Proceedings of Scotts Turfgrass Research Conference

Volume 1 - Entomology

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EDITORS

Herbert T. Streu
Department of Entomology and Economic Zoology
Rutgers University, New Brunswick, New Jersey

Richard T. Bangs
O. M. Scott and Sons Company
Marysville, Ohio

O. M. Scott and Sons Company • PUBLISHER
Marysville, Ohio

PREFACE

This Proceedings includes the papers presented by the conference speakers and the subsequent discussion by conference participants. It is the first Proceedings concerned with turfgrass research and treats Entomology, one of the many disciplines contributing to turfgrass management.

Participants at the conference included 29 scientists from 27 states and Scotts research staff. At that time, some states had little or no turfgrass entomology research activity and those assembled felt that this may have been the first gathering of so many entomologists interested in turfgrass insect research.

The conference was held at the research facilities of O. M. Scott and Sons Company, Marysville, Ohio, and is the first of a series. As such, the editors wish to thank the speakers and participants for their cooperation in bringing this volume to completion. Proceedings of Scotts Turfgrass Research Conference, Vol. 2 - Pathology, is now being prepared.

H. T. Streu

R. T. Bangs

CONTENTS

PARTICIPANTS

J. WAYNE BREWER
Assistant Professor
Department of Entomology
Colorado State University
Fort Collins, Colorado

JOHN E. CASIDA
Professor of Entomology
Division of Entomology
University of California
Berkeley, California

GORDON FIELD
Extension Entomologist
Cooperative Extension Service
University of Rhode Island
Kingston, Rhode Island

PHILIP J. HAMMAN
Associate Entomologist
Entomology Department
Texas A & M University
College Station, Texas

ELVIS A. HEINRICHS
Assistant Professor
Agricultural Biology Department
University of Tennessee
Knoxville, Tennessee

JAMES A. KAMM
Research Entomologist
Entomology Research Division
Oregon State University
Corvallis, Oregon

DAVID L. KEITH
Extension Entomologist
Department of Entomology
University of Nebraska
Lincoln, Nebraska

COSTAS KOUSKOLEKAS
Assistant Professor
Department of Zoology-Entomology
Auburn University
Auburn, Alabama

J. LARRY LUDKE
Department of Zoology
Mississippi State University
State College, Mississippi

DEAN K. MCBRIDE
Assistant Entomologist
North Dakota State University
Fargo, North Dakota

BURRUSS MCDANIEL
Associate Professor
Entomology-Zoology Department
South Dakota State University
Brookings, South Dakota

RICHARD L. MILLER
Extension Entomologist
Unit of Entomology and Economic Zoology
Ohio State University
Columbus, Ohio

GERALD J. MUSICK
Assistant Professor
Department of Entomology
Ohio Agricultural Research and Development Center
Wooster, Ohio

H. PAGE NICHOLSON
Chief
Water Contaminants Characterization Activity
Southeast Water Laboratory
Athens, Georgia

GORDON R. NIELSEN
Department of Entomology
The University of Vermont
Burlington, Vermont

ROLAND W. PORTMAN
Extension Entomologist
University of Idaho
Moscow, Idaho

STANLEY RACHESKY
Area Adviser-Pesticides
Entomologist
University of Illinois
Chicago, Illinois

ROSCOE RANDELL
Extension Specialist
Section of Economic Entomology
Illinois Natural History Survey
Urbana, Illinois

ROBERT L. ROBERTSON
Extension Entomologist
School of Agriculture and Life Sciences
North Carolina State University
Raleigh, North Carolina

JOSEPH L. SAUNDERS
Assistant Entomologist
Western Washington Research and Extension Center
Washington State University
Puyallup, Washington

DONALD L. SCHUDER
Professor in Entomology
Department of Entomology
Purdue University
Lafayette, Indiana

EVERETT SPACKMAN
Extension Entomologist
University of Wyoming
Laramie, Wyoming

LOYD L. STITT
Pesticide Specialist
Agricultural Biochemistry and Pest Control Division
University of Nevada
Reno, Nevada

HERBERT T. STREU
Associate Research Professor
Department of Entomology
Rutgers University
New Brunswick, New Jersey

THOMAS L. STRINGFELLOW
Assistant Professor of Entomology
University of Florida
Plantation Field Laboratory
Fort Lauderdale, Florida

HUGH E. THOMPSON
Associate Professor
Department of Entomology
Kansas State University
Manhattan, Kansas

GEORGE P. WENE
Associate Entomologist
Department of Entomology
University of Arizona
Tucson, Arizona

ELLSWORTH H. WHEELER
Professor of Entomology
Leader-Pesticide Chemicals Program
Department of Entomology
University of Massachusetts
Amherst, Massachusetts

THOMAS R. YONKE
Assistant Professor of Entomology
Department of Entomology
University of Missouri
Columbia, Missouri

TOXICOLOGY OF INSECTICIDES COMMONLY USED IN TURF MAINTENANCE

John E. Casida
Division of Entomology
University of California
Berkeley, California

There is an increasing awareness in the scientific community, and among the public as a whole, that insecticides must be properly used or the short and long term effects in man and on the environment will exceed tolerable limits. In the context of the seminar subject, this means that insecticides for turf maintenance must be properly used or more problems will be created than solved.

Most of these problems which may be created are general problems resulting from any use of insecticides. Within arthropod populations, destruction of pollinators, predators and parasites is of great concern. Resistance limits the period of time during which the insecticide can be used, at practical dosages, before there is a selection of resistant pest strains. Persistent chlorinated hydrocarbons do an excellent job of insect control but their use is, in all probability, going to decline because it appears that the effect of this continued use in the environment will exceed tolerable limits. It is abundantly clear that certain chlorinated hydrocarbons do give sizable residues in many parts of the environment and in human tissues, that these residues persist for a period of time, and that they do not, in some areas, degrade at a rate commensurate with their rate of introduction into the environment. There is a food chain accumulation potentially endangering certain birds and many vertebrate and invertebrate animals of the lakes and oceans. Situations of insecticide misuse have resulted in proposals, which have gained support, to restrict or even ban selected insecticide chemicals. Thus, there is justification for considering the persistence, degradation and toxicology of insecticides used in turfgrass entomology.

Insect control in turf differs somewhat from that in agricultural situations. One major problem in agricultural entomology, that of residues in food or feed, is not present in turfgrass entomology. Lawn treatment frequently involves mixtures of pesticides, or of pesticides with fertilizers and/or seed. These chemicals, individually or in mixtures, may be stored for years by the homeowner before use and, consequently, package and storage stability become of great importance. Insecticides generally are applied to agricultural areas by experienced persons, or under the advisement of qualified agents. This is not the case with turfgrass treatment where the user has little or no supervision and no instructions except those on the package label or, possibly, those provided by the nurseryman. Children and pets are potentially exposed much more than in any other area of insecticide usage outdoors. Turf treatment occurs in surburban and urban areas under a tremendous range of climatic conditions. Extensive areas are treated, and not at dosages comparable to those used in agriculture, but rather at 2 to 5 times the dosage levels used in agriculture. Turfgrass treatments possibly are a significant source of environmental contamination by insecticides persisting in the soil or washing off in the surface or ground waters.

My future discussion will concentrate on four insecticides frequently present in lawn-care products. These insecticides represent four different chemical types, each of a different mode of action and persistence characteristics. Fortunately, each of these four chemicals is the one of its class that will do the job with minimum hazard. Pyrethrins, piperonyl butoxide and methoxychlor are used for control of nuisance insects in the lawn. Chlordane, at about 5 lb/acre, and carbaryl, at the same dosage level, are important turfgrass insecticides. Let us consider these compounds in sequence.

Pyrethrins and Piperonyl Butoxide

An important crop in some parts of the world, particularly Kenya, is a species of chrysanthemum, Chrysanthemum cinerariaefolium, containing the insecticidal pyrethrins, which are obtained as a crude extract by appropriate extraction of the dried flowers. The powdered flowers have actually been used in insect control for at least 150 years. The extract contains six insecticidal esters, the most important being the pyrethrins, illustrated by pyrethrin I (Fig. 1). Pyrethrin I is a very complex chemical containing only carbon, hydrogen and oxygen. It is an ester with a cyclopropane group, a cyclopentenolone group and two unsaturated side chains. There are 16 possible isomers, but only the one shown occurs naturally.

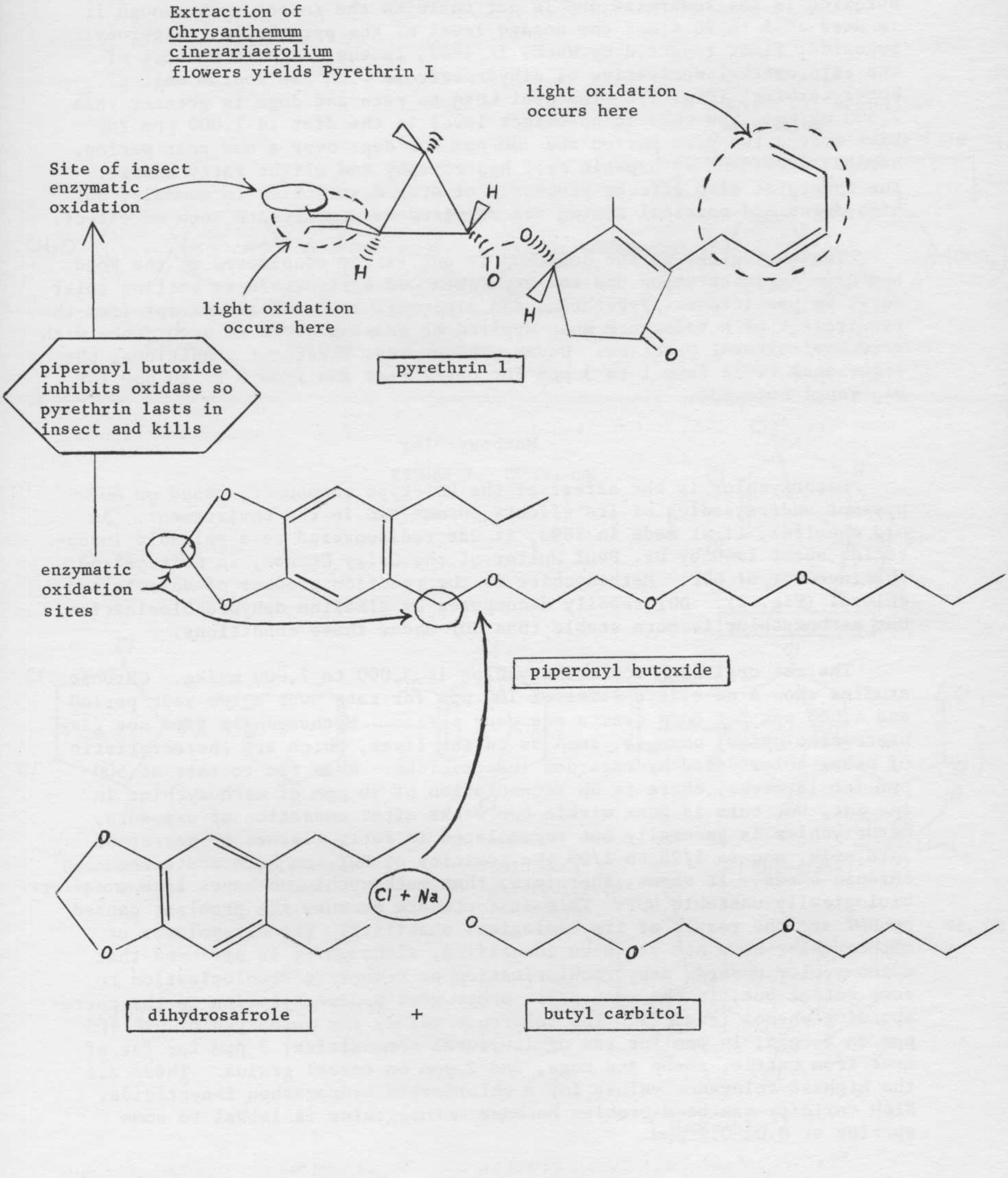
The safety of pyrethrins is established, in part, by studies with rats. The oral LD_{50} is 200 mg/kg and the dermal LD_{50} is greater than 1,800 mg/kg. When incorporated into the rat diet, no effect on the rat is detected at 1,000 ppm; at higher levels hepatic damage consists of slight bile duct proliferation. A dose just below the acute lethal dose can be administered daily for the lifetime of rats with little or no injury. There is no indication of tumor production.

Human poisoning by pyrethrins is very unlikely. They are generally considered to be the safest insecticide in use. This is partially so because of their long history of use without harmful consequences. In fact, they have ever been used without ill effects by oral administration as anthelmintics. Pyrethrins are poorly absorbed through the skin and are of low inhalation toxicity. Symptoms of acute poisoning are nervous manifestations. The safety of pyrethrins is probably the result of rapid breakdown or detoxification in the mammal, although the chemistry of this breakdown in the body is not fully understood. Injury is most frequently the result of an allergenic factor in the pyrethrins which gives a contact dermatitis similar to pollinosis, or an asthma-type reaction in a few sensitive persons, frequently those with a broad allergic background.

Pyrethrins are never a residue problem when they are exposed, even briefly, to light. These materials are very light unstable, undergoing oxidation to non-toxic products by chemical changes on the two ends of the molecule (Fig. 1). Pyrethrins will not accumulate as environmental contaminants. Any problems resulting from their use will be from those organisms initially exposed. They are toxic to fish. Many species suffer paraylsis or death from dosages in the range of 0.1 to 10 ppm.

Insects break down pyrethrins rapidly by an oxidative enzymatic process forming a non-toxic derivative (Fig. 1). This breakdown is so rapid that a second chemical, piperonyl butoxide, is usually added to impede

FIGURE 1: PYRETHRIN 1 AND PIPERONYL BUTOXIDE



the process (Fig. 1). Both materials are oxidized in the insect so when both are present at the same time, piperonyl butoxide can spare the pyrethrin from destruction. Pyrethrins are the insecticide. Piperonyl butoxide is the synergist and is not toxic to the insect even though it is used at 5 to 20 times the dosage level of the pyrethrins. Piperonyl butoxide, first reported by Wachs in 1947, is the reaction product of the chloromethyl derivative of dihydrosafrole with the sodium salt of butyl carbitol (Fig. 1). The oral LD_{50} to rats and dogs is greater than 7,500 mg/kg. The chronic no-effect level in the diet is 1,000 ppm for rats over a two year period and 700 ppm for dogs over a one year period. Damage is evident as hepatic cell hypertrophy and slight fatty change. The synergist also affects processes of drug destruction in mammals, but high doses and critical timing are required to demonstrate such an effect.

The toxicology of the compound is one factor considered by the Food and Drug Administration and the Department of Agriculture in setting tolerances on pesticides. Pyrethrins and piperonyl butoxide are exempt from the requirement of a tolerance when applied to growing crops in accordance with good agricultural practice. Under post-harvest treatment conditions, the tolerances range from 1 to 3 ppm for pyrethrins and from 8 to 20 ppm for piperonyl butoxide.

Methoxychlor

Methoxychlor is the safest of the DDT-type compounds, based on our present understanding of its effects on man and in the environment. An old chemical, first made in 1893, it was rediscovered as a valuable insecticide about 1940 by Dr. Paul Muller of the Geigy Company in Switzerland, the inventor of DDT. Methoxychlor is the reaction product of anisole and chloral (Fig. 2). DDT readily decomposes by alkaline dehydrochlorination, but methoxychlor is more stable than DDT under these conditions.

The rat oral LD_{50} for methoxychlor is 5,000 to 7,000 mg/kg. Chronic studies show a no-effect level of 100 ppm for rats over a two year period and 4,000 ppm for dogs over a one year period. Methoxychlor does not give histopathological changes, such as in the liver, which are characteristic of other chlorinated hydrocarbon insecticides. When fed to rats at 500 ppm for 18 weeks, there is an accumulation of 30 ppm of methoxychlor in the fat, but this is gone within two weeks after cessation of exposure. Methoxychlor is generally not accumulated in fatty tissues or secreted into milk, and is 1/25 to 1/50 the toxicity of DDT, on both acute and chronic bases. It seems, therefore, that methoxychlor behaves like a biologically unstable DDT. This is fortunate because the problems caused by DDT are the result of its biological stability. The metabolites of methoxychlor have not yet been identified, although it is presumed that methoxychlor undergo dehydrochlorination or reductive dechlorination to some extent but, in the most part, under goes O-demethylation to the corresponding phenol (Fig. 2). The tolerance values for methoxychlor are 100 ppm on forage; 14 ppm for raw agricultural commodities; 3 ppm for fat of meat from cattle, sheep and hogs, and 2 ppm on cereal grains. These are the highest tolerance values for a chlorinated hydrocarbon insecticide. Fish toxicity can be a problem because methoxychlor is lethal to some species at 0.02-0.2 ppm.

FIGURE 2: METHOXYCHLOR

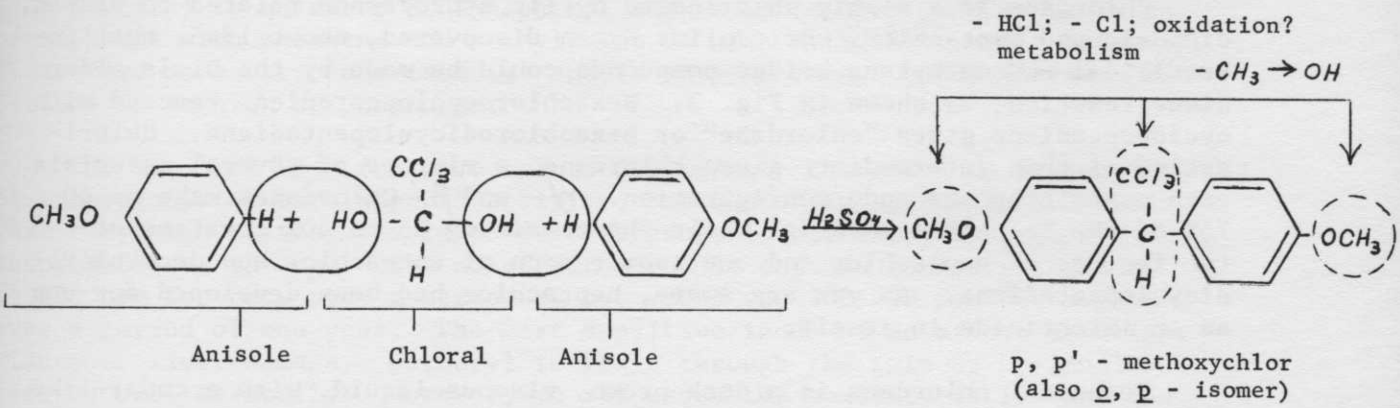
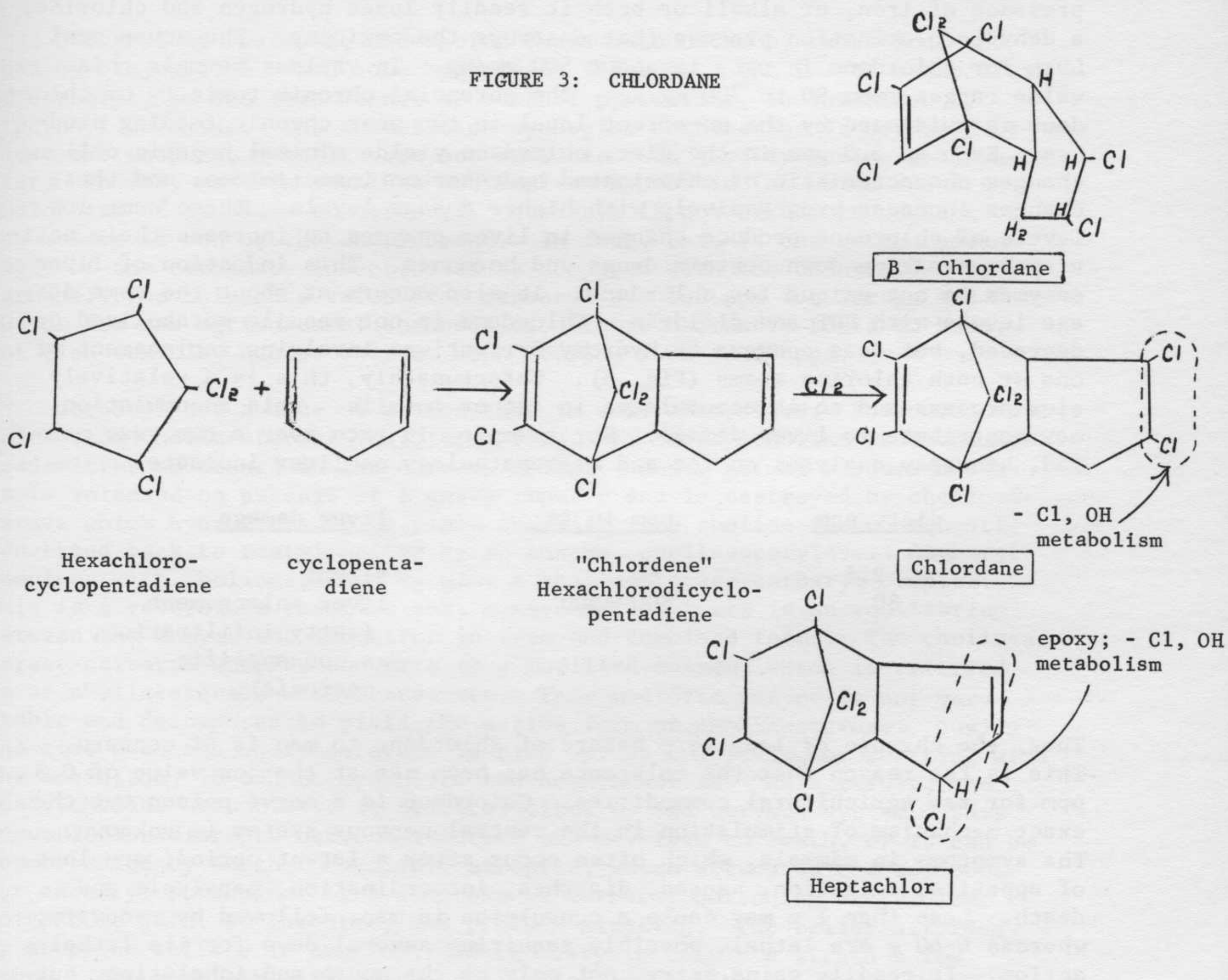


FIGURE 3: CHLORDANE



The toxicity and persistence of methoxychlor have not been reinvestigated in recent years, as has been done so extensively with DDT. However, should this be done, there is every reason to believe that the indicated biological instability and safety of methoxychlor will be confirmed.

Chlordane

Chlordane is a highly chlorinated cyclic hydrocarbon related to aldrin, dieldrin and heptachlor. Dr. Julius Hyman discovered, about 1945, that insecticidal endomethylene bridge compounds could be made by the Diels-Alder diene reaction, as shown in Fig. 3. Hexachlorocyclopentadiene reacted with cyclopentadiene gives "chlordene" or hexachlorodicyclopentadiene. Chlorination of this intermediate gives chlordane, a mixture of several materials each containing the endo configuration. α- and β-Chlordanes make up 60-75% of the technical material while the remaining 25 to 40% consists of two isomers of heptachlor and one isomer each of enneachlor and decachlorodicyclopentadiene. As you are aware, heptachlor had been developed for use as an insecticide in itself.

Technical chlordane is a dark brown, viscous liquid, with a cedar-like odor, which is insoluble in water but soluble in organic solvents. In the presence of iron, or alkali or both it readily loses hydrogen and chlorine, a dehydrochlorination process that destroys the toxicity. The acute oral LD_{50} for chlordane in rats is about 500 mg/kg. In various mammals this value ranges from 80 to 700 mg/kg. The potential chronic toxicity of chlordane is evidenced by the no-effect level in two year chronic feeding studies. Even at 2.5 ppm in the diet, chlordane yields minimal hepatic cell changes characteristic of chlorinated hydrocarbon insecticides, and these changes increase progressively with higher dosage levels. These same low levels of chlordane produce changes in liver enzymes to increase their activity in breaking down certain drugs and hormones. This induction of liver enzymes is not unique for chlordane. It also occurs at about the same dosage levels with DDT and dieldrin. Chlordane is not readily metabolized or degraded, but does convert to hydroxy derivatives involving replacement of one or both chlorine atoms (Fig. 3). Unfortunately, this is a relatively slow process and so it accumulates in fat or in milk. This accumulation may contribute to liver damage. For example, in rats over a two year period, bioassay analyses on fat and histopathology on liver indicate:

diet, ppm	ppm in fat	liver damage
2.5	80	slight
80	800-4500	liver enlargement (fatty infiltration, a non-specific necrosis).

Thus, the chronic or long-term hazard of chlordane to man is of concern. This is the reason that the tolerance has been set at the low value of 0.3 ppm for raw agricultural commodities. Chlordane is a nerve poison but the exact mechanism of stimulation in the central nervous system is unknown. The symptoms in mammals, which often occur after a latent period, are loss of appetite, agitation, nausea, diarrhea, incoordination, paralysis and death. Less than 1 g may cause a convulsion in man, followed by recovery; whereas 6-60 g are lethal, possibly requiring several days for its lethal action. It readily gains entry, not only by the mouth and inhalation, but also through the skin.

Fish kill occurs at 0.2 to 2 ppm, or at dosages of about 1 lb/A. Chlordane is also highly toxic to bees. Most important, it is a persistent compound and may accumulate in the environment, unless used with great care.

