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Fisheries Ecology

TOXICITY OF SOME INSECTICIDES TO *LEPIDOCEPHALUS THERMALIS* (CUV. & VAL.)

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Using the tropical loach, *Lepidocephalus thermalis* (Cuv. & Val.) as the test fish, bioassays were carried out with commercial insecticides. Dimecron was found to be the least toxic, malathion more toxic, metacid and parathion still more toxic and endrin the most toxic. 48-hr LC_{50} values expressed as ppm for adult fish were as follows: dimecron 44·25, malathion 20·61, metacid 5·75, parathion 1·269 and endrin 0·003329. Smaller fish were found to be less resistant to the effects of these insecticides than larger ones.

INTRODUCTION

The effect of pesticides on the ecosystem has been a subject of detailed study by various workers (Khan & Bederka, 1974). The indiscriminate use of pesticides in certain areas has caused measurable damage to many species of fishes. The full extent of damage has never been estimated because in developing countries even a general assessment of the fauna and flora has not been fully undertaken. Our information on the detrimental effects of pesticides in general on life system is still fragmentary and much less is known regarding this aspect on fishes.

Although pesticides are aimed at one or a few species in biotic communities, usually these toxicants have some impact either directly or indirectly on more species. The application of pesticides directly to crop lands, forests and other habitats may reduce and sometimes temporarily exterminate not only the pests, but also some non-target species in the treated region. The direct effects of applications are relatively easily observed, the indirect effects are difficult to detect.

Serious alterations in the aquatic environments affecting fish life are reported in India by many authors, like Hora (1942), Ganapathi and Alikunhi (1950) and Ray and David (1966). All of them, no doubt, stress the importance and seriousness of the problem, but do not try to evaluate directly the toxicity of chemically complex wastes to aquatic life. Even though remarkable progress in this line of investigation has been made in other countries, it is only very recently, that studies to determine the level of toxicity of various pollutants on different groups of fishes have been triggered off in India. Works of Rao *et al.* (1967), Konar (1968, 1969, 1970), Mathur (1969), Arora *et al.* (1971a, b) Bhatia (1971), Toor *et al.* (1973), Toor and Kaur (1974) among others are particularly noteworthy in this regard.

The problem of the impact of biocides on the environment is a very involved one (Vinson *et al.*, 1963) and this needs detailed scrutiny. The problem assumes special significance since the chlorinated insecticides may persist for long periods ranging from 6 months to 30 years depending on the chemical, its dosage and characteristics of the environment (Pimentel & Goodman, 1974) and their movement through the environment is related in large measure to their persistence.

That there is a substantial reduction in the number of fresh water fishes in the state of Kerala is widely recognised. Unaccounted fish kills have been reported from time to time from various places. The exact cause of decline in the fresh water fish and frog population still remains unaccounted.

During the present study, a series of tests were conducted to study the degree of toxicity of certain pesticides on the fish *Lepidocephalus thermalis*. This species is commonly found in the small streams adjacent to paddy fields, and, therefore, exposed to the maximum effect of the pesticides.

Materials and Methods

Specimens of *L. thermalis*, collected from small pools and canals around Trivandrum city were used for the tests.

The chemicals used in the present bioassay tests are widely used in rice fields of the state as pesticides, such as endrin 20% EC, malathion 50% EC, dimecron 100% EC, Metacid 50% EC and Parathion 50% EC.

The static bioassay procedure outlined by Doudoroff *et al.* (1951) with some modifications in regard to laboratory techniques to suit the objective of the present investigation was employed during the present study. Tests were conducted at room temperature 27 $\pm$ 3°C. The specified period of exposure was 48 hr.

Overnight exploratory tests were first performed with only two specimens per concentration tested. Then for carrying out full scale bioassays, a series of five logarithmic test concentrations were calculated from the exploratory range. LC_{50} values of each pesticide for 24 and 48 hr were calculated by probit analysis method. Physical reactions of the fish were also observed during the period of exposure to pesticides.

With a view to finding out whether the sensitivity of the adult and young fish to pesticides differ, two day static bioassays were run with fish of about 50 mm and 35 mm.

