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Indirect Effects of Esfenvalerate (Insecticide) on the Density of Periphytic Algae in Artificial Ponds

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Pesticides used in Danish agriculture might contaminate surface waters. One active substance is esfenvalerate that is allowed to be used against pests in crops (DEPA 1988). Little is known about indirect effects on organisms in natural ponds, and studies have been initiated at Roskilde University. The present paper describes effects of the formulated insecticide Sumialpha (active substance esfenvalerate) on the growth of periphytic diatoms colonizing object glasses placed above the sediment. A hypothesis might be that an indirect effect might occur when the grassers are reduced in number, as the algae increase their growth. Esfenvalerate is very toxic to fish and invertebrates with LC-50 in the range of 0.05 to 1 ppb. The toxicity to algae is not studied (DEPA 1988).

MATERIALS AND METHODS

In 1994 six ponds each of approximately 72 sq m surface and a depth of 0.6 - 0.7 m were dredged. Sediment was taken from a natural and not pesticide impacted pond, and the sediment was homogenized and implanted in the six artificial ponds. One pond serves as a reference and three ponds were sprayed with Sumialpha August 17, 1995. The ponds were sprayed as if they were farmland. The esfenvalerate concentrations were 1/16, 1/8 and 1/4 of the recommended use in agriculture. The nominal concentrations at total distribution in the water volume are respectively 35 ng/L, 77 ng/L and 132 ng/L. The oxygen concentration was measured by electrodes at the surface. Nitrate was measured by a nitrate-electrode. Phosphate was measured by a spectrophotometer-based method (DS 291, 1990). Silicon was measured by atomic absorption spectrophotometer (DS 2214 & DS 259, 1990).

Five object glasses in a frame were placed 1 cm above the sediment in each pond, and the periphytic algae invaded the object glasses. The object glasses were placed in the ponds July 27, 1995 at 12.00, and one of the object glasses is removed from each pond after 22, 29, 43 and 56 days respectively. The incubation time before spraying with esfenvalerate is 10 days. The number of periphytic algae were counted on four occasions in the following two months. For counting, one glass was collected from each pond and immediately taken to the laboratory. The

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bottoms of the glasses were cleaned, and two cover slips were placed on the object glass. An inverted microscope with a grid covering an area of 0.25 sq mm was used. The periphytic algae were identified by the Laboratory of Environmental Biology (Olrik 1995). The number of perifytic algal species or genus Epithemia turgida, Navicula sp., Pinnularia sp., Synedra acus and Nitzschia palea was counted in 6-14 areas selected by a stratified random method and divided between the two cover slips. In total 162 counts of each alga were made. The algae within the area were counted and algae on the borderline of the grid were included. Dead algae were excluded and algae in a distinct division phase counted twice. Epithemia turgida overgrew the glass in some samples, and total counting was not possible. In these cases the number was estimated to be more than 400. The statistical analysis uses the number of 400 which is an underestimation.

The data were analysed using a two-way ANOVA (analysis of variance) on the square-root of the counts with the concentration level and day as independent variables. The square-root transformation was selected in order to eliminate heteroscedasticity (the phenomenon that variance increases with the count) and achieve accordance with the normality assumptions of the ANOVA (Zar 1984).

Invertebrates were collected in the sediments by tubes with an area of 22 sq cm. For each measurement 10 samples were taken stratified random from an area of 150 x 50 cm.

RESULTS AND DISCUSSION

Chemical parameters are shown in Table 1.

The five periphytic algal species or groups appeared in a different number, see

Table 1. Phosphate, nitrate and silicon in the water of a reference pond and ponds with different nominal concentrations of esfenvalerat (ng/L).

	Pond - Reference		Pond - 35 ng/L		Pond - 77 ng/L		Pond - 132 ng/L	
Date 1995	17.8	5.9	17.8	5.9	17.8	5.9	17.8	5.9
Phosphate µg/L	20	10	14	< 5	11	8	11	< 5
Nitrate mg/L	3.7	2.5	3.6	3.4	2.9	2.3	2.8	2.5
Silicon mg/L	5.2	-	9.9	-	7.0	-	6.6	-

- No measurement

Table 2. The average and standard deviation (in brackets) of the number of periphytic algae in the reference pond and ponds with different concentrations of esfenvalerate during a period of 34 days.

