

Clinical Use of Dichlorvos (Nuvan®) and Trichlorfon (Neguvon®) in the Treatment of Salmon Louse, *Lepeophtheirus salmonis*. Compliance with the Recommended Treatment Procedures

By K. Grave, M. Engelstad, N. E. Søli and E.-L. Toverud

Department of Pharmacology and Toxicology, Norwegian College of Veterinary Medicine/National Veterinary Institute, Oslo, Ewos A/S, Skårer, and Department of Therapeutics, University of Oslo, Norway.

Grave, K., M. Engelstad, N. E. Søli and E.-L. Toverud: The clinical use of dichlorvos (Nuvan®) and trichlorfon (Neguvon®) in the treatment of salmon louse, *Lepeophtheirus salmonis*. Compliance with the recommended treatment procedures. Acta vet. scand. 1991, 32, 9-14. – Veterinarians representing one third of the Norwegian fish farms were asked about the clinical use of dichlorvos and trichlorfon by use of a questionnaire. A total of 45 veterinarians had experience in treatment of salmon lice with these organophosphates. Forty-nine percent of the veterinarians reported that the fish farmers in their region solely used the recommended treatment equipment when delousing the fish, of these ¼ always oxygenated the treatment solution. Repeated treatment were always prescribed by 24% of the veterinarians, while 44% did this occasionally. Of the 45 veterinarians 7% were often present and 44% were occasionally present at the fish farms in connection with the treatment. The answers showed that compliance with the recommended treatment procedures was unsatisfactory.

clinical evaluation; information sources; supervision; repeated treatment; recommended treatment equipment; oxygenation.

Introduction

Infestations with the salmon louse (*Lepeophtheirus salmonis*) have become a major ectoparasitic problem in the farming of Atlantic salmon (*Salmo salar*) and rainbow trout (*Oncorhynchus mykiss*) in Norway. Sales figures of dichlorvos (Nuvan® 500 mg/ml emulsion) and trichlorfon (Neguvon® 97% powder) indicate a dramatic increase in the salmon lice problem (Grave *et al.*, 1991). The main objective of the present study was to obtain information about the clinical use of dichlorvos and trichlorfon with special emphasis on the compliance with the recommended treatment procedures.

Materials and methods

A questionnaire was designed and tested through a pilot project involving 10 veterinarians working in fish farming practice. The questionnaire was then sent to all the veterinarians (220) working in 3 of the most important fish farming counties in Norway: Hordaland, Møre and Romsdal, and Nordland. These counties represented on average 33% (258) of the licenced fish farms in Norway (Fosheim and Parman 1989). The questionnaires were mailed in May 1988, and after 2 months the veterinarians that had not returned the questionnaire, were contacted by telephone and interviewed.

General questions about the veterinarian's job in the fish farming industry and year of education were included in the questionnaire. Furthermore, the questionnaire requested information on clinical manifestations of salmon lice infestations when drug treatment was initiated, treatment procedures recommended, the veterinarians' supervision in the delousing process, changes in the treatment procedure, and adverse drug reactions caused by dichlorvos and/or trichlorfon.

Results

All the 55 (25%) veterinarians that were professionally engaged in fish health gave written answers. Three of the fish veterinarians were employed by the fish farmers, the others (52) were hired as District Veterinary Officers (DVO), by the local district council or in private practice. Of the 55 fish veterinarians, 46 had experience from treatment of salmon lice.

At the time of answering the questionnaires 71.7% (33) prescribed dichlorvos, 23.9% (11) prescribed trichlorfon, and 2.2% (1) prescribed both drugs. On average, 63.0% (29) had previously prescribed trichlorfon. One (2.2%) of the veterinarians prescribed treatment in fresh water.

