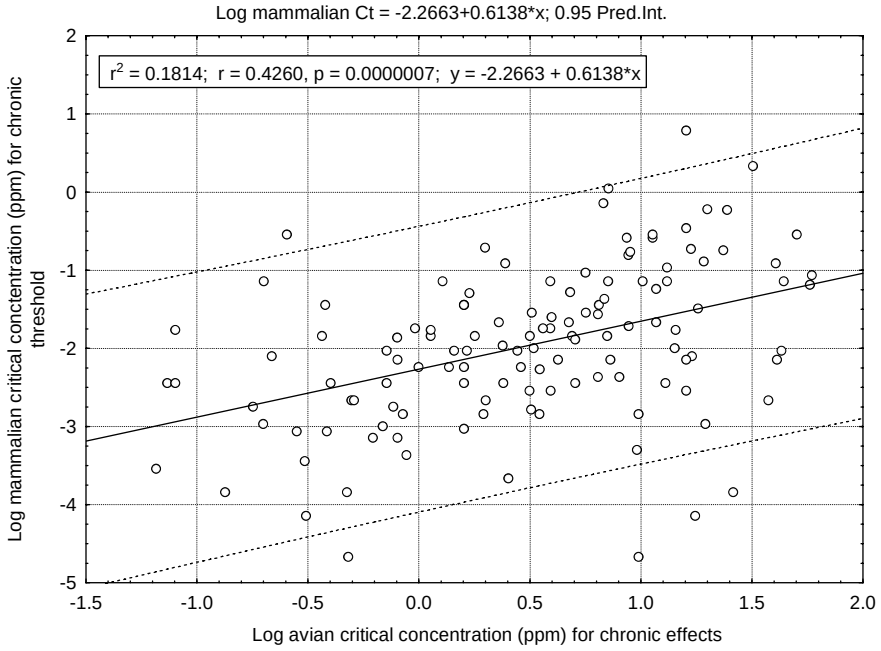
Figure 2: Log-log plot of mammalian chronic threshold exceedance against time (in days) that the residues remain above this threshold.



3.3.2 Bird – mammal comparison

Because the chronic risk indices developed here carry a higher level of uncertainty than do the acute measures (i.e. they are more difficult or impossible to validate against real word outcomes), it is useful to determine whether the indices are related and could be boiled down to a single estimate of chronic risk for both birds and mammals. In Figure 3, we plotted the inherent chronic hazard for birds and mammals in the form of the critical food concentration calculated for the two scenarios. This does not take into consideration the application rate of the pesticide.

Figure 3: Comparison of chronic toxicity thresholds for birds and mammals in the form of food residue concentrations in accordance to the exposure models chosen (see Appendix C).



Some products clearly have a very high inherent chronic toxicity to mammals but not to birds and vice versa. There is a relationship overall but relatively weak with only 18% of overall variance explained by the regression. This argues for keeping avian and mammalian risk indices separate.

Because application rates and environmental half-lives are key components of our final risk indices and they apply equally to both the bird and mammal indices, the bird-mammal correlation is much better for the final risk indices, whether the degree of exceedance of critical intake levels (Figure 4) or the amount of time residues in the environment are above those critical levels (Figure 5).

Nevertheless, the regression and prediction bounds show that the error associated with predicting

one from the other might range by as much as plus or minus two orders of magnitude for the exceedance ratio and plus or minus one order of magnitude for the time needed to drop below levels that are chronically toxic as defined here.

Figure 4: Regression (and 95% prediction) bounds between avian and mammalian chronic risk in the form of the ratio of initial residue values to the chronic toxicity threshold.

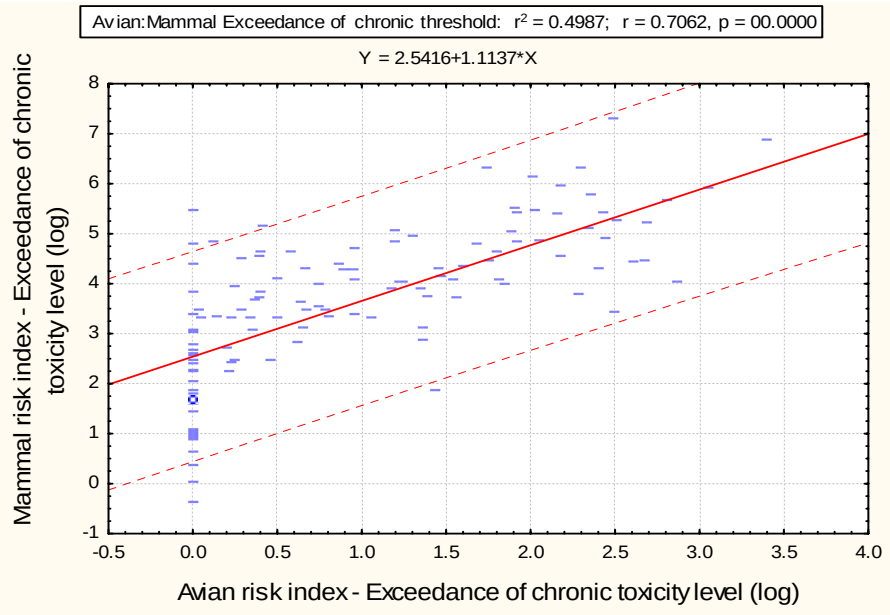
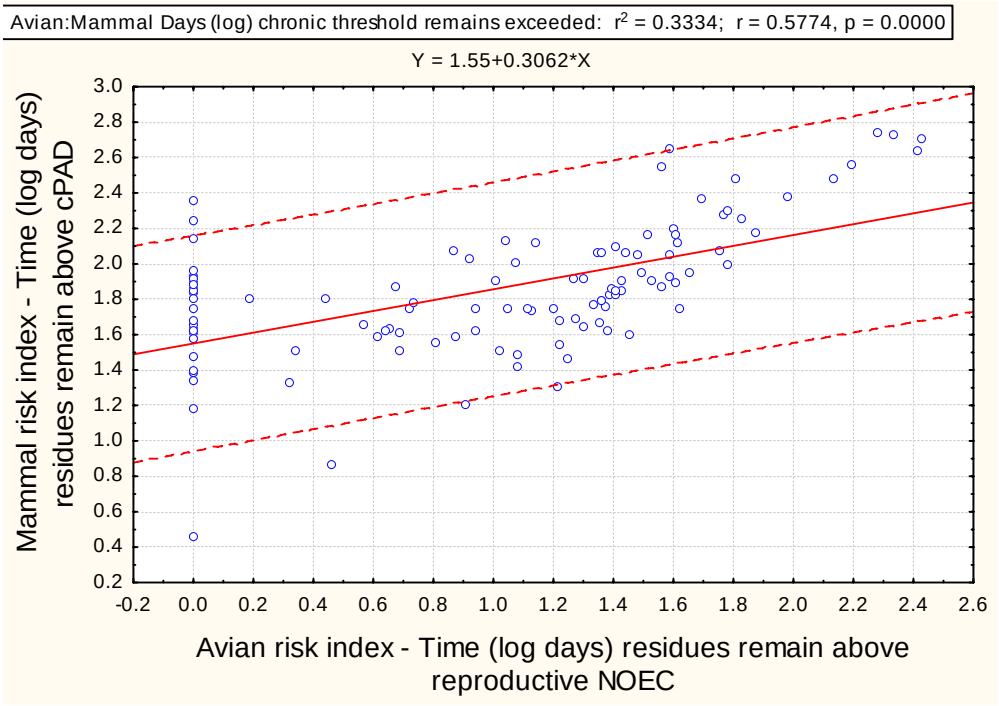


Figure 5: Relationship between avian and mammalian chronic risk in the form of the number of days (log values) after application when residues exceed the chronic toxicity threshold.



We were still unable to include a number of pesticides in our chronic rankings. These are listed in table 7a&b for mammals and birds respectively.

Table 7a: List of active ingredients with currently missing chronic data for mammals.

`	**AI Accepted Name**
NAA	1-Naphthalene actetic acid (form not specified)
DXB	2,4-D (unspecified amine salt)
DXF	2,4-D (unspecified ester)
BAD	6-Benzyladenine
AMN	Aminoethoxyvinylglycine
AMI	Amitrole
MOR	Chinomethionat
CCC	Chlormequat (form not specified)
CHL	Chlorthal (form not specified)

Table 7a: List of active ingredients with currently missing chronic data for mammals.

`	**AI Accepted Name**
NAD	Naphthaleneacetamide
CUZ	Copper (copper hydroxide)
CUY	Copper (copper oxychloride)
CUS	Copper (copper sulphate)
DIH	Dichlorprop (form not specified)
FER	Ferbam
FRA	Florasulam
FLR	Fluroxypyr 1-methylheptyl ester
GPI	Glyphosate (isopropylamine salt)
GPM	Glyphosate (mono-ammonium salt)
GPP	Glyphosate (potassium salt)
GPT	Glyphosate (trimethylsulfonium salt)
FBZ	Indar
IDO	Iodosulfuron-methyl-sodium
MAB	MCPA (dimethylammine salt)
MAS	MCPA (potassium salt)
MBS	MCPB (sodium salt)
MEC	Mecoprop (form not specified)
MEA	Mecoprop (potassium salt)
MEZ	Mecoprop d-isomer (amine salt)
MEW	Mecoprop d-isomer (potassium salt)
FAA	N-Decanol
FAB	N-Octanol
PID	Picloram (triisopropanolamine salt)
PFN	Picolinafen
PIR	Pirimicarb
PYZ	Pyrazon (chloridazon)
QPE	Quizalofop p-ethyl
AME	S-Metolachlor
SUL	Sulphur
MMM	Thifensulfuron-methyl
ZIN	Zineb
ZIR	Ziram

Table 7b: List of active ingredients with currently missing chronic data for birds.

PMRA AI Code	AI Accepted Name
NAA	1-Naphthalene actetic acid (form not specified)
TCM	2-(Thiocyanomethylthio)benzothiazole
DXB	2,4-D (unspecified amine salt)
DXF	2,4-D (unspecified ester)
DPB	2,4-DB (form not specified)
BAD	6-Benzyladenine
AMN	Aminoethoxyvinylglycine
DYR	Anilazine
CCC	Chlormequat (form not specified)
CHL	Chlorthal (form not specified)
CLM	Cloransulam (form not specified)
CUY	Copper (copper oxychloride)
CUS	Copper (copper sulphate)
DIK	Dichloran
DIH	Dichlorprop (form not specified)
AVG	Difenzoquat (methyl sulphate salt)
DIN	Dinocap
DPA	Diphenylamine
EPT	EPTC
ETM	Ethametsulfuron (form not specified)
ETF	Ethephon
FPF	Fenoxaprop-p-ethyl
FER	Ferbam
FZA	Fluazifop-p-butyl
BMS	Flusilazole
FOR	Formaldehyde
FAL	Fosetyl-al
GPS	Glyphosate (acid)
GPM	Glyphosate (mono-ammonium salt)
GPP	Glyphosate (potassium salt)
ASS	Imazamethabenz (form not specified)
IMP	Imazethapyr
MAH	Maleic hydrazide (form not specified)
MAB	MCPA (dimethylammine salt)
MAS	MCPA (potassium salt)
MAE	MCPA (unspecified ester)
MBS	MCPB (sodium salt)

Table 7b: List of active ingredients with currently missing chronic data for birds.

PMRA AI Code	AI Accepted Name
MEC	Mecoprop (form not specified)
MEA	Mecoprop (potassium salt)
MEZ	Mecoprop d-isomer (amine salt)
MEW	Mecoprop d-isomer (potassium salt)
MFN	Metalaxyl-m (mefenoxam)
NAD	Naphthaleneacetamide
NAP	Naptalam (form not specified)
FAA	N-Decanol
NIO	Nicosulfuron
FAB	N-Octanol
PAQ	Paraquat (form not specified)
PHS	Phosalone
PIC	Picloram (form not specified)
PID	Picloram (triisopropanolamine salt)
PYZ	Pyrazon (chloridazon)
PYR	Pyrethrins
QPE	Quizalofop p-ethyl
SUL	Sulphur
ZIN	Zineb
ZIR	Ziram

All four chronic indices are listed in Appendix E for all active ingredients ranked by the active ingredient name. In Table 8, we have listed those products with the highest reproductive risk to birds. For each of those products, initial residue intake was at least 10 times higher than the estimated reproductive toxicity level and residues were above the estimated reproductive toxicity threshold for more than 10 days. It is notable that, for a number of pesticides, reproductive effect thresholds were exceeded by 100 or even 1000-fold and for 100 days or more. Closer scrutiny and/or re-evaluation of these products would certainly be reasonable in order to ascertain whether exposure to birds is indeed occurring. It also raises questions about the role that reproductive

toxicity has played (or failed to play) in registration decisions.

