Review of incidents with wildlife related to paraquat

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Preface

In October 2004 Syngenta Inc. commissioned the Institute of Environmental Sciences of Leiden University (CML) to undertake a review of wildlife incidents related to the herbicide paraquat. That review, the results of which are described in this report, could not have been undertaken without the generous support of the many people who supplied us with information. Particular thanks are due to all those mentioned in Appendix II. Special thanks are also due to Pierre Mineau of the National Wildlife Research Centre (NWRC), Canada, who very critically reviewed the draft version of the report. We take this opportunity to thank Ms Edith Roos (CML), who retrieved all the scientific literature. Thanks are also due to Nigel Harle for his careful correction and editing of the English.

W.L.M. Tamis
Leiden, February 2005

Summary

General
Following a comprehensive review, the herbicide paraquat was included in Annex I of European Union Council Directive 91/414/EEC. During the later stages of the decision of the European Union on Annex I inclusion, the German authorities made a declaration to the Standing Committee on the Food Chain and Animal Health of the European Union. As part of this declaration they asked Syngenta to report, *inter alia*, on the current situation regarding the ecotoxicological impact associated with the use of paraquat. During the assessment of the European Union, impacts on mammals, in particular hares (*Lepus europaeus*), and on birds were identified as areas requiring further review.

Research goal and approach
The main goal of the present study was to review incidents involving mammals (especially hares) and birds related to paraquat. Incidents with companion animals (dogs, cats etc.) and livestock (pigs, sheep, geese etc.) were also reviewed, however. This review embraces, to differing degrees in different countries, all paraquat-related incidents involving these animals from the first year that paraquat appeared on the market (1964) through to 2004. Although paraquat-related incidents from all over the world were taken into account, in principle, the main focus was on certain West European countries with well-developed national incident monitoring schemes. The main sources of information on incidents were the scientific literature and the data collected under these national incident schemes. All incidents were counted and classified according to year and locality of the incident and cause of poisoning. Because national incident frequency may be influenced by a range of factors (e.g. presence or absence of monitoring scheme or national paraquat consumption) data on these factors were also sampled to better interpret the number of incidents, especially for certain West European countries.

Overall conclusions for all animals
From before 1970 through to about 2002 there have been twenty-nine publications in thirteen countries, mainly European (ninet), containing information on paraquat-related incidents involving animals. The total number of paraquat-related incidents with animals reported in the literature was about 230. For the period from 1985 onwards, information was retrieved from incident monitoring schemes in five countries (United Kingdom, France, Germany, Netherlands, United States), under which some 185 paraquat-related incidents with animals were reported. These numbers include all known incidents in which paraquat was identified in these sources as the suspected, probable or certain cause of poisoning.

Conclusions for vertebrate wildlife
The main focus of this study was on wild mammals (especially hares) and wild birds. However, these accounted for only a minority of the incidents reported in the literature and incident monitoring schemes. Paraquat-related incidents involving wildlife were found in the literature for three countries only: the UK, France and the Netherlands. If we include the incidents suspected of being paraquat-related, the total number involving

wildlife is about 32 in seven publications for the period from before 1970 to about 1995. The cause of most incidents (21) was not identified (but was possibly approved use), while for the remainder (11) it was approved use. In 31 incidents hares were involved and in one incident hedgehogs. Paraquat-related incidents recorded under incident monitoring schemes were retrieved from three countries: the UK, France and the USA. If we include suspected paraquat incidents, the total number of wildlife incidents reported under incident monitoring schemes was 43 between 1986-2001. The cause of poisoning was approved use (11), unknown (22), misuse (1) and abuse (9). The vertebrates involved in poisoning after approved use of paraquat were hares (10) and a wild goose species (1). Animals involved in poisoning due to other causes were mainly foxes (11), hares (7) and badgers (7). Only one paraquat-related incident with farmland birds was reported under the incident monitoring schemes.

Conclusions for companion animals and livestock
Incidents with companion animals and livestock make up the bulk of all paraquat-related incidents. They are found in nineteen publications from ten countries. They involved mainly dogs and to a lesser extent cats. Only in four incidents was livestock involved (pigs, sheep, poultry and geese), including one large incident in Australia in which about 700 sheep were maliciously poisoned. The main causes of paraquat poisoning of companion animals and livestock are: unknown, deliberate abuse or misuse. It was only the UK incident monitoring scheme that had any reports in this category, with a total of about one hundred paraquat-related incidents involving mainly companion animals. Again, the main causes of poisoning were abuse or unknown.

Influence of controlling factors on number of incidents
Unfortunately, only fragmentary information could be retrieved regarding factors controlling or influencing the number of reported incidents. Consequently, there could only be similarly fragmentary investigation of any influence of these various factors on numbers of incidents (see chapters 3 to 9 for further details). For some western European countries a positive correlation was found between national paraquat consumption and number of paraquat-related incidents .

Discussion of the reliability and suitability of incident monitoring schemes
In the discussion section, the reliability and appropriateness of incident monitoring schemes are discussed. Incident monitoring schemes have already proved their usefulness as a post-registration instrument for a number of very toxic pesticides with serious ecological side-effects. However, such schemes will fail to pick up the majority of pesticide-related incidents and the same will also hold for incidents involving paraquat. The chances of a paraquat-related poisoning incident being published are small, given a series of problems and barriers in the process of finding, diagnosing and reporting such incidents. The number of paraquat-related incidents reported in this study is therefore clearly an underestimate. It is strongly recommended that national incident monitoring schemes be standardised and harmonised and that they be extended to include an assessment of the possible causes and levels of poisoning at different probability levels.

Samenvatting

Algemeen
Na een uitgebreide beoordelingsprocedure is het herbicide paraquat op de Annex I geplaatst van de Raad Richtlijn 91/414/EEC van de Europese Unie. Als onderdeel van deze procedure heeft Duitsland Syngenta, een belangrijke producent van paraquat, verzocht een rapport te maken over onder andere de huidige stand van kennis met betrekking tot de ecotoxicologische effecten van paraquat, met name op wilde zoogdieren, in het bijzonder de haas (Lepus europaeus), en wilde vogels.

Onderzoeksdoel en werkwijze
Het hoofddoel van voorliggende studie was het maken van een overzicht van alle incidenten met zoogdieren (in het bijzonder hazen) en vogels in het wild ten gevolge van het gebruik van paraquat. Ook de incidenten ten gevolge van paraquat met huisdieren (honden, katten etc.) en vee (varkens, schapen, ganzen etc.) zijn in kaart gebracht. Voor verschillende landen zijn, in meer of mindere mate, alle incidenten vanaf de introductie van paraquat op de markt (1964) tot en met 2004 in beschouwing genomen. In principe zijn alle incidenten van over de gehele wereld in beschouwing genomen, maar met name is veel aandacht besteed aan enkele West-Europese landen omdat deze een goede nationale incidenten registratie hebben. De belangrijkste bronnen van deze studie zijn de (wetenschappelijke) literatuur en de nationale incidenten registraties. Alle incidenten ten gevolge van paraquat zijn geteld en geclassificeerd naar jaar, land en oorzaak van vergiftiging (opzettelijk, ongeluk, toegestaan gebruik, onbekend). Allerlei factoren, zoals bijv de aanwezigheid van de nationaal incidentenregistratie of het totale nationale gebruik aan paraquat, van invloed hebben invloed op het totaal aantal incidenten. Daarom is informatie over deze conditionele factoren verzameld voor enkele West-Europese landen. voor de interpretatie van het aantal incidenten ten gevolge van paraquat.

Algemene conclusies voor alle dieren
Er zijn 29 publicaties uit dertien landen, voornamelijk uit Europa (negen) met informatie over incidenten door paraquat met dieren in de periode van voor 1970 tot en met 2001. Het totaal aantal gerapporteerde incidenten is ongeveer 230.Van vijf landen (Engeland, Frankrijk, Duitsland, Nederland en de Verenigde Staten van Amerika) is informatie verzameld van de nationale incident registraties vanaf 1985. Deze incident registraties bevatten circa 185 incidenten door paraquat met dieren. De genoemde aantallen incidenten omvatten alle incidenten waarbij paraquat werd genoemd als vermoedelijke, mogelijke of zekere oorzaak.

Conclusies voor wilde dieren
Deze studie is met name gericht op incidenten door paraquat met wilde dieren. Deze maakten echter maar een klein deel uit van alle incidenten vermeld in de verschillende bronnen. Incidenten met wilde dieren ten gevolge van paraquat werden gevonden voor drie landen: Engeland, Frankrijk en Nederland. Er zijn circa 32 incidenten (inclusief de vermoedelijke) incidenten door paraquat met wilde dieren in zeven publicaties voor de periode van voor 1970 tot en met 1995. Van de meeste incidenten (21 incidenten) kon de

oorzaak niet worden vastgesteld (maar waarschijnlijk ten gevolge van toegestaan gebruik) en voor het overige deel (11 incidenten) was de oorzaak vastgesteld als toegestaan gebruik. In 31 incidenten waren hazen betrokken en in één incident egels. Het aantal incidenten door paraquat met wilde dieren in nationale incident registraties zijn gevonden voor drie landen: Engeland, Frankrijk en de V.S. Het totaal aantal incidenten (inclusief de vermoedelijke gevallen) ten gevolge van paraquat in de nationale incidenten registraties bedroeg 43 in de periode 1986 tot en met 2001. In veel gevallen was de oorzaak van de incidenten onbekend (22) of toegestaan gebruik (11). De wilde dieren betrokken bij de incidenten na toegestaan gebruik van paraquat uit de nationale incidenten registraties waren hazen (10) en een wilde ganzensoort. De wilde dieren betrokken bij de incidenten door paraquat door andere oorzaken bestonden voornamelijk uit vossen (11), hazen (7) en dassen (7).

Conclusies voor huisdieren en vee
De incidenten met huisdieren en vee maakten het grootste deel uit van alle gevonden incidenten door paraquat met dieren. Incidenten met deze diergroepen door paraquat werend gevonden in negentien publicaties voor tien landen. Het betroffen hoofdzakelijk honden en in mindere mate katten. Slechts in vier incidenten was vee betrokken (varkens, schapen, pluimvee en tamme ganzen), inclusief een groot incident met 700 schapen opzettelijk vergiftigd met paraquat in Australië. De belangrijkste oorzaken van de incidenten door paraquat van huisdieren en vee zijn achtereenvolgens onbekend, opzettelijke vergiftiging of ongelukken. Alleen de nationale incident registratie van Engeland bevatte ongeveerd honderd incidenten voornamelijk met huisdieren door paraquat. Opnieuw zijn de belangrijkste oorzaken opzettelijke vergiftiging of onbekend.

Invloed van conditionele factoren op het aantal incidenten
Informatie over de factoren die van invloed zijn op het totaal aantal gerapporteerde incidenten konden jammer genoeg slechts fragmentarisch worden verzameld. Derhalve is ook de interpretatie van de invloed van deze factoren op het aantal incidenten fragmentarisch.(zie hoofdstukken 3 tot en met 9 en de bijlagen voor nadere details). Er werd een positief verband geconstateerd voor Europa tussen de hoeveelheid paraquat gebruikt in een land en het aantal incidenten door paraquat met dieren.

Discussie over de betrouwbaarheid en bruikbaarheid van nationale incident registraties
In de discussie wordt ingegaan op de betrouwbaarheid en bruikbaarheid van de nationale incident registraties om het aantal incidenten te bepalen. De nationale incidenten registraties hebben inmiddels hun bruikbaarheid bewijzen als post-registratie instrument voor een aantal zeer giftige bestrijdingsmiddelen met sterke neven-effecten. Desalniettemin zullen de meeste incidenten door bestrijdingsmiddelen niet worden genoteerd in de nationale incident registraties. Dit geldt ook voor paraquat. De kans dat een incident door paraquat met wilde fauna uiteindelijk wordt gepubliceerd is klein door allerlei problemen en barrières in het proces van vinden, diagnose en rapportage. Dat betekent dus dat het aantal gerapporteerde incidenten ten gevolge van paraquat met wilde dieren een duidelijke onderschatting is. Een standaardisatie (inclusief een waarschijnlijkheidsclassificatie van de oorzaak van vergiftiging) en harmonisatie van de nationale incident registraties wordt sterk aanbevolen.

Contents

1 Introduction

1.1 General information on paraquat

Paraquat is a broad-spectrum contact herbicide. General background information on paraquat was obtained from a number of reviews, e.g. EPA (1982), WHO (1984) and Eisler (1990). Paraquat is widely used in approximately 130 countries, especially in Asia and South America. It has been on the market in Europe since 1964. It is one of the herbicides used in zero- or low-tillage farming ("chemical plough"), promoted primarily to prevent soil erosion. Its herbicidal and toxicological properties depend on production of an oxygen radical which causes cell death. When paraquat reaches the soil, it becomes rapidly and strongly adsorbed to the clay minerals present and thereby becomes inactivated.

Paraquat is not only an effective herbicide; it is also toxic to animals and man. Mammals are generally more sensitive than birds. The LD50 for mammals lies between 20 and 200 mg/kg, with dog, guinea pig and rabbit the most sensitive species. If paraquat is ingested, the bulk leaves the body unchanged in the faeces. Absorbed paraquat reaches all organs, but accumulates selectively in the lungs. Lung damage is therefore characteristic of paraquat poisoning, but not in all animals (not in the rabbit, for example). If usage recommendations are duly adhered to, the risks to man and animals posed by paraquat are claimed to be negligible. Unfortunately, paraquat is often misused, with accidental or malicious poisoning of animals as well as suicide being reported. Primarily because of such misuse, there is substantial opposition to paraquat by trade union organisations and environmental non-governmental organisations (e.g. Madeley 2002, Dinham 2004). In some countries paraquat has been banned (e.g. Sweden) or its use restricted (e.g. Germany).

1.2 European approval of paraquat under conditions

Following a comprehensive review, paraquat was included in Annex I of European Union Council Directive 91/414/EEC. During the later stages of the decision of the European Union on Annex I inclusion, the German authorities made a declaration to the Standing Committee on the Food Chain and Animal Health of the European Union. As part of this declaration they asked Syngenta, one of the main manufacturers of paraquat, to prepare a report on the current situation, globally, regarding accidents, suicides and ecotoxicological impact associated with the use of paraquat. A further evaluation was requested, to be made after five years.

The purpose of the present report is to perform an independent review of the available data, to provide the German authorities with a picture of the current situation with respect to ecotoxicological impact. During the assessment of the European Union, impacts on mammals, especially on hares (*Lepus europaeus*), and birds were identified as areas requiring further review. The hare, in particular, is regarded as very sensitive to paraquat, based on known wildlife incidents, field experiments (Newman 1971, *cit*. in EPA 1982, De Lavaur *et al.* 1973, Grolleau 1981) and the low LD50 for rabbits.

The work reported on here, focusing on mammals, in particular hares, and birds as indicators of ecotoxicological impact, was undertaken as an independent review by the Institute of Environmental Science (CML) of Leiden University at the request of Syngenta.

1.3 Overall goal and research strategy

The main goal of this study is to review known incidents with mammals (especially hares) and birds related to paraquat. Incidents with companion animals (dogs, cats etc.) and livestock (pigs, sheep, geese etc.) were also reviewed, however. Paraquat-related incidents involving humans are not addressed in this study. The review embraces, to differing degrees in different countries, all paraquat-related incidents involving animals from the first year that paraquat appeared on the market (1964) through to 2004. Although paraquat-related incidents from all over the world were taken into account, in principle, the main focus was on certain West European countries with well-developed national incident schemes. The main sources of information on incidents were the scientific literature and the data collected under these national incident schemes.

All incidents were counted and classified according to year and locality of the incident and cause of poisoning (approved use, misuse, abuse, unknown cause). Of particular interest for the present study were incidents involving approved use of paraquat. Because national incident frequency may be influenced by a range of factors (e.g. presence or absence of a monitoring scheme, national paraquat consumption, types of application, animal population size), data on these factors were also sampled to better interpret the number of incidents, especially for certain West European countries. To put the incidents potentially related to paraquat into a broader context, incidents related to pesticides as a whole were also considered.

2 Sources and methodology

2.1 Sources of information

This review takes as its basis the following sources of information:

- Scientific literature: see Appendix I for a description of the literature databases consulted and the search profiles used.
- The grey literature (i.e. reports) is generally not very accessible: it is less likely to be available in libraries and its very existence often remains unrecorded. Reports relating to wildlife incidents available at Syngenta were supplied by the company.
- Databases and similar data sources: some countries like the Netherlands, France, Germany and the UK have databases on registered incidents. Databases and other data sources with information on (historical) use of paraquat per country and information on labelling were supplied by Syngenta. The wildlife incident data available at Syngenta were also supplied by the company.
- Experts & NGOs: a number of experts and NGOs were consulted, as detailed in Appendix II.

All information from these sources was evaluated for scientific reliability, with particular attention being given to the evidence presented for the cause of poisoning.

Regional representativeness

Although wildlife incidents from all over the world are in principle of interest, the focus of this study is on incidents that have occurred in West European countries, for which systematic incident data are available. More in particular, the study focuses primarily on the following countries, each of which operate a more or less systematic incident monitoring scheme:

- the Netherlands: incidents reported by CIDC[1]
- France: incidents reported in SAGIR[2] by ONCFS[3]
- Germany: incidents reported by BVL[4]
- United Kingdom: incidents reported in WIIS[5] by MAFF[6]

Incidents from the United States, as reported in EIIS[7] by the US EPA[8], were also included at a later stage of the study.

[1] *Centraal Instituut voor DierziekteControle.*
[2] *Surveillance Sanitaire Nationale du Gibier.*
[3] *Office National de la Chasse et de la Faune Sauvage.*
[4] *Bundesamt für Verbraucherschutz und Lebensmittelsicherheit* (Federal Office of Consumer Protection and Food Safety, Division of Plant Protection Products).
[5] Wildlife Incident Investigation Scheme.
[6] Ministry of Agriculture, Fisheries and Food.
[7] Ecological Incident Information System.
[8] United States Environmental Protection Agency.

For these five countries, all the cited information sources were duly examined. For other countries, in principle only the scientific literature was considered. In these latter countries it is not expected that wildlife incidents are systematically monitored.

Review period
In principle the time period that was taken into consideration was 1964[9] – 2004. However, as wildlife incident monitoring schemes have only been operational since about 1980 it is very unlikely that there are any systematic wildlife incident data prior to this date that are suitable for use in this study.

2.2 Parameters of analysis: paraquat incidents

Incidents with wildlife, companion animals and livestock
The main research question addressed was how many paraquat-related incidents involving mammals (especially *lagomorpha*[10]) and birds have been reported over the years.

In as far as information on these was readily available, paraquat-related incidents involving other animal groups, including farm livestock and companion animals (cats and dogs), were also taken into account. The MAFF and BVL incident monitoring schemes do report incidents with companion animals and livestock and so these incidents were duly included. In addition, incidents with companion animals and livestock reported in the scientific literature were also considered.

Besides these incident reports, a number of articles on paraquat-related field research were also reviewed, as these provided additional information on the ecotoxicological effects of paraquat. This literature is not discussed but only listed.

Cause of incidents
Animals found dead may have died of a variety of causes, including pesticide poisoning, disease, trauma and starvation. In this project we considered only those incidents held to relate to poisoning by a pesticide, in particular paraquat.

The subject of this study, then, are incidents caused by the acute toxic effects of paraquat and other pesticides. The indirect effects of pesticides on animals were not reviewed, thus excluding population effects arising through changes in habitat or reduced food availability due to pesticide use.

[9] Paraquat sales by the forerunners of Syngenta started in 1964.
[10] *Lagomorpha*: rabbits, hares and pikas. Eighty living species are currently recognised as lagomorphs, in 2 families containing 13 genera. Native populations are found on all continents except Australia and Antarctica, although they are absent from southern South America and most islands. However, they have been introduced by humans to many areas where they were not part of the original, indigenous fauna (Myers & Sorin, 2002).

Cause of pesticide poisoning
Poisoning incidents may be due to different kinds of pesticide use and as far as possible these were assigned to one of the following four categories (Fletcher *et al.*, 1995):

- **Approved use** of the product, according to the specified conditions for use.
- **Misuse** of a product, by careless, accidental or wilful failure to adhere to the correct practice.
- **Abuse** of a pesticide, in the form of deliberate, illegal attempts to poison animals.
- **Unspecified** use, where the cause could not be assigned to one of the above categories.

2.3 Parameters of analysis: controlling factors affecting number of incidents

For each individual country reviewed, Appendices III to VII present a full analysis of controlling factors of possible influence on the number of incidents reported. Where relevant, this information was presented in the main text.

2.3.1 Type of incident monitoring scheme

One way to observe any changes to an incident monitoring scheme is to examine wildlife incidents involving other pesticides besides paraquat. Reported wildlife incidents with other pesticides were therefore also retrieved for proper interpretation of those relating to paraquat. In this project, however, no interpretation of the latter incidents was undertaken.

To describe the incident registration systems of the different countries systematically, these were characterised in terms of the following key criteria (De Snoo *et al*., 1999):

- the organisation responsible for gathering data on incidents and reporting them;
- the 'field reporters', i.e. those initially bringing in the animal carcasses;
- costs, i.e. how the monitoring scheme is financed;
- types of incidents, in terms of pesticide use (abuse, approved use, misuse);
- types of incidents, in terms of animal species;
- procedure: 1) shipment of samples and description of find circumstances, 2) pathological and chemical analysis and 3) registration in database.

