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Environmental hazard/risk assessment of pesticides used in agriculture for birds and mammals. The Dutch concept. Part 1. Introduction and synopsis of the decision scheme.

R. Luttik

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Summary

This report is the first one of a series in which the methodology for hazard/risk assessment of the use of pesticides for birds and mammals will be presented. After a general introduction a synopsis of the developments of the last 10 years has been given. The presented hazard/risk assessment scheme is a compilation of all decision scheme concerning birds and mammals up to now in the Netherlands and consists of 5 modules. In module A one is lead stepwise by way of yes/no questions to the module that is applicable to the mode of use of a particular pesticide. In module B the exposure by granules, treated seeds, slug pellets or baits for rodents is considered. Module C deals with the exposure by pesticides used for spraying crops/plants and/or insects, module D with exposure by drinking water and module E with secondary poisoning. Exposure routes like inhalation or contact and other secondary poisoning pathways will be incorporated into the scheme as soon as available.
Furthermore, attention has been given to the considerations for the use of particular cutoff criteria and a description of the terms used in the scheme has been given.

Samenvatting

Dit rapport is het eerste van een serie waarin een methode voor de beoordeling van het risico van bestrijdingsmiddelen voor vogels en zoogdieren wordt gepresenteerd. Na een algemene introductie wordt een overzicht van de ontwikkelingen van de laatste 10 jaar gegeven. Het risicoschattingschema (beslisboom) bestaat voorlopig uit 5 modules. In module A wordt men met behulp van ja/nee vragen naar die module geleid die gezien de toepassingsmethode of gezien de expositieroute van toepassing is op het gebruikte bestrijdingsmiddel. Module B gaat in op de blootstelling via granulaten, behandeld zaad, slakkenkorrels en lokaas voor knaagdieren, module C behandelt de blootstelling via bespoten gewassen en/of insekten en module D gaat in op de blootstelling via drinkwater. Module E betreft blootstelling via de voedselketen (secondary poisoning).
Blootstelling via de lucht (inhalatie) of via contact en andere voedselketens dan beschreven in module E worden opgenomen in de beslisboom zodra deze gereed zijn. Het rapport besteed ook aandacht aan de overwegingen waarom een bepaald criterium wordt gehanteerd, daarnaast wordt een beschrijving gegeven van de termen die in de beslisboom worden gebruikt.

1 Introduction

1.1 Historical background

In 1975 the Dutch Pesticides Act of 1962 was amended to increase the possibilities of evaluating pesticides with regard to risks to the environment. Before that date, the environmental evaluation was only limited to an estimation of the risk of leaching. The reason was that authorities responsible for the registration of pesticides became increasingly aware of the consequences which regular input to the environment of chemical substances, including pesticides, can entail. Because of these changed insights into the environmental risks of pesticides, industry has carried out many studies since 1975. In addition to tests considered necessary for the registration before 1975, such as the route and the rate of conversion in soil and the risk of leaching from soil to ground water, it also became mandatory from 1980 onwards to provide data on the behaviour of pesticides in surface water, adsorption onto suspended solids and toxicity to aquatic organisms, such as algae, crustaceans and fish. This change in insights did not only take place in the Netherlands, but could also be noticed in many other West European countries and in the United States and Canada.
In the Netherlands several groups are or have been working on the development of new environmental standards, criteria or decision schemes:
- WOMB (Werkgroep Operationalisering Milieucriteria Bestrijdingsmiddelen): the task of this interdepartmental working group is to make general standards for soil, ground water and surface water ready for operation.
- Several ad hoc working groups of the Working-group on Environmental Effects (Steungroep M) of the Dutch Commission for Authorisation of Pesticides (CTB) which are developing hazard/risk assessment schemes for evaluating pesticides.
- USES (Uniform System for Evaluation of Substances) - Development of a decision supporting uniform system for priority setting and evaluation of chemical substances.
- DRANC (Dutch Risk Assessment system for New Chemicals) - Development of an evaluation system for the risk of new chemical compounds for humans and for the environment (incorporated in USES).

This report presents a method to assess the hazard/risk for birds and mammals for the use of pesticides in agriculture and the following survey of the developments of the last 10 years is therefore restricted to birds and mammals.

Until recently the evaluation of pesticides with regard to birds in the Netherlands was only limited to a classification of the toxicity of the compound. This classification is based on compound characteristics and does not give an estimation of the risk of the use of pesticides for birds. Mammalian toxicity data were only used for the risk assessment for human beings. Incidentally steps were undertaken to reduce or to prevent the risk for birds and mammals when using a particular pesticide. For instance the use of chlorinated hydrocarbons came under increased scrutiny because of environmental impacts, particularly to wildlife. Especially during the 1960s and 1970s a lot of research was carried out concerning the side-effects of chlorinated hydrocarbons on raptors (buzzards, sparrowhawks, kestrels and owls), terns, eiders and cormorants (de Snoo & Canters, 1987). A total prohibition of the use of DDT became operative in 1973 and for dieldrin in 1977. Before those bans particular methods of application were already forbidden, like the use of dieldrin for seed treatment after the occurrence of clear side-effects in the field. These measurements lead to - sometimes spectacular - recovery of the involved raptorial species. Because of bird mortalities in the field caused by organo-mercury dressings also these compounds were banned. The use of methiocarb for seed treatment is not allowed on small seeds (e.g. cereals) because this could lead to poisoning of small bird species (Aerts, 1985). Based on field incidents with parathion a note was written over the considerations by the evaluation of the toxicity of pesticides for birds when used for the control of leatherjackets (Jobsen & van Gestel, 1985). A method was described with which the risk of the use of parathion could be compared with other compounds used for the control of leatherjackets.

In 1986 the U.S.EPA published a report in which a method was described for assessing the ecological risk of the use of pesticides for fish, birds and mammals and in 1992 they published a report on the comparative analysis of acute avian risk from granular pesticides. In the Netherlands a first onset is given for assessing the risk for birds when eating contaminated fish (secondary poisoning) in the report "Catch-up operation on old pesticides: an integration" (Canton et al., 1990). In 1991 a general algorithm for risk-assessment on secondary poisoning was published. An analysis of two food chains was presented: water ==> fish ==> fish-eating birds or mammals and soil ==> earthworms ==> worm-eating birds or mammals (Romijn et al., 1991a and 1991b).
Within the framework of the European and Mediterranean Plant Protection Organization (EPPO) the development of a risk assessment scheme for terrestrial vertebrates started in 1991. After acceptation of the scheme by the EPPO Working Party and Council this scheme is sent to member governments for comment.

The results of these activities can be of importance for possible adaptations of the Uniform Principles by the European Communities. In the <u>draft</u> 'Commission

Proposal for a Council Directive establishing Annex VI of directive 91/414/-EEC concerning the placing of plant protection products on the market (2646/-VI/92-EN, Rev.2) the part concerning birds and mammals is formulated as follows:

'Member States shall evaluate the possibility of exposure of birds and other terrestrial vertebrates to the plant protection product under the proposed conditions of use; if this possibility exists they shall evaluate the degree of short term and long term risk, including on the reproduction, to be expected for these organisms after use of the plant protection product according to the proposed conditions of use.'

'If there is a possibility of exposure for birds and other non-target terrestrial vertebrates no authorization shall be granted if:

- the acute and short term toxicity/exposure ratio for birds and other non-target terrestrial vertebrates is less than 10, and the long term toxicity/exposure is less than 5 unless it is clearly established through an appropriate risk assessment that under field conditions no significant impact occurs after use of the plant protection product according to the proposed conditions of use;
- the bioaccumulation factor (BCF, related to fat tissue) is greater than 1 unless it is clearly established through an appropriate risk assessment that under field conditions no unacceptable effects - directly or indirectly - occur after use of the plant protection product according to the proposed conditions of use.'