Table 8: Products with the highest reproductive risk to birds; having initial calculated exposures at least 10 times above reproductive threshold and with residues calculated to be higher than reproductive threshold for at least 10 days. The combined rank is based on the summed rank for both indices. Where a DT50 values were missing and the time index could not be computed, the same rank was given to both indices.

PMRA AI Code	AI Accepted Name	Avian Log exceedance of repro NOEC	RANK	Avian - Time (log days) of repro NOEC exceedance	RANK	FINAL AVIAN RANK
BET	Bensulide	2.688	5	2.428	2	1
DIQ	Diquat (form not specified)	2.603	7	2.414	3	2
THI	Thiram	2.805	4	1.872	9	3
DIA	Diazinon	3.399	1	1.655	16	4
DCF	Dicofol	3.053	2	1.608	19	5
FOM	Formetanate (form not specified)	2.149	19	2.331	4	6
MTL	Metolachlor	2.494	9	1.617	17	7
PFL	Permethrin	2.282	16	1.783	11	8
MCZ	Mancozeb	2.019	21	1.827	10	9
DUR	Diuron	1.904	27	2.278	5	10
LUN	Linuron	1.912	25	1.979	8	11
TRF	Trifluralin	2.864	3	1.456	29	12
SMZ	Simazine	2.341	14	1.590	22	13
VPR	Hexazinone	1.565	36	2.193	6	14
TPR	Triclopyr	1.843	29	1.750	15	15
TET	Chlorothalonil	2.173	17	1.557	24	15
CUZ	Copper (copper hydroxide)	1.261	46	2.460	1	17
MOR	Chinomethionat	1.726	33	1.759	14	17
DCB	Dichlobenil	2.040	20	1.530	25	17
DUB	Chlorpyrifos	2.480	10	1.393	34	20
TZL	Thiabendazole	1.356	43	2.131	7	21
AMI	Amitrole	1.959	23	1.512	26	22
MTR	Metiram	1.741	32	1.607	20	23
PRT	Phosmet	2.398	12	1.378	36	23
DIM	Dimethoate	2.356	13	1.371	37	25
MOM	Methamidophos	2.015	22	1.428	30	26
CAF	Carbofuran	2.676	6	1.250	45	27

Table 8: Products with the highest reproductive risk to birds; having initial calculated exposures at least 10 times above reproductive threshold and with residues calculated to be higher than reproductive threshold for at least 10 days. The combined rank is based on the summed rank for both indices. Where a DT50 values were missing and the time index could not be computed, the same rank was given to both indices.

PMRA AI Code	AI Accepted Name	Avian Log exceedance of repro NOEC	RANK	Avian - Time (log days) of repro NOEC exceedance	RANK	FINAL AVIAN RANK
TRI	Trichlorfon	2.292	15	1.359	39	28
ACP	Acephate	2.420	11	1.303	42	28
TRL	Triallate	1.215	48	1.782	12	30
GOO	Azinphos-methyl	2.510	8	1.222	47	31
OXB	Oxamyl	1.911	26	1.405	33	32
OXR	Oxyfluorfen	1.451	39	1.586	23	33
NBP	Napropamide	1.172	51	1.766	13	34
ESF	Endosulfan	2.172	18	1.335	41	35
PRO	Prometryne	1.242	47	1.615	18	36
BAX	Metribuzin	1.599	35	1.424	31	37
DOD	Dodine (dodecylguanidine monoacetate)	1.194	50	1.599	21	38
CYM	Cypermethrin	1.537	37	1.407	32	39
ENT	Endothall (form not specified)	1.345	44	1.495	27	40
CAB	Carbaryl	1.302	45	1.481	28	43
VIL	Vinclozolin	1.877	28	1.272	44	45
ATR	Atrazine	1.468	38	1.387	35	46
GPI	Glyphosate (isopropylamine salt)	1.936	24	1.206	49	47
ACA	Acifluorfen (form not specified)	1.386	41	1.362	38	49
MAN	Maneb	1.674	34	1.222	46	51
TPM	Thiophanate-methyl	1.362	42	1.354	40	52
CAP	Captan	1.809	30	1.080	50	53
BZN	Bentazon (form not specified)	1.800	31	1.078	51	54
MPR	(S)-Methoprene	1.434	40	1.211	48	56
NAL	Naled	1.199	49	1.299	43	58
IMI	Imidacloprid	1.055	52	1.022	52	67

For mammalian wildlife, it is more difficult to judge the importance of the cPAD exceedance because of the safety factors built into that measure intended to protect humans. In Table 9, we listed all active ingredients where cPAD levels were exceeded by at least 1000 fold. For many pesticides, this exposure above cPAD levels was predicted to last for more than 100 days. Based on cPAD exceedance only, the 'prize' for the most undesirable product goes to chlorpyrifos with an exceedance of approximately 5 million-fold!

Table 9: Products with the highest reproductive risk to mammals; having initial calculated exposures at least 1000 times above USEPA cPAD. The combined rank is based on the summed rank for both indices. Where DT50 values were missing and the time index could not be computed, the same rank was given to both indices.

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	RANK	Mammal - Time (log days) of cPAD exceedance	RANK	FINAL MAMMAL RANK
DUR	Diuron	5.455	12	2.735	1	1
FOM	Formetanate (form not specified)	5.337	17	2.726	2	2
BET	Bensulide	5.152	19	2.710	3	3
MTR	Metiram	6.227	3	2.161	26	4
MCZ	Mancozeb	5.404	13	2.254	19	5
THI	Thiram	5.597	10	2.172	23	6
LUN	Linuron	4.774	29	2.376	13	7
PAQ	Paraquat (form not specified)	4.546	38	2.656	4	7
TER	Terbacil	4.466	41	2.648	5	9
MAA	MCPA (acid)	5.090	21	2.131	29	10
MAE	MCPA (unspecified ester)	5.090	21	2.131	29	10
DIA	Diazinon	6.787	2	1.955	49	12
DIQ	Diquat (form not specified)	4.367	45	2.639	6	12
DOD	Dodine (dodecylguanidine monoacetate)	4.746	31	2.198	22	14
FED	Fenamidone	4.722	33	2.247	20	14
MOM	Methamidophos	6.066	5	1.906	58	16
CAB	Carbaryl	4.869	26	2.054	40	17
DUB	Chlorpyrifos	7.245	1	1.859	66	18
DPP	Diclofop-methyl	4.659	34	2.093	33	18
DCF	Dicofol	5.828	8	1.889	62	20

Table 9: Products with the highest reproductive risk to mammals; having initial calculated exposures at least 1000 times above USEPA cPAD. The combined rank is based on the summed rank for both indices. Where DT50 values were missing and the time index could not be computed, the same rank was given to both indices.

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	RANK	Mammal - Time (log days) of cPAD exceedance	RANK	FINAL MAMMAL RANK
PHS	Phosalone	4.518	39	2.079	34	21
SMZ	Simazine	5.057	23	1.924	52	22
NAL	Naled	5.001	24	1.919	54	23
TRL	Triallate	3.969	63	2.296	16	24
OXB	Oxamyl	5.374	15	1.854	68	25
TRI	Trichlorfon	6.227	3	1.793	81	26
VPR	Hexazinone	3.631	78	2.559	7	27
FLT	Flufenacet	4.324	48	2.059	39	28
DCB	Dichlobenil	4.802	28	1.902	60	29
NBP	Napropamide	3.849	72	2.283	17	30
IMP	Imazethapyr	3.604	81	2.555	8	30
ESF	Endosulfan	5.898	7	1.769	84	32
BMS	Flusilazole	3.780	73	2.269	18	32
CYZ	Cyromazine	3.595	82	2.554	9	32
DIM	Dimethoate	5.705	9	1.755	85	35
DIK	Dichloran	5.144	20	1.835	74	35
OXR	Oxyfluorfen	4.242	54	2.052	41	37
MEI	Dimethenamid	4.550	37	1.904	59	38
PRO	Prometryne	3.953	64	2.118	32	38
MER	Mesotrione	4.337	46	1.928	51	40
KRB	Propyzamide	3.472	84	2.363	14	41
FOF	Fomesafen	4.006	61	2.060	38	42
TPR	Triclopyr	3.909	67	2.077	35	43
EPT	EPTC	5.458	11	1.736	93	44
TET	Chlorothalonil	4.486	40	1.872	64	44
NAP	Naptalam (form not specified)	4.156	57	1.985	47	44
DIC	Dicamba (form not specified)	3.905	68	2.067	37	47
PZN	Pymetrozine	3.894	69	2.074	36	47
DXA	2,4-D (acid)	4.459	42	1.870	65	49
QTZ	Quintozene	4.774	29	1.802	79	50
DIN	Dinocap	3.923	66	2.018	44	51

Table 9: Products with the highest reproductive risk to mammals; having initial calculated exposures at least 1000 times above USEPA cPAD. The combined rank is based on the summed rank for both indices. Where DT50 values were missing and the time index could not be computed, the same rank was given to both indices.

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	RANK	Mammal - Time (log days) of cPAD exceedance	RANK	FINAL MAMMAL RANK
FAD	Famoxadone	4.199	56	1.912	56	52
PEN	Pendimethalin	3.060	103	2.484	10	53
TZL	Thiabendazole	3.023	105	2.479	11	54
ACP	Acephate	5.351	16	1.648	102	55
ETF	Ethephon	4.294	49	1.853	69	55
EFR	Ethalfluralin	4.567	36	1.783	83	57
VIL	Vinclozolin	4.944	25	1.693	95	58
BAX	Metribuzin	4.262	50	1.850	70	58
ENT	Endothall (form not specified)	3.857	71	1.953	50	60
DPB	2,4-DB (form not specified)	4.259	51	1.850	71	61
PFL	Permethrin	3.722	76	1.995	46	61
MAN	Maneb	4.739	32	1.674	97	64
ATR	Atrazine	4.081	58	1.831	76	67
GOO	Azinphos-methyl	5.197	18	1.538	121	69
GLG	Glufosinate ammonium	4.245	53	1.751	86	69
CYM	Cypermethrin	4.001	62	1.823	77	69
CFP	Clodinafop-propargyl	5.389	14	1.479	126	72
MAH	Maleic hydrazide (form not specified)	3.156	102	2.020	43	74
DYR	Anilazine	5.950	6	1.296	140	75
PYA	Pyraclostrobin	3.334	92	1.917	55	76
DBR	Deltamethrin	4.324	47	1.634	103	77
ETS	Ethofumesate	3.019	106	2.001	45	78
FPF	Fenoxaprop-p-ethyl	3.628	79	1.832	75	81
PRT	Phosmet	4.255	52	1.627	105	82
ACA	Acifluorfen (form not specified)	3.688	77	1.787	82	84
BZN	Bentazon (form not specified)	4.580	35	1.483	125	85
PIC	Picloram (form not specified)	3.057	104	1.910	57	86
MAL	Malathion	4.217	55	1.624	107	87
FLZ	Fluazinam	3.227	99	1.858	67	88
AMZ	Amitraz	4.849	27	1.207	144	91
CAF	Carbofuran	4.404	44	1.466	127	91

Table 9: Products with the highest reproductive risk to mammals; having initial calculated exposures at least 1000 times above USEPA cPAD. The combined rank is based on the summed rank for both indices. Where DT50 values were missing and the time index could not be computed, the same rank was given to both indices.

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	RANK	Mammal - Time (log days) of cPAD exceedance	RANK	FINAL MAMMAL RANK
PYD	Pyridaben	4.057	59	1.607	112	91
CYP	Cyprodinil	3.296	93	1.804	78	91
TRR	Triforine	3.393	87	1.751	87	95
CFZ	Clofentezine	3.387	88	1.750	88	96
TRF	Trifluralin	3.948	65	1.595	113	97
FOL	Folpet	3.768	74	1.631	104	97
CYH	Cyhalothrin-lambda	3.384	89	1.750	89	97
MTL	Metolachlor	3.355	90	1.746	91	101
IPD	Iprodione	3.339	91	1.744	92	102
FZA	Fluazifop-p-butyl	3.421	85	1.658	99	103
MEX	Tribenuron methyl	3.393	86	1.654	101	105
CAP	Captan	4.006	60	1.425	128	106
TRA	Tralkoxydim	3.625	80	1.618	108	106
BTL	Desmedipham	3.274	95	1.735	94	108
MML	Methomyl	4.407	43	0.865	147	109
IXF	Isoxaflutole	3.746	75	1.572	118	111
SOD	Sethoxydim	3.572	83	1.551	119	113
DPA	Diphenylamine	3.858	70	1.220	142	117
CYO	Cymoxanil	3.232	98	1.589	115	118
MFN	Metalaxyl-m (mefenoxam)	3.166	101	1.589	116	120
BRY	Bromoxynil (octanoate)	3.251	96	1.510	122	121
IMI	Imidacloprid	3.239	97	1.509	123	122
TFZ	Tebufenozide	3.227	99	1.507	124	123
TCM	2-(Thiocyanomethylthio) benzothiazole	3.288	94	1.345	134	125

3.4 Chronic risk from granular and seed treatment applications

The number of particles needing to be ingested by a 15 g bird or 25 g mammal to reach the chronic threshold is given in Tables 9 and 10. For the more reproductively-toxic products, approximately 1/100th of a seed per day is sufficient to reach the estimated reproductive threshold.