Carbaryl

Carbaryl is an ester of 1-naphthol and carbamic acid made by reaction of naphthol with phosgene and methylamine or with methylisocyanate (Fig. 4). It is used as a very pure material and is staple, except under alkaline conditions or at high temperatures.

The rat oral LD_{50} for carbaryl is 540 mg/kg. There are no indications of tumorogenic or carcinogenic activity, but there are recent indications that very high dietary levels produce teratogenic effects (embryonic abnormalities) in dogs. The no-effect level in chronic toxicity studies is 200 ppm for rats over a period of two years and 200-400 ppm for dogs over a period of one year. The most sensitive index of an effect is slight kidney or liver damage. Carbaryl is toxic through the skin or by inhalation as well as orally. However, in all cases the toxicity is low and the toxic hazard is not of great concern under normal use conditions.

Carbaryl is unstable, undergoing rapid metabolism by oxidation, and then by conjugation, with some hydrolysis (Fig. 4). The insect metabolism of carbaryl, in the same manner as that of pyrethrins, is inhibited by piperonyl butoxide. The insecticide-synergist combination is not used because the economic benefits are not sufficient to justify adding the synergist. In man, certain naphthol derivatives appear in the urine and are indicative of exposure to carbaryl. Carbaryl is not likely to persist or accumulate in man or the environment. In fact, this is one of the advantages of the carbamate insecticides as compared with the chlorinated hydrocarbons. The tolerance values for carbaryl are 100 ppm for forage and 5 to 10 ppm for raw agricultural commodities. It is extremely toxic to bees, but fish toxicity occurs only at high levels, such as 25 ppm.

Carbaryl has a mode of action that is well understood. Poisoning results from cholinesterase inhibition (Fig. 5). Acetylcholine is a chemical transmitter substance in the nervous system. Under normal circumstances, it is released on passage of a nerve impulse and is destroyed by cholinesterase which hydrolyzes it to yield choline. The choline is subsequently converted back to acetylcholine by an enzyme, cholineacetylase. Carbaryl combines with cholinesterase to give a cholinesterase-carbaryl complex. This is a reversible reaction and, consequently, there is an equilibrium between the enzyme and inhibitor in free and combined forms. The cholinesterase-carbaryl complex converts to a modified enzyme, which is referred to as cholinesterase-methylcarbamate. This modified enzyme is not very stable and decomposes to yield the active form of cholinesterase. During the time when the cholinesterase is tied up, by complexing or reacting with the inhibitor, it cannot hydrolyze the acetylcholine. As a result, the acetylcholine accumulates at critical sites in the nervous system. This accumulation disrupts nervous function and may lead to death, or it can be counteracted by another chemical, atropine, which serves as the antidote for carbaryl poisoning. The symptoms of carbaryl poisoning are violent epigastric pain, if ingested, and profush sweating. The relief afforded by atropine sulfate is amazing, and recovery is complete within a few hours. The reversibility of the cholinesterase inhibition means that, in contrast to organophosphate insecticide chemicals, a blood cholinesterase

FIGURE 4: CARBARYL

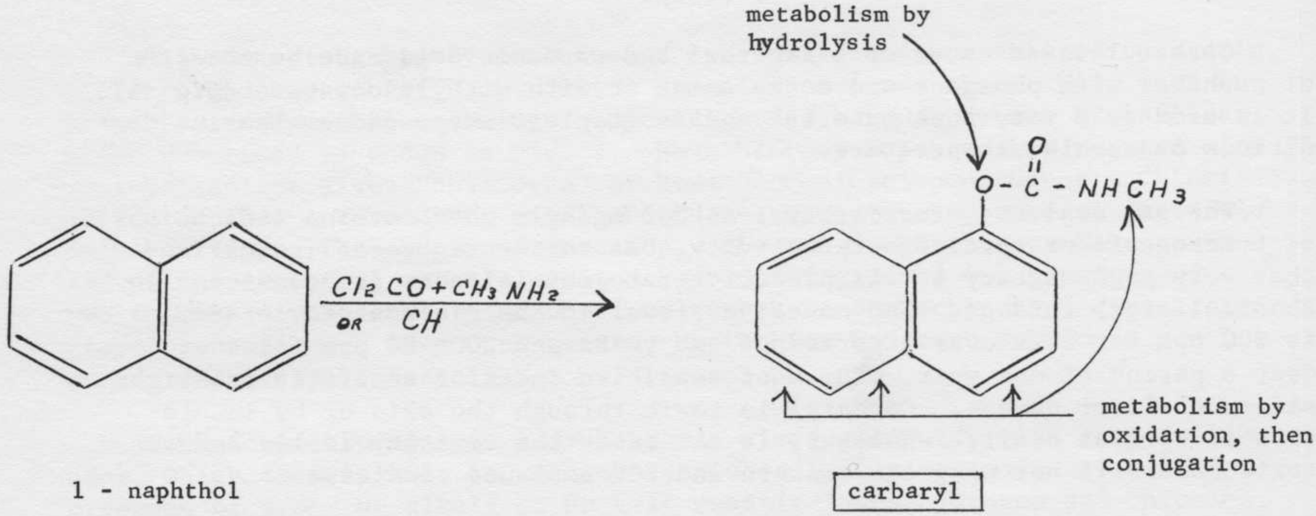
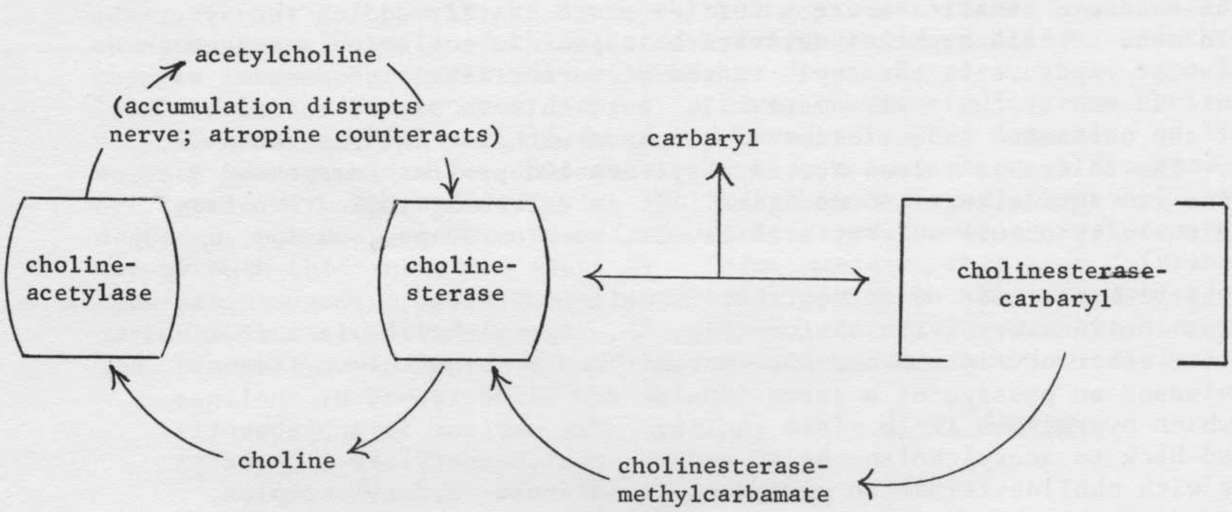


FIGURE 5: CARBARYL MODE OF ACTION IN NERVE



sample will not give a good indication of exposure by showing strong inhibition of activity. The activity probably will be reversed in the course of assay and appear normal even though a potentially hazardous exposure had occurred. Because carbaryl is rapidly metabolized and the cholinesterase inhibition is reversible, the daily tolerated dose of carbaryl is only slightly less than the acute hazardous dose.

Summary

Large amounts of insecticides are used in the treatment of turf. Careful judgment must be exercised in selecting insecticides and conditions for use in order that effective control is accomplished with minimum environmental contamination and hazard to non-pest animals. Pyrethrum, piperonyl butoxide and methoxychlor are considered to be safe under normal conditions. Chlordane is a persistent toxicant which stays in the soil for many months, or years. It has high toxicity to beneficial insects, fish and mammals, the latter suffering changes in liver histopathology and function at very low dosage levels. Great care must be exercised to prevent contamination of other parts of the environment by chlordane as it is applied for turfgrass insect control. Carbaryl is effective and is less persistent and hazardous than chlordane.

Careful consideration should be given now to the alternatives, in the way of chemicals or control procedures, to minimize the use of large amounts of persistent chlorinated hydrocarbon insecticide chemicals in the treatment of turf.

DISCUSSION PERIOD

Mr. Portman: Dr. Casida, what per cent of heptachlor appears in chlordane? In other words, can we say that chlordane is comprised of 5%, 2% or 1% heptachlor?

Dr. Casida: The heptachlor content is small and probably depends on the manufacturing conditions.

Dr. Wheeler: I was a little surprised you did not include diazinon in your list of chemical controls. Would you care to comment on materials of that nature?

Dr. Casida: From a toxicology standpoint, diazinon, except under certain storage conditions, is a relatively safe phosphate, both from the aspect of acute and chronic toxicity. One problem that can occur is that in the storage of diazinon, there is a chance of picking up a small amount of water which initiates a reaction leading to the production of monothio tepp. To prevent formation of this toxic product, care must be exercised in storage, particularly of technical diazinon. Otherwise, the toxicology of diazinon is similar to that of parathion, except that it requires a much higher dose to elicit the same toxicity, both acute and chronic.

Dr. Musick: Dr. Casida, would you like to make a comparison of the relative mammalian toxicity of the OP's in comparison to the carbamates?

Dr. Casida: I have had occasion to work with hundreds of OP's and carbamates and I find it rather difficult to generalize. The range within each group from materials of an acute oral LD_{50} could be less than 1/10 mg/kg to more than a thousand. There are broad ranges in the chronic toxicity with each type of insecticide so you have to be specific in comparing them from a toxicity standpoint. There is a possibility of generalizing in some aspects of their action. When the phosphates inhibit cholinesterase they form a phosphoryl cholinesterase that is quite stable; therefore, the cholinesterase inhibition may be prolonged. With the carbamates, the inhibited cholinesterase is a carbamoylated enzyme which has a relatively short half-life. Cholinesterase inhibition is usually not detected except under special assay conditions.

Dr. Heinrichs: Can you tell me why phosphates break down so much faster than the chlorinated hydrocarbons? What is involved here chemically?

Dr. Casida: The phosphates act by inhibiting cholinesterase. To do so, they react as an anhydride to phosphorylate the enzyme. By a somewhat similar mechanism, they will react with water and this hydrolysis can be catalyzed by certain enzymes, phosphatases or esterases, so there is a device to break them down that is not available for the chlorinated hydrocarbons. Usually, the chlorinated hydrocarbons can only be oxidized or dehydrochlorinated.

Dr. Stringfellow: You have mentioned that atropine might be used for counteracting an overdose of cyanide. How about the use of Tupam?

Dr. Casida: Tupam shouldn't be used for carbaryl poisoning. Animal studies indicate that the use of Tupam might be harmful.

Dr. Wheeler: Several thousand pounds of chlordane have been used safely over the last 15-20 years by homeowners. It is not picked up in diet studies, except very infrequently, and as far as I know, it hasn't been monitored in fish and other forms of life. Yet, I got the idea from your discussion that we may be dealing with a more hazardous material than I had thought. How do you bring those two observations together - wide experience, and the fact that you think of it as a rather hazardous material?

Dr. Casida: Chlordane, because of its biological and chemical instability, is less hazardous than other endomethylene bridged chlorinated cyclodienes (aldrin, endrin, dieldrin, etc.), but it still has a greater persistence than the other materials I discussed. It has an effect on liver pathology at a relatively low level. I do not have as much information on the actual persistence of chlordane as I would like.

Dr. Wene: Have you ever made studies on the breakdown of DDT and chlordane in the soil? In Arizona we find that it takes about a year for the half-life of DDT. What has your research shown?

Dr. Casida: My personal research has not dealt with the fate of these in the soil.

Mr. Portman: Could you tell us or give us a definition of the term half-life in relation to pesticides?

Dr. Casida: It is a convenient term, but it does not have much validity. It may be used to designate the amount of time necessary for half of the applied material to disappear. A first order disappearance curve is implied, which means there is one primary factor that initiates and continues to be the limiting factor in the disappearance, and this is usually not the case. Initially, the compound may volatilize or wash off. In addition, it may photodecompose or penetrate. There may be redistribution and metabolic fate problems as well as photodecomposition, so the slope of the degradation curve changes greatly. The first half-life may be one day; the second half-life may be ten days; the third half-life may be one year.

Dr. Thompson: You talked about degradation products with a sort of implication that these products are going to be less toxic than the original material. We had a graduate student in our department a few years ago who was applying malathion to bean plants. He put them under ultraviolet and infrared lights and came up with malaoxon. As I remember, that is a much more toxic material to warm-blooded animals than the original material. How often does this happen?

Dr. Casida: Frequently. These reactions are usually taken into consideration in deriving tolerance values. The phosphorothionates (such as malathion) undergo both metabolic and light-induced oxidations of the phosphorothionate grouping to the oxygen analog (such as malaoxon or paraoxon or others). There is some indication that you can also get an isomerization of the sulphur to a S-alkyl derivative, which is also toxic. But the prominent reaction is the oxidation to the oxygen analog. There are many other oxidations of phosphates that, again, are photo- or biological-induced and yield active products. The same holds for some of the carbamates. The most prominent activation reactions within the chlorinated hydrocarbons are those involving the photoisomerization of aldrin, dieldrin, endrin and related compounds. The mammalian toxicology is somewhat similar for the photodegradation products and the original compound. Some of these form quite readily and are difficult to separate by gas chromatography.

Dr. Wheeler: Speaking as a toxicologist, and without political leanings, would you give us your very candid and frank opinion regarding the situation with respect to DDT and some of the other chlorinated hydrocarbons? Should they be restricted?

Dr. Casida: I concur with the recommendations of the Committee on Persistent Pesticides of the Division of Biology and Agriculture, National Research Council, in this respect. This Committee carefully considered the large body of evidence and came up with seven recommendations, the first four of which are:

1. That further and more effective steps be taken to reduce the needless or inadvertent release of persistent pesticides into the environment.

2. That, in the public interest, action be increased at international, national and local levels to minimize environmental contamination where the use of persistent pesticides remains advisable.

3. That studies of the possible long-term effects of low levels of persistent pesticides on man and other mammals be intensified.

4. That efforts to assess the behavior of persistent pesticides and their ecological implications in the environment be expanded and intensified.

Dr. Schuder: Dr. Casida, I am sure there is no question about the toxicology of some of these things. Most of us don't want to use toxic materials that are a hazard to ourselves, pets, friends or our neighbors. Would you care to comment a little on the difference between hazard and toxicology? Hazard, the way it's formulated; hazard, the way it is used?

Dr. Casida: The LD_{50} values are obviously not a direct indication of the hazard of a compound in use. To begin with, these values are obtained with rats or laboratory animals and not with man. Further, the hazard depends upon how much you use and how you use it. There are two general types of exposure: one is acute-that from an exposure within a 24-hour period; the other is chronic, or long-term exposure. The hazard from phosphates is largely from acute (or subacute) exposure. The chlorinated hydrocarbons, with the exception of endrin, isodrin and a few related compounds which are readily absorbed through the skin, tend to be hazardous from the chronic rather than the acute standpoint. If you could put the question more specifically, I might be able to make my comment more precise.

Dr. Schuder: What I am really getting at is that the materials under the loose term of "hard" pesticides are now under severe criticism. This is forcing us, as entomologists, to move from some of the materials we liked to use because they had a long residual period, which is essential for the control of grubs, borers in trees, etc. In general, we must go to the phosphates to get the job done. These various influences, in many instances, are forcing us to use a material that is an acute hazard. I was wondering if this is a wise way to go as far as the toxicologist is concerned.

Dr. Casida: You are asking some rather intriguing questions. It is clear that the cost of the persistent chlorinated hydrocarbons in man and on the environment has approached a tolerable limit. In my view it is necessary to replace the persistent chlorinated hydrocarbons wherever it is possible. There are not replacement compounds in all cases. There is a compromise in almost every case where a phosphate or a carbamate is used to replace a chlorinated hydrocarbon. You will not get the persistence of control you are used to. There are other types of compounds that are potentially marketable within the next couple of years. They are on the drawing boards. I don't think they will replace the chlorinated hydrocarbons in the same sense we are used to. What you want is a "hard" pesticide that is so selective in its toxicity that no one is going to be concerned about its persistence. That is a rather difficult property to find. You may find highly selective compounds but if they are too selective, it may be economically unfeasible to market them.

Dr. Saunders: When you started off, Dr. Schuder, I thought you were asking this question. As an example, I'll use Temik, the toxicology of which is quite severe; but through formulation, you get a product that is quite easily handled. Do we consider this enough when we are working with these insecticides? Several workers have said, "I won't touch the stuff," when actually it is easier to work with than some of the materials they are handling. On the same line, we are now using ultra-low-volume quite a lot. Ultra-low-volume is completely different because we are doing away with the water. We no longer have the same pesticide. We have a completely different pesticide for practical consideration, although it's the same basic compound. Would you comment on that, Dr. Casida?

Dr. Casida: Well, you certainly have a different toxicological picture with each change in formulation. For example, a relatively pure, unformulated pesticide may actually increase in toxicity as you dilute it with certain carrier solvents, if these solvents enhance penetration through the skin. From the standpoint of the applicator, the toxicology should be based on the formulation and the dose that is actually being used, rather than on the technical insecticide chemical.

Dr. Miller: I just want to comment on Dr. Schuder's statement. As we move away from the chlorinated hydrocarbons and some of the materials we have been using, I think we had better brace ourselves for some very interesting happenings. We have experienced one of them already, using methyl parathion for alfalfa weevil control. When we were using methoxychlor, Alfatox and some of these other materials, bees that were working in treated fields would get a little groggy and maybe fly back to the hive, fall down a few times and shake the material off, but now they don't even get back to the hive. They are just barely able to get out of the field.

Mr. Simmons: I would like to make one comment concerning this business of chemicals. I hope we can look forward to somehow resolving the controversy that now exists. Then industry and academic scientists, putting their efforts into the development of new chemistry, will lead the way to new methods of control. I think we have demonstrated that this can be done; that we can develop selective, broad spectrum and safe methods of control. All we need to do is direct our energies towards this goal.

CONTROL OF SOUTHERN CHINCH BUG,

BLISSUS INSULARIS,

IN BRAZOS COUNTY, TEXAS

Philip J. Hamman
Associate Entomologist
Agricultural Extension Service
of Texas A & M University
College Station, Texas

The following discussion is based upon work in extension entomology that has been done in Texas on ornamentals and turfgrass. The research effort, therefore, is necessarily of an applied nature or results from demonstrations.

The work done in 1967 and 1968 on the control of the southern chinch bug (Blissus insularis Barber) was necessary because this is the number one turfgrass pest in our state. Damaging populations have been present since the early 1950's but have increased considerably in the last 4 or 5 years. It is very difficult, even in the rainy years, to maintain a St. Augustinegrass lawn without having some chinch bug problem. The insect is confined to those areas where St. Augustinegrass is grown, which extends from the lower Rio Grande Valley northward to just south of the San Antonio area and east along the gulf coast and north into east Texas.

Homeowners were failing to achieve effective control and we attempted to find some of the reasons. The objectives of our tests were to determine if applications at certain times of the year would reduce chinch bug populations and prevent damage. Also, we wanted to find the best method of application and formulation to be used.

Ten lawns in Brazos county that had a previous history of chinch bug infestations were selected. Dursban, ethion, Trithion and, later, Akton and Aspon+DDT were applied in both the EC and granular formulations. All applications were made using equipment normally employed by the homeowner; that is, the "hose-on" applicator for EC formulations and the cyclone spreader for granules.

Pre- and post- treatment chinch bug populations were determined by the modified can method using a piece of irrigation pipe, sharpened and serrated on one edge, which was pushed into the soil and filled with water. The number of chinch bugs that floated to the top in a 10 minute period were counted. All materials and formulations performed equally as well, with the exception of diazinon EC. We found that Dursban, Akton and Aspon+DDT in either formulation performed a little better than the other materials in the length of control. During the two years we also found that two applications controlled chinch bugs effectively without grass damage.

In some instances, homeowners wait until damage is apparent or quite extensive before applying some type of control measure. Then, even if chinch bugs are controlled, dead areas in the lawns may result. We were attempting to provide information by which a homeowner could make insecticide applications at a certain period of the season and not only prevent damage, but also control chinch bugs.

Table 1. Southern chinch bug population data reflecting the performance of the materials used (see Table 2.) in controlling this lawn pest, Brazos County, 1967.

Lawn	Pre-Treatment Counts[1/] (avg. no. chinch bug/ sq ft)	Post-Treatment Infestation Counts [2/] (avg. no. chinch bug/sq ft) — Weeks After Treatment: 4	5	6	7	8	9	10	11	12	13+
1	3	0	-	-	-	2	-	-	-	1	retreated
		2	-	4	14	retreated					
		0	-	-	2	-	-	4	-	-	6
2	8	0	-	2	-	4	-	12	-	45	retreated
		1	-	4	-	7	-	14	-	32	
3	8	0	-	-	1	-	2	-	-	0	retreated
		0	-	2	-	4	-	10	22	83	
4	2	0	-	1	-	0	-	2	-	retreated	
		0	-	0	-	1	-	1	0	0	2
5	9	1	-	-	0	-	-	1	-	2	
		0	-	-	1	-	-	2	-	2	
6	24	0	-	-	1	-	-	2	-	2	retreated
		0	-	-	2	-	-	1	-	0	4
7	15	0	-	-	1	-	-	2	retreated		
		0	-	-	2	-	-	4	-	-	3
8	27	0	1	-	-	1	-	2	0	0	0
9	45	0	1	-	-	1	-	-	2	-	-
10	183	1	2	-	-	2	-	-	4	-	-

1/ Population counts made just prior to initial application.

2/ Damage is generally observed soon after populations reach an average of 10 per square foot.

Table 2. Breakdown of treatments showing materials and formulations used, rates, date of initial treatment and dates of treatment in southern chinch bug control demonstrations in Brazos County, 1967.

Lawn	Area Treated (sq ft)	Insecticides	Formulation[1/]	Rate (Formulation/ 1000 sq ft)	Rate (lbs actual/ 1000 sq ft)	Initial Treatment Date	Retreated
1	9,000	Dursban	1% G	2.87 lb	0.0287	April 17	July 12 Sept. 2
2	4,454	Diazinon	4 lb/gal EC	0.8 cup	0.2	April 20	July 12
3	7,475	Diazinon	14.3% G	1.4 lb	0.2	April 20	July 12
4	13,800	Carbophenothion (Trithion)	5% G	4 lb	0.2	April 22	July 9
5	4,000	Ethion	4 lb/gal EC	0.8 cup	0.2	May 9	Aug. 4
6	18,000	Ethion	5% G	4 lb	0.2	May 24	Aug. 4
7	15,000	Carbophenothion (Trithion)	2 lb/gal EC	1.6 cup	0.2	May 26	Aug. 4
8	8,000	Aspon+DDT	3.2 Aspon + 4.4% DDT granule	6.3 lb	0.2 (Aspon)	July 27	---
9	11,000	Akton	1% G	4 lb	0.04	Aug. 4	---
10	8,700	Aspon+DDT	3.2% Aspon 4.4% DDT	6.3 lb	0.2 (Aspon)	Aug. 21	---

1/ G = granular formulation
EC = emulsifiable concentrate

Data in Table 1 show results from tests in ten lawns, the insecticides tested, rates of application and initial treatment dates and retreatment dates. In the south central area of the state and in a large area of the gulf coast region, an initial application in late April, followed by a second application in mid-July, effectively controlled chinch bugs and prevented damage. Insecticides, formulations, rates of application and treatment dates are presented in Table 2. Low pretreatment counts (Table 1) were made in lawns which had been watered extensively. The work was initiated in 1967, an exceptionally dry year. We had a dry winter, spring and summer, and it seemed that chinch bugs appeared in this area from the time the grass started to "green-up." Test results were quite variable in 1968 due to wet weather. Actually, chinch bugs didn't appear until the last of July or first of August, and then populations built up rather slowly. In treatments with the diazinon EC formulation, at the end of the 12 week period there was a considerable population build-up to around 45 chinch bugs per sq ft. The rest of the materials in the test-Trithion, Dursban, ethion, Akton and Aspon+DDT-were effective in controlling chinch bugs and reducing populations. We found that around 20 chinch bugs per sq ft would cause visible damage. I think Tom Stringfellow's data from Florida puts this number around 30 per sq ft.

(Editor's Note: Questions directed to Dr. Hamman were withheld until after Dr. Stringfellow's presentation.)

TURFGRASS INSECT RESEARCH IN FLORIDA

Thomas L. Stringfellow, Entomologist
Plant Field Laboratory
University of Florida
Fort Lauderdale, Florida

Introduction

In the Homestead area, farming is done in broken coral rock; and in Ft. Lauderdale, on sand. Irrigation in these areas is very important. When discussing control of chinch bugs (Florida's most important turf pest), 30 gal of water per 1,000 sq ft is suggested to drench treatments into the soil. No distinction is made between granular materials, wettable powders or emulsifiable concentrates for control of these insects. For granules, 30 gal of water per 1,000 sq ft should be applied to "wet" the granules in. This is several thousands of gallons of water per acre on the greater part of Florida's sod-farm production. Consequently, one of our major research efforts is to determine if some of the wetting agents will allow a reduction in the amount of water applied per acre. Even a 25% reduction in the amount of water used for insecticide applications would amount to a substantial saving.

