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Metabolism of p,p'-DDT by the Freshwater Planarian *Phagocata gracilis*

E. A. Onwumere and M. R. Wells

Department of Biology, Middle Tennessee State University, Murfreesboro, TN 37132

Metabolism of p,p'-DDT to DDD and DDE by Planarians (Phagocata velata) was first reported in 1974 (PHILLIPS et al. 1974). The major metabolite was shown to be p,p'-DDD. During the same year, KOUYOUMJIAN and UGLOW (1974) reported the toxicity levels of p,p'-DDT, p,p'-DDD and p,p'-DDE for the Planarians Polycelis felina and Crenobia alpina. Their data indicated that p,p'-DDD was more toxic to Planarians than p,p'-DDT or p,p'-DDE. More recently KOUYOUMJIAN and VILLENEUVE (1979) reported on the effects of DDT on regeneration and fission in Polycelis felina and Crenobia albina. They also reported DDE to be the major metabolite of DDT in these European Planarians. The present study describes the metabolism of p,p'-DDT by Phagocata gracilis.

MATERIALS AND METHODS

The planarians (Phagocata gracilis) used in this study were collected from a spring-fed stream located in an abandoned limestone quarry alongside State Road 141 south of the dam at Center Hill Reservoir near Smithville in Dekalb County, Tennessee. Water from the stream was collected in several containers and brought into the laboratory at the same time with the planarians.

Planarians were fed beef liver weekly. After each weekly feeding, planarians were transferred to enamel pans containing fresh filtered stream water. The worms were kept in the laboratory for at least two weeks prior to treatment with DDT.

Planarians were separated into 27 groups (three control groups and twenty-four test groups) of 20 worms each. Each of these 27 groups was placed in separate glass culture dishes containing filtered water from the same stream from which the planarians were collected.

Planarians were starved for six days. On the seventh day, the test groups received a piece of beef liver, approximately 0.1 gm, which had been perfused with 10 ppm p,p'-DDT (99%). The three control groups were fed liver with corn oil only. Beef liver with DDT in corn oil was also placed in dishes containing water from the stream to determine if microorganisms in the water or beef liver were metabolizing DDT. Following 1 hour of

feeding, the liver was removed from the culture dishes. The planarians were removed from the treatment dishes at 3 hr., 6 hr., 12 hr., 24 hr., 36 hr., 48 hr., 72 hr., and 2 weeks after treatment with DDT and analyzed for DDT and its metabolites by the method of PHILLIPS et al. (1974).

RESULTS AND DISCUSSION

This study indicates that Phagocata gracilis converted DDT into at least two metabolites, DDD and DDE (Fig. 1). There were no deaths from insecticide treatment in any of the groups used in this study. DDT was not metabolized by the microorganisms in the water collected from the stream. Neither DDT nor its metabolites were detected in any of the groups fed beef liver perfused with corn oil only.

Reductive dechlorination of DDT to DDD was the major metabolite observed. At 3 hours of treatment, the concentration of DDD observed was lower than that of DDT. Following this period, a rapid increase in DDD concentration occurred and continued through 36 hours after treatment with DDT. The concentration of DDE and DDT residues observed at this period of treatment (36 hours) were well below that of DDD. However, after 36 hours of treatment DDD concentration dropped rapidly, but it remained above that of DDE and DDT.

The two most common routes of DDT metabolism are dehydrochlorination to DDE, oxidation to kelthane (dicofol), and reductive dechlorination to DDD. These routes of metabolism, however, may not lead to detoxification. For example, KOUYOUMJIAN and UGLOW (1974) reported that p,p'-DDD was more toxic to the freshwater planarian, P. felina, than p,p'-DDT; the LC50 (mean lethal concentration) values approximated a 4:3 ratio of toxicity for p,p'-DDT and p,p'-DDD, respectively. In another study, KOUYOUMJIAN and VILLENEUVE (1979) reported similar observations in P. felina and a second species, P. crenobia.

The data presented in this study, however, indicate that DDT and its metabolites were not lethal to P. gracilis. This would support the work of BATEY and WELLS (1980) who reported that 60 minutes exposure of P. gracilis to beef liver perfused with 10 ppm of p,p'-DDT, p,p'-DDD, and p,p'-DDD in corn oil did not produce symptoms of DDT poisoning in this species. In an earlier study, PHILLIPS et al. (1974) reported that with another freshwater planarian, P. velata, DDT was metabolized into DDD and DDE with no adverse effects on this species; reductive dechlorination of DDT to DDD was the major metabolite.

