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THAMES REGION

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REGIONAL FISHERIES ECOLOGY & RECREATION ADVISORY COMMITTEE
MEETING: 8 JULY 2005

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TITLE: SHEEP DIP IMPACTS ON AQUATIC LIFE

RECOMMENDATIONS

The Committee is invited to

1. note Environment Agency activity to reduce the impacts of sheep on the aquatic environment;
2. consider possible options;
3. advise on the best way forward.

1.0 BACKGROUND

1.1 Sheep pests such as scab, blowfly, ticks and lice are controlled by using chemical insecticides either by immersion (dipping), 'pour ons', showers, jetters or injectables. Sheep dipping is the most widespread method of pest control, especially for scab, and it is common practice in early autumn when the risk of infestation is greatest.

1.2 Following dipping, residues of the chemical remain in the sheep's fleece and may be lost to the environment through drips, sheep walking through watercourses, loss of wool, product misuse, and in processing of fleeces. A further potential source arises from the disposal of used sheep dip. Disposal to land is the normal method but requires Environment Agency authorisation under the 1998 Groundwater Regulations.

1.3 Dipping-related sources are important in upland Wales, Cumbria, Northumbria, Kent and other areas of sheep farming, whilst industrial sources are more important in the fleece processing areas of West Yorkshire and Devon.

1.4 The two major chemicals authorised as sheep dip by the Veterinary Medicines Directorate (VMD) are cypermethrin and diazinon. Although both compounds are highly effective against target pest species, they are also toxic to invertebrates and fish at very low concentrations. Reflecting their high ecotoxicity, environmental quality standards (EQSs) have been set which specify limits in surface waters below which adverse effects are not expected to occur. Cypermethrin is up to 1000 times more toxic to aquatic life than diazinon and hence has a much lower EQS.

1.5 Diazinon has been linked with ill health in sheep farmers and the VMD has required changes to its delivery method to reduce exposure to operators.

2.0 SHEEP DIP IMPACTS ON AQUATIC LIFE

2.1 The Environment Agency's Chemicals Science team has reviewed the evidence for impacts of sheep dip on the aquatic environment. Its report is at Annex 1.

2.2 Detailed investigations in Wales over the last few years have shown severe declines in invertebrate biology at a number of locations caused by contamination by sheep dip chemicals. Recent intensification of monitoring appears to be leading to a greater incidence of such cases, suggesting the problem is widespread. Since August 2003, there have been 57 sheep dip-related incidents in Wales alone, affecting 29 catchments. Most of these incidents have arisen from apparent routine use of cypermethrin. Several of them are being pursued with legal action where the source could be clearly identified.

2.3 Substantial impacts on invertebrates are likely to affect fish stocks due to loss of food sources. Trout fisheries may also suffer reduced fishing income because of effects on fly life hatches.

2.4 Recent evidence indicates effects on olfactory mechanisms in salmonid fish at concentrations close to the EQS. These could have important consequences for migration and breeding success and bring into question whether the current EQS values are sufficiently stringent.

2.5 Sheep dip chemicals cause around one third of all freshwater EQS failures with between 39 to 70 failures each year in the period 2000 - 2003. Failures occur most frequently in areas of sheep rearing (Wales, Northumbria, Kent) and in areas associated with the processing of fleeces (West Yorkshire).

2.6 Levels of these compounds in water is almost certainly under-estimated because:

(a) spot sampling means that 'peaks' in exposure will often be missed;

(b) the analysis method underestimates cypermethrin levels by 25-50%;

(c) cypermethrin rapidly leaves the water by adhering to sediments and biota.

2.7 Under the Water Framework Directive (WFD), initial River Basin Characterisation has recently been completed. This included desk-based work on the risk posed by sheep dip. This work estimated that around half of Wales is at risk of failing to meet the WFD objective of Good Ecological Status because of sheep dip.

3.0 CURRENT AND RECENT ACTIVITIES TO REDUCE SHEEP DIP IMPACTS

3.1 The Environment Agency's Sheep Dip Strategy (1999) established our long-term objective to eliminate the need to dip or shower sheep as a control against ectoparasites. However, it recognised that on animal welfare grounds, farmers currently need a range of options to treat the parasitic infection of sheep effectively.

3.2 The Strategy set out 29 actions to reduce the impacts of sheep dip on the environment. In the main these have been achieved through the following:

- Production of a Sheep Dip Code of Practice under the Groundwater Regulations;
- Improved awareness raising and advice for users and contractors;
- Enforcement of the Groundwater Regulations (1998);
- Development of a tool to improve sheep flock management and so reduce the need to treat;
- Common Agricultural Policy reform to remove headage payments for sheep;

3.3 The Salmon and Freshwater Fisheries Review made recommendations relating to sheep dip issues. There are four recommendations that are either in part or wholly for the Environment Agency to progress. A summary of these and the actions taken is at Annex 2.