Of those veterinarians (36) that prescribed dichlorvos either at the time of answering

the questionnaire (34) or earlier (2), 41.7% (15) changed to dichlorvos during 1986, 47.2% (17) during 1987, and 2.8% (1) in the summer 1988. Three (8.3%) of the veterinarians did not answer that question. The veterinarians had obtained the information about the »new« drug dichlorvos from 1 or more sources. Colleagues were the most important source for 24 of the veterinarians, 10 received the information from the fish farmers, 6 from the literature, 2 from the drug company marketing the drug, and 8 from public institutions, of which the Norwegian College of Veterinary Medicine was the most important.

The veterinarians' criteria for prescribing treatment with dichlorvos or trichlorfon are shown in Table 1.

The type of equipment used when delousing with dichlorvos or trichlorfon is shown in Table 2.

The frequency of controlling the oxygen concentration in the water when delousing with dichlorvos or trichlorfon using a treatment unit as the equipment, is shown in Table 3.

Repeated treatment against salmon lice was recommended by 24.4% (11) of the 45 veterinarians, 44.4% (20) did this occasionally, 17.8% (8) never recommended repeated treatment, and 13.3% (6) did not answer that question. As many as 73.3% (33) of the

Table 1. Clinical evaluation of salmon lice infestations before prescribing treatment with dichlorvos or trichlorfon. The figures represent 45 veterinarians.

Clinical Evaluation	No of veterinarians
No wounds, lice present	14 (31.1%)
Surface wounds	11 (24.4%)
No wounds/lice present or surface wounds	9 (20.0%)
Deep wounds	3 (6.7%)
Combination of criteria	4 (8.9%)
No answer	4 (8.9%)
Total	45 (100 %)

Table 2. Type of equipment used when delousing with dichlorvos and trichlorfon. The figures represent 45 veterinary regions.

Type of equipment	Practice regions
1) Treatment unit	22 (48.8%)
2) Plastic skirt	8 (17.8%)
3) Open net-pen	2 (4.4%)
4) Either 1, 2 or 3	7 (15.6%)
5) No answer	6 (13.3%)
Total	45 (100 %)

veterinarians were informed about the need of repeated treatment. The veterinarians obtained information about the need for repeated treatment from one or more sources. Colleagues represented the most important source for 20 of the veterinarians. Eight of the veterinarians obtained the information from the literature, 4 from the fish farmers and 5 from public institutions, of which the Norwegian College of Veterinary Medicine was the most important. Only 1 of the veterinarians answered that this information was given by the drug company marketing the drug.

A total of 85.3% (29) of the veterinarians prescribed dichlorvos dosages that were in accordance with the sea water temperature, 2.9% (1) ignored the sea water temperature, and 11.8% (4) did not answer that question. The corresponding figures for the 12 veterinarians that prescribed trichlorfon at the time of answering the questionnaire were 75.0% (9), 16.7% (2), and 16.7% (2), re-

spectively. For the 29 veterinarians that had prescribed trichlorfon earlier these figures were 75.8% (22), 13.7% (4), and 6.9% (2), respectively.

Of the 45 veterinarians prescribing dichlorvos or trichlorfon only 6.7% (3) were often present at the fish farms when the delousing process took place, 44.4% (20) were present occasionally, 48.7% (21) were never present, and 2.2% (1) did not answer that question. Of the 34 veterinarians that prescribed dichlorvos, 8.8% (3) had experienced poisoning of the fish during the treatment. The corresponding figure for trichlorfon was 9.8% (4 of 41). Answers given about the number of incidents, and dosage and treatment procedure used in connection with the incidents were, unfortunately, incomplete.

Discussion

Trichlorfon (Neguvon® 97% powder) was approved for fish in 1980 and included in the Norwegian Compendium of Veterinary Me-

Table 3. Oxygenation of the treatment solution when delousing with dichlorvos or trichlorfon using a treatment unit.