Table 10: The number of particles needing to be ingested by a 15 g bird to reach the chronic threshold for reproductive effects.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to avian chronic threshold	Rank
IMI	Imidacloprid	Corn seed	0.01	1
DIA	Diazinon	Corn seed	0.01	2
COY	Terbufos	granular	0.01	3
THI	Thiram	Corn seed	0.03	4
CAP	Captan	Corn seed	0.03	5
DAZ	Dazomet	granular	0.03	6
MCZ	Mancozeb	Corn seed	0.04	7
VIT	Carbathiin	Corn seed	0.04	8
MTA	Metalaxyl	Corn seed	0.05	9
TRF	Trifluralin	granular	0.05	10
TPM	Thiophanate-methyl	Corn seed	0.10	11
COD	Clothianidin	Corn seed	0.12	12
VIT	Carbathiin	Cereal seed	0.13	13
DIA	Diazinon	granular	0.18	14
DUB	Chlorpyrifos	granular	0.21	15
THE	Thiamethoxam	Corn seed	0.28	16
MAN	Maneb	Cereal seed	0.28	17
DFZ	Difenoconazole	Corn seed	0.29	18
IMI	Imidacloprid	Canola seed	0.44	19
TEU	Tebuconazole	Cereal seed	0.51	20
THI	Thiram	Cereal seed	0.74	21
TEL	Tefluthrin	granular	0.88	22
THI	Thiram	Canola seed	0.91	23
TLL	Triadimenol	Cereal seed	1.47	24
TRL	Triallate	granular	2.58	25

Table 10: The number of particles needing to be ingested by a 15 g bird to reach the chronic threshold for reproductive effects.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to avian chronic threshold	Rank
MTA	Metalaxyl	Cereal seed	2.82	26
FLD	Fludioxonil	Corn seed	2.94	27
NXI	Acetamiprid	Canola seed	2.94	28
DFZ	Difenoconazole	Cereal seed	3.13	29
VIT	Carbathiin	Canola seed	6.49	30
IPD	Iprodione	Canola seed	7.10	31
COD	Clothianidin	Canola seed	7.22	32
NBP	Napropamide	granular	8.64	33
THE	Thiamethoxam	Canola seed	9.05	34
THE	Thiamethoxam	Cereal seed	9.37	35
TRT	Triticonazole	Cereal seed	17.25	36
MTA	Metalaxyl	granular	18.27	37
CAB	Carbaryl	granular	18.73	38
EFR	Ethalfluralin	granular	21.10	39
MTA	Metalaxyl	Canola seed	32.96	40
FLD	Fludioxonil	Cereal seed	34.88	41
DFZ	Difenoconazole	Canola seed	42.63	42
FLD	Fludioxonil	Canola seed	406.88	43
MFN	Metalaxyl-m (mefenoxam)	Canola seed	Missing data	
MFN	Metalaxyl-m (mefenoxam)	Cereal seed	Missing data!	
MFN	Metalaxyl-m (mefenoxam)	Corn seed	Missing data	
EPT	EPTC	granular	Missing data	
MFN	Metalaxyl-m (mefenoxam)	granular	Missing data	

For the 25g mammal, the number of particles needing to be consumed to reach the daily cPAD becomes very small with less than 1/10,000th of a particle being sufficient for the more chronically-toxic compounds. As was the case for the liquid formulations, chlorpyrifos takes first 'prize' as the most hazardous pesticide.

Table 11: The number of particles needing to be ingested by a 25 g mammal to reach the chronic threshold as determined by the USEPA cPAD.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to chronic cPAD	Rank
DUB	Chlorpyrifos	granular	<0.0001	1
DIA	Diazinon	Corn	<0.0001	2
THE	Thiamethoxam	Corn	<0.0001	3
COY	Terbufos	granular	<0.0001	4
VIT	Carbathiin	Corn	0.0001	5
THI	Thiram	Corn	0.0003	6
VIT	Carbathiin	Cereal	0.0004	7
DAZ	Dazomet	granular	0.0005	8
DIA	Diazinon	granular	0.0005	9
IMI	Imidacloprid	Corn	0.0005	10
THE	Thiamethoxam	Canola	0.0012	11
THE	Thiamethoxam	Cereal	0.0013	12
CAP	Captan	Corn	0.0015	13
MAN	Maneb	Cereal	0.0017	14
MTA	Metalaxyl	Corn	0.0023	15
DFZ	Difenoconazole	Corn	0.0027	16
COD	Clothianidin	Corn	0.004	17
EPT	EPTC	granular	0.0063	18
THI	Thiram	Cereal	0.0082	19
EFR	Ethalfluralin	granular	0.01	20
THI	Thiram	Canola	0.0102	21
TEU	Tebuconazole	Cereal	0.0127	22
IMI	Imidacloprid	Canola	0.0198	23
TEL	Tefluthrin	granular	0.0208	24
VIT	Carbathiin	Canola	0.0223	25
TPM	Thiophanate-methyl	Corn	0.0254	26
DFZ	Difenoconazole	Cereal	0.0296	27
TRF	Trifluralin	granular	0.03	28
TRL	Triallate	granular	0.0313	29
CAB	Carbaryl	granular	0.035	30
FLD	Fludioxonil	Corn	0.0353	31
MFN	Metalaxyl-m (mefenoxam)	Corn	0.0373	32
TLL	Triadimenol	Cereal	0.0808	33
NBP	Napropamide	granular	0.125	34
MTA	Metalaxyl	Cereal	0.143	35

Table 11: The number of particles needing to be ingested by a 25 g mammal to reach the chronic threshold as determined by the USEPA cPAD.

PMRA AI Code	AI Accepted Name	Type of particle	No. Particles to chronic cPAD	Rank
IPD	Iprodione	Canola	0.2034	36
NXI	Acetamiprid	Canola	0.2348	37
COD	Clothianidin	Canola	0.2529	38
DFZ	Difenoconazole	Canola	0.404	39
MFN	Metalaxyl-m (mefenoxam)	Cereal	0.4047	40
FLD	Fludioxonil	Cereal	0.4191	41
MCZ	Mancozeb	Corn	0.6728	42
MTA	Metalaxyl	granular	0.925	43
MFN	Metalaxyl-m (mefenoxam)	granular	1	44
MTA	Metalaxyl	Canola	1.6684	45
TRT	Triticonazole	Cereal	2.2697	46
MFN	Metalaxyl-m (mefenoxam)	Canola	4.7217	47
FLD	Fludioxonil	Canola	4.8892	48

4 VALIDATION

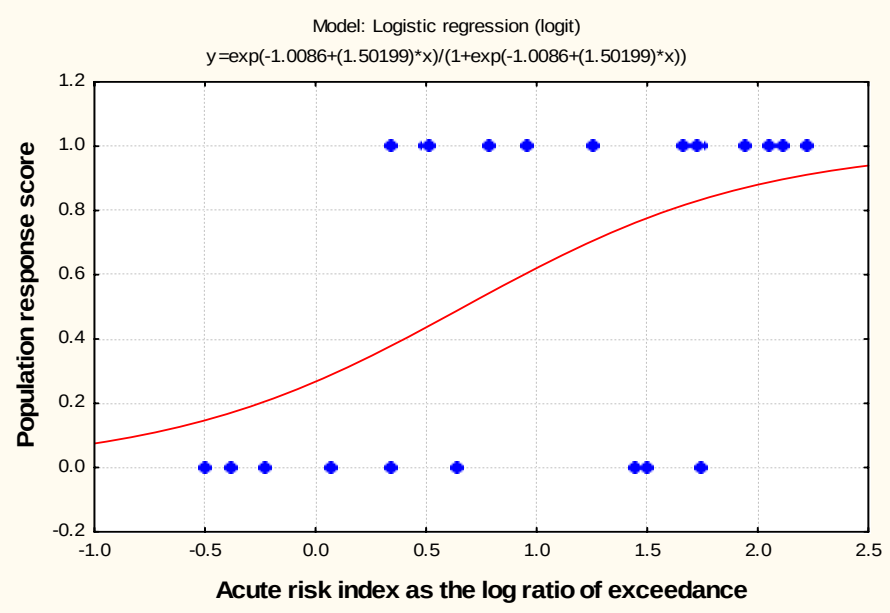
The avian acute index is based on field-based results already (Mineau 2002) and the results (in % of kill) should be readily useable to restrict the risk of mortality below some arbitrary threshold.

There are fewer small mammal studies then there are bird studies. Nevertheless, these were assembled to see whether we could validate either our acute or chronic risk index. A useful starting point for locating relevant studies was the review article of Sheffield et al. 2001. Because finding dead rodents or other small mammals in fields is unlikely, we emphasized those studies that used trapping (usually live trapping and marking) in order to look at the population response of a pesticide application. The data are heavily biased to a few active ingredients (especially azinphos-methyl), because of EPA-sponsored research attempting to validate their risk assessment paradigm with that active ingredient. A population response was variously defined as

reductions in some age or sex cohorts which could indicate mortality, or as changes in reproductive rates (e.g. pregnancy rates etc…) indicative of a more targeted effect on the reproductive process. Indeed, the majority of effects were of the first type with only a few pesticides (e.g. carbaryl) showing reproductive effects per se. Because of the paucity of data, both types of effects were pooled without consideration of their causal nature or the ease with which they could be reversed post-spray. Although small mammal populations are able to bounce back very quickly from catastrophic mortality events, the impact may have ripple effects on consumers.

We scored all available studies (see Appendix F) as to whether the authors had shown (or not) a population effect from the given pesticide application. The usual caveats attached to this type of analysis certainly apply here – for instance, we had to take each study at face value without regard for its experimental design and, hence, its statistical power. We plotted the results logistically against the acute index derived as the ratio of exceedance of the HC5 value (see section 3.1) (Figure 6).

Figure 6: Logistic plot of small mammal population-level effects (0=no effect; 1=statistical effect of spraying) against the acute risk expressed as the HC5 exceedance ratio.



Model is: logistic regression (logit) No. of 0's:9.000000 (39.13044%)
No. of 1's:14.00000 (60.86956%)
Dependent variable: Population response score Independent variables: 1
Loss function is: maximum likelihood Final value: 12.103412915
-2*log(Likelihood): for this model= 24.20683 intercept only= 30.78909
Chi-square = 6.582261 df = 1 p = .0103045
Classification accuracy : 78.6%

The finding of a significant model indicates that the risk index, as defined here is somewhat predictive of a population-level effect in small mammals. This does not consider how quickly such a population might rebound but does indicate a perturbation, measurable with a live-trapping study. On the basis of that model, a ratio of exceedance of approximately 5 or higher would carry a 50% risk of causing a measurable population perturbation. Given how the acute risk index was constructed, this is equivalent to saying that population effects are likely 50% of the time when the estimated residues in foliage are such as to give rise to the accumulation of 5 times the median estimate of 5% tail of acute toxicity distribution for mammals in the first 24 hours post application.

Logically, at least two other factors might be important in determining the extent of the population impact in the small mammal studies that comprise our sample. The relative dermal to oral toxicity has been shown in the avian models to be very important (Mineau 2002). It was entered here although it meant the loss of the carbaryl datapoints. Secondly, the persistence of the insecticides (or predicted foliar DT50) would be expected to influence the likelihood of population level effects. Both were entered into the analysis.

We selected the best model by the best subset method, an iterative method based on maximum likelihood estimation, and Akaike's Information criterion (AIC). The AIC penalizes for the number of independent variables in the model. Since we have a small number of studies, we used the correction for small sample size (AICc). Burham and Anderson (2002) suggest that models with a delta AICc of 2 or less show a substantial level of empirical support. Values over 10 show no or almost no empirical support.

Table 12: Best models including log acute exceedance, dermal toxicity index and foliar DT50 as predictors of small mammal population effects based on available sample of mark-recapture studies.