4.0 OPTIONS FOR FUTURE ACTIVITY

4.1 The Environment Agency believes that the way in which cypermethrin sheep dip is currently being used is having unacceptable impacts on the environment. Given the on-going severe environmental impacts there is a clear need to increase activity to reduce these impacts. We will establish a National Pollution Reduction Plan (PRP) for sheep dip that will inform the Programme of Measures under the WFD.

4.2 The PRP could contain the following:

- Further work on awareness raising and improvement in best practice for sheep dipping to include revising the Sheep Dip Code of Practice and promoting improved sheep flock management;
- An industry-led voluntary approach to reduce the impacts of sheep dip along similar lines to the existing "Voluntary Initiative" for pesticides;
- Further characterisation of the problem under the WFD by developing comprehensive monitoring programmes and undertaking further risk assessment;
- A programme of research on the sources and impacts of sheep dip, mitigation methods and development of effective alternatives to sheep dip;
- Review by VMD of the authorisation of sheep dip chemicals and introduction of further regulatory controls on use;

- A cross-Government/industry phase-out strategy for sheep dip whereby alternative approaches are promoted that maintain animal welfare standards and do not affect farmer livelihoods;
- Work with retailers and assurance schemes to facilitate uptake of best practice and/or a phase out of sheep dip;
- Consideration of whether cross-compliance under the Single Farm Payment could be used.

4.3 This PRP will require input from VMD, the sheep dip manufacturers and the farming and textile industries. A cost-effectiveness analysis will be undertaken to identify the best package of measures that balances the needs of the environment, farmers and animal welfare alike.

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ANNEX 1

ENVIRONMENTAL IMPACTS OF SHEEP DIP CHEMICALS: A REVIEW OF AVAILABLE INFORMATION

Chemicals Science, Environment Agency

SUMMARY

1. Cypermethrin and diazinon are insecticides contained in products approved for the control of several pests of sheep. Although both compounds are highly effective against target pest species, they are also toxic to invertebrates and fish at very low concentrations. Reflecting their high ecotoxicity, Environmental Quality Standards (EQSs) have been developed which specify limits in surface waters below which adverse effects are not expected to occur.

2. Cypermethrin and diazinon can persist in the environment for a period of days or weeks before being broken down by a combination of biotic and abiotic processes. Diazinon is broken down more rapidly at acidic and alkaline pHs than at neutral pHs whereas cypermethrin breakdown is favoured only under alkaline conditions. For cypermethrin, sorption onto sediments and biota is a further major fate process.

3. Despite guidance on measures to reduce the risks of environmental contamination, both compounds continue to be detected in surface waters, frequently at concentrations in excess of their respective EQSs. Indeed they are responsible for most of the EQS failures reported by the Environment Agency in its annual monitoring programme for pesticides. Failures occur most frequently in areas of sheep rearing and in areas associated with the processing of fleeces.

4. The level of environmental contamination by these compounds is almost certainly under-estimated because (a) reliance on spot sampling means that ‘peaks’ in exposure will often be missed, (b) routine analysis systematically underestimates concentrations of the trans isomer of cypermethrin and (c) partition of cypermethrin from the water column to sediments and biota will rapidly deplete concentrations present in water, thereby underestimating the extent of environmental contamination.

5. Operational investigations in Wales have attributed declines in invertebrate biology at a number of locations to contamination by sheep dip chemicals. Research has shown that certain taxa are particularly sensitive, allowing changes in invertebrate diversity and abundance to be linked with exposure to these chemicals. Intensification of this type of monitoring activity appears to be leading to a greater incidence of such cases, suggesting the problem is widespread.

6. Reported trends in both the incidence of EQS failures and pollution incidents may not reflect the true situation because not all incidents have been formally reported. Since August 2003, 57 sheep dip-related incidents occurred in Wales, affecting 29 catchments. Several of these incidents are being pursued with legal action where the source could be clearly identified.

7. Recent evidence indicates effects on olfactory mechanisms in salmonid fish at concentrations close to the EQS. These could have important consequences for migration and breeding success and bring into question whether the current EQS values are sufficiently stringent.

1. Introduction

This paper summarises information about the environmental impacts arising from the use of approved sheep dip chemicals in the UK. It draws mainly on monitoring programmes and research undertaken by the Environment Agency in England and Wales but also makes reference to external research where this is relevant.

The purpose of the paper is to highlight the Agency's concern about the continued use of current sheep dip products and to prompt debate about ways in which environmental impacts can be mitigated.

