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Dominion Plant Inspection Service,
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Editor-Librarian -- W. C. McGuffin,
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Alberta

Members

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B. Berck, Stored Products Insect Laboratory, Winnipeg

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G. S. Brooks (deceased), formerly of Winnipeg

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INTRODUCTION

The Entomological Society of Manitoba completed its third successful year in 1947 as a formal society. Only a few changes in membership took place and it is gratifying to note that the several members outside of Manitoba maintained their interest in the Society to the extent of retaining their membership.

In addition to the usual spring and fall meetings, a special meeting was called in September for the purpose of considering the proposed organization of an Entomological Society of Canada. The Entomological Society of Manitoba has given strong support to this movement and at the special meeting a suggested constitution was drawn up for transmission to the Committee on National Entomological Organization. Subsequent developments indicated that financial difficulties are impeding the formation of a National Organization but the Manitoba Society has gone on record as being in favour of supporting any effort directed towards the formation of an Entomological Society of Canada.

The regular spring and fall meetings were well attended. The discussions at the spring meeting and the series of four excellent review papers presented at the fall meeting may be found in the body of the Proceedings.

The International Great Plains Conference of Entomologists accepted the invitation of the Entomological Society of Manitoba to hold their annual meeting in 1948 at Riding Mountain National Park, Manitoba. Following their acceptance, preliminary organizational work was undertaken by the Manitoba group for the purpose of arranging for accommodation and forming the necessary committees.

The assistance of the Extension Service, Manitoba Department of Agriculture, in the publication of these Proceedings is gratefully acknowledged by the Society.

R. R. LEJEUNE
President

THE APRIL GENERAL MEETING

Eleven members attended the spring general meeting held in the Dominion Forest Insect Laboratory on April 22, 1947.

The meeting was divided into two sessions--a morning business session and an afternoon session at which scientific subjects were discussed.

The Business Session

Article 3 of the constitution was amended to make loss of membership automatic when a member neglects to pay the annual levy for two consecutive years.

The Secretary-Treasurer submitted a financial report which was adopted. Mr. W. C. McGuffin reported that the Proceedings of the Entomological Society of Manitoba would soon be ready for distribution. Appreciation was expressed of the stenographic work of Misses K. Ostapchuk, V. Schewchuk and S. Dougall. The Secretary was directed by the meeting to forward a letter of thanks to Mr. R. C. MacKay, Director of Extension, Department of Agriculture, Province of Manitoba for his assistance in publishing the proceedings.

The meeting discussed the matter of compiling a list of common names for insects of Manitoba, which had been requested in a letter from Mr. C. R. Douglas. Mr. J. McLintock and Dr. R. D. Bird were named to appoint a committee to co-ordinate this project.

It was agreed that the Society extend an invitation to the International Great Plains Conference of Entomologists to meet in Manitoba in 1948 if accommodation can be secured at Clear Lake or elsewhere in the province.

Officers elected for the year 1947 were: Mr. R. R. Lejeune, President; Mr. C. A. S. Smith, Vice-President; Mr. W. S. McLeod, Secretary-Treasurer and Mr. W. C. McGuffin, Editor-Librarian.

The minutes of this meeting are included as Appendix I of these Proceedings.

The Scientific Session

The afternoon session was devoted to presentation and discussion by the members of informal reviews of their current entomological work.

Field Crop Insects: Dr. Bird reported on the work of the Dominion Entomological Laboratory at Brandon. Aside from the work on grasshoppers, this laboratory is chiefly concerned with the sweetclover weevil project and the vegetable insect survey.

The work on sweetclover weevil, which had been reported upon a year ago, had been continued during the summer of 1946. The weevil was found during the summer as far west as Lethbridge in Alberta. In southern Manitoba, feeding of the weevil, coupled with drought and root rots, destroyed many plantings completely.

The weevils emerged at an exceptionally early date in 1946 and six spring flights were observed in May and June. Soil sifting yielded relatively few larvae this year--a total of only 16 per square foot as compared with 282 per square foot in 1945. The month of May was hot and dry and the female weevils laid continuously. Some of them produced up to a total of 1600 eggs each. Most of the eggs laid after July 1, 1946 perished owing to high temperatures on the surface of the soil. There was probably a fairly high mortality in June also. The fall migration was observed at only one locality in the Portage area this year. A fungus, Beauveria Bassiana, which had been discovered in 1945, caused about 27 per cent mortality in the early part of the season that year. Efforts to locate this fungus during 1946 failed but another disease organism, Hirsutella sp., was discovered. It produced a high mortality later in the season. No parasites have as yet been observed.

Measurements of soil surface temperatures showed that the optimum for the weevil is between 70° and 90°F. Emergence from hibernation takes place between 57° and 64°F., and above 110°F. the weevil becomes entirely inactive. Soil temperatures as high as 126°F. were recorded during the summer.

Measurements of larval head capsules indicate that there are four instars.

Studies of food preference show that sweet clover is favoured over alfalfa but, curiously enough, the weevils raised on alfalfa produced more eggs than those raised on sweet clover.

The Brandon workers have found that seeding clover in moist soil at the normal seeding time is preferable to seeding it later in an effort to avoid the weevils. Various tillage methods have been tested and best results from surface tillage in late July have been secured by the use of the duck-foot cultivator and the one-way disc. In the late fall, deep ploughing may be practised but surface cultivation is of no value.