2.3.2 Use of pesticides and paraquat: volume and type of (approved) application

Pesticide use
As mentioned, changes in pesticide use over time were used in combination with changes in the total number of pesticide-related incidents to signal possible changes in the search efficiency of incident monitoring schemes. Note, however, that total pesticide use and number of incidents are only rough parameters for normalisation purposes. Given that most of the pesticides in use are of low acute toxicity, few if any incidents are to be expected. Ideally, normalisation of the number of reported incidents should be based on the quantity of pesticides potentially causing acute toxicity incidents. Because of reductions in application rate due to changes in pesticide chemistry, moreover, changes in tonnage

pesticide use over the years do not always mean a true reduction in the use of potentially acutely toxic pesticides. However, an extensive, detailed report of trends in pesticide incidents and pesticide use for compounds other than paraquat is beyond the scope of the present study. Here, then, we have simply taken total pesticide consumption as our point of reference.

The amount of pesticides used in a given country can essentially be estimated from either:

1. sales statistics, or
2. usage surveys.

Different figures are obtained in each case[11]. Usage surveys represent actual use, while sales data often also include stocks, which are not actually consumed.

In this study pesticide use has in principle been based on figures reported by FAO (FAO, 2004). FAO maintains a database containing general data on pesticide consumption for many countries throughout the world over the last decade. The pesticides are grouped into several categories. This database provides quantitative data on the amounts of pesticides used in (or sold to) the agricultural sector expressed in metric tons of active ingredient.

For some countries (Netherlands, United Kingdom, United States) pesticide usage data were also available and these were then used (see text box). Differences between sources are identified but not analysed.

Paraquat use

The figures for paraquat use employed in this study are based on data provided by Syngenta (2004). For the UK it was possible to extrapolate to total paraquat sales, but for all other countries paraquat use data represent sales by Syngenta only.

Paraquat product label

For each country, approved applications of paraquat were taken from product labels, as provided by Syngenta (2004). It was assumed that this label information was the most recent available. Particular attention was paid to:

- changes in approved applications over time;
- presence of warnings related to environmental and wildlife hazards.

[11] Inter-country comparison of sales and use statistics should be undertaken with great caution, bearing in mind that the volumes of active ingredient reported in a given country often do not include all uses or chemical classes of crop protection products. Thus, molluscicides, rodenticides and growth regulators are included in the statistics of some countries but not others. In addition, individual plant protection products may be grouped differently in different countries.

Alternative sources of pesticide use data

Netherlands
An additional source of information on Dutch pesticide use are the sales statistics reports published by NEFYTO (*Nederlandse Stichting voor Fytofarmacie*) (NEFYTO, 1984-2003).

United Kingdom
Another source of data on UK pesticide use is the usage statistics database (Central Science Laboratory, 2004), employing the methodology described by Thomas (2001).

United States
Estimates of US pesticide use were taken from the EPA's "Pesticide Industry Sales and Usage" report (Kiely *et al*., 2004). Besides covering the years 2000 and 2001, this report also includes historical information from 1964 onwards.

2.3.3 Changes in lagomorph and bird populations

Animal population dynamics may be influenced by a whole range of human activities besides pesticide use. Changes in population size probably influence the number of incidents occurring, because the potential for poisoning by pesticides in general and paraquat in particular will depend on the number of potential victims. For any constant level of paraquat usage, the number of paraquat-related incidents reported may therefore well decline as fewer and fewer potential victims remain, for whatever reason.

On the other hand, it can be argued that changes in wild animal population size may be an indication that pesticide use is indeed affecting wildlife (see for example Edwards *et al.,* 2000). However, a correlation between changes in population size and changes in paraquat use does not necessarily imply a causal relationship, for population changes may very well be due to factors other than paraquat, such as other pesticides, changes in habitat, general intensification of farming and so on. It is only when a sudden and substantial increase in paraquat use coincides with a sudden and substantial decrease in population size that an adverse impact of the pesticide on the population may be suggested (but not proven).

Hares
Trends in hunting bag records were used as an indicator[12] of population trends in the European brown hare (*Lepus europaeus*) for the United Kingdom, Germany (Edwards *et al.,* 2000), the Netherlands (KNJV, 2002) and France (Marboutin and Péroux, 1996). For

[12] The usefulness of changes in hunting bag records as an indicator of population change is disputable. However, other data based on census programmes, for example, were not often available.

the Netherlands a population time series based on hare census data was also available (DAZ[13]).

Birds

Only very few paraquat incidents with birds are reported in the literature and under the various national incident monitoring schemes. These related to different species, moreover, and for this reason avian population trends were not described in this study.

[13] *DAZ DagActieve Zoogdieren* (DayActive Mammals) is a co-operative monitoring network run by several Dutch organisations: CBS, VZZ and SOVON.

3 Results for the Netherlands

3.1 Incidents reported in the literature

Incidents with wildlife

In the Netherlands two major wildlife incidents involving approved paraquat use have been reported (de Snoo and Canters, 1988). The first incident dates from November 1977 and occurred in the Bath polders. Several fields with green manuring crops (rye grass) had been treated with paraquat and dalapon. Shortly after this treatment a substantial number of hares were found dead, the estimated number totalling around 150. Most carcasses were not suitable for further examination, but two were investigated by the Dutch Central Veterinary Science Institute, CIDC. The two hares were clearly starved. Pathological deformities were observed in intestines, liver, kidneys and lungs. The concentrations of paraquat found in the stomach contents ranged from <4 to 25 mg/kg, that of the intestine contents from 58 to 104 mg/kg. CIDC concluded that the death of these hares was attributable to paraquat poisoning. The second incident occurred in January 1982 at Schiphol Airport after treatment of grassy fields between the runways. Eleven hares were found dead and four of these were examined by CIDC. Paraquat was detected in the intestines and stomach of three animals, in concentrations ranging from 2 to 24 mg/kg. The animals investigated were in a poor condition, having point haemorrhages in the stomach, and the liver was intact. Here, too, CIDC concluded that the cause of death was paraquat poisoning.

We checked whether EBHS (European Brown Hare Syndrome) might be an alternative explanation for these two incidents. According to dr. S. Broekhuizen (written communication) EBHS has never been a serious problem in the Netherlands and he concluded that this will not have played a role in either of these two incidents.

Although there are four publications reporting pesticide incidents with wildlife in the Netherlands from 1950-1998, they do not contain a single reference to any paraquat-related incident. Van Lieshout & Hoskam (1972) have reported on intentional poisonings of wild birds during the period 1950-1972, while for the period 1975-1989 the Working Group on Wild Bird Mortality reported on all wild bird incidents, including poisoning by pesticides (WG-WBP 1989). Tamis *et al.* (1999) and De Snoo *et al.* (1999) have reported all wildlife incidents known to have occurred in the periods 1989-1998 and 1990-1994, respectively.

Incidents with companion animals

For the period 1980 to 1982 a Dutch pesticide action group reported thirteen paraquat-related incidents involving dogs, five of which died, and ten such incidents with cats, of which three died (SNV 1985). No further details on the circumstances or on toxicological or pathological examination are provided. De Snoo & Canters (1988) also describe four

fatal paraquat-related incidents with companion animals that occurred in 1982 (written communication: Department of Veterinary Science of Utrecht University). It is not clear whether these latter incidents are included in those reported by SNV. There have been no publications reporting paraquat-related incidents involving Dutch livestock.

3.2 Incidents reported in national incident monitoring scheme

3.2.1 Incidents reported

Number of incidents due to pesticide poisoning
Figure 3.1 shows the total number of reported wildlife[14] incidents[15] with mammals and birds involving pesticides, as registered under the Dutch monitoring scheme for the period 1989-2003 (CIDC, 1989-2003). As can be seen, the number of incidents reported by CIDC fluctuates sharply. We received no data for the year 1999. Over the entire period 1989-2003 there were no reported incidents involving paraquat.

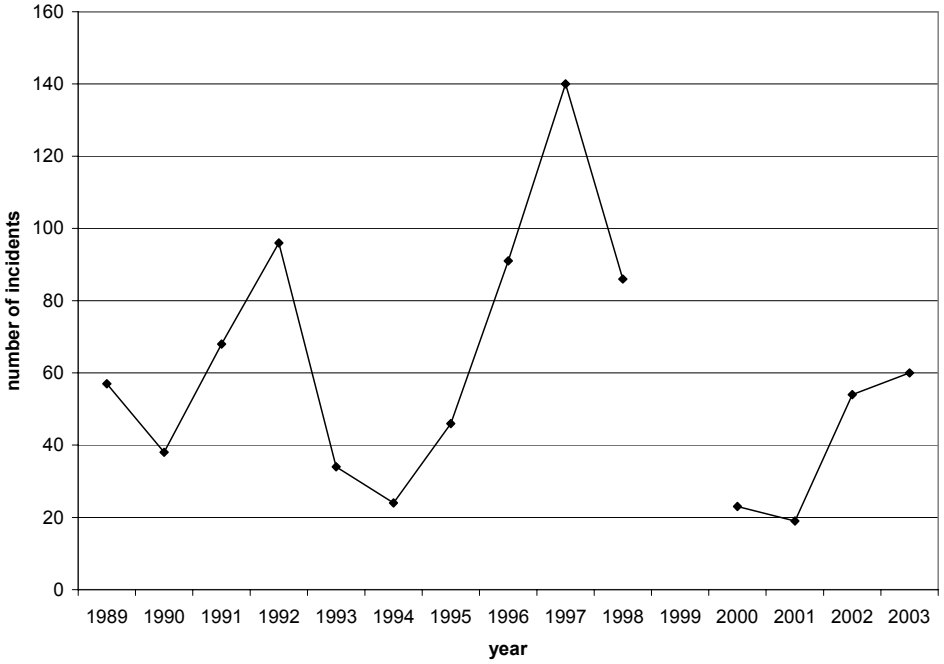

Figure 3.1 Annual number of reported pesticide incidents with wildlife[16] in the Netherlands, 1984-2003 (CIDC, 1989-2003).

[14] 'Wildlife' here includes mammals and birds only, thus excluding incidents with fishes, frogs and bees. The monitoring scheme registers wildlife incidents only, so incidents with companion animals and livestock are not registered.
[15] The incidents reported in the figure are 'cases' rather than fatalities. The total number of incidents shown in the figure is the sum of incidents involving mammals and birds.
[16] Mammals and birds only, i.e. no incidents involving companion animals or livestock, nor fishes, frogs or bees.

Cause of poisoning

Table 3.2 provides a breakdown of pesticide-related incidents (all pesticides) involving vertebrates according to pesticide usage category for the period 1989-2003 as reported by CIDC.

Table 3.2 Annual number of pesticide-related incidents with mammals and birds in the Netherlands, 1989-2003, with percentage breakdown by cause (CIDC, 1989-2003)

	abuse	approved use	misuse	unspecified use	**total**	abuse	approved use	misuse	unspecified use
	n	n	n	n	**n**	%	%	%	%
1989	40	1	5	11	**57**	70	2	9	19
1990	21	3	1	13	**38**	55	8	3	34
1991	28	6	0	34	**68**	41	9	0	50
1992	46	4	0	46	**96**	48	4	0	48
1993	29	0	0	5	**34**	85	0	0	15
1994	20	0	2	2	**24**	83	0	8	8
1995	38	0	0	8	**46**	83	0	0	17
1996	65	1	2	23	**91**	71	1	2	25
1997	85	3	4	48	**140**	61	2	3	34
1998	62	1	0	23	**86**	72	1	0	27
1999									
2000	13	0	0	10	**23**	57	0	0	43
2001	14	1	0	4	**19**	74	5	0	21
2002	49	1	0	4	**54**	91	2	0	7
2003	57	0	0	3	**60**	95	0	0	5
total	**567**	**21**	**14**	**234**	**836**	**68**	**3**	**2**	**28**

Table 3.2 shows that in the period 1989-2003 by far the majority of vertebrate incidents are attributable to pesticide abuse, the relative share fluctuating somewhat and averaging about 68% for the period as a whole. Approved use of pesticides explains only a small fraction of the incidents with vertebrates. Again, the proportion of incidents involving approved use fluctuates, but averages around only 3% for the period as a whole. For a substantial fraction of the incidents the cause of death in terms of pesticide usage was unspecified (for the period as a whole, 28%).

Species composition of paraquat-related incidents

No incidents with paraquat have been reported by CIDC under the Dutch incident monitoring scheme.

3.2.2 Controlling factors affecting number of incidents

Below we briefly review several factors of possible influence on the number of reported incidents. A more extensive description can be found in Appendix III.

Incident monitoring schemes
A systematic incident monitoring scheme has been in place in the Netherlands since 1989. However, paraquat analysis is not part of the standard toxicological procedure. In 1994 there was an important change in the reporting regime, with the cost of analysis no longer being borne by the government but having to be paid by the party reporting the incident. It is unclear whether this change has influenced the total number of reported incidents.

Changes in the use of paraquat and other pesticides
According to FAO, aggregate pesticide and herbicide use in the Netherlands remained relatively constant during the period 1991-1998 (see figure III-2 in appendix). Since then (i.e. up to 2002) there seems to have been a substantial decrease in total pesticide use and a slight decrease in herbicide use, however. Over the period 1986-2000 there was a decrease in the use of paraquat (see figure III-3 in appendix). Peak paraquat use in this period occurred around 1988. Between 2000 and 2004 use seems to have remained more or less stable. Paraquat use is estimated to account for about 0.5% of aggregate Dutch pesticide use. In recent years the principal uses of paraquat in the Netherlands are for weed control in potatoes, tree nurseries, legumes and bulb flowers (see table III-4 in appendix).

The Dutch product label includes the ‘skull and crossbones’ danger symbol with the caption 'Poisonous'. No specific guidelines are given for environmental protection. Information regarding changes in label information over the years was not available. Consequently, we do not know whether there have been any changes in approved uses, restrictions or other label information over time, let alone the dates of any such changes.

Changes in hare population size
On the assumption that hunting records are a good indication of hare population size, the Dutch hare population seems to have remained fairly stable over the period 1980-2000 as a whole (see figure III-6 in appendix). Over the shorter period 1994-2003, however, hare census counts reveal a different picture of the number of brown hares surviving in the Netherlands. According to these counts, there was a marked decline in the Dutch hare population over the period 1994-2003 (see figure III-5 in appendix).

3.3 Synthesis and conclusions for the Netherlands

There are literature reports of two major incidents involving hares, one in 1977 and one in 1982, both of which were due to approved use of paraquat. Over the period 1989-2003 no paraquat-related incidents with wildlife were reported under the incident monitoring scheme.

For 1980 to 1982, the literature reports about 23-27 paraquat-related incidents involving companion animals. However, the reports in question do not provide enough information for these incidents to be evaluated. Because companion animals and livestock are not registered under the Dutch wildlife incident monitoring scheme, no paraquat-related incidents were reported for the period 1989-2003.

In the Netherlands paraquat-related incidents are thus only reported for the period 1977-1982. One explanation for this might be changes in the approved uses and labelling of paraquat. As stated, though, we were unable to obtain the historical data to verify this. Another explanation might be that it was during that period that paraquat use peaked in the Netherlands. However, we only had paraquat use data for the period 1986-2004 and these showed a maximum in 1988. Again, then, we had insufficient data to verify this hypothesis. Yet another explanation might be that the extensive search for information on pesticide side-effects in the Netherlands undertaken by De Snoo & Canters (1988) was for the years 1986-1988 This might explain why paraquat-related incidents are known only for the years prior to publication of that study.

Despite the fact that the Netherlands has an incident monitoring scheme, there are indications that this scheme is not efficient at monitoring paraquat-related incidents. Paraquat is not part of the standard toxicological analysis and only if there are strong indications that paraquat is involved in an incident is the sample actually analysed for presence of the compound. Furthermore, the numbers of incidents reported may possibly have been affected by the change in reporting regime that occurred in 1994, which may have led to the number of reported incidents due to approved use and/or misuse declining or even falling away altogether.

4 Results for France

4.1 Incidents reported in the literature

Incidents with wildlife
Newman (1971, *cit.* in EPA 1982: p.37) reports several major incidents with hares in France in the 1970s, but gives no further details on numbers, situation or analyses. Edwards *et al.* (2000) describe paraquat-related incidents with hares (*Lepus europeaus)* in France and the United Kingdom. They describe a number of historical incidents before 1971 (although no reference is given in Edwards *et al.* (2000), these are most likely the same as those reported by Newman (1971)). These were unpublished and unconfirmed paraquat-related incidents with large numbers of hare fatalities. However, they argued that these incidents may have been misinterpreted and might be the first, unrecognised outbreaks of the virus disease EBHS (European Brown Hare Syndrome). Further details on these historical incidents are given in section 5.1.
Edwards *et al.* (2000) also describe the results of the SAGIR incident monitoring scheme in France for the period 1986-1996. Eight dead hares were reported as being paraquat-related (total hare mortality approx. 13,588, of which some 212 poisoned). As these data will be described in detail in the next section, we shall not discuss them here.
De Snoo *et al.* (1999) also analysed all known pesticide incidents with wildlife occurring in France between 1990 and 1994. During that period no paraquat-related incidents were reported in France.

Incidents with companion animals and livestock
No literature on paraquat-related incidents with companion animals and livestock was found.

Field experiments
Besides the literature concerning pesticide-related incidents with animals, we found several articles describing field experiments in France with hares and rabbits in enclosures to investigate the effect of paraquat and repellent substances (De Lavaur *et al.* 1973, Grolleau 1981). Since these were *experiments*, they are not discussed here.

4.2 Incidents reported in national incident monitoring scheme

4.2.1 Incidents reported

Number of incidents due to pesticide poisoning
The information on incidents received from France was incomplete. The total number of registered wildlife fatalities[17] over the period 1986-2003 was 36,017. Although hares account for a large proportion (37%) of the fatalities registered under the French incident monitoring scheme (SAGIR), other species are also cited, *viz.* birds (14%), ungulates

[17] In SAGIR the number of dead animals is registered, i.e. fatalities rather than incidents.

(34%), rabbit (10%) and carnivores (5%) (Gaillet, 2004; presentation of the SAGIR network at a Syngenta workshop, 2004).

Unfortunately, we were unable to obtain any other information besides the hare data. From the reported fatalities of hares no information could be retrieved on the cause of death in terms of paraquat use.

Figure 4.1 reviews the number of hare fatalities[18] reported under the French incident scheme in which pesticides and paraquat were identified as a likely cause of poisoning[19] during the period 1986-2003. The total number of reported hare fatalities was 22,043 over this period. In the same period the number of poisoning fatalities was 447, of which 9 were due to paraquat. Other causes of death were disease (10,777) and EBHS (4,224). For the remainder no diagnosis was feasible (ONCFS, 2004).

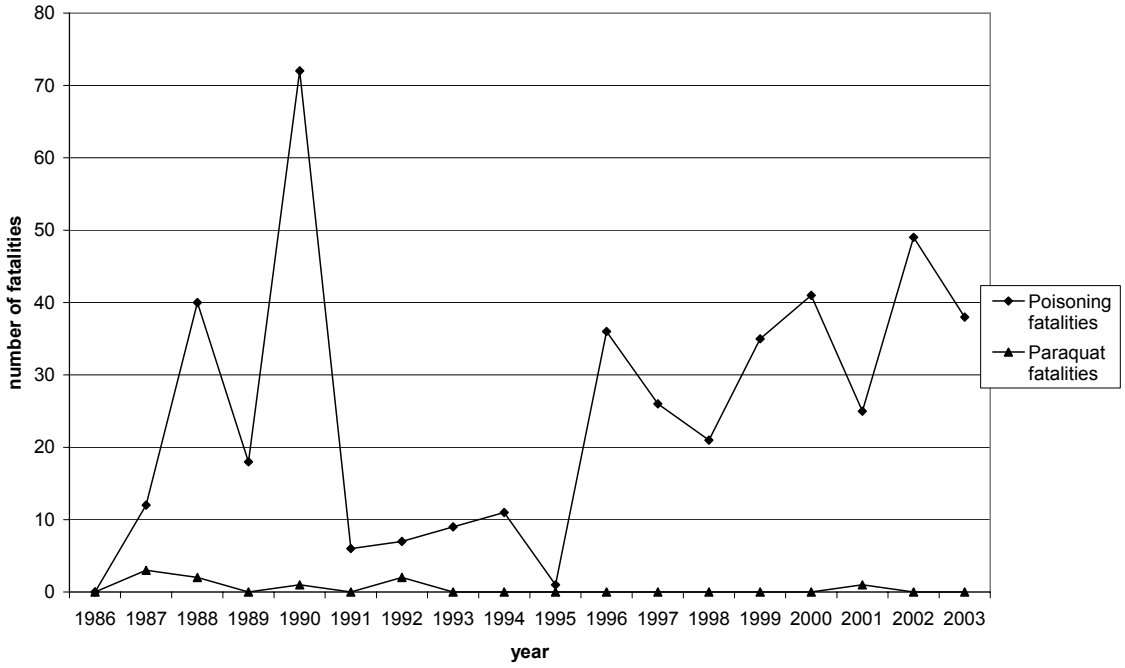

Figure 4.1 Annual pesticide- and paraquat-related hare fatalities in France, 1986-2003 (source: ONCFS[20])

In France the annual number of pesticide-related hare fatalities has fluctuated widely. Between 1986 and 1990 there appears to have been an increase, dropping to a lower, but again rising level in the period 1991-1995. Then, from 1995 onwards, there seems to be a new increase in the number of hare fatalities.

[18] Note again that the incidents reported in the figure are fatalities, not incidents.
[19] Poisoning includes not only pesticide poisoning but also poisoning by plants (1%), metals (1%) and undefined poisoning (16%).
[20] *Office National de la Chasse et de la Faune Sauvage.*

Only between 1986 and 1993 were a few hare deaths reported as being related to paraquat, with a further, isolated incident in 2001. For the overall period 1986-2003 the share of paraquat poisoning in total pesticide-related mortality was 2% on average.