Var. 1	Var. 2	Var. 3	d.f.	AICc	Delta AICc	Log L.Ratio	p
Log acute exceedance			1	24.05348	0.00000	8.97207	0.002741
Foliar DT50 FINAL	Log acute exceedance		2	24.92546	0.87198	11.26676	0.003576
Foliar DT50 FINAL	Log acute exceedance	Rat DTI	3	25.72427	1.67079	14.08699	0.002789
Log acute exceedance	Rat DTI (oral/dermal*1000)		2	27.08091	3.02743	9.11131	0.010508
Foliar DT50 FINAL	Rat DTI (oral/dermal*1000)		2	28.73972	4.68624	7.45250	0.024083
Foliar DT50 FINAL			1	31.48578	7.43230	1.53978	0.214651

Table 12: Best models including log acute exceedance, dermal toxicity index and foliar DT50 as predictors of small mammal population effects based on available sample of mark-recapture studies.

Var. 1	Var. 2	Var. 3	d.f.	AICc	Delta AICc	Log L.Ratio	p
Rat DTI (oral/dermal*1000)			1	31.93547	7.88199	1.09009	0.296452

Based on this analysis, the most parsimonious model is still the one with toxicity index only. Despite a higher log-likelihood ratio, the addition of DTI and foliar DT50 does not result in significant model improvement because of the high penalty associated with additional predictor variables. Addition of those two variables – especially the foliar DT50 – does result in a better classification of outcomes so the idea of using these variables in a predictive fashion should not be discarded. However, the limited dataset (20 studies; 7 insecticides represented) does not allow us to fully conclude their usefulness. The replication of the predictor variables in the dataset adds to the uncertainty of overall model performance.

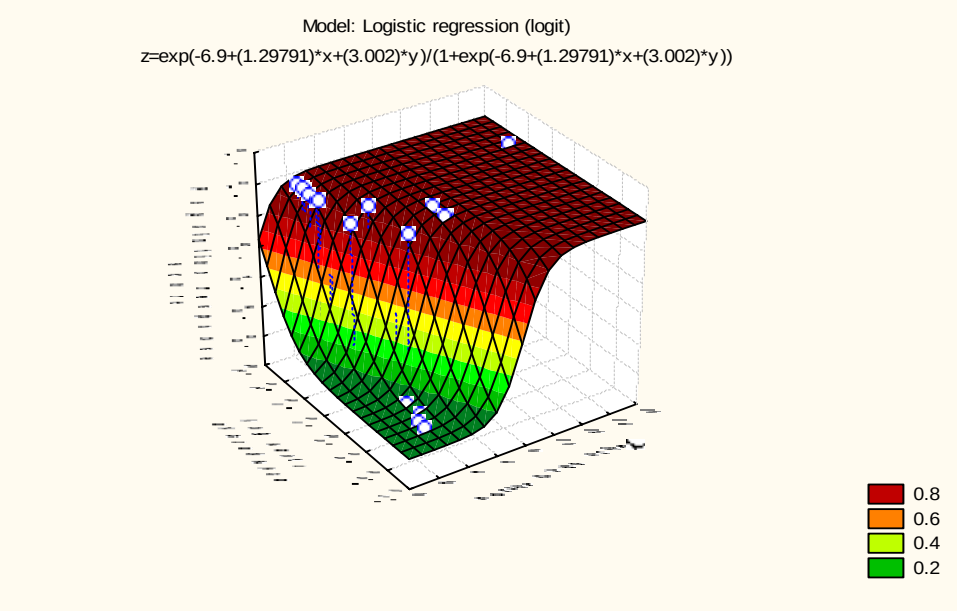
The analysis was repeated with Log acute exceedance only and foliar DT50 in order to make use of the full dataset (23 studies; 8 insecticides) (Table 13). This time, the AIC analysis indicated that the model including foliar DT50 was the most parsimonious.

Table 13: Best models including log acute exceedance, and foliar DT50 only as predictors of small mammal population effects based on available sample of mark-recapture studies.

Var. 1	Var. 2	d.f.	AICc	Delta AICc	L.Ratio	p
Foliar DT50 FINAL	Log acute exceedance	2	24.66118	0.00000	14.35013	0.000765
Log acute exceedance		1	29.46998	4.80880	6.58226	0.010300
Foliar DT50 FINAL		1	32.77982	8.11863	3.27243	0.070453

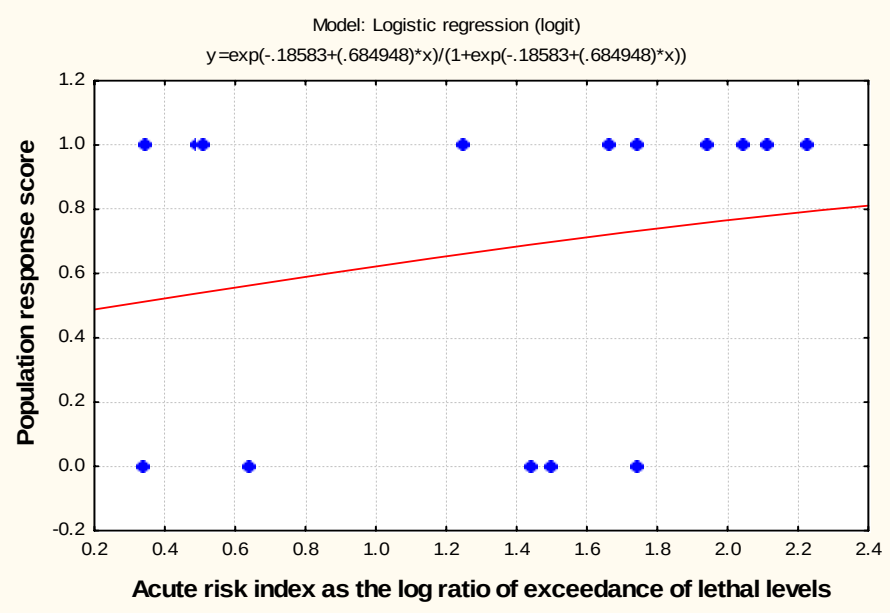
The 3D model is depicted in Figure 7 with a population response score of 1 indicative of a population effect. There is 85% classification accuracy of the 23 studies and foliar DT50 loads as expected: risk increases at a lower toxic exceedance level when the foliar DT50 is higher.

Figure 7: Likelihood of population effect in sample of small mammal mark-recapture studies based on the best model from table 13, incorporating toxicity (measured as the log of exceedance of acute toxicity levels after application) and foliar DT_{50}.



Among the field studies retained for analysis, there are those that were performed in enclosures with no emigration or immigration and those that were carried out in open (unenclosed) plots. In theory, it should be easier to detect pesticide-induced declines on enclosed populations. However, restricting the data to enclosure studies only did not yield a good model – largely because of the loss of studies at lower levels of acute toxicity which did not allow for discrimination of a good dose-response.

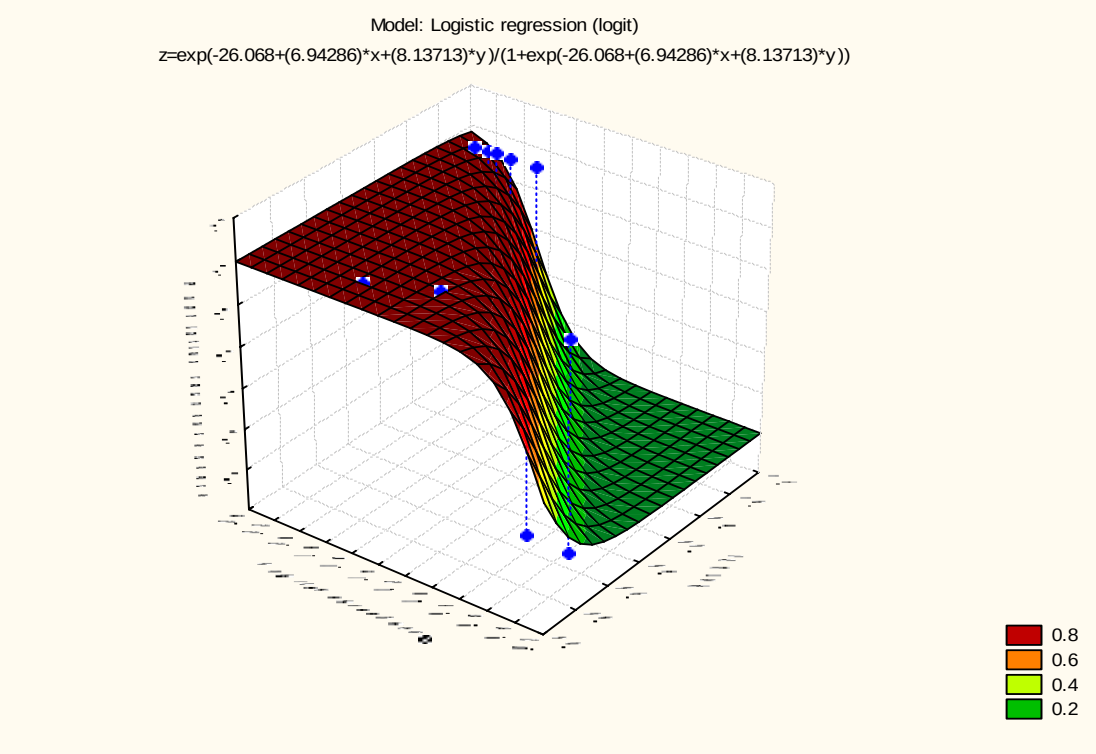
Figure 8: Likelihood of population effect in sample of enclosed small mammal mark-recapture studies based on toxicity alone (measured as the log of exceedance of acute toxicity levels after application).



This time, however, addition of the rat dermal toxicity significantly helped the model. As was the case with avian field studies (Mineau 2002), risk appears to increase at relatively lower oral toxicity scores if the pesticides are more toxic through the dermal route. For a pesticide that is relatively well absorbed dermally (e.g. DTI>2.4), population risk starts rising beyond an exceedance level of approximately 0.5 on the log scale or a ratio of approximately 3. For a compound at the very low end of the dermal absorption spectrum (e.g. rat DTI<1.6), risk to the population starts increasing at a log exceedance of approximately 1.6 on the log scale or an exceedance ratio of approximately 40. However, we should caution that the sample size of studies is extremely small and representing three compounds only (diazinon: 4 studies; endrin: 1 study; azinphos-methyl: 8 studies). The arbitrary cutoffs mentioned above (e.g. a DTI of 1.6) actually fall outside of the dataset available. Therefore, these conclusions should be treated as very

tentative but they are nevertheless reported here because of the parallel with the situation in birds.

Figure 9: Likelihood of population effect in sample of <u>enclosed</u> small mammal mark-recapture studies based on the best model incorporating toxicity (measured as the log of exceedance of acute toxicity levels after application) and a dermal:oral toxicity ratio.



Model is: logistic regression (logit) No. of 0's:5.000000 (38.46154%)
No. of 1's:8.000000 (61.53846%)
Dependent variable: Population res Independent variables: 2
Loss function is: maximum likelihood Final value: 5.024131057
-2*log(Likelihood): for this model= 10.04826 intercept only= 17.32324
Chi-square = 7.274977 df = 2 p = .0263292
Correct classification success: 87.5%

5 ACKNOWLEDGEMENTS

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7 APPENDICES

APPENDIX A: Active ingredients that were excluded from the analysis with justification.

The compounds in red are in-use products that should be incorporated into our ranking scheme.

AI Code	AI Accepted Name (PMRA)	Why were these AI rejected?
ALP	Aluminum phosphide	Post harvest application or use as rodenticide
MGP	Magnesium phosphide	Post harvest application
PHI	Phosphine	Post harvest application
BDX	Cyanazine	Historical EP only; label in hard copy
DIE	Dieldrin	Historical EP only; label in hard copy
DIG	Dichlorprop present as dimethylamine salt	Historical EP only; label in hard copy
DIS	Disulfoton	Historical EP only; label in hard copy
DNB	Dinoseb in free form	Historical EP only; label in hard copy
DXS	2,4-D present as sodium salt	Historical EP only; label in hard copy
END	Endrin	Historical EP only; label in hard copy
ETY	Ethoxyquin	Historical EP only; label in hard copy
FEM	Fenitrothion	Historical EP only; label in hard copy
MTB	Metobromuron	Historical EP only; label in hard copy
PRL	Propanil	Historical EP only; label in hard copy
PTH	Parathion	Historical EP only; label in hard copy
CUB	Copper (tribasic copper sulphate)	Incomplete data (no toxicity data)
FLB	Flamprop-m (form not specified)	Incomplete data (no toxicity data)
GIA	Gibberellic acid A3	Incomplete data (no phys/chem data)
GIB	Gibberellins	Incomplete data (no toxicity or phys/chem data)
SUS	Lime sulphur or calcium polysulphide	Incomplete data (no phys/chem data)
CPN	Chloropicrin	Fumigant
DSG	1,3-Dichloropropene	Fumigant
KMC	Potassium n-methyldithiocarbamate	Fumigant
MBR	Methyl bromide	Fumigant
MIS	Methyl isothiocyanate	Fumigant
MTM	Metam (form not specified)	Fumigant
FDR	Pyridate	Not in the database - Historical EPs only
ABM	Abamectin	Not used on crops
ALM	d-trans Allethrin	Not used on crops

The compounds in red are in-use products that should be incorporated into our ranking scheme.