It was noted that the population of the weevil was lower than usual during the autumn of 1946. It is hoped that the study may be continued either in the Portage area or in the Graysville area during the coming season.

Mr. Westdal reported on the work of the vegetable insect survey which had been started in 1945 in a small way and was enlarged during 1946. Its primary purpose is to identify vegetable insects and determine their abundance and their population trends in various regions of Manitoba. If populations of pest insects can be forecast through this survey, control measures may be planned to better advantage. In 1946, sweeps were taken weekly at the collecting points. Insects captured were killed and taken to the laboratory for identification. This procedure involved too much laboratory work to be practical. It is hoped during the coming season to pay particular attention to about 25 species which are of greatest importance and to identify as much of the material as possible in the field. Insects will be located chiefly by searching, sweeping and soil sifting methods. Already the data gathered indicate that populations of pests may vary greatly within narrow geographical limits. Similarly, the percentage of parasitism of a common pest, such as the Colorado potato beetle, may vary widely from place to place.

Mr. Seyward Smith, reporting on his studies of insect physiology with particular attention to nutrition of Melanoplus mexicanus on various food plants, outlined the methods of the investigation. The work consisted of placing young grasshoppers in cages supplied with the desired food plant and also placing similar nymphs in glass jars supplied with clippings from the plants. The criteria used were mortality and oviposition rates. Data have been gathered on the effects of feeding various food plants to M. mexicanus. The rate of development of the grasshoppers has not proved to be a particularly useful measure. Consistently, dandelion has produced the highest survival rate while alfalfa has given the highest mortality rate and the lowest egg production. Renown wheat and Plush barley have produced the greatest number of grasshopper eggs. Differences between varieties of the same food plant have not yet been shown but it is hoped to pursue this study in 1947. It is also proposed to observe the cumulative effect of various foods on succeeding generations. This cumulative effect is already apparent in the case of alfalfa since the strain of grasshoppers fed on this food has died out after three generations. During the coming season, particular attention will be paid to the effects of different varieties of cereal plants and it is hoped to investigate the basis for varietal differences. In order to do this, it may be possible to evolve an artificial medium which will provide an adequate diet and then, by eliminating various elements in succession, to investigate the effect of each on the nutrition of grasshoppers. Another method which seems feasible is to grow plants on nutrient solution and, by varying the nutrients, to affect the chemical make-up of the plant and thus to study the effect of these changes on the insects. Possibly variations in available nitrogen will be tested first, with a study of trace elements to follow. It is hoped that such experiments will give information of value in baiting work and in studies of the range of insect pests and their annual fluctuations of population.

Stored Products Insects: In the absence of Dr. Smallman, Mr. Berck reported on the work of the Stored Products Insect Laboratory. The principal investigation in 1946 was concerned with the biology and control of spider beetles, Ptinus villiger. An experiment was carried out in 75 flour warehouses in Manitoba to test the relative effectiveness of: DDT-in-water, DDT-in-oil, Gammexane-in-oil, Gammexane smoke, magnesium oxide and aluminum oxide. The results were assessed by comparisons of the number of eggs laid in indicator sacks placed in all sheds. As compared to untreated sheds the best control was obtained with DDT-in-water, DDT-in-oil and Gammexane-in-oil. These treatments showed 95% control and were not significantly different one from the other. Cotton sacks treated with DDT or DDD, and untreated paper sacks, were both highly efficient for protection of the enclosed flour. On the basis of this investigation definite recommendations for the future control of spider beetles in flour warehouses are to be made to the milling industry.

Biological studies of the spider beetle have definitely established that the female beetle oviposits through the mesh of cotton flour sacks. The egg-laying period starts in April and ceases in July; adults emerging in the fall do not lay eggs at that time. Further studies on the biology of this insect will be made.

The laboratory has initiated an investigation of DDT residues found on various structural surfaces in food processing plants and food warehouses. As a basis for this work, Mr. Berck is investigating chemical methods of measuring DDT. During the coming summer an attempt will be made to determine quantitatively the loss of DDT applied to box car surfaces to protect stored products in transit.

A major investigation, being undertaken by the laboratory this year, is a study of the ecology and control of mill insects. The first part of this investigation will be concerned with factors affecting the growth of the mill population throughout the entire year following a general fumigation. The possibility of using low volatility fumigants in semi-open locations, such as milling machines, will be investigated.

An investigation of the possibilities of electronic sterilization of cereals is to be carried out with the co-operation of the National Research Council. Mr. F. L. Watters will devote his attention to this project.

In reporting on his own work, which is concerned with DDT residue analysis, Mr. Berck listed ten problems, the answers to which could be provided in whole or in part by chemical analysis. For the box car residue problem, exploratory experience with one gravimetric and two spectrochemical methods of DDT analysis was acquired. Using the Schechter-Haller method, it was found possible to detect 5 micrograms (mmg) p,p'-DDT with a replicability in standard curve studies of 1 mmg.

in the range 10-125 mmg. Much work has still to be done to test the suitability of this method for experimental requirements and will involve recovery tests, evaluation of possible interfering substances, and standardization of procedures for deposition of DDT residues and their subsequent removal for analytical purposes.