	Pond - Reference				Pond - 35 ng/L				Pond - 77 ng/L				Pond - 132 ng/L			
Date 1995	18.8.	25.8.	8.9.	21.9.	18.8.	25.8.	8.9.	21.9.	18.8.	25.8.	8.9.	21.9.	18.8.	25.8.	8.9.	21.9.
Epithemia turgida	4.0 (2.4)	0.9 (0.9)	0.6 (1.4)	0.2 (0.4)	12.3 (5.7)	33.8 (10.2)	123.8 (31.2)	36.0 (20.4)	1.7 (2.9)	1.4 (1.3)	120.5 (47.2)	>234	21.9 (12.8)	226.5 (32.0)	>400	>400
Navicula sp.	0.1 (0.3)	0.9 (1.2)	1.4 (0.8)	1.5 (1.2)	0.2 (0.4)	3.6 (1.6)	4.1 (1.4)	4.3 (1.8)	0.4 (0.7)	1.0 (0.8)	0.8 (0.9)	0	0.9 (0.7)	0	0.7 (0.8)	0.3 (0.7)
Pinnularia sp.	0	0	0.1 (0.3)	0	0.2 (0.4)	0.1 (0.3)	0.4 (0.5)	0.6 (0.8)	0.1 (0.3)	0.2 (0.4)	5.2 (4.3)	14.5 (6.5)	0.3 (0.5)	0.5 (0.5)	0.1 (0.3)	0.1 (0.3)
Synedra acus	0	0.3 (0.5)	0.1 (0.4)	0.2 (0.4)	0.2 (0.6)	0.2 (0.4)	0.5 (0.8)	0.1 (0.3)	0	0.1 (0.3)	0	0	0.2 (0.4)	0	0	0
Nitzschia palea	0	0	0.1 (0.3)	0	0	0.1 (0.3)	0	0	0	0	0	0	0	0	0	0

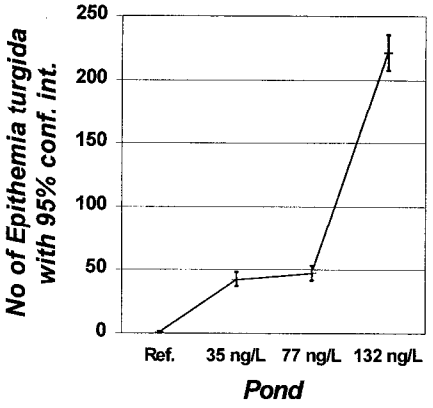

Figure 1 Number of *Epithemia turgida* with 95 % confidence intervals as function of concentration of esfenvalerate. Result of ANOVA.

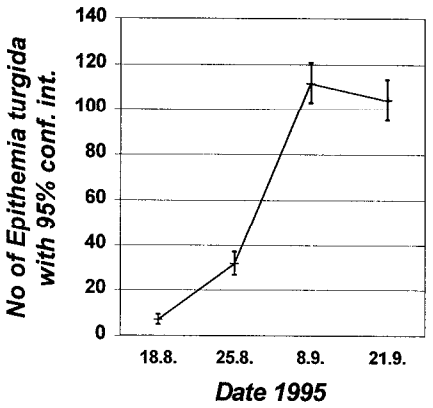

Figure 2 Number of *Epithemia turgida* with 95 % confidence intervals as function of day of sampling. Result of ANOVA.

Table 2. Nitzschia palea was only found in two counts, and it was excluded.
The ANOVA results for Epithemia turgida are shown in figures 1 and 2. The density of algae was tested against concentration and sampling date.
There is a clear dose-response effect of the concentration of esfenvalerate in the ponds on the number of Epithemia turgida. Also, the number of Epithemia turgida shows a significant increase with time, as well as a significant interaction effect of concentration and sampling date. No significant effects were found for Synedra acus, Navicula sp. and Pinnularia sp.

In the study period periphytic algal density increased in the ponds with the nominal highest concentration of esfenvalerate. Esfenvalerate in the present concentrations did not have a limiting effect on the growth of the algae. The chemical analysis did not indicate a shortage of nutrients in ponds with a low number of periphytic algae.

A number of invertebrates were found in the sediment and among these, gastropodae and ephemeroptera are known to be periphyton algae grazers (Crossland 1982). The group of gastropodae was not impacted by esfenvalerate but as shown in Table 3 ephemeroptera was absent at higher levels of esfenvalerate.
The extinction of ephemeroptera is not caused by lack of oxygen since oxygen was sufficient at these depths of the ponds.
The increased density of periphytic algae indicates an increased effect of esfenvalerate on algae abundancy. Esfenvalerate in higher concentrations kills some of the algae-grazing invertebrates. After the experiment, it was found that there were perch in pond 77 ng/L. We can not exclude the possibility that the fish have eaten ephemeroptera from the beginning of the experiment August 17.

Table 3. The number of animals per sq m with 95% confidence intervals (in brackets) for the group of ephemeroptera on different dates and concentrations of esfenvalerate.

Date 1995	Pond - reference	Pond - 35 ng/L	Pond - 77 ng/L	Pond - 132 ng/L
17.8.	182 (50 , 466)	182 (50 , 466)	0 (0 , 168)	273 (100 , 594)
24.8.	318 (128 , 656)	0 (0 , 168)	0 (0 , 168)	0 (0 , 168)
21.9.	773 (450 , 1237)	45 (1 , 253)	0 (0 , 168)	0 (0 , 168)

The surface water in the Danish farm land consists of numerous ponds, originating from former marl pits, and many streams. Farming practice makes it impossible to avoid pesticide impacts of surface waters.

When esfenvalerate ends in the soil, biodegradation takes several months and there is a potential runoff to the surface waters. Half of the esfenvalerate is hydrolysed in different types of soils at 15 °C over a period from 41 to 180 days (DEPA 1988).

Esfenvalerate is assessed to be immobile in the soil and consequently it does not present a threat to the groundwater. The adsorption of esfenvalerate in the soil is not measured but assessed from studies of a similar pesticide (DEPA 1988).

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