2. Background

Sheep are prone to attack by a number of pests such as scab, blowfly, ticks and lice which can be controlled through the use of chemical insecticides contained in products that are either poured on to the fleece of sheep ('pour ons'), injected directly ('injectibles') or in which the sheep are immersed ('dips'). Sheep dipping is the more widespread method of pest control, especially for scab, and it is common practice in early summer and autumn when the risk of infestation is greatest. Until recently, it was a legal requirement under the Sheep Scab Order (1997) to treat infected sheep.

Following treatment, residues of the chemical remain in the sheep's fleece and may be lost to the environment through dripping onto impermeable surfaces, dripping from treated fleeces, loss of wool, product misuse, sheep walking through watercourses, and in processing of fleeces. A further potential source arises from the disposal of spent sheep dip. Disposal to land is the normal method but requires Environment Agency authorisation under the 1998 Groundwater Regulations.

The relative importances of the different sources illustrated in Figure 1 are not well understood but it is reasonable to conclude that industrial sources (fleece processing) are a more important cause of EQS exceedances in Northern England whilst dipping-related sources are more important in upland Wales and other areas of sheep farming (details provided later).

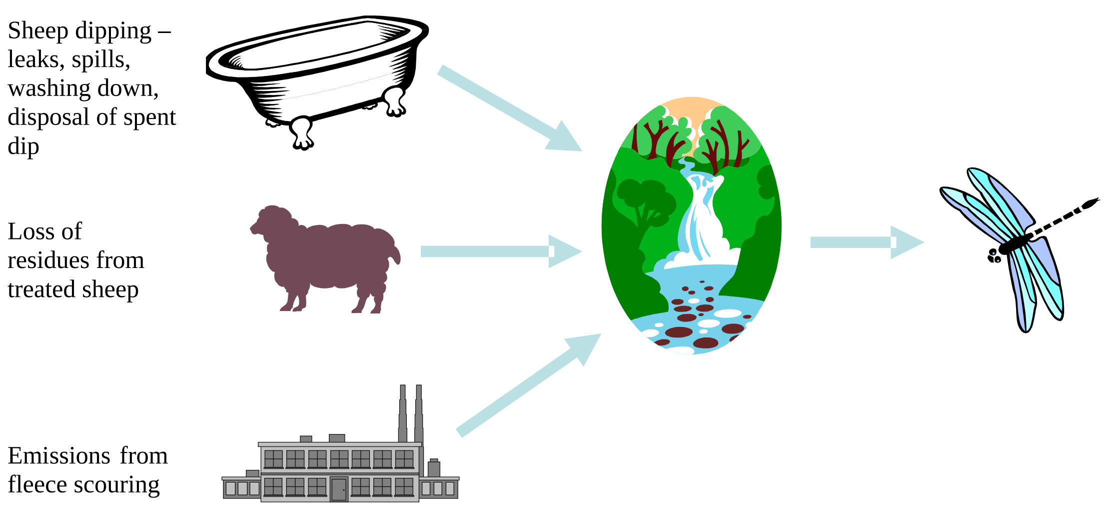

Figure 1 Possible sources of sheep dip and pathways to the aquatic environment

3. The chemicals used

In the UK, sheep dip products must be approved for use by the Veterinary Medicines Directorate (VMD). These products are effective by virtue of the insecticides they contain, the organophosphate (OP) diazinon and the synthetic pyrethroid (SP) cypermethrin.

In recent years, products based on the synthetic pyrethroids have assumed greater importance because (a) these active ingredients are less toxic to operators and by-standers who may come into accidental contact with the product, and (b) there is no longer a legal requirement to treat for scab, a condition that is more effectively controlled by OP insecticides. The synthetic pyrethroids are less persistent in the environment than many of the organophosphate and carabamate insecticides but, as we explain later, are highly toxic at low concentrations to many aquatic fauna.

The environmental fate of these insecticides is determined by their physico-chemical properties. Diazinon is more water soluble and, by virtue of its lower octanol:water partition coefficient, is less likely to bioaccumulate or to sorb to biota and sediments. Indeed, cypermethrin is rapidly lost from the water column by a process of sorption in this way. Both substances are liable to biotic and abiotic degradation in the environment with typical half-lives in water of a few weeks. Whereas cypermethrin is stable under acidic conditions, diazinon hydrolysis is increased under both acidic and alkaline conditions compared to that at neutral pH. Analysis of cypermethrin is complicated by the existence of three asymmetric carbon atoms in the molecule giving rise to 2 x 2 x 2 = 8 different isomers, four adopting a trans conformation and four a cis conformation. Routine analysis of cypermethrin underestimates the true concentration present in a sample because the reference standard used is a mixture of cis isomers that can fail to quantify the trans isomers present.