AI Code	AI Accepted Name (PMRA)	Why were these AI rejected?
ARP	Arsenic pentoxide	Not used on crops
ARS	Imazapyr	Not used on crops
AZN	Azaconazole	Not used on crops
BBU	Bromacil present in free form, as dimethylamine salt, or as lithium salt	Not used on crops
BDC	Bendiocarb	Not used on crops
BNS	Borax	Not used on crops
BOA	Boracic acid (Boric acid)	Not used on crops
BOC	Disodium octaborate tetrahydrate	Not used on crops
BTS	Bis(trichloromethyl)sulfone	Not used on crops
CAZ	Carbendazim	Not used on crops
CNB	Chloroneb	Not used on crops
CRO	Chromic acid	Not used on crops
CUO	Cupric oxide	Not used on crops
CUP	Cuprous oxide (also expressed in terms of copper as elemental)	Not used on crops
CUQ	Copper 8-quinolinolate	Not used on crops
CUR	Copper as elemental, present as mixed copper ethanolamine complexes	Not used on crops
CXF	Cyfluthrin	Not used on crops
DAM	Daminozide	Not used on crops
DEB	Denatonium benzoate	Not used on crops
DFB	Diflubenzuron	Not used on crops
DIR	Dithiopyr	Not used on crops
DOM	Dodemorph-acetate	Not used on crops
DVP	Dichlorvos plus related active compounds	Not used on crops
ETO	Ethylene oxide	Not used on crops
FBT	Fenbutatin oxide	Not used on crops
GAR	Tetrachlorvinphos	Not used on crops
HQB	Oxine benzoate	Not used on crops
IPB	Iodocarb (proposed common name)	Not used on crops
ISX	Isoxaben	Not used on crops
KRE	Fosamine ammonium	Not used on crops
MEE	Mecoprop present as acid	Not used on crops
MGK	N-Octyl bicycloheptene dicarboximide	Not used on crops
MSM	Arsenic as elemental, present as monosodium methane arsonate (MSMA)	Not used on crops
OXA	Oxadiazon	Not used on crops

The compounds in red are in-use products that should be incorporated into our ranking scheme.

AI Code	AI Accepted Name (PMRA)	Why were these AI rejected?
PAZ	Paclobutrazol	Not used on crops
PBU	Piperonyl butoxide	Not used on crops
PCP	Pentachlorophenol plus related active chlorophenols	Not used on crops
PTX	Oxycarboxin	Not used on crops
QAC	N-alkyl (40% C12, 50% C14, 10% C16) dimethyl benzyl ammonium chloride	Not used on crops
QAK	Didecyl dimethyl ammonium chloride	Not used on crops
QAO	N-alkyl (67% C12, 25% C14, 7% C16, 1% C18) dimethyl benzyl ammonium chloride	Not used on crops
REZ	Resmethrin	Not used on crops
SDD	Sodium dimethyldithiocarbamate	Not used on crops
TCS	TCA present as sodium salt	Not used on crops
TRB	Etridiazole	Not used on crops
TXP	4-(Cyclopropyl-alpha-hydroxy-methylene)-3,5-dioxo-cyclohexane	Not used on crops
ZNO	Zinc oxide	Not used on crops
BAY	Propoxur	Not used on crops
MEU	1-Methylcyclopropene	Post harvest application
CIP	Chlorpropham	Post-harvest application

APPENDIX B: Predicting Foliar Half Life

The foliar DT_{50} value was available for 134 of the 207 pesticides ranked here. Most of the values were obtained from the USDA Natural Resources Conservation Service (NRCS) in the form of their Pesticide Properties Database (PPD). The foliar DT_{50} variable is used in the evaluation of chronic risk as a proxy for residue degradation rates in avian foodstuffs – notably insects. Unfortunately, this is probably the least standardised variable to be collected on pesticide active ingredients. Variation undoubtedly occurs at the field level from plant to plant, insect to insect and also because of weather effects (rainfall, humidity, sunlight intensity etc.). Furthermore, there is a lack of method standardization in the literature, so that some sources examine only pesticides on the leaf surface, while others blend fruit or leaves for examination. We used USDA estimates where available and also attempted to create a model that would estimate foliar DT_{50} from other more accessible parameters.

To develop this model, foliar half life values for all chemicals in the Gleams and USDA 2005 PPD databases were used. The complete dataset of Gleams and USDA information was divided in two; chemicals used in Canada, and those not used in Canada. The chemicals used in Canada were included in a training set and all other chemicals were used to validate the model. Some foliar half-lives in the GLEAMS and USDA databases were marked as 'estimated values', and these were not included in our analysis. Subsequent analysis showed that most of these values were clear outliers in the models we developed, suggesting that they had been poorly estimated. For each chemical, the values for the octanol water partition coefficient (K_{ow}), the organic carbon soil sorption coefficient (K_{oc}), and soil DT_{50} were also obtained from the Gleams and USDA databases, as well as from a proprietary database of company data from the Pest Management

Regulatory Agency (PMRA) and the Pesticide Manual. Any chemical missing one of the above values was removed from the analysis, which left a total of 123 pesticides with complete data.

In our dataset, the foliar DT_{50} ranged from 0.5-30 days. Some of the values appeared to be over-represented and were therefore suspect; there were 23 chemicals (18%) with a foliar DT_{50} value of 3 days and 25 pesticides (20%) with a value of 5 days. There were also 19 pesticides with a reported DT_{50} of 30 days (15% of total); perhaps this value is more a maximum rather than an actual determined value. Even though we suspect that some of these values are approximations, they were all used in the analysis.

In some studies soil DT_{50} is used to approximate foliar DT_{50} (Villa *et al.* 2000), and in our data we found that there was a strong correlation between foliar DT_{50} and soil DT_{50} ($r = 0.62$ $p<0.01$; table 1). The variables log water solubility and log K_{ow} were also correlated ($r = -0.74$ $p<0.001$). The log normalized water solubility was correlated with molecular weight and log K_{oc} (both $r = -0.47$ $p< 0.01$). The other variables were not strongly correlated ($r<0.30$).

We used AIC (Akaike information criteria) (Burnham and Anderson 2002) to identify the most plausible models and relevant variables to select. Small sample size corrections (AIC_c) were calculated in order to keep the models as parsimonious as possible. In keeping with the results of Villa and colleagues (2000), our analysis found that the best models all included log soil DT_{50} (table 2). The best model contained log soil DT_{50}, log water solubility and log vapour pressure, followed by a model with log soil DT_{50}, log K_{ow} and log vapour pressure. The weight ratio of 1.86 between these two models indicated that they are equally acceptable. The similarity is not surprising, given the high inverse correlation between log water solubility and log K_{ow}. The best model is highly significant and reasonably predictive ($R^2= 0.43$ $p<<0.00001$ figure 1). There are

some outliers, some of which proved to be older chemicals not in use today.

Table B1: Correlations between variables used in analysis.

	Log K_{ow}	mw	log foliar	log soil	log solubility	log K_{oc}	log vp
Mw	.2900	1.0000	.0102	.0491	-.4663	.3071	-.2775
	p=.001	p= ---	P=.911	p=.589	p=.000	p=.001	p=.002
log foliar	-.0731	.0102	1.0000	.6295	.0531	.1230	-.1891
	p=.422	p=.911	P= ---	p=.000	p=.560	p=.175	p=.036
log soil	.0916	.0491	.6295	1.0000	-.1073	.2668	-.0791
	p=.313	p=.589	P=.000	p= ---	p=.238	p=.003	p=.385
log solubility	-.7419	-.4663	.0531	-.1073	1.0000	-.4733	.0392
	p=0.00	p=.000	P=.560	p=.238	p= ---	p=.000	p=.667
log K_{oc}	.3144	.3071	.1230	.2668	-.4733	1.0000	-.1426
	p=.000	p=.001	P=.175	p=.003	p=.000	p= ---	p=.116
log vp	.1117	-.2775	-.1891	-.0791	.0392	-.1426	1.0000
	p=.219	p=.002	P=.036	p=.385	p=.667	p=.116	p= ---

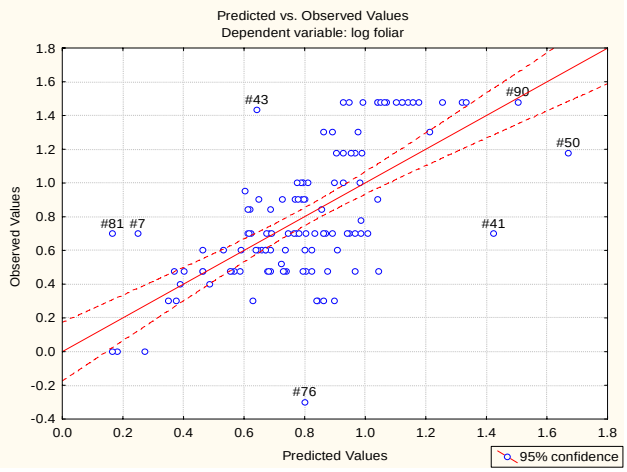
Table B2: Top models found by using AIC analysis N=123. molecular weight = mw vapour pressure=vp

factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	df	AIC_c	ΔAIC_c	Akaike weight	Ratio	R^2	p<<
log soil	log solubility	log vp				3	60.01	0.00	0.177	1.00	0.43	0.000001
log soil	log K_{ow}	log vp				3	61.24	1.24	0.095	1.86	0.43	0.000001
log soil	log vp					2	61.45	1.44	0.086	2.06	0.41	0.000001
log soil	log solubility	log vp	log K_{oc}			4	62.16	2.16	0.060	2.94	0.42	0.000001
log soil	log solubility					2	62.20	2.19	0.059	2.99	0.40	0.000001
log soil	log solubility	log vp	mw			4	62.20	2.20	0.059	3.00	0.42	0.000001
log soil	log K_{ow}					2	62.41	2.41	0.053	3.33		
log	log vp	log				3	62.4	2.46	0.052	3.41		

Table B2: Top models found by using AIC analysis N=123. molecular weight = mw vapour pressure=vp

factor 1	factor 2	factor 3	factor 4	factor 5	factor 6	df	AIC_c	ΔAIC_c	Akaike weight	Ratio	R^2	p<<
soil		K_{oc}					6					
log soil	log vp	mw				3	63.01	3.01	0.039	4.49		
log soil	log vp	log K_{ow}	log Koc			4	63.05	3.04	0.039	4.58		
log soil						1	63.33	3.32	0.034	5.26	0.40	0.000001

Figure B1: Model fit for the best AIC model: log soil DT_{50}, log water solubility and log vapour pressure (R^2= 0.43 p<<0.00001). Some of the worst outliers are identified: 7 Anilazine; 41 Dieldrin; 50 Endrin: 43 Diflubenzuron; 76 Methomyl; 90 Naled.



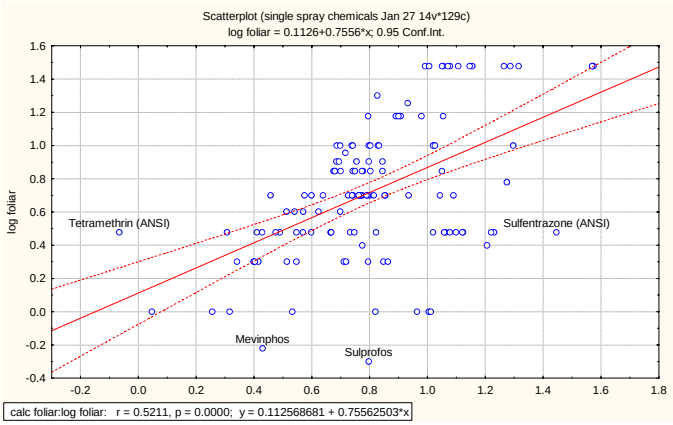
The equation for the best model was:

Log foliar DT_{50}= -0.024 +0.41* log soil DT_{50} + 0.023* log solubility - 0.031*log vp

Despite the higher AIC_c score, the inclusion of water solubility and vapour pressure in the model only added 3% to the explained variance. Indeed, for the 5 pesticides for which we used the model to predict foliar DT_{50}, we obtained the same answer whether we used the full model or soil DT50, once the answer was rounded to the nearest day.