1.2 Aim of the report

This report is the first one of a series in which the methodology for hazard/risk assessment of the use of pesticides for birds and mammals will be presented. In 1992 and 1993 the following reports will be published:

Environmental hazard/risk assessment of pesticides used in agriculture for birds and mammals. The Dutch concept.

Part 1 Introduction and a synopsis of the decision scheme
Part 2 Exposure by pesticides used for seed treatment
Part 3 Exposure by pesticides used for spraying crops
Part 4 Exposure by pesticides used in granules
Part 5 Repellency

Possible supplementary studies will deal with the following aspects:

- The number of available seeds and granules per unit area in relation to incorporation into the soil,

- The use of uncertainty factors for acute effect assessment (exposure 1 or several days) when only 1, 2 or 3 LD50s or LC50s are available for the assessment.
- Comparison of the empirical relation between the LD50 and the available amount of active ingredient per unit area and the behaviour of birds and mammals searching for food.

This report (part 1) describes the methodology for hazard/risk assessment of the use of pesticides in agriculture for birds and mammals in general. It is a compilation of all schemes concerning birds and mammals available up to now. In chapter 2 the decision scheme is presented and attention has been given to the considerations for the use of particular cutoff criteria and a description of the terms used in the scheme is presented. The discussion can be found in chapter 3 and the references in chapter 4.

2 Description of the decision scheme

2.1 Introduction

The decision scheme will be used to make an assessment of possible negative consequences of the use of pesticides for birds and mammals. Side-effects in the widest sense are effects on non-target organisms. There are two types of side-effects:
- toxic side-effects and
- ecological side-effects.

Two different types of toxic side-effects can be distinguished: direct and indirect side-effects. Direct toxic side-effects occur when besides the target organisms also non-target organisms are poisoned. This type of side-effects occurs predominantly if the pesticide has a wide scope of action. Indirect toxic side-effects are effects on organisms from a higher trophic level, when organisms of a lower trophic level are acting as a go-between (secondary poisoning). Especially for persistent pesticides this type of effect can be expected.
Ecological side-effects are effects which can not directly be related to poisoning of the non-target species. Such side-effects can be noticed as changes in the availability of food or changes in the structure of the habitat. Ecological side-effects via food can occur when for instance the pesticide influences the population density of prey items, i.e the food supplies (e.g. mice) of a particular raptorial species. Ecological side-effects via the habitat can occur by alterations of the structure of the vegetation (e.g disappearance of shelter places).
In practice different types of side-effects can be noticed at the same time. The hazard/risk of ecological side-effects is not covered by the decision scheme.

2.2 Decision scheme

A schematic reproduction of the decision scheme can be found in figure 1 to 5 on page 10 to 17. The decision scheme consists of 5 modules:

Module A	General module
Module B	Exposure by granules, treated seed, slug pellets or baits for rodents
Module C	Exposure by pesticides used for spraying crops
Module D	Exposure by drinking water
Module E	Secondary poisoning

In the modules 3 different types of boxes and two different types of arrows are used:

- boxes with a single line are steps in the scheme where a choice has to be made (yes/no possibilities),
- boxes with a double line are boxes where a statement is made or a reference to an other module is given,
- boxes with a double vertical line and a single horizontal line are boxes with conclusions about the degree of risk,
- double lined arrows are indicating the route which has to be followed in the scheme,
- single lined arrows are indicating that when a particular module has been runned one has to go back to the A module to look for other exposure possibilities.

In some cases in the risk assessment it is necessary to distinguish between birds and mammals. Because LC50 tests with mammals are almost never available, acute exposure can only be assessed with LD50-values. Mammals do not use grit for grinding food in the stomach, so this part of the scheme is only applicable to birds. Because of these differences between birds and mammals separate versions of module B, C and D are presented for each group.

2.2.1 Module A (general module)

In this module one is lead stepwise by way of yes/no questions to the module that is applicable to the mode of use of a particular pesticide. However it is possible that birds or mammals are exposed by several ways by the use of a pesticide. In this case more modules have to be runned. Furthermore, some exposure routes are not yet available (e.g. inhalation, contact, etc.), but they will be incorporated into the scheme as soon as available.

2.2.2 Module B (exposure by granules, treated seed, slug pellets or baits for rodents)

In the first step of this module the amount of active ingredient in/on 1 granule or seed is compared with the LD50 of the species of concern (see chapter 2.5). When the quotient is ≥ 1, high risk is assumed for the species of concern, which means that for the species 50% or more of the animals will die after consumption of 1 particle.
In step 2 it is assumed that the complete daily food intake (DFI) of the species of concern consists of the particles under consideration. When the quotient (active ingredient in DFI / LD50 of the species of concern) is ≤ 0.001, low risk for birds or mammals is assumed.
In step 3 one has to decide if the particles do resemble natural food or natural grit. Differentiation is necessary because it is assumed that natural food will be eaten until the bird or mammal is saturated, in contrary to grit consumption (not ad libitum).
As trigger-value for grit consumption 20 particles has been chosen. Research carried out by Best and Gionfriddo (1991a and 1991b) showed that the mean number of grit particles in the stomach of birds (from Iowa and Utah) is between 0 and 70 (Common Pheasant 38 and House Sparrow 69). Only for one species (the House Sparrow) the half-life of the grit particles in the stomach is approximately known: DT50 = 3 days. This means that a House Sparrow has to consume ± 12 grit particles a day to keep up the same level. Because so little is known about these matter a trigger value of 20 is proposed. When the quotient (LD50(species of concern) / amount of active ingredient in 1 particle) is ≤ 20, risk is assumed to be present. The "real" risk has to be assessed by comparing the characteristics of the particles and the characteristics of natural grit in combination with the toxicity of the pesticide.
When an particle resembles natural food it is supposed that the risk for birds and mammals is related to the amount of available active ingredient per unit area. High risk is assumed when the quotient (number of available particles per 1 m^2 / LD50 of the species of concern expressed in particles) is ≥ 10. Low risk is assumed when the quotient is ≤ 0.1. Corrections can be made for the degree of incorporation and for repellency (when applicable).

The risk assessment for baits for rodents starts at the step where the amount of available particles per m^2 is compared with the LD50 of the species of concern expressed in particles, because in the Netherlands much attention is given to prevent poisoning of non-target species when baits for rodents are used.

2.2.3 Module C (exposure by sprayed crops (insects))

Birds and mammals can be exposed to a particular pesticide by way of their food (i.c. sprayed crops/plants or insects). The concentration in the food can be determined from measured concentrations in the food or can be estimated using the relations described in chapter 2.5.
At first it is assumed that a bird or mammal will gather its whole daily food intake in a few hours on the treated field. This short term oral exposure is compared with the LD50 of the species of concern. Secondly it is assumed that a bird or mammal will gather its whole daily food intake during several days (5 days) on the treated field. This exposure is compared with the LC50-value. In the last place it is assumed that a bird or mammal will gather its whole daily food intake during a longer period (≥ 28 days, depending on the duration of the test) on the treated field. This "chronic" exposure is compared with the "chronic" No Observed Effect Concentration (NOEC).