Table 1 summarises the products currently available and the active ingredients they contain and Table 2 summarises trends in the use of OP and SP sheep dips, based on total UK sales.

Table 1 Sheep Dip products used in the UK

Product	Active ingredient
Coopers Ectoforce	Diazinon
Osmonds Gold Fleece	Diazinon
Paracide Plus	Diazinon
Auriplak Fly and Scab	High-cis Cypermethrin
Ecofleece	High-cis Cypermethrin
Robust	High-cis Cypermethrin

Table 2 Sales (tonnes p.a.) of sheep dip products 2000-2004 (VPC Annual Report 2004 – Appraisal Panel for Human Suspected Adverse Reactions to Veterinary Medicines)

Year	2000	2001	2002	2003	2004
OP[1]	10	48	13	54	20.5
Non-OP[2]	9	1.7	4.5	8	5.5

Clearly, annual sales of sheep dips fluctuate markedly. The drop in sales of non-OP dips in 2001 coincided with the return to the market of OP dips, whilst a general decrease in sales of both OP and non-OP dips in 2004 may be linked to a shift toward the use of pour-ons and injectables rather than dips.

4. Risk reduction

Codes of practice have been developed for the use and disposal of sheep dip in response to continuing concerns about the number of pollution incidents arising from the use of sheep dip chemicals (MAFF Code of Good Agricultural Practice for the Protection of Water (1998) and Defra Groundwater protection Code: use and Disposal of Sheep dip Compounds (2001)). In 2001 the Environment Agency published 'Best Practice Guidelines for the Management of Sheep Flocks' (Environment Agency, 2001, R&D Technical Report P396). This was followed by the production of a risk

[1] From 2001-4, OP refers to diazinon only but in earlier years also includes propetamphos
[2] Non-OP refers mostly to cypermethrin. The only other SP approved for use in sheep dip (flumethrin) was withdrawn in 2003

assessment strategy for sheep farmers so that unnecessary chemical usage could be minimised ('Flock Management and Ectoparasite Control in sheep: development of an Ectoparasite Risk assessment Strategy for Sheep Farmers' Environment Agency, 2003, R&D Technical Report P2-167/TR). The strategy helps farmers identify the risk factors associated with scab and lice infestation, and to select products and treatment periods that would be most effective under different circumstances.

Further research has focussed on the fate and redistribution of spent sheep dip following disposal. Measures to promote degradation of spent pyrethroid-based products (mixing with lime to raise pH, thereby promoting hydrolysis) have been identified but a survey of farms ('Characterisation and Field Evaluation of Sheep Dip Chemical Disposal: Phase 1', Environment Agency, 2004, R&D Technical Report P2-250/TR) showed that, even with approved methods of disposal, there was clearly potential for migration of sheep dip chemicals into groundwater by leaching or run-off to surface waters.

Despite these measures, pollution from sheep dip continues to pose a serious problem in UK watercourses. In the following Sections, we summarise the available evidence for adverse effects of cypermethrin and diazinon.

5. Evidence of environmental impacts

Evidence for potential and actual impacts of the two main active ingredients used in Sheep Dip, cypermethrin and diazinon, is available from a variety of sources:

a) Ecotoxicity studies
b) Environmental Quality Standards
c) Environment Agency Pesticide Monitoring
d) Pollution Incident Reports (NIRS)
e) Operational Investigations

a) Ecotoxicity studies

A substantial body of experimental ecotoxicity data is available for both diazinon and cypermethrin. Most of the data have been generated under laboratory conditions and are based on observations made after 24 -96 hours. Such exposure periods are relevant to incidents resulting in exposure for short periods, such as might occur in a spillage. The toxicity data from these experiments are usually expressed as LC50 values (the concentration killing 50% of a test population). Some chronic (long-term) studies are also available, in which toxicity is more usually expressed as the highest test concentration at which no adverse effect could be seen (the 'no-effect concentration', NOEC).

Diazinon

Like other OP insecticides, diazinon acts by inhibiting the enzyme acetyl cholinesterase which is involved in the transfer of nerve impulses. When inhibited, the neurotransmitter acetylcholine is no longer broken down and a continuous, uncontrolled firing of nerve impulses results.

Diazinon exhibits high acute toxicity to invertebrates, with acute LC50 values between 0.2 and 800 μgl-1. Among the most sensitive species are the crustaceans of the genus *Gammarus* and water fleas e.g. *Daphnia* spp. Insect larvae are also highly sensitive with acute toxicities at only slightly higher concentrations (e.g. 48h LC50 to the mayfly, *Cloeon dipte*rum of 7.8 μg/l). Chronic no-effect concentrations below 1 μg/l are also reported.