The validation set of data included 129 chemicals not used in Canada. The best model from table 2 was used to predict foliar half life in the validation set. There was a significant relationship between calculated and observed foliar half life although only 27% of overall variance was explained by the model (r^2=0.27 $p<0.000001$; see figure B2).

Figure B2: Observed log foliar DT_{50} vs. calculated log foliar DT_{50} of the validation set, for chemicals not used in Canada. Some of the most obvious outliers are identified.



Appendix C: Details of calculation of risk measure

A) Avian chronic risk

- For every a.i. the lowest NOAEC (measured as mg pesticide a.i./ kg food) for each of the two species – Bobwhite and Mallard was retained as the value of interest. In some cases, tests were repeated, often because the first studies failed to detect a true NOAEC. Taking the smaller value for each species / a.i. combination increased the chances that a true NOAEC would be retained. Typically, two species only are tested for reproductive effects. A few tests have been carried out on the Japanese quail but not in sufficient numbers to meet our purpose.

- In some cases, a NOAEC was not available but a LOAEC was provided. We compiled available NOEACs and LOEACs from the USEPA one liner database (B. Montague pers. comm.) and calculated that the median spacing between the log NOAEC and log LOAEC was 1.23 based on a sample of 272 studies. This ratio was therefore used to obtain a NOAEC where the lowest level tested produced an effect. This may underestimate toxicity, especially for compounds of high toxicity.

- The NOAEC has been criticised as a toxicological endpoint, especially in the context of aquatic toxicity testing and we fully agree with this criticism. However, it is currently not feasible to extract an ECx type of value from the current avian reproduction tests. Furthermore, NOAEC values are commonly compiled by some jurisdictions (e.g. the USEPA) and made public. This is therefore the best chance we have to minimise data gaps. The limitations of the current avian reproduction test have been discussed in detail in Mineau et al. (1994) and Mineau (2005).

- In the usual reproduction study, Bobwhites (weight 210 g; unpublished industry

studies) have a peak food consumption of approximately 10% of their bodyweight in food per day; measured food intakes for Mallards (approx. 1000g) are highly variable and peak above 20% of bodyweight (unpublished industry studies). This is counter to expected allometric relationships where, the smaller the bird, the larger its proportional food intake. Mallards in the laboratory tend to spill a lot of food and it is therefore difficult to estimate their true consumption. As verification, the allometric equation of Nagy (1987) for non-passerine birds was used to estimate food consumption even though it is recognised that Nagy's algorithms apply to birds in the wild. One expects wild birds to have higher maintenance requirements than birds kept in the laboratory. On the other hand, the birds in the laboratory are induced to lay an unreasonable clutch size which is likely to increase their food intake compared to an equivalent bird in the wild.

- Dry food intake = $0.302 * bw(g)^{0.751}$
- Laboratory diet was estimated to have 11% moisture content based on a personal communication from Joann Beavers with Wildlife International, one of the major testing laboratories.
- Therefore, for the Bobwhite intake of lab diet (actual weight) should be:

  Intake = $(0.302 * 210^{0.751})/0.89$ (propn. dry wt.) = ~ 19 g

  …. which is approximately 90% of the observed 10% of bodyweight.

- For the Mallard, the same formula returns a value of 61 g/day or a little over 6% of its bodyweight per day rather than the observed 20%. Because of the spillage problem

mentioned previously, and assuming the figure of 21 g per day (10% of bodyweight) in the Bobwhite to be correct, we adjusted the result of the Nagy calculation by the same proportionate amount – raising the approximate food intake in the Mallard to 67 g/day.

- Ideally, food intake rates should be obtained from the actual study. This is not possible however; the estimated food intakes of 21 g/day or 67 g/day for the Bobwhite and Mallard respectively were used to convert all NOAEC values to NOAELs (critical pesticide intake levels) expressed as mg a.i. of pesticide / kg bird / day.

- Therefore:

  $NOAEL_{mallard}$ (mg a.i./kg bw/day) = ($NOAEC_{mallard}$ (mg/kg food) * 0.067 kg food/day) / 1 kg bw

  $NOAEL_{bobwhite}$ (mg a.i./kg bw/day) = ($NOAEC_{bobwhite}$ (mg/kg food) * 0.021 kg food/day) / 0.210 kg bw

- A geometric mean of $NOAEL_{mallard}$ and $NOAEL_{bobwhite}$ was calculated.

- In order to use the compound-specific interspecies variation in acute toxicity, we derived standard deviations (SDs) for acute data in the following way:

  - A single geometric mean log LD50 value was obtained for each species-pesticide combination as outlined in Mineau (2001b).

  - Where the number of species tested was 4 or more, we derived a SD. This was only possible for 38 of the 207 active ingredients, primarily the more acutely-toxic

insecticides. For all other a.i.s, a pooled SD of 0.465 (after Aldenberg and Luttik 2002) was used.

- The extrapolation factor (a factor to be applied multiplicatively to the mean untransformed NOAEL) was defined as follows after Aldenberg and Luttik 2002):

$EF^{median} = (10^{\sigma})^{Kp}$

… where Kp is the z score of 1.64 in the case of the 5% tail of a normally-distributed species sensitivity distribution. This is equivalent to:

$EF^{median} = 44.14^{\sigma}$ … or to an extrapolation factor of 5.8 for the pooled variance estimate of bird acute data.

- The median extrapolation factor (EF) was then applied to the geometric mean NOAEL in order to obtain the critical toxic effect level for a sensitive bird at the 5% of the putative distribution of reproductive toxicities.

- This critical level was then converted back to a food residue equivalent, assuming a 15g insectivorous bird based on the allometric equation for passerine species (Nagy 1987), and assuming that insects have approximately 70% water content.

Note: The exact parameters of the scenario could be debated (and are) at length. However, these are not critical if we are only interested in a relative ranking of products. However, we chose values in common use in risk assessment calculations so as to provide reasonable values in line with those that would be obtained by regulatory bodies in North America or Europe. For example, the latest EU guidance (Council Directive 91/414/EEC, dated 25 September 2002) bases

some of its risk assessments on a 10g insectivorous songbird. Based on a slightly more circuitous calculation of daily energy intake, caloric value of insects and assimilation efficiency, they arrive at an estimated food intake/body weight ratio of 1.04 – or 15.6 g insect fresh weight per day. Our value is slightly lower, and therefore leads to an assessment that is less protective.

- $Intake_{15\ g\ insectivore} = (0.398 * 15^{0.850})/0.30 = 13.2$ g insects (FW)/day
- Critical residue concentration C_t (mg a.i. / kg fw insects) = $NOAEL_{15\ g\ songbird,\ 5\%\ tail}$ (mg a.i./kg bw/day) * 0.015 kg bw / 0.0132 kg fw insects / day

- The initial insect concentration after application was estimated from the application rate and a Residue per Unit dose factor of 29 – i.e. expecting about 29 ppm for a 1 kg a.i./ha application. This is the number currently recommended in the European guidance document for bird and mammals chronic assessments (European council 2002). There have been many proposals other than this value and the measurement of insect residues after spray is the subject of intensive study in the EU currently.

- The ratio of initial to critical insect concentration can be computed as the first risk measure.

- The final calculation entails estimating the amount of time needed for insect residues to drop from Co to Ct, assuming first order loss rate and using the foliar DT50 as the best estimate of residue persistence.
  - If Co < Ct, risk = 0, which is 0 days

- If Co > Ct, measure the number of days required to drop to Ct given the foliar half life.

Measure removal rate K from foliar half life ($t_{1/2}$)

$$K = \frac{\ln (0.5)}{-t_{1/2}}$$

…. and the critical time $T_c = (\ln (Co / Ct)) / -k$ …… measured in days.

- Foliar DT50 estimates were obtained from the USDA as described in Appendix B. Where the foliar DT50 was not available but a soil half-life value was, we estimated the former by means of the regression equation:

Log foliar half life = -0.024 + (0.41 * Log soil half life) + (0.023 * log solubility) – (0.031 * log VP)

B) Mammalian acute risk

- For the mammalian scenario, we used the small herbivorous mammal (vole) scenario outlined in the EU guidance document (European Commission 2002).

- This scenario assumes a 25 g animal with a daily energy requirement of 68 kj/day. Given a diet of cereal shoots with an energy content of 18 kj/g dry weight, moisture content of 76.4% and assimilation efficiency of 46%, this scenario results in a net consumption of ~ 35 g fresh weight per day or 139% of body weight per day (European Commission op. cit.). Again, the exact scenario used will not result in rankings being changed.

- From the same source, we used suggested residue per unit dose values of 142 ppm and 76 ppm for acute and chronic exposure respectively.

- Dietary intake (over 24hrs) = 35 g foliage/day * application rate (kg ai/ha) * 142 (µg residue/g foliage/kg ai/ha) = X (µg residue/day)

- Effect level is estimated as ….

  HD_5 (in mg/kg body weight) * 0.025 kg bw * 1000 = µg residue

  The Risk Quotient = $\frac{\text{Exposure (in µg residue/day)}}{\text{Effect (µg residue)}}$

C) Mammalian chronic risk

- The cPAD is given in mg/kg bw/day. Based on the above scenario for the 25 g herbivore, this value was transformed to a foliage residue level.

- The ratio of dietary intake at peak residue levels and the cPAD (Community Population Adjusted Dose) is the first risk measure.

- In a manner analogous to the above description for the avian chronic risk, the second risk measure is the number of days that residues in the environment remain above a concentration in cereal foliage which corresponds to the EPA-determined ($CPAD_{chronic}$) for daily intake in a 25 g herbivore. Residue decline is based on the foliar half-life of the pesticide.

Ct (critical toxicity level) = cPAD in mg/kg bw/day

$$= \frac{\text{cPAD} * 0.025 \text{ kg} * 1000}{\text{35 g foliage/day}} = \text{critical conc. in µg a.i./g foliage}$$

If Co < Ct, risk = 0, which is 0 days

If Co > Ct, measure the number of days

Measure removal rate K from half life $t_{half.}$

$$K = \frac{\ln(0.5)}{-t_{half}} \text{ (foliar)}$$

$$\text{Critical time } T_c = \frac{\ln\left(\frac{Co}{Ct}\right)}{-K} \text{ in days}$$

For seed treatments and granulars, the risk is calculated in an analogous fashion to that calculated in birds – by computing the number of particles needed to reach either the acute or chronic toxicity threshold.

APPENDIX D: Summary of the different risk measures used in this report.

		Model species		Exposure	Toxicity endpoint		Risk	
		Body weight	Diet		Measure	Detail	Measure	Field Validation
Bird acute risk	Liquid applications	20-1000g	Variable	Based on application rate. Results indicate that dermal input is very important but exposure per se is not quantified in this field-based approach.	HD5 corrected for scaling	Calculated based on Mineau et al. (2001b)	Likelihood of observable avian mortality based on modeling of field studies	Field studies on foliar pesticide applications. Need of adjustment factors for applications to bare soil, especially if incorporated.
Bird acute risk	Granular or seed treatments	15g	Variable	Amount of a.i. per particle estimated	HD5 corrected for scaling	Calculated based on Mineau et al. (2001b)	Number of particles needed to reach toxicity endpoint	Many field cases but risk confounded by granule base, seed type etc…
Bird chronic risk	Liquid applications	15g	Insectivore	Residue intake calculated immediately after pesticide application	Estimated reproductive threshold: Critical daily residue intake to achieve NOAEL.	Based on available repro NOAELs corrected for acute inter-species variance	Exposure to Toxicity ratio and number of days residues remain above reproductive threshold	NO
Bird chronic risk	Granular or seed treatments	15g	Variable	Amount of a.i. per particle estimated	Estimated reproductive threshold: Critical daily residue intake to achieve NOAEL.	Based on available repro NOAELs corrected for acute inter-species variance	Number of particles needed to reach toxicity endpoint	NO

		Model species		Exposure	Toxicity endpoint		Risk	
		Body weight	Diet		Measure	Detail	Measure	Field Validation
Mammalian acute risk	Liquid applications	25g	Herbivorous	A day's worth of ingestion of contaminated broadleaf foliage (EU scenario)	Median estimate of 5% tail of acute toxicity distribution for mammals	Calculated from ETX 2.0	Typical Hazard quotient	Mark-recapture studies with small mammals
Mammalian acute risk	Granular or seed treatments	25g	Variable	Amount of a.i. per particle estimated	Median estimate of 5% tail of acute toxicity distribution for mammals	Calculated from ETX 2.0	Number of particles needed to reach toxicity endpoint	NO but some evidence that mammals not attracted to non-organic granule bases
Mammalian chronic risk	Liquid applications	25g	Herbivorous	Residue intake calculated immediately after pesticide application	Chronic Population Adjusted Dose (cPAD)	Based on available compilation of USEPA data	Exposure to Toxicity ratio and number of days residues remain above cPAD	NO
Mammalian chronic risk	Granular or seed treatments	25g	Variable	Amount of a.i. per particle estimated	Chronic Population Adjusted Dose (cPAD)	Based on available compilation of USEPA data	Number of particles needed to reach cPAD	NO

APPENDIX E: Final Chronic Toxicity Indices for Birds and Mammals

Where exposure is lower than critical thresholds or where residues persist above threshold for <1 day, this is indicated by a 0 value.