Ft. Lauderdale is probably in the epicenter of chinch bug activity. This insect, once identified as Blissus leucopteris insularis, has now been elevated to Blissus insularis (formerly known as the lawn chinch bug) and is known as the "southern chinch bug."

A typical sod field of FB 137, No-Mow bermudagrass in a turf nursery in the Palm Beach area severely infested with sod webworms is shown in Fig. 1. There are two groups of webworms in Florida, the Pachyzancla spp. and the Crambus spp., which are commonly encountered in more northern areas.

Sod Webworm Research

Two species of webworms in the genus Pachyzancla are shown in Fig. 2. In addition, Mocis spp., or grass loopers, as well as armyworms infest Florida turf. Problems with these pests are usually limited to the rainy seasons. In June and July, during the dry season, populations diminish and during the second rainy season in August and September, they build up again.

We used 10 ft by 10 ft plots replicated four times in experiments for control of sod webworms. Ten minute counts of 4 sq ft sections within each plot were made. Starting at one corner and leaving a 2 ft border inside the plot, counts were made throughout each plot so that no spot was counted twice. This gives a random estimate of the population present in the plot. We added 6-8 ml of a 2% emulsified pyrethrins mixture to a quart of water and sprinkled it within a 4 sq ft counting frame. Then we counted the number of webworms that came to the surface in a 10 minute period (Fig. 3).

Sevin and toxaphene have controlled webworms, but required treatment every two weeks. Results from tests in 1968 showed that Akton at 1 lb per acre gave good kill within three days, but more important, provided good control through five weeks. Typical Akton treated and untreated areas infested with webworms are shown in Fig. 4.

Fig. 1

A typical sod field in the Palm Beach area of Florida.

Fig. 2

Life stages of the two species of sod webworm found in Florida turfgrass.

Fig. 3

Method of sprinkling pyrethrins mixture within a

4 sq ft frame for counting sod webworm larvae.

Fig. 4

Turfgrass treated with Akton for sod webowrm control

(left) compared with untreated grass (right).

Sod webworm tests are not easily analyzed due to localized, discrete populations. Data from the untreated control (Table 1) shows the highs and lows in a typical population in our area. Moving 1 or 2 miles from this area results in a change in population dynamics. There may be a population peak a mile away and a population low in a nearby area. Control and treatment data reflect these variations.

Data is presented in Table 1 from tests with Akton, Gardona, Dyfonate and Bromophos (brofene). Almost all of these materials provided control for approximately two weeks. In addition, Dylox, Dylox-pyrethrin combinations and Dylox-Meta Systox-R combinations have been tested and it was found that leaf-feeding caterpillars were controlled by granular applications of Dylox on golf course greens. Vapona added to Akton at the rate of ¼ lb per acre did not give additional control of sod webworms. The University of Florida, Institute of Food and Agriculture Sciences, now recommends toxaphene, Sevin, DDT, diazinon and Akton for control of sod webworms. Data from the October 9, 1968, work (Table 2) contributed to these recommendations.

Chinch Bug Research

Data provided by the Division of Plant Industry in Florida shows that dollars expended for control of chinch bugs exceed costs for all other insect pests, with the possible exception of the citrus rust mite. There are approximately 460 licensed lawn spray operators in Florida; about half are in the southern area. Figures in a 1965 census indicate that the statewide lawn pest control business is $21 million a year and it is estimated that 90% of this money is derived from chinch bug work. A lawn can be fertilized and sprayed for chinch bugs and sod webworms in Florida for 2 to 3 cents a square foot annually, but still there are chinch bug problems from April through November.

Table 3 shows the results of a typical test of Bromophos effectiveness. The average of about 60 chinch bugs per sq ft in the pretreatment counts, with an 8 minute flotation count, is very high. It is desirable to detect at least 30 insects per sq ft within our 100 sq ft plots, replicated four times before a test is made. A ring-type counter, 13.55 inches in diameter is used to make these counts.

Table 4 shows the results of a four week test conducted in Plantation, Florida. The dotted lines indicate potential control while the underlined numbers indicate control. A chinch bug infestation of 20 to 30 bugs per sq ft may be enough to cause a lawn to wilt and be a problem. As the data indicate, counts in the untreated plots decrease, due to the onset of the winter months. Normally, we follow our tests for 7 or 8 weeks, often beginning counts on the first day or two after treatment to obtain data on initial knockdown. Comparisons of initial knockdown as well as residual activity were made in this test. VC 13 did not provide immediate knockdown such as that provided by Monsanto CP 47114, a very promising compound that seems to provide good control at 7 lbs per acre. Bromophos (Brofene) in this test was slow to provide control and seems to be best at a minimum rate of 8 lbs per acre. Geigy's GS 13005 is also promising. Diazinon was not effective, and was used at ½ pound more than suggested in Florida's recommendations. Trithion apparently continued to be effective over the state. Although there have been some verbal reports of resistance, this has not been confirmed in the laboratory. Resistance to Diazinon and parathion, however, has been confirmed. VC 13 is also an effective control for nematodes, how-

Table 1. Evaluation of insecticides applied August 16, 1968, for control of sod webworms.

Treatment	Avg. No. Sod Webworms per Four Square Feet[a] Pretreatment Aug. 13	Three Days Aug. 19	One Week Aug. 23	Two Weeks Aug. 30
Akton, 1 lb/acre	59.25	0.25	0.25	0
Akton, 2 lb/acre	60.75	0	0	0
Akton, 1 lb/acre and Vapona, 1/4 lb/acre	59.50	2.75	0	0
Akton, 2 lb/acre and Vapona, 1/4 lb/acre	51.75	1.25	0	0
Vapona, 1/4 lb/acre	75.25	6.75	2.0	2.25
Gardona, 1/2 lb/acre	74.75	3.50	0.75	2.50
Gardona, 1 lb/acre	70.75	0.75	0.25	1.00
Dyfonate, 3 lb/acre	67.25	1.00	0	0
Bromophos, 4 lb/acre	59.00	2.50	0.25	0
Bromophos, 6 lb/acre	61.50	2.25	0.25	1.00
Bromophos, 8 lb/acre	78.50	6.75	0	0
Control (Untreated)	72.50	17.25	5.75	3.25
Toxaphene, 5 lb/acre (Standard)	91.75	6.00	0.25	1.00
Sevin, 5 lb/acre (Standard)	50.50	0	0	0

[a]Four plots were used for each treatment and results averaged. Each plot measured 10 ft by 10 ft or 100 sq ft.

Table 1. (Continued)

Treatment	Avg. No. Sod Webworms per Four Square Feet[a] Three Weeks Sept. 6	Four Weeks Sept. 13	Five Weeks Sept. 20
Akton, 1 lb/acre	0	0	1.50
Akton, 2 lb/acre	0	0	0
Akton, 1 lb/acre and Vapona, 1/4 lb/acre	0.75	0.25	2.0
Akton, 2 lb/acre and Vapona, 1/4 lb/acre	0	0	0.50
Vapona, 1/4 lb/acre	19.50	12.75	9.25
Gardona, 1/2 lb/acre	44.50	19.00	6.25
Gardona, 1 lb/acre	30.00	19.75	11.75
Dyfonate, 3 lb/acre	8.00	11.75	26.25
Bromophos, 4 lb/acre	32.50	13.25	7.75
Bromophos, 6 lb/acre	14.00	7.75	3.75
Bromophos, 8 lb/acre	11.75	8.25	14.00
Control (Untreated)	25.00	18.25	10.00
Toxaphene, 5 lb/acre (Standard)	18.00	22.25	8.25
Sevin, 5 lb/acre (Standard)	23.75	21.75	11.25

[a]Four plots were used for each treatment and results averaged. Each plot measured 10 ft by 10 ft or 100 sq ft.

Table 2. Evaluation of insecticides applied October 9, 1968, for control of sod webworms.

	Avg. No. Sod Webworms per Four Square Feet[a]					
	Pre Treatment	Three Days	One Week	Two Weeks	Three Weeks	Four Weeks
Treatment	Oct. 6	Oct. 12	Oct. 16	Oct. 23	Oct. 30	Nov. 6
Dylox + Pyrethrins (Spray 5.5 lb + 0.6 oz/acre	32	2	1	1	8	12
Dylox (Granular) 5.5 lb/acre	26	2	1	1	8	26
Dylox + Pyrethrins (Granular) 5.5 lb + 0.6 oz/acre	22	4	1	1	3	11
Toxaphene (Spray) 5 lb/acre	33	1	1	0	6	11
Control (Untreated)	32	14	8	4	6	12

[a]Four plots were used for each treatment and results averaged. Each plot measured 10 ft by 10 ft or 100 sq ft.

Table 3. Evaluation of insecticides applied July 25, 1968 for control of the southern chinch bug, Blissus insularis Barber.

	Avg. No. Chinch Bugs per Square Foot (Eight Minute Flotation Count)[a]				
	Pretreatment	Two Days	Four Days	One Week	Two Weeks
Treatment[b]	July 25	July 27	July 29	Aug. 1	Aug. 8
Bromophos, 4 lb/acre	59.00	56.75	37.75	36.00	28.25
Bromophos, 6 lb/acre	34.25	30.50	12.00	7.75	20.75
Bromophos, 8 lb/acre	32.75	16.00	12.75	5.25	20.25
Lannate, 10 lb/acre	43.75	11.25	10.00	11.75	22.00
Lannate, 15 lb/acre	67.75	31.50	22.25	18.00	15.75
Trithion, 10 lb/acre (Standard)	31.75	8.25	7.25	3.00	5.50
VC-13, 35 lb/acre (Standard)	67.75	80.25	77.00	30.25	3.25
Control (Untreated)	90.25	81.75	87.00	73.25	95.50

[a] Satisfactory control indicated by underscore; potential control by broken underscore.

[b] All treatments applied as spray applications.

Table 3. (Continued)

Treatment[b]	Avg. No. Chinch Bugs per Square Foot (Eight Minute Flotation Count)[a] Three Weeks Aug. 15	Four Weeks Aug. 22	Five Weeks Aug. 29
Bromophos, 4 lb/acre	33.50	54.00	60.75
Bromophos, 6 lb/acre	39.25	51.50	63.75
Bromophos, 8 lb/acre	13.50	18.50	65.00
Lannate, 10 lb/acre	22.00	55.50	62.75
Lannate, 15 lb/acre	46.00	58.25	76.00
Trithion, 10 lb/acre (Standard)	22.75	12.50	34.25
VC-13, 35 lb/acre (Standard)	20.75	35.25	63.75
Control (Untreated)	70.25	100.00[c]	86.25

[a] Satisfactory control indicated by underscore; potential control by broken underscore.

[b] All treatments applied as spray applications.

[c] Numbers of insects in excess of 100 per square foot were not recorded.

Table 4. Evaluation of insecticides applied September 19, 1967, for control of the southern chinch bug, Blissus insularis Barber.

Treatment[b]	Avg. No. Chinch Bugs per Square Foot (Eight Minute Flotation Count)[a] Pretreatment Sept. 13	Two Days Sept. 21	Six Days Sept. 25	Two Weeks Oct. 2	Three Weeks Oct. 9	Four Weeks Oct. 17
Bromophos, 4 lb/acre	62.50	37.50	25.25	5.75	25.00	25.25
Bromophos, 8 lb/acre	66.50	39.00	1.00	1.50	4.25	1.00
Bromophos, 12 lb/acre	66.50	18.50	0.50	0	1.50	2.50
Monsanto CP 47114, 2 lb/acre	77.50	32.00	5.25	3.00	4.00	5.75
Monsanto CP 47114, 5 lb/acre	66.25	2.50	0	0	0.25	1.75
Monsanto CP 47114, 7 lb/acre	62.25	4.75	0	0.50	1.50	0.50
Monsanto CP 47114, 10 lb/acre	100.00[c]	4.75	0.50	3.00	1.00	0.75
Geigy 13005, 5 lb/acre	59.50	7.50	5.00	2.25	7.75	2.50
Geigy 13005, 10 lb/acre	42.75	3.50	0.50	3.50	1.50	3.00
Diazinon, 4.5 lb/acre (Standard)	72.00	11.75	0	2.25	13.00	6.75
Trithion, 10 lb/acre (Standard)	66.25	12.75	0.25	0.50	2.25	1.25
VC-13, 35 lb/acre (Standard)	63.25	55.75	5.00	0.25	0.25	2.75
Control (Untreated)	58.25	44.75	39.75	40.50	32.75	18.25

[a] Satisfactory control indicated by underscore; potential control by broken underscore.

[b] All treatments applied as spray applications.

[c] Numbers of insects in excess of 100 chinch bugs per square foot were not recorded.

ever, there are reports that it does not control the cyst nematode in Florida.

Last year Bromophos was tested on one of the island areas in Ft. Lauderdale. These areas always seem to have warm temperatures that enhance chinch bug activity. Bromophos did not seem to have the residual effectiveness of Trithion (Table 4) and again, in this test, 8 lbs/acre appears to be the minimum amount necessary. Lannate has good nematocidal properties, but has not shown effectiveness for control of chinch bugs.

Some research has been conducted on St. Augustinegrass searching for plant resistance to the chinch bug. Dr. John Long and Jake Gruis of Scotts have conducted similar resistant variety tests. Sixteen varieties of pasture St. Augustinegrasses are recognized in Florida. The varieties planted for lawns include Bitterblue and Floratine. At one time Floratine was marketed with the hopes that it would be chinch bug resistant, but it doesn't appear to be. It is hoped that one of our existing varieties may provide a resistant or tolerant selection. Varietal tests have been conducted by planting the selections in large bread-baking pans using a uniform planting date, sterilized sand, watering and fertilizing them in the same way and then transfering 250 chinch bugs into each pan. There were at least three replications of each pan for each variety. Four selections of St. Augustinegrass are shown in Fig. 5. The one on the far left, pan #10, and the one on the right, pan #8, are in better condition than the grasses in pans #3 and #4.

Data from one of the varietal tests is presented in Table 5. In this test, six varieties were evaluated for resistance to the chinch bug. Resistance is evaluated in several ways. First, by the grass's reaction to a specific population restricted to that grass, you can put a cage over the top of the pan to restrict the insects; or second, by measuring reproductive potential. In addition, preferential feeding studies can be conducted. From this, and other tests, two superior varieties have been selected-Zalesky No. 1 and BYS No. 1. At least three pans of each selection were planted and each infested with 250 chinch bugs after the grass was established. Several weeks later, pans with a low number of chinch bugs were found in two varieties, averaging 3 and 1 respectively. In comparison with two other selections, of which there were nine replications planted, there was a marked difference in the injury to the grass and number of chinch bugs observed. The actual numbers have not been presented here because the technician making the insect counts was instructed, when he reached 100 insects in 8 minutes, to stop counting. It would have been interesting to determine the actual number of insects present in each pan. But results do show significant differences in comparison with the other selections of grasses. Bitterblue or Floratine selections were considered controls since they are our most commonly planted turfgrasses. Results show they are less susceptible hosts than Selection No. 1 or 6 and there are significant differences in susceptibility between the grasses. I think the real answer for long term control of the southern chinch bugs lies in this direction.

The University of Florida now recommends eight materials for chinch bug control. There are some insecticides available for chinch bug control in other states which have been found ineffective throughout Florida and, consequently, the extension service does not recommend them. Such compounds are carbaryl, Akton, Bromophos (Brofene) and BHC-DDT. Recommended compounds are Dursban, Zytron, Baygon, trithion, VC 13, Aspon, ethion and diazinon.

Fig. 5

Selections of St. Augustinegrass under test for resistance to the Southern chinch bug, Blissus insularis Barber.

Table 5. Comparison of St. Augustinegrass selections for resistance to the southern chinch bug, Blissus insularis Barber.

		No. Chinch Bugs (Ten Minute Flotation Count)[a]								
Selection Plot	1	2	3	4	5	6	7	8	9	Avg.
Zaleski No. 1	0	1	9							3.33
EBY No. 1	5	0	0							1.66
Selection No. 1	53	61	100	13	45	21	100	100	100	65.88
Selection No. 6	100	100	100	100	100	93	100	100	100	99.22
Bitter Blue	44	18	9	14	71	7				27.16
Floratine	100	4	9	12	18	24				27.83

[a]Number of insects in excess of 100 chinch bugs were not recorded.

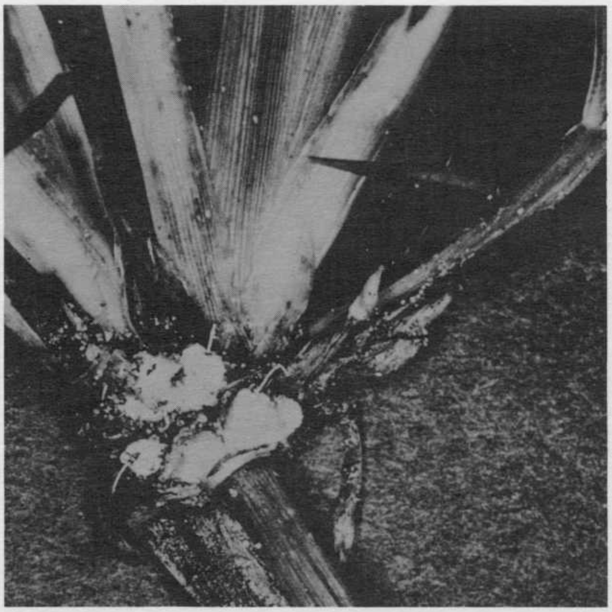


Fig. 6

St. Augustinegrass infested with rhodesgrass scale.

Scale Insects

There are two species of scale insects in Florida that are serious pests of turfgrasses. The larger of the two is the rhodesgrass scale (Fig. 6), shown on St. Augustinegrass. This pest usually attacks the finer grasses, such as bermuda and zoysia, when temperatures are 65-80 degrees. In 1968 the turf in the Orange Bowl was replaced with an artificial turf because of control problems with this pest. The scale can occur in such large populations that the crawler stages may be mistaken for mites.

Rhodescale is a difficult insect to control and most of the recommendations suggest repeated treatments. A large number of materials were tested, including several that were expected to do a good job on scale insects. The treatments starred in Table 6 are the comparative standards and are recommended in Florida. Treatments are ranked according to their relative effectiveness. Note that the pretreatment counts average around 15 adult scale insects per 2 inch core. We take two 2 inch cores in a 4 sq ft plot, and there are four replications of each plot. Pretreatment counts in this test reflect rather large populations; post-treatment counts indicated only one material showed promise when only one application was made. This material was Dyfonate, which at this writing is still an experimental product with no label registration.

It is difficult to collect research data on the rhodesgrass scale during the winter months, since cold weather greatly reduces the population. Results shown in Table 7 are from a test in which cold weather killed the insects. Potassium permanganate, included in this test, works pretty well on spider mites but doesn't have the residual effectiveness needed for this particular pest. Dyfonate looks very good but results of this experiment were affected by cold weather and may not be reliable.

The hunting billbug, Sphenorphorus venatus, is also found in Florida, but has not been a serious pest on turf in recent years.

Table 6. Evaluation of insecticides applied December 7, 1967, for control of the rhodesgrass scale, Antonia graminis (Mask.) in Florida Bermudagrass No. 137.

Treatment	No. Plots[b]	Avg. No. Adult Scales per 2 Square Inch[a] Pretreatment Dec. 5	Three Weeks Dec. 28	Six Weeks Jan. 16
Akton, 2 lb/acre	4	18.5	17.9	15.3
Gardona, 1 lb/acre	4	16.4	27.0	18.6
Dyfonate, 4 lb/acre	4	11.9	8.5	1.3
Dursban, 2 lb/acre	4	19.9	14.5	9.5
Dasanit, 10 lb/acre	4	13.5	14.3	11.0
Baygon, 10 lb/acre	4	14.0	13.5	7.9
Sevin, 5 lb/acre	4	15.9	20.0	18.3
Ethion-Oil, 7.5 lb + 17.5 qts/acre	4	17.0	22.5	13.1
Summer Oil, 17.5 qts/acre	4	12.9	20.0	19.4
Diazinon, 8 lb/acre	4	16.6	13.3	6.8
Parathion, 4 lb/acre (*Standard)	4	17.9	23.9	12.6
Malathion, 10 lb/acre (*Standard)	4	19.3	24.4	16.8
Control, (Untreated)	4	24.0	23.5	19.4

[a]Based on examination of two 2 square inch cores per plot.

[b]Plots were replicated four times for each treatment; plots were 2 ft by 2 ft or 4 sq ft.

Table 7. Evaluation of insecticides applied March 15 and April 24, 1968, for control of the rhodesgrass scale, Antonia graminis (Mask.) in Florida Bermudagrass No. 137.

Treatment	No. Plots[b]	Avg. No. Adult Scales per 2 square inch[a] Pretreatment March 14	Three Weeks April 5	Nine Weeks May 15
Potassium Permanganate, 5.5 lb/acre	4	23.0	0.9	6.8
Dyfonate, 4 lb/acre	4	16.4	0.1	0.4
Dursban, 4 lb/acre	4	17.3	1.1	0.1
Baygon, 10 lb/acre	4	23.9	0.1	0.4
Diazinon, 8 lb/acre	4	17.8	0.5	0.4
Parathion, 4 lb/acre (*Standard)	4	22.0	0.6	1.4
Malathion, 10 lb/acre (*Standard)	4	17.5	0.6	0.3
Control, (Untreated)	4	17.0	5.0	4.3

[a]Based on examination of two 2 square inch cores per plot.

[b]Plots were replicated four times for each treatment; each plot was 2 ft by 2 ft or 4 sq ft.

DISCUSSION PERIOD

Dr. Wheeler: Dr. Hamman, at the time of your first treatment, what stages of chinch bug were present? Were they mostly adults?

Dr. Hamman: Primarily the population was adults, but we did observe a good number of nymphs or immature forms.

Mr. Simmons: I understood Dr. Stringfellow to say that he was surprised that granules worked. I wonder if you would be willing to comment on your work with granules versus liquids?

Dr. Hamman: We used the two formulations mainly to compare their effectiveness on chinch bugs, but our particular interest was developing effective recommendations for homeowner use. Finding that the granular materials were as effective as most of the emulsifiable concentrates, we are recommending primarily granules for homeowner use because of the ease of application. When applying liquids at the rates of 20-25 gallons per 1,000 sq ft with a hose-on sprayer, most homeowners can do a pretty accurate job on the first 2,000 sq ft. After that, the sun beats down and they begin to get a little discouraged. I am sure the rest of the lawn is not treated as it should be. And after all, we are concerned with control, efficiency and effectiveness. With one of these cyclone-type fertilizer applicators, once it is calibrated, lawns can be treated about as fast as a person can walk. This was the reason for the comparison of granular materials and sprays.

Dr. Stringfellow: The hose-on applicator commonly used in Florida will equal, I believe, a 3 gallon, 5 gallon and a 15 gallon sprayer. So, if the homeowner has a sprayer that applies 15 gallons, he can only treat 500 sq ft. When he gets to the second or third filling, at the end of 1,500 sq ft, he's real frustrated. One other thing on this question of granulars-in southern Florida we find that 75% of the homes have sprinkler systems. You can put out small cans and measure to be sure that your pattern of water is sufficient. It's no trouble to run the sprinkler an hour on each section. So, we find granular formulations to be very convenient to the homeowner, in addition to being about equally effective with the sprays.

Dr. Hamman: In using sprays or liquids, the lawn has to be watered thoroughly before applying spray materials. This watering is equivalent to a real good irrigation and is necessary for the sprays to be effective. Granular materials can be applied on a dry lawn and then watered in a normal watering process to achieve control. Several homeowners, on the otherhand, don't apply the water initially when using sprays. We don't have as many sprinkler systems and it just doesn't get done. This, and the ease of application, leaves us to lean more in our recommendations towards the granular materials.

Dr. Wheeler: Would there be any advantage and would it be economically feasible to add a small amount of pyrethrins to one of the other formulations to increase the activity of sod webworms at the time the material goes on and, thus, give more chance for the toxicant to operate?

Dr. Stringfellow: I believe that was the point in Chemagro's combination with Dylox, don't you? Sometime ago a young fellow wrote a Master's thesis at LSU on the effectiveness of several materials for the control of chinch bug. He found that BHC-DDT was the most effective of the materials, or at least equally effective. BHC, the pyrethrins, Vapona and some other materials are great activators or irritants. We can get Akton to work in areas where it normally works very poorly by the addition of a quarter pound of Vapona per acre. I'm told that you can take Dylox and change the pH in the tank and turn it into Vapona and other things, and get it to work in a similar manner. I think the pyrethrins addition should be, in theory, a very good method. I've only run one test with pyrethrins and Dylox against Dylox alone or Dylox in combination with Meta-Systox-R, and we could not find statistically significant differences. As hard as it is to run sod webworm tests, one test is not enough to give you a good answer on that. I've never run the pyrethrins combination for chinch bug control. We have run a good deal of Vapona combinations.

Dr. Schuder: I would like to reinforce his statement. I tried the pyrethrins-Dylox materials and we got, if anything, poorer results with the combinations than with the straight Dylox. I'm just wondering if a systemic, possibly in the granular form, which would be a slow release deal, wouldn't be a good way to investigate. We have had excellent results on other scales in Indiana in this type of situation.

Dr. Stringfellow: During a test this past year in Palm Beach, we overtreated with Thimet. It did a wonderful job of controlling mole crickets and the rhodesgrass scale.

