Total Population Density of Crustacea and Aquatic Insecta as an Indicator of Fenthion Pollution of River Water

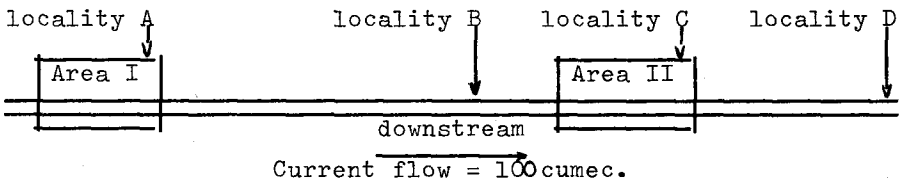
by L. P. VAN DYK, C. G. GREEFF, and J. J. BRINK
Plant Protection Research Institute
Private Bag X134, Pretoria 0001, South Africa

Pollution of water by pesticides such as fenthion (0,0 - dimethyl 0 - (4 methylmercapto-3-methylphenyl) thiophosphate) used on or next to a river, may be monitored either by residue analysis of water samples or by population counts of indicator organisms. Previous reports indicate the important effect of pesticides on the population density of freshwater fauna (COPE 1966).

Fenthion is used in the control of Red-billed Quelea birds (Quelea quelea), a pest of wheat along the lower-Orange river. Control measures involve spraying along the riverside and on islands where the birds roost at night. Although care is usually taken to minimise drift, contamination of the river usually occurs. A monitor program involving both the population density of aquatic Insecta and Crustacea, and the residue analysis of water samples was tested experimentally. The results are reported in this paper.

METHODS

Experimental design Fenthion was applied aerially as a 50:50 mixture of the 40 percent oil miscible formulation and diesolene at a rate of six ℓ. of active ingredient/ha. Two areas situated on the lower-Orange river were sprayed. The river flows through semi-arid desert at these areas and farming is concentrated on the riverside and on islands. The spraying areas and the sampling localities can be illustrated schematically as follows:



The distance between sampling localities A and B is 10 km, between B and C about 1 km, and between C and D about 20 km. Area I was at Sultanasoord, where the river flows in a single channel and area II was at Gifkloofkeerwal, where the river branches and many islands are formed. Area I was sprayed one day after area II so that the sampling locality C was affected directly by spraying and indirectly by the fenthion transported from area I. Samples collected at B and D re-

Bulletin of Environmental Contamination & Toxicology,
Vol. 14, No. 4 © 1975 by Springer-Verlag New York Inc.

flects the effect of the transported fenthion.

Samples were collected before and immediately after spraying and then on certain days for up to seven days after spraying.

Residues Three separate water samples were collected at the sampling localities. Samples of two ℓ. of water each were collected in cork-stoppered brown-glass bottles. The samples were extracted with 200 ml purified hexane which gave 85 percent recovery according to laboratory experiments. Extractions were performed in the brown-glass bottles by adding the hexane to the water and shaking the bottles for two min. The whole sample was poured into a separating funnel and after separation the water was discarded and the hexane filtered through phase-separating filter paper into a graduated cylinder. The filtrate was concentrated in a Kuderna-Danish evaporator to less than 10 ml and further evaporated to two ml in a gentle stream of dry air.

The water samples were analysed by GLC. A two m by 3 mm glass column containing 3% SE 30 on 80/100 mesh chromosorb Q was used, the temperatures were, inlet: 210°, column 215°, flame photometric detector 200°. The flow rates for the gases were nitrogen: 70 ml/min and 150, 20 and 40 ml/min for hydrogen, oxygen and air respectively. The minimum detectability was 0.1 ng i.e. 100 ng/ℓ. water for fenthion and 0.5 ng i.e. 500 ng/ℓ. water for fenthionsulfoxide (no sulfoxide was found in the water samples).

Population densities The biological samples were collected with a handnet 10 000 mesh. At each sampling locality three different sampling points were chosen and three samples taken at each point. The habitats at the different sampling points differed from dense reeds at the side of the river, to stagnant pools with a sandy bottom. The sampling points were at the river edge with little direct current. Formalin was added directly after sampling. The samples were thoroughly washed with water in a handnet (10 000 mesh) and sieve (22 mesh) in the laboratory. Leaves and twigs were washed carefully and removed from the samples. The macro sample left on the sieve was washed into a glass container with water and counted. The micro sample was washed into a perspex holder and the volume adjusted with water to 200 ml. A blender rotating at a slow speed of 30 rev/min was used to give a homogenous distribution of the micro samples, and 25 ml was subsampled for microscopic examination. The total population density was calculated as the combination of the macro- and microscopic population density counts. The population density is calculated as number of organisms x 18.83. The value 18.83 is a constant, derived from the mesh openings of the net, devided by the surface of the handnet, in this case 541.14 cm^2 (CHUTTER AND NOBLE 1966).

