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MONITORING INSECTICIDE RESIDUES IN THE ESTUARINE ENVIRONMENT

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An estimation of the composition of pesticides used in Texas shows that about 16 per cent of the total pesticides used are chlorinated hydrocarbon compounds and the remaining 84 per cent are less persistent types such as the organophosphates and carbamates.

The quantity of pesticides used annually in Texas is conservatively estimated to be in excess of 170 million pounds, and increasing in use at a rate of 10 to 12 per cent per year.

Approximately 89.5 per cent of the pesticide use in Texas is for agricultural purposes. The breakdown of uses indicates that cotton receives 38 per cent, sorghum 42 per cent, rice 3 per cent, citrus 0.5 per cent, and vegetables 6 per cent.

Home and municipal use amount to about 10.5 per cent of that applied. Most of that used in the home is normally applied in such a manner that little contributes to environmental pollution. However, yard use would probably contribute substantial amounts. Municipal uses include mosquito and disease vector control in cities and other controls at international airports, and are being carefully watched in our sampling program.

Most of the persistent pesticides applied manually remain in place except in extreme flooding or dust storms. In aerial application, as little as 50 per cent may actually reach the target intended. Aerial drift, codistillation with water, volatilization from soil surfaces, and leaching by heavy rains are some means by which this material moves on the land.

Persistent pesticides normally find their way into the estuarine system by becoming attached to soil particles. These soil particles become suspended in the streams and estuaries during periods of heavy runoff and spread with the currents in the estuarine system. A study of water flow from the mouth of a river throughout the estuarine system will reveal where high residues may be expected.

In studying the occurrence of pesticide residues in the estuarine system, we have sampled oysters, fish, and shore birds. The sedentary habit of the oyster, plus the biological magnification of residues up to 70,000 times more than the amount found in the water, makes this animal suitable for residue distribution studies. Without knowing the exposure period and residue level in the estuarine water, quantitative data would be doubtful at best.

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Young fish between 1 and 6 months of age are being used for additional residue data. In most instances our samples are composed of plankton feeders. This allows us to determine the amounts being accumulated at this particular trophic level in the food chain. Adult predator fish are analyzed to determine levels present and the amount in their reproductive organs. The highest step in the food chain from which our samples are taken is the fish-eating shore birds. These random bird samples have indicated unduly high residues present in those species examined. For example, a peregrine falcon contained 56 ppm of DDE in the liver and over 8 ppm of DDE in the brain. A white pelican contained DDE in the following amounts: 84 ppm in body flesh, 120 ppm in the liver, 18 ppm in the brain, 31 ppm in the heart, and 16 ppm in the kidney. In addition this same pelican contained over 2 ppm of dieldrin in some body parts, and polychlorinated biphenyl compounds ranging in concentration from 38 ppm in the brain to 115 ppm in body tissue.

The gain of persistent pesticide residues in the ecosystem is fairly constant. The incidence and amount have increased considerably since our monitoring program began in 1965. The residues of DDT have been found in over 80 per cent of the oyster samples analyzed. Incidence of dieldrin residue in oyster tissue samples has increased from less than 1 per cent in 1965 to 35 per cent in 1968. Other residues found were not in sufficient quantities, nor found often enough, to produce significant data. Incidence of pesticide residues in fish tissue is significantly higher than in oysters. Almost all fish samples analyzed contained the residue of DDT or its metabolites, 50 per cent contained dieldrin residue, and over 11 per cent contained endrin residue.

Although the oyster is an extremely valuable test animal, it does have its limitations. The oyster has the ability to accumulate and eliminate pesticide residues at a regular rate. This loss of residue prevents a quantitative analysis of the amount of exposure. Fish accumulate residues from both the surrounding water and the food they eat. The concentration in fish will vary with species, but will range from 10,000 to 40,000 times higher than the amount in the surrounding water. These accumulation rates will vary with species, composition of the diet, and the kind of chemical to which exposed. Fish, unlike the oyster, tend to store the accumulated residue in adipose tissue throughout the body and in various body organs. Seasonal growth, stress, disease, food supply, and reproduction may alter the level found at a given time in an individual or species. Shore birds feeding on contaminated fish also concentrate these chemicals. The random data gathered on these birds indicate that some species may be suffering damage from present levels. We have studied only those birds whose diet consists of fish or other estuarine species.

Examples of population decline may be demonstrated by the almost total disappearance of the brown pelican from the Texas Coast, and the reduction in numbers of reddish egrets. Numbers of birds reported to

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be nesting on Green Island in the Laguna Madre has decreased from 5,000 in 1950 to less than 200 at the present time. In 1968 an extensive survey by airplane revealed less than 1,000 reddish egrets on the entire Texas Coast.