Answer	Dichlorvos	Trichlorfon
Yes	6 (31.6%)	5 (22.7%)
No	7 (36.8%)	11 (50.0%)
Yes/No	2 (10.5%)	2 (9.1%)
No answer	4 (21.1%)	4 (18.2%)
Total	19 (100 %)	22 (100 %)

dicine (Tørisen 1980) that year. Dichlorvos (Nuvan® 500 mg/ml emulsion) was introduced for fish in Norway in 1986, but it was not approved and included in the Compendium until the spring of 1988. This investigation shows that most of the veterinarians started to prescribe dichlorvos before the drug was approved for free prescription and before a drug monograph was included in the Norwegian Compendium of Veterinary Medicines (Tørisen 1988). Information about the clinical use of dichlorvos was, however, published in the Norwegian Veterinary Journal by Horsberg et al. (1986 and 1987).

For trichlorfon the Compendium recommends a treatment procedure based upon the method developed by Brandal & Egidius (1979). A corresponding method is recommended for dichlorvos (Horsberg et al. 1987, Tørisen 1988). The recommended treatment procedure involves transportation of the fish into a treatment unit. Only 48.9% of the veterinarians reported that the fish farmers in their practice region solely used the recommended treatment unit.

When the drug concentrate is added to an open net-pen or to a net-pen surrounded by a plastic skirt, it is only possible to use the treatment solution once. Additionally, it cannot be transported away for dumping after inactivation. These treatment methods both increase the amount of dichlorvos and trichlorfon used in salmonid farming and increase the pollution of the marine environment with these drugs.

According to Wotten et al. (1982) the largest numbers of *L. salmonis* occur in the late summer and autumn when the temperature is normally in the range of 9-14° C. These results are in agreement with the results of Grave et al. (1991) who found the highest use of dichlorvos and trichlorfon in July-November. Thus the main use of these drugs takes place when the metabolic activity and

oxygen demand in salmonids are relatively high. If a treatment unit is used when delousing the fish, the oxygen dissolved in the sea water inside the tarpaulin bag will be gradually consumed. There are indications that a low oxygen level increase the toxicity of dichlorvos in salmonids (Høy & Horsberg, unpublished data). Moreover, trichlorfon is transformed into the much more potent organophosphorous compound dichlorvos in sea water, a reaction that is accelerated by increasing temperature (Ecobichon 1979, Samuelsen 1987). The uptake of xenobiotics is also enhanced by increased sea water temperature (Murty 1986). Oxygenation of the treatment solution throughout the treatment procedure is therefore recommended (Brandal & Egidius 1979, Tørisen 1980, 1982, 1984, 1986 and 1988). The veterinarians in this study reported that a large proportion of the fish farmers did not oxygenate the treatment solution. This increases the probability of the fish being intoxicated with dichlorvos or trichlorfon.

The life-cycle of *L. salmonis* involves 10 stages, of which the 4th-10th are all parasitic on the fish host. Dichlorvos and trichlorfon are effective against the 3 last stages, the so called post-chalimus stages of *L. salmonis* (Wotton et al. 1982, Wotton 1985). The pre-chalimus and free-living stages of the parasite are not affected by treatment with dichlorvos or trichlorfon. Newly hatched larvae that are able to invade a host within 3 days (Johannessen 1975) will, together with the pre-chalimus stages of the parasite grow to maturity on the fish host in 3-4 weeks, dependent on the sea water temperature. A second treatment is therefore necessary after 3-4 weeks (Brandal & Egidius 1979, Wotten et al. 1982).

Information on the need for repeated treatment when delousing with dichlorvos has been published by Horsberg et al. (1987) and

in the Norwegian Compendium of Veterinary Medicines (*Tørisen* 1988). This information is lacking for trichlorfon. The need for repeated treatment is, however, emphasized in the pamphlet accompanying the trichlorfon preparation (Neguvon®, 97% powder) and in the publication by *Brandal & Egidius* (1979). Although most of the veterinarians were informed about the need of repeated treatment, only 24.4% prescribed this.

The dosage regimen for trichlorfon was changed in 1987 (*Anon* 1987) due to heavy mortalities after trichlorfon treatment (*Røttereng et al.* 1986, *Salte et al.* 1987, *Horsberg et al.* 1988). From that time the advice has been to regulate the dose in accordance with the sea water temperature, as for dichlorvos (*Horsberg et al.* 1987, *Tørisen* 1988). At least 75% of the veterinarians were aware of this change in the dose and were complying with it.