Treatments for one of our latest tests include potassium permanganate, Dyfonate, Dursban, Baygon, diazinon, parathion, malathion, control, CP 47114, Bromophos, Akton, Niagara 10242, Furdan, ethion, Mocap and GS 13005. I don't know why I did not put in Meta-Systox-R or Cygon as systemics. One of the reasons we selected some of these materials has to do with our other recommendations. We put Baygon in because it is used in a wide number of cases; Dursban was used for the same reason. Dyfonate had an ususual vaporous action. I can't explain why we recommend materials like malathion when they often require several repeated treatments. And I can't explain why ethion and oil combinations do not perform better than our data indicates. Rhodesgrass scale is a difficult insect to control and repeated treatments is the only answer I can suggest.

Dr. Saunders: Dr. Stringfellow, do you consider Baygon systemic as far as grass goes? Does anyone have any information on this?

Dr. Stringfellow: I have not considered it as a systemic.

Dr. Heinrichs: Dr. Stringfellow, would you comment on the future of biological control in sod webworm work? Is there a future, such as the use of nematodes?

Dr. Stringfellow: I have never given this adequate thought but, for one example, let's consider sod webworms. The generations of sod webworms come and go in such peculiar ways. I have heard Dr. Stratton Kerr of the University of Florida suggest repeatedly that he felt the weather conditions might have been deleterious to some predator-parasite relationship, and this was why they built up. I do not know enough about this segment. My research duties are split between turf and ornamentals and one-third of my time is now spent on the Caribbean fruit fly. I would like to do more in this direction.

Dr. Heinrichs: I have one other question, Dr. Stringfellow. You said you had 10 ft by 10 ft plots, is that right?

Dr. Stringfellow: We try to. We run little turf research on our own station. It is all run in cooperation with other people. When we have searched five or six days and need one more plot, sometimes I'll change the sizes down to 5 ft by something, always 100 sq ft, though. We try to leave a 2 ft border. Never do we count on top of another count. On the chinch bug studies, however, we do bias our counts. We check the area we think will give us the highest count. Chinch bug counts are not made at random.

Dr. McDaniel: Dr. Stringfellow, I don't want to put you on the spot, but whenever you controlled chinch bugs with your materials, did you ever find that the growth of grass in this area was stunned? I am not talking about counts as far as chinch bugs are concerned, but the grass not coming back as you would expect with the chinch bug population lower.

Dr. Stringfellow: Yes, we do run into this problem, particularly where we have a complex of pest and cultural problems. I have a good question and it is one I hope that many of you get. A pest control operator once asked me, "I have chinch bug problems, nutritional problems and nematode problems. What problem should be corrected first?" I couldn't think of anything to say but to fertilize, get the grass strong enough to withstand treatment shocks and then apply controls. Well, that's the wrong answer. The right answer is to take care of the chinch bugs first. You can't afford to delay chinch bug treatment, then take a good look at the nematode situation. In our area, this is the next problem that should be controlled. We find that some of the materials we use don't work toward inhibition of growth as much as they accelerate growth.

Dr. McDaniel: The reason I brought this up is that in 1965, in Corpus Christi, they had a bad chinch bug problem. Nurserymen in the area collected soil samples for examination. Ironically enough, the damage was being caused by chinch bugs, but after they were controlled, further damage occured by a ground pearl. This damage, of course, was down in the roots. Most of the time you wouldn't survey this particular area. As far as control measures, I don't know. But this is one of the problems they were running up against; the fact that they were going out and getting rid of chinch bugs, but not getting results as far as comeback of the grass.

Dr. Miller: About once every 10 to 15 years, Kentucky seems to have a very heavy infestation of sod webworm. It almost destroys 35 to 50 per cent of the lawns; then this problem ceases for another 8 or 10 years. We also noticed that, when a lawn had been treated with aldrin or dieldrin for grubs, in about 2 to 4 years the same area was heavily infested with sod webworms. This may mean that we are destroying some natural predators or something. We recommended Sevin and diazinon for control of sod webworms. Two cupfuls of the 50W Sevin per 1,000 sq ft in 3-5 gallons of water did a very good job for us. We had two generations and a partial third. Control was unually achieved within 24 hours. Diazinon, at about one cupful per 1,000 sq ft, began offering control in 30 minutes.

Dr. Stringfellow: We find many insecticides do a good job in Florida on our species of sod webworms, but we are going to change our philosophy. We want a product that only has to be applied to golf greens every 4-5 weeks. The application cost is becoming expensive in terms of labor.

We have a changing picture of grasses in Florida. More and more bahiagrass is being seeded, especially in northern areas. This is an overseeded grass, but there are bahiagrass cut turf farms in Florida. The principal insect pest in bahia seems to be the mole cricket. I have not conducted any research on this pest so I can't say much about it.

Dr. Thompson: I have two questions, Dr. Stringfellow. One, on sod webworms, the ones you work with are thatch inhabitants rather than burrowing type, right?

Dr. Stringfellow: Yes, sir.

Dr. Thompson: And on billbugs, do you find you get a mixture of all life stages all year around?

Dr. Stringfellow: I can't say. I have never worked on billbugs, except passive collection for predators and parasites with Harry Nakao from Hawaii.

Mr. Simmons: Dr. Stringfellow, is there a timing factor in relationship to the control of scale insects? Could you control them at a specific time of the year?

Dr. Stringfellow: We made several observations for occurrence of the crawlers over a period of two years, but we could not pinpoint this. We had hoped to forecast an outbreak of sod webworm, and this is where we got into trouble. In one area, we could find where they were coming on; in another area, they were going to a low point. The generations overlapped badly. I can't say much for these observations since they lasted only two years. It would be better to catch scales in a crawler stage, of course. But once they are under their parchment covering, it's difficult to reach them. That is why the systemics should perform well, especially on chinch bugs. In our testing, this was not true.

Mr. Simmons: One other question, Dr. Stringfellow. Do I understand that Akton is not effective on chinch bugs? Is this a rate factor or is it just lack of effectiveness?

Dr. Stringfellow: If a product will work in northern Florida, central Florida and southern Florida, three distinct habitates or ecological areas, then we recommend it. But if it won't work in one of the areas, we don't recommend it. Akton performed well in northern and central Florida and was granted a state label. This product, on the other hand, did a very poor job in selected areas in southern Florida. We combined Vapona with it and were able to increase the activity. We don't recommend Akton for chinch bugs over the entire state, however it is excellent for sod webworm control. I would say that Akton is about the same as diazinon for control of chinch bugs. It is certainly superior to carbaryl in our areas.

Mr. Simmons: Dr. Stringfellow, do you feel that Akton remains long enough on the soil surface to give true residual effect? In other words, if you infested the plot with sod webworms, say five weeks after treatment, would Akton be effective?

Dr. Stringfellow: I don't know. Certainly that's a very definite part of the test that should be followed up, to bring insects back into the treated area and expose them to the residual. I can't give you a specific answer on that.

Mr. Simmons: Dr. Hamman, would you just review briefly your other insect problems in Texas, other than chinch bugs? Do you have rhodesgrass scale?

Dr. Hamman: I suppose the biggest problem would be chinch bugs and behind that would be bermudagrass mites in bermuda, which would be in the northern and western parts of the state. As of late, the white grub appears to be a tremendous problem. It appears there are three areas that are particularly concerned here: the lower Rio Grande Valley, which is an entomologist nightmare in any sense; the Corpus Christi area; then around Dallas and Fort Worth where we have the biggest problem on white grubs. We can't determine whether it is resistant to some of the chlorinated hydrocarbons or whether it is a mechanical thing of not getting the materials down through the thatch into the soil. But these are the three biggest. Rhodesgrass scale is confined mainly to large pastures.

Mr. Simmons: Where would sod webworms stand, Dr. Hamman?

Dr. Hamman: They would run last right now. We see most of this on golf courses.

Dr. Schuder: I think I can give you some indication about this Akton residual. We used Akton three years as an experimental. Most of the time we apply our materials about the 7-10th of June and the last data taken about August 3, 4 or 5. Akton gave residual control through those three years for about a 7-8 week period. I didn't put larvae in the plots, but two broods were used in the interim, so I think this will give you some indication.

Dr. Wene: Dr. Stringfellow, do you have bermudagrass mites in Florida? What do you recommend for control?

Dr. Stringfellow: Diazinon. We find bermudagrass mites easy to control versus other mites.

Dr. Wene: We find that the bermudagrass mite is building up resistance to diazinon. Even at triple dosage, diazinon does not control it. We find a better control than diazinon is good fertilization and plenty of irrigation water.

Dr. Stringfellow: Dr. Wene, how about Morocide, Morestan and Morton's chemical, Carzol?

Dr. Wene: I haven't tried those. It is noteworthy that in the Phoenix area they absolutely cannot get control with diazinon, which is our standby.

PESTICIDES IN WATER

H. Page Nicholson
Agricultural and Industrial Water Pollution Control
Research Program
Federal Water Pollution Control Administration
Department of Interior
Southeast Water Laboratory
Athens, Georgia

As preface to the subject "Pesticides in Water" I'd like to point out that we consider the matter of trace pesticide residues in water merely symptomatic of a much greater problem involving traces of organic substances from almost all aspects of life, particularly from industrial sources. We have only three really basic disposal systems available--air, earth and water, and we certainly are using water to a high degree at this time. We happen to be able to do something about pesticides. Pesticides are foremost in our attention because they are designed as toxic substances and for some of them, at least, we can perform analyses so successfully.

Water pollution by pesticides became a subject of concern and interest in the 1940's concurrent with the rapid advances in pest control that began about that time. Many of these synthetics are remarkably lethal to aquatic forms of life. Farmers were startled at the sudden loss of fish in their ponds and streams following rains sufficient to cause run-off from treated crop land. Aerial applications of DDT, to control forest insects, were quickly followed by losses of valuable sports fish and the aquatic insects upon which they fed.

The first instance of a serious nature that came to my attention was about 1950 when the farmers in Alabama first began to use some of the chlorinated hydrocarbon insecticides. Toxaphene was one of the favorites; so was BHC and DDT. The first year they used these substances in any quantity at all, they believed they had to reapply them every time it rained as they had been accustomed to doing when using calcium arsenate on cotton. After several weeks the whole area was covered by a series of intense thunderstorms, and runoff containing pesticides wiped out fish in 14 tributary streams in the Tennessee River Valley.

We still experience periodic losses from this sort of thing but we know considerably more about causes and prevention. We are aware that sublethal quantities of pesticides, primarily the chlorinated hydrocarbon insecticides, occur widely and frequently in likes, streams and even in the sea. This is indirectly evident through the recovery of residues from the tissues of fish, and directly evident by chemical analysis of water.

During a study in 1964 on pesticide pollution in the United States, samples were examined from 56 rivers and 3 of the great lakes. Chlorinated hydrocarbon insecticides were found in 44 rivers and in Lake Michigan at Milwaukee at concentrations ranging from .002 to .118 mg/l. Dieldrin was found in 39 rivers and Lake Michigan; DDT, or its metabolite, DDE, was found in 25 rivers; and endrin was found in 22 rivers and in Lake Michigan.

The two principal sources of water contamination by pesticides today are run-off from the land and discharges of industrial wastes. Other causes are carelessness, accidents and activities intend to control aquatic life, such as weeds, fish or insects.

One of the earliest attempts to evaluate pesticide run-off was made near Atlanta, Georgia, in 1954 (Tarzwell and Henderson 1956). At that time, the white fringed beetle was a problem. Dieldrin was being used at the rate of about 4½ lbs per acre for its control. There was an infestation on the lawns at Lawson General Hospital near Atlanta and a study was initiated there to see what run-off occurred. The rate of application was 4.6 pounds per acre in an attapulgite-type clay; formulation was applied at 50 lbs per acre. Only lawn grass areas were treated. Water run-off from this area, diluted with that from roofs and paved streets, funneled into one draw and was collected at that time. Analyses were very crude in those days and were made by bio-assay on fathead minnows. Toxic concentrations were found during the first three significant rains that followed application. All three rains came within a week. The area was a grassy slope of about seven acres. About 1½ acres were covered by pavement and buildings. This is the only instance that I know of in which turf and lawn areas were studied to determine the run-off contribution from them. However, these contributions from the land surface must be considered together with contamination from other sources, such as the effluents discharged from plants manufacturing the basic pesticide chemicals.

As a further consideration of run-off, in 1959 my laboratory studied the course of water pollution in the Flint Creek drainage system in northern Alabama, where cloudbursts caused tremendous fish kills (Nicholson, Grzenda, and Teasley 1966). The site consisted of 400 sq miles of cotton growing area drained by a single river system. It was ideal to study because cotton culture was the only source of insecticides in the area. There were no other sources of pollution. Samples of water, taken at a municipal water treatment plant at the downstream end of the water basin, indicated what was occurring upstream. Again, toxaphene, DDT and BHC were the principal compounds involved and accounted for 84 to 99% of all the pesticides applied annually. The water sampling was done at the municipal treatment plant almost continously for about seven years.

Results showed the following: Insecticides did run off the land and entered the river from the watershed, rather than from a few favorably located cotton fields. Toxaphene, DDT and BHC were recovered in water samples in concentrations generally less than 1 mg/l. The highest mean recoveries were usually made during the summer of the season of application. Nearly all the water samples contained insecticides year around during the years of heaviest application.

DDT exhibited a marked affinity for sediment, and suspended sediment was the primary vehicle for its transport. Toxaphene and BHC, on the other hand, were transported primarily as a solution in the water. This was determined by installing a microfiltering system on the water lines, just before the water passed through our sampling system, the sediment was removed for separate analysis. DDT was always found on this sediment sample. Toxaphene and BHC, however, went through the filter and were found in the water. The system treated the muddy water coming in with alum and lime to set up a floc that removes the sediments. Again, DDT was found in the sedimentation basins, but the toxaphene and BHC went through the treatment system in the finished water that was delivered to the customers. Values on all the pesticides were extremely low--less than 1 ppb. I should add that DDT was not detected very often. This inferred that it was held on the land considerably tighter than were the other two materials. To get into the water, it would have to ride "piggyback" on eroded soil particles.

Earlier it was mentioned that manufacturing wastes also contain quantities of pesticides sufficient to have a decided impact on water quality. The types of industries involved include the basic producers of pesticides, firms that reclaim used pesticide drums, and textile plants that use dieldrin to mothproof woolen fabrics. These plants usually have liquid wastes requiring disposal; wastes that frequently contain residues of unrecovered pesticides. An example will illustrate a situation and how it was managed.

A plant in Alabama that manufactures parathion and methyl parathion experienced a breakdown in its treatment system in 1961 which resulted in a discharge of about two million gallons of wastes into the river. There was an activated sludge treatment system and a biological treatment system that normally handled this waste quite efficiently. But the concentration of parathion in the waste was high enough to poison the organisms in the sludge. Then the effluent from this treatment plant was diluted 1 to 20 with domestic wastes from a city and passed through a second activated sludge treatment system. The concentration of parathion also poisoned the organisms in this plant. Consequently, the city by-passed the whole mess, untreated, into a river. The net result was that fish, turtles and snakes died along 28 miles of the stream into which these wastes were discharged. The creek entered the Coosa River, whose average discharge was then about 28 times greater than that of the creek. Even with this dilution, parathion residues were recovered 90 miles down the Coosa and some lesser fish kills occurred there. After a second accident in 1966, the company constructed a concrete-lined basin for temporary storage of its waste should another emergency arise. We haven't had any problem since that time. It was a very simple, but adequate device to prevent further accidents.

Perhaps the third and most significant cause of pesticides pollution is accidents and its handmaiden carelessness. Intensive educational campaigns sponsored by agriculture, conservation, water pollution control and public health agencies and by the agricultural chemicals manufacturing industry have reduced the frequency of such occurrences. Most farmers have learned that it is inadvisable to dump unused pesticides where they might run into a waterway, or to wash out spray equipment in a creek. Aerial applicators are also intent on protecting ponds and rivers. Nevertheless, we still find some instances of water pollution by pesticides that occur as the result of thoughtlessness and accidents. An incident in which human health was at stake will serve as an example.

In 1964 a Florida rancher instructed his hired hand to dispose of approximately fifty 4-lb bags of 15% parathion dust. The farm hand, unknown to the rancher, dumped the bags off a highway bridge into the Peace River one mile upstream from the municipal water supply intake of Arcadia, a town of about 6,000 people. This act was discovered when some boys fishing near the bridge hooked a bag and had the foresight to report it. Arcadia's water supply was immediately reverted to an auxiliary well. Citizens were instructed not to use the water and flushing of the mains was begun. Subsequent analysis of the water samples showed that the parathion concentration in the distribution system, even after flushing, was generally less than 1 ppb.

The bags of parathion had been dumped into the river about 10 days before their discovery. Fortunately, these bags were polyethylene-lined and resisted rapid disintegration. Many were recovered unbroken and those that did disintegrate apparently did so intermittently over a period of several weeks. We know this because during our analyses we would pick up a sudden blip that would pass on and off again. This may have been the reason that residue levels sufficiently high to be a real threat to human health did not occur. All but 8 to 12 bags of this material were eventually recovered.

We should say something about ground water pollution in any discussion of this kind. The potential for pesticide contamination of ground water appears to be much less than for surface water; however this can occur.

Another case is on record in Florida where the municipal water supply wells for a city of about 25,000 persons contained low levels of parathion. Again, usually less than 1 ppb over a several-month-period in 1962 and 1963. The city's water supply consisted of surface water which reached the municipal water treatment plant by means of a canal from a citrus fruit-producing area and five wells that were located in the vicinity of the treatment plant. The water from both sources contained parathion. The wells were rather shallow, drilled only to a depth of about 100 ft. It is speculated that heavy pumping from the wells drew surface water down from the canal.

A more serious incident occurred in the South Platte River Basin near Denver in the mid-1950's caused by seepage of 2,4-D from an industrial waste lagoon. Wells in a 6½ sq mile area were sufficiently contaminated to cause crop damage when this water was used for irrigation.

We have examined many well water supplies in the southeastern states and in only a few instances have we detected any evidence of insecticides. In those few cases, I recall only two in which direct contamination did not seem to be the possible cause. Researchers in California, on the other hand, reported recovering a broad range of chlorinated hydrocarbon insecticides, including dieldrin, from underground tile drains in irrigated crop land. They did not speculate on how the insecticides entered the drains. A possible route might be through cracks or other direct passages from the surface.

Water contamination by pesticides is common at concentrations less than 1 ppb. Higher concentrations occur intermittently, but of what significance are such occurrences? Quite clearly, the unintentional killing of aquatic life by overwhelmingly lethal concentrations of pesticides is harmful and undesirable. Occurrences of this type are generally local, readily apparent and sporadic, with partial or total repopulation occurring quickly.

Widespread, long-term, low-level contamination of the environment is much more difficult to evaluate and is a matter of growing public concern. It is caused primarily by a few compounds, members of the chlorinated hydrocarbon insecticide group, the so-called "hard insecticides" that persist so long in nature and, therefore, escape from our control after they are applied. Other pesticides, by and large, either degrade with reasonable rapidity, or their usage is so restricted as to be of less concern, except in special cases. One is tempted to speculate as to whether there would have been the great public outcry over pesticides during the past 10-15 years if it had not been for the few hard insecticides.

The single, sublethal manifestation with chlorinated hydrocarbons that is most obvious, and the significance of which is least understood, is that of biological accumulation. Biological accumulation may occur, either through direct absorption from the water, or by absorption and passage through the food chain. The implications for damage are great, but well defined examples of proved harm are few in number, perhaps because biological accumulation is not as generally damaging as feared. Also, perhaps, because the ecological relationships are so extremely complex they are difficult to unravel.

Light has been cast on this phenomenon by a number of researchers. Dr. Cope, who until recently was with the Fish Pesticide Research Laboratory at Columbia, Missouri, investigated the distribution of DDT through various compartments of a simplified ecosystem (Cope 1965). He used radio-tagged DDT and started with 20 mg/l added to water in an aquarium. Two weeks later he found 0.42 mg/l in the water. At that time the soil contained 6 mg/kg. The vegetation growing in the water contained 15,600 mg/kg. Two weeks later he added fish to the aquarium which, in two more weeks, contained 1,000 mg/kg. This is a well documented case of biological accumulation and I think it is the basis for many of our problems with DDT in Lake Michigan and in other naturally occurring waters.

Gakstatter, who used to be with our staff, and Dr. Weiss in North Carolina exposed bluegills and goldfish in aquaria to tagged DDT, dieldrin and lindane (Gakstatter and Weiss 1967). They showed that dieldrin and DDT were readily transferred from contaminated fish held in clean water. Research with endrin has shown the same thing. I think this is significant because, apparently, some of the persistent insecticides are not only capable of undergoing biological magnification, but also of cycling and recycling between the water and the organisms living in it. This, again, has implications in connection with the Lake Michigan situation where DDT is already in the lake.

The lake is a great biological sink with DDT accumulating in the fish. Laboratory work has shown that DDT is far from being in dead storage. A scientist, using radio tagged DDT, showed that it was not permanently stored in the fatty tissues or any other tissues, but was again cycling within the fish and back into the lake again where it may be picked up by other fish. It can also go through the food chain and back into the fish again. Accumulation of pesticides in the bodies of fish has been cited as the probable cause for secondary poisoning of some varieties of fish-eating birds.

Keith (1966) reported an unusually high mortality of fish-eating birds between 1960 and 1962 at the Tulelake National Wildlife Refuge in California, which he attributed, again circumstantially, to ingestion of toxaphene accumulated in the fish. Evidently, federal land was leased to farmers for production of crops and insecticides were used. Keith continued his studies into 1965 and 1966 when endrin was the principal insecticide used on this irrigated farm land. He indicated a marked increase in endrin in all trophic levels during the crop growing season from May to September, with a subsequent decline to near or below detectable limits in the off-season. Endrin, unlike toxaphene, was not established as a permanent residue and no wildlife losses were recorded. I think this is significant because it shows that, apparently, not all of the so-called hard insecticides are equally accumulative or equally persistent in food chain compartments.

Butler (1966) has done extensive work on the effects of low levels of chlorinated hydrocarbons on oysters. He showed that DDT in the water at levels as low as 1 ppb caused a 20% reduction in the oyster growth. Pesticides, according to Butler, may be the cause of mortality, loss of production and changes in the direction of natural selection in estuarine fauna.

Burdick and his co-workers in New York demonstrated that lethal amounts of DDT can be transmitted from female lake trout to their off-spring through the egg (Burdick et al. 1964). Lethality, in that case, bore no relation to the concentration in the female. The fry died when the final contents of the yolk sacs were absorbed. These deaths occurred when the eggs contained DDT equivalent to 2.9 mgs/kg, or more, of fry and accounts for the complete loss of lake trout fry in 1955 and 1956 at a Lake George fish hatchery. This is a most subtle adverse effect that would be detected only under hatchery or laboratory conditions.

The influence of transovarily conveyed pesticide residues in a subject is worthy of further research. The period of dependence upon stored foods in the egg may be the vulnerable period in the life histories of a number of species, as far as pesticides are concerned. If this is true, the chances are very slight that population losses would be directly observed in nature, short of virtual elimination of a major species. Some persons have claimed that this manifestation has only occurred in the salmonids. This is true, but these species are essentially the only ones managed in a hatchery where the eggs are actually handled. I would like to see much more work done on other species not normally involved in this type of hatchery management.

Much has been written about the effects of long-term exposure of aquatic organisms to pesticides at sublethal levels. We still have a remarkably small amount of compelling, positive information indicating danger from organic, chlorinated insecticides. DDT has received by far the most attention, possibly because its residues are so universally distributed. We need more research on other persistent insecticides. Although we do not have agreement within the scientific community concerning the danger of persistent residues in living organisms and in the environment, perhaps all of us could agree that it would be much better if we did not have these uncontrolled residues.

Now, a word about pesticide pollution control. The Southeast Water Laboratory has responsibility within the Federal Water Pollution Administration for research leading to the control of pesticide pollution. Control is generally easiest at source points. That is, at industrial sources where a waste effluent is discharged to a stream at a single outfall. We are currently beginning an inventory of waste treatment practices at pesticide-manufacturing and pesticide-using industrial plants with the desire to establish a mutually beneficial relationship with some of these industries. Control may be accomplished by a variety of waste treatment processes and by in-plant process changes.

The control of pesticide pollution associated with rural run-off is much more difficult to accomplish because its entrance into water courses is not localized. Control, therefore, must be by other means and ultimately rests in the hands of pesticide users. Land management practices designed to retard water run-off and soil erosion certainly are helpful measurers. The retention of an untreated buffer strip adjacent to mountain streams was shown to prevent the run-off of DDT applied for forest insect control.

We are conducting research with pure clay mineral model soils to develop fundamental concepts relative to the retention or non-retention of representative pesticides on land. Recently our scientists, cooperating with associates at Purdue University, demonstrated that the triazine herbicides are irreversibly adsorbed onto montmorillonite clay and, in the process, undergo chemical change to an innocuous compound.

The basic concepts developed from this work were later confirmed with natural soils. Results frequently are directly applicable to rural run-off control recommendations. Also, research has shown that pesticide run-off from land is directly related to run-off losses of both water and surface soil. They serve to transport pesticides from farm or forest to water courses. Controlling this process are a variety of factors, including climate, soils, hydrologic factors, physiographic and cultural factors. If we knew more about the interplay of soil types, slope of the land, rainfall and other climatic factors, cropping practices and the behavior of pesticides in use, we should be able to recommend measures to reduce the importance of rural run-off as a source of pollution by pesticides.

A comparable development has already been made in agriculture. I refer to the universal soil loss equation that is applicable to guiding conservation farm planning throughout the U. S. The factors upon which this equation is based are rainfall, soil erodability, slope length and gradient, cropping management and erosion control practices. The possibility of extending the universal loss equation and applying it to the prediction and control of pesticide pollution associated with rural run-off seems good and we are exploring it.