It should be noted that the two sources used (Syngenta workshop 2004 and ONCFS) report conflicting figures for the total number of SAGIR-registered hare fatalities occurring in the period 1986-2003. In the Syngenta workshop presentation the number of registered fatalities was held to be about 13,326 (37% of 36,017). However, the time series received from ONCFS showed the total number of reported hare fatalities to be appreciably higher: about 22,043. The information we received was insufficient to explain this difference. One possible explanation might be a difference between the number of reported deaths and the number of carcasses on which diagnosis was feasible.

4.2.2 Controlling factors affecting number of incidents

Below we briefly review a number of factors of possible influence on the number of reported fatalities. For a more extensive description the reader is referred to Appendix IV.

Incident monitoring scheme
In France a systematic incident monitoring scheme, SAGIR, has been in operation since 1986. Analysis procedures include pathological and, if necessary, toxicological analysis. Analysis to identify paraquat forms part of the standard toxicological analysis. No information was available on any changes that may have occurred in the incident monitoring scheme.

Changes in the use of paraquat and other pesticides
In the period 1990-2001 aggregate French use of pesticides and herbicides remained more or less stable, with a slight decrease setting in in recent years, *viz.* 1999-2001 (see figure IV-2 in the appendix). Use of paraquat, too, seems to have decreased over the period 2000-2004 (see figure IV-3 in the appendix). Paraquat is estimated to account for about 0.2% of total pesticide use in France. In recent years paraquat has been used for weed control in many types of crops, including vines, orchards, nurseries and forage crops (see figure IV-4 in the appendix).

The French label includes the ‘skull and crossbones’ danger symbol with the caption 'Toxic'. It also provides environmental protection guidelines, including dedicated information on safety precautions to protect wildlife, specifically hares and livestock (see appendix IV). Information regarding any changes in label information over time was not available. We therefore do not know whether or when there have been any changes in approved uses, restrictions or other label information.

Changes in hare population size
Hunting bag records of hares for 4 districts in the north-east of France have been analysed by Marboutin and Péroux (1995). In these districts, at any rate, the number of brown hares fluctuated markedly over the period 1973-1983 (see figure IV-5 in the appendix). The degree of fluctuation varies from district to district. Since about 1983 there

appears to have a gradual decline in the hare population. We assume the trend found in these districts is representative of population changes throughout France.

4.3 Synthesis and conclusions for France

Only two publications were found reporting paraquat-related incidents with hares in France. One of these related to before 1970, the other to the period 1986-1996. The total number of incidents could not be reconstructed for two reasons. First, the incidents prior to 1970 were combined with incidents occurring in the UK (19 incidents in all). Second, for the period 1986-1996 only the bare mortality statistics were presented. The pre-1970 paraquat incidents in France have been evaluated by Edwards *et al*. (2000), who concludes they had possibly been misinterpreted.

For the period 1986-2003 the only hare mortality data received were those registered under the SAGIR incident monitoring scheme. These were largely the same as the data cited in the literature. A total of 9 paraquat-related hare fatalities are reported, most of them in the period 1986-1993. Information on the total number of pesticide-related hare deaths are conflicting. Although no causes of the hare paraquat poisonings are mentioned, it may be safely assumed that these were cases of approved use.

No literature on paraquat-related incidents with companion animals and livestock was found, nor was any data on incidents involving other wildlife, companion animals and livestock found or retrieved from the incident monitoring scheme.

There was not enough information available about any changes to the incident monitoring scheme, paraquat use, approvals, restrictions or labels, nor about population dynamics. These factors could therefore not be correlated with the number of paraquat-related incidents involving hares.

5 Results for the United Kingdom

5.1 Incidents reported in the literature

In the United Kingdom the Wildlife Incident Investigations Scheme (WIIS) has been operational since about 1964. There are numerous publications describing this scheme and its results. The organisation of WIIS is described in detail in Appendix V. The main publications on WIIS not mentioning paraquat-related incidents are Brown *et al.* (1977), Hamilton *et al.* (1981), Fletcher & Hardy (1986), Greig-Smith (1989), Hart & Clook (1994), Hunter (1995) and Fletcher (1994). The WIIS data on hares (since about 1964) and all other species (since 1985) are presented in detail in the next section. There is an overlap between the paraquat-related incidents reported in the literature and the data retrieved from WIIS.

Incidents with wildlife or unspecified incidents
Six publications containing information on paraquat-related incidents with British wildlife were found. A first set of articles focuses on a number of paraquat-related incidents with hares before 1970. There may be an overlap of incidents in these publications. The oldest publication on paraquat-related incidents with wildlife is ARC (1970), which reports on incidents with hares in treated cereal stubbles in autumn. They stated there was no evidence of permanent damage to populations. No further details of number of incidents or animals involved are given, nor of the methods used.
Newman (1971 *cit.* in EPA 1982) report two incidents in which about 70 to 80 hares were killed following the spraying of paraquat on grassy stubbles. These are therefore apparently different incidents than those reported for treated cereal stubbles by ARC (1970). In some cases paraquat residues ranging from 1 to 5 ppm were measured. No further information was available on these incidents, nor could the original publication be retrieved to evaluate these findings.
Edwards *et al.* (2000) describe paraquat-related incidents with hares (*Lepus europeaus)* in the United Kingdom and France. Among these are several historical incidents that occurred in the period 1964-1971. There were nineteen unpublished paraquat-related incidents. The average number of hares per incident is about 20 (range 5-120). No pathological details of these incidents is available. The incidents occurred after spraying of grass and lucerne stubbles. Residues were measured in nine of the nineteen incidents. Edwards *et al.* conclude that this is confirmation of exposure but not death due to paraquat. They also argue on the basis of circumstantial evidence that these cases may in fact be the first, unrecognised cases of EBHS (European Brown Hare Syndrome, a viral disease).

Hardy & Stanley (1986) describe the poisoning incidents registered under WIIS during the period 1964-1983, but do not specify whether these involved wildlife, companion animals or livestock. Over this entire period there were 2100 suspected incidents, 44% of which were pesticide-related. About fifty per cent of the incidents could be ascribed to misuse or deliberate abuse. In that period there were eleven herbicide-related incidents, eight of them involving paraquat. In addition, the authors note that an unspecified number

of incidents had been investigated where paraquat poisoning was suspected and describe the difficulties of diagnosing for paraquat poisoning. No specific data on species, cause etc. is given with respect to these paraquat poisonings other than that paraquat was among the pesticides deliberately abused. It is not known whether this publication includes the incidents reported in Newman (1971 *cit.* in EPA 1982), ARC (1970), Longstaffe *et al.* (1981), Barton & Gaskell (1982) and Edwards *et al.* (2000).

Edwards *et al.* (2000) analyse the population dynamics of the brown hare (*Lepus europaeus*) in the United Kingdom in relation to aggregate paraquat use and the number of paraquat-related incidents with hares in the period 1974-1997. During that period 104 fatal incidents with hares were analysed. There were two confirmed paraquat incidents, in 1976 and 1990. In both cases several hares were found dead near sprayed grass or potato fields in June and August (approved use). These results will be presented in detail in the next section.
Fletcher & Grave (1992) describe the poisoning incidents due to approved pesticide use registered under WIIS in the period 1987-1991. In that period several hedgehogs (*Erinaceus europaeus*) had been poisoned in one incident after a roadside verge had been sprayed.
De Snoo *et al.* (1999) also mention the paraquat-related incidents in the period 1990-1995 with hedgehogs and hares reported by, respectively, Fletcher & Grave (1992) and Edwards *et al.* (2000). De Snoo *et al.* (1999) also report three incidents in which paraquat had been used for intentional poisoning (abuse) but do not specify the animals involved.

Incidents with companion animals, livestock etc.
Six articles were found with information on this category of paraquat-related incidents in the UK, most of them involving companion animals.
Darke *et al.* (1977) describe ten fatal incidents with ten dogs (probably before 1975). All the carcasses underwent pathological as well as toxicological examination. They all showed the typical lung deformities associated with paraquat poisoning and the compound was detected in tissues of four of the dogs. All the animals were from a rural environment. In only four of the cases was there known to be access to paraquat. Two dogs lived in a household where paraquat had been used twice in the month prior to the onset of illness. Two dogs were connected to paraquat-poisoned bait for foxes. All the other dogs lived in the neighbourhood and it was known that some had scavenged bait.
Longstaffe *et al.* (1981) describe the pathological and toxicological differences between accidental (moderately lethal dose) and malicious (high lethal dose) paraquat poisonings. They bases themselves on two dogs and three cats that had died as a consequence of a single deliberate paraquat poisoning incident in autumn 1977 and five dogs that had died in the period 1977-1980 (several incidents, cause unknown), presumably as a result of accidental paraquat ingestion.
Barton & Gaskell (1982) describe one paraquat-related incident with four dogs on a farm that occurred in 1982. One of the dogs was known to have eaten bait poisoned with paraquat by the dog's owner and the other three had probably been poisoned by the same bait. Based on the circumstances and clinical and pathological examination of the dogs, they presumed this incident was indeed a case of paraquat poisoning.

Quick (1990) describes one incident involving acute and sub-acute paraquat poisoning in a pack of foxhounds around 1990 (exact year not given). On returning from a hunt, five of a pack of ten foxhounds became ill and all these died after one to six days. A clinical, pathological and toxicological examination was carried out on all the dogs. Although the source of the paraquat was unknown, it was hypothesised that the thirsty hounds drank from a paraquat-contaminated puddle.
Barnett & Fletcher (1998) describe poisoning incidents due to pesticide misuse ("negligent use") over the period 1994-1996. They describe one paraquat-related incident with a horse. The incident resulted from overspraying of paraquat into a field where a horse was kept. In another incident paraquat and diquat were mixed at four times the recommended strength, but in this case no casualties were reported.

Campbell (1999) describes the reports ("inquiries") to the Veterinary Poisons Information Service (VPIS) of poisoning incidents in the period 1993-1998 involving companion animals (mainly dogs and cats). In these six years 3,813 incidents were reported, of which 117 (3%) were paraquat-related. There were 190 fatal incidents, of which 34 (18%) involved paraquat. During this period the number of paraquat-related incidents increased and the only animals involved were dogs. Paraquat was characterised as a frequent cause of mortality. Many of the cases reported occurred as a result of (suspected) deliberate poisoning. Each inquiry was followed up by an questionnaire to the veterinary practitioner with a view to determining the outcome of cases. In 1997 4,687 incidents were reported to the VPIS and in 57% of the cases these were confirmed in the questionnaire. In ten per cent of these confirmed cases the poisonings were fatal, with pesticides being implicated in one third of the latter. Paraquat was responsible for eight confirmed fatal incidents in 1997 (Editorial 1998).

Field research and experiments
Edwards (1979, *cit.* in WHO 1984) describes a bird population monitoring study on a farm in the UK over a five-year period in which paraquat use was much higher than normal. This study found no population-level effects on any bird species. As we were unable to retrieve this publication, these findings could not be evaluated.
Besides the literature concerning pesticide-related incidents with animals, one article was found describing a field experiment with rabbits in enclosures to investigate the effect of paraquat (Newman 1971 *cit.* in EPA 1982 p 37/38). Since this was an *experiment*, the results are not discussed further here. In addition, the original publication could not be retrieved.

5.2 Incidents reported in national incident monitoring scheme

5.2.1 Incidents reported

Number of incidents due to pesticide poisoning

Figure 5.1 reviews, for the period 1986-2002, the number of incidents[21] reported under the UK incident monitoring scheme WIIS in which pesticides were identified as a likely cause of poisoning. The incidents include vertebrate wildlife, livestock, companion animals, exotic species, fish, beneficial insects, suspected baits and suspicious substances (source: MAFF, 1986-2002). As stated in the previous section there is a certain overlap between the paraquat-related incidents reported in the literature and the data retrieved from WIIS.

Over the period 1986-2002 there were a total of 3,040 pesticide-related incidents. During this period the number of annual incidents due to pesticide poisoning seems to have decreased from 250 a year in the late eighties to 130 a year at the turn of the century.

For paraquat the trend seems to be more nuanced. From 1985-1989 the number of annual incidents increased, subsequently remaining more or less stable in 1990-1995. In the final period, 1995-2003, there seems to have be a slight decrease. The total number of paraquat incidents over the entire period 1986-2002 was 174, with paraquat accounting for an average of about 6% of all pesticide-related incidents.

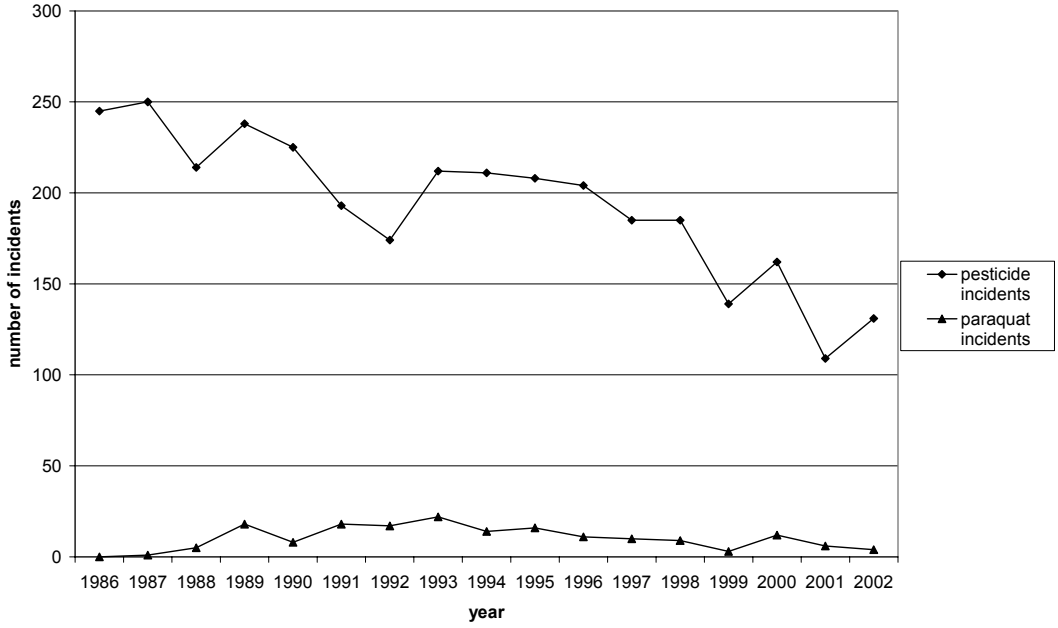

Figure 5.1 Annual number of reported pesticide incidents[22] in the UK, 1986-2002 (MAFF, 1986-2002)

[21] The incidents reported by MAFF are 'cases' rather than fatalities and each incident may involve casualties of different species.

[22] The incidents relate to vertebrate wildlife, livestock, companion animals, exotic species, fish, beneficial insects, suspected baits and suspicious substances.

Cause of poisoning

Table 5.2a provides a breakdown of the pesticide-related vertebrate incidents (all pesticides) according to pesticide usage category for the period 1994-2002 as reported by MAFF. Table 5.2b presents a similar breakdown for the paraquat-related vertebrate incidents (in this study extracted from MAFF annual reports for the years 1987-2002)[23].

Table 5.2a, for pesticides as a whole, shows that by far the largest share of incidents is attributable to pesticide abuse: 64% on average. Approved use explains only a minority of the incidents involving vertebrates. The relative share of approved use averages 4%.

For paraquat, too, by far the majority of incidents is attributable to abuse: 80% on average for the period 1994-2002. In the period 1995-2002 the relative share of abuse proves to be much higher than in the period 1987-1994. The table seems to indicate that in 1995 there was a change in methodology in which many incidents formerly classified as unspecified were now classified as abuse. Both approved use and misuse of paraquat explain only a minority of the incidents involving vertebrates. In the period 1987-2002 there was 1 incident attributable to approved use and 4 attributable to misuse, of a total of 145 poisoning incidents.

Table 5.2a Annual number of pesticide-related incidents with vertebrates in the UK, 1994-2002, with percentage breakdown by cause (MAFF, 2002)

	abuse	approved use	misuse	unspecified use	**total**	abuse	approved use	misuse	unspecified use
	n	n	n	n	n	%	%	%	%
1994	115	12	21	43	**191**	60	6	11	22
1995	112	5	21	37	**175**	64	3	12	21
1996	136	11	19	30	**196**	69	6	10	15
1997	125	3	21	21	**170**	74	2	12	12
1998	95	4	45	29	**173**	55	2	26	17
1999	61	7	31	31	**130**	47	5	24	24
2000	95	9	22	23	**149**	64	6	15	16
2001	81	2	6	15	**104**	78	2	6	14
2002	78	5	19	24	**126**	62	4	15	19
total	**898**	**58**	**205**	**253**	**1414**	**64**	**4**	**14**	**18**

[23] Note that there is a difference in time period for the incidents by the total of pesticides and the paraquat incidents. The overview for the total of pesticides was taken over from MAFF, which only gave an overview for the period 1994-2002. The overview for paraquat was derived from the different annual reports.

Table 5.2b Annual number of paraquat-related incidents with vertebrates[24] in the UK, 1987-2002, with percentage breakdown by cause (extracted from MAFF, 1987-2002)

	abuse	approved use	misuse	unspecified use	**total**	abuse	approved use	misuse	unspecified use
	n	n	n	n	n	%	%	%	%
1987				1	**1**	0	0	0	100
1988				4	**4**	0	0	0	100
1989	4		1	13	**18**	22	0	6	72
1990	1	1	1	5	**8**	13	13	13	63
1991	5			8	**13**	38	0	0	62
1992	7			8	**15**	47	0	0	53
1993	9			13	**22**	41	0	0	59
1994	4	0	2	5	**11**	36	0	18	45
1995	13	0		1	**14**	93	0	0	7
1996	9				**9**	100	0	0	0
1997	6				**6**	100	0	0	0
1998	9				**9**	100	0	0	0
1999				3	**3**	0	0	0	100
2000	2			1	**3**	67	0	0	33
2001	5				**5**	100	0	0	0
2002	3			1	**4**	75	0	0	25
total 87-02	**77**	**1**	**4**	**63**	**145**	**53**	**1**	**3**	**43**
total 94-02	**51**	**0**	**2**	**11**	**64**	**80**	**0**	**3**	**17**

Species composition of paraquat-related incidents

During the period 1987-2002 there were 177 paraquat-related incidents involving at least 246 animals. Table 5.3 reviews the number of incidents[25] related to paraquat, classifying them according to cause and type of organism. By far the greatest number of paraquat incidents relate to companion animals (about 62%), particularly dogs (48%) and cats (13%). Wildlife vertebrates make up some 17% of the incidents (14% mammals, 3% birds). In 12% of the incidents suspicious material (e.g. bait) is found without victims. Honeybees contribute to 5% of the incidents. Finally, 2% of the incidents are related to livestock.

[24] Incl. wildlife vertebrates, livestock, companion animals, exotic species and fish; excl. beneficial insects and suspected baits and suspicious substances.

[25] Note that the total number of incidents is 177 rather than 174. This difference is due to the fact that an incident may involve more than one species. In this table, however, incidents with more than one species are counted as separate incidents.

During the period 1987-2002 there was 1 hare incident (involving 1 fatality) reported under the WIIS scheme, in 1990[26]. Edwards *et al.* (2000) report on the number of hare incidents over the longer term[27]. According to these authors there were only 2 paraquat-related incidents with hares in the UK during the period 1974-1997. We also received the original data from Edwards *et al.* (2000). Based on these original (summarised) data there were 7 other incidents in which paraquat was involved. Apparently the evidence was not strong enough (despite that fact that lung congestions were reported) to classify these incidents as paraquat-related (see appendix VIII). However, the incidents could be classified as possible paraquat incidents.

Note that during the period 1987-2002 there were several paraquat related incidents with other wild mammals such as badgers (7 incidents), feral cat (1 incident), foxes (11 incidents), a hedgehog (1 incident) and a rabbit (1 incident). There were 3 incidents involving wild birds (crow, rook, magpie, kestrel and pheasant).

[26] In a workshop presentation at Syngenta (2004) an additional incident with hares was reported, involving potato desiccation, which is not a labelled use. This incident was not reported in the WIIS 1994 annual report, however, nor in the original spreadsheet used by Edwards *et al*., 2000 (see appendix).

[27] Before 1986 there was no systematic annual reporting of incidents in the UK, with hare incidents being extracted from a variety of paper records from different regions (pers. comm. Mark Fletcher, CSL).

Table 5.3 Paraquat-related incidents and fatalities during the period 1987-2002, broken down by cause and organism

	incidents					fatalities				
	abuse	approved use	misuse	unspecified use	**total**[28]	abuse	approved use	misuse	unspecified use	**total**
companion animals										
cat	14		1	8	**23**	17		1	11	**29**
dog	56		1	28	**85**	81		4	41	**126**
guinea fowl				1	**1**				2	**2**
livestock										
chicken				1	**1**				3	**3**
horse			1	1	**2**			1	1	**2**
vertebrate wildlife										
mammals										
badger	1			6	**7**	1			7	**8**
feral cat	1				**1**	1				**1**
fox	4		1	6	**11**	5		3	6	**14**
hare[29]		1			**1**		1			**1**
hedgehog[30]				1	**1**				2	**2**
rabbit				1	**1**				1	**1**
bird										
bird (crow, rook, magpie)	1				**1**	6				**6**
kestrel	1				**1**	1				**1**
pheasant	1				**1**	30				**30**
beneficial insects										
honeybee		8		1	**9**		?		?	**?**
baits and samples										
bait	17				**17**	17				**17**
sample	1	2			**3**	1	2			**3**
Unknown[31]				11	**11**				11	**11**
total	**97**	**11**	**4**	**65**	**177**	**160**	**>3**	**9**	**>74**	**>246**

[28] Note that the total number of incidents is 177 rather than 174. This difference is due to the fact that an incident may involve more than one species. In this table, however, incidents with more than one species are counted as separate incidents.