Plant Inspection: Mr. C.A.S. Smith reported on interceptions of insect pests in shipments entering Canada through Winnipeg. The broad bean weevil, Bruchus sp., the coffee bean weevil, foreign grain beetle, flat grain beetle, and others were noted. Treatments were applied to such shipments, usually by means of methyl bromide at one pound per thousand cubic feet. A shipment of broom corn from Italy exhibited many holes presumably made by the European corn borer but no insects could be found.

Vegetable Insects: Mr. W. S. McLeod reported on onion maggot research conducted during 1946. The aim of the experiment had been to investigate the possibility of a reduction in dosage of some of the more promising treatments noted in earlier work. Plots receiving 0.5% Gammexane dust at variable rates indicated that both 100 pounds per acre and 200 pounds per acre gave controls that were significantly better than in the untreated check plots. Similar plots receiving variable concentrations of the Gammexane dust at the uniform rate of 200 pounds per acre showed a significant control of the maggot with applications of 0.5% and 0.25% dust. A spray containing 0.026% Gammexane was applied at dosages ranging from 18 to 290 gallons per acre. All treatments gave significantly better control than the check but it would appear from the data that an application of at least 75 gallons per acre would be needed to give a satisfactory degree of control. A number of miscellaneous treatments were also tested. Of these, a 50% DDT dust applied as a seed treatment pound for pound of seed was best and showed promise of being effective at a reduced dosage. It was even better than a 50% DDT dust applied three times at weekly intervals to the plants at the rate of 200 pounds per acre. Third in efficiency was the calomel treatment, consisting of pure calomel as a seed treatment at the rate of one pound of calomel to two pounds of seed followed by three applications of 4% calomel dust at weekly intervals, starting when the plants were about an inch high. Fourth was the old standard Bordeaux-oil emulsion. The fifth and final treatment, corrosive sublimate 1:1600 solution, was once again a failure and the degree of control secured was not significantly better than in the check.

Forest Insects: Mr. R. R. Lejeune, reporting in a general way on the work of the Dominion Forest Insect Laboratory, stated that the forest insect survey was to be expanded. Major problems of the laboratory continued to be the larch sawfly, the spruce budworm and the jack pine budworm. Mr. Lejeune then called upon various members of the staff to deal with their respective fields.

Mr. W. C. McGuffin, reporting on the forest insect survey, stated that, while 1100 collections had been received during 1946, it was hoped to increase this number to approximately 1500 during the coming year. During the past winter, both larvae and pupae had been overwintered variously in a root cellar, in a refrigerator and in cages in the ground. At the time of the meeting, insects from the root cellar and the refrigerator had been incubated and were beginning to emerge. Particularly good results, the best for several years, had been secured with pupae from the root cellar. It had been found that contact moisture was more important than humidity in the container in preserving the health of the stored insects. Even a single short period of desiccation could have a serious result on development. Insects in cages in the ground had not been inspected but would be brought into the laboratory in May.

Colour dimorphism in several species of larvae of the Geometridae was to be studied.

For the coming year, it was hoped to appoint one man to test sampling methods for the use of forest insect rangers with the object of securing uniformity in sampling. It was also intended to have the rangers set up permanent sample plots during the coming fall.

Mrs. W. S. Barker, also reporting on the forest insect survey, indicated her intention to investigate the life history and biology of two species of Olethreutidae, as well as several other species of Tortricidae and Pyralidae that would be studied if living material could be obtained for study.

Mr. B. Filuk reported on an investigation of the effect of biological agents in the natural control of the spruce budworm in the Spruce Woods Forest Reserve. Twenty-four trees were selected at the beginning of the season for examination. These showed an initial population averaging 18.1 larvae in the second instar per hundred terminals. Of these, an average of 4.1 per hundred terminals managed to pupate by the end of June, a population drop of 77%. Of the larvae collected during this study, some were sent to Winnipeg for rearing, while others were preserved for later examination. These latter proved to be parasitized in 45% of the dissections. Pupae also were collected and sent in for rearing. Of these, 43% were found to be parasitized. Predators and diseases were also observed and were found to account for 6.4% of the original population. The data secured, analyzed on the basis of original population, accounted almost exactly for the 77% population drop which had been found to exist in this area. Colonies of two species of spruce budworm parasites were released during the season. Egg counts were made in an effort to determine the overwintering mortality of the spruce budworm.

Later in the season, Mr. Filuk carried on larch sawfly investigations in Riding Mountain National Park. A considerable amount of information was gathered on defoliation of tamarack and cocoon counts were taken for a four-year study of a method of estimating sawfly populations.

During the fall of 1946, a total of 28,000 larch sawfly cocoons were collected in various parts of Manitoba and sent to laboratories at Belleville, Sault Ste. Marie and Winnipeg. At Winnipeg, dissections of larvae in the cocoons revealed no parasitism in cocoons collected north of the 53rd parallel. Parasitism by _Mesoleius aulicus_ was heavy in some areas; non-existent in others. However, the effectiveness of _Mesoleius_ in the control of larch sawfly was materially reduced by the fact that _Mesoleius_ eggs sometimes failed to hatch inside the body of the host sawfly larva.

A study was begun late in the season of the effect of water level in tamarack swamps on the survival of cocooned larvae hibernating in the ground cover beneath the trees. The purpose of the study was to provide information for the possible control of the larch sawfly during its hibernation period by manipulation of the water levels in marshy areas of the forest. A total of 4000 cocoons were collected and placed in screened frames containing moss packing. The frames, each containing 200 cocoons, were buried in a swamp in Riding Mountain National Park at various depths in relation to the water level. Samples of cocoons were removed monthly from each frame during the fall for examination. At the time of Mr. Filuk's report, no conclusions as to the effect of this treatment had been reached. It was intended to examine more cocoon samples after the spring thaw to determine the survival rate of the larch sawfly larvae in each frame.