Results

A comparative statement of LC_{50} values for the different compounds has been tabulated in Tables I & II. As may be seen from the tables, LC_{50} values for different compounds showed wide differences. Moreover, in each case, the values decreased with the increase of time of exposure, i.e., the resistance of the fish decreases with the experimental time. Results of the probit analysis are presented in Figs. 1-8. The mortality rate for 24 hr is higher in all insecticides except in malathion.

The results of tests conducted with smaller specimens *L. thermalis* are presented in Table II. These results suggest that in general bigger/older specimens can tolerate higher concentrations of the insecticides than smaller/younger specimens. Consequently the LC_{50} values are also higher for the larger size group.

TABLE I

24- and 48-hr LC_{50} values of various insecticides on adult L. thermalis

Insecticides	24 hr LC_{50} values	48 hr LC_{50} values
Dimecron	53.63	44.25
Malathion	22.69	20.61
Metacid	5.98	5.75
Parathion	1.858	1.269
Endrin	0.003754	0.003329

As no death occurred in any of the control tanks, death of the fish in the experimental tanks could be attributed to the toxicity of pesticides.

TABLE II

24- and 48-hr LC_{50} values of various insecticides on young L. thermalis

Insecticides	24-hr LC_{50} values	48-hr LC_{50} values
Malathion	12.50	7.75
Metacid	3.427	3.292
Parathion	1.361	not workable

Physical reaction—The fish, in toxic solutions exhibited darting movements, excitation, muscular spasm causing short, jerky movements, and frequent attempts to leap out of water, etc. Finally, they lie on their sides and die. In no case, evidence of any physical affliction by these toxic compounds was noticed. The physical reactions of the fish in each insecticide have been carefully recorded and presented in Table III.

DISCUSSION

The results of the bioassay studies indicate that chlorinated hydrocarbons are much more toxic to the fish than the organic phosphate combinations. This finding is in agreement with that of Newson (1967), Nishiuchi and Hoshimoto (1967), Rao *et al.* (1967) and Toor *et al.* (1973).

The five insecticides tried have different degrees of toxicities. Among the five, dimecron is the least toxic, malathion more toxic, metacid and parathion still more toxic and endrin the most toxic.

The effects of malathion on fish have already been studied. Henderson and Pickering (1958) recorded TLm values of malathion for fatheads as 25 ppm in 24 hr and 22 ppm in 96 hr, whereas Tarzwell (1958) has given the 96 hr TLm value for fathead minnows as 12.5 ppm. Katz (1958) reported the 96 hr TLm value for chinook salmon as 0.023 ppm. According to Nishiuchi and Hoshimoto (1967) the 48 hr TLm value of malathion for *Cyprinus carpio* is 4.5 ppm. By conducting

TABLE III

Physical reactions of L. thermalis *to different insecticides*

Malathion	Dimecron	Metacid	Parathion	Endrin
Less excitation	Less excitation	High excitation	High excitation	Pronounced excitation
Jerky movements	Swam rapidly	Swam rapidly and tried to leap out of water	Irregular swimming	Swam rapidly
—	—	—	Continuous quivering of head	Frequently swam on surface
Less opercular beat	Irregular movements of operculum	Less opercular beat	Irregular movements of operculum	Irregular movements of operculum
Partial loss of equilibrium	Often lost equilibrium	Often lost equilibrium	Complete loss of equilibrium	Partial loss of equilibrium
Lie on side	Lie on side	Lie on side	rose to surface and turned upside down	Lie on side and made feeble movements
Death	Death	Death	Death	Death

bioassay studies with carps, Arora *et al.* (1971 b) found *Labeo rohita* to be most resistant of the four carp species tried, the 24 hr and 96 hr TLm values being 7·15 mg/litre and 5·05 mg/litre. Bhatia (1971), using *Puntius ticto* as test animals, determined the 24, 48, 72 and 96 hr TLm values of malathion as 0·0135, 0·011, 0·011 and 0·0074 ml/litre respectively. For the exotic carp, *Cyprinus carpio communis*, the maximum sublethal dosage is 17 ppm and the minimum lethal dose is 20 ppm (Toor *et al.*, 1973). In the present series of tests with malathion, 24 hr LC_{50} values for large specimens of *L. thermalis* is 22·69 ppm and for small ones 12·5 ppm whereas 48 hr values are 20·61 and 7·75 ppm respectively.

