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# P R O C E E D I N G S

of the

# ENTOMOLOGICAL SOCIETY OF MANITOBA

DECEMBER 1946

Volume 2 Number 1

Proceedings of the

ENTOMOLOGICAL SOCIETY OF MANITOBA

Vol. 2 December, 1946 No. 1

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# LIST OF MEMBERS

Executive

President -- B. N. Smallman, Stored Product Insect Laboratory

Vice-President -- R. R. Lejeune, Forest Insect Laboratory

Secretary-Treasurer -- W. S. McLeod, The University of Manitoba

Editor-Librarian -- W. C. McGuffin, Forest Insect Laboratory

Members

W. R. Allen, Army Experimental Station, Suffield, Alberta

Ruth Barker (Mrs. W. S.), Forest Insect Laboratory, Winnipeg

B. Berck, Stored Product Insect Laboratory, Winnipeg

R. D. Bird, Dominion Entomological Laboratory, Brandon

A. W. A. Brown, Army Experimental Station, Suffield, Alberta

W. A. Cumming, Manitoba Hardy Plant Nursery, Dropmore

B. Filuk, Forest Insect Laboratory, Winnipeg

H. A. Fyfe, Forest Insect Laboratory, Winnipeg

F. J. Greaney, North-West Line Elevators' Assoc., Winnipeg

R. H. Handford, Field Crop Insect Laboratory, Kamloops, B. C.

R. J. Heron, Forest Insect Laboratory, Winnipeg

E. C. Martin, Provincial Apiarist, Winnipeg

A. V. Mitchener, The University of Manitoba, Winnipeg

J. McLintock, Virus Laboratory, Winnipeg

J. A. Munro, North Dakota Agricultural College, Fargo, N. D.

D.J. Petty, Dominion Seed Potato Certification Service, Winnipeg

L. G. Putnam, Dominion Entomological Laboratory, Lethbridge, Alta.

C. A. S. Smith, Dominion Plant Inspection Service, Winnipeg

D. S. Smith, Dominion Entomological Laboratory, Brandon

J. B. Wallis, Royal Crest Apartments, Winnipeg

H. W. Westdal, Dominion Entomological Laboratory, Brandon

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## INTRODUCTION

The Entomological Society of Manitoba, formally constituted in 1945, has continued to prove its usefulness during 1946. Although a number of the original members have taken posts outside the Province, most of them have retained their memberships, and a number of new members have been obtained, so that the Society has actually increased its membership. The Society now has wide representation beyond the Province, since some of the new members are stationed outside Manitoba and, indeed, one is an American entomologist.

Volume I of the Proceedings of the Society drew much favourable comment from entomologists outside the Society, and many requests were received for succeeding volumes. The comments indicated that special value was attached to the reviews presented in Volume I. This favourable reception was encouraging and the Society now presents the second Volume of its Proceedings.

Two general meetings were held during the year--the spring meeting and the fall meeting. Following what has become an established pattern, the spring meeting was in the nature of an informal conference among Manitoba entomologists, while the fall meeting featured formal reviews of wider entomological interest. The discussions at the spring meeting were confined to entomological work being carried on within the Province; these discussions are reviewed in the text of the Proceedings. The fall meeting was distinguished by four important reviews presented, on invitation from the Society, by visiting and member entomologists. These reviews are reported in full in the text of the Proceedings.

The Society wishes to acknowledge the assistance of the Extension Service, Manitoba Department of Agriculture, in the publication of these Proceedings.

BEVERLEY N. SMALLMAN
President.

## THE SPRING MEETING

At the spring meeting held in the Dominion Forest Insect Laboratory on April 23, 1946, ten members were present.

The meeting was divided into two sessions, -- a business meeting, and scientific business.

### The Business Session

Professor A. V. Mitchener reported that most of the common names submitted to the American Association of Economic Entomologists' Committee on Common Names had been placed on ballot. The results of this ballot were not known at the time.

The Secretary-Treasurer submitted a financial report which showed that the Society had a balanced account.

Excerpts from complimentary letters received after the distribution of the first volume of the Proceedings of the Entomological Society of Manitoba were read.

The Chairman, Dr. Smallman, presented the budget for 1946. Ways and means of securing support for the Society were discussed.

Officers elected for the year 1946 were: Dr. B. N. Smallman, President; Mr. R. R. Lejeune, Vice-President; Mr. W. S. McLeod, Secretary-Treasurer. A new office was created, that of Editor-Librarian, and Mr. W. C. McGuffin was elected to fill this position.

The minutes of this meeting are given in detail in Appendix I.

### Scientific Business

Reviews of current entomological work in Manitoba, as represented by the members present, were given in informal briefs.

Insect Pests of Man and Animals: Mr. McLintock, discussing equine encephalitis, reported that the work of testing last season's collections of mosquitoes had just been completed and had resulted in isolating the virus from two samples of *Culex tarsalis* taken in the Portage and Morden districts. There had been the odd case of encephalitis in horses near Portage la Prairie last summer. It is concluded that the virus still exists in Manitoba and that it is carried by mosquitoes during the summer. As yet its overwintering host has not been discovered.

The plans for the coming season include a continuation of the regular survey together with a special effort in six different areas of the Province to see if the virus can be identified in each area during what will, it is hoped, be a non-epidemic year.

Vegetable Insects: Professor A. V. Mitchener and Mr. W. S. McLeod led the discussion in this field. The first report, by Mr. McLeod, dealt with work conducted by the Department of Entomology on onion maggot in Dutch onion sets. A total of 29 different treatments, involving a number of different materials, had been tested in 1945. A calomel treatment gave almost perfect control but was considered impractical because of its high cost and the retarded growth of the treated plots. A treatment with pure DDT (technical grade) was also highly satisfactory, though unsuitable to practical application in its present form. Three treatments with Gammexane were almost equally effective and showed great promise.

Subsequent work during the winter on greenhouse experiments had indicated that there might be need for great caution in the use of Gammexane as an insecticide for application to the soil. Plans for the 1946 season, however, called for further experiments with this chemical as well as work with 50% DDT dust.

Professor A. V. Mitchener reported on studies with 5% DDT in kerosene solution used as a barn spray in the University hog barn. A single application of this material on July 15th was still killing flies as late as the end of September. The housefly was the most common species but data were collected on the abundance of other species in the collections made in the barn.

An experiment had also been conducted on the use of Gammexane, DDT, derris and calcium arsenate on potatoes. DDT showed up very well against the Colorado potato beetle, potato flea beetle and other insects.

Field Crop Insects: Dr. Bird and Mr. Putnam presented an outline of the work planned in their field in Manitoba for 1946. Dr. Bird reported that grasshopper work in Western Canada would henceforth be under the direction of Dr. Handford from his headquarters in Kamloops, B.C. Mr. Putnam was expected to continue his work on this insect, though possibly under change of headquarters to another laboratory. Mr. D. S. Smith would probably be carrying on the grasshopper food studies on his return to Canada.

Dr. Bird expressed the hope that some work might be done with DDT on potatoes; that the vegetable insect survey, initiated last year, might be continued and expanded; that a man to study fruit insects might be attached to the Brandon Laboratory this summer; and that the work with the sweet clover weevil might be continued.

Dr. Bird then described in some detail the information already secured in the investigation of the sweet clover weevil. Data on the life history, spring and fall migrations, oviposition, soil penetration, hibernation and natural enemies have been obtained. Much work has been done on cultural controls. Dr. Bird stated that on the basis of the present knowledge of this pest he would make the following recommendations to the farmers: (1) fall tillage of the margins of a field where there were definite indications of an invasion of the weevil, (2) shallow cultivation with a one-way disc immediately after cutting the clover for hay, and (3) planting of new fields as far as possible from the current hay field in order to avoid the fall migration of the weevil.

Mr. Putnam reported in some detail the experiments conducted during the past three years on the effect of modern tillage implements on grasshopper populations. Ploughing with the moldboard plough and even with disc ploughs had given beneficial results in past years but these implements have more or less gone out of use on the Prairies and it has been felt that more recent methods of cultivation should be investigated in order to discover whether they are capable of reducing the numbers of the injurious species of grasshoppers.

Mr. Putman also reported briefly on experiments conducted by the Entomological Section (Department of National Defence) stationed at Suffield, Alberta, during the war. In experiments with aeroplanes it was found that dinitro-o-cresol was highly effective as a contact poison against grasshoppers. An application of 0.3 lbs. per acre was sufficient to produce 100% kill, provided it was applied in such a manner as to touch all insects. The results were rapid and striking but no evidence of stomach effect was noted. Preliminary experiments with aerosol generators were performed, also.

Stored Product Insects: Dr. Smallman discussed the establishment of the new Stored Products Laboratory together with plans for the coming year. During 1945, experiments had been conducted in 22 warehouses against the spider beetle. DDT, aluminium oxide and magnesium oxide were applied to the sheds as residual insecticides, using the normal contact spray technique as a check. All three treatments were significantly better than the contact spray. Experiments were also conducted with sacks which had been treated with these same materials. It was found that DDT gave the best control, but for practical reasons, magnesium oxide was used by the milling industry in 1945. During the 1946 season it is planned to enlarge the experiment to include 80 flour sheds and 6 materials: DDT in oil, DDT water suspension, Gammexane oil spray, Gammexane smoke, aluminium oxide and magnesium oxide. Sacks are to be treated with DDT and with Rothane $D_3$. Paper containers are also to be investigated and it is hoped to commence biological studies on the principal stored products pests.

Forest Insects: Mr. Lejeune discussed in a general way the projects which are being conducted by his laboratory. During 1945 the main projects were concerned with the jack pine budworm and the European larch sawfly. The budworm has shown a decline in numbers recently but investigations on the effect of pollen, parasites and host plants on the epidemiology of this species are being continued. The sawfly, however, is increasing in importance. Tamarack is being heavily attacked and considerable time is being devoted to parasite population studies on this host. An expansion of the forest insect survey is planned.

Mr. Heron reported on the status of the budworm work in greater detail. It is hoped that a little more work on the host plants of the two races of this pest will bring this particular project to a definite conclusion. At the present time, there is a jack pine form and a spruce form. All the evidence points to the probability of the eventual development of two distinct species. At the present time hybrid larvae are inseparable on appearance alone from the original types but the pupae of hybrids are intermediate, though tending toward the spruce form. The pupae of the two races are capable of being identified by an expert.