Blank cells denote missing information.

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
ACA	Acifluorfen (form not specified)	3.688	1.787	1.386	1.362
ACP	Acephate	5.351	1.648	2.420	1.303
AME	S-Metolachlor			0.376	0.939
AMI	Amitrole			1.959	1.512
AMN	Aminoethoxyvinylglycine				
AMZ	Amitraz	4.849	1.207	2.434	0.908
ASS	Imazamethabenz (form not specified)	2.923	2.242		
ATR	Atrazine	4.081	1.831	1.468	1.387
AVG	Difenzoquat (methyl sulphate salt)	2.652	2.422		
AZY	Azoxystrobin	2.217	1.344	0.000	0.000
BAD	6-Benzyladenine				
BAX	Metribuzin	4.262	1.850	1.599	1.424
BET	Bensulide	5.152	2.710	2.688	2.428
BMS	Flusilazole	3.780	2.269		
BRY	Bromoxynil (octanoate)	3.251	1.510	0.492	0.690
BTL	Desmedipham	3.274	1.735	0.808	1.128
BZN	Bentazon (form not specified)	4.580	1.483	1.800	1.078
CAB	Carbaryl	4.869	2.054	1.302	1.481
CAF	Carbofuran	4.404	1.466	2.676	1.250
CAP	Captan	4.006	1.425	1.809	1.080

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
CCC	Chlormequat (form not specified)				
CFP	Clodinafop-propargyl	5.389	1.479	0.000	0.000
CFZ	Clofentezine	3.387	1.750	0.782	1.113
CHE	Chlorimuron-ethyl	1.677	1.922	0.000	0.000
CHH	Boscalid	2.417	2.123	0.252	1.141
CHL	Chlorthal (form not specified)				
CLE	Clethodim	2.983	1.841	0.000	0.000
CLM	Cloransulam (form not specified)	1.568	1.540		
CNQ	Clomazone	2.147	1.330	0.211	0.322
CSL	Chlorsulfuron	1.376	2.137	0.000	0.000
CUS	Copper (copper sulphate)				
CUY	Copper (copper oxychloride)				
CUZ	Copper (copper hydroxide)			1.261	2.460
CYH	Cyhalothrin-lambda	3.384	1.750	0.031	0.000
CYM	Cypermethrin	4.001	1.823	1.537	1.407
CYO	Cymoxanil	3.232	1.589	0.342	0.614
CYP	Cyprodinil	3.296	1.804	0.144	0.443
CYZ	Cyromazine	3.595	2.554	0.364	1.560
DBR	Deltamethrin	4.324	1.634	0.000	0.000
DCB	Dichlobenil	4.802	1.902	2.040	1.530
DCF	Dicofol	5.828	1.889	3.053	1.608
DFF	Diflufenzopyr (form not specified)	1.364		0.000	
DIA	Diazinon	6.787	1.955	3.399	1.655
DIC	Dicamba (form not specified)	3.905	2.067	0.740	1.345
DIH	Dichlorprop (form not specified)				
DIK	Dichloran	5.144	1.835		

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
DIM	Dimethoate	5.705	1.755	2.356	1.371
DIN	Dinocap	3.923	2.018		
DIQ	Diquat (form not specified)	4.367	2.639	2.603	2.414
DME	Dimethomorph	2.376	1.749	0.223	0.722
DOD	Dodine (dodecylguanidine monoacetate)	4.746	2.198	1.194	1.599
DPA	Diphenylamine	3.858	1.220		
DPB	2,4-DB (form not specified)	4.259	1.850		
DPI	Clopyralid	2.149	1.155	0.000	
DPP	Diclofop-methyl	4.659	2.093	0.955	1.405
DPY	Rimsulfuron	0.287	0.456	0.000	0.000
DUB	Chlorpyrifos	7.245	1.859	2.480	1.393
DUR	Diuron	5.455	2.735	1.904	2.278
DXA	2,4-D (acid)	4.459	1.870	0.285	0.675
DXB	2,4-D (unspecified amine salt)				
DXF	2,4-D (unspecified ester)				
DYR	Anilazine	5.950	1.296		
EFR	Ethalfluralin	4.567	1.783	0.405	0.731
ENT	Endothall (form not specified)	3.857	1.953	1.345	1.495
EPT	EPTC	5.458	1.736		
ESF	Endosulfan	5.898	1.769	2.172	1.335
ETF	Ethephon	4.294	1.853		
ETM	Ethametsulfuron (form not specified)	0.000			
ETS	Ethofumesate	3.019	2.001	0.358	1.075
FAA	N-Decanol				
FAB	N-Octanol				

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
FAD	Famoxadone	4.199	1.912	0.949	1.265
FAL	Fosetyl-al	2.277	-0.121		
FBZ	Indar			0.000	
FED	Fenamidone	4.722	2.247	0.000	0.000
FER	Ferbam				
FEX	Fenhexamid	2.722	1.215	0.000	
FLD	Fludioxonil	0.825	1.611	0.000	0.000
FLM	Flumetsulam	0.873	1.657	0.000	0.000
FLR	Fluroxypyr 1-methylheptyl ester			0.000	0.000
FLS	Flucarbazone-sodium	0.920	1.386	0.000	0.000
FLT	Flufenacet	4.324	2.059	0.867	1.361
FLZ	Fluazinam	3.227	1.858	0.040	0.000
FMS	Foramsulfuron	0.000		0.000	0.000
FOF	Fomesafen	4.006	2.060	0.958	1.438
FOL	Folpet	3.768	1.631	0.400	0.656
FOM	Formetanate (form not specified)	5.337	2.726	2.149	2.331
FOR	Formaldehyde	2.797	1.308		
FPF	Fenoxaprop-p-ethyl	3.628	1.832		
FRA	Florasulam			0.000	
FZA	Fluazifop-p-butyl	3.421	1.658		
GLG	Glufosinate ammonium	4.245	1.751	0.657	0.941
GOO	Azinphos-methyl	5.197	1.538	2.510	1.222
GPI	Glyphosate (isopropylamine salt)			1.936	1.206
GPM	Glyphosate (mono-ammonium salt)				
GPP	Glyphosate (potassium salt)				
GPS	Glyphosate (acid)	2.475	1.392		

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
GPT	Glyphosate (trimethylsulfonium salt)			1.508	
HEC	Hexaconazole	0.999	1.676	0.000	0.000
IDO	Iodosulfuron-methyl-sodium			0.000	0.000
IMI	Imidacloprid	3.239	1.509	1.055	1.022
IMP	Imazethapyr	3.604	2.555		
IMZ	Imazamox	0.000		0.000	0.000
IPD	Iprodione	3.339	1.744	0.958	1.202
IXF	Isoxaflutole	3.746	1.572	0.000	0.000
KRB	Propyzamide	3.472	2.363	0.746	1.695
KRS	Kresoxim-methyl	1.819	1.397	0.000	
LUN	Linuron	4.774	2.376	1.912	1.979
MAA	MCPA (acid)	5.090	2.131	0.415	1.042
MAB	MCPA (dimethylammine salt)				
MAE	MCPA (unspecified ester)	5.090	2.131		
MAH	Maleic hydrazide (form not specified)	3.156	2.020		
MAL	Malathion	4.217	1.624	0.880	0.943
MAN	Maneb	4.739	1.674	1.674	1.222
MAS	MCPA (potassium salt)				
MBS	MCPB (sodium salt)				
MCZ	Mancozeb	5.404	2.254	2.019	1.827
MEA	Mecoprop (potassium salt)				
MEC	Mecoprop (form not specified)				
MEI	Dimethenamid	4.550	1.904	0.579	1.009
MEM	Metsulfuron-methyl	0.787	1.895	0.000	0.000
MER	Mesotrione	4.337	1.928	0.000	0.000
MEW	Mecoprop d-isomer (potassium salt)				

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
MEX	Tribenuron methyl	3.393	1.654	0.276	0.565
MEZ	Mecoprop d-isomer (amine salt)				
MFN	Metalaxyl-m (mefenoxam)	3.166	1.589		
MML	Methomyl	4.407	0.865	1.751	0.464
MMM	Thifensulfuron-methyl			0.254	0.404
MOM	Methamidophos	6.066	1.906	2.015	1.428
MOR	Chinomethionat			1.726	1.759
MPR	(S)-Methoprene	1.798	1.309	1.434	1.211
MTL	Metolachlor	3.355	1.746	2.494	1.617
MTR	Metiram	6.227	2.161	1.741	1.607
MXF	Methoxyfenozide	2.404	2.133	0.000	
MYC	Myclobutanil	2.759	2.164	0.614	1.511
NAA	1-Naphthalene actetic acid (form not specified)				
NAL	Naled	5.001	1.919	1.199	1.299
NAP	Naptalam (form not specified)	4.156	1.985		
NBP	Napropamide	3.849	2.283	1.172	1.766
NIO	Nicosulfuron	0.325	0.733		
NXI	Acetamiprid	2.397	1.592	0.461	0.876
OXB	Oxamyl	5.374	1.854	1.911	1.405
OXR	Oxyfluorfen	4.242	2.052	1.451	1.586
PAQ	Paraquat (form not specified)	4.546	2.656		
PEN	Pendimethalin	3.060	2.484	0.646	1.809
PFL	Permethrin	3.722	1.995	2.282	1.783
PFN	Picolinafen			0.000	
PHS	Phosalone	4.518	2.079		

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
PHY	Propamocarb hydrochloride	2.950	2.167	0.000	
PIC	Picloram (form not specified)	3.057	1.910		
PID	Picloram (triisopropanolamine salt)				
PIR	Pirimicarb			0.529	1.090
PMP	Phenmedipham	2.478	1.615	0.000	
PON	Propiconazole	2.302	2.361	0.000	0.000
PRI	Primisulfuron-methyl	2.722	1.801	0.000	0.000
PRO	Prometryne	3.953	2.118	1.242	1.615
PRT	Phosmet	4.255	1.627	2.398	1.378
PSF	Prosulfuron	1.721	1.234	0.000	
PYA	Pyraclostrobin	3.334	1.917	0.000	0.000
PYD	Pyridaben	4.057	1.607	0.491	0.690
PYR	Pyrethrins	1.217	1.607		
PYZ	Pyrazon (chloridazon)				
PZN	Pymetrozine	3.894	2.074	0.243	0.870
QPE	Quizalofop p-ethyl				
QTZ	Quintozene	4.774	1.802	0.116	0.187
QUC	Quinclorac	1.514	1.179	0.000	0.000
SLF	Sulfosulfuron	0.950	1.575	0.000	0.000
SMZ	Simazine	5.057	1.924	2.341	1.590
SOD	Sethoxydim	3.572	1.551	0.640	0.805
SPI	Spinosad	2.619	1.626	0.000	0.000
SUL	Sulphur				
TCM	2-(Thiocyanomethylthio)benzothiazole	3.288	1.345		
TER	Terbacil	4.466	2.648	0.386	1.585

PMRA AI Code	AI Accepted Name	Mammal Log exceedance of cPAD	Mammal - Time (log days) of cPAD exceedance	Avian Log exceedance of repro NOEC	Avian - Time (log days) of repro NOEC exceedance
TET	Chlorothalonil	4.486	1.872	2.173	1.557
TEU	Tebuconazole	2.647	2.034	0.204	0.920
TFS	Triflusulfuron methyl	2.187	1.338	0.000	
TFY	Trifloxystrobin	2.532	1.963	0.000	0.000
TFZ	Tebufenozide	3.227	1.507	0.218	0.337
THI	Thiram	5.597	2.172	2.805	1.872
TPA	Tepraloxydim	1.944	1.846	0.000	0.000
TPM	Thiophanate-methyl	2.789	1.666	1.362	1.354
TPR	Triclopyr	3.909	2.077	1.843	1.750
TRA	Tralkoxydim	3.625	1.618	0.384	0.642
TRF	Trifluralin	3.948	1.595	2.864	1.456
TRI	Trichlorfon	6.227	1.793	2.292	1.359
TRL	Triallate	3.969	2.296	1.215	1.782
TRR	Triforine	3.393	1.751	0.671	1.047
TRS	Triasulfuron	2.417	1.882	0.000	0.000
TRT	Triticonazole	0.571	1.381	0.000	0.000
TZL	Thiabendazole	3.023	2.479	1.356	2.131
VIL	Vinclozolin	4.944	1.693	1.877	1.272
VPR	Hexazinone	3.631	2.559	1.565	2.193
ZIN	Zineb				
ZIR	Ziram				
ZOX	Zoxamide	1.692	1.401	0.000	0.000

Appendix F: Tabulated HD5 values for birds and HC5 values for mammals.