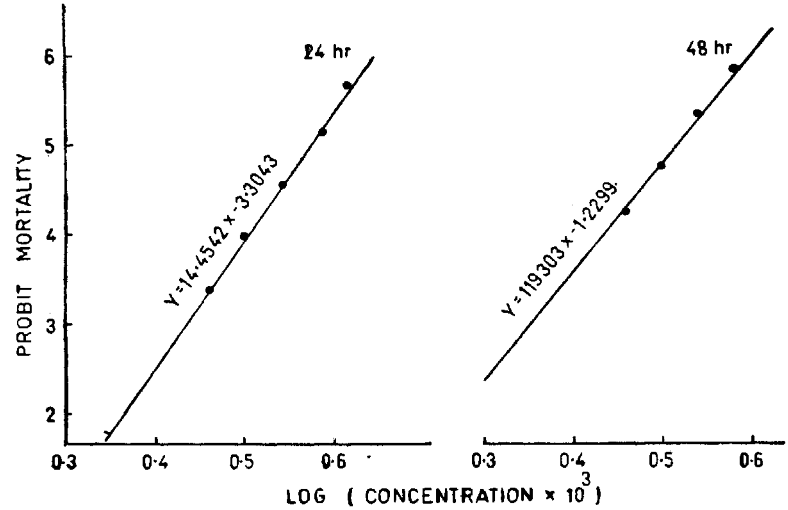

FIG. 1. Probit regression curve of adult *L. thermalis* in endrin

Bhatia (1971) noted the TLm values of dimecron on *Puntius ticto* as 0·47, 0·47, 0·43, 0·41 ml/litre of 50% dimecron for 24, 48, 72 and 96 hr respectively. In the present bioassay studies, the LC_{50} values for 24 & 48 hr are 53·63 ppm and 44·25 ppm respectively. Here it is worthy to note that a maximum dose of 100 ppm of dimecron in water was found non-toxic to shinghi fish (CIBA-Geigy agrochemicals, brochure pertaining to dimecron 100).

It was not possible to find out the exact tolerance limits of any fish to metacid from previous literature. The tests conducted with adult specimens of *L. thermalis* of two different size groups indicated that the LC_{50} values for 24, 48 hr are 5·98 and 5·75 ppm respectively and for young specimens 3·427 and 3·292 ppm respectively.

Rao *et al.* (1967) reported the TLm values for parathion in *Puntius puckelli* as 2·9, 2·7 and 2·1 ppm for 24, 48 and 96 hr respectively whereas in the present test, the 24 and 48-hr values are determined for large fish as 1·858 and 1·269 ppm, respectively and for small fish the 24-hr value as 1·361 ppm.

The insecticide endrin has been used earlier for bioassay studies using different species of test fishes. Mount (1960) while investigating the toxic effects of various chemicals like toxaphene, endrin, aldrin, heptachlor, chlordane, guthion, malathion and carbaryl found endrin the most toxic of all. According to him, survival of the bluntnose minnow and the guppy in endrin exceeded 50% at 0·4 ppb and 100% at 0·1 ppb. Fingerlings of *Labeo fimbriatus* and *Danio* sp. are found to tolerate a concentration of less than 0·009 ppm of endrin (Sreenivasan &