Mrs. Barker described the parasite work being conducted on the European larch sawfly in co-operation with the Belleville Laboratory. This work presents many problems which remain to be solved, including one which is concerned with the high percentage of unhatched eggs of *Mesoleius* which are found in dissected sawfly larvae. Studies on the field habits of *Mesoleius* are also needed.

The introduced parasite, *Mesoleius*, has become widely distributed in Manitoba since its release, but its present effectiveness in control of the sawfly is probably poor. Dissection of hibernating sawfly larvae revealed a high percentage of unhatched *Mesoleius* eggs. Field studies on the oviposition habits of *Mesoleius* are planned for the coming summer.

Mr. McGuffin dealt with the forest insect survey. Collections are made during the summer by Forest Insect Rangers and collaborators scattered throughout Western Canada. Specimens received from them are examined and, where necessary, reared in the insectary. Work on the identification of larvae is continuous. It is hoped to increase the scope of the work during the coming season and especially to observe the progress of tent caterpillar infestations which are advancing into Manitoba from the west and of the larch sawfly infestation which is moving in the opposite direction from our province into Saskatchewan. The survey will be facilitated by the use of four army vehicles which have been released to this laboratory.

## THE FALL MEETING

The fall general meeting was held on November 19th. The meeting was divided into two sessions -- a business meeting, and scientific business.

### The Business Session

The business session was held at the Dominion Forest Insect Laboratory; fourteen members were present.

Dr. Smallman reported that various organizations had offered assistance to the Society in the preparation and mimeographing of the Proceedings. Various other reports were brought in, the details of which may be found in Appendix II.

### Scientific Business

Following the business meeting, the members adjourned to the University of Manitoba to hear a number of scientific reviews on various topics of interest to entomologists. This portion of the meeting, and the discussion which followed the papers, was open to the public, and about fifty visitors and students took advantage of the opportunity to hear these excellent reviews. Major Brown spoke during the forenoon while Dr. Bird and Mr. Allen addressed the afternoon meeting.

During the noon intermission, members and guests attended a luncheon at which they were privileged to hear a talk by Dr. H. E. Gray on "Entomology and the Food and Agriculture Organization of the United Nations". Dr. Gray was a delegate at an F.A.O. conference in Washington.

It was the unanimous opinion of those present that we were indeed privileged to hear such authentic and timely reviews.

Summaries of these papers are reported on the following pages of this volume of the Proceedings.

REVIEWS

## NEW ORGANIC INSECTICIDES

Major A. W. A. Brown

The title of this address is one which has been used in paraphrase, and is being used, in numerous papers and addresses up and down the continent these days. My only excuse for adding yet another one to this subject is that a gathering of this kind would perhaps appreciate a general paper, and this field is large enough for each speaker to treat it in his own way. For this time I will stress the angle of the multiplicity of organic compounds that are available as insecticides, bringing out some of the less well-known compounds. Acknowledgement must be made of receipt of a copy of Dr. F. C. Bishopp's recent address to the Agricultural Insecticide and Fungicide Association sent to me by Mr. W.A. Ross after this paper had already been prepared, some data from which I have now included. Also very useful was the recent summary on Organic Insecticides by Hoskins & Craig in the Annual Review of Biochemistry for 1946.

The search for organic substitutes for arsenicals has been proceeding for the past quarter-century, as a result of the increasing danger of consumer poisoning by residue, and of the growing realization that the old methods were like "shooting at sparrows with a cannon" (Lauger, Martin & Mueller in their paper on the development of DDT*). But it has been during the years of World War II, when the supply of pyrethrins was virtually cut off from America, that this search became intense. Naturally, in view of their importance for the health and survival of troops, stress was laid on compounds to control mosquitoes, flies, mites and lice, and a far-reaching network of projects was assigned by the O.S.R.D. to find and test them. On termination of hostilities the information thus gained is being made public, and the insecticides thus developed are being tested against the whole gamut of agricultural insect pests.

Three really good new insecticides have been developed in the war years, but at least three times that amount are in the

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* Copies available from Greigg Company, 89 Barclay Street, New York City.

developmental stages. Not less than five years elapse between the first laboratory or small scale field tests and the attainment of insecticide status. Of the ten thousand odd organic compounds that have been tested in one way or another, it is probably safe to say that there are at least one hundred which have a chance, on further testing through a wide range of insect species, stages of development and modes of application, of being worthy of development as insecticides.

We will go on to consider in more detail some twenty insecticidal compounds which have been developed during the war or in the decade preceding it.

DDT: - Dichlorodiphenyltrichloroethane was discovered as an insecticide in 1940 by Swiss workers, and its scope has been tremendously enlarged and characterized in the past four years. Being an odorless, crystalline solid, it is easy to handle. Its outstanding characteristic is its persistence, due to its infinitesimally low vapour pressure. Its toxicity varies rather greatly from species to species. Its extremely high residual toxicity to flies and mosquitoes is well known. Also of outstanding value is its high toxicity to lepidopterous larvae, a highly destructive class of agricultural pest. In our own laboratory we have found it, for instance, excellent against spruce budworm and flax bollworm larvae, but relatively ineffective against grasshoppers, wheat stem sawfly adults, and muscoid larvae. Notable is its complete failure to control mites. It would appear that the desirable properties of DDT as an insecticide are enhanced by an affinity for the chitinous cuticle, on permeating which, it acts on the nerve endings to produce tetanic convulsions. DDT is not phytotoxic and exhibits a very low order of toxicity to man and animals.

A thorough search has been made among the chemical analogues of DDT for even better insecticides. So far none have been found to surpass its general desirability, although at least three promising analogues have been turned up.

Methoxy-DDT: - the di-p-methoxy analogue, ranges from one-half as toxic to fifty per cent more toxic than DDT to various household pests, and exhibits a much faster knockdown while showing high persistence. A number of recent tests against field-crop insects have, however, shown it much less toxic than DDT. Nevertheless, its reported lower toxicity to mammals and high insecticidal activity in certain cases still encourages its development.

TDE or DDD, the dichloroethane analogue, has shown about the same toxicity rating as DDT to household insects, but has been found to be much more toxic to anopheline larvae than DDT. The di-p-fluoro derivative, known as GIX, has been claimed by the Germans to be more toxic than Gesarol, their DDT preparation. However, no American tests have found it superior, and many tests have found it a good deal inferior. Although giving quicker kill, it is not considered worthy of further development.

Gammexane: - British work during the war years found that certain preparations of benzene hexachloride or hexachlorocyclohexane were very toxic to insects. Later it was found that this toxicity was mainly due to the gamma isomer, which commercial benzene hexachloride or "666" contains to the extent of about ten per cent. In almost all laboratory tests against insects, gammexane has given excellent results. For example, sprays against flies by the turntable method have shown it to be eighteen times as toxic as DDT and twice as toxic as pure pyrethrins. Results obtained in our laboratory indicate that it is 160 times as toxic as DDT to the granary weevil. Moreover, it is a miticide. It is perhaps safe to say that it is the closest thing we have yet to a "universal" insecticide. However, in the field or under artificially ventilated conditions the results have not been as outstanding. The fact that it has given kills at distances remote from the point of application, and that it possesses an appreciable volatility above 30°C, renders it probable that it has a fumigant effect. It is likely that it so acts in soil treatments, where recent English work has shown it to be highly effective for wireworm control, confirming the unpublished results of the Dominion Entomological Laboratory, Saskatoon. An intriguing theory of gammexane's insecticidal action is that it masquerades as inositol, a hexahydroxy-cyclohexane of the same stereochemical configuration, which is a member of the Vitamin B complex. Preparations of "666" unfortunately possess an offensive odour, and gammexane dusts of over 0.2% content have been reported to cause burning of young foliage and reduction of germination. In our own field work we have found this insecticide very effective against grasshoppers when applied as aerosols, and against wheat stem sawfly adults when applied as thermally-generated smokes.

Compound 1068: — a chlorinated aromatic compound of the empirical formula $C_{10}H_6Cl_8$ developed very recently by the Velsicol Corporation, Chicago. Figures have been published showing it to be more toxic than DDT against houseflies, cockroaches, aphids and the potato beetle, but inferior against anopheline mosquitoes.

It is also highly effective against the body louse and red spider. In our own experience we have found it scarcely toxic against larvae of spruce budworm and flax bollworm, and wheat stem sawfly adults. Indeed, the poor results that U.S.D.A. have had with it against armyworm, celery leaf tier, and variegated cutworm prompts the statement that it is not effective against lepidopterous larvae. However, in confirmation of previous American work, we have found it to be the best contact insecticide yet for grasshoppers, and its residual effect to be fifteen times that of its nearest competitors, "666" and DNOC. It is probable that its outstanding role is as a stomach insecticide. In an aircraft baiting operation we were able to effect 91% control of Melanoplus mexicanus with bran-sawdust bait at the rate of 0.6 pounds of 1068 per acre. Its reputed toxicity to animals is losing ground when put to quantitative tests, and it has so far shown no phyto-toxicity.

Compound 3956: - a chlorinated bicyclic terpene, has very recently emerged as an excellent insecticide with properties similar to DDT, i.e., slow kill but great persistence. It has been found to be both more toxic and more persistent than DDT to body lice. Like DDT but in contrast to 1068, it has shown considerable toxicity to the three lepidopterous larvae tested. It is miticidal, and effective against grasshoppers. From these preliminary results, it is possible that 3956 will be found to combine the desirable properties of both 1068 and DDT.

Hexaethyl Tetraphosphate: - an outstanding insecticide which has been developed by the Germans under the name of "Bladan". It is now being produced by Monsanto Limited. Preliminary work has shown it to be far more effective than either DDT or nicotine against aphids. It is, however, unstable in water.

Lauseto-neu - chloromethyl p-chlorophenyl sulfone: - another German insecticide, used by them as an anti-louse impregnant. Although claimed by them as superior to Gesarol, it has shown itself consistently inferior to DDT in the hands of American testers.