Field data have shown that most of the oyster samples contain less than 1 ppm residue of DDT or its metabolites. The fish samples routinely contain from about 1 ppm to 3 ppm. Some samples have contained up to 5 ppm. The few bird samples examined have contained from 10 ppm to over 100 ppm of DDT or its metabolites as mentioned previously. Except in the case of shore birds that have been found dead and containing high pesticide residues, species mortality has not been verified.

After careful evaluation of data from our monitoring program and review of the current literature in the field, it appears that population changes due to pesticide poisoning carry the greatest threat to estuarine species. For example, if pesticide residue caused a 10 per cent decrease in survival of a species, at the end of 5 years, only 59 per cent of the original population level would remain. If we added such factors as reduced fertility, decreased life span, plus the accumulative effect of these various factors acting in combination, then we might begin to see how dramatic population changes could occur.

Pesticide application on the agricultural portion of the coastal plain increases as we progress south from Galveston Bay to the more tropical lower Laguna Madre. This application corresponds to the increasingly warm climate and the progression from one annual crop to two, or even three annual crops near the south end of the Coast.

Along with this increase in agricultural activity, comes increased application of pesticides per acre. Data from the monitoring program have shown a marked decrease in the number of young sea trout, Cynoscion nebulosus, in this area of high pesticide useage. In 1964 area biologists in the lower Laguna Madre caught 30 juvenile trout per acre in samples. By late 1965, this figure had dropped to 25 per acre. In 1966 the catch was 12 per acre. In 1968, sampling intensity was increased in an attempt to locate the missing juvenile trout. Over 100 samples were taken. The result of this sampling was that only 41 juvenile trout were caught in 15 acres. In June and July of 1969 over 200 samples in this same area yielded only 7 juvenile trout.

Examination of juvenile fish data showed that, in the areas with little DDT residue, the number of juvenile trout was higher than in those areas where DDT residue was high. Residues have ranged as high as 8 ppm in trout gonads and eggs. In some fresh water species 2.5 ppm in these same organs have caused 100 per cent mortality of juveniles.

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In order to give more credence to this data, I would like to state that, in 36 samples taken in St. Charles Bay, a total of 230 juvenile trout were caught, while in the southern Laguna Madre only 7 individuals were caught in 250 samples. As the number of trout per sample decreased our personnel increased the number of samples because they felt their sampling might be at fault, rather than fewer trout being present.

The present levels of chlorinated hydrocarbon pesticides in the estuarine environment are having no noticeable effects on the growth of either oysters, fish, or birds. However, since 1960 or 1961 our field biologists have noted a decrease in oyster spat set in some areas. This would indicate a decrease survival of young. As previously mentioned, data now indicate a decrease in the survival of young sea trout. An effort is now being made by our staff, as well as by other organizations, to determine the degree of decreased survival of young shore birds in these same areas.

Data are being accumulated on residue levels in both reproductive organs and eggs of sea trout and some shore birds. Areas in which samples have high residue levels in eggs and gonads are also the same areas where the smallest number of juvenile sea trout have been found.

These data indicate that, somewhere between the time of fertilization of the egg and the first few weeks of life, mortality is occurring. Whether this mortality is due to increased body burdens, stress, loss of ability to compete, or outright death from poisoning is not known.

Our monitoring program has shown that residues of several chlorinated hydrocarbon pesticides are present in varying amounts in estuarine species. Also shown is biological magnification through the food chain. In only two instances has residue increased due to direct exposure. After Hurricane Beulah, in 1967, and Hurricane Candy, in 1968, a brief increase in DDT rather than its metabolites indicates that exposure at that time was directly from the water rather than through the food chain. The impact of the chlorinated hydrocarbon compounds is noticeably appearing as an alteration in reproductive ability. Other less noticeable effects could also be occurring. These would be behavorial alteration and disruption of species balance.

The present monitoring program has documented the quantities of pesticides in various species, environmental distribution of pesticides, and the influence of pesticides on juvenile mortality.

Data not known include the volume of application in specific areas, the kinds of chemicals applied, the amounts present in streams and estuaries, and the scope of the long term effects from these chemicals.

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Our studies now focus on specific habitats, specific species, food organisms consumed, and changes in and among the various species in the environment. These items are needed to identify sites of danger, or to gain assurance of a lack of danger.

Where sites of danger have been located, such as in the lower Laguna Madre, sampling is being increased in order to define the area and determine the species affected.

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