THE SEPTEMBER MEETING

A meeting of the Society was held on September 24 at the Dominion Forest Insect Laboratory, Winnipeg. Sixteen members attended. The main topic of discussion was the proposed organization of an Entomological Society of Canada. A suggested Constitution, which had been drawn up by the Executive and the Manitoba members of the Committee on National Entomological Organization, formed the basis of discussion.

The work of the Committee for the listing of the insects of Manitoba was briefly reviewed; a number of the members reported progress in this project.

It was announced that the I.G.P.C.E. is to meet at Clear Lake, Manitoba in August of 1948 as the guests of the Society. Mr. R. R. Lejeune was appointed Secretary of the Conference.

An invitation for the Entomological Society of Manitoba to affiliate with the Entomological Society of Ontario was declined, at least until the outcome of efforts to organize a National Society is known.

The minutes of this meeting are included as Appendix II of these Proceedings.

THE NOVEMBER GENERAL MEETING

The fall general meeting was held at the University of Manitoba, Fort Garry on November 11, 1947.

The Business Session

Thirteen members attended the brief business session which opened the meeting.

The members expressed their sympathy for Mrs. G. S. Brooks in the loss of her husband, George Shirley Brooks, a member of this Society.

Mr. C.A.S. Smith reported that a brief (Appendix III) had been prepared by the Executive and submitted to the Honorable D. L. Campbell, Minister of Agriculture and Immigration, Province of Manitoba. The Honorable Mr. Campbell, however, was unable to give the Executive any assurance of financial assistance from Provincial Government funds.

Mr. Lejeune, who had attended the Annual Meeting of the Entomological Society of Ontario, reported on the meetings of the full Committee on National Entomological Organization. He stated that financial problems would probably delay the formation of a National Society for some time. Except for a promise of support from the province of Prince Edward Island, definite assurance of financial assistance was lacking from provincial or Dominion government sources. It had been decided that entomological societies should continue on the present basis for at least another year but that the Committee on National Organization should not cease to function. Dr. W. R. Thompson, Editor of the Canadian Entomologist, expressed his determination to expand and improve this publication. Mr. Lejeune also reported the favorable comments of several entomologists on the Proceedings of the Entomological Society of Manitoba.

The meeting then approved a motion that the Society should strongly support the formation of an Entomological Society of Canada in the near future, either with or without a national publication but with such a publication as its ultimate aim.

The minutes of this meeting are included as Appendix VI of these Proceedings.

The Scientific Session.

Following the business session, visitors and members heard a number of reviews of topics of interest to entomologists. A period of discussion followed the presentation of each paper. Dr. J. A. McLeod of the Department of Zoology, The University of Manitoba, spoke on "The Importance of Insects in Fish Production". He was followed by Dr. R. L. Post, Associate Entomologist of North Dakota Agricultural College, who discussed "Modern Methods of Storing and Preserving Insects".

During the noon intermission, members and their guests attended a luncheon at which Dr. W. F. Hanna, Officer-in-Charge of the Dominion Laboratory of Plant Pathology in Winnipeg, spoke on the topic "Entomology as Seen by a Plant Pathologist".

In the afternoon, Dr. R. W. Salt of the Dominion Entomological Laboratory at Lethbridge, Alberta, addressed the meeting. He spoke on "Some Recent Advances in the Study of Diapause in Insects". This address was followed by a short film in colour entitled "Insect Pests of Stored Foods". Dr. B. N. Smallman, Officer-in-Charge of the Stored Products Insect Laboratory at Winnipeg, gave the commentary which accompanied the showing of the film. The final paper was presented by Mrs. W. S. Barker of the Forest Insect Laboratory in Winnipeg, who discussed "The Species Concept".

Members expressed their appreciation of the reviews presented at the meeting. Texts of the papers are included in the following pages of these Proceedings.

THE IMPORTANCE OF INSECTS IN FISH PRODUCTION

J. A. McLeod

The role of insects in the diet of fishes is an important one but one that has not received the attention it deserves at any time even up to the present moment. Literature relevant to the subject is extremely scanty and scattered and any information along this line usually appears to have been relegated to a secondary position in texts or current periodicals. Why this has been so is difficult to say because one has only to look at the marked correlation between the abundance of certain species of insects and certain species of fish to realize that insects constitute an extremely important factor. Of all the factors which go to make up the environmental resistance of an animal species, food is one of the most important.

The subject in its entirety is a very large one and to conform to our limitations of time I propose to confine this discussion to a few aspects of it. Marine fishes, with the possible exception of a few which feed in in-shore waters, need not enter into the present discussion as they never come into contact with insects. However, fresh-water fishes of widely differing sizes, taxonomic groups, habits and habitats are dependent in whole or in part on insects for sustenance. With certain fish species, insects comprise the preferred food items in the absence of which they may survive with difficulty or not at all. With other species, they form alternate types to be utilized periodically, and with a third group they may be regarded simply as casual items of diet. However, in all species, excepting the strictly plankton feeders, they are very important links in the complex food chains between producer and final consumer.