In the 6th-9th editions of the Norwegian Compendium of Veterinary Medicines, it was advised that delousing with trichlorfon had to take place under supervision of an expert in that field (*Tørisen* 1980, 1982, 1984 and 1986). In the 10th edition (*Tørisen* 1988) this has been changed to »under supervision of a veterinarian«. This information, however, is lacking in the monograph for dichlorvos (Nuvan® 500 mg/ml emulsion).

Only one half of the veterinarians had been supervising the clinical use of dichlorvos and trichlorfon, and thus had been in a position to advise the fish farmers about the practical use of the drugs and how to treat with optimal effect. In this study as many as 10% of the veterinarians reported that they had experienced intoxications with dichlorvos or trichlorfon. The importance of supervision in the use of dichlorvos and trichlorfon by the veterinarians is probably underestimated as an important tool to achieve optimal drug therapy.

According to *Wotton et al.* (1982), it is important to consider the proportion of salmon lice in the post-chalimus stages before starting to treat in order to reduce reinfections and thus reduce drug use. Most of the veterinarians only considered the clinical signs on the fish before starting drug treatment. Only 8.9% included a combination of criteria, namely the stage in the salmon lice life cycle and the season of the year, before starting drug treatment. The guidelines about when to start treatment (*Wotton et al.* 1982) are based upon experience from Scottish fish farming. The conditions in Norway are probably similar and thus the guidelines are applicable.

This investigation showed that compliance with the recommended treatment procedures for dichlorvos and trichlorfon was unsatisfactory. It is therefore necessary to inform veterinarians about the importance of complying with the recommended treatment procedures to improve the treatment results.

Acknowledgement

This work was supported by grants from the Norwegian Medicinal Depot and the Norwegian Agriculture Research Council. The authors thank the veterinarians participating in the investigation.

References

- Anonymous*: Nytt doseringsregime for Neguvon® ved behandling mot lakselus. (A new dosage regime for Neguvon® used in the delousing of salmon.). *Nor. Vet. Tidsskr.* 1987, 99, 598.
- Brandal PO, Egidius E*: Treatment of salmon lice (*Lepeophtheirus salmonis*, Krøyer, 1838) with Neguvon® - description of method and equipment. *Aquaculture* 1979, 18, 183-188.
- Fosshem E, Parmann G*: Norsk havbruk. Akvakultur (Norwegian Aquaculture). Georg Parmann Presseservice, I/S Norsk Havbruk. Nesoddhøgda, Norway, 1989, 223 pp.
- Grave K, Engestad M, Sæli NE*: Utilization of dichlorvos and trichlorfon in salmonid farming in Norway during 1981-1988. *Acta vet. scand.* 1991, 32, 000-000.