DNOC: - In this insecticide we reach the group developed in the pre-war years. It shows a consistently high toxicity to almost all insects in all stages, taking effect quickly and by direct contact. It also possesses some residual potency. It is especially effective by contact against Orthoptera, notably grasshoppers. It will achieve 100 per cent mortality of Melanoplus mexicanus at spot dosages of the order of 0.2 pounds per acre, and we have obtained conspicuous kills on infested farmland with this compound in oil sprays from aircraft and in steam-generated fogs or aerosols. However, DNOC is a phyto-toxic compound (the weedicide Sinox is its sodium salt) and much work remains to be done on the tolerances of various crops to it. In field trials on summer-fallow, burning was found to appear at deposits between five and ten pounds per acre. Although it burns and stains the skin and irritates the mucosa, it is of a low order of toxicity to man and animals; we have found that sheep and goats will gain weight in a paddock sprayed with it at twenty pounds per acre. The alkali salts of DNOC have been reported as being explosive when in a dry condition.

A compound showing similarities to the above is dinitro-cyclohexylphenol marketed under the generic name DN. In order to cut down its phytotoxicity and increase its persistence by reducing its volatility, it is generally marketed as the dicyclo-hexylamine salt. It has found use practically in dusts against mites, thrips and scale in citrus groves.

A class of compounds, the aliphatic thiocyanates known commercially as Lethanes, have been developed as pyrethrin substitutes for knockdown in housefly and cockroach control. Lethane 384, being butoxy-thiocyanodiethyl ether, is the one most commonly used and it received wide application for control of head lice. Lethane 60, thiocyanoethyl laurate, had application in anti-body louse belts during the war. As far as agricultural insects are concerned, work in our laboratory has not shown the lethanes to be effective insecticides.

Phenothiazine: - or thio-diphenylamine, is a favourite insecticide for the control of screw worm and hornfly in livestock. It is quite safe to use in myiasis wounds and as intestinal doses to control fly breeding in dung. It is a stomach insecticide, showing no contact toxicity, and is ineffective against certain species, notably grasshoppers.

There follow three insecticides which have not given outstanding results to date: Thanite (bornyl thiocyanoacetate), Valone (isovaleryl indandione), and Xanthone, which has been useful for codling moth sprays only, and I believe is now being abandoned. (Pentachlorophenol, marketed as Dowicide 7, has shown some promise as a general insecticide.)

Another class of organics, the Azo compounds, is being recommended for development by the United States Department of

Agriculture as a result of their tests on leaf-feeding insects at Orlando, Fla. They are, azobenzene, aminoazobenzene or phenylazoaniline, and its hydrochloride. The U.S.D.A. have found azobenzene to be particularly effective against red spider and other mites, either as a wettable powder or a fumigant. In our own limited testing on agricultural insects we have not as yet found it very effective. Other promising American miticides are Hydroxypentamethyl-flavan and Bis-(4-chlorophenoxy) methane.

There remain the older organic insecticides, Pyrethrins, Rotenone, Nicotine and Anabasine. They still compare favourably with the new insecticides being developed, and in certain fields of control they still excel. It may be of interest to point out that out of four agricultural insects tested this year in our laboratory, for three of them Pyrethrins were the most effective contact insecticide on the basis of weight of pure compound, and in the case of the fourth (sheep ked) Rotenone was the most effective. The disadvantage of pyrethrins being their short supply and expense and their sale in dilute solutions, efforts are being made to make a little go a long way by the use of adjuvants or synergists. The most conspicuous one is piperonylcyclohexenone, the mixture of which with dilute pyrethrins is now on the market as P-C-H 100 of Dodge and Olcott. Some substituted PCH's recently tested are even better and possess insecticidal value of their own. Of interest too, is the combination of DDT for persistent effect with pyrethrum for knockdown, now being formulated on a physiological basis by Dr. Hurst of Cambridge as Activated DDT.

Considerable advance has been made in recent years in new fumigants that are effective in doses of the order of five mgms. per litre of air, or less. In these developments the older compounds such as methyl bromide, carbon disulfide and ethylene oxide are being left far behind, and we are approaching the toxicity of hydrogen cyanide (1 mg/litre or less) without its extreme danger to humans. First came the German Trichloracetonitrile and the American Ethide (1,1-dichloro-1-nitroethane) and effective at three to ten mg/litre. Then Acrylonitrile was found superior, being generally effective at about 2 mg/litre for flour insects. Finally Dichloroethyl-ether has been developed which, besides being toxic to stored products insects at dosages between 1 and 2 mg/litre, is also an extremely efficient contact insecticide. Sprays on infested soil have given very good control of cabbage maggot, wireworms, plum curculio and cutworms, while its vapour is highly effective against greenhouse thrips. Another recent soil fumigant is D-D, a crude mixture of dichloropropene and propylene dichloride, which has been found highly effective against wireworms, peach borer, and rootknot nematode in Hawaii. It would appear that the more toxic fumigants are discovered as less volatile compounds are investigated. It is also not hard to find substances of much lower volatility which are even more toxic per unit weight of vapour, viz., nicotine and perhaps gammexane; such compounds may have an important application in soil fumigation.

What of the future discovery of new insecticides? Has the testing of so many thousand compounds taught us anything to guide us into special lines of investigation? We have learned one thing--that the appearance of insecticidal activity is so haphazard that one can approach as close as an analogue or even a steric isomer to a first-rate compound without a glimmer of insecticidal potency. Or one might have hit the compound itself but passed it over because of the wrong test species, method or stage.

However, we do know enough to pick out certain groups and configurations which are more likely to yield rewards than others, -- quite apart, of course, from the immediate analogues of such insecticides as DDT, rotenone and nicotine. It may safely be said that the most promising group are Chlorinated Hydrocarbons. We have already seen that chlorinated aliphatics -- chloroethanes, -- propanes, -- propenes, etc., are likely to include good fumigants. Then the chlorinated aromatics number among them our best insecticides -- Gammexane, DDT, 1068, 3956, and Pentachlorophenol. It may be that the significant factor is the formation of the highly active acid chloride radicle. To give an idea of the variation in toxicity of close analogues-- in DDT, the methoxy, ethoxy, methyl and dichloroethane analogues are toxic, while the o- and m-dichloro, dichloroethylene and tetrachloroethane are relatively non-toxic.

Under nitrogenous compounds, a promising group includes the Pyridine derivatives, containing Nicotine, Anabasine and their analogues. Synthesis and testing have shown the Dipynidyls to contain good insecticides, but none has yet been developed.

Another rewarding nitrogenous group is the Azo compounds (-N=N-) which, as we have seen, has yielded azobenzene and its p-amino derivative. The work of Swingle and associates has also revealed a number of effective Semicarbazones ($=N-NH-CO-NH_2$), notably those of acetone and the aldehydes of certain cyclopentanes and cyclohexanes.

Then there is the group of Nitro compounds which has given us Nitrodichloroethane (Ethide) as a fumigant, and DNOC and DN as contact insecticides. Both Tattersfield and Bushland, who have tested in this group, have found decided insecticidal activity among dinitrobenzenes, dinitrophenols and dinitrocresols.

Finally among nitrogenous compounds, the Nitriles (-C≡N) are liable to yield rewards, for instance, yielding Acrylonitrile among the aliphatics as a fumigant, and the aromatic Phthalonitrile which has been found highly toxic to housefly and lepidopterous larvae.

Sulphur-containing compounds are liable to include insecticides. First there are the Sulfides, sulfoxides and sulfones, the p-dichlorophenyl derivatives of which were all found by Geigy's workers to be highly toxic to clothes moth larvae, and gave them the lead to re-synthesize and test DDT. Lausetoneu, a chloromethyl sulfone of p-dichlorophenyl, is the only one to have been commercially developed.

Then there are the Thiocyanates (-S-C≡N), which may resemble the nitriles in owing their toxicity to the hydrocyanic acid radicle. They have been commercially developed under the name Lethanes. A promising compound developed by American workers is dithiocyanoethyl sulfide, containing both thiocyanate and sulfide sulfur. An example of an active sulfur and nitrogenous compound is thiourea, highly toxic for housefly larvae.

A promising but complex group is the Heterocyclic compounds, notably those containing two benzene rings linked by either one or two atoms of S, N, or O. Phenothiazine (thiodiphenylamine) contains S and N. As good or better are Diphenylene oxide (O), Dibenzothiophene (S), Acridine (N), Dihydrophenazine (N & N) and Phenoxathiin (O & S). They are probably mainly stomach insecticides.

A configuration likely to indicate activity is the Ether linkage. Dichloroethyl ether, an excellent fumigant and contact insecticide, is an example. PCH is the methylene ether of a biphenyl analogue. Rotenone contains an ether linkage, as also does Lethane 384.