In the meantime, socio-economic developments are occuring outside the field of water pollution control. They tend to reduce the water pollutional impact of the persistent organo-chlorine insecticides. The development of resistance to insecticides among cotton, corn and sugar cane pests, for example, has forced the total or partial abandonment of formerly preferred hard insecticides in favor of more effective and, incidentally, less persistent types. Food and Drug Administration controlled tolerance levels are requiring other changes.

As you are well aware, there is a growing public concern in environmental contamination control that is bringing forth attempts to outlaw the use of some of these compounds. Michigan has done it now. Sweden has brought about a change in their laws that will enable them to undergo a two year trial period to see if they can decontaminate their environment by not using DDT. I think the trend is in this direction. Maybe this is good; maybe it's not, only time will tell. But I think, in the meantime, there are a few things that can be done to minimize the distribution of DDT in the environment. Certainly, where there are adequate substitutes, these can be used. If I had my choice, I would prefer to see this approach tried first before any of these compounds are outlawed.

References Cited

Burdick, G. E., E. J. Harris, H. J. Dean, J. M. Walker, J. Skea, and D. Colby. 1964. The accumulation of DDT in lake trout and the effect on reproduction. Trans. Amer. Fish. Soc. 93:127-136.

Butler, P. A. 1966. Fixation of DDT in estuaries. Trans. 31st N. Amer. Wildlife & Natural Resources Conf. Publ. by Wildlife Management Institute, Washington, D. C.

Cope, O. B. 1965. In "Research in Pesticides." Academic Press, New York, p. 115.

Gakstatter, J. H. and C. M. Weiss. 1967. The elimination of DDT-C^{14}, dieldrin-C^{14}, and lindane-C^{14} from fish following a single sublethal exposure in aquaria. Trans. Amer. Fish. Soc. 96:301-307.

Keith, J. O. 1966. Insecticide contamination in wetland habitats and their effects on fish-eating birds. J. Appl. Ecol. 3(Suppl.): 71-85.

Nicholson, H. P., A. R. Grzenda, and J. I. Teasley. 1966. Water pollution by insecticides: A six and one-half year study of a watershed. Proc. Symp. Agr. Waste Waters. Water Resources Center, Univ. Calif., Davis. Rep. 10:132-141.

Tarzwell, C. M. and C. Henderson. 1956. Toxicity of dieldrin to fish. Trans. Amer. Fish. Soc. 86:245-257.

DISCUSSION PERIOD

Dr. Thompson: I have two questions, Dr. Nicholson. First of all, in this monitoring of streams, do the people that do this have target chemicals they are looking for, or are they going to detect just anything that comes along?

Dr. Nicholson: That's a good point to bring up. You know we have in the neighborhood of 600 to 700 basic pesticidal chemicals and, in the minds of the general public, when we talk about monitoring for pesticides, they think that we are monitoring for all of these compounds. This certainly is not true. I don't know the exact number we can detect at the present time within the concentration limits that we would expect to encounter. As I have indicated, this is generally less than a part per billion. We can handle most of the chlorinated hydrocarbons, quite a number of the organophosphorous materials and some herbicides. I would say out of this total of six or seven hundred, there are about 100 that we can do very much about in water at these levels. When we are talking about monitoring, we are talking primarily about the chlorinated hydrocarbons plus a few more specific chemicals.

Dr. Thompson: I was thinking about something like soluble nitrogen salts that might come along from fertilizers.

Dr. Nicholson: That is a different type of analysis. We do this sort of thing when we are looking specifically for fertilizer residues.

Dr. Thompson: I am a little sensitive to this because of the feedlot wash-outs we are experiencing in Kansas. The other question I have is in connection with tagging. When you tag with a radioactive isotope, isn't the tag on an ion? It doesn't follow the molecule, does it? It's located on the active part of the molecule isn't it?

Dr. Nicholson: That depends on where the tagging is done. It is true that you have to be careful here. We ran into this on some work with silvex where the only thing we could get tagged was one of the side chains. We ran into trouble when this began to breakdown and form metabolites. With DDT, I believe one of the carbon atoms is tagged, and it's on the ring rather than anywhere else. I think with it we are on pretty safe ground.

Mr. Smith: When observing pollution problems you said it was quite easy to see fish and crustacean destruction. I was thinking, and this goes for soil as well as water, that one of the last things to be studied are the effects on the microscopic forms of life. Are your research laboratories doing any research along these lines?

Dr. Nicholson: We are doing very little with pesticides and microorganisms. Most of this work is going on in the Agricultural Research Service and in the universities. Our mission assignments prevent us from doing research work of this nature. We have several laboratories throughout the country. The work effort has been divided to make sure logical coverage is provided and we don't have a duplication of effort. One of the things we are not permitted to work on is the effects of pesticides. We can work on the fate of them, but we are not doing much of anything in microbiology with pesticides right now.

Mr. Smith: You say there are government laboratories around that are doing this?

Dr. Nicholson: In our group, no, not on microorganisms and pesticides. That's to the best of my knowledge.

Dr. Robertson: Dr. Nicholson, do you have any idea what the fate of carbaryl is in your run-off? I believe you said DDT was suspended on the sediment and toxaphene was in solution. Do you have any idea what would happen to the carbaryl in the surface run-off?

Dr. Nicholson: No, only that it is not considered to be one of the more persistent compounds. We haven't studied run-off of this compound or related carbamates. We are just getting around to trying to improve the analytical methodology in water so we can work at the levels we would expect to encounter. Right now the analytical methodology for the carbamates in water is unsatisfactory from our standpoint.

Dr. Robertson: I was interested because nearly all of our golf courses have lakes or ponds on them stocked with fish. We have had to eliminate using chlorinated hydrocarbons such as chlordane, aldrin, dieldrin, etc. Excellent green June beetle grub control has been obtained with Sevin. I have some golf course superintendents that would like to treat their fairways, but they abound on city water supplies. These fairways are still untreated and are going to be until we find out a little bit more, I guess.

Dr. Nicholson: Well, you have two separate cases there. You have to be very careful about city water supplies to satisfy everybody concerned. As far as the first question is concerned-the effects on the fish-I know of no information, published or otherwise, indicating that such a problem has been encountered with Sevin. Because of the nature of the compound, I wouldn't anticipate that this would be a problem, but we will have to look at it to make sure.

Dr. Portman: Dr. Nicholson, is it not true that most of the DDT that has shown up in Lake Michigan is coming from urban or industrial application, rather than agriculture?

Dr. Nicholson: I have heard that surmise but haven't seen any results of studies to prove or disprove it. I think it is something that someone should take a look at.

Dr. Ludke: Dr. Nicholson, in response to the question earlier about the microorganisms, I believe Dr. Butler and his group have done some work at the Gulf Breeze Laboratory (Bureau of Commercial Fisheries), specifically with DDT. I know they were doing some work about a year and a half ago.

Dr. Wheeler: Dr. Robertson, before I forget, how long do you get effective control of green June beetle grubs with Sevin?

Dr. Robertson: You get immediate control. If you apply Sevin in the afternoon, most of the grubs will be controlled the next morning. It is a one-shot control with no appreciable residual control, but it gives a real fast knock-down. We are recommending 2 lbs per acre. The most dramatic results come from a fall application since the grubs are fairly close to the surface of the ground at that time; but it will work during the spring and summer.

Dr. Nicholson: In connection with your earlier question on Sevin in public water supplies, the publication "Water Quality Criteria" published by the Federal Water Pollution Control Administration in May 1968, has a list of surface water criteria for pesticides in water supplies. The carbamates are listed with a permissible criterion of 0.1 ppm, although it would be desirable if it were totally absent.

Dr. Saunders: Just a comment on that control with Sevin. It is my understanding that it can only be incorporated with the first inch of soil. It hangs up in the top layer.

Dr. Robertson: I don't know how deep we were going but we seemed to get the same control with just 3 or 4 gallons of total material per acre as we did if we went up to 15 or 20 gallons. We did not have to drench it in. This, undoubtedly, had some effect that we don't know about.

Mr. Simmons: Dr. Robertson, could you answer one other question. Have you tested the water for insecticides on those golf courses where fish were killed?

Dr. Robertson: No.

GENERAL DISCUSSION PERIOD

Mr. Bangs: We have been talking about the pesticide problem in general and the search for information on many questions we do not have answers for at the present time. Two examples involved the states of Michigan and New York. Shocking regulatory and legislative proposals awakened a large segment of the pesticide industry as to just how serious the current pesticide climate could be when action is taken which is not supported by factual information.

A Pesticide Advisory Panel of scientists appointed by Michigan's Governor Romney recommended that registration of lawn pesticide-fertilizer mixtures should be discontinued. During the early spring of 1969, Michigan State University Experiment Station concurred with this recommendation, although chlorinated hydrocarbon pesticides were their only concern.

Regulatory action was considered because of two situations; possible contamination of rivers from urban effluents and possible misuse or overuse of specialty pesticide-fertilizer products by urban residents.

Two meetings were held with representatives of industry, the Department of Agriculture, Michigan State Experiment Station and Extension to discuss the proposal and exchange information with the various groups represented. An immediate result of these meetings was an understanding that the major need was to make certain that urban residents have an opportunity to benefit from modern pesticide technology, provided it can be done without fear of contaminating the environment.

Secondly, Director B. Dale Ball of the Michigan Department of Agriculture appointed a committee including representatives from each of these organizations. The purpose of the committee was to explore areas of concern relating to current recommendations of the Michigan State Agricultural Experiment Station regarding specialty pesticide-fertilizer mixtures, and to develop acceptable guidelines for registration of such mixtures.

When this committee had investigated the facts available, there was no evidence to link the use of specialty pesticide-fertilizer mixtures to possible contamination of rivers from urban effluents. The committee unanimously agreed upon three basic recommendations concerning possible misuse or overuse of these products by urban residents. They were:

1. That close liaison exist between the Department of Agriculture and the University personnel on pesticide-fertilizer mixtures being registered. If questions or doubts exist, the Department should examine supporting data in full before registering.

2. Labeling guidelines recommended:
   (a) Products must be clearly identified as pest control products.
   (b) Emphasis in labeling must be on pest control aspect of product.
   (c) Product labeling should emphasize particular use, i.e., crabgrass control, grub control, etc.
   (d) Product labeling should emphasize application, i.e., "For lawns," "For ornamentals," etc.

3. Continued function of the committee in the area of pesticides in general, and specialty products in particular.

The committee's recommendations were accepted by the Michigan Commission of Agriculture for one year, with results to be appraised at that time.

A bill introduced in the New York Senate, which would prohibit any combination of a commercial fertilizer and a pesticide except in a container of 50 pounds or more, met with swift attention. A meeting was held with Senator Theodore Day to explore all pertinent information available relative to this legislation. It included representatives of the State Department of Agriculture, Department of Health, Cornell University, Cooperative Extension Service and 14 representatives of pesticide industries marketing these products in New York State.

After thorough discussion of what factual information was available, cooperative action was proposed, similar to the Michigan situation, and there was no further action on this legislation.

Both of these situations prompted the formation of a Committee within the National Agricultural Chemicals Association to assume the responsibility of dealing with the safety and effectiveness of specialty pesticide-fertilizer mixtures. Industry representation on this committee includes Scotts, Elanco, Chevron (Ortho), Bordens, Velsicol, Swift and Stauffer. All the work of this committee can be funneled through an official state committee, such as the one formed in Michigan, and thereby increase the total effectiveness of both.

Dr. Robertson: You were talking primarily about the small package fertilizer-pesticide mixture. I don't remember the exact year, but some four or five years ago, the Board of Agriculture in North Carolina banned or outlawed the use of pesticide-fertilizer mixtures, but they exempted specialty bags 25 lbs and under. The others were for agriculture, a different situation.

Mr. Simmons: I might say that we are doing some work here at Scotts to determine the relationship of these pesticides to the environment. Our previous efforts have been to define the influence of these materials on plant growth; in other words, using grasses to bio-assay for persistence and degradation of materials. Several years ago we conducted work with quail. We are extending that work this year. We also are extending our efforts to learn more about where the material goes from the target area. At this particular time we have no reason to believe that the materials, like our pre-emergence herbicides, are moving away from the target area, but we will have specific information to back this up within the next few months.

Dr. Miller: We have raised this question in Ohio. It takes a lot longer now and a lot more money to get a compound labeled because you have so many more agencies to go through. The Food and Drug Administration, the USDA and the rest have the data submitted to them, but whose responsibility is it when the material is labeled? They have the information and it would look to me like they should have the answers to some of our questions.

Dr. Nicholson: We shouldn't lose sight of the fact that many of the problems we are facing now with environmental contamination were not foreseen. Any amount of information in the hands of the regulatory bureaus would not have prevented this sort of thing. I don't know whether that is an adequate answer to your question or not. I think, also, that the Food and Drug Administration, in giving their approval for the licensing and labeling of new compounds, is now taking a new attitude, possibly an unofficial one, in regard to game fish and game animals. That is, if they believe that the residues of a compound are going to occur within game fish that would be highly undesirable, I don't think they are going to give their approval to granting a label for these compounds even though they have no legal responsibility for establishing permissible levels in game fish. Maybe it isn't my place to comment on this, but this is something I have observed in conferring with people on various committees.

Dr. Field: It seems that the recommendations for the uses of pesticides come to us by many routes and sometimes when you try to check back on the scientific evidence, there is none. The testing isn't in the published literature. I have particular reference to ornamental and shade tree chemicals. You try to check back on the work that underlies the recommendation and you can't find it in the literature. At least at Rhode Island we have had difficulty finding it. It may be that the company registering the product has the data, but it's not in the literature.

Mr. Simmons: I think we could comment on that particular statement. The registration of a material for interstate shipment is accompanied by information to support the uses on that label. Some of it is developed by commercial companies like ourselves, while other information is developed by the experiment stations. Information is pooled wherever possible. I would also like to take a moment to comment on Dr. Miller's question. One of the means by which the Food and Drug Administration has to check on the recommendations for the use of an insecticide or other pesticide could come through their food sampling program. If I recall correctly, they have sampled foods in a number of different cities quite extensively. Their information shows that insecticides used correctly are not contaminants in our food crops. I think this is a good assurance. The residues for our foods are apparently at a level within the tolerances set by the Food and Drug Administration. The one area that seems to be of real concern is those insecticides that are getting into the aquatic food chain.

Dr. Saunders: Pardon me for being very unscientific here, but we have literally thousands of ornamentals. I think we are partially unique in our area, but not completely so. I am sure that a lot of other areas in the United States have many ornamentals--native and imported. Likewise, we have a great number of insects. The research hasn't been done, but the insects are there and we extrapolate. We make an educated guess because you cannot possibly get all of this work done. I'm sure you are aware that only in recent years has there been any appreciable work done on ornamental and turfgrass insects. Registrations are very broad on the parent compounds that are put out. Some of the ornamental registrations are very, very broad. They are intentionally that way. We have gotten away with things in ornamentals that we wouldn't be able to get away with anywhere else. I think it is a good thing we can, even though a lot of these recommendations are just to the best judgment and knowledge that we have.

Dr. Streu: I would like to speak about Dr. Field's comment on where the recommendations originate. I have seen Extension people in New Jersey who look at other stations' recommendations and, inasmuch as another station makes a recommendation, New Jersey very often will copy it if they think it is a good, sound one. Now, Gordon, you might want to make one in your state and find out how many other stations will pick it up and put it in their recommendations, especially in ornamentals.

I worked in pesticide registration in Washington, also, for awhile reviewing labels and so forth. Much of that work Tom has spoken about is good. Much of it is done by people like you and I, who may get small grants-in-aid to do work on a specific product, like evaluation of chinch bugs. This kind of data never gets published. There's no real place to put it. But it does get buried in the files in Washington and often there is very substantial data to support the use of a particular product. I agree that it is kind of loose in some cases, but in other cases it is very substantial, although not available.

Mr. Simmons: I would like to support Dr. Streu's comments. I think several of us in this room have never been able, by telephone, to convince anyone in the Federal Pesticide Regulation group that they should allow a use on the label without data. The comment always comes back, "Get the information and then we will let you put it on the label." I can think of one case where there is a certain amount of uncertainty about an insecticide usage. It is in the area of grub control which, in turn, eliminates damage from skunks and moles. I think all of us know that if we eliminate the grub supply we seldom, if ever, get any damage from skunks digging into turf, but try to come up with some data to support the recommendation. We achieved control once here on our local golf course by splitting a fairway. That is the only area that I know of where there isn't extensive data to support a use on our labels.

Dr. Miller: Just a comment on what Dr. Streu mentioned. It is very common in Extension to share recommendations with other states. Ohio has approximately 600 acres of greenhouse vegetables under glass, which probably puts us close to being number one in the nation, at least in the midwest. I think most of the states look to us for information because we are the ones who have the most acreage and the ones who are doing the most work. On the other hand, we look to Illinois and Iowa for corn recommendations. We don't have too many people in ornamental research so you just struggle along and when you see something that looks pretty good, you use it. It is very common to share. How else can you do it? If you would look at the midwest you would probably find that, other than timing, most of our problems are quite similar. We are just about forced into borrowing because so many of our researchers are going into basic studies and our problems are multiplying.

Dr. Streu: This works two ways, Dr. Miller. I might cite a recent example; one that I brought up in several of our ornamental workshops in Entomology at our annual meetings. California published some information several years ago about, I think, phytotoxicity on field grown Croft lilies through the use of Systox. In New Jersey we have done three years' work on the use of

Systox on greenhouse grown Croft lilies. Well, the information from California got into recommendations and, I believe, if I might be personal, into Ohio recommendations. Here is a recommendation, as far as I am concerned, which was wrong. It was picked up from information which was not very good and put into recommendations, yet New Jersey recommends that the grower use Systox on his lilies and this was not picked up. Dr. Field, I think your point on where we get our information was very well made. Since we do share information, I think we ought to be a little more careful where we get it.

Dr. Thompson: A lot of this information is printed in state publications, many of which aren't widely distributed. We should have some kind of directory of people working in this area of turf and ornamentals who would take it upon themselves to make sure this information gets around. For example, when we found billbugs in zoysia grass, we would have run a big experiment starting right from scratch if it hadn't been for an industrial representative telling us of some work they had done in Florida. Their data, printed in various Florida publications, included the life history of billbugs and methods for control. We were able to expand our research from this information.

Dr. Portman: We have heard about the effect of an acid condition and an alkaline condition in breaking down chemicals. I might say that while DDT will hold up for possibly eight years in our calcareous soils in southern Idaho, I doubt if you can get 10 lbs of chlordane to last in those same soils and control wireworms for more than 4 or 5 years.

Mr. Simmons: Of all the chemicals we have talked about, only one falls into the "almost safe" group--pyrethrins. Shouldn't we look at these chemicals from the standpoint of the job they will do, versus the related risks? Let's pick one chemical that has been discussed several times today--chlordane, one of the better materials for grub control. From what we know now, there is very little of this material moving into the environment. If we take known factors into consideration, is there a need for the chemical, and what is the risk involved? Aren't these questions that have to be answered? I don't know of anything we do or use in this environment where there isn't some degree of risk.

Dr. Field: There has been an expanded interest in, not only insecticide run-off, but also in nitrogen, phosphorous and potassium, and the eutrophication of our rivers, streams, ponds and lakes.

Dr. Wheeler: I have one comment about a favorite subject of mine. How many of you get worried about the use of a name, Systox for example, to indicate a chemical with an extremely high toxicity. I have heard people come into stores and ask for Systox when they definitely meant Meta-Systox-R. I think all of us should use our influence and request the Pesticide Regulation Division, since they do have the control over the use of trade names, to try to avoid such possible conflicts. This, to me, is a very hazardous situation. I have been in stores where they carry both Meta-Systox-R and Systox, and the homeowner could easily forget the Meta and R and just ask for Systox. It is a real hazardous situation.

Dr. Miller: A couple of years ago at the Northcentral Branch Meeting of the Entomology Society, Lyle Goleman sponsored a resolution to require that the common name of a chemical be placed on the label underneath the trade name, or whatever name you were putting on there, so that all of us could tell a homeowner or a garden center operator to look in such and such a place. This would be standardized so we could talk about carbaryl, or whatever some of the other names are. I don't even try to remember these things anymore because you tell a person to go buy azinphosmethyl and he looks at you like you have blown your lid or something. It doesn't do you any good to tell him to buy this, because it is not on the label. This may come up again and it certainly would be a big help to us in Extension where we could recommend the common name, if all of them had common names. I certainly would hope they could come up with some easier names to pronounce than some they have now.

Dr. Wheeler: Now you have hit a favorite subject. If you fellows would stop using the name azinphosmethyl it would be helpful. Azinphosmethyl has no official standing; therefore, it is not required on labels. Just because the Entomological Society uses it is no reason that you should use it in talking to the general public. Carbaryl is another matter. It is an officially accepted common name and we should use it. You can go into a store and ask for Sevin and they will tell you they haven't got it. Actually, it may be listed on the label as carbaryl and the clerk is just not familiar with it's common name (Sevin). The USDA Pesticide Regulation Division is studying the feasibility of a regulation requiring manufactures to either come up with a common name at the time the chemical is registered in a product, or the common name must be included in the list of active ingredients. Of course, that is where you have to go to be absolutely sure you see it on a label.

SOME CUMULATIVE EFFECTS OF PESTICIDES IN THE TURFGRASS ECOSYSTEM

Herbert T. Streu
Department of Entomology and Economic Zoology
Rutgers University
New Brunswick, New Jersey

Much of the work of applied entomologists is concerned with applying pesticides once, or possibly twice, and evaluating the effects on a specific organism. The resultant information is practical and useful, but is only relevant to the control of that specific pest. Agricultural chemicals, however, are applied regularly to specific systems and the effects are obviously cumulative. This is especially true in the turfgrass system. For example, in New Jersey sod webworm control recommendations include monthly applications of insecticides. Some, like chlordane, are highly residual. For some nematicides, such as diazinon, (applied as Sarolex^R) there are recommendations for use on turfgrass as high as 40 lbs per acre.

It has been the objective of research being conducted at Rutgers to determine some of the effects of annual applications of pesticides on turfgrass. Some of this work has been published. Much of it is not and the objective of this paper is to present some of both results.[1]

Our work began in 1962 when we found a heavy infestation of sod webworms in a utility-type turf surrounding a local manufacturing plant. A number of pesticides were applied for insecticidal evaluation and, besides sod webworm control, a growth response in the grass was observed. In 10 ft by 10 ft contiguous plots, responses ranged from a yellowing of the grass to an enhanced growth consisting of greener and more vigorous growth when compared with untreated plots. Using a rating system of 1 to 5, where 5 equalled the least growth and 1 was the best, results over several seasons showed that treatments with three organo-phosphate materials (ethion, diazinon and carbophenothion) yielded consistently better growth of the grass when compared with untreated grass (Fig. 1). Moreover, clipping yields showed that the two materials, ethion and carbophenothion, gave significantly higher yields (dry weight) when compared to the check (Fig. 2).

Furthermore, a third of each untreated plot was found to consist of crabgrass towards the end of the fourth season. Plots treated with ethion and carbophenothion, however, contained significantly less crabgrass. This is probably a result of the more vigorous growth (Fig. 3). Enhanced growth effects, after five years, were also reflected in the amount of undecomposed organic matter accumulated. Almost twice as much thatch was observed in ethion plots.

Plant parasitic nematode populations associated with the grass were also examined using the Esser sampling tool (Esser, MacGowan and Van Pelt 1965). (We highly recommend the use of this efficient device.) Results

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1/ This paper contains some unpublished preliminary results which may be changed in final publication.

Fig. 1. - Growth indices observed in grass plots treated with three annual applications of pesticides. 1, worst growth; 5, the best.

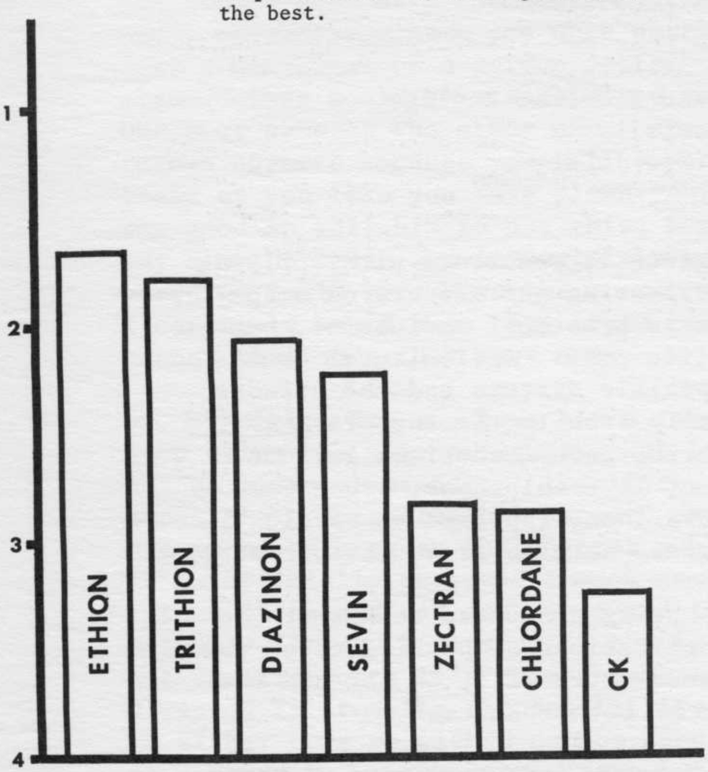


Fig. 2. - Clipping yield in grams dry weight from grass plots treated with three annual applications of pesticides.