2.2.4 Module D (exposure by drinking water)

Birds and mammals can be exposed to a particular pesticide by drinking contaminated water. There are two possible exposure sources. Species that frequent water bodies are liable to ingest residues of active ingredients that reach surface water. Some species may also take up liquid products directly by drinking, for instance from puddles of sprayed liquid or reservoirs held in the axis of leaves. For the last exposure route it is assumed that exposure only will occur during a short period (less than 1 day). In this case the whole daily water intake is compared with the LD50 of the species of concern. In case of exposure by way of drinking surface water it is also assumed that a bird will drink its whole daily water intake during several days (5 days) from contaminated surface water. This concentration in the drinking water is compared with the LC50 value.

2.2.5 Module E (secondary poisoning)

There are many routes in the environment where secondary poisoning can occur. In the first place two models: the water - fish - fish-eating bird or mammal pathway and the soil - worm - worm-eating bird or mammal pathway have been developed (Romijn et al., 1991a and 1991b). In the future, other pathways can be incorporated in the risk assessment scheme, if necessary.

2.3 PED/LD50, PEC/LC50 and PEC/NOEC quotient

In 1990 a method for setting quality standards for the environment was developed by the RIVM (Van de Meent et al., 1990). With this method a maximum permissible concentration (MPC) can be calculated, which indicates a maximum concentration of a chemical in water or soil where no unacceptable adverse effects on the ecosystem are expected. The aquatic or terrestrial ecosystem is supposed to be protected if 95% of the species is protected. This means that in the ecosystems the species NOEC is not exceeded for 95% of the species. The negligible level is defined as 1% of the upper limit. See "Premises for Risk Management" (Anonymous, 1989a).
This method is made suitable for calculating NOECs for birds and mammals by Romijn et al. (1991a). Depending on the nature and the amount of available toxicological data a refined or preliminary extrapolation method can be used (see also Slooff, 1992).

The refined-extrapolation method has to be used if NOECs are available for a minimum of 4 different species. This method is originally developed by Van Straalen/Denneman (1989) and has been modified by Aldenberg and Slob (1992). It can be used to estimate a NOEC value for the group of birds or mammals at which the NOEC for no more than 5% of the species is exceeded. The one-sided 50% confidence limit to the NOEC-value is used for the risk assessment. A condition to the application of the refined extrapolation method is that the data are log-logistically distributed.
Because birds and mammals are not equally sensitive to xenobiotics (Walker, 1983) it is possible that, when a NOEC(ecosystem is calculated for a combined set of birds and mammals, the 5% of the species which have a NOEC below this level consists entirely of members of the most sensitive group. Although the refined extrapolation method allows for differences in sensitivity of taxonomic groups as long as the data follow a log-logistic distribution, birds and mammals are treated separately.

In the case of less than 4 NOECs for different species and in the case that only LC50 values are available, the preliminary extrapolation method must be used (see table 1).

Table 1 - Preliminary extrapolation method

Available information	Safety factor
Lowest acute LC50 value if less than 3 data available for different species	1000
Lowest acute LC50 value if more than 2 data available for different species	100
Lowest chronic NOEC value if less than 3 data available for different species	10 (Compare this value with the extrapolation based on LC50 values. Select the lowest value for the risk assessment)
Lowest chronic NOEC value if more than 2 data available for different species	10

The hazard/risk assessment of long-term exposure is carried out with the NOEC(ecosystem). High risk is presumed when the PEC/NOEC(ecosystem) is > 1 and low risk is presumed when the PEC/NOEC(ecosystem) is ≤ 0.01.

The hazard/risk assessment of short-term exposure is carried out with LD50 or LC50 toxicity data. If the PED/LD50 or the PEC/LC50 > 0.1 high risk is presumed and if the PED/LD50 or the PEC/LC50 ≤ 0.001 low risk is presumed. Criterion according to the 'Milieucriterianotitie' (Anonymous, 1989b and 1991) is that effects are not allowed to occur to the most sensitive species that is tested. This means that the concentration is not permitted to exceed 1/10 of the lowest LC50 or LD50 obtained from short-term tests with birds or mammals.

2.4 Schematic presentation of the decision scheme

For module B, C and D separate versions are available for birds and mammals. Modules A and E are identical for birds and mammals.

Figure 1 MODULE A (General module for birds as well as mammals)

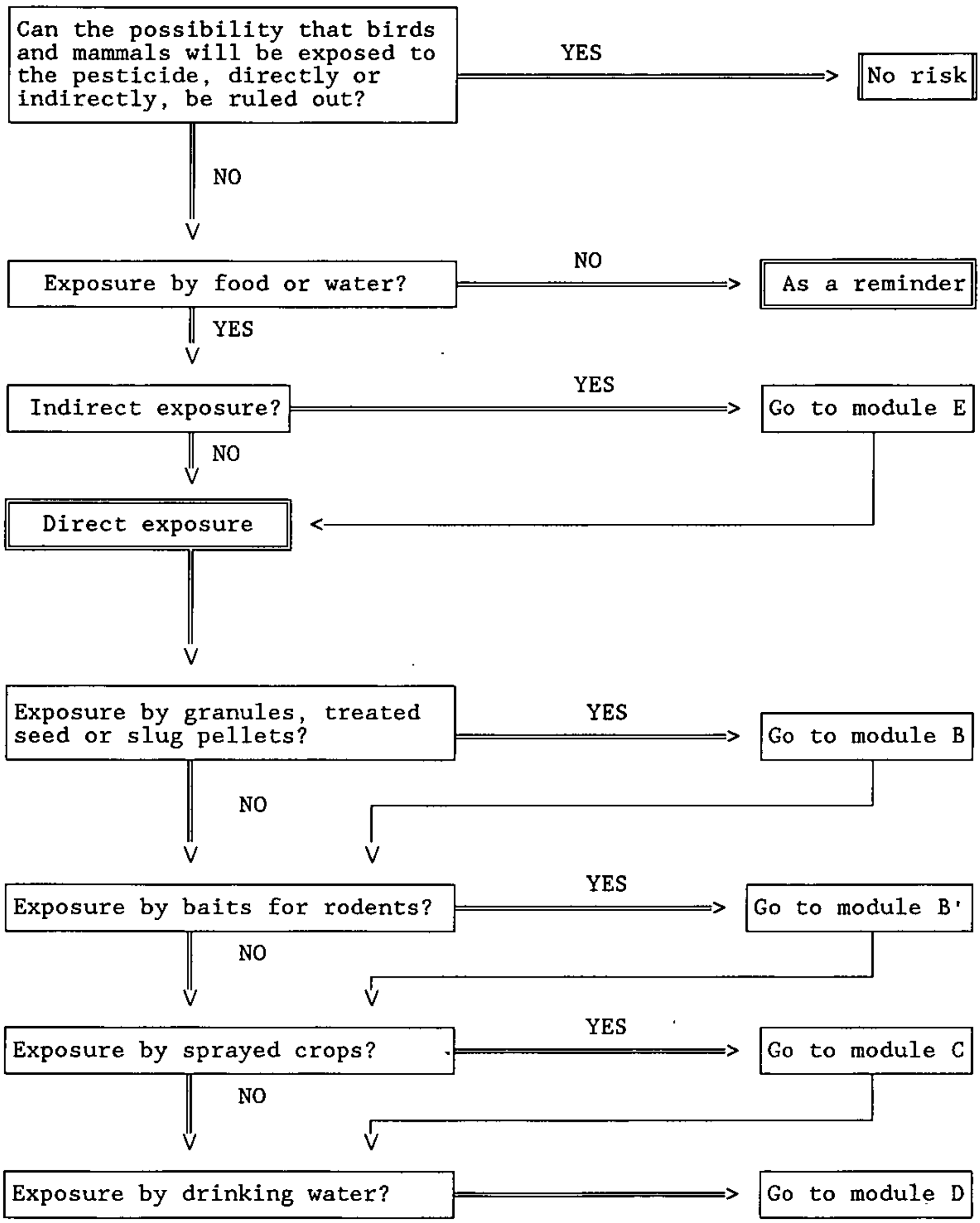


Figure 2A MODULE B AND B' (Exposure by granules, treated seed (including pillorized seed), baits for snails (starting at B) and baits for rodents (starting at B') for birds).