The correlation of the configuration of C & O with toxicity has been discussed at length by Lauger, Martin & Mueller. They related the toxicity of the coumarin group of poisons (including the highly toxic but undeveloped dehydracetic acid and derivatives of benzotetronic acid), of the pyrethrins and of rotenone to their possession of the following configurations:

```
              O
              ||
-C = C - C - O -          (Lactone: Coumarin)
 O
 ||
-C -C = C - O -           (Ether: Rotenone)
            O
            ||
C - C - C - O -           (Ester: Pyrethrins)
 \ /
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in which the carbon atoms are attached to lipoid-soluble groups such as cyclopropane, benzene, benzofuran and benzopyran. Following this theory they were able to synthesize a DDT analogue containing cyclopropane instead of trichloroethane and found it highly toxic.

Considering the relative youth of this field of applied science, it has made an excellent start towards achieving toxic agents specially suited for particular insects in their particular environments, so that chemical control may respect the cautions of the ecologists, and may march hand in hand with biological control of insects.

# ENTOMOLOGY AND THE FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

H. E. Gray

You have all no doubt heard of the work of the Food and Agriculture Organization of the United Nations. FAO, as it is popularly called, is one of the important branches of the parent organization and its intentions in general could probably be well summarized by saying that it is interested in providing a practical answer to freedom from want. Even today, as far too often in the past, there is a fairly large percentage of the population with inadequate food. In many countries the spectre of starvation is continually present. Last year the death toll from this cause was tremendous. It is the aim of FAO to provide more food, better food, and better health for the people of the world who are not as plentifully supplied as we are. Many of them are, at best, on a subsistence level and there is no relief in sight through their own efforts.

FAO has a wide field of interest. At many of the general sessions, the meetings are concerned with economics, production statistics, distribution, and all the other phases of agriculture, including forestry. Canada has played an important part in connection with its activities and has quite a number of members on its general committees. For instance, our own Deputy Minister of Agriculture is Chairman of the General Finance Committee. The organization has been particularly fortunate in the choice of its director, Sir John Orr, who is a distinguished biologist and nutritionist. On his staff are a number of specialists in various fields and they, from time to time, request the services of workers in different fields in order to deal with specific problems.

In April 1946 a committee was set up by FAO to produce a memorandum on the significance of waste through the infestation of stored food stuffs by insects, mites, rodents and moulds and to indicate the type of remedies likely to be most efficient. As part of the general scheme, a plan was also submitted to the Director General regarding a world survey of the problem.

You may be interested in some of the men who were on the Committee. Representatives were drawn from Great Britain, United States and Canada. The two representatives from Great Britain were Dr. J. W. Munro and Dr. A. P. B. Page of the Imperial College of Science and Technology, London. Dr. Munro, formerly a forest entomologist, has been interested in food problems for a number of years and is conversant with many of the problems in areas throughout the British Empire. Dr. Page has done a considerable amount of research work, particularly in the field of fumigation. There were several entomological representatives from the United States -- Dr. P. N. Annand, Chief of the Bureau of Entomology and Plant Quarantine, Dr. F. C. Bishopp, Assistant Chief of the Bureau of Entomology and Plant Quarantine who is well known to many of you for his work in connection with insects affecting man and animals, Dr. C. M. Packard, Chief of the Cereal Crop Investigations, Dr. R. T. Cotton of the same bureau who has charge of the Stored Product Insect Laboratory at Manhattan, Kansas and whose work in the field of stored products is too well known to require any further comment, and S. B. Fracker of the Agricultural Research Administration. In addition, to those interested primarily in entomology, Mr. F. E. Garlough of the Fish and Wildlife Service in Chicago was responsible for the evaluation of the damage and other phases of the problem involving rodents. The work in connection with moulds was handled by Dr. Hukill of the Bureau of Plant Industry at Ames, Iowa and by Dr. Johnson of the same service at Beltsville, Maryland. Mr. E. G. Boerner of the Production and Marketing Administration at Washington was an able adviser in connection with market grades and many allied problems. Canada was represented by Mr. H. G. Crawford, Dominion Entomologist, and the speaker.

The work of the committee necessarily fell into three groups: (1) insects and mites, (2) rodents, and (3) moulds. After a preliminary session, the committee was broken into sub-committees to deal with the details of the problem. Dr. R. T. Cotton was elected chairman of the committee dealing with the insect phases and as that is the section which we are most concerned with as entomologists, I will endeavour to give a little more detail with respect to it.

The report of the committee might be divided into two main topics. The first consisted of an estimate of losses and the general recommendations for action to reduce these, while the second section dealt with detailed preventive and control measures.

One of the first problems was to compile an accurate estimate of the damage caused by the various pest organisms and this was not only a difficult and onerous task, but even when it was completed we were not too happy about the figure submitted, as at best, it was an estimate rather than a figure based on entirely reliable statistics. The United States Department of Agriculture supplied us with many records, the best available, but even in the field of production, the figures from various sources did not always agree with respect to countries where statistics are kept regularly and carefully. The figures on insect damage were much less satisfactory than those with respect to production and in many cases were very sketchy. Actual damage varies greatly from country to country. In Canada, the losses sustained to cereal grains by insects is low in comparison with countries such as India, China, parts of Africa, and other warm countries.

After reviewing the losses sustained in various parts of the world, the committee made what we considered to be a very conservative estimate with respect to the losses caused by each of the groups of pests. In the case of insects, it is felt that a minimum of five per cent loss was sustained by cereal products in storage, that the loss occasioned by rodents was at least four per cent, while on the average the moulds probably caused an annual loss of not less than one per cent. This makes a total of ten per cent which is certainly a minimal figure.

The losses are not only physical but often nutritional. In many cases, insects destroy the germ end of the kernel, thus rendering the remaining portion much less nutritive than was the original grain. The fouling and pollution of cereal grains by rodents results in considerable quantities of such products being discarded as unfit for human use. While in many seasons, loss from moulds may be relatively small, in a season which is favourable to their development they may be so disastrous that total loss of the commodity stored often occurs.

Because of the world shortage of food, it was considered imperative that every step possible should be taken to reduce losses to a minimum. This will require drastic improvement in the methods of handling materials both in producers' hands and in commercial channels. It involves a program of inspection and the prompt application of remedial measures wherever necessary. Insect-proof, rodent-proof, and weather-proof facilities are essential for food storage and transportation. Most food losses are preventable and it is only through the education and widespread use of control measures that sizable reductions in losses can be effected.

It was proposed that a world survey of food wastage by the insects, mites, rodents and moulds should be carried out in order to secure more reliable figures with respect to the losses occuring in storage. Information with respect to the extent to which prevention and control measures are now being carried out and an appraisal of the possibilities of extending these through education are world needs.

The second section of the report dealt with prevention and control measures applicable to both large and small scale operations. In the countries which produce large quantities of cereal products for export and which, in the main, have satisfactory storage facilities, the problem is quite different than in countries where production is mainly by the peasant-producer for the maintenance of himself and his family. For this reason, specifications were written to meet both sets of conditions. Even in the larger countries with good terminal facilities, more attention can profitably be devoted to insect control. Savings effected in this way make more grain available for export.

Reducing losses is equally important, however, in countries where grain is produced for the maintenance of the local population. Every effort should be directed to safeguarding the crops in peasant-producers' hands. While the amount in each storage pit or container may not be large, it is a most difficult matter to replace and make available to those same people, adequate supplies of grain to replace what is often destroyed. Starvation can and often does occur before these local supplies can be replaced. The collection of grain now in the hands of peasant-producers and the storage in well-equipped regional warehouses appears to be one method of drastically reducing the present losses in such areas.

In conclusion may I make a plea for a more adequate reporting of damage sustained by pests whether this occurs in the field or in storage. I appreciate only too well that it is by no means an easy task to make an accurate estimate of pest damage but there is certainly a dearth of reliable information along these lines. Data of this kind should be reported on a quantitative basis rather than on a monetary one because in the last analysis, everything must be reduced to quantities rather than dollars. This phase of biology requires considerable investigational work as to the best methods of evaluation in order that we can have accurate and workable estimates of damage in the future.

# SOME RECENT ADVANCES IN ECONOMIC ENTOMOLOGY

R. D. Bird

When I was asked by your executive to address this society, I believe I was assigned the subject "Recent Advances in Entomology". Obviously the whole subject could not be covered, so I had a wide field from which to choose.

Probably the most rapid advance in recent times, and certainly the most spectacular, has been in the field of new insecticides. Many articles have appeared. You have all been doing considerable reading and some experimenting in this field. I do not intend today to dwell on this subject, but instead will touch on other aspects which have not been so widely publicized.

Entomology, like other sciences, has passed through times when its various branches have seen periods of popularity, later to fade into disrepute. At one time taxonomy was the rage; now it is very difficult to get anyone to do this important work. Life history studies had a period of passing interest. Now interest centres on the development of new insecticides and applied statistics. The insect, in some cases, is merely an object on which a chemical or mathematical problem is based. All these specialized branches help to develop entomology, but workers get so engrossed in their own field that they fail to appreciate the insect as a living organism reacting to all the factors of its environment. We need men of broad vision such as the masters of the last generation, J. H. Comstock, L. O. Howard, Norman Criddle and others -- men who had a grasp of the whole field of entomology and natural history and did not lose sight of the insect in the maze of subjects which make the forest of environmental factors, by concentrating on individual trees.

D. L. van Dine, in his presidential address to the fifty-seventh annual meeting of the American Association of Economic Entomologists 1945, submitted the following list of some of the major problems in the field of economic entomology:

"The possible value to agriculture of the insecticidal materials and equipment developed for military purposes.

"Continued search for new and better insecticidal materials, particularly organic materials that do not possess the undesirable qualities of metallic substances.

"Some of the known insecticidal materials should be retested against insects to determine their residual toxicity.

"Continued research to further reduce the per acre requirements of insecticides for control, by improvements in formulations and in equipment and methods of application.

"Studies to determine the normal physiology of insects as well as the physiological condition produced by insecticides.