[29] In a workshop presentation at Syngenta (2004) an extra incident with hares was reported, involving potato desiccation, which is not a labelled use. This incident was not reported in the WIIS 1994 annual report, however, nor in the original spreadsheet used by Edwards *et al*., 2000 (see appendix).

[30] In Fletcher & Grave (1992) this case was reported as an approved use incident involving more than one hedgehog.

[31] For some of the incidents in the period 1987-1989 the type of species could not be derived from the annual reports.

5.2.2 Controlling factors affecting number of incidents

Below we briefly review a number of factors of possible influence on the number of reported incidents. For a more extensive description the reader is referred to Appendix V.

Incident monitoring scheme
The UK has a systematic incident monitoring scheme in place. Analysis procedures have a pathological and, if necessary, toxicological component. Analysis to identify paraquat is part of the standard toxicological analysis. No reports were found concerning changes over time in the incident monitoring scheme.

Changes in the use of paraquat and other pesticides
Over the years there has been a (slight) increase in total pesticide consumption in the UK (see figure V-2 in the appendix). Between 1996 and 2002 sales of paraquat nearly halved (see figure V-3 in the appendix). The share of paraquat in overall pesticide consumption is estimated to be about 1%. In recent years paraquat has been used for weed control, mainly in potatoes and cereals (see table V-4 in the appendix).

The product label contains guidelines for environmental protection, including specific guidelines to protect livestock and hares (see appendix V). Information regarding changes in label information over time was not available. Consequently, we do not know whether there have been any changes in approved use, restrictions or other label information over time have, let alone the dates of any such changes.

According to a study of long-term trends in UK paraquat use (Edwards *et al.* 2000), use doubled between 1965-1975, halved in the period 1975-1985 and was more or less stable in the period 1985-1995.

Changes in hare population size
According to UK hunting bag records, the number of brown hares decreased dramatically between 1960 and 1990 (see figure V-5 in the appendix). From 1960 to 1980 the national population declined by nearly 75%. From 1980-1995 onwards the population seems to have remained more or less stable, albeit at a lower level (Edwards *et al.,* 2000).

5.3 Synthesis and conclusions for the United Kingdom

Six publications were found with information on paraquat-related incidents involving wildlife, predominantly hares. The total number of incidents cited in the literature is between 15 and 20 for the period prior to 1970 through to about 1995. The main reason for this imprecision is that it is often unclear whether incidents are reported more than once in different articles. Before 1970 a maximum of 19 incidents with hares were reported for the UK and France together (Edwards *et al.*, 2000). However, these authors conclude that the incidents had possibly been misinterpreted. The figure of 15-20 wildlife incidents prior to 1970 found in the literature is therefore a maximum. Subsequent to 1970 only 3

incidents with wildlife are reported in the literature that are attributable to approved paraquat use in which hares (2) and hedgehogs (1) were involved.

The total number of paraquat-related wildlife incidents sampled by WIIS between 1987 and 2002 was about 25 to 30 (at least 64 animals). Nine wildlife species were cited, predominantly foxes and badgers. In most cases in which the cause is known, the animals were deliberately poisoned.

There are 6 publications with information on paraquat-related incidents with companion animals and livestock. Between 1975 and 1996 a total of about 15-20 such incidents occurred. Most paraquat-related incidents involved dogs and the main cause of poisoning was paraquat abuse. One incident with a horse was published. If we include the results of the Veterinary Poisons Information Centre (VPIS) for the period 1993-1998, then the total number of incidents increases by 117, of which 34 fatalities (only dogs, probably mainly pesticide abuse).

The total number of paraquat-related incidents with companion animals and livestock reported under the WIIS scheme was about 112 between 1987 and 2000. These involved 162 animals, mainly dogs and to a lesser extent cats. Again the cause of most incidents was deliberate poisoning (abuse). Livestock was mentioned in 3 incidents (horse, chicken).

For the period 1960-1985 information on pesticide incidents, pesticide use and incident monitoring schemes is lacking[32]. The conclusions below therefore relate mainly to changes in factors occurring in the period 1986-2002.

The total number of paraquat incidents in this period was approximately 174; this figure encompasses wildlife, companion animals, livestock, bait and samples. The total number of pesticide incidents in this same period was 3,040. Since about 1995 the annual number of paraquat-related incidents has been slowly declining. Between 1986-2002 the total number of pesticide-related incidents reported under WIIS halved. This may indicate either that enhanced pesticide policy and farming practices have led to less incidents (e.g. reduced use of highly toxic organophosphates and carbamates) or, alternatively, that the intensity of searching has declined. Since 1985 there has been a reduction in paraquat consumption. The decline in paraquat-related incidents might therefore be an artefact of diminished search intensity or of reduced agricultural paraquat use. With regard to labels only recent information could be retrieved, with no historical information forthcoming. It was consequently not possible to relate changes in the number of incidents to changes in label information. The decline of the hare population had already set in before the introduction of paraquat.

[32] Only for hares is long-term information available on incidents, paraquat use and population size. During this period only one hare incident occurred.

6 Results for Germany

6.1 Incidents reported in the literature

Incidents with wildlife, companion animals or livestock
The only source describing wildlife incidents in Germany during the period 1990-1995 is Snoo *et al*. (1999). Of these incidents, none were related to paraquat.

Field research
There is one article describing field research on the effects of paraquat application on mouse populations in forest plantations in Germany. No apparent effects could be found on voles (*Microtus agrestis* and *M. arvalis*). At one site numbers of shrews (*Sorex araneus* and *S. minutus*) were approx. 50% lower after paraquat application (shrews were scarcely present at the other site). No or almost no paraquat residues were measured in the faeces or hairs of the mice, although no data was provided as to when (number of days after paraquat application) these measurements were made (Bäumler 1977), neither were these field research data analysed statistically. The EU Scientific Committee on Plants concluded that "the lack of replication precludes statistical assessment of whether the decrease in shrews was caused by paraquat. Even if the decrease in shrews was caused by paraquat, the study does not permit a conclusion on whether the effect was due to direct toxicity, or indirect effects……. The Committee therefore considers this study to be inconclusive" (SCP 2002). We agree with the SCP that there was no replication and no distinction could be made between direct and indirect effects of paraquat. In our opinion a valid statistical analysis of the results is possible, though, because of the design of the field research (repeated measurements in before-after-control-experiments).

6.2 Incidents reported in national incident monitoring scheme

6.2.1 Incidents reported

Number of incidents due to pesticide poisoning
Figure 6.1 reviews the number of vertebrate incidents[33] reported annually under the German incident monitoring scheme in the period 1988-2003 in which pesticides were identified as a likely cause of poisoning (BVL[34], 2004). Over this period the number of vertebrate incidents ranged between 0 and 16 per year and totalled 65 in all. The reported incidents involved wildlife (mammals, birds, frogs/toads), companion animals (dogs, cats) and livestock (goats, pigs, chickens). In Germany no incidents with paraquat have been reported.

[33] The incidents reported in Germany are 'cases' rather than fatalities. Each incident may involve casualties from several species.
[34] Federal Office of Consumer Protection and Food Safety, Division Plant Protection Products (BVL)

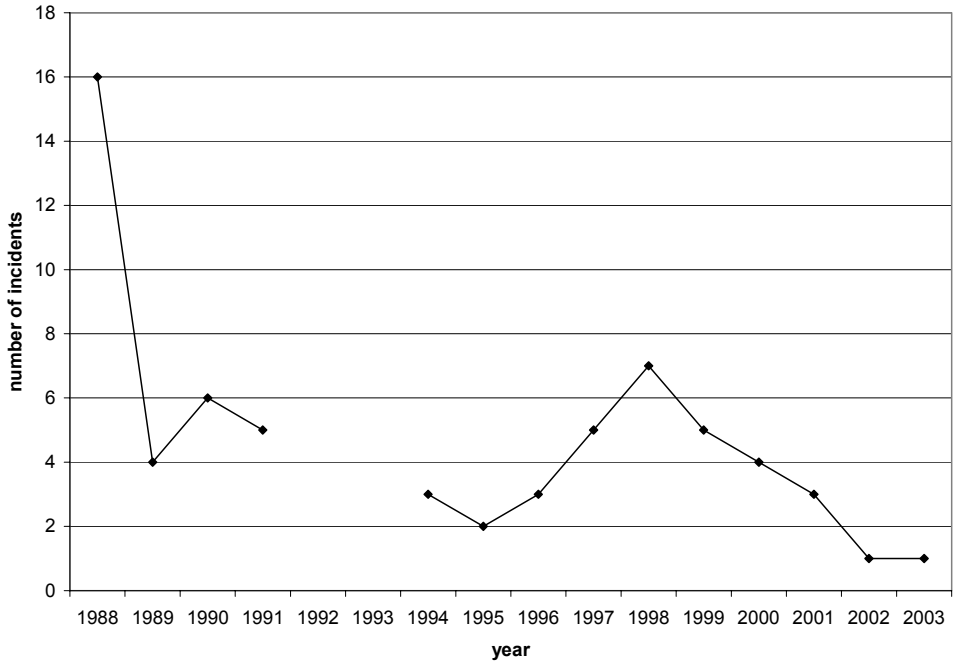

Figure 6.1 Annual number of reported pesticide incidents with vertebrates[35] in Germany, 1986-2002 (BVL, 2004).

Cause of poisoning

Table 6.2 provides a breakdown of the pesticide-related vertebrate incidents (all pesticides) according to pesticide usage category for the period 1988-2003 as reported by BVL. As the table shows, for most of the incidents the type of pesticide usage is unknown. The relative share of unspecified causes in the sum total of vertebrate incidents fluctuates, averaging around 46% for the period as a whole. Abuse and approved use of pesticides explain a substantial fraction of the incidents involving vertebrates. The share of these causes fluctuates and averages 29% and 17%, respectively, for the period as a whole. Only a minority of incidents are due to pesticide misuse. Misuse was reported only in the initial years 1988-1991, with no such cases being reported by BVL from 1994 onwards.

[35] Wildlife (mainly mammals and birds), companion animals (dogs, cats) and livestock (goats, pigs, chickens.

Table 6.2 Annual number of pesticide incidents with vertebrates in Germany, 1988-2003, with percentage breakdown by cause (source: BVL, 2004)

	abuse	approved use	misuse	unspecified use	**total pesticides**	abuse	approved use	misuse	unspecified use
	n	n	n	n	n	%	%	%	%
1988	9	3	1	3	**16**	56	19	6	19
1989	1	1	2		**4**	25	25	50	0
1990		1	1	4	**6**	0	17	17	67
1991	1	2	1	1	**5**	20	40	20	20
1992									
1993									
1994	2			1	**3**	67	0	0	33
1995				2	**2**	0	0	0	100
1996	1			2	**3**	33	0	0	67
1997	2			3	**5**	40	0	0	60
1998	1	2		4	**7**	14	29	0	57
1999				5	**5**	0	0	0	100
2000		1		3	**4**	0	25	0	75
2001	1			2	**3**	33	0	0	67
2002		1			**1**	0	100	0	0
2003	1				**1**	100	0	0	0
total	**19**	**11**	**5**	**30**	**65**	**29**	**17**	**8**	**46**

Species composition of paraquat-related incidents
Under the German incident monitoring scheme no incidents with paraquat have been reported by BVL.

6.2.2 Controlling factors affecting number of incidents

Below we briefly review a number of factors of possible influence on the number of reported incidents. A more extensive description can be found in Appendix VI.

Changes in incident monitoring schemes
Germany has a systematic incident monitoring scheme in place. However, analysis to identify paraquat is not part of the standard chemical-toxicological procedure. It is possible, furthermore, that not all incidents are reported to the national scheme because the regional governments (*Länder)* are responsible for investigations and national-level reporting is voluntary. No information is available on possible changes to the incident monitoring scheme.

Changes in the use of paraquat and other pesticides
Total pesticide use remained more or less constant from 1990 to 2001, as did paraquat use from 2001 to 2004 (see figures VI-2 and VI-3 in the appendix). In Germany paraquat accounts for about 0.04% of national pesticide use. In addition, paraquat use is here restricted to a very limited number of crops (see table VI-4 in the appendix), use being

authorised for weed control in maize, sugar beet, nursery seed patches and viticulture and for facilitating the harvest in grass seed cultivation. Application on maize, sugar beet and nursery seed patches is allowed only once every 4 years on the same site, moreover.

The product label contains two danger symbols: the ‘skull and crossbones’ symbol with the caption 'TOXIC' and a ’dead tree and fish’ symbol with the caption 'ENVIRONMENTAL HAZARD'. Specific guidelines are also given for the protection of water (see appendix VI). Information regarding changes in label information over time was not available. We do not therefore know whether or when any changes in approved use, restrictions or other label information may have occurred.

Changes in hare population size
German hunting bag records indicate that the number of hares declined by almost 50% over the period 1960-1980. Since 1980 the population seems to have remained more or less stable (see figure VI-5 in the appendix).

6.3 Synthesis and conclusions for Germany

According to the literature and the incident monitoring scheme (operational since 1988), no paraquat-related incidents with wildlife, companion animals and livestock have been reported in Germany.

This apparent absence of paraquat-related incidents may be due to the design of the incident monitoring scheme, in two respects. First, paraquat is not routinely measured in the event of a poisoning incident. Second, reporting of incidents to the national monitoring scheme is voluntary, with the regional government (*Bundesländer)* responsible for incident investigation.

The absence of paraquat incidents may also be due to the low level and restricted use of paraquat in Germany (0.04% of total pesticide use).

7 Results for the United States

7.1 Incidents reported in the literature

Incidents with wildlife
No publications were found on paraquat-related wildlife incidents in the USA.

Incidents with companion animals and livestock
Three paraquat-related incidents have been reported involving companion animals and poultry in the USA.
Leonparcher (1976) report one dog with a localised injury (1975?). The owner had recently used paraquat and the dog was observed drinking from a drain in which the left-over herbicide solution had been discarded. The animal was investigated clinically and subsequently recovered.
Bisschoff *et al.* (1998) report one paraquat-related incident with six dogs from the same area in 1996. All the animals died and all were investigated for pathological symptoms. Besides these six dogs at least three other dogs, three cats and poultry had been reported dead in the same period in the same area and these were suspected to be victims of the same poisoning. Diagnosis was feasible only after analysis of the vomit (raw meat) of one dog. Toxicological analysis revealed paraquat in different organs, but not in the kidneys.
Cope *et al.* (2004) report seven dogs presumed maliciously poisoned with paraquat in 2003 from the same area. All animals died and were investigated for pathological symptoms. In four cases paraquat could be detected. Diagnosis of paraquat poisoning in the remaining three dogs was made through a combination of history of exposure, clinical analysis and histopathology.

Field research
Besides these incidents, three publications were found concerning field research with paraquat.
In two monitoring studies (Chevron Chemical Co., 1974 and 1977, *cit.* in EPA 1982) no effects on birds or other wildlife were identified. This research is described very briefly in EPA (1982) and the conclusion of EPA (1982) is that these studies were of limited value owing to the methods used. We did not manage to retrieve these publications and so were unable to evaluate the methods used or the results.
The second field study focused on the presence of herbicide residues (alachlor, atrazine, linuron and paraquat) in deer mice (*Peromyscus maniculatus*) inhabiting conventional and minimum tillage arable fields (Benson *et al.* 1985). Herbicide application was found to have no effect on population levels or short-term mortality, although the publication provided no data or statistical analyses. Of the herbicides mentioned, it was suspected that metabolites of paraquat were found in the mice in all fields where this compound had been applied. However, the identity of these presumed metabolites was not determined.

7.2 Incidents reported in incident monitoring scheme

7.2.1 Incidents reported

No information was received from the US EPA on incidents relating to the group of pesticides as a whole.

Over the period 1992-2004 two wildlife incidents were reported in the USA as being associated with paraquat. All two involve the dichloride salt of paraquat and all two are bird kills: five Canada geese due to approved use and 4 undefined birds due to unspecified causes. No paraquat-related mammal kills have been reported.

The certainty level assigned to the two incidents was "probable" for the Canada geese case and "possible" for the other case, the later indicating a relatively high degree of uncertainty that paraquat was responsible for the observed effects. This epithet "possible" is generally used when paraquat was applied prior to the incident, but with no evidence, such as positive identification of the chemical in residue analysis, to corroborate that the pesticide was indeed the cause. There was therefore no certainty as to paraquat being the cause of this incident (pers. comm. Nicholas Mastrota, US EPA).

7.2.2 Controlling factors affecting number of incidents

Below we briefly review a number of factors of possible influence on the number of reported incidents. A more extensive description can be found in Appendix VII.

Changes in incident monitoring scheme
The United States operates a systematic incident monitoring scheme at the national level. However, the country does not have a programme requiring incidents to be reported to EPA headquarters. Local or state authorities are responsible for investigating incidents, but because of budget constraints this often fails to occur. Furthermore, analysis to identify paraquat is not always part of the standard toxicological analysis. No information was available concerning changes in the incident monitoring scheme.

Changes in use of paraquat and other pesticides
Over the period 1964-1979 there was a rapid and marked increase in total pesticide use in the USA, followed by a similar decrease in the period 1979-1987. Since 1987 total pesticide use has remained more or less stable, although, surprisingly, with a slightly higher level between 1994 and 1997 (see figure VII-2 in the appendix).

We received no information on US paraquat use or consumption. Nor was there any information available regarding changes in label information over time. Consequently, we do not know whether or when there have been any changes in approved use, restrictions or other label information over time.

7.3 Synthesis and conclusions for the United States

In the literature we found no mention of paraquat-related incidents with wildlife in the United States. The US EPA database (EIIS[36]) contains 2 wildlife incidents for the period 1992-2004 that are probably and possibly associated with paraquat (all of them involving birds). The cause of poisoning was approved use (1 case) and undefined (1 case).

Three publications describe 3 paraquat-related incidents with companion animals (mainly dogs) and poultry. In all cases the cause of poisoning was deliberate abuse. Incidents involving companion animals and livestock are not registered in EIIS.

The small number of paraquat incidents reported in EIIS may be due to the fact that reporting to US EPA is voluntary. Another reason may be that paraquat analysis is not a standard element of toxicological analysis.

[36] Ecological Incident Information System.

8 Results for other countries: incidents reported in the literature

8.1 General

For countries other than the Netherlands, France, Germany, United Kingdom and United States, we did not consult the original data of any incident monitoring schemes. Below, then, we report only incidents cited in the literature for seven other countries.

8.2 Incidents in other European countries

Paraquat-related incidents with animals have been reported from four other European countries. Although there are several other countries with an incident scheme in place, such as Norway and Denmark, there are no reports of any paraquat-related incidents with animals (e.g. De Snoo et al. 1999, Hansen & Brimer 1999). In Denmark paraquat has been banned since the 90's and one old publication by Clausen and Karlog (1977) about yellow-coloured animals caused by herbicides could not be retrieved. In Norway there is very little if any use of paraquat.

Ireland
Two publications on paraquat-related incidents with dogs and pigs were found for Ireland. Rogers *et al.* (1973, also reported in Humphreys, 1978) report one incident with four pigs and two dogs on the same farm. Three of the pigs and one dog died, with the other animals recovering. The dead animals underwent a standard pathological and toxicological examination. No probable cause of death could be determined. Weeks later an unopened sack of meal was found to have been punctured. A brown fluid had been added to the meal, probably with malicious intent to poison the animals, and it proved to be paraquat. As the carcasses had already been destroyed, no toxicological analysis had been carried out to ascertain the presence of the substance in the animals. It was therefore concluded that the diagnosis must remain one of suspected paraquat poisoning.
O'Sullivan (1989) report one incident with a dog which recovered from a confirmed paraquat poisoning in 1985. The author remarks that: "(t)he dog had been noted to stray the day before onset of illness in a locality where previous fatal cases of paraquat poisoning had recently occurred". Apparently these earlier incidents of paraquat poisoning were not published. Confirmation of the clinical diagnosis was based on toxicological analysis of urine samples. The article gives no information about the probable cause.

Switzerland
In Switzerland two incidents are reported by Hösli (1977), both occurring in the winter of 1976-1977. In one case a dog accidentally received an undiluted paraquat solution between its hind legs. The dog licked itself and died. It was subsequently examined clinically and pathologically. In another incident two dogs with different owners from the

same village died and were diagnosed as paraquat poisonings after pathological (both dogs) and toxicological (one dog) examination.

Spain
For Spain the results of monitoring intentional poisoning incidents in the period 1992-2002 are reported by Motas-Guzmán *et al.* (2003). Of the 123 incidents suspected of being deliberate poisonings, 102 were analysed (pathological and toxicological examination) and in 50 of these pesticides were found (total: 107 animals). The authors note that the number of incidents is an underestimate, because of animal recovery, poor recognition by officials etc. In three of these poisoning incidents paraquat had been used. In two incidents paraquat was added to bait (bones/meat, cheese) and two dogs died. The third case is not described in detail.

Greece
For northern Greece the results of monitoring animal poisonings in the period 1990-1995 are reported by Antoniou *et al.* (1997). In 78% of the 926 animals killed in 193 incidents, pesticides were identified as the probable cause of death. No exact data or records are presented and apparently there was only a toxicological examination. No distinctions are made as to type of cause. The most common victims were cats, dogs, sheep, birds and bees. Carbamates (50%-75%) and organophosphates (25%-45%) were the most important pesticides implicated and paraquat is cited as one of the next most common pesticides used in these poisonings. From the article it can be deduced that in five of the 193 incidents paraquat (2.5%) was involved.

Hungary
One reference has been found of one incident with paraquat involving two dogs in Hungary (Salyi, *et al*., 1994).

8.3 Incidents on other continents

Only one publication was found reporting on paraquat-related incidents in American countries other than the USA.