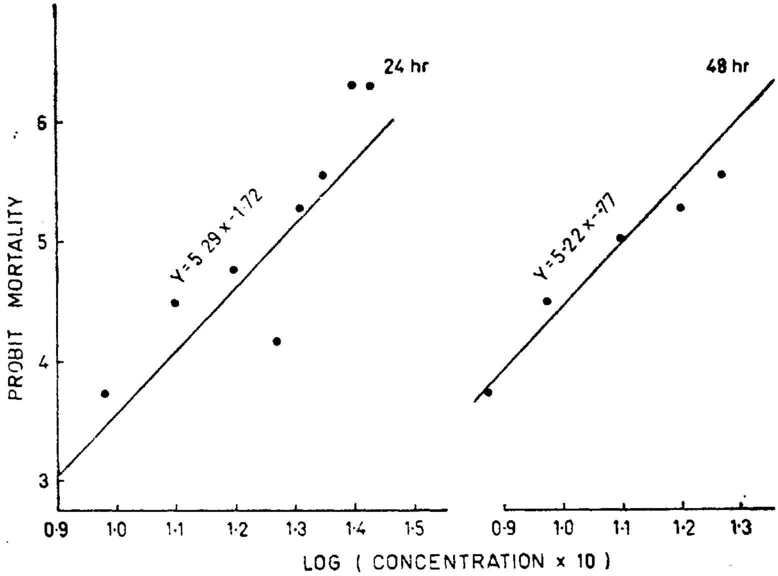

FIG. 2. Probit regression curve of adult *L. thermalis* in parathion

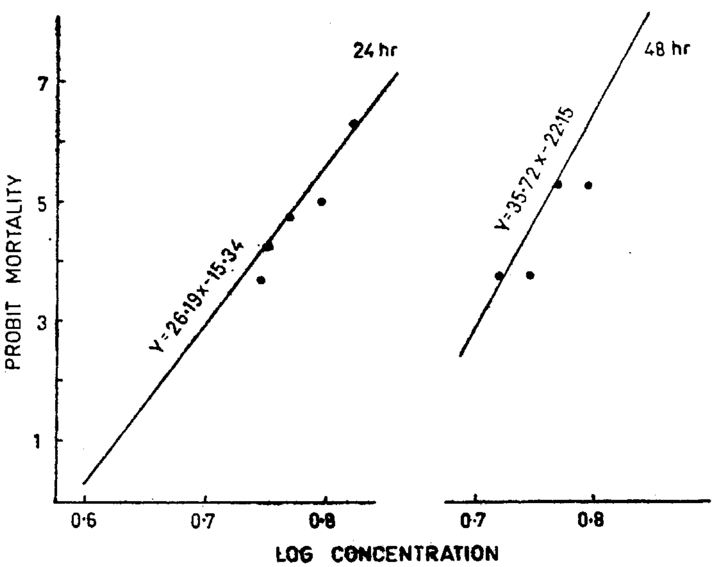

FIG. 3. Probit regression curve of adult *L. thermalis* in metacid

Natarajan, 1963). The median lethal levels of *Puntius puckelli* for endrin are evaluated as 0·00315, 0·00155 and 0·00125 ppm for 24, 48 and 96 hr respectively (Rao *et al.* 1967). For *Cyprinus carpio,* Toor *et al.* (1973) determined the maximum sublethal doses of endrin as 0·00180 ppm and the minimum lethal dose as 0·003 ppm. Tests with adult specimens of *L. thermalis* in the present study revealed the values to be 0·003754 ppm for 24 hr and 0·003329 ppm for 48 hr. On comparison of the results of the experiments with endrin, it is found that the resistance of the loach to endrin is slightly more than that of the carp, as was also observed by Kubota (1960) in the case of the Japanese loach and carp.

The above-mentioned comparison of results provides information on the widely different reactions which different fish may exhibit to one and the same