Fishes, generally speaking, are notoriously omnivorous and, in either the microphagous or macrophagous species, it is generally assumed that the food organisms appear in the diet in roughly the same proportions as they occur in the environment. However, this is hardly true as some show a rather well-developed food-specificity. At any rate, in order that a fish be insectivorous, only a few basic requirements must be met.

(1) The fish must have a taste for insects and be hungry.

A few freshwater fishes undergo a seasonal fast each year which may last from a few days to weeks, e.g. lake trout, but the majority require several hours every day to satisfy their appetites. Contrary to popular belief, they mostly feed at night.

(2) The fish must have a mouth capable of ingesting the insects in question and an alimentary system capable of handling this type of food.

Some fishes appear to be casual feeders. These simply swim along, opening their mouths periodically and taking in anything that comes in the way. This group includes the strictly plankton feeders which are largely toothless and have small mouths, e.g. dark-back tulibee (Leucichthys artedi). Others, in addition to being plankton feeders, actively search out macroscopic food organisms in the water, at the water-air interface or at the water-soil interface. Such species, e.g. whitefish, goldeye, etc., have mouths of moderate size and may have weak teeth. A third group includes those voracious feeders such as the pike, pickerel, some trouts, etc., which have large mouths and powerful teeth and usually prey on other fishes, frogs, crayfishes, or even the young of aquatic birds and mammals. Surprisingly enough, many of these consume quantities of insects. Whether this is accidental or intentional is sometimes difficult to say.

(3) The fish must be able to detect the presence of the food organism.

In the first place, fishes are almost colour blind and the eye lens has a fixed focal length. By moving back and forth, a fish can bring images into sharp focus over a very narrow range. Thus, a fish sees clearly only when the object is a definite distance away from it. On the other hand, the retina of the eye is very sensitive to changes in light intensity and any flash in the water is quickly detected. Sight is a relatively unimportant sense as many species feed at night or in the benthonic portion of the habitat. Most fishes are extremely sensitive to vibrations in the surrounding water and the senses of smell, taste and touch appear to be well developed, even though the receptor organs are confined to certain restricted areas of the body (Reighard 1917, White 1919).

(4) The fishes and the insects must come together in the same habitat, at least briefly.

Different fishes differ equally as much in their physical and chemical requirements as they do in their food requirements. Some prefer shallow, fast-running water, others shallow, still water such as marshes and in-shore lake water, while others prefer the surface or even the benthonic regions of deep lakes. What complicates the picture is that the habitat-specificity of the fish may change with age or from season to season. For example, a fish species may occur in shallow, in-shore water during the winter, invade fast streams during the spring and then retire to the bottoms of deep lakes during the heat of the summer. Thus, it must find an adequate food supply in each place or undergo a temporary fast. This may account for the marked variations in the diets of many fishes. Insects, likewise, are widely distributed, pronouncedly specific as regards choice of habitat and also undergo wide migrations. At first glance, it might appear that the possibility of the proper species of fish and insects coming together would be very remote, but this is not the case.

In considering the availability of insects, one might also assume that only larvae, pupae, nymphs and adults of aquatic insects are important as items of diet of fishes. This is not true, particularly during seasons of open water, when large quantities of terrestrial insects are eaten. For example, Embody and Gordon 1924 found that grasshoppers comprised up to 11.2 per cent by volume of the diet of brook trout (Salvelinus fontinalis) in certain American streams. I have personally watched both whitefish and goldeyes taking a vast assortment of Lepidoptera, Hymenoptera, Diptera, Orthoptera, etc., from the surface of quiet water, particularly in the evening.

Insect inhabitants of rapids and flowing streams are made available by the currents to the coinhabitant fish and also to the fish of the lake into which the stream flows.

Thus, the problem resolves itself into a study of the ecology of insects and a study of the ecology of fishes.

Perhaps it will serve the present purpose best if I use local situations as examples and confine this talk to the most important body of water, the most important insect foods of fishes and the most important insectivorous fishes. This would narrow it down to a consideration of Lake Winnipeg, representatives of four orders of insects and two species of fish, namely, the whitefish *Coregonus clupeaformis* and the sturgeon *Acipenser fulvescens*. The whitefish has been exceeded in commercial importance only in recent years by the pickerel *Stizostedion vitreum*. Even so, the whitefish catch for Lake Winnipeg alone runs around five million pounds annually. However, production varies considerably from year to year, largely, it appears, because of variations in food supply of which insects form an important part.

During the first year or two of its life, the whitefish is microphagous and feeds on plankton in in-shore waters or near the surface of the open lake. After this period, until it reaches commercial size at six to seven years or until the end of its life, it becomes largely macrophagous. It may feed at the surface or in open water to some extent, but it is primarily a bottom feeder.

Lake Winnipeg has an area of 9,300 square miles but a maximum depth of only 66 feet. However, it holds a fair depth over much of its area. 85 per cent of the bottom is of fine silty mud which is highly productive (Bajkov, 1930).

Here is found a widely varied bottom fauna, which includes the following in order of their importance as fish foods (Neave, 1934):

1. *Amphipoda*
   Pontoporeia sp.