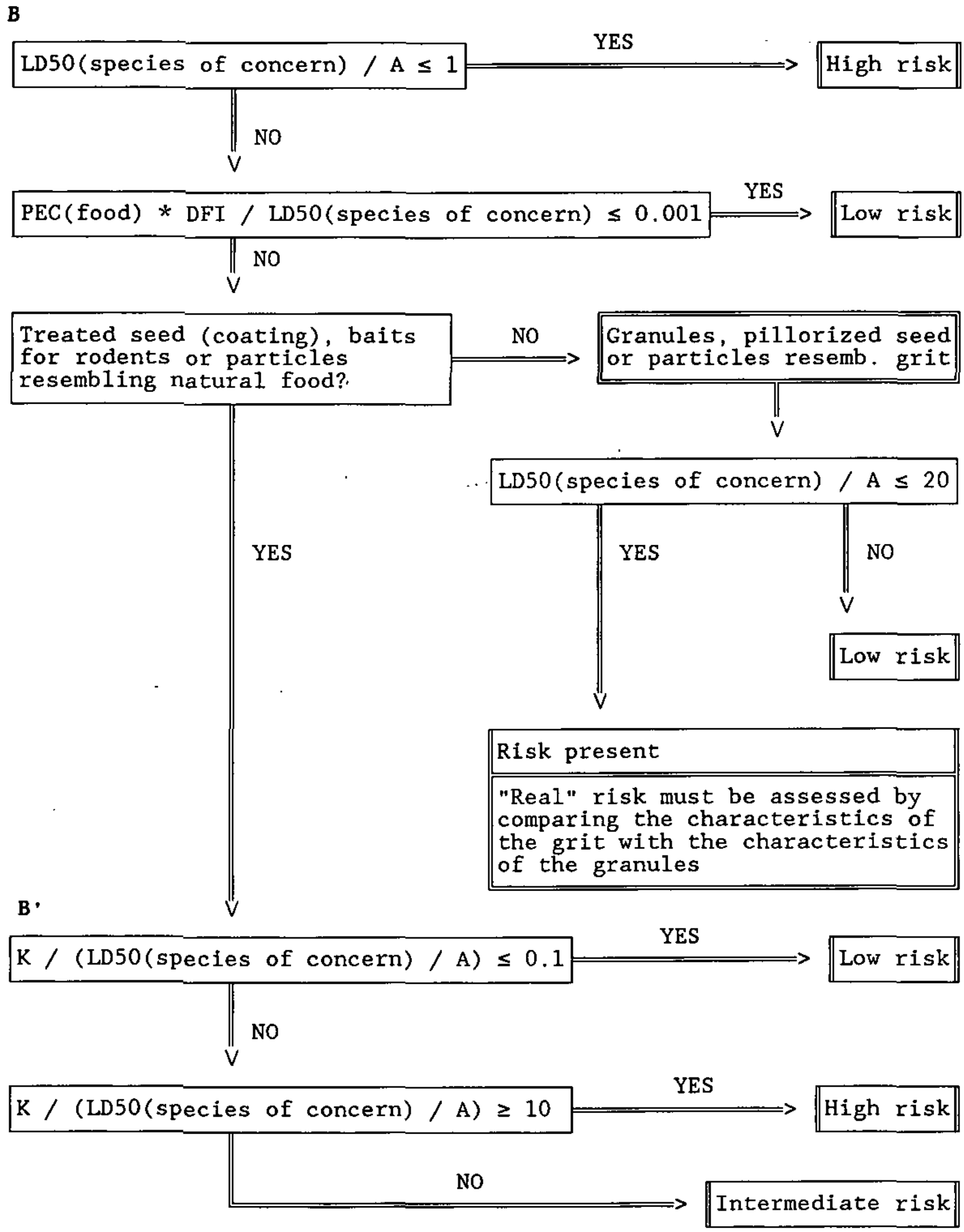


Figure 2B MODULE B AND B' (Exposure by granules, treated seed (including pillorized seed), baits for snails (starting at B) and baits for rodents (starting at B') for mammals).

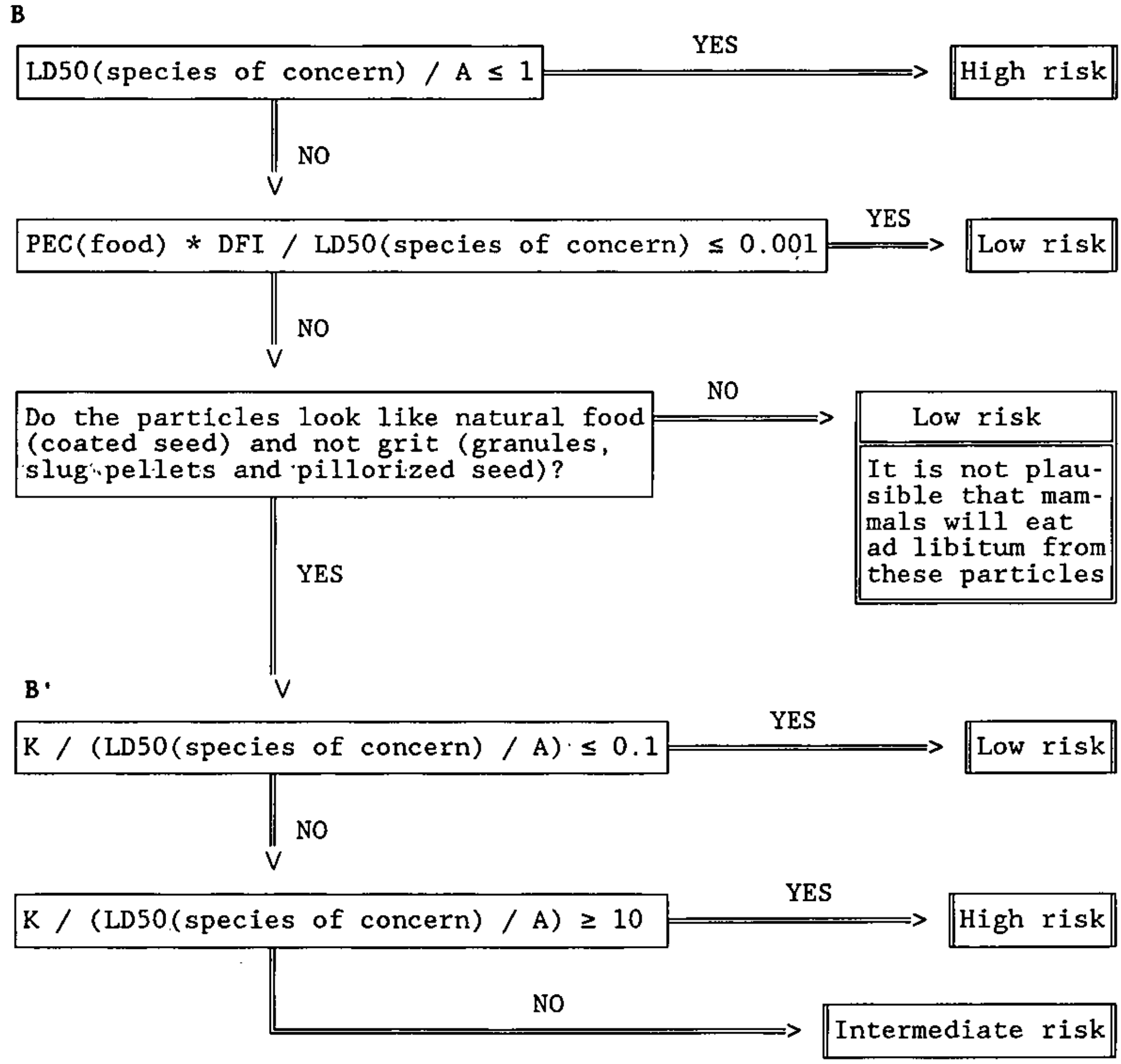


Figure 3A MODULE C (Exposure by pesticides used for spraying crops/plants (insects) for birds. The risk for short term exposure can be assessed with part C' and long term exposure with part C").