Cuba
Rivera (1973) report that 60 geese (poultry) died after a neighbouring field was treated with paraquat. Although the geese were fenced off from the treated field, it was hypothesised that heavy rain ran down a slope, forming puddles accessible to the geese. There was clinical and pathological examination of the cadavers. As we were unable to retrieve the original publication, no further details of this incident can be given (year of incident, toxicological examination etc.).

Only two publications were found on paraquat-related incidents with animals in Asia.

Malaysia
For Malaysia incidents have been reported by Chooi *et al*. (1986). They describe two incidents with dogs after field application of paraquat in 1986. Diagnosis was based on clinical and pathological examination. These both seem to be instances of poisoning after approved use of paraquat, but the descriptions are too brief for reliable cause classification. The authors also refer to other fatal paraquat-related incidents involving four dogs published in 1985, but we did not manage to retrieve this article.

For the Australasian continent three paraquat-related incidents with animals have been published.

New Zealand
Cruickshank (1982) describes a possible successful antidote to metaldehyde poisoning in New Zealand. In the last sentence of his article he remarks that this antidote also proved successful in a mild case of paraquat poisoning. No further information on this case was given, however.

Australia
Two articles were found with paraquat-related incidents involving companion animals and livestock in Australia.
Johnson & Huxtable (1976) report two incidents (no year mentioned). In the first, concentrated paraquat (20%) had been used to "spot" weed-infested areas on a property. One cat was observed eating the grass, which had been treated the previous day. One dog also fell ill. The dog died, but the cat recovered after several weeks. This undiluted use of paraquat is apparently a case of misuse. Diagnosis was based on clinical and pathological examination. In the second incident, a cat died after a dilute (20%) solution of paraquat had been applied to a garden area. Diagnosis was based on clinical and pathological examination.
Philbey & Morton (2001) describe one very large incident on a farm during the period 1990-1992. Some 700 sheep in several paddocks died after their drinking water had been deliberately poisoned with paraquat. A pathological examination was performed on three sheep and all proved to have a variety of lung symptoms. The diagnosis of paraquat poisoning was only possible after the discovery and toxicological analysis of the odd-coloured and -smelling drinking water in the troughs. This was a clear case of malicious poisoning using paraquat.

8.4 Conclusions for the other countries

From five other European countries about fourteen paraquat-related incidents with animals are reported in five articles. In most of these incidents dogs were involved and in one incident also pigs. No incidents with wildlife are reported. Misuse and abuse were the only causes of poisoning cited.

From the other continents a minimum of eight incidents with geese, dogs, cats and sheep are reported in six articles. No incidents with wildlife are reported. It is striking that in a large proportion of these incidents (4 out of 8) approved use is the probable cause of poisoning.

9 Synthesis, conclusions and discussion

9.1 Synthesis and conclusions

Overall synthesis and conclusions regarding all vertebrate animals
This study is concerned with paraquat-related incidents involving animals, in particular wild mammals (especially hares) and birds. Information on such incidents was retrieved from the literature and from incident monitoring schemes, between which there was a partial overlap.

We found twenty-nine publications from thirteen countries, mainly European (nine), containing information on paraquat-related incidents with animals, dating from prior to 1970 through to about 2002. The total number of paraquat-related incidents with animals found in the literature was about 230. These numbers include all known incidents where paraquat was identified in these publications as the suspected, probable or certain cause. A number of relevant publications could not be retrieved for several reasons (e.g. incomplete references), so the figure of 230 is probably a minimum. The publications vary widely with respect to the amount and type of information provided on causes, circumstances (e.g. crops), analysis methods and results, which complicated interpretation.

From five countries (United Kingdom, France, Germany, Netherlands, United States) information was retrieved from incident monitoring schemes for the period from 1985 onwards. Under these schemes at least 185 paraquat-related incidents have been reported with animals. Data retrieval from some of these monitoring schemes was incomplete (e.g. France), so this figure of 185 is a minimum. There are considerable differences in how these monitoring schemes are organised, which complicated interpretation of the data they provided.

Synthesis and conclusions regarding wildlife
The main focus of this study was on wild mammals (especially hares) and wild birds. However, these constituted only a very small fraction of the incidents reported in the literature and incident monitoring schemes.

Paraquat-related incidents involving wildlife were found in the literature for three countries: the United Kingdom, France and the Netherlands. If we include suspected paraquat incidents (about 19 incidents with hares), the total number of incidents with wildlife is about 32 in seven publications for the period from before 1970 to about 1995. The cause of most incidents (21) was not identified (but was possibly approved use) and was positively cited as approved use in the remaining cases (11). In 31 incidents hares were involved and in one incident hedgehogs. No incidents with farmland birds were reported in the literature.

Paraquat-related incidents reported under incident monitoring schemes were retrieved from three countries: the United Kingdom, France and the United States. If we include suspected paraquat incidents (about 7 incidents with hares), the total number of wildlife

incidents reported under incident monitoring schemes was 43 between 1986-2001. The cause of poisoning was approved use (11), unknown (22), misuse (1) and abuse (9). The vertebrates involved in poisoning after approved use of paraquat were hares (10) and a wild goose species (1). Animals involved in poisoning due to other causes were mainly foxes (11), hares (7) and badgers (7). Most hare incidents registered under these incident monitoring schemes had already been published by Edwards *et al.* (2000). Only one paraquat-related incident with farmland birds was reported under the incident monitoring schemes.

Only fragmentary information was found on the crops involved in the paraquat-related incidents after approved use. The main crops reported were grasslands (Netherlands, UK), green manuring crops like lucerne (France) and cereal stubbles and potatoes (UK).

Synthesis and conclusions regarding companion animals and livestock
Besides the incidents involving wildlife, paraquat-related incidents with companion animals and livestock reported in the literature and under incident monitoring schemes were also analysed. These make up the vast bulk of all paraquat-related incidents. Since they are not the focus of the present study, only a few summary conclusions are presented.

Paraquat-related incidents with companion animals and livestock were found in twenty publications for eleven countries. It is mainly dogs and to a lesser extent cats that were involved. Only four incidents involved livestock (pigs, sheep, poultry and geese), including one large incident with about 700 sheep maliciously poisoned in Australia. The main causes of paraquat poisoning of companion animals and livestock are either unknown, deliberate abuse or misuse.

Only under the UK incident monitoring scheme have paraquat-related incidents been reported with companion animals (109: 85 dog, 23 cat) and livestock (2 horse, 1 chicken). All these occurred between 1987 and 2002. Again, the main causes of poisoning were abuse or unknown.

Influence of controlling factors on number of incidents
We were able to obtain only fragmentary information on any factors controlling or influencing the number of reported incidents. Consequently, analysis of trends in the number of incidents in relation to these factors could likewise be no more than fragmentary.

In the United Kingdom the recent decline in the number of paraquat-related incidents has coincided with a declining number of pesticide-related incidents in general (possibly indicating reduced search efficiency or reduced use of highly toxic organophosphates and carbamates) and with declining use of paraquat. These factors may well explain the decrease in the number in paraquat-related incidents recorded.

In the United Kingdom and the Netherlands a relatively large number of (suspected) paraquat-related incidents with wildlife occurred before around 1980. It is possible that the addition of an emetic, a blue pigment and a stench compound to the paraquat formulation after about 1975 (see Edwards *et al.* 2000) had a repellent effect and therefore re-

duced the number of incidents post-1980. However, other causes (e.g. changes in approved applications) cannot be excluded either. The lion's share of the incidents in France occurred before 1992. As the information on controlling factors was incomplete for France, too, however, we have no clues as to the cause of this phenomenon.

We found a positive relationship between national paraquat consumption and number of paraquat-related incidents per country in western Europe. Of the countries with an incident monitoring scheme within the European Union, the United Kingdom has used the greatest amount of paraquat and also had the greatest number of paraquat-related incidents. However, there may also be other factors involved.

Number of incidents as an indicator of ecotoxicological impact?
We found reports of about 40 paraquat-related incidents (including about 25 suspected paraquat incidents) with wildlife related to approved use in four countries, dating from before 1970 through to 2001. This in itself, however, does not form grounds for concluding that the ecotoxicological impact of paraquat is small, because that would presume that all paraquat-related incidents were indeed found, analysed, reported and published. This is obviously not the case for paraquat as with any other pesticide and this issue is discussed in more detail in the next section.

9.2 Discussion

Two types of incident research
For fair interpretation of the small number of paraquat-related incidents involving wildlife it is necessary to reflect on the methods used to gather this information. Do these incidents form a truly representative sample of all the paraquat incidents actually occurring?

Two main methods have generally been used to monitor and register incidents. The first relies on clinical and pathological incident reports by veterinarians and is used principally in cases of deliberate poisoning of companion animals. Publication of such reports has been *ad hoc*. The second main method involves incident monitoring schemes in which information on incidents is more or less systematically collected and registered on a national basis. In this case the incidents involve a variety of species and causes in terms of pesticide usage. Reports are often published annually.
If we compare for the United Kingdom (see section 5.2) the number of incidents with companion animals reported *ad hoc* by veterinarians and under the incident monitoring scheme (WIIS), then the first method describes only a minority of the incidents reported under the incident monitoring scheme. This is even truer of the wildlife incidents. In the following discussion we shall therefore focus on the methodologies used in the incident monitoring schemes.

Organisation of incident monitoring schemes
Incident monitoring schemes have already proved their value as a post-registration instrument for a number of very toxic pesticides with marked ecological side-effects. In some of these cases approval regimes have been revised accordingly. However, it is ques-

tionable whether incident monitoring schemes are also a useful post-registration tool for moderately toxic pesticides like paraquat. Their value is also to be queried when it comes to monitoring the extent of ecotoxicological side-effects on wildlife populations.

To answer these questions we need to look at the chain of events from pesticide application through to publication of any incident. The full chain comprises the following steps: 0) pesticide application, exposure and (sub-)acute effects on animals (the incident), 1) finding and reporting of the affected animal, 2) analysis and diagnosis of the cause of the incident, 3) central registration and/or publication of the incident. We focus on the latter three steps.

Finding, diagnosing and reporting incidents requires, in the first place, a scientific and organisational infrastructure. Most incidents have been reported in Europe, and especially in the United Kingdom, although only a small fraction of worldwide paraquat sales is for European use. Hardly any incidents have been reported from Asia or South and Central America, the destination of a large proportion of global paraquat production. In these regions a lack of scientific and organisational infrastructure is the probable cause of the absence of incident reports. On a global scale, then, the total number of incidents reported is most likely an underestimate.

Find chance in incident monitoring schemes

The low efficiency of incident monitoring schemes for finding affected or dead animals by poisoning in general has been discussed in many publications (e.g. Greig-Smith 1988, 1991, Summerville & Walker 1990, Brown *et al.* 1996). Afflicted animals tend to hide and often become inactive (e.g. Fryday *et al.* 1996). Even the chance of finding a large and conspicuous animal like a swan is reported to be as low as 16% (e.g. Hart & Clook 1994). Finding animals that are sub-acutely poisoned is complicated by many animals living at a remove from treated areas, obscuring any direct relationship with pesticide application. An added complication is that wildlife that is sub-acutely exposed may recover and these cases will never be recognised as pesticide-related incidents. A final complication in the case of sub-acute poisoning is that animals may first suffer a general set-back in health, eventually to die of a secondary infection. In the case of multiple causes of death, the role of pesticides may be not recognised.

These factors reducing the chance of finding the victims of pesticide-related incidents are also relevant for paraquat; the inactivity of affected animals is also a well-known clinical symptom of paraquat poisoning, for example.

The way incident monitoring schemes are organised is of enormous influence on the find chance and number of incidents reported (see e.g. De Snoo *et al.* 1999). Comparing the number of hares reported under “systematic” incident monitoring schemes, for example, we see that tens of thousands of hare fatalities were reported in France, about one hundred incidents with dead hares in the United Kingdom and fewer than ten such incidents in the Netherlands (for results and explanations, see the individual chapters on these countries).

A final issue with respect to find chance is the relative likelihood of reporting for abusive versus approved pesticide use. The emphasis of most incident schemes is probably on cases of abuse. These often involve larger numbers of animals, with baits containing a high concentration of pesticide (making chemical detection easier), and authorities will be more prone to investigate to the full when an incident looks like a flagrant case of abuse.

False positive and false negative diagnoses

If a dead animal is found and brought to a veterinarian or research institute there are no guarantees that a correct diagnosis will be made. Two different kinds of error are possible in diagnosing a pesticide-related incident: a false positive and a false negative. These problems also occur with paraquat, but no comparison has been made with other pesticides with respect to these diagnostic problems.

The problem of false positive diagnosis is discussed in one publication: Edwards *et al.* (2000). They conclude that, for lack of pathological evidence, several large incidents with hares before 1970 in the United Kingdom and France could not in fact be classified as paraquat-related. In our opinion, however, for lack of the same information it cannot be ruled out that these incidents were indeed related to paraquat. In this study we have therefore classified these incidents as suspected cases of paraquat poisoning.

The problem of false negative diagnosis for paraquat has often been noted in the literature (see references in preceding chapters). The clinical and pathological symptoms of paraquat poisoning can be easily confused with symptoms of other kinds of poisoning or disease. In addition, paraquat is not routinely measured in most incident monitoring schemes and clues of paraquat poisoning have sometimes been found only coincidentally. Even if it is known that paraquat is involved, however, diagnosis may be obscured by the fact that pathological and toxicological symptoms depend on the dosage. In the case of acute poisoning, animals die within a few days and do not develop the typical pathological symptoms, even though the presence of paraquat in the animal is readily measurable. In the case of a sub-acute poisoning pathological symptoms do develop, but as paraquat is very rapidly excreted via faeces and urine, it may no longer be measurable after a few days.

The requirement of circumstantial, pathological and toxicological evidence for a paraquat poisoning may be good standard procedure, but strict application thereof probably means that some paraquat-related incidents will remain unnoticed.

Incident reporting

Positive diagnosis of pesticide poisoning, as with paraquat, should be followed by a report and publication. The annual reports of the different incident monitoring schemes differ widely in scope and level of detail. Results are not always published and many pesticide-related incidents may therefore go unnoticed. The way an incident monitoring scheme is organised may also hamper publication of paraquat-related incidents. In Germany and the USA, for example, it is local or regional authorities that are responsible for incident analysis, but reporting to the national incident scheme is voluntary. The final

step is publication of the incident in a peer-reviewed scientific journal. Not all scientific research carried out is published in such journals, however, providing another reason why incidents may go unnoticed.

Underestimation of number of incidents and of ecotoxicological impact

Summarising, most pesticide-related incidents will not be registered under incident monitoring schemes and this will also hold true for paraquat. The chances of a paraquat-related poisoning incident being published are small because of a variety of problems and barriers in the process of finding, diagnosing and reporting these incidents. The reported number of paraquat-related incidents cited in this study is therefore clearly an underestimate of the number that have actually occurred as would be the case with any pesticide. In our opinion it is important to standardise and harmonise incident procedures, including a probability classification as to the cause and level of poisoning, as in the national US EPA incident monitoring scheme, for example.

Improvements of post-registration research

One possible improvement (*cf.* De Snoo *et al.* 1999) to incident monitoring schemes is to respond to incidents that are probably related to approved pesticide use by setting up an intensive monitoring campaign based on planned, systematic sampling. Another possible improvement is to use information on pesticide-related incidents associated with approved use to set up a systematic field study (including control sites, sufficient replicas, a clear diagnostic procedure with probability classification etc.). Such field studies could be carried out with hares, as in the case of the field study by Sullivan (1996) into the effects of glyphosate on population parameters of snow hares (*Lepus americanus*) in Canada.

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Appendices

Appendix I: Scientific literature databases consulted and search profiles used

Different scientific literature databases were consulted to track down relevant literature on wildlife incidents related to paraquat and other pesticides. The focus of this study is on incidents involving hares (*lagomorpha*) and birds (*aves*), with human side-effects outside the present scope. As the topic of interest is the reporting of incidents occurring in the field, moreover, ecotoxicological laboratory research is also beyond the scope of this project.

The following databases yielded relevant references:

- ISI Web of knowledge – web of science
- AGRICOLA
- AGRALIN
- BIOSIS

Web of science, AGRICOLA and AGRALIN

For the databases Web of science, AGRICOLA and AGRALIN the following keywords were used:

wildlife or birds or mammals or rabbits or hares or pikas or dog or mouse or rat
and
paraquat or pesticide or weedkiller or herbicide or insecticide or fungicide
and/or
incident or poisoning or mortality

BIOSIS

For the BIOSIS database the following search profile was used:

L1 SEA PESTICIDE# OR HERBICIDE# OR FUNGICIDE# OR
PARAQUAT
L2 SEA HARE? OR LAGOMORPH OR LEPUS OR LEPORIDAE OR BIRD# OR AVES OR MAMMAL#
L3 SEA WILDLIFE OR HUNTING RECORD# OR INCIDENT# OR
POPULATION DECLIN? OR FIELD STUD?
L4 SEA L1 AND L2 AND L3
L5 SEA L1 AND WILD BIRDS
L6 SEA (L4 OR L5) NOT (ORGANOCHLORIN? OR CHLORINAT?
OR VIVO OR VITRO OR DDE OR DDT OR DIOXON OR CHLORIN?)

Appendix II: Contacts

Country	Contact	Address	
USA	Nicholas Mastrota	Environmental Protection Agency Office of Prevention, Pesticides and Toxic Substances/Office of Pesticide Programs USA Tel 703-305-5247 Fax 703-305-6309 Email Mastrota.Nicholas@epa.gov	Incident Monitoring & Registration
Canada	Pierre Mineau	National Wildlife Research Centre (NWRC) Canada Tel (613) 998-0518 Email: pierre.mineau@ec.gc.ac	Pesticides expert
UK	Mark Fletcher	Central Science Laboratory Sand Hutton York YO41 1LZ United Kingdom Tel +44 (0)1904 462 000 Fax +44 (0)1904 462 111 Email m.fletcher@csl.gov.uk	Incident Monitoring & Registration
UK	Peter Edwards	Peter Edwards MBE Syngenta Jealotts Hill International Research Station Bracknell Berks RG42 6EY United Kingdom Tel: +44 (0) 1344 414158 Email peter.edwards@syngenta.com	Syngenta
UK	John Bembridge	Regulatory Manager, EAME Regulatory Affairs Syngenta, European Regional Centre Priestley Road, Surrey Research Park Guildford, Surrey, GU2 7YH United Kingdom Tel: +44 (0) 1483 260044 Fax: +44 (0) 1483 260019 Email john.bembridge@syngenta.com	Syngenta
UK	PAN UK	Pesticide Action Network UK, Development House, 56-64 Leonard Street, London EC2A 4JX United Kingdom Tel +44 (0) 20 7065 0905, Fax +44 (0) 20 7065 0907 Email admin@pan-uk.org	Environmental organisation
France	Jean-Roch Gaillet	Office National de la Chasse et de la Faune Sauvage (ONCFS) BP20 78612 Le Perray-en-Yvelines cedex France Tel +33 (1) 30 46 60 24 Email j.r.gaillet@oncfs.gouv.fr	Incident Monitoring & Registration

France	Phillipe Berny	Pharmacie-Toxicologie Ecole Nationale Vétérinaire de Lyon 1 av Bourgelat B.P. 83 69280 Marcy l'étoile France Tel +33 (4) 78 87 26 31 Email p.berny@vet-lyon.fr	Incident Monitoring & Registration
Netherlands	Pedro Zoun	Centraal Instituut voor Dierziekte Controle Houtribweg 39 8221 RA Lelystad Postbus 2004 8203 AA Lelystad The Netherlands Tel +31 320 2 38800 Fax +31 320 2 38050 Pedro.Zoun@wur.nl	Incident Monitoring & Registration
Netherlands	Werner Pol	College voor de Toelating van Bestrijdingsmid-delen (CTB) P.O. Box 217, 6700 AE Wageningen The Netherlands Tel: +31 (0) 317 47 18 10 Email: werner.pol@ctb.agro.nl	Pesticides admission
Netherlands	Robert Luttik	RIVM P.O. Box 1 3720 BA Bilthoven The Netherlands Tel: +31 (0) 30 274 91 11 Email: Robbert.Luttik@rivm.nl	Pesticides toxicity
Netherlands	Frank de Jong	RIVM P.O. Box 1 3720 BA Bilthoven The Netherlands Tel: +31 (0) 30 274 91 11 Email: Frank.de.Jong@rivm.nl	Pesticides toxicity
Netherlands	Sim Broekhuizen	Alterra Wageningen University The Netherlands Tel: +31 (0) 317 47 87 57 Email Sim.Broekhuizen@wur.nl	Hare populations
Netherlands	Vilmar Dijkstra	Zoogdiervereniging VZZ Oude Kraan 8 6811 LJ Arnhem The Netherlands Tel: +31 (0) 26 3705318 Fax: +31 (0) 26 3704038 Email: v.dijkstra@vzz.nl Website: http://www.vzz.nl	Mammal populations

Netherlands	Hans Muilerman	Stichting Natuur en Milieu (SNM) (Society for Nature and Environment) Donkerstraat 17, 3511 KB Utrecht, The Netherlands Tel. +31 (0) 30 2348293 Fax. +31 (0) 30 2312786 Email: h.muilerman@snm.nl	Environmental organi-sation
Netherlands	Nefyto	Nefyto P.O. Box 80523 2508 GM The Hague The Netherlands tel 070-7503100 fax 070 3549766 Email nefyto@nefyto.nl	Pesticides sales data
Netherlands	Ton Rotteveel	Plantenziektenkundige dienst (Plant Protection Service) Postbus 9102 6700 HC Wageningen The Netherlands Tel +31 (0) 317 49 69 11	Netherlands Plant Pro-tection Service
Germany	Marion Lehmann	Bundesministerium für Verbraucherschutz, Ernährung and Landwirtschaft - BMVEL (Federal Ministry of Consumer Protection, Food and Agriculture) P.O. Box 14 02 70 53107 Bonn Germany Tel +49 1888 529 3687 Email marion.lehmann@bmvel.bund.de	Ministry
Germany	Roger Waldmann	Bundesamt für Verbraucherschutz und Lebensmittelsicherheit (BVL) -Abteilung Pflanzenschutzmittel- Messeweg 11/12 38104 Braunschweig Germany Tel.: +49 (0) 531/299-3549 Fax: +49 (0) 531/299-3005 Email: Roger.Waldmann@bvl.bund.de http://www.bvl.bund.de	Incident Monitoring & Registration

Appendix III: Controlling factors, The Netherlands

Incident monitoring scheme

Table III-1 characterises the incident monitoring scheme in operation in the Netherlands in terms of a number of key criteria (Snoo *et al*., 1999, CIDC).