2. *Insects*
   Hexagenia limbata nymphs)
   Hexagenia rigida nymphs) EPHEMEROPTERA
   Ephemera simulans nymphs)
   Blasturus cuspidus nymphs)

   Chironomidae larvae & pupae DIPTERA

   Phryganea cinerea larvae) TRICHOPTERA
   Molanna flavicornis larvae)

   Pteronarcys dorsata nymphs) PLECOPTERA
   Isoperla bilineata nymphs)

3. *Mysidacea*
   Mysis relicta

4. *Branchiopoda*
   Estheria sp.

5. *Mollusca*
   Musculium sp.
   Sphaerium sp.
   Valvata sp.
   Amnicola sp.

Next to Pontoporeia, the two species of Hexagenia are of major importance in the whitefish diet according to the data gathered from the examination of several hundred stomachs. This is due to three main factors:

1. They are extremely abundant and widely distributed.
2. They are always present and easily captured.
3. They are large and nutritious.

Hexagenia limbata and Hexagenia rigida nymphs occur in the ratio of about 7 to 1 over the lake bottom from close to shore to a depth of 55 feet but, while the distributions of the two overlap a good deal, the centers of population are not the same. However, they occur in the phenomenal numbers of up to 150,000,000 per square mile.

Both species have a life span of two years, which is most important from the point of view of available fish food since, even though the crop of the current year suddenly emerges, there is still a crop of yearlings present (Neave 1932, Needham 1901). Thus the fish are not obliged to find an alternate food type or starve until a new crop of nymphs is produced.

Each female produces on the average about 3,500 eggs. These are extruded in two compact masses which disintegrate in the water so that the eggs have a chance to become distributed by currents, etc., as they sink to the bottom. Under experimental conditions simulating natural ones, the eggs are found to hatch in 17 to 19 days but, in colder regions, they may require up to 36 days (Clemens 1915). Neave was able to bring about artificial insemination of eggs in small dishes and got a hatch of about 50 per cent.

It is not definitely known how many ecdyses a nymph may undergo but, at the age of one year, it has a length, on the average, of 14 mm., although females are larger than males. At two years, the average length of a full-grown nymph is 22 mm.

The first winged subimagines appear from June 20 to July 1 but the height of the emergence is not reached until July 12 or 15 and is over in 48 hours. The greatest numbers of winged forms do not occur simultaneously at all points on the lake but may vary a few days irrespective of latitude.

The fully grown nymphs migrate in-shore and rise to the surface where their skins split on the dorsal side and the subimagines take to the air. They are weak fliers, but most of them emerge during the early morning when, usually, it is calm or any air currents are on-shore. These conditions assist them in reaching the marginal scrub. The breeze also frequently piles the cast skins in drifts along the shore.

The subimagines attach themselves to bushes, buildings, etc. During the second day, they undergo a final moult to become sexually mature imagines. Toward evening of that day, they become restless and begin to move about and, by nine in the evening, all have taken to the air, usually millions strong, to execute a mating dance. The swarm, under favorable weather conditions, will form directly over the first fringe of vegetation beyond the open shore (usually 50 to 100 yards) and will form as a narrow, vertical curtain of great height and hundreds of yards, even to miles, in length.

As mating occurs, the females, assisted by the off-shore breeze which commonly occurs at this time, move toward the water, losing altitude all the while and finally depositing the egg masses on the surface. Death follows almost immediately but the adult bodies are relatively unimportant as fish foods. It is important to note that the adult alimentary system is degenerate and unable to take in food but it is useful as an aerostatic organ during the mating flight.

Weather conditions are important at the time of emergence, mating and egg laying. So much depends on these two days that a sudden storm at this critical time can appreciably reduce the future crop of Hexagenia nymphs.

The last stage nymph of Blasturus cuspidus has a slightly different behaviour pattern. It migrates up small inflowing temporary or permanent streams just about breakup in the spring usually to emerge from ponds or sloughs at a later date, normally before drying up occurs. The maximum distance migrated is one mile and the rate about 200 yards per day even in strong currents (Neave 1930).

The two species of Hexagenia comprise a food supply which is both abundant and widely distributed in Lake Winnipeg and is present at all seasons. They are utilized by a wide range of fishes but principally by the whitefish and the sturgeon. The maximum number taken from one whitefish stomach is around 100 specimens but as high as 2,100 have been taken from a single sturgeon stomach at one time.

There appears to be a strong correlation between a particular type of silty bottom and *Hexagenia* nymph distribution and abundance and, again, between *Hexagenia* nymphs and whitefish and sturgeon. This connection is so pronounced that on field surveys when we find one we habitually look for the others and, strangely enough, in the majority of cases we find them.

A wide range of chironomid larvae and pupae rank next to the Ephemeroptera as valuable insect fish foods in Manitoba and particularly in Lake Winnipeg. Some of the larvae are case builders, while others are naked. Some vary in color from brown to gray, but others are bright red and comprise the so-called blood worms. All species of importance as fish foods are bottom dwellers, living in the accumulated debris and mud.

Unfortunately for the fishing industry in Manitoba, the bottoms of the more recent lakes of the Pre-Cambrian region are almost barren. Here one finds a bottom layer of very flocculent, grayish-green muck of organic origin, from a few inches to several feet in thickness. Disintegration is slow and it produces a low oxygen concentration and a high acidity in the surrounding water. It is very unproductive of other organisms but, surprisingly enough, one can almost invariably find at least a few robust chironomid larvae.