"Extended research in taxonomy is urgent, since in insect control the identity of the species concerned is of first importance.

"Wide ecological studies, to determine the factors that influence the distribution and abundance of insects.

"The highly important work on foreign insect parasite exploration and introduction, necessarily suspended during the war, should be restored at the earliest possible date.

"Further research is needed concerning the possible control of noxious plants by the use of plant-feeding insects, as illustrated by the work in California against the Klamath weed.

"The research on organisms of disease pathogenic to injurious insects should be extended. The value of such work is demonstrated by the control gained in the mass production and distribution of the milky disease against the grubs of the Japanese beetle.

"The effect of insecticidal materials on beneficial insect parasites, predators and pollinators should be determined. As an agricultural insecticide, DDT is capable of destroying insect parasites along with their hosts unless measures are developed to alleviate such hazard."

He also points out, "Many other sciences involved in the different phases of insect control must be included in our research if we are able to maintain a well balanced program. We all appreciate the co-operation that is indicated in the fields of physics, horticulture, agronomy, plant breeding and ecology, to name a few of the more important subjects in addition to those I have mentioned. Illustrations of the research needed in these sciences will occur to all of us."

We must not forget that the insect is what we are studying and that it reacts to all the factors of its environment, be they food, climate, weather, parasites or disease, and that each species and race reacts differently.

The first requirement in our study in any region or on any crop is a complete qualitative and quantitative survey of injurious, beneficial and neutral insects. This is emphasized by E. O. Essig in his presidential address to the fifty-sixth annual meeting of the American Association of Economic Entomologists. We must know the species that are present and how they fluctuate in numbers before we can determine the factors that cause these fluctuations, be they natural or man made, such as chemicals, cultural practices, or resistant crops. Quoting from Essig in the above address, "The possibilities of reliable insect forecasts are being appreciated more and more, and it is only by careful training and long experience that this important realm can yield benefits to crop protection. It is a field that should not be neglected."

W. L. Popham, Assistant Chief of Bureau of Entomology and Plant Quarantine, U.S.D.A., in his address to the Pacific Slope Branch of the American Association of Economic Entomologists, June 1946, stressed the importance of surveys. Quoting from his address, "Surveys of one type or another are fundamental to sound research, quarantine, or control; yet for the country as a whole we have put little into them. Often we have been unaware of a newly introduced pest until confronted with an emergency that has developed to a point that suppressive action of any kind is ineffective and costly. With new insecticides constantly coming into the picture, and with new and improved methods available for applying them, opportunities for revolutionary developments in the field of pest control are at hand. To make optimum use of these facilities and to bridge the gap between research and farmer-application of the principles developed by research, we must certainly modernize our procedures for learning what pests we where they occur, how they happened to get there, and how they are behaving. In my opinion, two of the most conspicuous weaknesses in our pest-control work are inadequate surveys and the absence of facilities for demonstrating in a business-like manner the findings of research. Growers will do a far better job of pest control when we are in a position to anticipate their troubles, and have improved our facilities of getting sound information to them."

I have laboured at some length on the importance of a well-rounded program in our entomological research and mentioned some of the gaps that we need to fill. I will now discuss some of the recent accomplishments.

Dr. L. Haseman, in his paper "Influence of Soil Minerals on Insects" (Journal of Economic Entomology, February 1946), shows how the deficiency of some minerals increases the susceptibility on certain plants to insect attack, contrary to the expectancy that insects would thrive best on well nourished plants. He propounds a theory that may radically change our whole scheme of controlling insect pests in the future, namely: "Economic entomologists should begin to think and do more about fighting insect pests through the soil and perhaps depend less on the spray gun . . . . . if our farming operations are actually developing bigger and better insect epidemics, then we should incorporate more soil conservation in our over-all plan of insect control." The chinch bug thrives and matures faster, lives longer and produces more offspring when nitrogen is withheld from the nutrient solutions of which corn plants are grown as food. In nature chinch bugs are found breeding heaviest on corn grown on thin, eroded hillsides rather than on the fertile soil at the foot of the slopes. This major pest seems to have benefited by intensive farming resulting in the robbing of the soil of its nitrogen supply. In the last 100 years the worst chinch bug outbreaks have occurred during dry seasons when the plants actually draw less heavily on the nitrogen supply. Hence, it may be this factor rather than the dry weather which favours the chinch bug.

In his studies of the greenhouse thrips, Haseman grew New Zealand spinach in flats with different nutrients in the greenhouse, while the thrips bred on a weed under the benches. The thrip was thus free to select spinach which met its nutritional requirements. Practically every plant in the lower nitrogen levels were attacked, some so seriously as to be almost killed.

Scarcely a plant in the higher nitrogen levels showed any sign of thrips injury. As in the case of the chinch bug, this insect is naturally adapted to satisfy its nutritional needs by passing up nitrogen rich plants and feeding on nitrogen starved plants. As the spinach crop matured, the thrips moved from the lower nitrogen levels to the plants on medium level of nitrogen with some plants in the high nitrogen level showing some damage. It seemed that the storing of some nitrogen in the developing seed lowered the nitrogen in the foliage of those plants on higher nitrogen levels sufficiently to make them attractive to the thrips.

In the case of the common grain aphid, Haseman found that while the aphid bred more uniformly on plants with full nutrients, shortages of sulphur, potassium, magnesium or phosphorous had no apparent effects. Deficiencies of either iron or nitrogen so affected the aphid that it succeeded in producing only a few offspring and survived for only a few generations.

Again quoting from Haseman, "From our findings . . . . . . . it would be a safe guess, and we aim to try to prove it, that when the Colorado potato beetle moved over from the wild nettle to the potato plant it found a new, more favourable combination of plant nutrients which simply changed it from an insignificant weed feeder to a revitalized nationwide menace to one of our most important crops." "Data on the white fly indicate that on petunia plants it thrives best on those grown on full nutrients and a shortage of either iron or potassium makes plants unsuited for normal development. On the other hand, in the case of tomatoes, the data indicate that plants on full nutrients are less attractive than those on either a phosphorous or a magnesium deficiency."

Haseman concludes, "It would seem that by lowering the total level of soil minerals through erosion, overcropping and faulty crop rotation, we are systematically improving conditions for our insect pests while making them less and less favourable for our crops, livestock and ourselves."

Dr. William A. Albrecht, also from the University of Missouri, in his paper "Discriminations in Food Selection by Animals" (The Scientific Monthly, May 1945) cites a number of examples of the ability of farm animals to select feed grown in soil with the necessary nutrients and the effect on the animals when compelled to subsist on feeds they would of choice refuse. Cattle are able to detect hay grown on fertilized land from that grown on unfertilized land when placed in different stacks or in different parts of the same stack. Similarly, hogs selected corn from self-feeders that had been grown on fertilized land, regardless of the variety. Rabbits showed stunted growth and reduced fertility when fed hay grown in soil lacking phosphate.

The effect of plants fed on different nutrietns on their insect pests brings up the possibility of feeding or injecting substances definitely toxic to insects into plants or animals to protect them from insect attack. Roark of the U.S.D.A. reviews this possibility in a paper "Feeding Chemicals to Plants and Animals for Pest Control" (Journal of Economic Entomology, February 1946). He points out that although a number of earlier workers failed in their attempts, this is a fertile field and should be investigated. "Recent reports of tests with other chemicals as internal remedies for external parasites compel us to change our opinion as to the ineffectiveness of this method of control." "Mortality as high as 100 per cent occurred when bedbugs were allowed to feed on a rabbit 3 to 5 hours after DDT was administered in doses from 228 to 400 mg. per kilogram of body weight." "Pyrethrum extract gave similar results not only with bedbugs but also with stableflies." "Now that we know that compounds insoluble in water (such as DDT, phenothiazine, and the pyrethrins) may prove effective when fed to animals, our horizon is greatly expanded." Thousands of the new synthetics may be of value. The same applies to plants as well as animals. "Derris constituents were translocated from the outer surfaces of leaves to first, second and third trifoliate leaves formed after the application of derris powder in water suspension to the first true leaves and stems of bean plants. These trifoliate leaves were found to be less palatable to Mexican bean beetle larvae than were similar leaves from untreated plants. The feeding of the larvae was definitely retarded.

Variation in the virulence of a species of aphid is demonstrated by C. D. Harrington "Biological Races of the Pea Aphid" (Journal of Economic Entomology, February 1945). "Under favourable temperature and food conditions, aphids reproduce parthenogenetically. The young are females and arise from unreduced diploid eggs. This method of reproduction may continue indefinietely in mild climates. In more rigorous climates, however, diploid sexual forms are produced when temperature and food conditions become less congenial with the approach of winter. Normal meiosis takes place in these sexuales resulting in the production of haploid sperm and eggs. The eggs are fertilized normally, and from them diploid stem mothers arise the following spring. The stem mothers presumably are heterozygous, since the odds are slight that their parents were homozygous. These stem mothers are true $F_1$ individuals, but since they reproduce parthenogenetically no segregation occurs among their progeny. Thus parthenogentically pure lines are established and maintained for several generations during the summer, producing a great population of aphids genetically identical to the original stem mothers. Segregation, long delayed by the intervention of several asexual generations, takes place with the meiotic development of sperm and eggs in the sexuales. The number of kinds of eggs and sperm produced is limited only by the extent of genetic variation between the sexual parents of the previous year and by the elements of chance involved in the mechanics of segregation."

In the southern part of its range, the pea aphid overwinters as living viviparous females. It is hence possible for populations to come from one stem mother and persist for years, particularly in isolated valleys where the original parent might have been brought in by man. Since each stem mother is the progenitor of a genetically homogenous parthenogenetic line, variation among aphid lines in the northern areas must be considerable. To test this theory Harrington collected aphids from 31 lines and raised them in the greenhouse. He was able to determine five separate biological races. He also found close relationship of size and virulence, indicating that these two characters are quantitatively inherited and that the difference between virulent and non-virulent aphids may be due to variation in the number of factors for size and vigour in the different genotypes. "Discovery of the multi-racial character of the pea aphid may help to answer several questions which have confused entomologists for some time. Wide variations frequently encountered in the efficacy of contact insecticides in various areas or in the same area from year to year may be due to different aphid races or to different proportions of vigorous and non-vigorous aphids in the total population." "Spotting", i.e. small patches showing heavy damage in fields otherwise lightly infested, may indicate the infestation and consequent spread of a virulent aphid line in a field generally infested with less virulent lines. The same explanation may apply to variations in damage from field to field and year to year.