RESULTS AND DISCUSSION

Area I including the sampling locality A was sprayed directly and fenthion concentration of 742 ng/ℓ. was determined directly after spraying. The total population density i.e. the combined total of Crustacea and aquatic Insecta dropped from 1502 organisms/m^2 to 908 organisms/m^2, one day after spraying. The fenthion concentration decreased steadily and no residue could be found four days after spraying. The total population density at A also decreased to 322 organisms/m^2 four days after spraying but then increased to 751 organisms /m^2 six days after spraying. In a directly sprayed area the total population density is thus immediately affected by fenthion, but as soon as the residues disappears the recovery is rapid.

The water sampling locality B was not directly sprayed, but fenthion was carried downstream for 10 km from area I. One day after spraying a concentration of 600 ng/ℓ. was found. This affected the total population density which dropped from 1718 organisms/m^2 to 165 organisms/m^2 (Fig 1). Repopulation was rapid from the fourth day onwards. The total population density thus served as a sensitive indicator of fenthion pollution at a locality downstream from the sprayed area.

Area II including locality C was sprayed one day before area I. Thus it may be expected that the population would be affected directly and by transported fenthion. The fenthion concentration at C initially dropped from 1012 ng/ℓ. directly after spraying to 126 ng/ℓ. seven hr after spraying and then increased to 785 ng/ℓ. two days after spraying (Fig 1). This increase can only be attributed to the fenthion transported downstream. The total population density at C served as an excellent indicator of the fenthion pollution, because after a sharp drop one day after spraying and a slight recovery on the second day, the total population density again dropped on the fifth day (Fig 1). The total population density increased rapidly after a low of 288 organisms/m^2 five days after spraying to 2994 organisms/m^2 seven days after spraying.

Locality D is 20 km downstream from area II and 31 km downstream from area I. It could thus be expected that the population density at D would seriously be affected by the fenthion transported downstream. The fenthion concentration at D one day after spraying at area II was found to be 19 000 ng/ℓ. This dropped steadily to 700 ng/ℓ. and 300 ng/ℓ. respectively, two and five days after spraying. No fenthion could be detected seven days after spraying. Again the total population density served as a good indicator. The total population density dropped from 638 organisms/m^2 before spraying to 65 organisms/m^2 two days after and 107 organisms/m^2 five days after spraying. Recovery of the population was slow compared to the other localities.