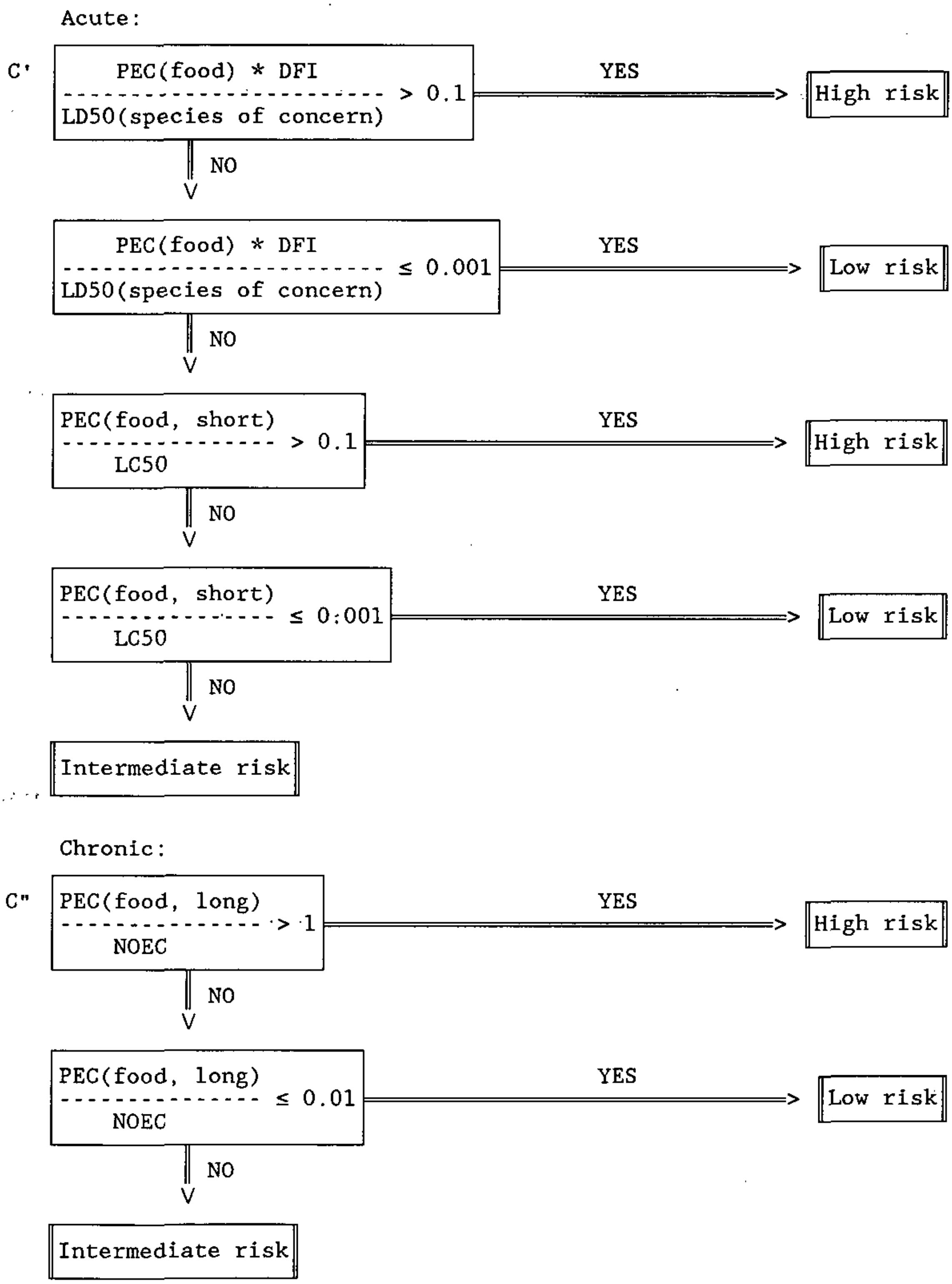


Figure 3B MODULE C (Exposure by pesticides used for spraying crops/plants (insects) for mammals. The risk for short term exposure can be assessed with part C' and long term exposure with part C").