In the fauna of Lake Winnipeg, many species of chironomids are present and the majority have larvae of sufficient size during the second half-year of their lives to form valuable fish foods. In fact, the stomach contents of some whitefish are found to comprise up to 200 chironomid larvae and nothing else.

The chironomids have a life span of one year only and consequently are less reliable as fish food than are the *Hexagenia* because the former are absent or of small size during about six months of each year.

Like the Ephemeroptera, the adults of a species emerge suddenly and almost simultaneously over a wide area but the adults are not as short-lived. Emergence of some species occurs just after breakup in the spring. Others emerge later so that fresh batches appear periodically until well on into the summer.

The adults are moderately weak fliers and usually retire to the shelter of vegetation, etc., near the water in windy weather. They are of little value as fish food. Many of the species execute a mating dance in the late afternoon or evening involving many millions of individuals. The dancing mass frequently assumes the shape of an inverted cone which forms up with its tip directly over an object such as a post or stone within a quarter mile of the lake shore. Within a short time of mating, oviposition takes place on the water surface and a new generation has its beginning.

One usually and quite naturally associates Trichoptera with well-aerated waters such as occur in in-shore regions or in moderate streams. This is the case in the mountains of the West and in the rocky lakes of Manitoba. Here they form an important item of diet of trout, bass, pickerel and, to some extent, pike. In some of the Pre-Cambrian lakes of Manitoba, I have seen great numbers of the larvae on submerged boulders and logs just below the surface even where wave action was pronounced. Passably good pickerel specimens, which were taken from the same lake, appeared to be subsisting entirely on these larvae at the time.

While it may seem unusual, two species of Trichoptera, namely _Phryganea cinerea_ and _Molanna flavicornis_, occur as larvae at depth as well as in the shallows in Lake Winnipeg and are widely utilized by fishes, particularly whitefish (Neave 1933).

The adults of _Phryganea cinerea_ are on the wing from the middle of June to August and have been seen to emerge from pupal skins at the surface of the water, sometimes several miles from land. It is probable that the eggs are laid on the surface of the water and not, as in some other species, on land at the water's edge. A single female produces a small batch of eggs numbering from 350 to 380. The normal length of the life-cycle appears to be one year, as few cases containing larvae can be found after the beginning of July.

The composition of the larval case in this species is interesting but variable. Near shore, it usually consists of bits of wood arranged in a spiral manner but farther out, where this material is not available, it may include a miscellaneous assortment of chitinous bits of Crustacea and insects, fish scales and fragments of mollusc shells or even the shells of small living molluscs.

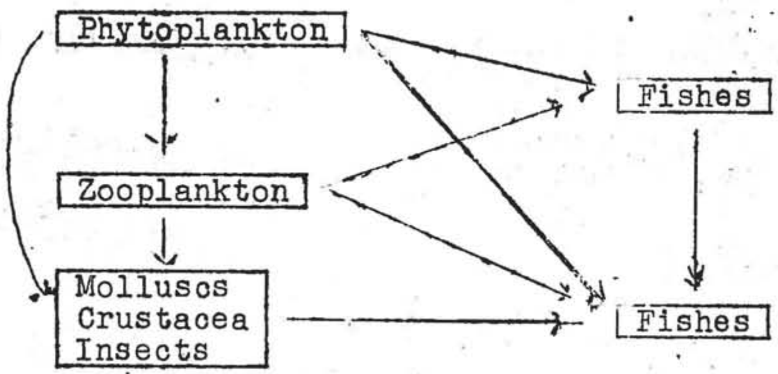
Molanna flavicornis is a somewhat smaller, less abundant species of slightly different habits and distribution. The larvae prefer sandy bottom but can exist on mud or clay bottom in Lake Winnipeg, providing there is a small admixture of coarser material from which to construct their cases. In this area, the case is almost exclusively of sand with rare examples of mollusc shells. Larvae of the species are consumed in vast numbers by the sturgeon (with whose distribution it largely coincides) but also by the whitefish to some extent.

Plecoptera, of course, are not found in the open waters of Lake Winnipeg but several species occur in abundance either along the shores or in the tributary rivers not far removed from the lake. In either case, they can be reached by fishes or some are carried by currents to within reach of the fish. Of these, Pteronarcys dorsata and Isoperla bilineata are perhaps the most important. In rapids on trout streams, members of this order assume a position of major importance.

The nutritive value of insects is another important consideration in a study of the diet of fishes. Most insectivorous fishes have either very powerful digestive juices or, as in whitefish and sturgeon, a grinding mechanism in the form of a gizzard; some may have both powerful juices and a gizzard. These enable the animals to utilize all the energy-yielding tissues of the insect excepting the heavily scleritized or chitinized parts which do not comprise more than 10 per cent at most. Many fish digestive systems can handle the larval cases of Trichoptera which they must do in order to get the larvae, even though the cases yield little or no nutritive material. Thus we see that many fishes have highly efficient digestive systems for both the handling and the recovery of insect food material.

Little or nothing is known at the moment, so far as I am aware, of the vitamin content of insect tissues but extensive analyses to determine their relative food values for rearing fish artificially or under natural conditions have been carried out and the results are quite favorable. One thing we have learned from practical experience is that fish thrive better on insects and other natural foods pound for pound, than they do on, for example, ground beef liver and heart.