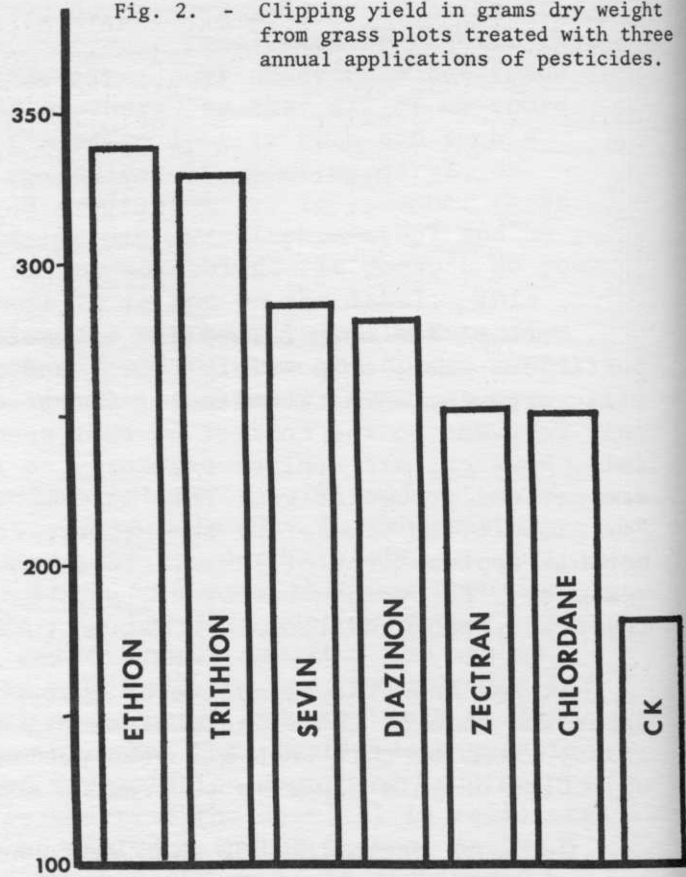
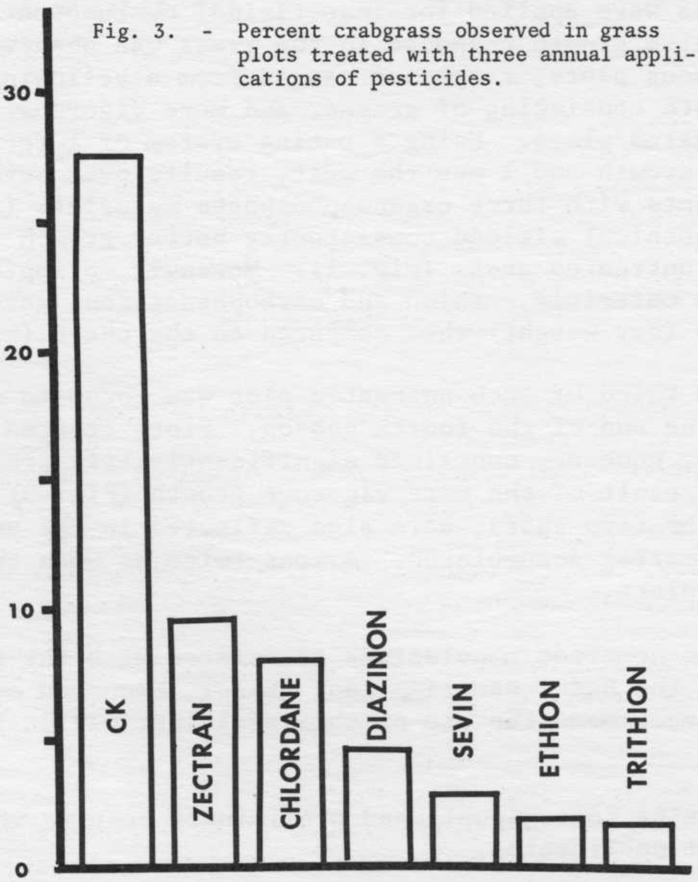


Fig. 3. - Percent crabgrass observed in grass plots treated with three annual applications of pesticides.



over a period of years showed that ethion, diazinon and carbophenothion had considerable nematicidal activity and we believe that this activity, in turn, was reflected in the increased topgrowth, the increased amount of thatch, etc. Similar results were found with a Helicotylenchus sp. These data were published in 1966 (Streu and Vasvary 1966).

Data from a series of years showed that in New Jersey most of the parasitic nematode populations decline drastically over the winter. Beginning at a low point each spring, populations tended to increase to high levels by the end of fall. Treatment with some materials, on the other hand, (diazinon, Baygon[R] and ethion) over a period of years gave consistently good nematicidal activity, holding populations relatively stable (Streu and Vasvary 1967).

Hairy chinch bug (Blissus hirtus Montandon) populations were also estimated through a series of years. The bug appears to prefer the red fescues which often are mixed with bluegrasses in the commonly used lawn mixtures. At the end of a summer, heavy chinch bug feeding may result in death or browning of most of the red fescues. Counts were made using a heavy gauge metal can, serrated on one edge. With a handle welded through the can, the device was driven into the ground and three counts were made per 100 ft^2 plot, 9 counts per treatment in 3 replicates.

Results showed that 30 days after treatment, the organophosphate materials effectively reduced chinch bugs populations (Fig. 4). Carbaryl treatment, however, resulted in control for only 10 days, after which increased populations were found. Chlordane treatment resulted in increased populations after 60 days, to where there were more than twice as many bugs as found in the check. Chlordane was apparently interfering with some natural population regulating mechanism present in the untreated plots.

Population estimates from the chlordane-treated plots and the check areas showed that the ratio of the number of chinch bugs in the chlordane plots to those in the check plots increased annually in 1964, 1965 and in 1966. However, 1967 and 1968 were very wet years and populations declined markedly, and were not counted. Counts in 1969 indicate that plots treated with chlordane were again very high in comparison to untreated areas. These differences are not simply a matter of insecticide resistance (Streu and Vasvary 1966).

Probably one of the most interesting results has been the change observed in the grass composition of the turf. Normally, in non-shade areas in home lawns and utility turf systems in New Jersey the turf consists of only about 10-15% red fescue with the remainder, bluegrass. After years of treatment with the organophosphate materials, we observed a change in the texture of the grass. This was due to differences in the amount of fescue which had succeeded to the point of dominance. Ethion, trithion and diazinon treatments resulted in an average of 44% red fescue (Fig. 5). The apparent ability of red fescue to compete more successfully after pesticide treatment has also been reported by Halisky, Funk and Engel (1967).

In more recent work, we have been measuring the activity of arthropods on the soil surface by using modified "Fichter" pitfall traps (Fitcher 1941), one placed in the center of each plot. Catches are harvested year round, every 1 or 2 weeks. Some preliminary results over one year (Fig. 6) show, for example, that surface inhabiting spider populations are greatest in

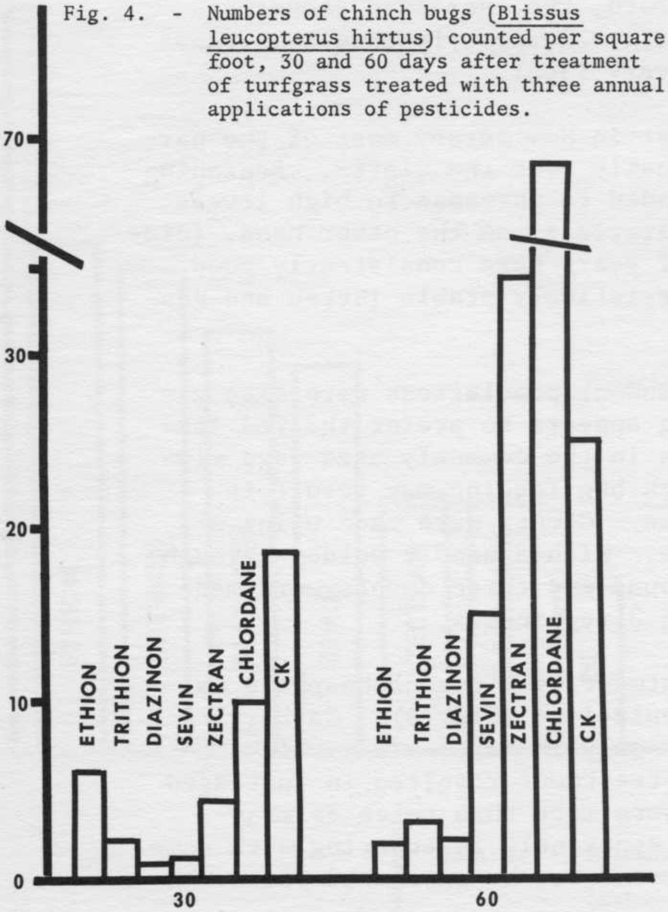


Fig. 4. - Numbers of chinch bugs (Blissus leucopterus hirtus) counted per square foot, 30 and 60 days after treatment of turfgrass treated with three annual applications of pesticides.

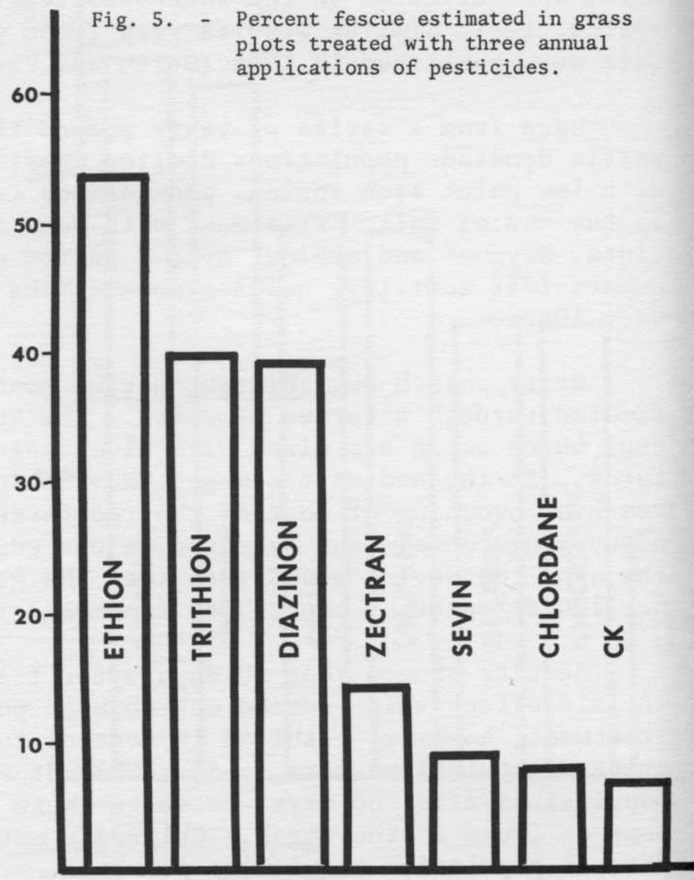
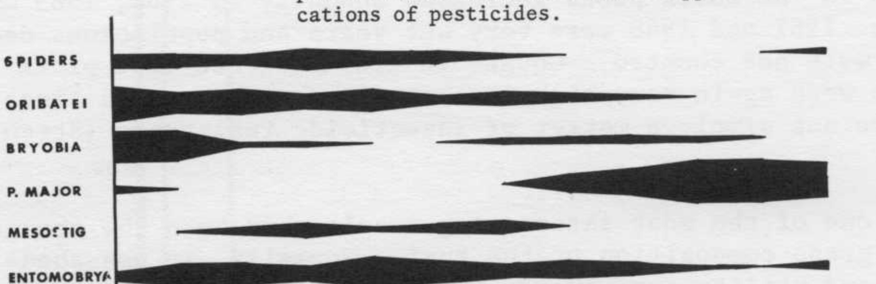


Fig. 5. - Percent fescue estimated in grass plots treated with three annual applications of pesticides.

Fig. 6. - Relative numbers of certain arthropods collected from pitfall traps in grass plots treated with five annual applications of pesticides.



April, with catches ceasing sometime about November, beginning again February and starting to increase in April. Heavy populations of bryobid mites were collected in spring (April and May). They disappeared and then reappeared in light populations for the rest of the time. The mesostigmatids, which are largely predatory mites, appear to have similar population trends. The Collembola, (Entmobrya, Neosminthuredes, Euzelia and Zenilla) populations are caught throughout the year. Staphylindid beetles are trapped only in June, July and August and then only in low numbers. Thrips appear in September, October and November. We are also collecting an unidentified immature stage of the Coccidoidea in very high numbers which disappears about November.

Penthaleus major (Dujés), a eupodid mite, begins to appear in the trap collections in October. Large numbers are collected in November, and they increase into December when they are very heavy and dominate in the collection times shown (Fig. 6). P. major, the so-called "winter grain mite" or "red-legged earth mite," has been reported as a major pest of small grains and certain other crops in Australia, New Zealand, South Africa, England, Texas, California, Kansas and Arkansas. Its occurrence east of the Mississippi is rare, and it has not been reported as a pest of turfgrass to my knowledge. This is an interesting mite in that it can build up to hugh numbers in a very short time and does not overwinter but, in fact, oversummers. The anus is dorsal and when the mite is disturbed it excretes a large drop of liquid from the anus, a behavior which may be a kind of defense mechanism.

P. major feeds on grass with chelae which rasp the cell surface. We have observed considerable damage on the grass blades which superficially resembles damage inflicted in the spring by clover mites. Estimates of numbers of P. major in the various treatments, using an index of plant injury, showed that the least numbers were present, or at least feeding, in ethion and carbophenothion treated areas. However, these differences did not correspond with the color differences observed in the plots in midwinter.

Another mite found in very high numbers is Bryobid praetiosa Koch, a common grass pest occurring in April and May. Feeding damage by this tetranychid can be severe, resulting in a silvered appearance of the grass due to removal of cell contents with piercing-type chelicerae. As with P. major, B. praetiosa populations were estimated by rating feeding damage using a system in which 0 equalled no feeding—5, the most. Ratings made on April 28 and May 10, 1969, showed very low feeding indexes in ethion treated plots, whereas the check was rated relatively high (Table 1). Again, ethion and carbophenothion gave us the best control. These plots had not been treated since June 1968! Carbophenothion and ethion, therefore, were effecting long term residual activity and may even have some systemic properties. Differences in the number of bryobids found in the pitfall traps also showed carbophenothion and ethion treatments yielded the lowest numbers of these mites.

Table 1. - Comparison of feeding damage on Kentucky bluegrass from Bryobia praetiosa. 0, none; 5, most. Ten blades were selected at random from plots treated with six annual applications of pesticides.

	Date	
Treatment	4-28-69	5-10-69
Ethion	0.02	0.13
Zectran	3.2	3.8
Diazinon	2.5	2.5
Trithion	0.2	0.6
Chlordane	2.5	2.5
Sevin	2.2	2.6
Check	2.7	2.4

Some pitfall traps only yield an estimate of the surface activity of organisms, soil samples were also taken in an attempt to make quantitative estimates of the numbers and kind of organisms present in the soil. Four, 2-inch cores were removed from each plot (12 per treatment) three times during a season. Eighty-eight cores were extracted at each sampling. A device, similar to that described by MacFadyen (1961), was used to remove the soil samples.

Results showed that ethion had the greatest effect on total soil Collembola as well as an effect on the total mite population towards the end of the season. Differences in total numbers of Collembola were found in carbaryl-treated plots about 19 days after treatment. Of the five species of Collembola present, no differences between treatments in the population structure were found. There were differences in total numbers, however.

One of the more interesting observations in this work is that after six years of treatment, we are finding very large differences in the amount of growth in the chlordane treated plots. As stated previously, we initially found a depression in the amount of growth when compared to the phosphates (Streu and Vasvary 1966). With continued usage, growth appeared to recover until this year, when the grass is almost as good as in the organophosphate treated plots. Counts of earthworm mounds has indicated that chlordane and some of the other pesticides are apparently affecting earthworm numbers and activity. This earthworm activity appears to be related to the amount of crabgrass found in the plots, according to data compiled for two years.

In summary, it is evident that annual applications of pesticides to turfgrass result in large ecological differences, some of which we have measured. A few of these differences are enhanced plant growth, menaticidal activity and certainly, considerable activity against many of the so-called "non-target" organisms. It may be a number of years before this work will be finished. We will continue to apply these materials and follow the changes, some of which I have tried to show you here this morning.

References Cited

Esser, R. P., J. B. MacGowan and H. M. Van Pelt. 1965. Two new nematode subsampling tools. Plant Dis. Rep. 49:265-6.

Fichter, E. 1941. Apparatus for the comparison of soil surface arthropod populations. Ecol. 22:338-9.

Halisky, P. M., C. R. Funk and R. E. Engel. 1967. Effect of granular pesticides on summer survival of Pennlawn red fescue. p. 49-55 in 1967 Report on Turfgrass Research. N. J. Agr. Sta. Bull. 818, 121 pp.

MacFadyen, A. 1961. Improved funnel-type extractors for soil arthropods. J. Anim. Ecol. 30:171-84.

Streu, Herbert T. and Louis M. Vasvary. 1966. Pesticide activity and growth response effects in turfgrass. Bull. N. J. Acad. Sci. 11:17-21.

Streu, Herbert T. and Louis M. Vasvary. 1967. The nematicidal activity of some insecticides in turfgrass, p. 77-93 in 1967 Report on Turfgrass Research. N. J. Agr. Sta. Bull. 818, 121 pp.

DISCUSSION PERIOD

Dr. Wheeler: Does the ethion-Trithion type of material also hit the earthworms?

Dr. Streu: Yes, on that last slide I think I showed that.

Dr. Wheeler: Not just the chlordane, but ethion and Trithion, also.

Dr. Streu: Yes, that's right. There's a relationship between the activity of these materials and the number of earthworm mounds. I don't know the number of earthworms because we haven't counted them. If these plots had been established to count animals like grubs, earthworms, etc., we would have to tear the plots up and we don't want to do this. All we can measure is the number of earthworm mounds themselves, which is just an assessment of the activity and does not represent the number of animals present.

Dr. Wheeler: Do you get a reduction in the number of mounds with the other materials, as well as with chlordane?

Dr. Streu: The estimated number of mounds run up to 56 per 100 sq ft. Chlordane treated areas had 8 castings per 100 sq ft. There were also reductions in the number of mounds in areas treated with ethion and carbaryl. Diazinon has the least effect. Zectran has practically no effect as compared to the check.

Dr. Wheeler: In what formulation are you applying these materials?

Dr. Streu: These are all emulsifiable concentrates. Most of them are 4 lbs per gallon, except chlordane, which is 8 lbs per gallon. They are applied with a watering can at a rate of 8 lbs per acre of active material. We went deliberately to the highest rate. Carbaryl and chlordane are applied once per year and the other materials are applied twice--once in June and once in July. This is what we recommend for the control of chinch bugs and other insects in New Jersey.

Dr. Portman: Is there any correlation between the amount of thatch and arthropods you have here?

Dr. Streu: We haven't evaluated that yet because we do not have the real story on the number of arthropods actually in the soil. There doesn't seem to be much of a relationship between surface activity. Your question is a good one because, obviously, if we change the system, we are going to change the animals which live in the system. Ethion, for example, gave us the largest amount of thatch. In some of our experiments the total number of Collembola, which are largely detritus feeders, have been reduced considerably. Now, when I get to the point where I can separate out this mite population and structure it, I hope some other mites which are detritus feeders also will be reduced, and may account in some way for the amount of thatch and also the amount of growth.

Dr. Portman: In a backyard situation where the clippings are allowed to drop and thatch develop, our lawns go out. Aerators, or what I call power lawn rakes, have been the only thing that has kept old established lawns looking good. I am just wondering if this relationship between the arthropods and heavy thatch might not be one of the situations that we should be looking at.

Dr. McDaniel: On your scale insects, obviously you were collecting these with your trap as they dropped in. This is the immature stage.

Dr. Streu: That's correct.

Dr. McDaniel: All the adults would be attached. The immature stages feed only intermittently. In fact, some of them don't feed at all until they actually settle. Now the question comes into mind, have you found the adult stage of the scale on the grass?

Dr. Streu: No we haven't. But we're picking this up in the soil.

Dr. McDaniel: A question in relationship to this is the use of the name, Coccidae. To a scale man this would indicate that it is with a specialized group. Yet, in your discussion, you said it may be an armored scale, a mealy bug or another scale insect. This would all be synonymous to a coccidologist. If this is a crawler, it could be a pseudococcid. It could also be one of the coccidae group, or if it is very, very small it could be one of the armored scales. But you would see these on the host itself and an inspection of the host should tell this. If it is a root infesting form, this is where you would miss the adult by not inspecting the root system to see if it is there.

Dr. Streu: We are collecting them in pitfall traps. Apparently there are a number of species involved, too.

Dr. Heinrichs: What is the name of those pitfall traps?

Dr. Streu: Fichter.

Dr. Heinrichs: Apparently these arthropods move very little in these 10 ft by 10 ft plots, right? Will they move from one plot to another?

Dr. Streu: Which ones are you talking about?

Dr. Heinrichs: I'm thinking about mites.

Dr. Streu: As the population increases, the bryobids will spread out over the plots.

Dr. Heinrichs: One pitfall trap per plot?

Dr. Streu: One per plot, right in the center. And if I had the time and was young enough, I would start this thing all over again. A lot of the answers to the problems in the design of the experiment will come out after we get all this data plugged into the computer and we go over it with our statisticians. I am sure the design is not a good one because the plots are contiguous, but this is the way we started in 1962. Tom Stringfellow mentioned specifically that he used buffer areas, and I'm sure we're going to have to go into that. Another researcher mentioned that we should start over because our present tests don't have a baseline. So what I am giving you here are results of accumulative effects which, as you mentioned, aren't very specific after this amount of time. Once we have identified the organisms and know what we are dealing with, we can redesign our experiments. Hopefully, we might start over again if we can find a suitable turfgrass area. You can attack this kind of work from about 14,000 different ways and every one of them would probably be valid. At least we have some information.

Mr. Simmons: Are you looking at the concentration of these materials in the soil analytically?

Dr. Streu: No, but there was a group of scientists at Rutgers that got together. There were eight of us, including soils people for chemistry, a microbiologist and plant pathologist. We also had a zoologist and a botanist, who were ecologists. I don't know how many other people were brought into this thing. We were going to look, not at a turfgrass system, but at an old field system with the application of pesticides. We were reviewed NIH. They said we had a good grant, but we ran out of money. Your question is pertinent because we have thought about this and we weren't funded on this grant, although it was approved.

Dr. Stringfellow: Here is a perfect opportunity for someone like the golf course superintendents of the United States, or some group like this, to step in and apply the right assistance at the right time to keep it going. It's bad not to continue with this kind of a research project.

Dr. Streu: One interesting point that has come out of this is that the effects of pesticides in turfgrass are really not as horrendous as you might think, even loading the system as we have.

Mr. Mayer: Have you done any work with bentgrasses? Specifically with nematodes on bentgrasses?

Dr. Streu: No, not in this area. We have done quite a bit of nematocidal work and picked up very high populations of *Hoplolaimous uniformis* associated with bentgrasses. This is the only nematode we have consistently found in bentgrasses. We have applied a number of nematocides, but have had no clear-cut results as far as the growth of the grass is concerned. So apparently in New Jersey, in northern grasses, the pathogenic effects of nematodes can be overridden with culture. You can fertilize and water and override the effects of pathogens which are apparently weak.

It should also be pointed out that only two nematodes showed effects of the pesticides. There were a number of others, including *Xiphinema*, *Hoplolaimus* and especially *Criconemoides*, which occurs in large numbers associated with turfgrass. These insecticides did virtually nothing to populations of *Criconemoides*, *Hoplolaimus* and *Xiphinema*. Now, if we look at it in this sense, we have pesticides which are really selective against this plant feeding nematode population in the soil. We have to be careful, I think, when we talk about nematocidal effects of phosphates or any other thing because it is not clear-cut. It is selective.

Dr. Stringfellow: Would you care to comment on the research Dr. Perry and others have done, showing that new nematocides do not necessarily kill nematodes? The nematodes are left alive in the soil, yet supposedly, the grass is no longer fed upon by them. Nematode counts still remain high, but the grass seems to recover. Have you found any of this to occur? We are finding this very commonly with certain nematocides in southern Florida.

Dr. Streu: No.

Dr. Schuder: On your pitfall trap, is there a provision for water to drain out? Is there a screen around the rim or something of this nature?

Dr. Streu: Yes, there is. I can't recall the publication, but someone did an evaluation on a whole series of pitfall traps and this was the best one. The sides are canted so the animal falls in and can't get back out. There is a cover, which keeps the rain from going into the funnel, but allows it to drain down through the sides through a 200 mesh copper screen. Then the water runs into the hole in which the pitfall trap is supported. We have been told to be very careful of pitfall traps, but I am amazed at the quantity of information we have gotten. Although it is not quantitative, it gives us an estimate of activity.

Mr. Simmons: I have one other question. In any of your work, have you seen any evidence of phosphate or carbamate activity on grubs?

Dr. Streu: We have not looked at grubs at all because it would necessitate tearing up the turf. There are some things we refuse to do because of the establishment of the grass itself. With regard to these little two-inch plugs, we have another turfgrass area which we have been treating with the same materials we use in the nursery. We can replace the plugs, which are only two inches, and we take four of these out of each 100 sq ft. To remove a larger amount than that, we would be tearing up the system itself. We fertilize and put lime on when our analysis shows it is needed, and irrigate when the grass is under an unusually heavy stress for water.

