The *In Vivo* Effect of p,p′ DDT on Na^+-K^+-Activated ATPase Activity in Rainbow Trout (*Salmo gairdneri*)

by

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Recent research has emphasized the importance of a glycoside sensitive Na^+-K^+-ATPase in teleost hydromineral regulation. The role of this enzyme in branchial and renal sodium and potassium transport has been confirmed (EPSTEIN et al. 1967, KAMIYA and UTIDA 1968, JAMPOL and EPSTEIN 1970, ZAUGG and McLAIN 1971).

Some recent work has sought to evaluate the potential of chlorinated hydrocarbon insecticides, and structurally related compounds, as selective inhibitors of Na^+-K^+-ATPase activity. However, a pattern of inhibition has not fully emerged. *In vitro* evidence indicates that p,p'DDT inhibits this enzyme's activity in tissue preparations from several marine teleosts (JANICKI and KINTER 1971). Additionally, *in vivo* inhibition has been demonstrated in gills and kidney of the minnow *Pimephales promelas* chronically exposed to the polychlorinated biphenyls Aroclor 1254 and 1242 (KOCH et al. 1972). While diminution of the enzyme's activity by DDT has been postulated as a site for pesticide toxicity in fish, a more recent work attests that p,p'DDT may not adversely affect Na^+-K^+-ATPase activity in rainbow trout (*Salmo gairdneri*) and, as a consequence, may have little physiological significance to hydromineral balance via Na^+-K^+-ATPase in the intact animal (DAVIS et al. 1972).

We report the *in vivo* effects of p,p'DDT on branchial and renal Na^+-K^+-ATPase activity of rainbow trout, and suggest a relationship between enzyme inactivation and impairment of the rainbow trout's ability to maintain hemeostasis.

MATERIALS AND METHODS

Rainbow trout weighing 95-120 grams were obtained from a local commercial trout ranch. After one week of acclimation to aquarium conditions the fish were grouped randomly and held in either fresh water (FW), 33 percent sea water (SW), or 100 percent SW.

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DDT was dissolved in corn oil and administered in gelatin capsules. Two insecticide concentrations--0.3 mg per dose (2.75 mg/kg) and 1.0 mg per dose (8.30 mg/kg)--were administered on alternate days for a total of seven treatments. Corn oil controls, which received corn oil and capsule but no DDT, and non-manipulated controls accompanied treated groups in each of the three salinities. Trout were sacrificed 72 hours after the final treatment. Tissues were handled and ATPase activities estimated in microsomal fractions from gills and kidneys as previously described (KAMIYA and UTIDA 1968).

RESULTS AND DISCUSSION

Inhibition of Na^+-K^+-activated ATPase activity accompanied treatment with both insecticide concentrations in each of the three salinities used. Analysis of variance indicated highly significant differences ($P < 0.01$) in renal and branchial activites of fish treated with DDT compared with manipulated and non-manipulated control groups (Table 1).

TABLE 1

Tissue	Salinity	DDT Dose	Sample Size	% Inhibition
Gill	FW	0.3 mg	7	33.0
		1.0	6	20.0
	33% SW	0.3	7	26.0
		1.0	7	41.0
	100% SW	0.3	6	67.0
		*		
Kidney	FW	0.3	7	30.5
		1.0	6	37.0
	33% SW	0.3	6	36.0
		1.0	6	24.7
	100% SW	0.3	5	25.4
		*		

*Trout subjected to the higher DDT concentration and held in 100% SW died prior to final DDT treatment.

There appears to be a relationship between the level of pesticide encountered by rainbow trout and the percent inhibition of branchial Na^+-K^+-ATPase activity. A relationship between salinity and propensity for inhibition also seems probable. Levels of renal ATPase inhibition, while statistically significant, exhibit no apparent differential response to either increasing salinity or increasing pesticide concentration for the range of combinations employed. Fish subjected to the higher DDT concentration, and held in 100 percent SW, survived only through the fifth treatment.

It may be concluded from these findings that DDT is capable of inhibiting Na^+-K^+-ATPase activities in tissues of chronically exposed rainbow trout. It is also possible to postulate the existence of a threshold effect based on insecticide concentration, and to speculate upon possible pesticide-salinity interactions of importance to fish which must adapt to waters of different salinities.

Detection of ATPase inactivation could prove to be an important index to tolerable levels of a large group of environmental contaminants. However, to be meaningful, measurable levels of inhibition should reflect physiological impairment of functions which require this enzyme system. We have correlated branchial ATPase inhibition with elevated serum sodium and osmolality in seawater-acclimated trout (unpublished manuscript). We have further demonstrated diminished renal reabsorption capabilities for fish held in fresh water (unpublished observations).

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