- Horsberg TE, Berge GN, Høy T:** Avlusning av fisk med et nytt ektoparasittmiddel (Delousing of fish with a new drug). *Nor. Vet. Tidsskr.* 1986, **98**, 333.
- Horsberg TE, Berge GN, Høy T, Djupvik HO, Hektoen H, Hogstad IM, Ringstad R:** Dichlorvos som avlusningsmiddel for fisk. Klinisk utprøving og toksisitetstesting. (Dichlorvos as a fish delousing agent. Clinical trial and toxicity testing). *Nor. Vet. Tidsskr.* 1987, **99**, 611-615.
- Horsberg TE, Høy T, Nafstad I:** Organophosphate poisoning of Atlantic salmon in connection with treatment against salmon lice. *Acta vet. scand.* 1989, **30**, 385-390.
- Johannessen A:** Lakselus, *Lepeophtheirus salmonis*, Krøyer (Copepoda, Caligidae). (Salmon lice, *Lepeophtheirus salmonis*, Krøyer). University of Bergen, 1975, 113 pp. (Thesis).
- Murty AS:** Toxicity of Pesticides to Fish. Vol. I. CRC Press, Florida, 1986, 178 pp.
- Røttereng PJ, Silset TO, Horsberg TE, Hektoen H:** Massedød av laks etter avlusning. (High mortality in salmon after delousing). *Nor. Vet. Tidsskr.* 1986, **98**, 885-887.
- Salte R, Syvertsen C, Kjønøy M, Fonnum F:** Fatal acetylcholin esterase inhibition in salmonids subjected to a routine organophosphate treatment. *Aquaculture* 1987, **61**, 173-179.
- Tørisen HM:** Felleskatalog over preparater i veterinærmedisinen 1980-1981 (The Norwegian Compendium of Veterinary Medicines 1980-81). 6th ed. I/S Farmainformasjon, Oslo 1980, 151 pp.
- Tørisen HM:** Felleskatalog over preparater i veterinærmedisinen 1982-1983 (The Norwegian Compendium of Veterinary Medicines 1982-1983). 7th ed. I/S Farmainformasjon, Oslo 1982, 117 pp.
- Tørisen HM:** Felleskatalog over preparater i veterinærmedisinen 1984-85 (The Norwegian Compendium of Veterinary Medicines 1984-86). 8th ed. I/S Farmainformasjon, Oslo 1984, 117 pp.
- Tørisen HM:** Felleskatalog over preparater i veterinærmedisinen 1986-87 (The Norwegian Compendium of Veterinary Medicines 1986-87). 9th ed. I/S Farmainformasjon, Oslo 1986, 118 pp.
- Tørisen HM:** Felleskatalog over preparater i veterinærmedisinen 1988-89 (The Norwegian Compendium of Veterinary Medicines 1988-89). 10th ed. I/S Farmainformasjon, Oslo 1988, 125 pp.
- Wotten R, Smith JW, Needham EA:** Aspects of the biology of the parasitic copepods *Lepeophtheirus salmonis* and *Caligus elongatus* on farmed salmonids, and their treatment. *Proc. R. Soc. Edinb. [Biol.]* 1982, **81 B**, 185-197.
- Wotten R:** Experience of sea lice infestations in Scottish salmon farms. International Council for the Exploration of the Sea 1985. Mariculture Committee, CM 1985/F: 7/Ref. M. 6 pp.

Sammendrag

Klinisk bruk av dichlorvos (Nuvan®) og trichlorfon (Neguvon®) ved avlusning av fisk. Etterlevelse av anbefalte behandlingsmetoder.

Målet med denne undersøkelsen var å samle informasjon om den kliniske bruken av dichlorvos (Nuvan®) og trichlorfon (Neguvon®), med spesiell vekt på etterlevelse av anbefalte behandlingsmetoder. En gruppe veterinærer som representerte ca. 1/3 av alle norske fiskeoppdrettsanlegg var med i undersøkelsen. Data ble samlet inn ved hjelp av et spørreskjema som veterinærene selv fylte ut. I alt hadde 45 av de veterinærene som deltok i undersøkelsen erfaringer med dichlorvos, trichlorfon eller begge disse legemidlene i behandlingen av lakselusangrep. Ca. 49% av veterinærene rapporterte at fiskeoppdretterne i deres praksisområde utelukkende brukte anbefalt behandlingspose ved avlusning av fisken. Av disse var det bare 1/4 som alltid oksygenerte behandlingsløsningen, slik anbefalt. Av de 45 veterinærene var det bare 24% som alltid forskrev gjentatt behandling mot lakselus, 54% forskrev dette av og til. Ca 7% av veterinærene var ofte til stede ved lakselusbehandlingen, 44% var til stede av og til. Resultatene fra denne spørreundersøkelsen viser at etterlevelsen av anbefalte behandlingsmetoder var utilfredsstillende.

(Received January 8, 1990; Accepted March 30, 1990).

Reprints may be requested from: K. Grave, Department of Pharmacology and Toxicology, Norwegian College of Veterinary Medicine, P. O. Box 8146, Dep. N-0033 Oslo 1, Norway.