Fish, planarians, molluscs and annelids are less sensitive but a 96h LC50 to rainbow trout of 90 μg/l is reported and lower LC50 values are reported for some warm water fish species such as bluegill sunfish (*Lepomis macrochirus*).

Studies on freshwater communities carried out under simulated field conditions confirm the high sensitivity of insect larvae and crustaceans with an estimated population-level NOEC for chironomids and cladocerans of <2.4 μg/l (Giddings et al, 1996, Environmental Toxicology and Chemistry, 15, 618-629) and significant drift of *Hyalella* even at concentrations of 0.3 μg/l (Arthur et al, 1983, Aquatic Toxicology, 4, 283-301).

Cypermethrin

Cypermethrin acts by altering ion permeability of nerve membranes, causing trains of nerve impulses that ultimately immobilise sensitive organisms. It has also been shown to inhibit ATPase enzymes involved in movement of ions against a concentration gradient; this action is critical to fish and aquatic insects because these processes are used to regulate oxygen exchange (Siegried, 1993, Environmental Toxicology and Chemistry, 12, 1683-1689).

Fish and invertebrates are particularly sensitive and a substantial body of experimental evidence has been gathered to quantify its toxicity. Much of these data refer to 'target' species such as midge and mosquito larvae but data for 'non-target' species have also been generated. Acute LC50 values for most crustaceans and insects lie in a range between 0.03 and 5 μgl-1. However, some species are much more sensitive, including some commonly encountered freshwater invertebrates (Table 3). On a simple concentration basis, cypermethrin is more toxic to aquatic invertebrates than diazinon.

Table 3 Acute toxicity of cypermethrin to some indigenous freshwater invertebrate species

Species	**Exposure duration (h)**	**LC_{50} (μgl-1)**
Freshwater shrimp, *Gammarus pulex*	96	0.009
Mayfly, *Cloeon dipterum*	96	0.02
Mayfly, *Baetis rhodani*	96	0.012
Water hog louse, *Asellus aquaticus*	24	0.2
Water boatman, *Corixa punctata*	96	5.0
Water flea, *Daphnia magna*	24	2.0
Whirligig beetle, *Gyrinus gyrator*	24	>5.0 (unable to swim and dive when exposed to 0.07 μgl-1)

In a comprehensive analysis of pyrethroid toxicity data, Solomon et al (2001, Environmental Toxicology and Chemistry, 20, 652-659) estimated that a cypermethrin concentration of 0.006 μgl-1 represented the lower 10th percentile of the distribution of arthropod sensitivities. In other words, at this concentration, we would expect to see significant mortalities in no more than 10% of the species present. Broadly similar conclusions were drawn by Friberg-Jensen et al (2003a and b, Aquatic Toxicology, 63, 357-371 and 373-389) from experiments on freshwater communities under field conditions, in which they showed that, over a period of 11 days, the no-effect concentration for sensitive taxa was 0.01 ugl-1.

Finally, much of the cypermethrin entering a watercourse will quickly sorb to bed and suspended sediments. Recent studies show that such residues are bioavailable, causing toxicity to benthic species at concentrations that can be explained by uptake from the sediment pore water (Maund et al, 2002, Environmental Toxicology and Chemistry, 21, 9-15). The significance of this observation is that sorption to bed sediments does not necessarily render residues of cypermethrin unavailable to exert biological impacts.

Other taxa, such as molluscs, algae, amphibians and fish are less sensitive to cypermethrin, as shown by the appreciably higher LC50 values for these taxonomic groups, although acute LC50 values as low as 0.5 μgl-1 are reported for some fish species (particularly salmonids).

Effects of cypermethrin and diazinon on the Atlantic salmon

A research programme undertaken by CEFAS between 1990-2002 has highlighted sublethal effects of sheep dip chemicals on salmonids at concentrations close to the EQS concentrations.

Moore and his co-workers (Moore and Waring, 1995, Journal of Fish Biology, 48, 758-775; Moore and Waring, 2001, Aquatic Toxicology, 52, 1-12) found that both diazinon and cypermethrin affected the olfactory system of the salmon, reducing the ability of the male fish to detect and respond to the female priming pheromone. This is important because it plays a key role in synchronising reproductive physiology and behaviour. In laboratory experiments, the olfactory system of the male fish was significantly affected by exposure to 0.4 µgl-1 diazinon and <0.004 µgl-1 cypermethrin. This resulted in a significant reduction in the sperm produced by the spawning male salmon exposed to cypermethrin. Moreover, endocrine responses of the male to the female priming pheromone was reduced after exposure to 0.06 µgl-1 diazinon. These concentrations are within the range measured in surface waters and are close to the EQS values for these substances (see later).