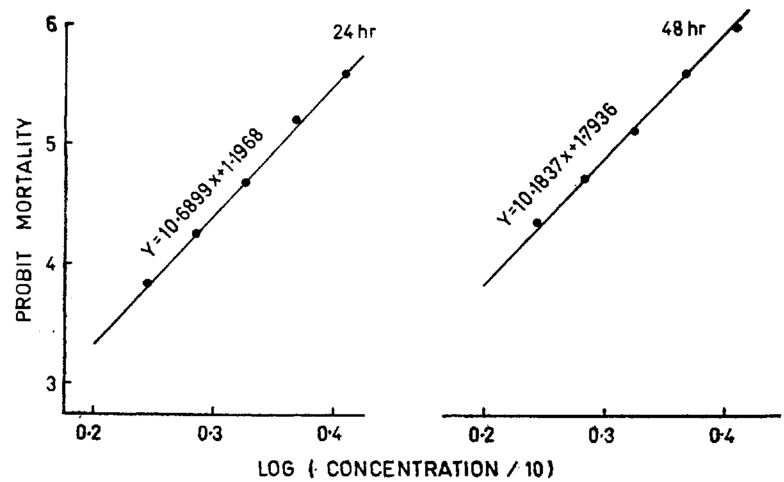

FIG. 4. Probit regression curve of adult *L. thermalis* in malathion

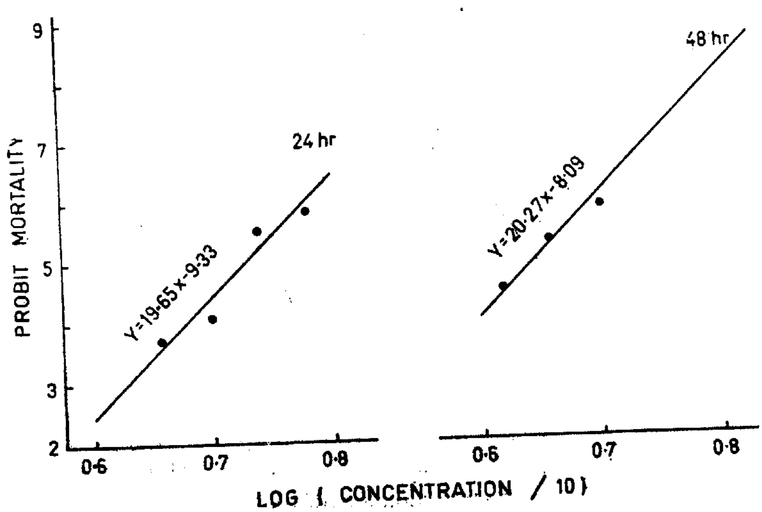

FIG. 5. Probit regression curve of adult *L. thermalis* in dimecron

chemical. Moreover, studies on the toxicity of pesticides to *L. thermalis* show that there is no correlation in the comparative toxicities of different pesticides to a fish.

From the results of the present study, it would appear that smaller fish are less resistant to the effects of these insecticides than larger ones. A possibility of a size-selective mortality following exposure to pesticides has been considered by several investigators. Weiss and Botts (1957) have reported that larger fish were more tolerant to the organic phosphorus compounds than were smaller fish. In acute toxicity studies with pesticides, tolerance was observed to increase with