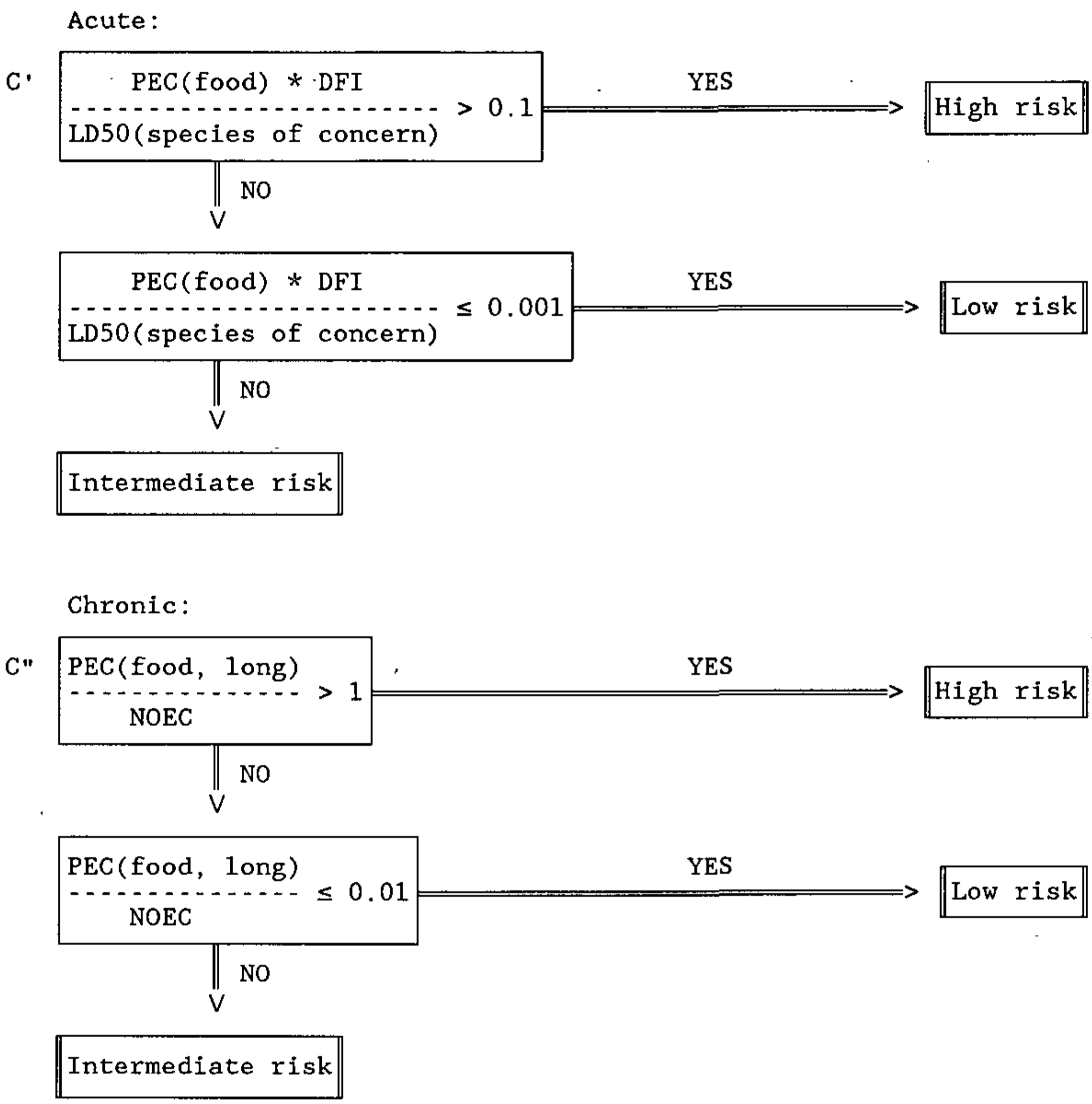


Figure 4A MODULE D (Exposure by (drinking)water for birds). The risk for exposure by drinking water from surface water can be assessed with part D' and the risk for exposure by spray liquid in puddles or axis of leaves with part D"

D' Exposure by drinking water from surface water

PEC(water) * DWI / LD50(species of concern) > 0.1 — YES ⟹ High risk

NO ⇓

PEC(water) * DWI / LD50(species of concern) ≤ 0.001 — YES ⟹ Low risk

NO ⇓

PEC(water, short / LC50 > 0.1 — YES ⟹ High risk

NO ⇓

PEC(water, short / LC50 ≤ 0.001 — YES ⟹ Low risk

NO ⇓

Intermediate risk

D" Exposure by spray liquid (puddles, axis of leaves)

PEC(spray liquid) * DWI / LD50(species of concern) > 0.1 — YES ⟹ High risk

NO ⇓

PEC(spray liquid) * DWI / LD50(species of concern) ≤ 0.001 — YES ⟹ Low risk

NO ⇓

Intermediate risk

Figure 4B MODULE D (Exposure by (drinking)water for mammals). The risk for exposure by drinking water from surface water can be assessed with part D' and the risk for exposure by spray liquid in puddles or axis of leaves with part D"

D' Exposure by drinking water from surface water

PEC(water) * DWI / LD50(species of concern) > 0.1 — YES ⟹ High risk

NO ⇓

PEC(water) * DWI / LD50(species of concern) ≤ 0.001 — YES ⟹ Low risk

NO ⇓

Intermediate risk

D" Exposure by spray liquid (puddles, axis of leaves)

PEC(spray liquid) * DWI / LD50(species of concern) > 0.1 — YES ⟹ High risk

NO ⇓

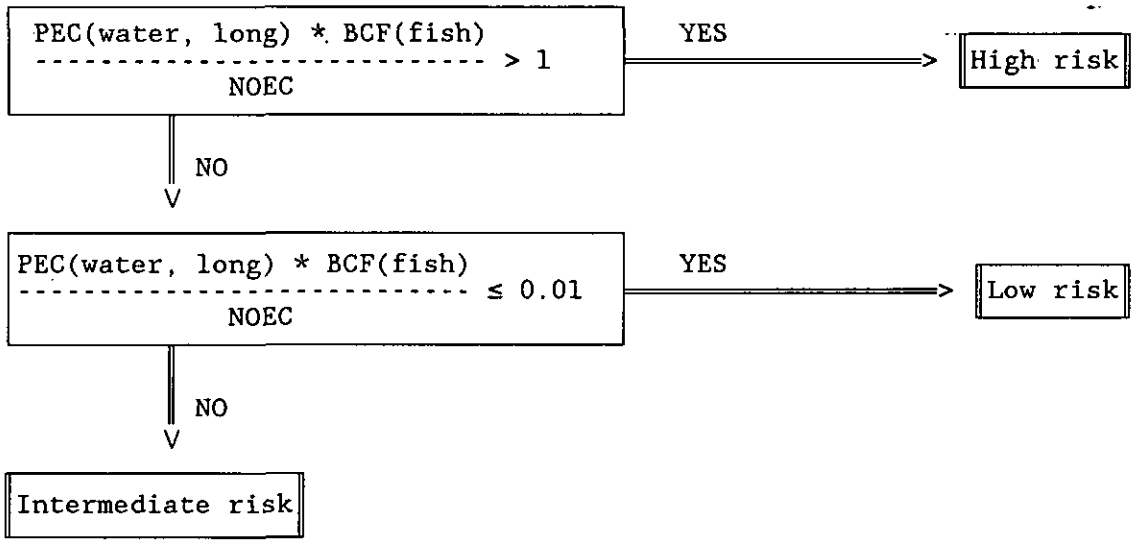
PEC(spray liquid) * DWI / LD50(species of concern) ≤ 0.001 — YES ⟹ Low risk

NO ⇓

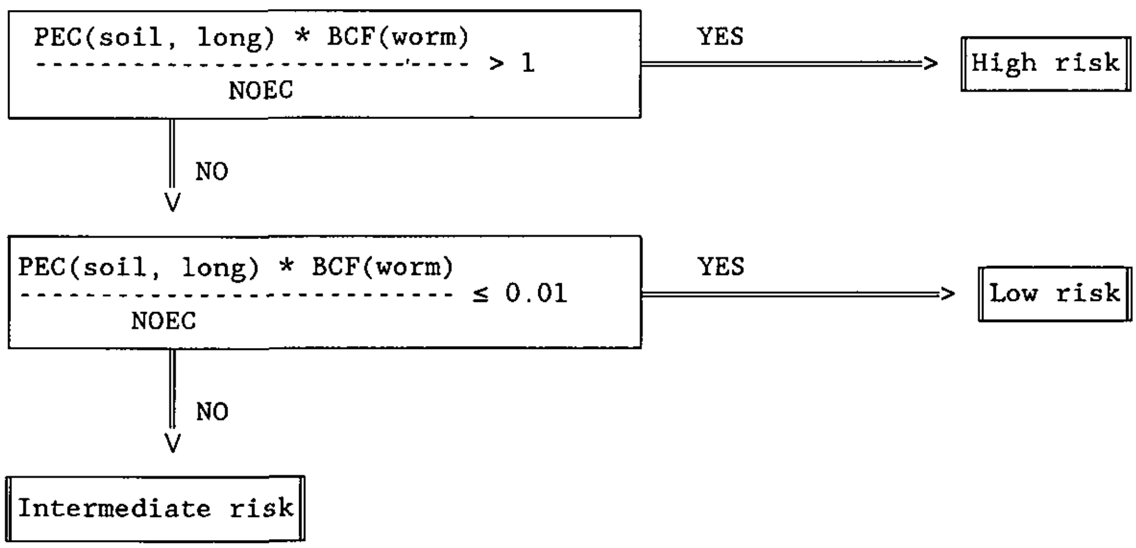
Intermediate risk

Figure 5 MODULE E (Secondary poisoning for birds as well as mammals)

Fish as food



Worms as food



2.5 Description of terms used in the decision scheme

Species of concern

In principle it is possible to carry out a risk assessment for all known species of birds and mammals, if the following data are available: mean body weight, daily food intake and the composition of the diet. The range of bird or mammal species liable to be exposed to a particular product depends on their use of the habitat, and other aspects of behaviour, such as feeding habits. For the purpose of risk assessment, species can be dealt with as a small number of categories, to which the nature of the risk is likely to vary substantially. The following nine categories are sufficient to cover the assessment of most types of product, although others may also be used, particularly in relation to specialised types of product.