Other effects on salmon reproduction were also seen, but at higher concentrations. These included effects on sperm motility, egg development and survival of the embryos. Sub-lethal effects on the surviving embryos (increased steroid and cortisol levels, decreased levels of thyroid hormones) were also evident following exposure to 5-10 µgl-1 diazinon. These effects are summarised in Table 4; they are significant because they point to possible impacts on reproduction at levels of diazinon and cypermethrin that can occur in the environment.

Table 4 Sublethal effects of sheep dip insecticides on Atlantic salmon, in relation to concentrations detected in surface waters. (Potter & Dare Science Series Technical Report 119, CEFAS 2003)

Endpoint	Diazinon (µgl-1)	Cypermethrin (µgl-1)
Threshold levels for harmful effects		
Olfactory disruption (males)	0.4	>0.001
Endocrine response (males)	0.06	-
Sperm reduction/mortality	-	>0.001-0.5
Embryo mortality/impairment	5-10	0.03
Environmental levels		
Max levels measured (EA Pesticide Monitoring Report, 2003)	0.1-5.2	0.002- 0.027
Max levels recorded in salmon rivers (CEFAS)	18.5-35	0.85

b) Environmental Quality Standards

Environmental Quality Standards (EQSs) for diazinon and cypermethrin have been developed (Environment Agency (2002) Proposed Environmental Quality Standards for cypermethrin and flumethrin in water. R&D Technical report P2-115/TR5). These are threshold concentrations derived from existing ecotoxicity data to which a safety factor has been applied, and below which no adverse effects are expected to occur.

They are not statutory standards but were developed for operational purposes, as benchmarks for water quality monitoring and for permitting discharges.

The EQSs are expressed as a Maximum Allowable Concentration (MAC) and a lower Annual Average (AA) concentration (Table 5). While the former is based on acute toxicity data, the latter uses chronic data, the lower value for the AA reflecting the greater toxicity following prolonged exposure to these insecticides. Both are used in the assessment of compliance with EQSs (see following Section) but whereas compliance with the MAC may be based on a single sample, compliance assessment against the AA requires several samples to be taken over a 12-month period.

Table 5 Operational EQSs for cypermethrin and diazinon

	Annual Average (μgl-1)	**Maximum Allowable Concentration (μgl-1)**
Diazinon	0.03	0.1
Cypermethrin	0.0002	0.002

c) Pesticide Monitoring Surveys

Pesticide Monitoring Report 2003 (EQS failures)

About one third of all EQS failures in freshwaters monitored in 2003 were caused by sheep dip chemicals. There are two main sources: sheep-dipping, especially in Wales and the north of England, and discharges from the wool processing industries centred on Yorkshire. In 2003, 44 sites failed EQS standards for cypermethrin and diazinon in England and Wales, compared with 50 sites in 2002, 39 sites in 2001 and 70 sites in 2000 (Table 6).

Although there appears to be a decline in the incidence of EQS exceedances since 2000, changes in sampling locations and the number of samples collected in a year (particularly to assess compliance with the AA) may mask underlying changes in occurrence. Interpretation is further complicated by improvements in analytical sensitivity for diazinon, so that samples previously declared to be free of diazinon might be shown to contain the insecticide. Furthermore, in routine analysis, only cis-isomers of cypermethrin are available in a sufficiently pure form to be used as a reference substance. This has an important consequence when reporting measured concentrations of cypermethrin. Instead of reporting the sum of all the peaks (including both cis and trans isomers), the contribution made by the trans isomers is effectively lost because only the cis isomers can be quantified. As a result, the reported concentrations systematically underestimate the actual concentration of cypermethrin present, by approximately 25-50%.

Despite these uncertainties, it is clear that routine monitoring shows that both cypermethrin and diazinon can occur in surface waters at concentrations that may pose a risk to aquatic biota.

Table 6 EQS failures for diazinon and cypermethrin in 2003 (EA Pesticide Database 2003)

Chemical	Region	EQS exceedances (number of sites)	Concentrations (ngl-1)
Diazinon		*AA*	
	Midlands	2	74.4 - 95.2
	NorthEast	9	32.2 – 98.5
	Wales	2	56.3 – 877.8
		*MA*C	
	Midlands	3	159 - 818
	NorthEast	16 failures from 9 sites	110 - 341
	NorthWest	2	106 – 295
	Wales	4	104 - 5244
Cypermethrin		*AA*	
	NorthEast	1	1.7
	Southern	6	0.2 – 0.7
	Wales	6	0.2 – 6.8
		MAC	
	NorthEast	1	20
	Southern	7	2.4 – 8.3
	Wales	7	2 -27

d) Pollution Incidents

Details of pollution incidents due to sheep dip chemicals are reported by various agencies, including the EA, SEPA, and WIIS, to the Ecopharmacovigilance group headed by the Veterinary Medicines Directorate (VMD). Numbers of confirmed incidents are subsequently described in VPC SARSS reports and in the VPC Annual Report.