The effect of a combination of physiological, genetical and ecological factors on Colias eurytheme is discussed by W. Hovanitz "Physiological Behaviour and Geography in Control of the Alfalfa Butterfly" (Journal of Economic Entomology, December 1944). This butterfly is found from southern Canada to Mexico. It is widely scattered and generally distributed and is not found in colonies in the wild state as are other butterflies. This is due to the scattered nature of its wild food plants and to the habit of the female who lays only one egg and a time and takes long intervening flights. This migratory habit renders it very unlikely that many eggs will be laid in a field unless there is a great concentration of individuals. The rotation in which alfalfa field are cut in parts of California renders this possible by concentrating the females on newly cut fields. If cutting of the fields wer correctly timed, the pupae would be destroyed and the damage prevented. The destructiveness of this insect is correlated with climatic conditions. The physiological limits, where known, can often be correlated with these factors in such a way that by a slight man-made manipulation, the balance of lethal conditions can be turned against the insect. This is possible in the hot, arid regions of Arizona and California where heat-protection places can be eliminated by cutting weeds around the fields. The elimination of adult food, also by the cutting of weeds, may reduce the egg-laying capacity of females to 5% or less. Conditions for hybridization and larval food mixups between the alfalfa and clover races with resultant sterilization and high mortality can be produced by planting a mixture of alfalfa and red clover.

Finally, I would like to mention a paper by E.A. Steinhaus, "Insect Pathology and Biological Control" (Journal Economic Entomology, October 1945). This paper does not report any new and recent findings, but it does give a good review of the whole subject. Steinhaus points out that because in the few cases where disease organisms have been tried to control insect outbreaks they have usually been unsuccessful does not mean that they are of no value. Thorough studies of the organisms by competent bacteriologists and mycologists have not been made. The experiments have been largely hit or miss attempts. Actually this field shows great promise but much fundamental work needs to be done.

In this brief review, I have been able to only scratch the surface of some aspects of the subject I have been assigned. I have attempted to show the advances that have been made in the biological field and that we should aim at a well-balanced program in our economic entomology. Too much specialization narrows our outlook and causes us to forget that the insect reacts to all the factors of its environment according to its species or biological race.

# INSECT NERVE PHYSIOLOGY WITH REFERENCE TO TOXICOLOGY

W. R. Allen

As with all animals, it is necessary that the stimuli of the insect's external and internal environment be translated into activity. The nervous system is the agency which conducts these stimuli to the sites of action and which controls and directs appropriate action. The arrangement and constitution of the insect nervous system will not be discussed here, except recent work upon the nature of nerve membranes.

## 1. The Neurones, Fibers and Their Possible Chemistry.

The neurones are the basic elements of the nervous system, the axon filaments where they run freely through the body constitute the nerves. Indirect histochemical data and optical studies (18, 19) have shown the presence of a thin lipo-protein sheath surrounding the individual nerve axons. The sheaths are like those of the so called non-myelinated nerve fibers of vertebrates, in that they are very thin, not more than a few per cent of the fiber diameter in thickness. Their extreme thinness can be appreciated from the fact that roach axons are ten to twenty microns, mosquito larvae axons less than two microns in diameter. This fine sheath consists of layers of lipids, probably phospholipids, and a protein which may be collagenous as in other animals. Optical evidence indicates the presence of an ultra structure, well in agreement with that recorded for other non-myelinated nerves. The ultra structure pictured for the central axis cylinder of the nerve, consists of an orientation of micells with their optical axes paralleling the length of the nerve. The nerve sheath, somewhat better known, consists of alternating laminations of protein and lipid micells, the optical axes here being arranged radially. However, the significance of this architectural structure in terms of nerve physiology is not presently known.

The central nerve cord and peripheral nerves are made up of groups of axon fibers, some neuroglia cells and are similarly surrounded by a homogeneous sheet, the "neural lamella". This sheet is secreted by an underlying layer of non-nervous cells. In the cockroach, the "neural lamella" appears to be a series of elastic, concentric, protein sheets which differ structurally and chemically from the protective coatings around vertebrate nerves. It appears not to be collagenous, and this protein seems to differ from that of the axon sheaths. It undoubtedly has a protective function and it appears freely permeable.

The chemical constitution of the insect nervous system may have somewhat the same characteristics as in Arthropoda which have been studied. The chemical constitution is given here in only approximate terms. The potassium content in crab nerve is some twenty times that occurring in the nerve of the frog. It is about thirteen times more concentrated in the crab nerve than in the surrounding blood. The calcium content is similarly concentrated about eleven times in the nerve of the same arthropod and it amounts to twice that of the frog nerve. If high concentrations such as these prevail in insects' nerves, they are probably of some significance, since potassium seems to be concerned with the release of nerve energy, and calcium with the integrity of the nerve membranes.

The carbohydrate content of crab nerve is relatively high, 2-20% (dry weight) in comparison to a probable 0.1% in vertebrates. Respiration in this type of nerve is characteristically high, although metabolic efficiency is below that of vertebrates.

The lipids of the bee's central nervous system (14) are the same in type and proportion as those occurring in the vertebrate brain about the time of visible medullation. Cerebrosides were not found and the sterol content was low. The total phospholipids amounted to approximately 1.5% sphingomyelin, 2% lecithin and 12% cephalin, on a dry weight basis.

2. Some Characteristics of Nerve Conduction.

The conduction of nervous impulses has been one of the oldest physiological problems (10). The facts concerning it will be briefly reviewed here. Various stimuli such as heat, mechanical impact, chemicals or an electric current, cause excitation which sets up an impulse and the impulse travels along the nerve fiber. The impulse can spread in either direction from the point of stimulation. A refractory period occurs after each excitation, during which a second stimulus does not promote an impulse. The all or none law prevails, which is stated in the following way by Adrian: "The relevant facts are these: that in the individual nerve fiber the wave of activity set up by a strong stimulus travels no faster than one set up by a weak, that it travels no further if there are obstacles to its progress (injuries or narcotized regions), that the refractory period is no longer and that the change of potential which accompanies the wave is no greater."

3. Theories of Nerve Conduction

Conduction of a nerve impulse is not due to a physical disturbance, which diminishes from the point of origin, but a disturbance is initiated enroute along the conducting nerve. Furthermore, any portion of a nerve which becomes active stimulates action in an adjacent portion. There are two principal theories as to how this conduction may be brought about; one is the electrical, the other the chemical theory. For a long time, it has been known that every active region is negative to an inactive region and that during the depolarization a measurable action current flows. The action potential (10, 12) is known to be sufficiently strong to initiate a response and the theory, now well established, is that a series of action currents are responsible for conduction. The fact that such action currents arise has been of great use in studying the passage of impulses along a nerve. Upon amplification, the spike of potential which occurs with each impulse may be projected by means of a cathode ray oscillograph onto a moving film.

Young (33), reviewing these phenomena in respect to the giant nerve fiber of the squid, considers that the potential difference between the inside and outside of the nerve "arises from the fact that the nerve surface is composed of a differentially permeable membrane which, together with the chemical changes going on inside the cell, leads to an unequal distribution of charged particles". Potassium is present in much greater quantities on the inside of the nerve than outside, nearly thirty times. The potential difference arising may be largely a potasium diffusion potential. However, he concludes this hypothesis does not fit all the known facts. Commenting upon the possible source of the action potential during the passage of a nerve impulse the author says, "The membrane becomes freely permeable to all ions and a current flows between the active and neighbouring regions, causing a breakdown of membrane of the latter, so that a wave of discharge sweeps over the fiber". He continues, "Dr. Cowan of University College, London, showed me some time ago that during the process potassium leaks out of the nerve fiber. Evidently the characteristics of the membrane at rest and in activity are of some fundamental importance . . . . .". Presumably then the loss of potassium from the nerves in response to a stimulus would initiate the action potential.

The chemical theory depends on the possibility that the active portion of the nerve releases some stimulating chemical substance to affect the resting portion. The theory has been constructed on one such substance, acetylcholine, which is known to cause nerve impulses. But a chemical, unless quickly dissipated, would not excite individual impulses with the proper periodicity. An enzyme cholinesterase, however, is present in many nervous tissues, which has the ability of reducing acetylcholine to choline and acetic acid with the desired rapidity. Nachmansohn (10) believes acetylcholine is primarily responsible for the action current and that it may have some relationship to the conduction of the impulse. A recent review (27) on the subject considers that this theory predicated upon the facts that nerve fibers contain and can synthesize acetylcholine, and that acetylcholine can depolarize membranes, is somewhat as follows. Stimulus to a nerve fiber results in a release of acetylcholine which depolarizes the neural membrane rendering it permeable to all ions, which results in the generation of an action potential. This stimulates the adjacent region of the neurone and brings about the release of acetylcholine there, thus repeating the whole process. The cholinesterase present destroys the acetylcholine allowing the membrane to recover its polarization. The recent modification of this theory is that the action potential is due solely to acetylcholine and that the old Bernstein theory of the depolarization of the neural membrane by inorganic ions is untenable.

Acetylcholine has been demonstrated in the nerves of many invertebrates. The insect nervous system is particularly rich in it. In <u>Carausius</u> and <u>Perplaneta</u>, two hundred micrograms per gram are present (4). More specifically (28) the nerve cord (thoracic ganglia and connectives, 3-5 mg.) of <u>Periplaneta</u> contains about 33 micrograms of free acetylcholine per gram, fifteen times the average amount in mammalian central neural tissue. Whole house flies (excluding wings and legs) contain 47 micrograms per gram. A very high concentration of a specific cholinesterase has been found (21) in the nervous tissue of the honey bee and American roach. In contrast to the esterase of vertebrates, this insect product was about three times more active against acetyl-B-methyl choline than acetylcholine. But why this should be is not clear. In terms of activity, the esterase of the bee was about equal to that of the vertebrate retina.

## 4. The Nerve Synapse.

The mechanism involved in the transmission of a nerve impulse across the neuro-neural synapses to allow integration of nerve cells or across the myoneural junction to produce muscular contraction, has been and is still subject to considerable controversy. Essentially the same theories as discussed in respect to conduction find support. The school of Eccles and others (5, 10) favours an electrical transmission. They point to the fact that high synaptic and end plate potential can occur, sufficient to promote a response in nerve or muscle, especially as they consider that acetylcholine functions in the very minor role of sensitizing nerve and muscle cells in order to facilitate an electric stimulation. These workers are inclined to deprecate the evidence of chemical transmission by acetylcholine based on the use of the drug eserine, which blocks the action of cholinesterase, one of the arguments of the many supporters of this theory. It is sufficient here that these opposing views be recognized.