AI Code	AI Accepted Name	Avian HD5 (oral) mg/kg bw	HD5 Mammals (oral) mg/kg bw
ACA	Acifluorfen (form not specified)	99.64	389.61
ACP	Acephate	18.52	121.14
AME	S-Metolachlor	241.81	683.42
AMI	Amitrole	531.35	1889.01
AMN	Aminoethoxyvinylglycine	14.00	1278.86
AMZ	Amitraz	41.83	274.74
ASS	Imazamethabenz (form not specified)	223.73	1213.24
ATR	Atrazine	408.98	448.54
AVG	Difenzoquat (methyl sulphate salt)	152.00	33.93
AZY	Azoxystrobin	232.29	1278.86
BAD	6-Benzyladenine	185.71	409.96
BAX	Metribuzin	42.01	188.36
BET	Bensulide	160.98	107.79
BMS	Flusilazole	153.18	218.49
BRY	Bromoxynil (octanoate)	210.03	55.84
BTL	Desmedipham	208.12	1831.05
BZN	Bentazon (form not specified)	32.40	215.16
CAB	Carbaryl	30.10	139.65
CAF	Carbofuran	0.21	3.05
CAP	Captan	25.32	2053.37
CCC	Chlormequat (form not specified)	53.57	10.68
CFP	Clodinafop-propargyl	168.99	484.60
CFZ	Clofentezine	493.60	810.48
CHE	Chlorimuron-ethyl	241.81	1049.18
CHH	Boscalid	9999.00	no data
CHL	Chlorthal (form not specified)	261.32	2859.62
CLE	Clethodim	232.29	494.38
CLM	Cloransulam (form not specified)	261.32	1278.86
CNQ	Clomazone	261.19	431.29
COD	Clothianidin	41.51	no data
COY	Terbufos	0.16	no data
CSL	Chlorsulfuron	481.70	725.76
CUS	Copper (copper sulphate)	43.89	no data
CUY	Copper (copper oxychloride)	45.95	183.36
CUZ	Copper (copper hydroxide)	219.11	70.87
CYH	Cyhalothrin-lambda	428.10	9.33

AI Code	AI Accepted Name	Avian HD5 (oral) mg/kg bw	HD5 Mammals (oral) mg/kg bw
CYM	Cypermethrin	1072.00	156.10
CYO	Cymoxanil	274.81	304.05
CYP	Cyprodinil	208.12	511.55
CYZ	Cyromazine	604.60	552.54
DAZ	Dazomet	53.33	128.83
DBR	Deltamethrin	97.09	28.76
DCB	Dichlobenil	79.33	450.75
DCF	Dicofol	72.37	334.74
DFF	Diflufenzopyr (form not specified)	541.43	no data
DFZ	Difenoconazole	207.13	436.02
DIA	Diazinon	0.59	50.13
DIC	Dicamba (form not specified)	62.26	439.42
DIH	Dichlorprop (form not specified)	48.65	no data
DIK	Dichloran	93.65	574.70
DIM	Dimethoate	5.78	94.69
DIN	Dinocap	249.71	no data
DIQ	Diquat (form not specified)	17.81	30.04
DME	Dimethomorph	208.12	1076.47
DOD	Dodine (dodecylguanidine monoacetate)	110.02	140.02
DPA	Diphenylamine	261.32	244.56
DPB	2,4-DB (form not specified)	178.40	206.16
DPI	Clopyralid	141.14	1119.15
DPP	Diclofop-methyl	555.00	238.56
DPY	Rimsulfuron	261.32	1278.86
DUB	Chlorpyrifos	3.76	55.18
DUR	Diuron	193.04	869.63
DXA	2,4-D (acid)	132.90	127.14
DXB	2,4-D (unspecified amine salt)	32.40	no data
DXF	2,4-D (unspecified ester)	63.87	184.68
DYR	Anilazine	315.99	285.57
EFR	Ethalfluralin	232.29	1278.86
ENT	Endothall (form not specified)	24.19	12.29
EPT	EPTC	25.32	559.82
ESF	Endosulfan	9.53	2.79
ETF	Ethephon	372.20	915.58
ETM	Ethametsulfuron (form not specified)	261.32	1896.86
ETS	Ethofumesate	485.67	6.00

AI Code	AI Accepted Name	Avian HD5 (oral) mg/kg bw	HD5 Mammals (oral) mg/kg bw
FAA	N-Decanol	447.00	4603.91
FAB	N-Octanol	447.00	no data
FAD	Famoxadone	261.32	1278.86
FAL	Fosetyl-al	785.42	1245.43
FBZ	Indar	271.16	no data
FED	Fenamidone	232.29	814.47
FER	Ferbam	193.00	895.61
FEX	Fenhexamid	232.00	1278.86
FLD	Fludioxonil	208.12	1278.86
FLM	Flumetsulam	261.32	1278.86
FLR	Fluroxypyr 1-methylheptyl ester	232.29	1278.86
FLS	Flucarbazone-sodium	232.29	1278.86
FLT	Flufenacet	186.76	312.42
FLZ	Fluazinam	206.97	1278.86
FMS	Foramsulfuron	232.29	1278.86
FOF	Fomesafen	481.70	406.82
FOL	Folpet	235.52	2301.95
FOM	Formetanate (form not specified)	5.19	4.85
FOR	Formaldehyde	82.21	45.73
FPF	Fenoxaprop-p-ethyl	193.05	961.33
FRA	Florasulam	101.06	1534.64
FZA	Fluazifop-p-butyl	339.88	809.22
GLG	Glufosinate ammonium	248.45	153.36
GOO	Azinphos-methyl	2.28	5.53
GPI	Glyphosate (isopropylamine salt)	232.00	1365.45
GPM	Glyphosate (mono-ammonium salt)	192.00	no data
GPP	Glyphosate (potassium salt)	144.33	no data
GPS	Glyphosate (acid)	232.29	1551.91
GPT	Glyphosate (trimethylsulfonium salt)	144.33	228.75
HEC	Hexaconazole	391.14	364.47
IDO	Iodosulfuron-methyl-sodium	218.50	684.96
IMI	Imidacloprid	8.43	65.73
IMP	Imazethapyr	223.73	1278.86
IMZ	Imazamox	214.40	1278.86
IPD	Iprodione	158.40	957.01
IXF	Isoxaflutole	249.71	1278.86
KRB	Propyzamide	733.08	2116.95

AI Code	AI Accepted Name	Avian HD5 (oral) mg/kg bw	HD5 Mammals (oral) mg/kg bw
KRS	Kresoxim-methyl	580.72	1278.86
LUN	Linuron	65.87	230.03
MAA	MCPA (acid)	39.23	187.74
MAB	MCPA (dimethylammine salt)	55.53	187.74
MAE	MCPA (unspecified ester)	289.58	no data
MAH	Maleic hydrazide (form not specified)	216.76	1278.86
MAL	Malathion	139.10	417.98
MAN	Maneb	345.34	1413.45
MAS	MCPA (potassium salt)	39.23	187.74
MBS	MCPB (sodium salt)	32.75	176.48
MCZ	Mancozeb	710.95	1638.54
MEA	Mecoprop (potassium salt)	82.11	no data
MEC	Mecoprop (form not specified)	82.11	no data
MEI	Dimethenamid	221.60	540.50
MEM	Metsulfuron-methyl	291.52	1278.86
MER	Mesotrione	500.96	1278.86
MET	Methoxychlor	291.52	673.17
MEW	Mecoprop d-isomer (potassium salt)	71.40	no data
MEX	Tribenuron methyl	261.32	1278.86
MEZ	Mecoprop d-isomer (amine salt)	69.92	no data
MFN	Metalaxyl-m (mefenoxam)	137.00	158.59
MML	Methomyl	8.46	8.55
MMM	Thifensulfuron-methyl	291.52	1278.86
MOM	Methamidophos	1.70	5.91
MOR	Chinomethionat	126.58	440.13
MPR	(S)-Methoprene	192.68	625.23
MTA	Metalaxyl	89.09	323.05
MTL	Metolachlor	241.81	711.05
MTR	Metiram	249.71	1490.11
MXF	Methoxyfenozide	261.32	1278.86
MYC	Myclobutanil	59.23	743.97
NAA	1-Naphthalene actetic acid (form not specified)	291.52	326.29
NAL	Naled	8.14	53.00
NAP	Naptalam (form not specified)	447.01	328.31
NBP	Napropamide	78.03	1463.95
NIO	Nicosulfuron	241.59	1278.86
NXI	Acetamiprid	20.91	47.14

AI Code	AI Accepted Name	Avian HD5 (oral) mg/kg bw	HD5 Mammals (oral) mg/kg bw
OXB	Oxamyl	0.78	1.15
OXR	Oxyfluorfen	614.58	1422.69
PAQ	Paraquat (form not specified)	41.19	13.93
PEN	Pendimethalin	137.00	613.38
PFL	Permethrin	3127.00	328.32
PFN	Picolinafen	261.32	1278.86
PHR	Phorate	0.34	0.85
PHS	Phosalone	106.27	45.49
PHY	Propamocarb hydrochloride	324.12	621.09
PIC	Picloram (form not specified)	216.76	1231.78
PID	Picloram (triisopropanolamine salt)	216.76	1231.78
PIR	Pirimicarb	6.78	31.87
PMP	Phenmedipham	425.08	1446.87
PON	Propiconazole	296.80	384.54
PRI	Primisulfuron-methyl	249.71	1291.65
PRO	Prometryne	447.00	444.58
PRT	Phosmet	1.24	21.11
PSF	Prosulfuron	108.34	283.61
PYA	Pyraclostrobin	248.00	1278.86
PYD	Pyridaben	279.50	106.63
PYR	Pyrethrins	963.39	172.85
PYZ	Pyrazon (chloridazon)	386.10	512.57
PZN	Pymetrozine	208.12	1488.60
QPE	Quizalofop p-ethyl	232.29	373.05
QTZ	Quintozene	255.45	3069.27
QUC	Quinclorac	232.29	936.28
SLF	Sulfosulfuron	261.32	1278.86
SMZ	Simazine	965.25	1045.81
SOD	Sethoxydim	482.63	1066.34
SPI	Spinosad	170.00	1112.39
SUL	Sulphur	500.00	1278.86
TCM	2-(Thiocyanomethylthio)benzothiazole	76.75	no data
TEL	Tefluthrin	178.63	9.60
TER	Terbacil	262.37	552.73
TET	Chlorothalonil	296.00	1808.59
TEU	Tebuconazole	347.30	361.71
TFS	Triflusulfuron methyl	261.32	1278.86

AI Code	AI Accepted Name	Avian HD5 (oral) mg/kg bw	HD5 Mammals (oral) mg/kg bw
TFY	Trifloxystrobin	232.00	1278.86
TFZ	Tebufenozide	249.71	1278.86
THE	Thiamethoxam	98.40	399.77
THI	Thiram	36.81	142.55
TLL	Triadimenol	965.25	286.76
TPA	Tepraloxydim	232.29	1278.86
TPM	Thiophanate-methyl	482.63	979.87
TPR	Triclopyr	163.58	123.35
TRA	Tralkoxydim	290.94	222.09
TRF	Trifluralin	245.55	1017.04
TRI	Trichlorfon	13.36	105.13
TRL	Triallate	261.44	370.18
TRR	Triforine	776.70	1446.87
TRS	Triasulfuron	249.71	1278.86
TRT	Triticonazole	232.29	511.55
TZL	Thiabendazole	261.32	921.38
VIL	Vinclozolin	291.52	2801.85
VIT	Carbathiin	10.68	876.45
VPR	Hexazinone	261.96	308.35
ZIN	Zineb	212.54	1319.21
ZIR	Ziram	29.45	87.43
ZOX	Zoxamide	232.29	1278.86