Since 1989 the Central Veterinary Science Institute (CIDC) has been charged by the Ministry of Agriculture[37] to systematically report incidents in the Netherlands. There was an important change in the reporting scheme in 1994: since then, analysis costs are no longer borne by the government but passed on to the party reporting the incident.

In relation to this paraquat project it is important to note that analysis of paraquat is not part of the standard chemical-toxicological analysis procedure.

Table III-1 The Dutch incident monitoring scheme

Systematic registration		yes
Organisation	Ministry of Agriculture	Central Veterinary Science Institute *(Centraal Instituut voor Dierziekte Controle,* CIDC)
Reporting parties	Criminal investigation agencies (police and General Inspection Agency, AID)	56%
	Private citizens	15%
	Bird rehabilitation centres and bird spotter groups	13%
	Forest and land management agencies	12%
	Water management agencies	4%
Costs	Institute for Animal Science and Health, ID-DLO	Until 1994
	Reporting party, except in case of criminal offence	1994-2004
Types of incidents	Cause of incident classified by type of pesticide use	Abuse Approved use Misuse Unspecified
	Types of animals and/or materials	Wildlife (since 1989 mainly mammals and birds)
Procedure	Sending and registration of find circumstances (location, date, circumstances etc.) and one of the indications: shot, trauma, poisoning.	
	Research, in two steps: 1. pathological section, if diagnosis is "likely poisoning" or "poisoning cannot be excluded", 2. chemical-toxicological analysis[38], on condition that the reporting party commissions the analysis and agrees to pay the costs	
	Registration of incident data and research results in a non-relational database (program: Word)	

[37] In full, Ministry of Agriculture, Nature and Food Quality (LNV).

[38] In most cases there are no indications to perform a specific chemical-toxicological analysis. In these cases a standard analysis is performed based on a general screening of pesticides using GC/MSD and TLC/EID tests. If these tests are negative, the samples are analysed on aldicarb, carbofuran, oxamyl and methiocarb using HPLC/DAD. In an extended research specific analysis is performed on strychnine and/or alfachloralose. Note that paraquat is not part of the standard analysis (CIDC).

National use of pesticides and paraquat

Total pesticide use

Figure III-2 charts the trend in total Dutch use of agricultural pesticides since 1984, showing component trends in herbicide and paraquat use.

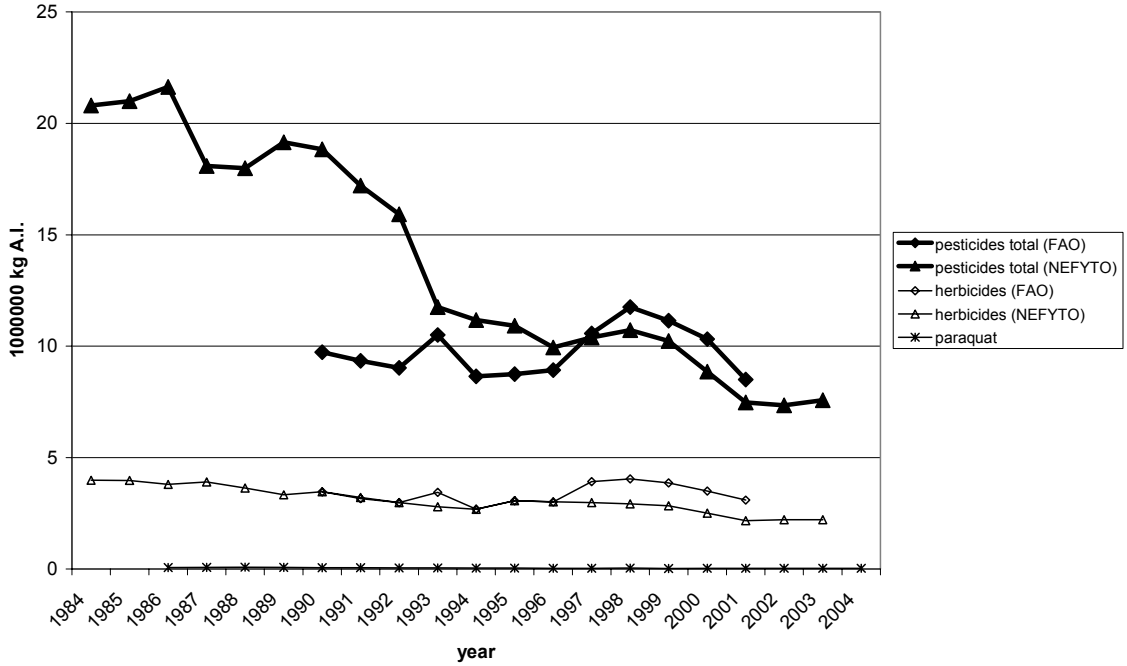

Figure III-2 Dutch agricultural pesticide use, 1984-2004 (sources: FAO, 2004; NEFYTO, 1984-2003; Syngenta, 2004)

According to the FAO data, total use of pesticides as well as herbicides fluctuated during the period 1991-2002. In the last few years (1998-2002) there seems to have been a considerable decrease in total pesticide use and a slight decrease in herbicide use. The NEFYTO figures show a long-term and substantial decline in total pesticide use. Herbicides, too, show a continuous but more moderate decline. Paraquat[39] accounts for only a very small fraction of overall use (about 0.5% of total pesticide use and 1% of total herbicide use).

Paraquat use

Figure III-3 shows Dutch sales of paraquat by Syngenta over the period 1984-2004. Between 1990 and 2004 paraquat sales declined, but seem to have remained more or less stable in the last few years (2000-2004).

Note that these figures are based on one producer only. This means that the total amount of paraquat used in the Netherlands has been underestimated. There are currently no figures available for total paraquat use in the Netherlands.

[39] Note that the paraquat consumption plotted in the figure is based on the sales of one producer only.

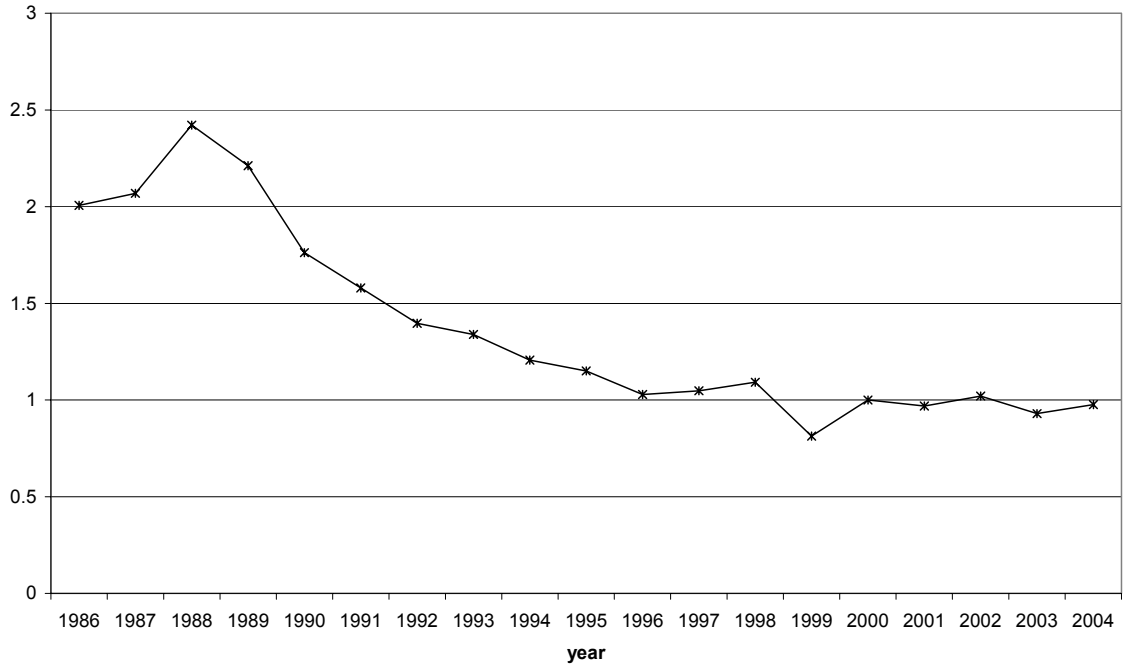

Figure III-3 Dutch sales of paraquat by Syngenta, 1986-2004, indexed year 2000 set 1 (source: Syngenta, 2004)

Paraquat product label
No information was received about any changes in labelling information over time.

The following Syngenta paraquat formulations are authorised for use in the Netherlands up to 09-09-9999[40] (CTB[41], 2005):

- ACTOR: paraquat concentration 120 gram per litre, year of introduction 1981
- GRAMANOL 300 EC: paraquat concentration 200 g/l,
- GRAMOXONE: paraquat concentration 200 g/l, year of introduction 1973

Other paraquat products from other producers that are authorised up to 09-09-9999 in the Netherlands (CTB, 2005):

- AGRICHEM Paraquat: paraquat concentration 200 g/l, year of introduction 1976
- LUXAN Paraquat: paraquat concentration 200 g/l, year of introduction 1997

The labels used by all three suppliers of paraquat-based herbicide formulations are essentially the same. The most recent change in labelling was in 1999. This was due to implementation of European directive 1999/45/EG, which aims to harmonise legal and administrative regulations among EU member states.

In the Netherlands the paraquat sold by Syngenta is used in the following crops and applications (table III-4).

[40] The expiry date 09-09-9999 refers to 'legal admission', duration of which is determined by decisions made in the EU.
[41] CTB: Dutch Board for the Authorisation of Pesticides.

Table III-4 Share of crops and applications in total Dutch paraquat use

Crop or application	% of sales[42]	Rate of use (l/ha)	Remarks and recommendations[43]
Potatoes	29	3-5	"on seed, starch and ware potato crops, provided it is applied before or, in the case of starch and ware potatoes, during emergence, as well as after the potato haulm has completely died off, shortly before harvest"
Tree nurseries	26	5	"on other crops, provided it is applied before emergence or before planting, or after emergence, if a protective screen is used between crop rows"
Legumes, outdoor	19	3-5	idem
Bulb flowers	13	3-5	idem
Others	13		

The product label contains user safety information and directions for use, storage and mixing.

The label shows the 'skull and crossbones' danger symbol with the caption 'Poisonous'. No specific guidelines are given with respect to environmental protection.

The label contains the following general remarks on directions for use:
"Drift during spraying of product should be avoided, e.g. by spraying with coarse droplets and under low pressure. Do not spray in strong winds… Spraying of dry vegetation is always preferable… Aerial application is prohibited."

Hare population

Figure III-5 reviews changes in the Dutch hare population, as monitored by DAZ[44]. Figure III-6 shows the trend in the number of hares killed by hunting in the Netherlands (KNJV, 2002).

[42] Market share based on year 2003.
[43] Remarks and recommendations quoted from original "Gramoxone" label.
[44] *DAZ DagActieve Zoogdieren* (DayActive Mammals) is a co-operative monitoring network run by several Dutch organisations: CBS, VZZ and SOVON.

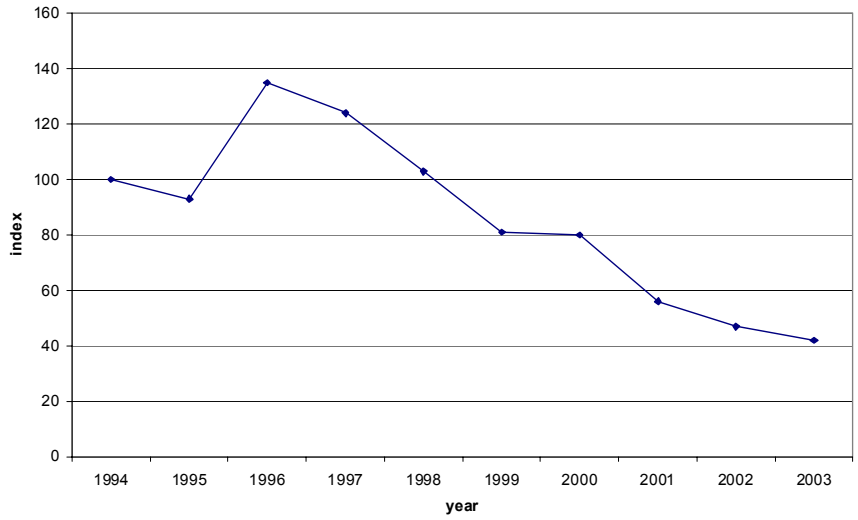

Figure III-5 Changes in the Dutch hare population, 1994-2003 (source: DAZ)

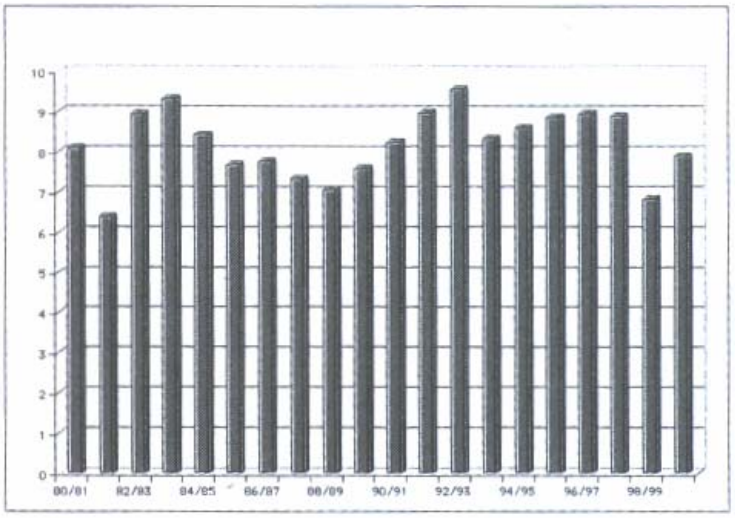

Figure III-6 Hares killed by hunting (number per 100 ha) in the Netherlands, 1980-1999 (source: KNJV, 2002)

According to the DAZ data, the Dutch population of brown hares (as well as rabbits) underwent a rapid decline over the period 1994-2003. The population of roe deer seems to be stable.

The records of the national hunting association KNJV paint a different long-term picture for hares in the Netherlands. Assuming that hunting records are an indication of the hare population size, the population seems to have been stable, although fluctuating, in the period 1980-2000.

Appendix IV: Controlling factors, France

Incident monitoring scheme

Table IV-1 characterises the incident monitoring scheme in use in France in terms of a number of key criteria (Snoo *et al*., 1999, ONCFS).

Since 1986 the *Office National de la Chasse et de la Faune Sauvage* (ONCFS), a French government agency, has operated a monitoring and reporting scheme on abnormal wildlife mortality: SAGIR[45]. Each French department has a coordinator, who organises local field surveys outlined at the national level.

Any wildlife carcasses found are sent to a *Laboratoire Vétérinaire Départemental* (LVD) for analysis together with records describing the find circumstances. The results of these departmental LVD examinations are forwarded to three national laboratories that coordinate the data and are eventually collated by ONCFS and reported annually and stored in the SAGIR database.

In relation to this paraquat project it is important to note that analysis of paraquat does form part of the standard chemical-toxicological analysis procedure in France.

Table IV-1 The French incident monitoring scheme

Systematic registration		Yes, SAGIR[13]
Organisation	Ministry of Agriculture	*Office National de la Chasse et de la Faune Sauvage,* ONCFS
Reporting parties	Hunting community	72%
	Veterinary practitioners and laboratories	12%
	Pet owners	8%
	Others (municipal authorities, humane societies)	8%
Costs	Hunting associations	70%
	Conservation agencies	30%
Types of incidents	Cause of incident classified by pesticide	Unknown?
	Types of animals and/or materials	Only hare incidents received, Database also contains other wildlife incidents
Procedure	Sending and registration of find circumstances (location, date, circumstances etc.), in each department	
	Research, in two steps: 1. pathological section, 2. chemical-toxicological analysis, in each department	
	Gathering of results from departments, registration of incident data and research results in a non-relational database	

[45] SAGIR: *Surveillance Sanitaire Nationale du Gibier.*

National use of pesticides and paraquat

Total pesticide use

Figure IV-2 charts the trend in total French use of agricultural pesticides since 1990, showing component trends in herbicide and paraquat use (FAO, 2004; Syngenta).

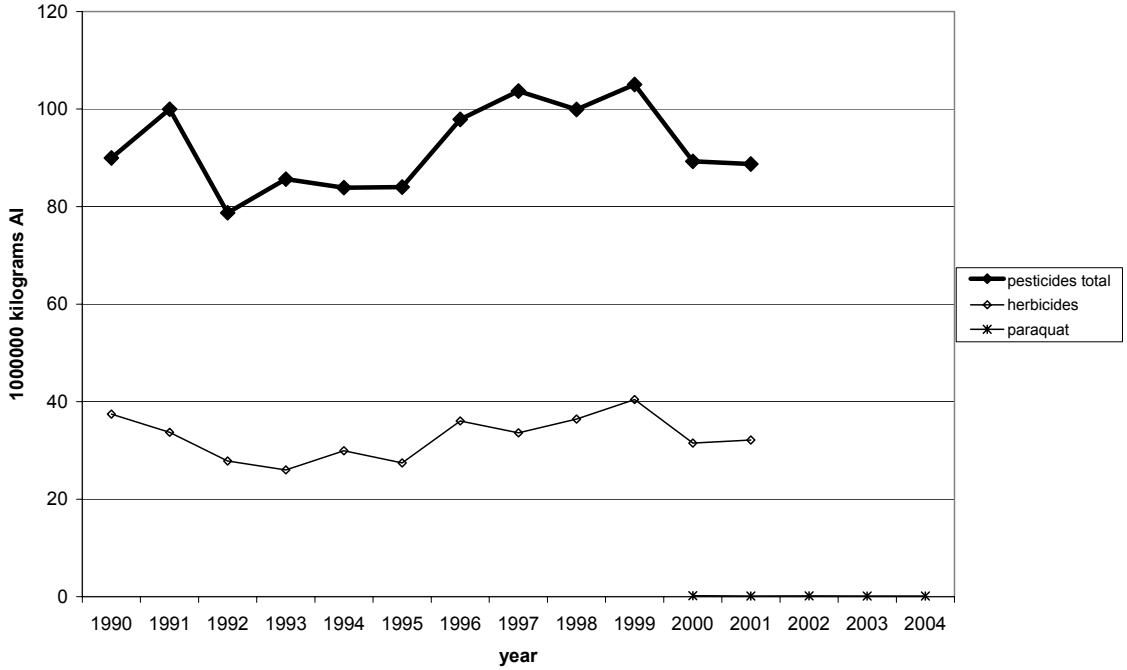

Figure IV-2 French agricultural pesticide use, 1990-2004 (sources: FAO, 2004; Syngenta, 2004)

According to FAO, total use of pesticides as well as herbicides fluctuated during the period 1990-2001. The total amount of pesticides used from 1992 to 1995 was substantially lower than from 1996 to 1999. In the last years reported (2000-2001) total pesticide use seems to have decreased once more (to nearly the 1992-1995 level). Herbicide use appears first to decrease between 1990 and 1993, then to increase slightly from 1993 to 1999, only to rise again in 2000 and 2001. Paraquat[46] accounts for only a very small fraction of overall use (about 0.2% of total pesticide use and 0.5% of total herbicide use).

Paraquat use

Figure IV-3 shows French sales of paraquat by Syngenta from 2000 to 2004, showing a general decline over this period.

Note that these figures are based on one producer only. This means that the total amount of paraquat used in France has been underestimated. There are currently no figures available for total paraquat use in France.

[46] Note that the paraquat consumption plotted in the figure is based on the sales of one producer only.

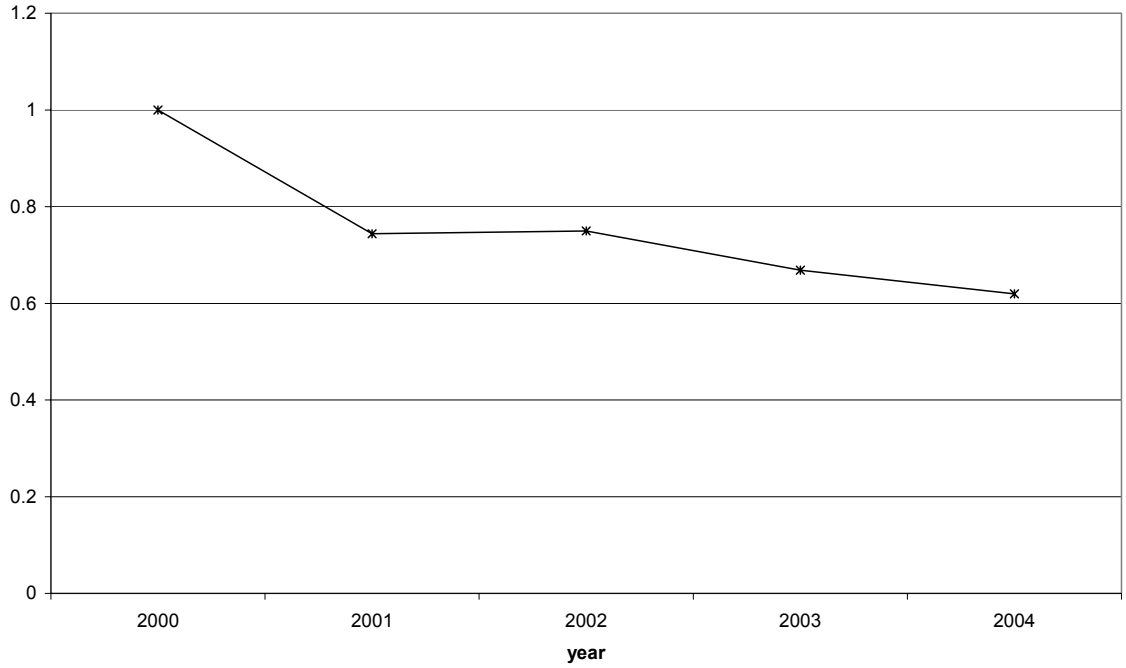

Figure IV-3 French sales of paraquat by Syngenta, 2000-2004, indexed year 2000 set 1 (source: Syngenta, 2004)

Paraquat product label
No information was received about any changes in labelling information over time.