1) Seed-eating birds
2) Seed-eating mammals
3) Grazing/browsing birds
4) Grazing/browsing mammals
5) Predatory and scavenging birds
6) Predatory and scavenging mammals
7) Insectivorous birds
8) Insectivorous mammals
9) Birds of wetlands

Which of these categories, and which species within them, are likely to be relevant in any particular case, depends on many factors, including patterns of habitat use (nesting, roosting, etc), migratory habits, the season of use of the product, and regional differences in the occurrence of particular species. As an example a more detailed list of seed-eating birds and mammals is presented in table 2.

LD50(species of concern)

LD50 values are conventionally expressed as mg/kg body-weight; for some purposes, it is necessary to adjust these units to take account of the body-weight (BW) of the animal concerned.

LD50(species of concern) = LD50 * BW in kg.

Table 2 List of some seed-eating birds and mammals and their body weight (mean and range); S = songbird.

Species		Mean body weight (g)	Range (g)	Ref.
BIRDS:				
Serin	*Serinus serinus* (S)	12.4	11.2 - 13.8	1
Goldfinch	*Carduelis carduelis* (S)	15.1	13.4 - 16.4	1
Linnet	*Carduelis cannabina* (S)	17.7	14.0 - 21.9	1
Meadow Pipit	*Anthus pratensis* (S)	18.3	16.3 - 20.2	2
Brambling	*Fringilla montifringilla* (S)	20.0	16.3 - 23.0	1
Tree Sparrow	*Passer montanus* (S)	21.0	16.0 - 25.5	1
Chaffinch	*Fringilla coelebs* (S)	22.2	16.5 - 28.9	1
Greenfinch	*Carduelis chloris* (S)	26.5	16.2 - 35.9	1
Skylark	*Alauda arvensis* (S)	40	27.0 - 52.4	2
Common Quail	*Coturnix coturnix*	102	70 - 140	3
Turtle Dove	*Streptopelia turtur*	152	120 - 208	4
Collared Dove	*Streptopelia decaocto*	195	125 - 249	4
Partridge	*Perdix perdix*	375	300 - 445	3
Woodpidgeon	*Columba palumbus*	499	420 - 613	4
Mallard	*Anas platyrhynchos*	1080	750 - 1572	5
Common Pheasant	*Phasianus colchicus*	1140	700 - 1565	3

Species		Mean body weight (g)	Range (g)	Range[8] (g)	Ref.
MAMMALS:					
Bank Vole	*Clethrionomys glareolus*	16.4	13 - 23	14 - 40	6
Common Vole	*Microtus arvalis*	30	8 - 46	14 - 40	6
Harvest Mouse	*Micromys minutus*	8	7 - 10	4.5 - 11	7
House Mouse	*Mus musculus*	17.1	12 - 20	14 - 32	7
Long-tailed Field Mouse	*Apodemus sylvaticus*	20.8	12 - 30	14 - 35	7
Yellow-necked Field Mouse	*Apodemus flavicollis*	31.5	18 - 50	20 - 50	7
Brown Rat	*Rattus norvegicus*	246	84 - 360	240 - 500	7
Black Rat	*Rattus rattus*	175	134 - 256	145 - 260	7
Garden Dormouse	*Eliomys quercinus*	--		50 - 140	7
Common Hamster	*Cricetus cricetus*	210	115 - 352	150 - 500	6

1 = Data obtained from the Ringing Group Van Lennep, 2 = Glutz von Blotzheim & Bauer, 1985, 3 = Glutz von Blotzheim et al., 1973, 4 = Glutz von Blotzheim & Bauer, 1980, 5 = Cramp et al., 1977, 6 = Niethammer & Krapp, 1978, 7 = Niethammer & Krapp, 1982 and 8 = Lange et al., 1986

A and K

A is the concentration of the active ingredient or a combination of several active ingredients per 1 particle. A particle is a treated seed, a granule or a bait. K is the number of particles per m^2, if relevant corrected for the percentages of incorporation.

DFI and DWI

Preferably information about the daily food or water intake of wild species has to be used for the calculations necessary for the hazard/risk assessment. These information is often based on measurements of captive animals, which may not be representative of what occurs in the wild. Food intake can be very variable, depending on the metabolic rates of species, the nature of their food, weather conditions, time of the year, etc. As a broad generalisation, it is sometimes assumed that small species (less than 100 g) eat about 30% of their body weight daily, on dry weight basis, whereas larger species eat about 10% (Kenaga, 1973). More accurate predictions of the Daily Food Intake (DFI) are available from Nagy (1987), using regression equations to predict dry weight intake for an animal of a particular body weight (BW):

All birds	$\log DFI = -0.188 + 0.651 \log BW$ ($n=50$, $r^2 = 0.919$),
Songbirds	$\log DFI = -0.400 + 0.850 \log BW$ ($n=26$, $r^2 = 0.915$),
Other birds	$\log DFI = -0.521 + 0.751 \log BW$ ($n=24$, $r^2 = 0.919$),
Mammals	$\log DFI = -0.629 + 0.822 \log BW$ ($n=46$, $r^2 = 0.958$).

(DFI and BW both in grams)

There is less information available on the Daily Water Intake (DWI) of animals, which varies greatly between species of different habits, and accordingly to a wide range of stresses. Robbins (1983) has reviewed information on water turnover rates (Q) for wild birds and mammals (which gives a rough estimate of water intake), providing the following predictive equations for unstressed animals with free access to water (BW in kg and Q in litres per day).

Mammals	$Q = 0.12 * BW^{0.84}$
Birds	$Q = 0.119 * BW^{0.75}$

PEC (Predicted Environmental Concentration)

In the risk assessment scheme four different PECs are used: PEC(food), PEC-(water), PEC(spraying liquid) and PEC(soil).

- PEC(food)

The estimation of residues on different categories of vegetation types is based upon the works of Hoerger and Kenaga (1972) and Kenaga (1973). In the earlier article the authors examined the residue levels from literature sources and tolerance data of 28 different pesticides in or on 60 crops (totalling more than 250 different pesticide crop combinations) at various time intervals after application. From these levels Hoerger and Kenaga developed maximum expected and typical (apparently, mean values) residue levels for the time period immediately after application (see table 3). Kenaga (1973) indicates that for small insects the residue data available for seeds are relevant whereas for large insects the data for pods are pertinent.
It has to be noticed, however, that measured data on feed concentrations are always preferable.

Table 3 Relation between the concentration on crops/insects (mg/kg) and the pesticide dosage (D in kg active ingredient per hectare) immediately after application.

Plant/insect category	Mean concentration	Maximum concentration
Range grass	112 * D	214 * D
Grass	82 * D	98 * D
Leaves and leafy crops	31 * D	112 * D
Seeds and small insects	29 * D	52 * D
Pods and large insects	2.7 * D	11 * D
Cereals	2.7 * D	8.9 * D
Fruit	1.3 * D	6.3 * D

If the diet of a bird or mammal species is known the concentration in/on the food (PEC(food)) can be calculated. For instance the average composition of the diet of the Common Partridge is 30% leaves, 30% cereals, 30% small seeds and 10% small insects, which will give a mean PEC(food) of (0.3 * 31 * D) + (0.3 *

2.7 * D) + (0.3 * 29 * D) + (0.1 * 29 * D) = 21.7 * D.