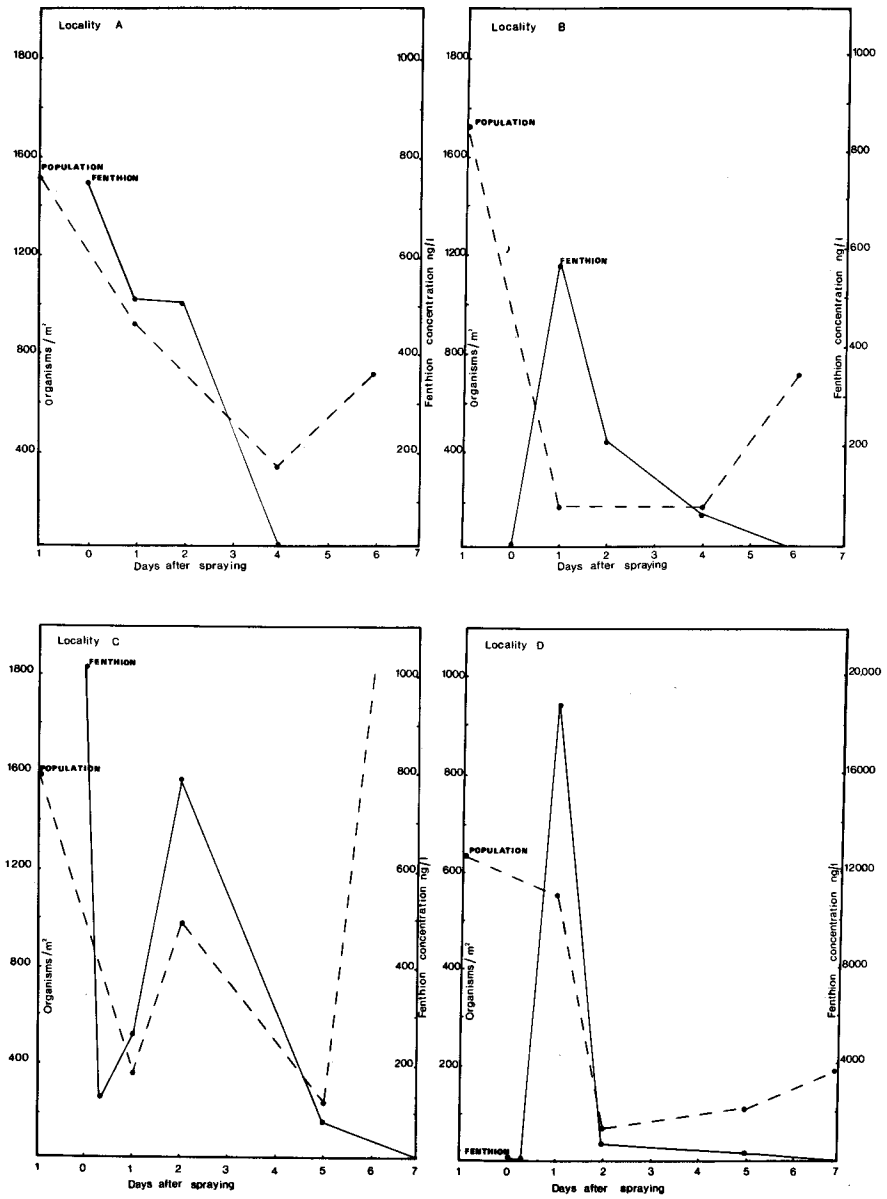


Figure 1: Influence of fenthion on the total population density of Crustacea and aquatic Insecta.

The population density of the classes and orders which constitute the total population density, may not reflect the general trend. The Crustacea, (mainly Caridina nilotica) reflected the general trend (Table 1). The orders of Insecta, however, differed in their reaction to pollution as was previously reported (WALL and MARGANIAN 1971). The Odonata, (mainly Pseudagrion spp) recovered rapidly at localities A and B where fenthion had a singular effect, but at the localities C and D, where more than one application polluted the river, the recovery was very slow (Table 1). A very slow recovery of Odonata population when compared to Crustacea population would thus indicate repeated pollution.

TABLE 1

Population density of Crustacea and aquatic Insecta at four localities.

LOCALITY	DAYS AFTER SPRAYING	POPULATION DENSITY (organisms/m^2) a)						
		CRUSTACEA	INSECTA					
			Odonata	Ephemeroptera	Hemiptera	Diptera	Coleoptera	Total
A	Before	36	38	270	287	843	29	1502
	1	2	23	11	71	781	21	908
	4	42	38	100	25	75	42	322
	6	84	52	446	4	126	40	751
B	Before	44	73	595	444	471	8	1718
	1	11	23	15	19	69	-	165
	4	23	8	34	69	25	4	165
	6	50	15	126	255	255	-	703
C	Before	27	8	601	506	190	262	1596
	1	4	4	190	4	132	4	343
	2	-	2	25	6	799	-	879
	5	-	-	-	25	201	2	228
	7	-	-	19	4	2958	-	299
D	Before	-	16	128	109	193	190	638
	1	25	4	38	117	264	105	555
	2	-	-	8	15	25	17	65
	5	2	-	23	40	29	13	107
	7	15	-	89	42	36	8	190

a) The population density is the mean of three replicates taken at three sampling points for each locality.

The Ephemeroptera population (mainly Beatis spp) is very susceptible to fenthion pollution, but the population also recovers rapidly (Table 1). Populations of this order would

thus serve as good indicators of fenthion pollution.

The effect of fenthion pollution on the Diptera population, (mainly Chironomidae) was slower than on the Ephemeroptera and the population did not increase rapidly at all localities (Table 1).

The Coleoptera population (mainly Hydrophylidae) is not a good indicator, because after the initial rapid decline, the population remains depressed for some time.

The Hemiptera population (mainly Corixidae, Notonectidae and Gerridae), recovers rapidly at all localities where the individuals were exposed to transported fenthion. At the localities directly sprayed, the population remained depressed even after seven days (Table 1). It would indicate that the recovery rate of the Hemiptera population may be used to establish the manner of pollution when compared to either Crustacea or Ephemeroptera population recoveries.

CONCLUSION

The total population density was proved to be a sensitive indicator of fenthion pollution and can be used when no analytical facilities are available. Furthermore sampling for chemical analysis is usually limited in volume and frequency, whereas the Crustacea and aquatic Insecta populations are continually present to monitor pollution. It is also an inexpensive method compared to the use of sophisticated collection samplers or resins. The only prerequisite is, that the total population density before pollution must be known, and this can be established by long-term observations.

REFERENCES

CHUTTER, F. M. and R. G. NOBLE: Arch. Hydrobiol. 62, 95 (1966)

COPE, O. B.: J. Appl. Ecol. 3 Suppl. 33 (1966).

WALL, Jr. W. J. and V. M. MARGANIAN: Mosquito News 31, 209 (1971).