The following Syngenta paraquat formulations are authorised for use in France:

- GRAMOXONE plus: paraquat concentration 100 gram per litre
- R'Bix: paraquat concentration 100 g/l
- Giror: paraquat concentration 40 g/l

It is not known whether any other paraquat formulations have been approved for use besides these Syngenta products.

In France paraquat is used mainly in the following crops and applications (table IV-4).

Table IV-4 Share of crops and applications in total French paraquat use

Crop or application	% of sales[47]	Rate of use (l/ha)	Remarks[48]
Vines, orchards and nurseries, weed control	32	4-6	Rate depends on weed density
Vines, orchards and nurseries, chemical leaf-thinning		1.4	
Forage crops	12	1.5-4	Annual weed control, rate depends on degree of crop emergence
Vegetables	1	1.5-4	Annual weed control, rate depends on degree of crop emergence
Other crops	55	1.5-4	Annual weed control, rate depends on degree of crop emergence
		4-5	Weed control in lucerne

The product label contains user safety information and directions for use, storage and mixing.

The label shows the 'skull and crossbones' danger symbol with the caption: 'Toxic'.

The safety precautions includes the following guidelines on **Environmental protection**:

"After use, take all necessary precautions to ensure that disposal of the packages does not involve a risk of contamination of the soil and surface or ground waters. Keep unused leftovers in the original packages, in a cool, well-ventilated place, under lock and key and out of reach of children, with a view to later re-use or disposal in accordance with current legislation. Prevent access to the treated area by livestock and pets for at least 24 hours after operations."

"Avoid discarding in the environment. Refer to the safety data sheet."

The label also contains information on **Gramoxone plus and wildlife**:
"The hare has occasionally shown a degree of sensitivity to paraquat because it displays the peculiarity of licking its fur when it is wet with dew."

"When treating lucerne, therefore, application should be made to dry vegetation, starting in the centre of the plot and adding to the solution 20 kg/ha of sulphate of ammonium, which has a powerful repellent effect on this species."

"If a pasture area is treated, livestock should be kept away for two days after application"

The label contains, among other things, the following **general remarks on directions for use**:
"Spray when there is little or no wind ."

"In a crop in active growth, application of GRAMOXONE PLUS requires the use of protective screens to avoid contact between the spray and green parts of the crop."

[47] Market share is the average for the period 2001-2004.
[48] Remarks quoted from original "Gramoxone plus" label.

Hare population

Figure IV-5 shows brown hare hunting records in 4 neighbouring districts of France (Marboutin & Péroux, 1995). Assuming these records are a good indication of population size, the figure shows the number of brown hares fluctuated strongly between 1973 and 1983. The degree of fluctuation varies from district to district, but in all districts the re appears to have been a gradual decline in hare numbers since about 1983.

The plotted data represent only the north-eastern part of France. No data were found for other districts, nor for France as a whole. Nor were hare population data found for the most recent period from 1991 onwards.

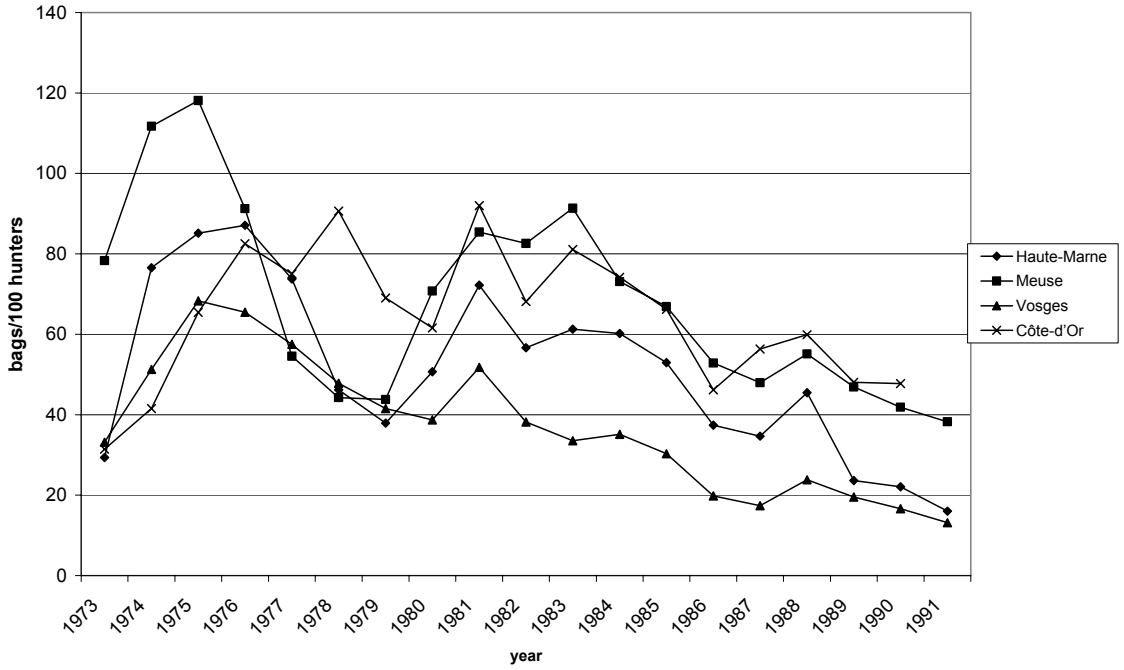

Figure IV-5 Hare hunting bag records in 4 neighbouring districts of north-eastern France, 1973-1991 (source: Marboutin & Péroux, 1995)

Appendix V: Controlling factors, United Kingdom

Incident monitoring scheme

Table V-1 characterises the incident monitoring scheme in operation in the United Kingdom in terms of a number of key criteria (Snoo *et al*., 1999, MAFF).

The Wildlife Incident Investigation Scheme (WIIS) is run by the UK's Agriculture Departments[49], with most of the post-registration surveillance being funded by the agrochemical industry via a levy on product sales. An Environmental Panel charged with advising the Advisory Committee on Pesticides on pesticide-related environmental problems has published annual reports on pesticide incidents since 1986 (MAFF, 1986-2002).

The Wildlife Incident Investigation Scheme (WIIS) investigates wildlife mortality, including deaths of beneficial insects, pets and certain livestock, when there is strong evidence to suggest that pesticide poisoning may be involved.

In relation to this paraquat project it is important to note that analysis of paraquat does form part of the standard chemical-toxicological analysis procedure.

Prior to 1986 there was no systematic reporting of incidents in the UK. For certain districts of the country, however, paper copies of individual reports are available. Before 1986 no distinction was made between different categories of use and abuse (pers. comm.. Mark Fletcher (CSL))

[49] In England and Wales by MAFF (Ministry of Agriculture, Fisheries and Food) and in Scotland by DAFS (Department of Agriculture and Fisheries for Scotland).

Table V-1 The UK incident monitoring scheme

Systematic registration		Yes, in WIIS
Organisation	Ministry of Agriculture	Environmental Panel of the Advisory Committee on Pesticides
Reporting parties	Criminal investigation	
	Private citizens	Nearly 100%
	Bird rehabilitation centres and bird spotter groups	
	Forest and land management agencies	
	Water management agencies	
Costs	Funded by agrochemical industry via levy on product sales	
Types of incidents	Cause of incident classified by type of pesticide use	Abuse Approved use Misuse Unspecified
	Types of animals and/or materials	Companion animals Livestock Wildlife Beneficial insects Suspicious materials
Procedure	Sending and registration of find circumstances (location, date, circumstances etc).	
	Research, in two steps: 1. pathological section, 2. chemical-toxicological analysis[50]	
	Registration of incident data and research results in a non-relational database	

National use of pesticides and paraquat

Total pesticide use

Figure V-2 charts the trend in total UK use of agricultural pesticides since 1990, showing component trends in herbicide and paraquat use.

According to the FAO data, overall use of pesticides and herbicides increased slightly from 1991 to 1999, while in recent years (2000-2001) there seems to have been a slight overall decline. Although there is some fluctuation in the CSL figures, they show a general downward trend over the period as a whole. Paraquat[51] accounts for only a very small fraction of overall use (about 0.3% of total pesticide use and 0.4% of total herbicide use).

The FAO and CSL data give very different pictures of the total amount of pesticides used in the UK. They also differ in the trends they describe over the years. For the period as a whole, FAO puts average pesticide use about 1.5 times higher than CSL. One possible explanation for this might be that FAO data are sales data rather than usage data.

[50] Over the years this scheme has widened its scope and now is able to detect most of the pesticides thought likely to cause animal deaths (Hardy et al. 1986).
[51] Note that the paraquat consumption plotted in the figure is based on the sales of one producer only.

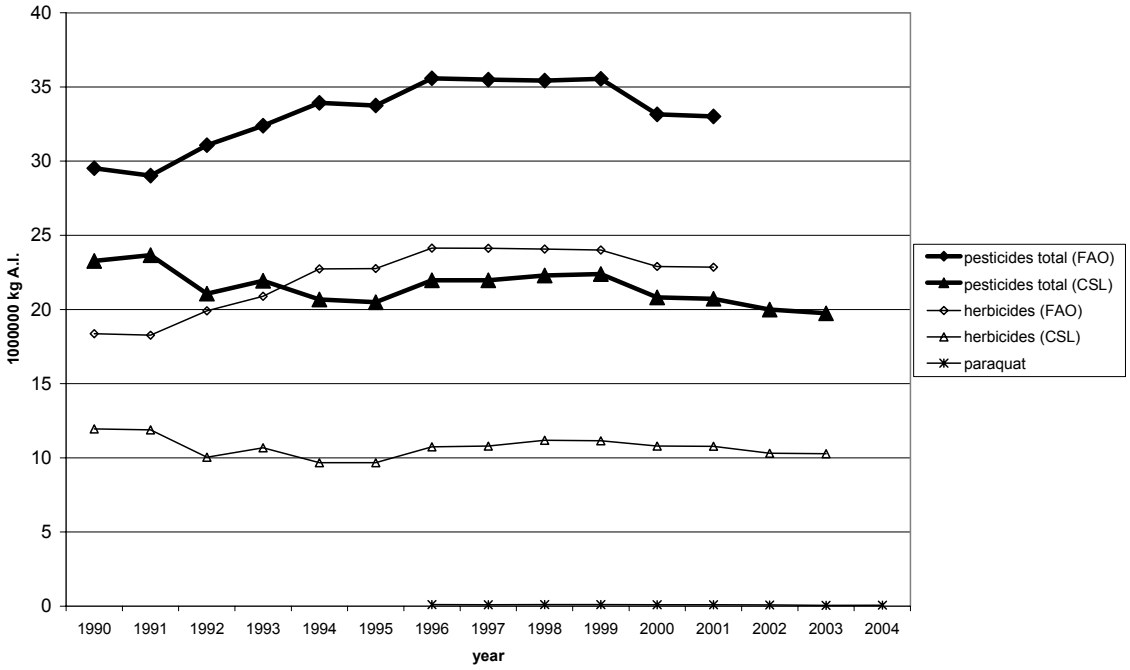

Figure V-2 UK pesticide use, 1990-2004 (source: FAO, 2004; CSL, 2004; Syngenta, 2004)

Paraquat use

Figure V-3 shows UK sales of paraquat by Syngenta from 1996 to 2004, showing a general decline over this period (source: Syngenta).

Note that these figures are based on one producer only. This means that the total amount of paraquat used in the UK has been underestimated. There are currently no figures available for total paraquat use in the UK. Over the period 2001-2004 the share of Syngenta in the total UK paraquat market is estimated to have been about 50%[52]. This market share is assumed to be relatively constant. Total paraquat use in the UK is therefore likely to be twice as high as shown in the figure. Total paraquat use is also likely to have decreased between 1996 and 2004.

According to Edwards *et al.* (2000) paraquat use appears to have doubled between 1965 and 1975, halved from 1975 to 1985 and remained more or less stable from 1985 to 1995.

[52] Estimate based on Syngenta's UK sales of paraquat for different applications (i.e. cereals, potatoes and legumes) and Syngenta's market share of products for these applications.

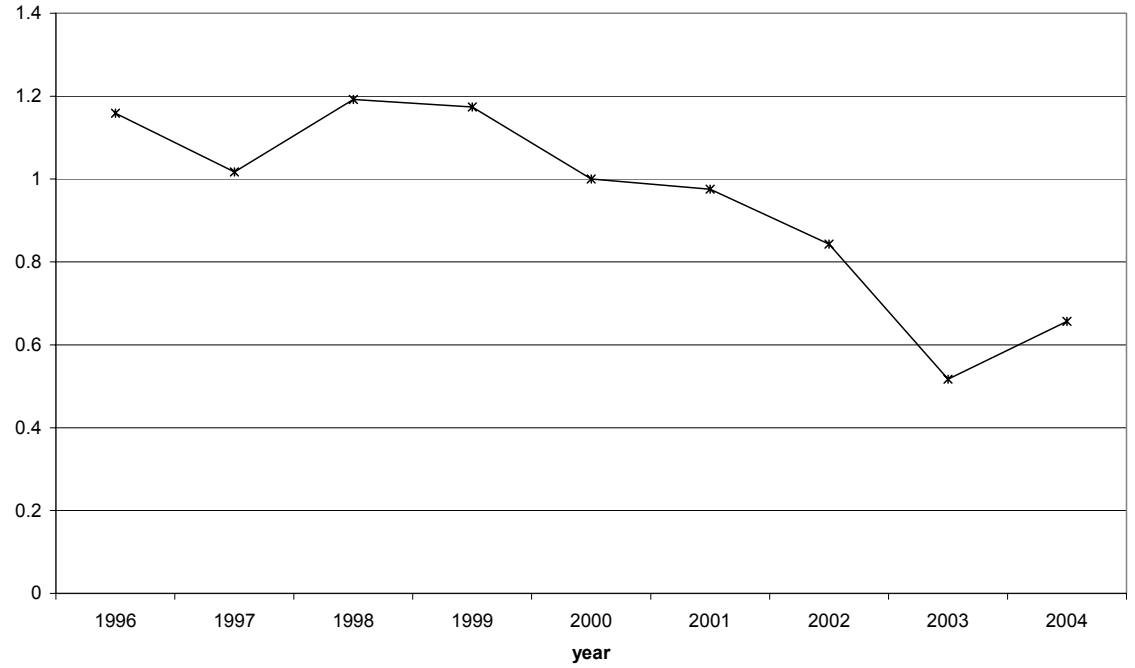

Figure V-3 UK sales of paraquat by Syngenta, 1996-2004, indexed year 2000 set 1 (source: Syngenta, 2004)

Paraquat product label
No information was received about any changes in labelling information over time.

The following Syngenta paraquat formulations are authorised for use in the UK:
- GRAMOXONE 100: paraquat concentration 200 gram per litre
- PDQ: mixture of paraquat/diquat; concentration 120/80 gram per litre

It is not known whether any other paraquat products have been approved for use besides these Syngenta products.

In the UK paraquat is used mainly in the following crops and applications (table V-4).

Table V-4 Share of crops and application in total UK paraquat use

Crop or application	% of sales[53]	Rate of use (l/ha)	Remarks[54]
"Potato weed control"	80	3-5.5	"Spray earlies and crops grown before for seed up to 10% emergence and main crop up to 40% emergence provided no plants are more than 15 cm (6 in) high. Do not apply after emergence to crops growing from diseased or very small tubers or under very hot, dry conditions."
"Cereal and other arable crops after arable crops"	20	2-4	"Use the higher rate for large weeds, volunteers or where heavy infestations are present"
"Cereals and arable crops after grass"		3-4	"Use the higher rate to kill old grass, the lower rate on annual grass and broad-leaved weeds growing after cultivation."

[53] Market share is the average for the period 2001-2004.
[54] Remarks and recommendations quoted from original "Gramoxone 100" label.

The product label contains user safety information and direction for use, storage and mixing.

The safety precautions include the following guidelines on **Environmental protection**:

"HARMFUL TO LIVESTOCK. Keep all livestock out of treated areas for at least 24 hours.

Paraquat can be harmful to hares; stubbles must be sprayed early in the day"

Hare population

Figure V-5 (from Edwards *et al.,* 2000) shows that the number of brown hares in the UK declined dramatically during the period 1960-1990, falling by nearly three-quarters between 1960 and 1980. From 1980 to 1995 the population seems to have remained more or less stable at this lower level.

According to Edwards *et al.* (2000) this decline in the hare population had already occurred before paraquat was introduced. The hypothesis is that the factors most likely responsible for the long-term decline are not paraquat-related but changes in agricultural management, primarily through loss of crop/landscape diversity affecting nutrition (Edwards *et al.,* 2000).

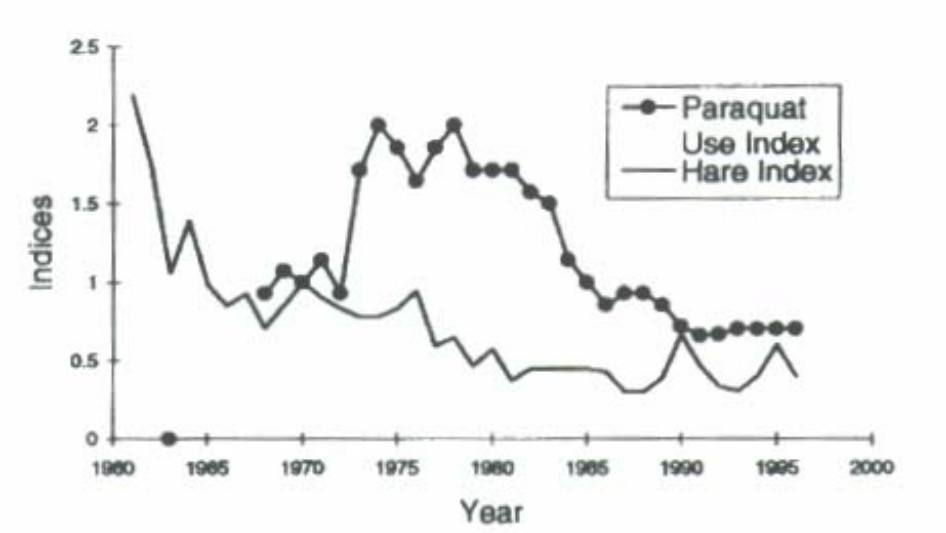

Figure V-5 UK hare population index and paraquat consumption index (Edwards et al., *2000)*

Appendix VI: Controlling factors, Germany

Incident monitoring scheme

Table VI-1 characterises the incident monitoring scheme in operation in Germany in terms of a number of key criteria (Snoo *et al*., 1999, BVL).

In Germany it is generally the *Länder* that are responsible for the monitoring of plant protection products, including wildlife incidents. Contrary to other member states in the European Union, there is no official reporting procedure. The Federal Office of Consumer Protection and Food Safety, Division of Plant Protection Products (BVL) collates information received from the individual *Länder*. As there is no obligation to report incidents, BVL data are based on voluntary reports. In relation to this paraquat project it is important to note that analysis of paraquat is not part of the standard chemical-toxicological analysis procedure. There was no information available on any changes that may have occurred over time in the reporting scheme.

Table VI-1 The German incident monitoring scheme

Systematic registration		No
Organisation	Ministry of Agriculture	BVL[55]
Reporting actors	Police	4%
	Private citizens	
	Nature conservation organisations	23%
	Hunting community	7%
	Staff of Plant Protection Service	66%
Costs	No standard procedure: *Länder*, Plant Protection Services, ??	
Types of incidents	Cause of incident classified by pesticide	Abuse Approved use Misuse Unspecified
	Types of animals and/or materials	Wildlife (mainly mammals and birds), also companion animals and livestock
Procedure	No standard procedure, based on voluntary reports in different *Länder*	
	Sending and registration of find circumstances (location, date, circumstances, indication of death etc.)	
	Research, in two steps: 1. pathological section, if diagnosis is "likely poisoning" or "poisoning cannot be excluded", 2. chemical-toxicological analysis[56]	
	Registration of incident data and research results in voluntary reports in different *Länder*.	

[55] BVL: *Bundesamt für Verbraucherschutz und Lebensmittelsicherheit* (Federal Office of Consumer Protection and Food Safety, Division of Plant Protection Products).

[56] Samples of poisoned animals can not be examined for all authorised active substances. The efforts must be limited by indication of a suspicion to few plant protection agents. So it is important to have an indication of the type of active substance or group. Therefore is not possible to generalize that laboratories do or do not test on paraquat at all (pers.comm: Waldmann (BVL)).

National use of pesticides and paraquat

Total pesticide use

Figure VI-2 charts the trend in total German use of agricultural pesticides since 1990, showing component trends in herbicide and paraquat use.