PESTICIDE RESIDUES IN TISSUES OF FISHES FROM NATIVE AND COMMERCIAL FISHERIES IN THE MISSISSIPPI DELTA

J. Larry Ludke
Zoology Department
Mississippi State University
State College, Mississippi

Introduction

Although insecticide resistance in insects has been recognized for about 55 years, vertebrate resistance was not reported until 1963 by Vinson, Boyd and Ferguson. Since 1963, several species of fishes from drainage ditches near heavily treated cotton fields have been found to be resistant to several pesticides (Ferguson, et al. 1964 and Ferguson and Boyd 1964). Levels of resistance range from 3 to 1,500-fold and are highest toward the chlorinated hydrocarbons. Highest levels of resistance are exhibited toward the cyclodienes, endrin, aldrin and dieldrin and the chlorinated camphene, toxaphene. Resistant fish can tolerate enormous residues of these insecticides with no apparent ill effects.

Mosquitofish (*Gambusia affinis*) exhibit the highest level of resistance in fishes (2,000-fold and greater), and have shown no toxicologic effects from whole-body residue of 1,041.66 ppm endrin after exposure to 2 ppm endrin for 7 days (Rosato and Ferguson 1968). These mosquitofish contained enough endrin to kill predators several hundred times their own weight. The selection to resistant game species (largemouth bass, *Micropterus salmoides*; bluegill sunfish, *Lepomis macrochirus*; etc.) could present man with a dietary hazard.

Little is known about the extent of contamination in the aquatic environments of the Mississippi delta where resistant fishes have been found. The following data were gathered in a preliminary study to determine the extent of common pesticide residues in native and commercially reared fishes in the Mississippi delta region.

Field Methods. The aquatic habitats studied probably represent the most and least contaminated conditions which the fishes in the study area exist. The three types of aquatic habitats studied were: (1) a highly contaminated drainage ditch (Humphreys Co., Miss.) containing resistant fish; (2) lakes representing various degrees of contamination because of their locations and topography, and (3) commercial catfish farms.

The drainage ditch is bordered by heavily treated cotton fields and received extensive run-off and, probably, some drift. Resistant mosquitofish from this ditch were analyzed for whole-body residues. Four lakes that are heavily fished were chosen as probable sites representing extremes of contamination. Little Eagle Lake, Humphreys Co., Miss., is bordered by wooded areas on all sides and receives only limited agricultural drainage. Sky Lake, Humphreys Co., Miss., is a shallow lake receiving direct run-off from cotton fields and extensive drainage from ditches running through the cotton fields. Two other lakes--Mossy Lake, Leflore Co., Miss., and Lake Washington, Washington Co., Miss. receive moderate amounts of agricultural drainage. Lake samples were based on muscle tissue only. Specimens from a catfish farm, Tharpe's Catfish Co., Sunflower Co., Miss., were sampled at the same time and in the same manner as those from the lakes for a direct comparison of the ecological situations. Sixteen catfish farms throughout the cotton-producing region of Mississippi were included in the sampling. Muscle and fat were analyzed. Also, additional tissues were tested on one occasion when a fish suspected of dying from cotton poison was brought to our laboratory.

An attempt was made to sample lakes monthly. Fish were collected from anglers whenever possible, and when they could not be caught, rotenone was used. Samples from the drainage ditch were seined; catfish were purchased or obtained by angling.

Analytical Methods. All samples from catfish farms and lakes were immediately placed on ice for transport to the laboratory. Samples from the drainage ditch, on the other hand, were transported live in water. The time between collection and extraction was about 24 hrs.

Tissue samples were extracted with hexane according to the method of de Faubert Maunder et al. (1964). Sample weights extracted were: muscle, 5.0 g; visceral fat, 2.0 g, and whole bodies of mosquitofish, 2.0 g. Samples were cleaned on florisil columns by the Mills procedure (Mills 1961).

A Barber-Colman model 5360 Pesticide Analyzer with 200 millicurie tritium source of electron capture detector was used to analyze the samples. The analytical column was 6' X 3.5 mm coiled Pyrex column with a stationary mixed phase of 1.5% OV-1 plus 1.95% QF-1 coated on Chromosorb W-HP. Operating parameters were: column oven, 195 C; injection port, 220 C; detector bath, 205 C, and nitrogen flow, 85 ml/min.

Percent recovery for p,p' -DDT, -DDD and -DDE ranged from 83 to 98%. Results of analyses are expressed as parts per million on a wet weight basis. Samples were analyzed for DDT, DDD, DDE, toxaphene and endrin residues.

Results and Discussion

Residue levels of DDT, DDD and DDE in whole, insecticide-resistant mosquitofish were analyzed periodically from August 1968 to May 1969. Wholebody residues of DDT and its metabolites were found to be highest during the months of October (50 ppm) and February (84 ppm) after periods of extensive rainfall (Fig. 1). DDT was consistently higher than its metabolites and in every month but November, DDD residue was greater than that of DDE. Toxaphene residues did not fluctuate, but showed a steady increase throughout the winter months—11, 82, 92 and 115 ppm for the months of August, October, November and February, respectively.

Lakes were sampled eight times over an 11-month period from June 1968 to April 1969. There was considerable monthly variation among tissue samples of each lake (Fig. 2). Although no seasonal trend is evident in the lakes as in the field drainage system, there does appear to be a relative difference between lakes. Residue levels in samples from Little Eagle Lake were consistently lower, ranging from 0.14 ppm to 0.79 ppm DDT plus metabolites (mean 0.44 ± 0.23 ppm). Lake Washington ranged from 0.19 to 1.70 ppm (mean 0.64 ± 0.52 ppm). Tissue residues from Sky Lake ranged from 0.39 to 2.00 ppm (mean $1.93 \pm .61$ ppm). Sky Lake was suspected of being the most contaminated lake studied because it receives large amounts

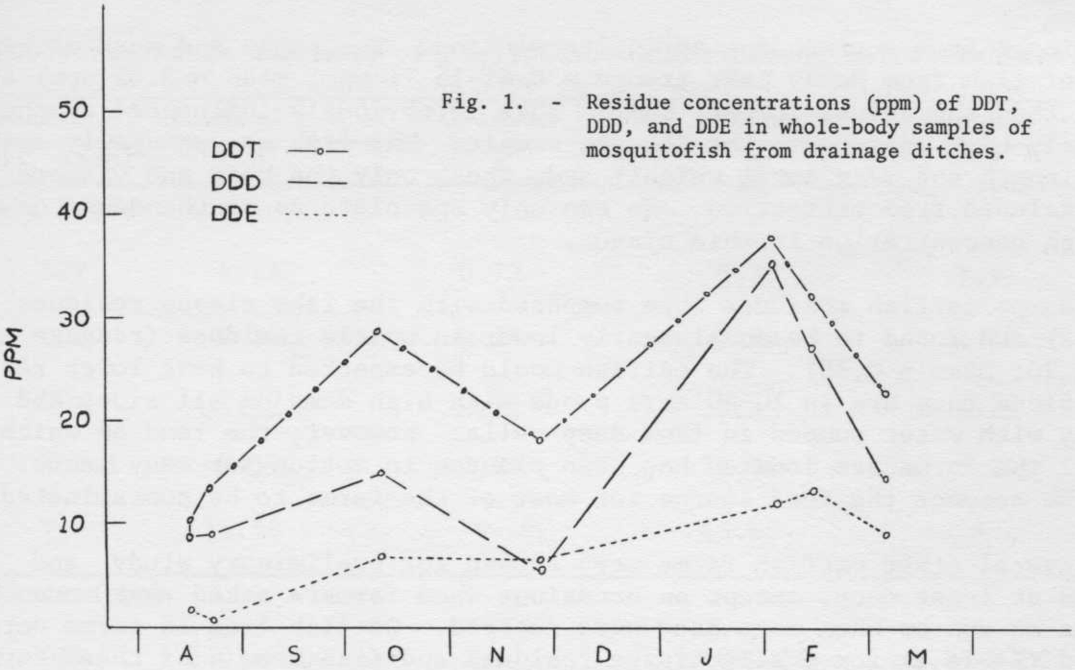
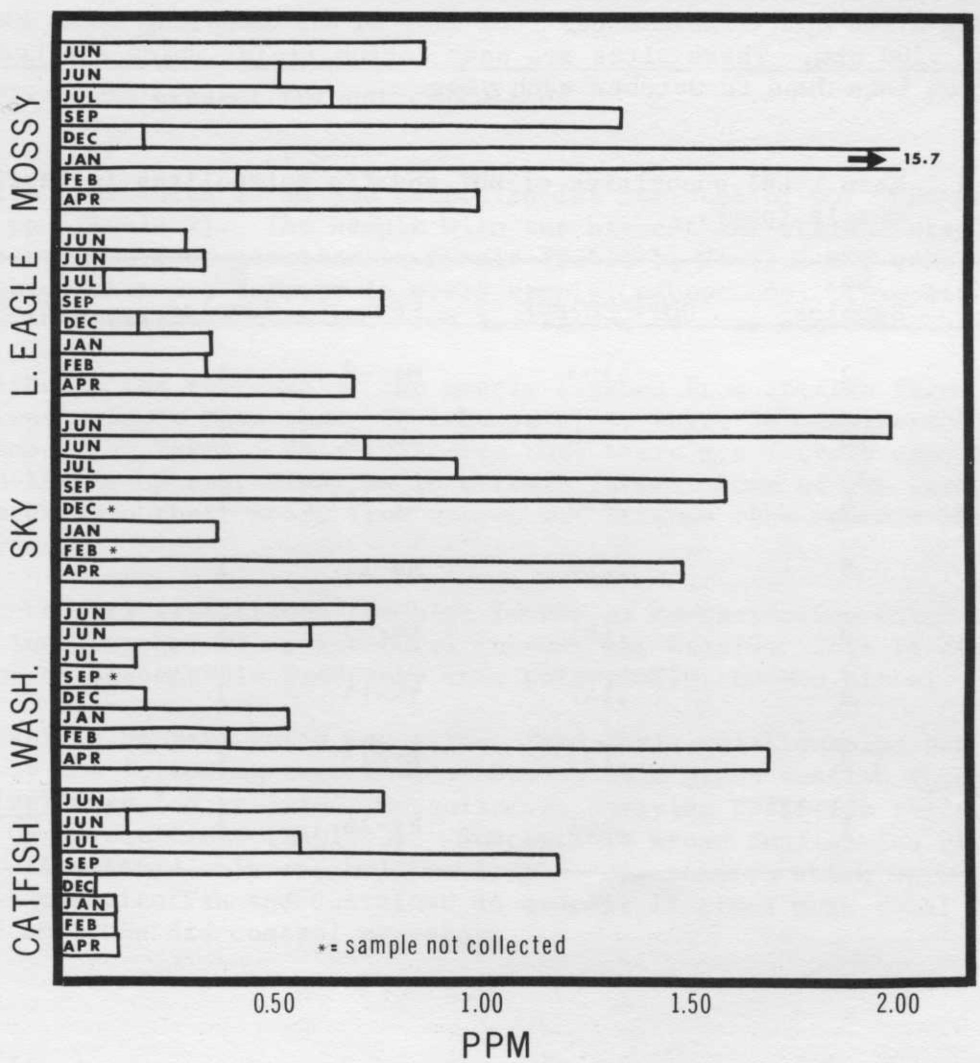


Fig. 1. - Residue concentrations (ppm) of DDT, DDD, and DDE in whole-body samples of mosquitofish from drainage ditches.

Fig. 2. - Residue concentrations (ppm) of DDT plus its metabolites in muscle tissue of game fish from lakes in the Mississippi delta.



of drainage from surrounding agricultural land. The range and mean of residues of fish from Mossy Lake (range = 0.41-15.71 ppm; mean = 2.61 ppm) are higher than the values for Sky Lake. This is obviously influenced by the extremely high residue in the January sample. The fish was unusually small (7 cm length and 27 g total weight) and, thus, only the head and viscera were excluded from extraction. We can only speculate as to the cause of the high concentration in this tissue.

Tharpe catfish residues were compared with the lake tissue residues (Fig. 2) and found to be consistently lower in muscle residues (range = 0.08-1.20; mean = 0.39). The catfish would be expected to have lower residues since they are in 10-40 acre ponds with high dams on all sides and usually with water pumped in from deep wells. However, the land on which some of the farms are located has been planted in cotton for many years. Also, we suspect the food source for most of the farms to be contaminated.

Several other catfish farms were chosen for preliminary study and sampled at least once, except on occasions when farmers asked that more samples be run or when more data were desired. Catfish from 16 farms were sampled (Table 1) for muscle tissue residues and fish from 4 of these farms (Table 2) were tested for fat residues. The lowest mean value detected for the total of DDT, DDD and DDE was .032 ppm and the greatest value was .441 ppm (Table 1). The mean for total DDT and metabolites of all catfish farms was 0.179 $\pm$ 0.105 ppm. The tissues from five of the sampling sites had residues over .200 ppm. These sites are near cotton fields which are heavily sprayed from late June to October each year.

Table 1. Mean total quantities of DDT and its metabolites in catfish muscle (ppm).

Farm	No. Samples	DDT+DDD+DDE	Farm	No. Samples	DDT+DDD+DDE
Ce-1	2	.103	Min-9	1	.218
Th-2	10	.340	Sk-10	1	.119
Co-3	4	.185	Mil-11	1	.111
De-4	5	.214	Ha-12	1	.183
Lu-5	3	.161	Me-13	1	.149
Re-6	9	.147	Ye-14	1	.282
St-7	2	.123	Br-15	1	.050
Wi-8	1	.441	Pr-16	1	.032

Table 2. Range and mean of pesticide residues found in catfish fat.

FARM:	Reed	Coleman	Dean	Lupher
No. samples	6	1	5	2
Avg Residue (ppm)				
DDT	4.76	0.72	6.79	1.95
DDT	2.14	0.74	2.94	1.80
DDE	1.79	0.74	3.76	1.59
Total	8.54	2.21	13.52	5.34
Tox.	18.58	*	45.88	*
Range (ppm)				
DDT	3.05-8.00	--	3.60-0.59	0.29-3.60
DDD	0.95-3.75	--	1.40-4.20	0.00-3.60
DDE	0.24-3.75	--	1.60-6.98	0.68-2.51

* Toxaphene present but not calculated

Fish from three farms had composite fat residues of DDT, DDD and DDE over 5 ppm (Table 2). The sample with the highest fat residue also had the highest residue concentration in muscle (Table 1, Wi-8). DDT concentration was greater than its isomers in every sample, except one. Toxaphene was present in catfish samples from two locations, but was not calculated.

Although the residues of the muscle tissues from catfish farms were consistently lower than those in lake samples, there is considerable variation among the farms. This indicates that there are factors causing increased levels of contamination in certain farms. Some of the farmers pump water into their ponds from bayous and ditches that meander through this area.

These data illustrates the high levels of contamination which aquatic populations exposed to agricultural run-off may attain. This is certainly a hazard to susceptible predators and, potentially, to man himself.

Possible dangers which may effect food-chain relationships are illustrated by the following experiment. Susceptible green sunfish (Lepomis cyanellus) were fed resistant mosquitofish carrying pesticide residues picked up in the field (Table 3). Susceptible green sunfish fed resistant mosquitofish lived only one-half as long as did sunfish which were fed susceptible mosquitofish and contained an average 11 times more total DDT, DDD and DDE than did control predators.

Table 3. Pesticide residues in susceptible green sunfish fed a continuous diet of resistant mosquitofish.

Sample	Days Until Death	DDT	DDD	DDE	Total	Endrin
1	7	1.18	2.35	0.78	(4.31)	----
2	28	0.85	0.13	0.49	(1.47)	----
3	28	0.62	0.46	0.62	(1.70)	----
4	44	1.70	1.06	1.89	(4.65)	0.28
5 (control)	91	0.04	0.02	0.06	(0.12)	----
6 (control)	97	0.22	0.15	0.22	(0.59)	----

Only one sample contained endrin, the use of which was drastically reduced after 1963. Toxaphene was present in trace quantities in all samples except the controls. Food sources used by some farmers for their catfish may be more contaminated than others, and some of the ponds are on land previously treated for cotton pests. Drift from nearby spraying may occasionally contaminate the ponds. The lowest composite residue (.032 ppm) found in muscle tissue of a catfish came from a pond which is several miles from the nearest pesticide-treated area.

Summary

Fishes living in drainage ditches and bayous near heavy agricultural drainage contain greater concentrations of pesticides than those living in lakes or commercial farm ponds. The amount of drainage and the nearness of lakes to treated areas is reflected in levels of pesticide residues found in the muscle tissues of native food species. Ditches reflect seasonal variation, probably due to drainoff, whereas lakes do not show a uniform seasonal trend. Tissues of fish from commercial fisheries contain less residue than naturally occurring populations. There are differences in the extent of contamination in commercial fisheries which seem to indicate there are practices or circumstances which may be altered in order to minimize the level of contamination of catfish reared for human consumption. We are presently preparing a much more extensive program to monitor the aquatic environments in the Mississippi delta region. We intend to analyze more tissues and tissue samples, water, soil and food sources to better determine the exact degree and sources of contamination.

References Cited

de Faubert Maunder, J. J., H. Egan, E. W. Godly, E. W. Hammond, J. Roburn, and J. Thompson. 1964. Clean-up of animal fats and dairy products for the analysis of chlorinated pesticide residues. Analyst 89:168.

Ferguson, D. E., D. D. Culley, W. D. Cotton, and R. P. Dodds. 1964. Resistance to chlorinated hydrocarbon insecticides in three species of freshwater fish. BioScience 14(11):43-44.

Ferguson, D. E., and C. E. Boyd. 1964. Apparent resistance to methyl parathion in mosquito fish, *Gambusia affinis*. Copeia 1964. 4:706.

Mills, P. A. 1961. Collaborative study of certain chlorinated organic pesticides in dairy products. J. Assoc. Offic. Agr. Chem. 44:171.

Rosato, P., and D. E. Ferguson. 1968. The toxicity of endrin-resistant mosquitofish to eleven species of vertebrates. BioScience 18:783-784.

Vinson, S. B., C. E. Boyd, and D. E. Ferguson. 1963. Resistance to DDT in the mosquito fish, *Gambusia affinis*. Science 139:217-218.

DISCUSSION PERIOD

Dr. Stringfellow: Dr. Ludke, how did you get the 5 g plug you took out of the side of the fish?

Dr. Ludke: The catfish were skinned. We tried to do it just as if they were being prepared for consumption. Then we took a scalpel and cut out a 5 g plug.

Dr. Stringfellow: At the same location and proximity to the stomach?

Dr. Ludke: Yes. They were directly on the side--pretty much underneath the dorsal fin. We would scale or skin the fish and cut out a plug.

Dr. Stringfellow: What did you use for untreated control?

Dr. Ludke: We're not really worried about untreated controls. All we were worried about in this particular experiment was comparing the three situations with the three populations.

Dr. Stringfellow: In a strobane-toxaphene total chlorine analysis, DDT, dieldrin or some of the other total chlorine analysis, there is enough chlorine to read a part or two per million of some of the pesticides simply from background interferences. How could you be sure the peak time and size of peak on your chromatograph were correct?

Dr. Ludke: We did recoveries to see what percent recovery we were getting. We took catfish from a catfish farm in the eastern portion of the state and extracted those. Certain pesticides were added and, later, extracted.

Mr. Westfall: Dr. Ludke, what is an acceptable level of DDT in fish? You showed us several instances with various levels, but what do you consider safe or acceptable?

Dr. Ludke: The levels vary for the particular pesticide. I think Dr. Nicholson could give you a better idea than I could as to exactly what the tolerances are. I didn't point it out, but in one graph there was an endrin value. Endrin was sprayed very heavily in that region up to about 1963 or 1964. Endrin has a zero tolerance, so any residue is supposedly not acceptable. I'm not sure about the situation with toxaphene, DDT and its isomers. I think 5 to 7 ppm comes to mind.

Dr. Stitt: I think the tolerance for DDT in fish has recently been established as 5 ppm by the Food and Drug Administration.

Mr. Gabert: Dr. Ludke, on that bar graph where you analyzed residues monthly in the different lakes, how many samples did you take each month?

Dr. Ludke: As I stated, this was not planned as one study and that should be apparent. We've been studying the ditch-type situation for a number of years. These represent a number of samples with pooled samples in each case. When we started out we were going to make a very extensive study of the lakes, but we got sidetracked onto the catfish study and struggled to keep it up. The sampling area is almost 150 miles from where we were located. I realize the sampling there was scanty but I think it gives you a general idea of the differences between the various lakes. As a matter of fact, the lakes we expected to be the least contaminated were consistently the most clear, even on the basis of one sample. We hope to go back and do quite a bit more.

Dr. Wittenbrook: Dr. Ludke, there has been a lot of interest lately in the mutagenic effects of pesticides. I was wondering if these resistant fish are actually mutagens, or are they the proper species?

Dr. Ludke: I think they probably are not mutagens. This is based on what is known about insect resistance. We can take even susceptible populations and test them at various concentrations. From this we can actually get fish that will do pretty well in comparison with some of our less resistant fish in our resistant populations. The development of resistance appears to be by natural selection.

Dr. Wittenbrook: One other question along the same line. I don't know how many fish you took out of there, but did you notice any minor differences in these fish?

Dr. Ludke: Are you talking about morphology?

Dr. Wittenbrook: Well, some overt or obvious difference. Maybe a slightly different placement of the fin or something.

Dr. Ludke: This is another thing we've wanted to do a study on for a good while, but we just haven't gotten to it. There is a definite behavioral difference. This is evident in two things. For instance, if we place a resistant or susceptible fish in a flowing system and give it a choice of going up channels with varied levels of pesticide, the resistant fish repeatedly will choose the less contaminated spot (depending on the pesticide). Also, the resistant fish are much more voracious. They are not nearly so secretive, but this could be due to the habitat, the presence of predators and so on. This difference, as far as choosing levels of pesticide concentration, leaves you to wonder.

Dr. McDaniel: How did you feed those resistant fish to the predators?

Dr. Ludke: In the case of the fish (bass, bluegills and green sunfish), all you have to do is put the resistant fish in the water and the predators hit him right away. We starved them for a week or two before we actually put the fish in. With the snakes, turtles and so on, you have to feed them forcibly. They're not natural predators.

Dr. McDaniel: What conclusions are you drawing from this?

Dr. Ludke: What we are trying to do is merely show the weight ratio, the level of contamination in the mosquitofish that would produce mortality.

Dr. McDaniel: You are saying that DDT killed the predators. Is that right?

Dr. Ludke: Yes.

Dr. McDaniel: Did you know how much DDT was in that resistant fish at the time the predator ate it?

Dr. Ludke: This wasn't DDT. The particular case that I showed was endrin. Yes, we knew actually how much was in the fish-about 4 micrograms.

Dr. McDaniel: Have you sampled all of these? Are you able to indicate that the predator died by a poison rather than suffocated or choked? There are multiple factors that can be involved.

Dr. Ludke: They exhibited very definite symptoms of poisoning. Plus, we had controls. We were feeding the same groups of fish that had not picked up the residues.

Dr. McDaniel: You had a control of five samples that you fed the nonresistant strain. Is this correct?

Dr. Ludke: I couldn't tell you. I don't recall.

Dr. McDaniel: What bothers me is that you have a strain here resistant to your insecticides. It must be resistant to many insecticides.

Dr. Ludke: Yes.

Dr. McDaniel: If it's resistant to many insecticides, you are accumulating data on a particular insecticide within that fish at that particular time.

Dr. Ludke: In that case, yes.

Dr. McDaniel: And now you are making interpretations in relationship to other insecticides?

Dr. Ludke: No, in that case only to that insecticide. We also knew how much DDT was in the fish being brought in.

Dr. McDaniel: Then which insecticide killed the predator?

Dr. Ludke: Well, I would bet that the endrin did. In fact, I'm sure of it. Approximately four micrograms of endrin was going into the predators with at least 1,000 to 10,000 fold less DDT, and endrin is more toxic than DDT. It's more toxic to all of the birds that we fed and to the fish. I couldn't tell you for sure about some of the reptiles.

Mr. Simmons: Dr. Ludke, would you review which pesticides you have picked up in those ditches? Also, how much DDT is used on the cotton crops in that area?

Dr. Ludke: The principal pesticides we picked up are *para*, *para*'-DDT; *para*, *para*'-DDD; *para*, *para*'-DDE; toxaphene, and endrin before about 1964. We still pick endrin up on occasions, and some ortho, *para*'-DDT. We have gotten dieldrin on one or two occasions, but we seldom find it in our fish. I can't think of any others we find in any significant amount. Now what was your second question?

Mr. Simmons: How much DDT is used on the cotton fields? Is it used each year and how many times a year?

Dr. Ludke: I can't give you the exact information on that. I know they usually begin spraying in early July and go all the way through October. The principal spray mixture is a combination of DDT, toxaphene and methyl parathion. The rate of application varies with the particular parts of the delta.

BIOLOGY OF TURF INSECTS IN RELATION TO CONTROL

James A. Kamm
Research Entomologist
Entomology Research Division
Department of Entomology
Oregon State University
Corvallis, Oregon

We are now in the final conference discussions at Scotts and I wonder (1) whether we, as entomologist, have been provided with new perspectives, and (2) do we really know enough about our pesticide problems to effectively argue the pros and cons. In my opinion, one thing conspicuously absent from our discussions thus far is the lack of emphasis on the biology of the many turf pests in relation to the pest to be controlled. This is one of the fundamentals taught in economic entomology, to know something about the insect you are trying to control.