Some properties of the synaptic transmission in the central nervous system of <u>Periplaneta</u> (17) have been studied. There are systems of sensory nerves leading from the large cercal nerve. One is direct and comprised of a few ascending fibers which pass uninterrupted through the caudal ganglion into the ventral nerve cord. The other sensory pathway is formed by many nerves which synapse in the ganglion with a few ascending giant fibers. The giant fibers appear to have the property of gathering up the responses (31) from the many fibers of the cercal nerve, producing a more intense response in the brain. The through fibers are not fatigued by electrical stimuli as long as the cercal nerve is responding. The effect of maximal stimulation above a critical frequency is to fatigue the synapses, and the giant fibers are not excited by stimuli applied to the cercal nerves, but may be stimulated directly. On the other hand, repeated low frequency submaximal stimulations (25/sec.) slowly fatigue or adapt the synapses. A momentary stimulation can be exerted in the giant fibers if the threshold of stimulation required to cross the synapse is increased. Possibly fatigue is caused in this instance by a relative prolongation of the refractory period.

## 5. Electrical Phenomena and Neuromuscular Systems.

The phenomenon of a spontaneous activity in nerve cords, isolated from the body, occurs irrespective of injury or motor effect. It has been described (1, 2, 8, 25) for the central nervous system of the frog, the isolated brain stem of gold fish also in several insect nerve systems. In Dytiscus (1) this activity is described as a persistent rhythmic discharge, which is essentially a repeated outburst of activity, each outburst consisting of a volley of potential spikes which slowly subside. The regularity of these outbursts agreed closely with rate of respiratory movements in resting insects, occurring at a frequency of about five a minute. The outbursts which accompany locomotion have a much higher frequency. The hypothesis of Adrian & Buytendijk (2) is "that the slow development and decline of the active state involves a slow increase and decrease of permeability in the dendritic region (or a slow depolarization and recovery)and that this will set up a repeated discharge".

The Roeders (25) found similar prolonged bursts of increased activity (for thirty seconds or more) in most isolated central nervous system preparations of Periplaneta; also groups consisting of four or five short bursts occurred. However, the most frequent activity recorded consisted of a steady by arhythmical background of action currents with sometimes rhythmic trains of single spikes of small groups of spikes superimposed on this background.

Increasing amounts of the drugs eserine and nicotine increased the spontaneous activity until steady trains of spikes, of greatly enhanced potential, appeared. Finally higher drug concentration eliminated all activity. It is of interest to note that Harline and Young (33) demonstrated rhythmic discharges somewhat of this nature when the end of a squid giant nerve fiber had sodium citrate (1%) applied. Calcium is precipitated here, initiating a repetitive discharge.

The work of Pringle (16) on the motor mechanism of the cockroach leg suggests the similarity to other arthropod neuromuscular systems (6, 29). In these systems few axons (2-5) pass into a bundle of muscle fibers, and each axon innervates every fiber in the bundle. There are then many end plates (myoneural junctions) well distributed over the length of the muscle fiber. In contrast, vertebrates have many axons entering a muscle, and each innervates only one or at the most a few fibers.

The abductor and adductor muscles of the dactylopidite of Cambarus cheliped receive two and three nerve fibers respectively (6). Where two motor fibers are present, the thickest axons cause a first contraction or twitch, the second or smaller fiber gives a slow contraction. The third fiber, when it is present, is an inhibitory fiber, which reduces the intensity of either contraction. Whereas in vertebrate striated muscle a single nerve impulse causes a maximal twitch contraction, several impulses must reach a crustacean muscle within a limited time (probably less than ten milliseconds) to cause a facilitation of muscle activity. This is certainly true for slow crustacean fibers and, to a lesser extent, in most fast ones. Fast and slow fibers innervate the extensor of the roach tibiae (16), but no inhibitory fibers have been found. The slow fiber did not give its characteristic tonic contraction until stimuli reach a frequency of 30/second. The threshold of the fast fiber was lower, at a frequency of 19/second a single twitch was produced for each stimulus received.

In vertebrates, the different degrees of contraction are due to the number of fibers which are contracted at any one time and remain contracted because of a continuing series of impulses. In crustacea, the contraction is the sum of many local contractions, each produced at one of the many end plates, and the extent of contraction depends on the rate of restimulation.

The function of inhibitory fibers becomes clear by comparison with the vertebrate mechanism. In this case, when a muscle contracts, its antagonist relaxes, and the process is controlled centrally by action of the neurones which maintain tonus. In arthropods, where inhibitory fibers occur, this inhibition is brought about peripherally. Opposing muscles are supplied with inhibitory as well as excitory fibers. These inhibitory fibers act to prohibit the undesired action of a muscle. This occurs when the inhibitory impulse, carried to the muscle by such a fiber, arrives before, coincident with or slightly after an excitory impulse.

## 6. The Action of Drugs on Insects.

Drug action may tell us something about nervous systems. Strychnine acts on _Mantis_ and _Periplaneta_ (24) to cause a drop in muscle tonus, increased locomotor activity and paralysis of the head appendages, symptoms similar to those which result upon destruction of the cerebral ganglia. Its action is then entirely depressant. This drug acts on the spinal cord of vertebrates to produce an opposite effect, the threshold between the neurones is presumably lowered and an inhibitory process may be turned into one of excitation.

Pilocarpine produces great excitation and high muscle tonus and appears to have excitatory action on the contra-lateral ganglia of the brain, since removal of this portion had the same effect. This drug is known to specifically stimulate the parasympathetic effectors of vertebrates.

Acetylcholine hydrochloride alone produces no marked change in behaviour; upon eserinized roaches an intense reaction appears, more intense than that occurring with pilocarpine.

More recently, an explanation has been offered to account for the apparent inactivity of the choline esters upon the cockroach nervous system. It has been shown that relatively enormous amounts of acetylcholine (25) are required to either alter the electrical activity in the roach nerve cord or to promote "DDT like" symptoms (28) upon injection into these insects. Similar inactivity has been noted when either carbaminoylcholine or acetyl-B-menthylcholine (28) are injected. The suggestion is made by Tobias et al that this lack of response may be due to the relatively slow circulation and approach to the neural structures upon injection, and to the relative impermeability of the nerve cord sheath to these substances.

Eserine alone promotes instantaneous spasm and immobility, from which the insects do not recover. This action certainly suggests the presence of acetylcholine in the nervous systems.

It is of interest to note here that eserine produces symptoms which resemble those of DDT. Tobias et al (28) report, "This is true whether the eserine be given intraabdominally or by local application to one of the thoracic ganglia. This, and the fact that the hypermotor symptoms of DDT or eserine poisoning can be stopped by the application of nicotine or atropine to the ganglion, emphasizes the importance of synaptic structures in the maintenance and development of the early symptoms ~~of hyperactivity after DDT~~."

Atropin, in the case of vertebrates, specifically blocks transmission in the autonomic ganglia and to the parasympathetic effectors, rendering these structures insensitive to acetylcholine and pilocarpine. However, in most cases, atropinized roaches show either normal or decreased activity upon subjection to pilocarpine.

Roeder concluded that vertebrate and insect central nervous systems were different on the basis of their different reactions to strychnine. The actions of pilocarpine, eserine and atropin suggested a pharmacological similarity between the insect nervous system and the vertebrate parasympathetic system.

These results were essentially confirmed by studying the electrical activity of the isolated ventral nerve cord of Periplaneta (25) prior to and after the application of drugs. It was shown that pilocarpine, eserine and nicotine, and to a lesser extent acetylcholine, raised the level of nervous activity; that prior atropin treatment may prevent excitatory action by pilocarpine; and that nicotine and eserine in relatively high concentrations produced a reversible inhibition of activity. These effects correspond to those produced on the cholinergic nerves of vertebrate automatic ganglia. Thus the insect nerouvs system would appear to be similar to it, as Roeder had previously suggested.

## 7. The Action of Toxins on Insect Nerves.

For the most part, the effects of toxic substances upon insect nervous systems have been studied in relation to either the typical muscular behaviour produced or paralysis, or to histopathological changes (11) in the nerves. Some slight attention has been given (13, 25) to the effect produced on action potentials. One study (21) considers the action of toxic agents upon nerve enzymes. This study attempts to learn which of several agents block or inhibit cholinesterase. It was found that the cholinesterase of bees is poisoned in vitro by eserine but is unaffected by curare and various insecticides such as nicotine, "DDT", pyrethrum, thanite, lethane, etc. Only sodium fluoride, of the materials tested, was able to cause a partial inhibition of this enzyme.

An interesting recent study (28) has demonstrated that DDT poisoning causes the free acetylcholine to rise some 200% in the central nervous systems of Periplaneta and Musca domestica. This rise occurs during the late prostrate phase of poisoning rather than during the early period of great hyperactivity. Normally, the acetylcholine content of the ganglia is 70% above that in the connectives. However, almost all the acetylcholine increase noted above occurs in the connectives. This response is not limited to DDT action, as prolonged anesthesia with cyclopropane, or the contact poison gama-hexachlorocyclohexane produce an erratic increase of acetylcholine. Tobias et al. state, "One step in the mechanism of increase of acetylcholine in roach cord after DDT appears to be the liberation of free ester from bound precursor.

In the normal roach cord, about 20% of the ester is in the bound form. When it increases after DDT, however, it is either all or almost all in the free form. It is suggested, therefore, that DDT, or more likely some metabolic intermediary, causes a liberation of free from bound ester. This might shift an equilibrium to favour formation of precursor. Such a new precursor could then be acted upon to liberate more free ester and so on. A reaction chain of this sort need not manifest itself in vitro possibly because of some deficiency in supplied substrates, catalysts, or the like. It has been suggested that DDT might most effectively act on such a precursor . . . . .".

Richards and Cutkomp (22) have considered with consummate detail the neuropathology of insects. They have raised serious objection to the interpretation of the histopathological effects which have been attributed to pyrethrum and other insecticides and synergists, by many authors. It is their contention that ". . . . . the visible pathological changes induced in nerves by insecticides are at least largely postmortem, and accordingly too complicated for analysis at the present time".

"It is logically considered that four degrees of toxic effects upon nerves are conceivable:

1. All cells may be indiscriminately affected such as when fixing fluids are used.

2. Substances may have a lower threshold of action against nerves.

3. Selective accumulation of toxic substances may occur in the central nervous system.

4. Substances may be specific in their action on nervous tissue, such as atropin.

Pyrethrum in common with other lipid soluble materials has been shown to penetrate selectively into and accumulate in insect nervous systems (23). However, in general, it would be difficult to assign these effects to the wide group of insecticidal agents.