The VPC Annual Report for 2004 (Table 7) appears to show no particular trend in the number of environmental incidents due to sheep dip insecticides (aquatic pollution) in Scotland, England and Wales. However, the number of incidents is almost certainly underestimated. For example, some incidents occurring in 2003 and 2004 have yet to be reported formally to VMD. Indeed, Agency records show 7 incidents (categories 2-3) in 2002, 12 in 2003 and a possible 43 incidents in 2004. This increase reflects in large part a growing awareness of problems and consequent monitoring activity, particularly in Wales. In 2004, Southwest (Wales) Region alone reported 32 incidents involving cypermethrin, including 12 category 1 incidents. In the same year, 42 incidents were reported in Wales, impacting 29 catchments and prompting 47 field investigations.

Throughout Wales, case files relating to pollution incidents that could be attributed to sheep dipping at particular farms have been assembled. In South-West Wales alone, 16 such case files are currently being prepared.

Table 7 Summary of environmental incidents 2000-2004 (Source: VPC Annual Report 2004)

Year	Aquatic incidents due to dip occurring in	
	England and Wales	Scotland
2000	8	17
2001	5	8
2002	12	4
2003	7	3
2004	to be reported	0

e) Operational Investigations

Reflecting concern about the occurrence and impacts of sheep dip in watercourses, a number of operational investigations have been mounted in Welsh Region in recent years. These have focussed on:

- emissions from sewage treatment works (STWs) receiving inputs from livestock markets or fellmongers/pelt processors and, more recently,
- investigations of watercourses in rural areas

Sewage treatment works

In 1997 and 1998, surveys of the discharges from 12 STWs found detectable concentrations of sheep dip chemicals in 11 of them. In the following year the study was extended to 28 STWs (Welsh Sheep Dip Monitoring Programme: Sewage Treatment Works Report, 1999-2000). Sheep dip chemicals (diazinon, propetamphos and cypermethrin) were found in the final effluent from all but one ‘control’ works (a works that did not receive any fleece-related inputs). Although MAC exceedances in the final effluent were commonplace, none were found in the receiving waters downstream of the STW outfall. Nevertheless, detectable residues were again found in the watercourse downstream of the STW outfall at 12 sites.

Watercourse investigations

Chemical monitoring was extended in 2000 in a joint programme between the Environment Agency Wales and Midlands Regions (Welsh Sheep Dip Monitoring Programme, 2000 and 2001). Monthly sampling at 50 sites in 2000 revealed detectable residues of OP and pyrethroid insecticides in 86% of sites, rising to 92% of sites in 2001. EQS (MAC) exceedances were frequent and most of these were attributed to cypermethrin (28% of EQS exceedances in 2000 and 20% in 2001). Improvements in the analytical limit of detection for diazinon around this time led to MAC exceedances that might previously have gone unnoticed. In contrast, a relaxation of the MAC for cypermethrin (from 0.001 to 0.002 ugl-1) meant that samples, which previously would have failed the MAC for cypermethrin, were now reported as non-exceedances.

Biological surveys in the same region (although separated from the chemical sampling programme) indicated reduced biodiversities on some sub-catchments of the Severn and Wye (a total 60km of watercourse). Whilst some could be traced back to contamination by sheep dip, conclusive evidence linking these impacts to sheep dip chemicals was lacking.

Between 2002 and 2003, Rutt (2004, Environment Agency Technical Memo TMW04_10) carried out an extensive survey of invertebrate biology and the occurrence of sheep dip chemicals in the Teifi catchment, South-West Wales, with a clearer attempt to assess the link between these chemicals and changes in biological quality. The survey was prompted by reports of reduced abundance in fly life in the upper Teifi that could be linked with a decline in invertebrate fauna over several decades, but especially since the early 1980s (Thomas, 2002). Subsequent surveys by Operations staff in 2001 and 2002 confirmed impacts to the invertebrate fauna in at least 30km of the upper Teifi catchment.

Rutt was able to exclude acidification, metal, nutrient and organic pollution as possible causes of this decline in invertebrate abundance. However, several strands of evidence pointed toward a link between the observed declines in invertebrate abundance and diversity and the presence of sheep dip chemicals. These were:

- Changes in species abundance that are characteristic of pyrethroid exposure, notably declines in certain species of mayfly (*Centroptilum* spp., *Procloeon bifidum*, and several *Baetis* spp.) and the stonefly (*Taenipterix neb*ulosa). In contrast, other caddisfly families and some water bugs (Hemiptera) appeared to be relatively unaffected by the presence of pyrethroids.