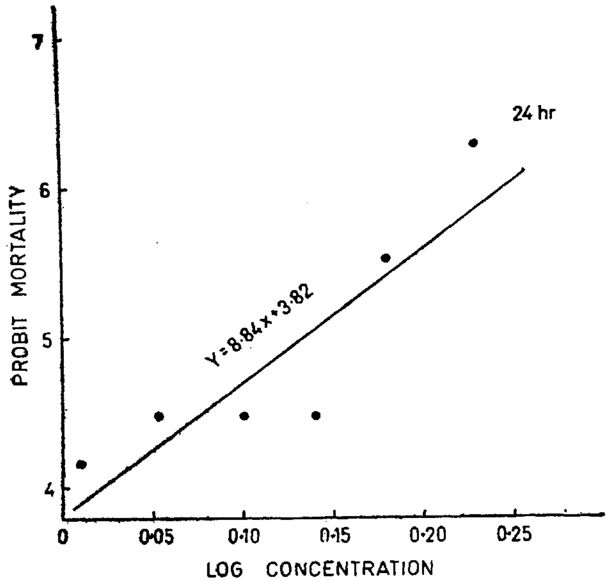

FIG. 6. Probit regression curve of young *L. thermalis* in parathion

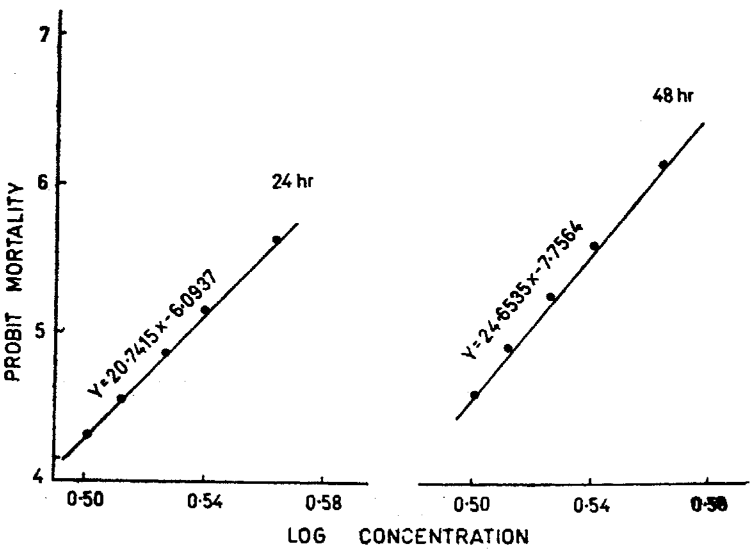

FIG. 7. Probit regression curve of young *L. thermalis* in metacid

size of the fish (Mount, 1960). Neuhold and Sigler (1960) noted that median survival time for carp *Cyprinus carpio* and rainbow trout exposed to flouride increased as a function of increasing fish size. Burdick *et al.* (1965) observed that the toxicity of the carbamate insecticide sevin to brown trout decreases with increasing length.

Allison *et al.* (1963) noted higher mortalities among smaller trout after either oral or immersion exposure to DDT. Likewise, sensitivity to chemicals as a direct function of body weight was demonstrated by Buhler & Shanks (1970) in the coho salmon that were fed on a diet containing DDT. According to Anderson and Fenderson (1970), the high residue levels in fish with low fat content compared with those in fish with low fat reserves is expected because fat fish have a greater capacity to store fat soluble hydrocarbons, i.e., there exists a positive relationship between fat percentage and DDT levels in fish. Moreover, attributes of age, origin, sex and possibly other factors account for variation in insecticide tolerance. In the present investigation, it is possible that the internal stress produced as a result of some sort of disturbance in the physiological process may have contributed to the observed difference in susceptibility of the fish. Positive evidence for this could only be arrived at by detailed examination of the internal organs, so as to locate the sites of absorption and deposition of the pesticides. But this aspect is not within the purview of the present investigation.

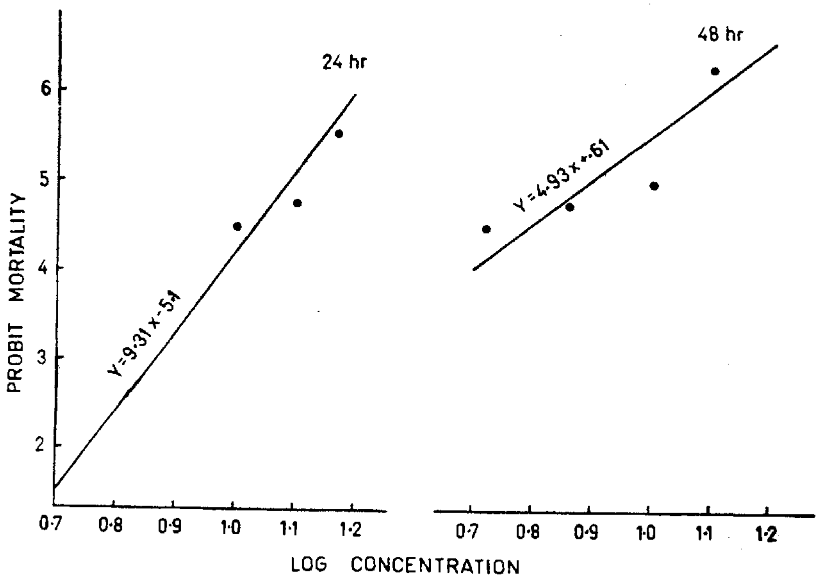

FIG. 8. Probit regression curve of young *L. thermalis* in malathion

The results of this series of tests are of special significance in that they provide useful information on the details of the concentration of biocides which could be tolerated by populations of fishes. Through proper surveillence of the medium in the proximity of cultivated lands such as paddy fields, rubber and tea estates, it would be possible to check the concentration of biocides in the habitat and thus take effective protective measures for the conservation of the surviving species of our already depleted fresh water fauna.

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