I have selected as examples of turf insects, the sod webworm complex in Oregon and the billbugs as they occur in the Pacific Northwest. These insects illustrate the variation in the biologies of turf insects and the diversity of factors involved when considering a pest problem. In the course of our discussions, I will raise a few questions that probably will provoke controversy. I intend to perhaps stimulate some thought and show, from one point of view, that sometimes we tend to get entrenched in our research methods and often continue to work on a problem even though it is no longer worthwhile.

The grass seed industry in Oregon presently consists of the following acreages: Kentucky bluegrass, 5,600; bentgrass, 8,160; ryegrass, 132,000: fine fescue, 18,000; red fescue, 14,500; tall fescue, 16,000, and orchardgrass, 10,000. All are grown in the Willamette Valley. The seed grass industry in Oregon is relatively new and includes well-organized growers' organizations that constantly introduce new varieties. They are interested in grasses, both for turf and forage, and seek new markets for their grass seed in the United States and abroad.

Sod Webworms

The life cycle of sod webworms is as follows. Eggs hatch to larvae which construct a shelter in the turf. There are many variations in shelter construction depending upon the habits of the particular insect, and it is difficult to generalize about sod webworms. For example, *Crambus trisectus* in Oregon is univoltine, but in the eastern United States there are 2-3 generations a year. The feeding habits of these insects also vary with the species. We found that *C. trisectus* feeds exclusively on the leaves of Chewings fescue whereas *C. topiarius* does equally well on either the roots or leaves. However, most of the sod webworms in Oregon feed on the chlorophyll-bearing part of the plant.

Sod webworms overwinter as larvae and for years workers have failed to locate the specific overwintering stage. *C. trisectus*, for example, diapauses as very small larva inside a hibernaculum that is very difficult to find among the litter and debris in the sod. The Eastern form of *C. trisectus* has an ash-gray color not characteristic of the Oregon form. Perhaps the color variation is a result of the host on which the larvae feed.

C. topiarius is probably better known as the cranberry girdler. Currently, this is Oregon's worst pest in the sod webworm complex found in grass seed fields, and of the cranberry industry along the Oregon coast. In the Willamette Valley, it is a sporadic pest. The adults fly in June and lay eggs at that time. Larvae require little food during the summer but with the September rains, the grass resumes growth and the larvae feed voraciously. A heavy infestation of larvae will completely separate the roots from the shoots by their feeding activities. The fungus, Beauveria bassiana, often accompanies heavy infestations of larvae. Infected larvae turn a dull pink and become flacid. I suspect that B. bassiana is one effective natural control of sod webworms in Oregon, but control occurs only after the larvae have inflicted their feeding damage.

C. bonifatelluns is a serious pest of lawns in the western United States. This insect rarely damages lawns in the Willamette Valley, but in eastern Oregon and California where it is quite dry, it is a serious problem, primarily in the bluegrasses. It is not a pest in the production of grass seed in Oregon. C. bonifatelluns prefers a well watered and maintained turf and is capable of devouring a lawn in the course of 4 or 5 generations each year.

Although the moths of C. tutillus are frequently abundant, I have never observed noticeable feeding injury by the larvae. The moths emerge in May to lay eggs and the resulting larvae progress to the third instar. Growth is extremely slow through the summer but with the advent of cooler weather in the fall, the larvae resume feeding and then diapause as nearly mature larvae. The fact that C. tutillus grows so slowly indicates that it would not produce economic injury unless extremely abundant.

The point I am trying to make is that the biologies of crambids are highly variable. Some species complete their life cycle in less than one month whereas others require a full year. Too often these insects are lumped together and called Crambus spp. Since the biologies of these species vary, the control should be tailored to a specific insect.

To digress for a moment, I wonder if we in research are asking the right questions to be answered through our investigative efforts. I would like to illustrate this with a few comments on some data of Dr. Terriere's at the toxicology laboratory at Oregon State University. He measured the ability of the Japanese quail, the rat, the house fly, the rainbow trout and the blowfly to epoxidate aldrin. Not only were there great differences among these animals to perform the epoxidation of aldrin, but also between the male and female quail. Dr. Terriere feels that other animals vary in ability to detoxify aldrin and also vary in the metabolite produced. For example, some insects make DDE, others Kelthane, others DDD, etc. Many are more toxic than their parent compound. The problem is that aldrin and many of these metabolites become part of the ecosystem.

I'm not sure it is realistic to ask the question, what levels of aldrin are harmful in our environment? At this time there is no reasonable way to get this information. But what must be decided in the near future is, are we going to invest more time on the chlorinated hydrocarbons and the persistent insecticides, or are we going on to the less residual materials? I have attempted to point out, by way of example, that there is not a practical answer to Dr. Nicholson's question concerning what level of DDT is harmful. He found 1 ppb in his watershed studies and I believe he made the statement that it was unlikely this concentration is doing any damage. Dick Bangs mentioned that there is no information to argue the point one way or another. But the fact remains that a poison has accumulated in the environment. It is doubtful that another 30 or 40 years of research would give the chlorinated hydrocarbons a clean bill of health in relation to long term effects. Wouldn't it be easier to get the information necessary to formulate short residual materials with a controlled release? It seems far easier to develop a battery of insecticides that are biodegradable to harmless by-products than to attempt to prove that residual insecticides have no harmful effects.

There is something we can do to reduce the source of pollution by insecticides. For example, Scotts and many of its competitors formulate turf products with various insecticides. Often, homeowners see the moths of sod webworms fluttering about their lawn and immediately feel that insects are consuming their grass. Usually, in Oregon, there is no relationship between the number of adults present and the larvae that do the damage, yet the lawn is treated every year. Is this a source of pollution in metropolitan areas?

Billbugs

Now, I would like to turn to the biology of the billbug, _Sphenophorus venatus confluens_, which is native to the United States. Several years ago Oregon growers reported failing stands and reduced seed yields or orchardgrass as a result of billbug damage. Until the advent of commercial seed production of orchardgrass in 1957, it was grown only to a limited extent in Oregon. In the last decade the acreage of orchardgrass has increased to 10,000 acres, most of which was grown in the Willamette Valley. The current outbreak of billbugs was undoubtedly correlated with the increased acreage of orchardgrass which apparently is an ideal host for the billbug.

In the spring the females chew a hole in the stem of orchardgrass at the base of the plant and then deposit an egg inside the cavity. The larvae develop inside the stem until the diameter of the stem restricts growth, then they chew an exit hole, leave the stem and initiate feeding on the roots. As the larvae feed, the root is severed from the shoot. Heavy infestations of billbug larvae may destroy the entire stand of orchardgrass. Prior to the billbug problem in orchardgrass, _S. v. confluens_ was not an economic test although commonly found in bluegrass and bentgrass lawns. The close relative, _S. venatus vestitus_, is a severe problem in turf in Florida, as Dr. Stringfellow mentioned; in Kansas, as Dr. Thomas indicated, and more recently has infested turf in California. _S. parvulus_ and _S. cicatristriatus_ sporadically damage bluegrass and bentgrass lawns in the Pacific Northwest, but none of the billbugs present enough of a problem to require yearly control.

In the case of _S. venatus confluens_, we detected a distinct peak of adult activity in April. By application of 3 lbs diazinon, or 1 lb aldrin per acre, very effective control was achieved, but only if applied during the peak activity of the adults in April. It appears to be an impossible task to control the larvae of the billbug since they are well protected in the crowns of plants and in the soil. The most severe larval feeding damage occurs in August. Systemic insecticides failed to give adequate control due to their rapid translocation to upward parts of the plant. Consequently, a billbug problem must be detected and treated in the spring before adults lay their eggs.

Oregon growers were desperate for a good insecticide to control billbugs and frequently resorted to massive dosages in attempts to control this pest. In some cases they were successful, but more often than not their efforts failed. After investigating the life cycle of the billbug and learning the proper time to apply the insecticide, 1 lb of aldrin effectively controlled the adults whereas 4 lbs failed to control the population when applied to kill the larvae. The point I have tried to make is that excessive dosages of insecticides are not substitutes for good biological information in the control of a pest. Effective control programs are based on a thorough knowledge of the insect's biology and, often, the byproduct is a reduction in pesticide pollution of the environment.

DISCUSSION PERIOD

Dr. Heinrichs: Do you know how many sod webworm species occur in Oregon? Is there a list of these?

Dr. Kamm: I believe we have in the neighborhood of 10 species associated with grass seed fields. We have other species that are commonly found in high mountain ranges. I'm reasonably confident that the number of common species we have would approach 18 or 19.

Dr. Heinrichs: How about rearing these? Do you rear these in a laboratory?

Dr. Kamm: Yes we do. I have, as have other workers, experienced much in the line of difficulty in trying to rear these insects. Bohart, in California, attempted to rear *Crambus* in stender dishes using grass clippings. This method is time consuming and often mold collects in the cultures. I have used this method in my diapause experiments using Chewings fescue which does not mold as readily as other grasses. I have a graduate student who will be completing his Master's Degree on the rearing of these on an artificial diet. As I recall, he has a diet that gets out about 85% of *Crambus trisectus* to adults. One of the problems encountered in rearing the moths is that they must mate the same night they emerge or otherwise their fecundity drops to the extent that you may not get any eggs at all.

I have also been interested in the *Beauveria bassiana* as a possible biological control agent. The mold inhibitors we use in the diet are fairly stout and, from preliminary work, are also toxic to *Beauveria*.

One interesting situation that involves the rearing of *Crambus trisectus* is that on some hosts it does quite well. However, if we rear *trisectus* on this to the third generation, those insects that emerge won't lay fertile eggs. I've had large numbers of moths and haven't been able to identify the problem. I believe there is a nutritional deficiency involved.

The host, if you are using grass, is important. There are many ramifications in the successful culture of these insects. I don't think we have a feasible method at this time for laboratory culture, due to the amount of work involved, but I believe we can improve our methods.

Dr. Kouskolekas: I would just like to add that there has been a recent report in the Journal of Economic Entomology from work done in Kentucky. It was on the rearing of sod webworms, if someone wants to cross check on the ingredients and the mold inhibitors.

Dr. Kamm: You are right. The paper you are referring to was done by Dr. Pass. He took a different approach than we did and used a bluegrass extract mixed in the diet. We have formulated a meridic diet in order to study the the effect of particular nutrients. We were able to successfully identify the compound that stimulated their larval feeding.

Mr. Simmons: Dr. Kamm, I wondered if you would briefly touch on the number of generations of sod webworms you have in the seed fields and what are the insecticides generally recommended for control?

Dr. Kamm: We approach insecticides this way; we don't make any recommendations for sod webworms in the Willamette Valley. In eastern Oregon where the principal economic problem is, we recommend diazinon which seems to be effective. We have two species there which are univoltine-Crambus plumbifimbriellus and Crambus vulgivagellus. They occur in mixed populations.

Mr. Simmons: I think we are all interested in new chemistry, as far as insecticides or any other compounds are concerned, but I wonder if this concern with the chlorinated hydrocarbons is not just a point in time and once this situation becomes resolved we will be concerned with the environmental effects of the phosphates or carbamates?

Dr. Kamm: Yes. This is very true. More than likely the chlorinated hydrocarbons will pass out of the picture, then other things will be in the limelight. DDT is the most pressing problem at this time; the other chlorinated hydrocarbons will be next. The thing that alarms me is that one rarely sees any information on the other insecticides. For example, a good deal is known about the degradation of diazinon. It dissipates fairly rapidly, yet I'm not sure that we know anything about the biological pathways, end products or if they accumulate. This is the type of information that is lacking. I don't think our attempts to justify the use of the chlorinated hydrocarbons will pay great dividends.

Mr. Simmons: I'll make one or two points on those comments. One is that there are materials that do a specific job for a specific use. We probably will continue to need those particular chemicals in our program for quite some time, and to continue using them we will need to develop more information. This is why there will be some continued work going on in this area. We also look for new activities, more effective activities and, certainly, safer activities wherever possible.

SOD WEBWORM AND BILLBUG

RESEARCH STUDIES

Hugh E. Thompson
Associate Professor
Department of Entomology
Kansas State University
Manhattan, Kansas

I was interested in following Dr. Kamm because we are working with a billbug that, as far as I can determine, is present in all stages all of the time. Note in Table 1 that on May 14, 16 we found only larvae in our experimental plots. We counted several 1 sq ft blocks out of 1,000 sq ft plots and found no adults, but at the same time the sod nursery people were operating a sod cutter in an adjointing field which was contiguous with the one we were working in. They were taking this sod to their stores for sale and adult billbugs were crawling out across the sidewalk from the sod. Even though we missed them in our counts, there were obviously some adult billbugs present.

One of the reasons we started on our control programs sooner than we wanted to was to prevent the sod nurserymen from distributing the insect while selling their sod. It's easier to control it in the nursery than it is to treat all the lawns where infested turf was installed.

Although Tom Stringfellow stated that the hunting billbug doesn't bother them too much down in Florida, we have lost zoysiagrass lawns in south-central Kansas because of this insect. We do know a little bit about the hunting billbug (Sphenophorus venatus vestita). On zoysiagrass the larvae tunnel through the rhizomes and the last instar occurs in the soil.

We are doing biological studies along with some of our control work. During the week between Christmas and New Year's, we found both adults and larvae present in the soil in Witchita. The adults were about 1½ in. deep and the larvae occur 2½ in. to 3 in. deep in the soil. They usually remain at that depth through the month of May, then gradually move closer to the surface. In some of my early control programs, where I applied insecticides in May, I think the chemical didn't penetrate deep enough to kill the larvae.

Because we had about 40,000 sq ft of bermudagrass available for our research, we made our blocks 50 ft by 20 ft. Some work with 10 ft by 10 ft plots was done in a smaller zoysiagrass area. Results of this work are presented in Tables 1 - 5.

We didn't use any of the chlorinated hydrocarbons because of previous work by Kerr in Florida. We were interested, however, in getting some data on Baygon for Kansas because of its impending use for control of this insect. Dursban was used in early tests, and appeared to give the best control. Scotts Cope Plus, also tested, controlled 50% of the billbugs.

Table 1. Comparative Numbers of Adults, Papae and Larvae of Hunting Billbug in Selected Plots in Myers Nursery at Various Dates.

(Check plots 2, 15 and 17 only include.)

	Date														
	5-14			5-26			7-11			7-19			8-7		
	l	p	a*	l	p	a	l	p	a	l	p	a	l	p	a
	31	0	0	30	0	0	22	0	6	28	3	7	22	12	9
	Percent Control														
larvae	100			100			79			74			56		
pupae	0			0			0			8			25		
adult	0			0			21			18			19		

* l = larvae, p = pupae, a = adults

Table 2. Control of Hunting Billbug Larvae on Midway Bermuda (Myer's Nursery, Wichita, Kansas). 1968

Treatment	Block No.	1		2		3		4		5		Total		Percent Control
		5/14	7/11	5/14	7/11	5/14	7/11	5/14	7/11	5/14	7/11	5/14	7/11	
Check	2	6	0	5	3	2	2	1	2	1	1	15	8	
	15	2	2	0	1	0	1	1	1	0	0	3	5	
	17	3	2	0	0	3	2	2	0	1	5	9	9	
												27	22	
Baygon	3	0	0	0	1	0	0	3	0	0	0	3	1	
	6	4	1	3	0	11	1	1	0	0	0	19	2	
	13	2	0	1	0	7	1	0	0	0	0	10	1	
												32	4	84.7
Lannate	1	2	1	2	3	0	1	4	1	3	0	11	6	
	9	5	6	0	0	1	0	0	1	1	1	7	8	
	14	0	0	1	1	0	0	4	0	0	2	5	3	
												23	17	9.3
Galecron	4	2	7	2	0	3	1	1	6	2	7	10	21	
	11	2	0	1	0	5	0	4	1	2	9	14	10	
	16	2	12	3	4	0	4	1	6	1	10	7	36	
												31	67	0
Dursban	8	3	0	0	0	4	1	2	0	1	0	10	1	
	10	3	0	2	0	1	0	1	0	0	0	7	0	
	18	2	0	2	0	1	0	4	0	3	0	12	0	
												29	1	95.8

Treatments applied May 17. 3 oz actual per 1,000 sq ft
Sample No. 1 = southeast corner of plot; No. 2 = center; No. 3 = northeast; No. 4 = northwest; No. 5 = southwest

Table 3. Control of Hunting Billbug Adults on Midway Bermuda (Myer's Nursery, Wichita, Kansas.) 1968

Treatment	Block No.	Sample No. 1 5/14	1 7/11	2 5/14	2 7/11	3 5/14	3 7/11	4 5/14	4 7/11	5 5/14	5 7/11	Total 5/14	Total 7/11	Percent Control
Check	2	0	0	0	0	0	1	0	1	0	0	0	2	
	15	0	0	0	1	0	0	0	0	0	0	0	1	
	17	0	2	0	0	0	0	0	0	0	1	0	3	
												0	6	
Baygon	3	0	3	0	0	0	0	0	0	0	0	0	3	
	6	0	0	0	0	0	0	0	0	0	0	0	0	
	13	0	0	0	0	0	0	0	0	0	0	0	0	
												0	3	50
Lannate	1	0	2	0	0	0	0	0	0	0	2	0	4	
	9	0	2	0	1	0	1	0	0	0	0	0	4	
	14	0	0	0	1	0	0	0	2	0	0	0	3	
												0	11	0
Galecron	4	0	0	0	0	0	0	0	0	0	0	0	0	
	11	0	0	0	0	0	0	0	0	0	0	0	0	
	16	0	1	0	1	0	2	0	1	0	2	0	7	
												0	7	0
Dursban	8	0	1	0	0	0	0	0	0	0	0	0	1	
	10	0	0	0	0	0	0	0	0	0	0	0	0	
	18	0	0	0	0	0	0	0	0	0	0	0	0	
												0	1	83.4

Treatments applied May 17. 3 oz actual per 1,000 sq ft

Table 4. Control of Hunting Billbug Larvae on Midway Bermuda (Myer's Nursery, Wichita, Kansas.) 1968

Treatment	Block No.	Sample No. 1 7/11	1 7/20	2 7/11	2 7/20	3 7/11	3 7/20	4 7/11	4 7/20	5 7/11	5 7/20	Total 7/11	Total 7/20	Percent Control
Check	2	0	0	3	0	2	0	2	1	1	0	8	1	
	15	2	0	1	2	1	1	1	6	0	4	5	13	
	17	2	0	0	3	2	0	0	3	5	2	9	8	
												22	22	
Cope Plus	5	0	1	1	0	0	0	0	0	5	0	6	1	
	7	1	5	2	6	0	1	3	5	4	6	10	23	
	12	3	0	0	2	1	0	0	0	7	1	11	3	
												27	27	0

When we make counts the insect is present as adult, larvae, pupae and probably eggs, although we haven't counted the last. Notice in Table 2 that Baygon gave fairly good larval control, but Dursban was considerably better. Neither material was very effective against adults, so we think larvae are going to be the stage to control.

Table 5. Control of Hunting Billbug Adults on Midway Bermuda (Myer's Nursery, Wichita, Kansas, 1968.)

Treatment	Block No.	1		2		3		4		5		Total		Percent Control
		7/11	7/20	7/11	7/20	7/11	7/20	7/11	7/20	7/11	7/20	7/11	7/20	
Check	2	0	0	0	0	1	0	1	0	0	0	2	0	
	15	0	0	1	1	0	1	0	0	0	1	1	3	
	17	2	1	0	0	0	0	0	1	1	0	3	2	
												6	5	
Cope Plus	5	0	0	0	0	0	2	0	0	0	0	0	2	
	7	0	0	0	0	0	2	0	0	1	0	1	2	
	12	2	0	0	0	0	0	0	0	2	0	4	0	
												5	4	4

The research plots in Tables 4-5 were treated with 25 lbs Scotts Cope Plus (carbaryl and chlordane plus fertilizer) on July 11 and posttreatment counts taken July 20.

The results of the work with Cope Plus are presented in Tables 4 and 5. I'll confess one thing, we did not give Cope Plus as long to work as we did the others. We only allowed about one week between the time we made the application and the first count. Another count in late December revealed billbug adults and larvae still there, whereas with some of the other treatments, they were not.

We also had some 10 ft by 10 ft control plots on zoysia (Tables 5A, 6 and 7). A 1 sq ft sample close to the center of each plot was dug out and examined for larvae and adults. We are pleased with Akton, as they are in Florida. It was found effective against both the larvae and adults. Data was compiled on the control of adults, larvae and pupae and gives a better picture of total control. Akton was still giving us a 100% control six months after the time of application. Although we are interested in the life history of this pest, the problem is a mixed population of adults and larvae at the same time. I don't think it ever goes into a diapause.

Table 5A. Control of Hunting Billbug Larves in Zoysiagrass (Wichita, Kansas, 1968.)

	Sample No.												
	1		2		3		4		5		Total		Per-cent Con-trol
Treatment	7/11	12/31	7/11	12/31	7/11	12/31	7/11	12/31	7/11	12/31	7/11	12/31	
Check	10	0	7	1	3	1	1	1	1	1	22	4	
VC 13	6	0	6	0	3	1	0	0	0	1	15	2	29.5
Akton	6	0	5	0	2	0	2	0	1	0	16	0	100
TH 427 I	3	0	4	1	2	0	2	1	1	0	12	2	11.9
Dasanit	3	0	4	0	3	0	2	0	1	1	13	1	60.7

Table 6. Control of Hunting Billbug Adults in Zoysiagrass (Wichita, Kansas 1968.)

	Sample No.											
Treatment	1		2		3		4		5		Total	
Check	0	0	0	1	0	0	0	0	0	0	0	1
VC 13	1	0	0	0	0	0	1	0	0	0	2	0
Akton	2	0	0	1	0	1	0	0	0	0	2	0
TH 427 I	4	0	0	1	0	1	0	0	0	0	5	2
Dasanit	2	0	0	0	0	0	0	0	0	0	2	0

Table 7. Control of All Stages of Hunting Billbug in Zoysiagrass (Wichita, Kansas 1968.)

	Sample No.												
	1		2		3		4		5		6		Per-cent Con-trol
Treatment	7/11	12/31	7/11	12/31	7/11	12/31	7/11	12/31	7/11	12/31	7/11	12/31	
Check	12	0	7	2	4	1	2	1	1	1	26	5	
VC 13	11	0	6	0	3	0	2	0	1	1	23	1	78.6
Akton	8	0	6	0	4	0	2	0	1	0	21	0	100
TH 427 I	7	0	4	2	2	1	2	1	1	0	16	4	0
Dasanit	10	0	4	0	3	0	2	0	1	1	20	1	74.0

Another sod webworm, Surattha indentella, damages buffalograss, a native grass that many of our golf courses prefer to keep as fairway grass. They mow it very short. They have sand greens or, where they are getting water to their golf courses, they are using bentgrasses for greens. The webworm has one generation a year and damages bermudagrass so severely that weeds come in.

The webworm makes a tunnel into the soil about four inches and lives in it. Where the tunnel comes out they extend a silken tube across the top of the ground. When they come in contact with a grass plant they stick their head out, cut the grass plant off and then pull it down into the tunnel. They will put 3 or 4 grass plants in the vertical tunnel during the night. As far as I can tell, they never come out of those silken tubes more than to stick their head out far enough to chew off the grass plant and pull it in. We spent many nights on the golf course with flashlights to make this observation, and found that we had to lie on our stomachs for 2 or 3 hours before we began looking for them. Only then could we find them with their heads out cutting off the grass plants.

The male is considerably smaller than the female, and when the female is gravid it is not able to fly more than 2 or 3 in. above the ground. A biological study on this insect has just been completed by Sorensen, who has made notes on its distribution and life history (Sorensen and Thompson 1969). He is continuing his work on the factors that influence the life history.

Determination of the sex ratio was a problem. Using a standard mosquito light-trap, only one female was caught during the summer of 1967. It was discovered, however, that a large number of female webworms were crawling around on the ground underneath the light-trap while it was operating. As a result, a large hole was made and the light-trap placed so the top of collector was level with the ground. When females hit the baffles they fell in, and we were able to collect about one female for each male in 1968. We are working on the life histories of these two turf pests but, in the meantime, we are being asked to provide control recommendations. It does present some problems when you have a mixed population of all stages, as with the billbugs. I agree with Kamm that we need to know as much of the biology as possible before making recommendations, if we have the time. However, golf course people, sod nurserymen and homeowners can exert a lot of pressure to get answers right now.

Reference Cited

Sorensen, K. A. and H. E. Thompson, 1969. Distribution of Surattha indentella Kearfott on buffalograss. J. Econ. Entomol. 62:750-2.

DISCUSSION PERIOD

Dr. Stringfellow: How extensive is your sod industry?

Dr. Thompson: In Wichita, we have four large sod nurseries with somewhere between 35 to 50 acres of sod in each.

Mr. Simmons: What about Baygon? How effective is it as a control for billbugs?

Dr. Thompson: Over a five week period, we did get the population down to about one-tenth of what it was before the applications. It's a real difficult thing. You can get your data biased by the fact that you make applications with various insecticides, then your cooperative comes along and cuts out some sod with a sod cutter. When he rolls the sod back, all of these billbugs are laying there. The cutter goes through right at the level where most of the billbugs are located in the middle of July. They believe that what you did, didn't control them. I think Baygon was acceptable at the time we did this work, but I would go with Akton as my strongest recommendation. It's a real heavy application. I want to do some gradation as different dosages to determine whether we can cut Akton back a little. It runs pretty close to 10 pounds in this work.

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