- Occasional presence in water samples of cypermethrin at concentrations in excess of those causing toxicity in laboratory tests.

- Presence of cypermethrin residues in sediment samples from the impacted area.

- Investigations at specific locations invariably revealed a link with some aspect of sheep treatment (eight such incidents were reported on NIRS in 2003).

- Evidence of poor practice (sheep treatment and flock management) from a farm visits campaign.

In the uplands of Wales in particular, the only plausible source of pyrethroids is sheep dip chemicals. Although the cis: trans ratio found in sediments or biota is sometimes indicative of arable cypermethrin (characterised by a ratio of cis:trans isomers of approximately 60%:40% instead of the 80%:20% cis:trans isomer ratio of approved sheep dip products), this simply reflects the illegal use of the (cheaper) arable formulation of cypermethrin for treating sheep.

Indirect impacts on populations of brown trout as a result of declining prey species have been suggested but are difficult to verify. Rutt (2004) suggests that low food abundance might encourage a more migratory life strategy rather than a predominantly residential one, with consequent falls in catch numbers of adult brown trout.

Although diazinon was encountered in water samples more frequently (9/15 locations) than cypermethrin (5/15 locations), this probably reflects the marked difference in water solubility and partitioning behaviour of the two pesticides. The higher log Kow of cypermethrin will favour sorption to biota and sediments, at the expense of residues in the water column, to a greater extent than for the more polar diazinon.

Finally, Rutt was able to confirm that sheep dip chemicals do not occur only in the Teifi catchment. Routine water chemistry sampling in other catchments in South Wales revealed residues of cypermethrin in water and also in samples of aquatic moss. Sampling of mosses is now practiced widely to monitor for the presence of cypermethrin in particular. This is because its low water solubility and high log Kow mean that any residues are more likely to be associated with biota, such as aquatic moss, especially when organic-rich sediments are sparse, than with the water column. Measured residues of cypermethrin in moss tissue effectively integrate the occurrence of cypermethrin in the stream over time; it is not possible to say whether the residues found in the moss have arisen due to a short exposure to a high concentration of cypermethrin, or to exposure to lower concentrations over a longer period of time.

Investigations in North Wales in 2004 have revealed a similar pattern of contamination by diazinon and cypermethrin. Routine water monitoring (Clay, pers. comm.) detected both chemicals at 15/16 sites on eleven catchments; the MAC for diazinon was exceeded on two occasions and the cypermethrin MAC on seven occasions. Biological investigations at some of these sites also revealed impacts on invertebrate communities with declines in abundance and species diversity that were regarded as indicative of sheep dip pollution.

Finally, it is also significant to note that, in Wales, contamination by sheep dip chemicals has been identified as the major risk to attaining good ecological status under the Water Framework Directive in 2010.

6. Conclusions

We have summarised evidence describing serious biological impacts in upland waters, particularly in Wales, that can be attributed to contamination by sheep dip chemicals. There are now several lines of evidence from laboratory and filed studies that clearly show the high potential for contamination and subsequent adverse effects on freshwater organisms, and that this is being translated into widespread impacts in the field. The Agency’s view is that this situation is not sustainable and measures are necessary to eliminate risks to aquatic life.

The Salmon and Freshwater Fisheries Review recommendations relating to sheep dip issues

Recommendation 140. The Government and the Environment Agency should continue to fund research into the effects of pesticides and veterinary medicines on fish and invertebrates, including the sub lethal effects. The results of this research should be made known to the bodies responsible for licensing these substances and should be taken into account by those bodies in deciding upon and reviewing approvals and conditions of use.

***Progress**: There is an on-going programme of research in this area funded by Defra and the Environment Agency. CEFAS have undertaken research into sub lethal effects of diazinon and cypermethrin on migratory salmonids. Tech Report 119 Research on migratory salmonids, eels and freshwater fish stocks and fisheries p29-34.*

Recommendation 141. Research should be carried out into the natural recovery of, in particular, upland streams after pollution events and on the best way to enhance this recovery.

***Progress:** There is an on-going project on the aquatic impacts of pesticides that will help address this. There are plans for further sheep dip research into aquatic exposure, effects and recovery.*

Recommendation 143. The Environment Agency's programme of sheep-dipping site inspections and guidance in best practice should be pursued with continued vigour, focussing particularly on upland sheep-farming areas where base-poor soils provide little or no natural buffering.

***Progress:** The Agency continues its programme of sheep dipping site inspections. We are using a risk-based approach and information from monitoring work to prioritise which sites are visited.*

Recommendation 145. The Environment Agency should make use of its powers to place closure orders on leaking or inappropriately sited sheep dipping installations.

***Progress:** We are not aware of having issued closure orders, but many would have received a site visit and an agreed programme of work to minimise risk of pollution.*