In this study the concentration of DDD, the major metabolite observed, increased rapidly and reached a peak, 49.48 ± 0.58 ppm/gm wet weight at 36 hours of treatment. Following this period, the concentration decreased gradually, but continuously, beyond 72 hours of treatment. Possibly, therefore, DDD was

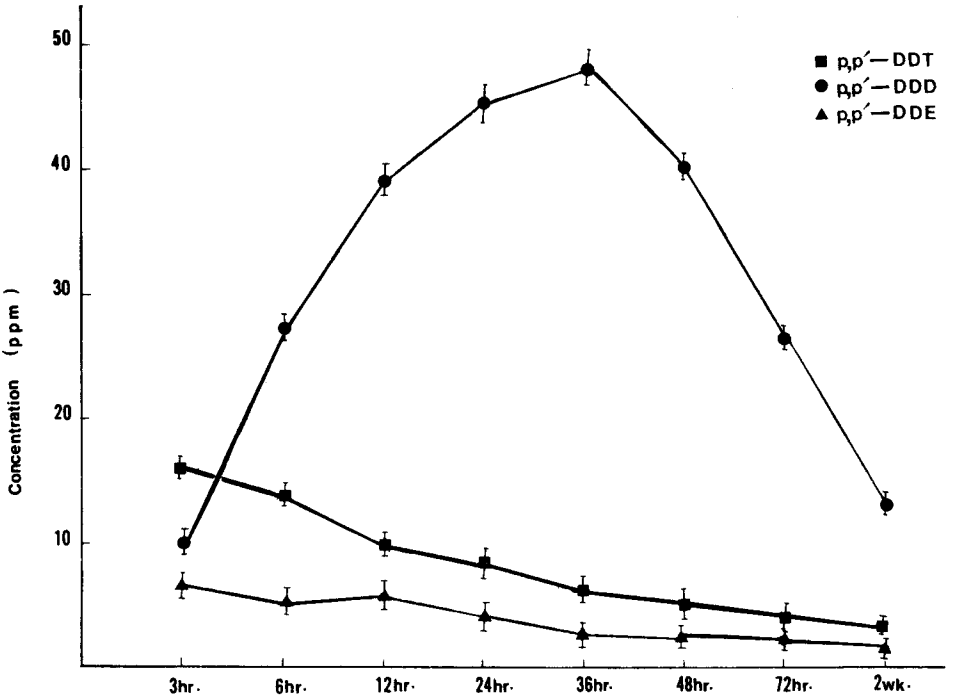

Figure 1. Metabolism of p,p'-DDT by Phagocata gracilis. Values expressed as ppm/g wet weight. Bar lines represent one standard error.

probably not an end product, but an intermediate in metabolism of DDT by P. gracilis. STERNBURG and KEARNS reported that DDD was converted to DDDE [1,1-bis(p-chlorophenyl)-2-chloro-ethylene] in some lower organisms after prolonged exposure to DDT. However, no other metabolite of DDT was observed in this study.

The metabolism of DDT to DDD and DDE suggests that microsomal enzymes are present. This group of enzymes is capable of metabolizing DDT into DDD and DDE by reductive dechlorination and dehydrochlorination respectively. PHILLIPS et al. (1974) suggested the involvement of such a system in the conversion of DDT into DDE and DDD in P. velata. This observation was confirmed by BALDWIN and WELLS (1978), who reported that 60-minutes exposure of P. velata to 10 ppm of p,p'-DDT in corn oil activated NADH-cytochrome reductase; the activity of NADH-cytochrome b_5 reductase was inversely related to DDT concentration.

P. gracilis and other planarians can accumulate organochlorine residues directly from the water through their surface membranes and also from their food source. The amount of accumulation is dependent upon the amount of insecticide present and the length of exposure. In this study, the levels of DDT

reported could lead to the problem of biological magnification since many organisms are known to feed on planarians: Coelenterata, Hirudinea, Pleoptera larvae, Trichoptera larvae, Megaloptera larvae, Hemiptera, Coleoptera, Mollusca, Odonata larvae, Amphibia, and Pices (DAVIES and REYNOLDSON 1969).

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