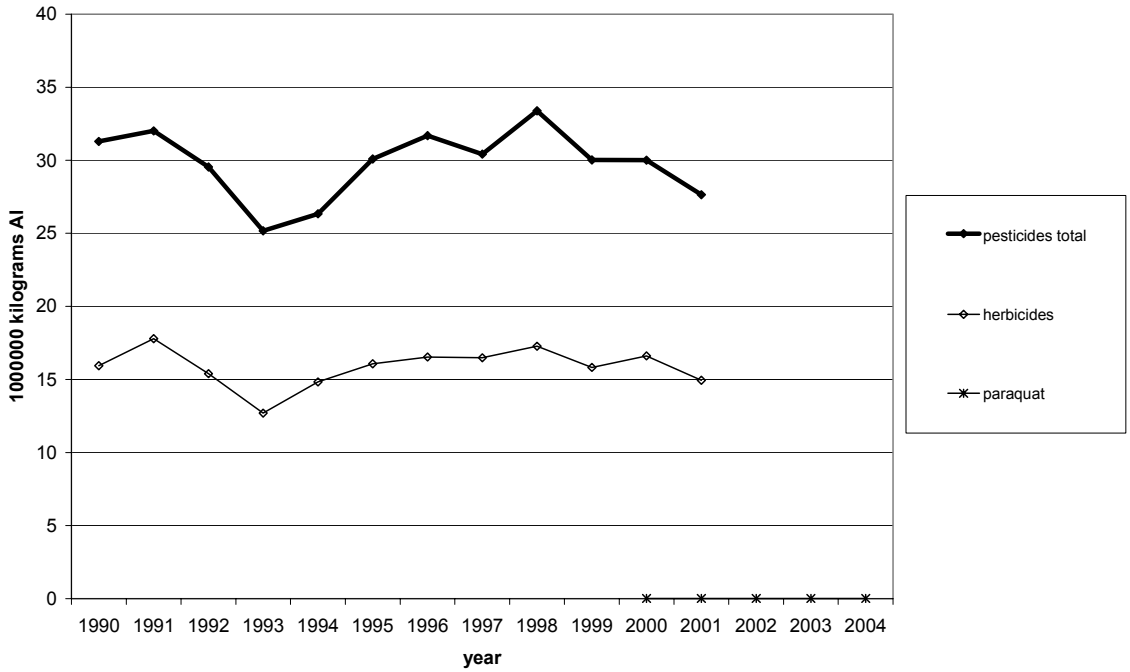

Figure VI-2 German agricultural pesticide use, 1990-2004 (source: FAO, 2004; Syngenta, 2004)

According to FAO, total use of pesticides as well as herbicides remained more or less constant over the period 1990-2002, although with a striking dip in the years 1993 and 1994. Paraquat[57] accounts for only a very small fraction of overall use (about 0.04% of total pesticide use and 0.07 % of total herbicide use).

Paraquat use

Figure VI-3 shows German sales of paraquat by Syngenta over the period 2000-2004. Between 2000 and 2004 paraquat sales fluctuated. No figures on historical paraquat use before 2000 were provided.

[57] Syngenta is the only supplier of paraquat in Germany.

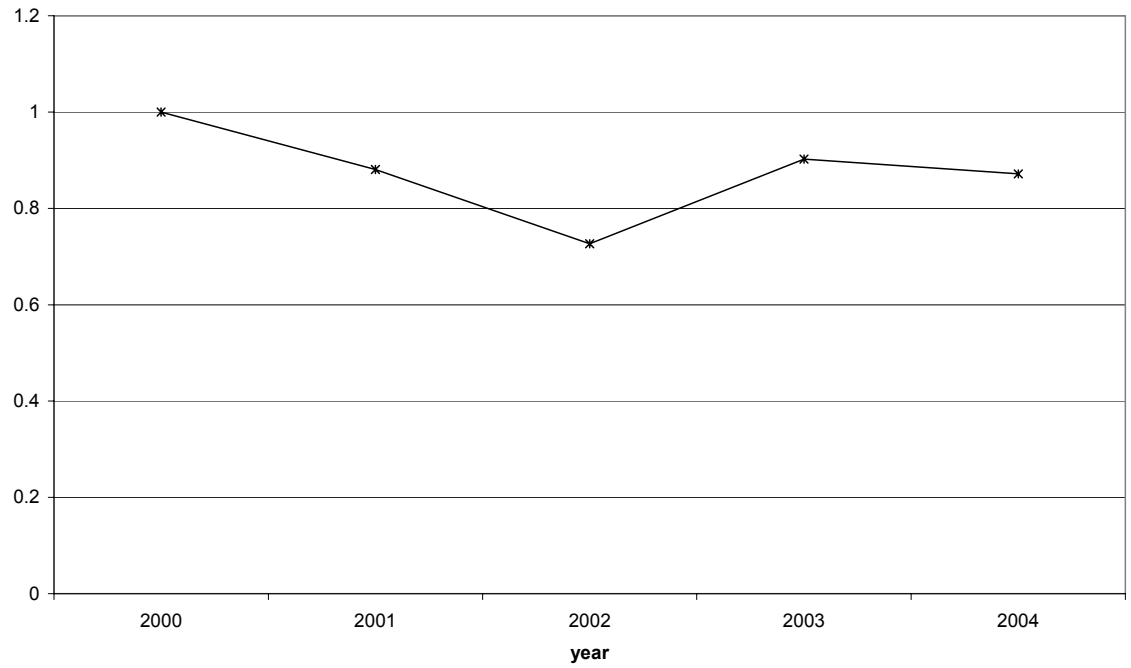

Figure VI-3 German sales of paraquat by Syngenta, 2000-2004, indexed year 2000 set 1 (source: Syngenta, 2004)

Paraquat product label
No information was received about any changes in labelling information over time.

Only one plant protection product containing paraquat as an active ingredient is authorised for use in Germany up to 31.12.2008: Gramoxone extra, produced by Syngenta (pers. comm.. R. Waldmann, BVL).

- Gramoxone extra: paraquat concentration 100 gram per litre

In Germany the application of plant protection products containing paraquat is severely restricted by law[58].

[58] (*Pflanzenschutz-Anwendungsverordnung in der Fassung der Verordnung zur Bereinigung pflanzenschutzrechtlicher Vorschriften vom 10. November 1992 (BGBl. I S. 1887), zuletzt geändert durch die Dritte Verordnung zur Änderung der Pflanzenschutz-Anwendungsve rordnung vom 23. Juli 2003 (BG-Bl. I S. 1533*

The following uses are authorised:
1. treatment to control weeds and cover fruits in **maize** or **sugar beets** before seed germination; on the same site every fourth year (application rate per treatment 0.4 – 0.6 kg a. i./ha);
b) to control weeds in nursery seed patches; on the same site every fourth year (application rate per treatment 0.4 – 0.6 kg a. i./ha);
c) to control weeds in **viticulture** in the planting year and up to the third year after planting (application rate per treatment 0.4 – 0.6 kg a. i./ha);

2. facilitating the harvest in the **cultivation of grass seeds** (application rate per treatment 0.3 kg a.i./ha).

Table VI-4 Share of crops and applications in total German paraquat use

Crop	% of sales	Rate of use	Remarks and recommendations[59]
Maize, sugar beet	??	4-6 l/ha, in 1000 l of water	"Before emergence of the crop; Until the 4th leaf or leaf pair or leaf whorl of the weeds /cover crops unfolds. By the direct sowing method in areas prone to erosion."
Tree nursery seed beds	??	0.4-0.6 ml/m2 in 0.1 l of water	"Before emergence of the crop. Spray with spray screen."
Vines	??	0.4-0.6 ml/m2 in 0.1 l of water	"During the vegetation period; until the 4th leaf or leaf pair or leaf whorl unfolds; Spray with spray screen. The agent does not have any sustained effect."
Grasses, facilitating the harvest	??	3 l/ha	"Before the harvest; BBCH 92 (dead ripeness) Application only on crops which are for producing seed. The precondition for use is the physiological ripeness of the seed. As ripening ceases after application of GRAMOXONE EXTRA, unripe seeds may have problems germinating. Only carry out germination samples in earth or after washing in clay or charcoal suspension, as otherwise the test results may be distorted by adhering residues. Damage to the crop plant is possible. Do not use the harvested / mown crop as animal feed in the year of treatment."

The product label contains user safety information and directions for use, storage and mixing.

The label shows two danger symbols:

- the 'skull and crossbones' symbol with the caption 'TOXIC'
- a 'dead tree and fish' symbol with the caption 'ENVIRONMENTAL HAZARD'.

Specific guidelines are given on the protection of water, including a condition for use laid down by the regulatory authority: "when using the agent, at least 5 metres' clearance must be observed between the area treated and any waterways….."

[59] Remarks and recommendations quoted from original "Gramoxone extra" label.

In addition, the product may not be used in nature protection areas, national parks or natural monuments.

Hare population

Figure V-5 shows trends in the number of hares killed by hunting in several EU member states (Edwards *et al.,* 2000). In Germany the number of brown hares declined dramatically over the period 1960-1990, falling by nearly a half between 1960 and 1980. From about 1980 to 1990 onwards the population seems to have remained more or less stable at this lower level.

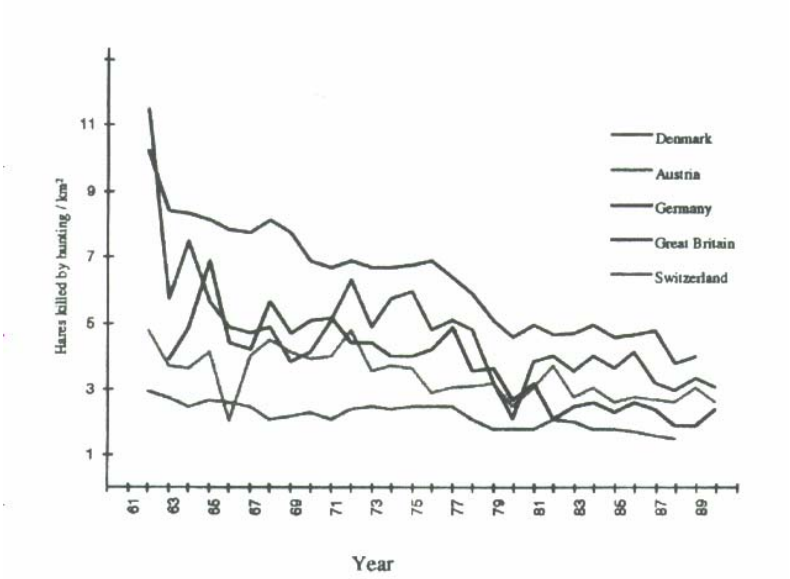

Figure VI-5 Hares killed by hunting (number per km^2) in Germany, 1960-1990

Appendix VII: Controlling factors, United States

Incident monitoring scheme

Table VII-1 characterises the incident monitoring scheme in operation in the USA in terms of a number of key criteria (Snoo *et al*., 1999, EPA).

Many ecological incidents are probably not observed or reported, but those that are reported to the competent authority (usually a state agency) are investigated and an incident report is generated.

In 1992 the Environment Protecton Agency (EPA) created a database called the Ecological Incident Information System (EIIS) to store information taken from these incident reports.

The two primary sources of incident reports are pesticide registrants and government agencies. Under section 6(a)(2) of the pesticide law FIFRA, pesticide registrants or manufacturers are required to report to EPA any information related to known adverse effects to the environment caused by their registered pesticides.

The second major source of information are investigative reports submitted voluntarily to the Agency by state and other federal agencies overseeing agriculture, wildlife, natural resources and environmental quality. Diagnostic reports are also obtained from the National Wildlife Health Institute (USGS), the Patuxent Wildlife Research Center (USGS), the Southwest Wildlife Cooperative Disease Study and state wildlife forensic laboratories. Information is also extracted from accounts of ecological incidents reported in newspapers and reliable internet sources.

The EIIS database was originally built in dBase III Plus, but was recently converted to a Lotus Approach application. It is a relational database consisting of 89 distinct fields contained within 13 related data tables.

Information in EIIS records, if available, includes the data and location of the incident, type and magnitude of effects observed in various species, use(s) of pesticides known or suspected of contributing to the incident, and the results of any chemical residue and cholinesterase activity analyses conducted during the incident investigation.

Ecological incidents play an important role in the Agency's risk assessment and decision-making process. For a given pesticide, widespread ecological incidents may confirm a risk already predicted by risk assessment models, or it may indicate that the actual risk is greater or less than that predicted by the model.

Source: http://www.epa.gov/oppefed1/general/databasesdescription.htm#eiis

Table VII-1 The US incident monitoring scheme

Systematic registration		Yes, EIIS[60]
Organisation	Ministry of Environment	US EPA[61]
Reporting parties	Pesticide registrants	
	Government agencies	
	State and other federal agencies	
	Newspapers and reliable internet sources	
Costs	??	
Types of incidents	Cause of incident classified by type of pesticide use	Abuse Approved use Misuse Unspecified
	Types of animals and/or materials	Wildlife (verte-brates and inverte-brates)
Procedure	Sending and registration of find circumstances (location, date, circum-stances etc.).	
	Research, in two steps: 1. pathological section, 2. chemical-toxicological analysis.	
	Registration of incident data and research results in a relational database EIIS (program: Lotus Approach application)	

National use of pesticides and paraquat

Total pesticide use

Figure VII-2 charts the trend in total US use of agricultural pesticides for the period from 1964 to 2004 (sources: EPA (Kiely *et al.,* 2004); FAO, 2004).

[60] EIIS: Ecological Incident Information System, http://www.epa.gov/oppefed1/general/databasesdescription.htm#eiis

[61] US EPA: United States Environmental Protection Agency.

Figure VII-2 US agricultural pesticide use, 1964-2004 (sources: EPA Kiely et al., 2004); FAO, 2004).

According to FAO, total use of pesticides as well as herbicides increased overall between 1990 and 1997. Although herbicide use appears to have declined initially, from 1990 to 1993, in the year 1994 use increased and remained more or less stable at a slightly higher level.

The EPA figures (Kiely *et al.,* 2004) provide a long-term picture of total pesticide use. From 1964 until 1979 there was a continuous and rapid rise in US pesticide use, followed by a rapid decline from 1979 to 1987. Since 1987 total pesticide use has stayed more or less stable, with, remarkably, a slightly higher level in the period 1994-1997. Comparison of the FAO data and EPA data shows a general match between the two, although the EPA data are slightly higher.

Paraquat use
No data on paraquat sales in the United States were received.

Paraquat product label
No information was received on the product label or any changes in labelling information over time.

The following Syngenta paraquat formulations are sold in the US:

- GRAMOXONE: paraquat concentration 200 gram per litre
- GRAMOXONE Max: paraquat concentration 360 g/le
- GRAMOXONE Super Tres: paraquat concentration 360 g/l

It is not known whether any other paraquat formulations have been approved for use in the US besides these Syngenta products.

The labels contain very extensive application instructions for different kinds of crops and for the different US states. These are not further elaborated here.

The product label contains user safety information and directions for use, storage and mixing.

The label shows the 'skull and crossbones' danger symbol with the caption 'Danger/Peligro, Poison'.

The safety precautions also include the following guidelines on **Environmental hazards**[62]:

"**Wildlife:** This product is toxic to wildlife. Do not apply directly to water, or areas where surface water is present, or intertidal areas below the mean high water mark. Do not contaminate water when cleaning equipment or disposing of equipment wash waters.

Drift: Gramoxone Max is a contact herbicide that desiccates all green plant tissue. Paraquat dichloride is toxic to nontarget crops and plants if off-target movement occurs. Extreme care must be taken to ensure that off-target drift is minimized to the greatest extent possible. Do not apply under conditions involving possible drift to food, forage, or other plantings that might be damaged or the crops thereof rendered unfit for sale, use, or consumption. Do not apply when weather conditions favor drift from treated areas. To avoid drift, do not make aerial applications during periods of thermal inversion. Refer to the local state laws, regulations, guidelines and spray drift information contained in the Direction for Use section for proper application to avoid off-target movement."

Hare population

No data gathered.

[62] Quoted from original "Gramoxone Max" label.

Appendix VIII: Original data on UK hare incidents from Edwards *et al.*, 2000 (summary)

Edwards *et al.* (2000) report two paraquat incidents with hares during the period 1974-1997, one in 1976 and one in 1990.

Before 1986 there was no systematic annual reporting of incidents in the UK, with hare incidents being extracted from various kinds of paper records for different regions (pers. comm. Mark Fletcher, CSL). A detailed look at these extracted data indicates that paraquat might have been involved in several more incidents (see table VIII-1).

There are three types of evidence that might point to possible paraquat poisoning:
1) the circumstances in which the victims are found, e.g. recent paraquat use at the location
2) pathological results such as congested lungs, and
3) pathological results such as haemorrhaging.

In all such incidents the cause of the death is classified in the UK as "unknown", however, probably because paraquat could not be identified as the most likely cause of death in a chemical analysis. These possible paraquat cases with cause "unknown" are not reported by Edwards *et al.*, (2000).

The discrepancy between the reported information in the records and the incidents finally reported as pesticide (paraquat) incidents calls for more detailed reflection on the monitoring and reporting procedure. In most systematic monitoring and reporting procedures the conclusion on the likely cause of death will be based on three criteria:

1. circumstances in witch the victim is found, e.g. location, knowledge about use of the location etc.,
2. pathological analysis of the victim,
3. in a possible poisoning case, chemical analysis of the victim.

In identifying an incident as being caused by paraquat, the chemical analysis phase thus appears to be crucial. Strict application of the criterion of chemical "proof" probably leads to underestimation of the number of poisoning incidents, however. There are reasons to believe that the properties of paraquat make potential paraquat poisoning incidents difficult to monitor and analyse, *viz.*:

1. it can take a while (several days) before an animal dies after exposure to paraquat,
2. the potentially sick animal will leave the site of exposure to seek shelter elsewhere and so will not be found in the vicinity (in which case the find circumstances will not reflect the actual situation) or will not be found at all,
3. paraquat is rapidly excreted and so will not be detected using chemical analysis.

Together, these factors may point to an erroneously low attribution of poisoning to paraquat, especially when chemical proof is employed as a strict criterion. It is therefore to be recommended that there be more detailed reporting of conclusions concerning cause

of death, in decreasing order of certainty based on chemical evidence, pathological evidence or circumstantial evidence only. In the reporting of incidents this would enable an indication to be given of the most likely cause as well as a "worst-case scenario" of lower probability.

Table VIII-1 Overview of data records on hare incidents, 1975-2002 (source: WIIS database, MAFF)

Year	Month	County	County	Cause	No	Comments
1975	March	Kent	Kent	UK	5	paraquat used in hops
1976	Jan	Norfolk	Norfolk	Paraquat	several	river meadow sprayed with paraquat
1976	March	Norfolk	Norfolk	UK	1	haemorrhaging (EBHS?)
1976	June	Hants	Isle of Wight	UK	c12	paraquat sprayed nearby, lung damage
1976	Sept	Cambs	Cambridgeshire	UK	1	paraquat sprayed nearby on grass
1977	Sept	Merseyside	Merseyside	UK	c12	paraquat sprayed nearby
1978	April	Oxfordshire	Oxfordshire	Pasteurellosis	10	paraquat sprayed nearby
1981	Jan	Cambs	Cambridgeshire	UK	20+	lungs congested
1981	Feb	Suffolk	Suffolk	UK	12	lungs congested
1982	March	Suffolk	Suffolk	UK	several	lungs congested
1982	May	Lincs	Lincolnshire	UK	6	lungs congested
1982	Sept	Suffolk	Suffolk	Chloralose	several	lungs congested
1984	Oct	Warwicks	Warwickshire	UK	4	haemorrhaging (EBHS?)
1984	Oct	Hants	Isle of Wight	UK	5	haemorrhaging (EBHS?)
1984	Oct	Gloucs	Gloucestershire	UK	15-20	haemorrhaging (EBHS?)
1984	Oct-Nov	Norfolk	Norfolk	UK	6	haemorrhaging (EBHS?)
1984	Oct-Nov	Suffolk	Suffolk	UK	10	haemorrhaging (EBHS?)
1984	Nov	Wilts	Wiltshire	UK	numerous	haemorrhaging (EBHS?)
1984	Nov	Dorset	Dorset	UK	1	haemorrhaging (EBHS?)
1984	Nov	Cambs	Cambridgeshire	UK	1	haemorrhaging (EBHS?)
1984	Dec	Merseyside	Merseyside	UK	numerous	paraquat sprayed nearby
1986	Dec	Norfolk	Norfolk	UK	c7	haemorrhaging (EBHS?)
1988	Nov	Essex	Essex	UK	8	haemorrhaging (EBHS?)
1988	Dec	Leics	Leicestershire	UK	9	haemorrhaging (EBHS?)
1989	March	N Yorks	N Yorkshire	UK	several	lungs congested
1989	April	N Yorks	N Yorkshire	UK	several	lungs congested
1989	Oct	Suffolk	Suffolk	UK	c65	lungs congested
1989	Oct	Lincs	Lincolnshire	UK	5	lungs congested
1989	Oct	Berks	Berkshire	UK	12	haemorrhaging (EBHS?)
1989	Oct	Cambs	Cambridgeshire	UK	c200	haemorrhaging (EBHS?)
1990	Jan	Herts	Hertfordshire	UK	several	haemorrhaging (EBHS?)
1990	August	D & Gallo-way	Dumfries and Gallosway	Paraquat	several	on potato crop
1990	Oct	I of Wight	Isle of Wight	UK	7	lungs congested
1992	July-Sept	Cambs	Cambridgeshire	UK	several	haemorrhaging (EBHS?)
1997	Sept	Norfolk	Norfolk	UK	3	potatoes sprayed with paraquat
1999	Oct	Grampian	Grampian	UK	numerous	haemorrhaging (EBHS?)