Two derivations of the PEC(food) are used in the decision trees:

- The PEC(food, short) is the mean concentration (in mg/kg food) during 5 days that can be found on crops or insects, depending on the half-life time of the applied pesticide;
- The PEC(food, long) is the mean concentration (in mg/kg food) during a longer period (depending on the duration of the toxicity tests) that can be found on crops or insects, depending on the half-life time of the applied pesticide.

The PEC(food, short) and PEC(food, long) can be determined if the half-life time of the pesticides on/in crops and/or insects can be calculated. The half-life time (DT50) should preferably be determined from residue data on crops or insects. If 3 or more measured data are available, the DT50 can be determined by means of linear regression. If 2 measured data are available, the DT50 can be calculated as follows:

$$DT_{50} = \ln2 * t / (\ln C_t - \ln C_0) \qquad (d)$$

in which: C_0 = concentration on food at day zero,
C_t = concentration on food at day t and
t = time.

The mean concentration of a pesticide in food during 5 or more days can be calculated as follows:

$$PEC(food, short/long) = C_0 * (1-e^{-(k * t)}) / (k * t) \qquad (mg/kg)$$

in which: $k = \ln2 / DT_{50}$ (d^{-1})

- PEC(water)

A part of the applied dosage of a sprayed pesticide reaches the surface water directly (drift) and/or indirectly (run-off and drainage). The concentration in the surface water as a result of drift can be calculated with the so-called 'SLOOT-BOX-model'. This model takes into account repeated dosage and several environmental processes like biodegradation, volatilization, advection, sedimentation and resuspension, and calculates a short-term and a long-term Predicted

Environmental Concentration. The model calculates an initial concentration (PEC(water)), a concentration several days after application (PEC(water, short)) and a concentration after about one year (PEC(water, long)). Further details, assumptions, and default-values are given by Linders et al. (1990).
Concentrations of pesticides in surface water (in this case a ditch) as a result of drift ($C_{water, drift}$) can be calculated as follows:

$$C_{water, drift} = \text{Dosage (kg a.i./ha)} * P_{drift} / 100 / \text{Depth of ditch}$$

in which: P_{drift} = percentage drift related to place and way of application.

- PEC(spraying liquid)

The concentration of a pesticide in spraying liquid can be calculated with the following formula:

PEC(spraying liquid) = dosage (kg a.i./ha) / amount of spray-liquid (l/ha)

- PEC(soil)

The concentration of a pesticide in the soil can be calculated as follows (Emans et al., 1992):

$$C_0 = \text{Dosage (in kg a.i./ha)} * 10^6 / (10^4 * H_{soil} * B_d)$$

In which: C_0 the concentration in soil at time 0:
H_{soil} is the depth of the soil layer: 0.05 m if not mixed with soil and 0.2 m if mixed with soil;
B_d = bulk density (for instance 1400 kg/m^3).

$$PEC(soil) = C_0 * (t * k)^{-1} * (1 - e^{-(k * t)})$$

In which: t = time;
k = ln2 / DT50.

Nota bene: In case no DT50 is available or can be calculated for food, water or soil no degradation or disappearance will be assumed and a kind of worst case calculation is carried out. In the case of risk assessment based on LD50 values no degradation/disappearance is assumed unless the compound has a vary quick degradation/disappearance rate (DT50 < 1 day).

BCF (Bioconcentration factor)

In the hazard/risk assessment preference is given to laboratory studies on BCFs for fish and worms over QSAR estimations (Romijn et al., 1991a and 1991b). If no laboratory studies are available, BCFs can be calculated with the following QSARs:

$BCF(fish) = 0.048\ K_{ow}$ (Mackay, 1982) and

$BCF(worm) = (Y_l / 0.66 * f_{oc}) * K_{ow}^{0.07}$ (Connell and Markwell, 1990)

In which: K_{ow} = the octanol/water partitioning coefficient;
Y_l = fraction fat;
f_{oc} = fraction organic carbon.

3 Discussion

This report describes a method for hazard/risk assessment of the use of pesticides in agriculture for birds and mammals. It is a compilation of all the schemes concerning birds and mammals available up to now in the Netherlands. In future supplementary parts will be added to the decision scheme like: exposure by air (inhalation) and dermal exposure (contact). In the case of indirect exposure via the food chain supplements will be necessary for the use of baits for rodents and for more comprehensive food chains. At the moment a study is carried out at the RIVM in which the pathway soil - soil organisms - small mammals/birds - raptors will be modelled for risk assessment and for setting standards for the environment. Besides the food chain modelling in the above project research is carried out on the following correction factors for the toxicity data (Luttik et al., 1992):

- laboratory versus field (metabolism),
- normal versus extreme conditions (metabolism),
- caloric conversion,
- food assimilation efficiency,
- pollutant assimilation efficiency and
- relative sensitivity.

No concept is available for incorporating ecological side-effects into the hazard/risk assessment. For instance in the Netherlands line-shaped elements (e.g. hedgerows) are created in re-allotment projects to connect remnants (islands) of environmental importance in agricultural areas. No scheme is available to assess the impact of the use of pesticides for plants and no models are available for assessing changes in the structure of the habitat and changes in the availability of the food for a particular species. Within the framework of the EPPO the development of a hazard/risk assessment scheme for plants will (probably) be started in 1993. Within certain marges models developed within the scope of the project 'Ecological sustainability of the use of chemicals' can predict changes in the density of functional groups for specific locations.

In case of short term exposure (one or several days) the lowest available scientifically sound LD50 or LC50 is used for the hazard/risk assessment, but it is completely uncertain whether the lowest LD50 or LC50 will be the "real" lowest LD50 or LC50. With the Van Straalen/Denneman (1989) method it is possible to calculate in case of more than 4 LD50s or LC50s the LD50 or LC50 for 95% of the species. Provisional results indicate that the lowest calculated value is approximately the lowest available measured value in case of more than 3 different values. But in case of only 1 or 2 values the underestimation of the risk can be very high (Luttik and de Snoo, in prep). Research will be carried out to provide uncertainty factors in case of 1, 2 or 3 LD50s or LC50s.

It will be necessary in future to validate the hazard/risk assessment method. Validation can be done by using data on incidents resulting from approved use. In the UK data on incidents with pesticides are collected in the frame of the Wildlife and Honeybee Incident Investigation Schemes for approved use, misuse and abuse of pesticides. Also in other countries, for instance in the United States and in the Netherlands, data on incidents are collected.
Validation can also be done using data from field tests, especially designed for investigating the impact of a particular use of a pesticide for birds and/or mammals.

It is important to note that the decision scheme is not attempting to estimate the actual number of birds or mammals that will receive a lethal dose, nor the probability of a given bird or mammal consuming a lethal dose. The amount of pesticide actually ingested by a bird or a mammal cannot be quantified. Estimates of that sort will depend on the number of hectares treated, the species and numbers of birds or mammals present in a given area and many factors of bird and mammalian behaviour, that have not yet been adequately documented.

Last but not least it is important to note that the hazard/risk assessment scheme must be handled with some care, because ecological knowledge of birds and mammals is a prerequisite when the scheme is applied. It is for example not likely that the whole daily food intake of a Serin will consist of peas or other large seeds. The smallest seed eating mammal, the Harvest Mouse, will eat large seeds.

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