Polarized light investigations undertaken after acute dosages of pyrethrum, showed that the colloid of the axis cylinder degenerated prior to the nerve sheath and that degeneration proceeded from the region of application towards and finally reach other regions. Concomitant with these observations it was emphasized that "the death of the animal does not bear any fixed relationship to the degree of degeneration of the central nervous system". Using histological technique, so-called "pyrethrum lesions" were observed but it was considered that "all the histological effects seen in our experiments are subsequent to irreversible paralysis and are accordingly to be classed as postmortem pictures". A point to be well considered in this regard is that autolytic degeneration in saline solution follows a course which gives a histological picture similar to that which occurs in pyrethrum killed nerves. In the words of the authors, "It seems questionable whether pyrethrum has any causal relationship to "pyrethrum lesions" other than killing the nerves. It is quite possible that a lethal concentration of pyrethrum develops in the central nervous system so far in advance of that in other tissues that advanced autolysis may develop there before other tissues even die."

Pyrethrum, "Thanite" and petroleum oils showed histopathological changes which may be considered similar to autolysis, being characterized by a distinct vacuolization of the nervous tissues. Valone, lipid solvents (such as zylol and chloroform) and certain essential oils (such as citronella, Eugenol and oil of thyme) produce effects more or less distinct from autolysis. There is a variety of manifestations of such action, various degrees of disintegration such as the appearance of discrete round particles on fixation, dissolution of nuclear chromatin or opacity, etc.

Valone (2 isovaleryl-1, 3 indandione) promotes the destruction of the ultra structure responsible for the optical properties of the axis cylinder viewed under polarized light. These properties were not affected in the nerve sheath and the nerve, when sectioned, showed normal histology except that a moderate amount of chromatin clumping occurred. Chromatin aggregation within the nuclei appears after acute dosages of pyrethrum and "Pyrin" (9) and also after "Thanite" and valone (22). This effect may be noted after asphyxiations by petroleum oils or may be induced by pressure or other agencies. However, there is some evidence that clumping is due to an increase of acidity in the nuclei. Richards and Cutkomp observe in regard to chromatin clumping after pyrethrum, "It seems very likely that this increased acidity may be due to the pyrethrum, but it would be difficult to prove that an "acid of injury" is really involved in this case. It is not yet known whether this is premortem (ce 1 viewpoint) when produced by insecticide action". It is, however, known that this histopathological effect is reversible before death when it arises as a result of asphyxiation.

8. The Possible Site of DDT Action.

Localized centers of insecticide action have not been reported, although studies have been made to locate the action sites of DDT. Periplaneta, Drosophila and crabs have been used in such work. With Drosophila (3) when phenolbarbitol, which enters the central and peripheral nervous systems, is injected before DDT, the typical symptoms of DDT are prevented. This, and the fact that DDT affected insects lose the typical DDT symptoms on the injection of phenobarbitol, indicated the neural action of DDT. Yeager and Munson (32) relate that a 10% DDT solution (in corn oil) injected into the leg of a cockroach or into the region of the ganglion of the same segment, produced twitching in the leg muscle within 5-10 minutes even after the motor nerve has been severed medial to the injected site. Since DDT caused no ganglionic excitation, it apparently excited, in their view, the motor rather than the sensory fibers. The site or sites of action occur presumably along the motor fibers between their origin in the ventral nerve ganglion and the nerve ending, producing in this way in the animal the typical clonic spasms of the trunk and appendicular muscles which follow acute dosages, resulting finally in paralysis.

Roeder and Weiant (26) investigated the possibility of high DDT concentrations (1600 p.p.m.) having a direct action on muscles or on the peripheral stumps of motor nerves. However, from the feeble response obtained, they are inclined to doubt that such action could account for DDT symptoms. DDT in several strong formulations had no effect on the level of spontaneous electrical activity of the isolated central nervous system. With the same technique and the ventral nerve cord of an otherwise intact roach, it was demonstrated by severing the cord above and below the recording electrodes that DDT increased nerve impulses by 700% in the ascending or sensory fibers. The large crural nerve, which is known to contain principally sensory fibers (15, 16) from the campaniform or hair sensilla in the metathoracic leg, was prepared in a manner to exclude the possibility of motor action by the leg. It was then found that if DDT emulsion (likely 1600 p.p.m.) is introduced into the cut end of the femur the following changes in electrical activity ensue. "In place of random spikes, a series of impulse trains appears and persists for hours. Each train seems to involve a single fiber which fires repetitively at a frequency of 300-400 spikes per second. The train declines slightly in frequency in 0.1 to 0.5 seconds. The spike height in each train is constant, although a number of different trains may occur simultaneously. Comparison with normal oscillograms suggests that while the untreated cell discharges a single spike at various intervals, under the influence of DDT every single spike is replaced by a short train, likewise repeated at intervals."

It is concluded that since as little as 0.01 p.p.m. of DDT in solution causes trains in the afferent fibers, in all probability roaches getting a minimum lethal dose would recieve a greater concentration than this, and hence would show DDT tremors due to "an intense and patternless bombardment of the motor neurones by trains of impulses originating in sensory endings."

It is suggested that DDT may act somewhat specifically on a particular group of sense organs. The campaniform sensillae on the trochanters of the roach leg may be one such group.

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APPENDIX I.

A meeting of the Entomological Society of Manitoba was held in the Dominion Government Forest Insect Laboratory at the University of Manitoba on Tuesday, April 23, 1946, at 9:30 a.m. Those present were: Dr. B. N. Smallman, Chairman, Dean A. V. Mitchener, Dr. R. D. Bird, Mrs. W. S. Barker, Messrs. R. R. Lejeune, J. McLintock, W. C. McGuffin, R. J. Heron, L. G. Putnam and W. S. McLeod, Secretary-Treasurer.

(1) It was moved by Dr. Bird and seconded by Mr. Heron that the minutes of the December meeting be adopted as read.

Carried

(2) Dean Mitchener reported that most of the common names submitted to the A.A.E.E. Committee on Common names following the December meeting had been placed on the ballot, that voting had been completed but that the results of the vote would not be known until they are published in the Journal of Economic Entomology.

(3) The Secretary-Treasurer read a financial report which showed a balance of $9.26 on hand. It was moved by Mr. McLeod and seconded by Mr. McGuffin that this report be adopted.

Carried

(4) Dr. Smallman presented a report on the publication of the Proceedings of the Entomological Society of Manitoba, Volume 1, describing the work which had been involved and expressing his appreciation of the assistance which had been so freely given by many members and friends of the Society.

It was moved by Mr. Lejeune and seconded by Mr. Heron that the Secretary write a letter of thanks to each of the three stenographers, Miss K. Ostapchuk, Miss M. McCowan and Mrs. M. Cherrett, who had done so much work on the typing of the manuscript and the cutting of stencils for the mimeographing.

Carried

(5) The Secretary then read excerpts from numerous letters forwarded by recipients of Volume 1 of the Proceedings. Without exception, these letters complimented the Society on its organization and accomplishments during its first year and extended best wishes for future activities.

In the discussion which followed, it was agreed that the policy of mimeographing the Proceedings should be followed for the time being and that minutes of regular meetings should be included as appendices but that it would no longer be necessary for the

Secretary to mail copies of the minutes to members after each meeting. Mr. Lejeune reported on the cost of semi-hard cardboard covers and members were unanimous in stating that our Society is not in a financial condition to bear such an expense. Satisfaction with the blue paper covers was expressed.

It was moved by Mr. McGuffin and seconded by Mr. McLintock that the statement, "The contents of this volume are for private distribution and are not for publication" should be retained in future volumes of the Proceedings.

(6) The Chairman then presented the Executive's report on estimated expenditures for 1946. It was the opinion of the meeting that this Society is doing a work which is of great value to those engaged in the practice of scientific entomology in Manitoba and indirectly, through them, to the public. It was thought, therefore, that we might reasonably expect a small measure of assistance from such institutions as the government entomological laboratories, the Provincial Extension Service, Department of Agriculture and the University of Manitoba, with respect to stenographic assistance, mimeographing, mailing, etc.

It was moved by Dr. Bird and seconded by Mr Lejeune that we seek the support of the public institutions named in the Executive's report for the activities of this Society.

<u>Carried</u>

(7) It was moved by Dean Mitchener and seconded by Mr. Lejeune that the annual levy be set at one dollar per member.

<u>Carried</u>

(8) The Chairman now called for an election of officers for the Society.

Those nominated for the office of President were: Mr. Lejeune (nominated by Dr. Bird), Dr. Smallman (nominated by Mr. Lejeune). It was moved by Dean Mitchener and seconded by Mr. Heron that nominations cease. The motion was <u>carried</u> and Dr. Smallman was elected by a show of hands.

Mr. Lejeune was nominated by Mr. McGuffin for the office of Vice-President. Dr. Bird moved and Dean Mitchener seconded that nominations cease. The motion <u>carried</u>, and Mr. Lejeune was declared elected by acclamation.

Mr. McLeod was nominated by Mr. McLintock for the office of Secretary-Treasurer. Dean Mitchener moved and Dr. Bird seconded that nominations cease. The motion <u>carried</u>, and Mr. McLeod was declared elected by acclamation.

(9) It was moved by Mr. Heron and seconded by Mr. McGuffin that we elect an officer to be known as the Editor-Librarian whose duties should be to supervise the preparation of the Proceedings and to file such publications as might be received in exchange. Carried

(10) Those nominated for the office of Editor-Librarian were: Mr. McGuffin (nominated by Mr. McLintock) and Mr. McLintock (nominated by Mr. McGuffin). It was moved by Mr. Heron and seconded by Mr. Lejeune that nominations cease. The motion was carried and Mr. McGuffin was elected by a show of hands.

(11) Moved we adjourn at 11:10 a.m.

B. N. Smallman,
Chairman.

W. S. McLeod,
Secretary-Treasurer.

APPENDIX II.

A business meeting of the Entomological Society of Manitoba was held in the Dominion Government Forest Insect Laboratory, at the University of Manitoba, on Tuesday, November 19, 1946 at 9:45 a.m. Those present were: Dr. B. N. Smallman, Chairman, Dr. R. D. Bird, Dr. J. A. Munro, Professor A. V. Mitchener, Mrs. W. S. Barker, Messrs. R. R. Lejeune, W. C. McGuffin, B. Berck, B. Filuk, H. Fyfe, H. Westdal, R. L. Post, D. S. Smith and W. S. McLeod, Secretary-Treasurer.

The minutes of the meeting of April 23, 1946, were read and adopted.

Dr. Smallman reported that various organizations had offered a measure of assistance to the Society in the preparation and mimeographing of the Proceedings but that the University had found itself unable to supply stenographic assistance to the Secretary in view of the pressure of ordinary work.

The Secretary-Treasurer then read items 7 and 8 of the minutes of the meeting of November 2, 1945 (Proceedings, Vol. 1, No. 1, p. 48) with regard to the expenditure of small sums of money during the intervals between business meetings. It was moved by Professor Mitchener and seconded by Dr. Bird that Section (d) of Article 3 be incorporated in the Constitution.

Carried

The Secretary-Treasurer reported the expense of a telegram to Major Brown. This expenditure was approved by the meeting.

The Secretary-Treasurer reported briefly on the correspondence received during the summer and read to the Society a brief note from Dr. V. B. Wigglesworth.

The Secretary-Treasurer gave notice of intention to move an amendment to the Constitution at the next regular meeting of the Society, the wording to be as follows:

> Moved that the following be inserted as Section (e) of Article 3 of the Constitution of the Entomological Society of Manitoba: "A member who neglects to pay the annual levy for two consecutive years shall automatically cease to be a member."

The notice of motion was discussed briefly and it was suggested that the Secretary-Treasurer should send out a statement to each member in arrears. Failure of a member to acknowledge two consecutive annual statements would result in the removal of his name from the roll, provided the proposed motion is passed at the next meeting.

Moved we adjourn at 10:15 a.m.

B. N. Smallman,
Chairman.

W. S. McLeod,
Secretary-Treasurer.