Insects are links in the food chains of fishes. Considering the lake or stream as a biome to the exclusion of outside sources of food, the primary producers are, of course, the plants and, particularly in open water, the phytoplankton. Very few fish of any value are able to utilize these organisms directly but must depend on intermediate forage types. The copepods, cladocera, etc., making up the zooplankton, live on the microscopic plants and convert a considerable amount of them into animal material. A few fishes consume plankton of both types but the bulk are macrophagous. Bottom dwelling molluscs, larger crustacea and, particularly, insect larvae and nymphs are the largest consumers of this material. It is thus converted into a form that is available to fishes.



REFERENCES

1. Bajkov, A., 1930. Biological conditions in Manitoba lakes. Contr. Can. Biol. and Fisheries 5:163-204.

2. Clemens, W. A., 1915. Rearing experiments and ecology of Georgian Bay Ephemeridae. Contr. Can. Biology 1911-1914; 112-128.

3. Embody, G. C, and M. Gordon, 1924. A comparative study of natural and artificial foods of brook trout. Proc. Amer. Fisheries Soc., 54th Annual Meeting; 1-16.

4. Forbes, S. A., 1888. On the food relations of fresh-water fishes. Ill. State Lab. of Nat. History, Aet. VIII; 475-538.

5. Hart, J. L., 1931. The food of the whitefish, Coregonus clupeaformis (Mitchill) in Ontario waters, with a note on the parasites. Contr. Can. Biol. and Fisheries, 6; 447-454.

6. Hart, J. L., 1930. The spawning and early life history of the whitefish, Coregonus clupeaformis (Mitchill) in the Bay of Quinte, Ontario. Ibid 6; 167-214.

7. Neave, F., 1930. Migratory habits of the mayfly, Blasturus cuspidatus Say. Ecology 11; 568-576.

8. Neave, F., 1932. A study of the mayflies (Hexagenia) of Lake Winnipeg. Contr. Can. Biol. and Fisheries 7; 179-201.

9. Neave, F., 1933. Ecology of the two species of Trichoptera in Lake Winnipeg. Internat. Revue 29; 17-28.

10. Neave, F., 1934. A contribution to the aquatic insect fauna of Lake Winnipeg. Internat. Rev. der Gesamten Hydrobiologie und Hydrographie 31; 157-170.

11. Needham, J. G., 1901. Aquatic insects of the Adirondacks. Ephemeridae. Bull. N.Y. State Museum 47; 418-429.

12. Needham, J. G. and R. O. Christensen, 1927. Economic insects of some streams of northern Utah. Utah Agric. Exp. Stn., Bull. 201; 1-36.

13. Ricker, W. E., 1930. Feeding habits of speckled trout in Ontario waters. Trans. Amer. Fisheries Society 60; 1-9.

14. Reighard, J., 1917. The senses and learning in fishes. Trans. Amer. Fisheries Society 46; 133-170.

15. Turner, C. L. and W. C. Kraatz, 1920. Food of young large-mouth black bass in some Ontario waters. Proc. Amer. Fisheries Society, 1920; 372-380.

16. White, G. M., 1919. Associations and color discrimination in mud minnows and sticklebacks. Jour. Exp. Zoology 27; 443-498.

MODERN METHODS OF STORING AND PRESERVING INSECTS

R. L. Post, Ph.D.

Editor's Note: The text of Dr. Post's excellent talk is unfortunately not available. The following is a brief report on his topic.

Dr. Post described the methods which he employs at the North Dakota Agricultural College in the preservation and storage of insect specimens. He brought with him from Fargo a large and interesting display of entomological equipment, including a drawer from a storage cabinet for insects. This was equipped with pinning trays and section labels to illustrate a method of filing pinned specimens. A convenient system of labelling and indexing collections of slides was explained. This system was particularly applicable to storage of material for student examination. Dr. Post also demonstrated the use of a small prism system for making drawings of microscopic objects.

A sample mount of particular interest to entomologists engaged in extension work illustrated stages in the life history of a beetle of economic importance. Specimens were secured with glue in transparent-topped display boxes. These were fastened in place on posters which pictured the insect and its damage in colour. Larvae for use in display mounts were also shown. These had been dehydrated by an alcohol-xylol method and the specimens then painted with oil colours in a life-like manner. Mounts of small insects on transparent cellulose acetate were viewed. Secured on pins, these mounts could be stored conveniently in the regular collection of pinned specimens.

It is Dr. Post's intention to publish a manual of entomological technique in the near future to be entitled, "How to Collect, Mount, Store and Display Insects". Complete information about the equipment and specimens mentioned above as well as the many other items displayed will be contained in this publication.

ENTOMOLOGY AS SEEN BY A PLANT PATHOLOGIST

W. F. Hanna

It is evident from the number in attendance at this meeting and from the variety of topics under discussion at your scientific session today that here in Manitoba a very keen interest is being taken in the study of entomology. Further evidence of this interest is to be found in the fact that you have such an active provincial organization, the Entomological Society of Manitoba. Considering the number of entomologists in Canada and the variety and importance of your problems, there is every reason to believe that you will soon succeed in forming an organization that is national in scope. I believe this question is already under active discussion.

When your Secretary asked me to address you today I explained that I was not qualified to discuss the scientific aspects of entomology. And yet my approach to your branch of science is not entirely that of a layman. So it was agreed that it might be of some interest to you if I were to discuss entomology from the point of view of a worker in a related field of biology -- plant pathology. During the past month I have had the opportunity of visiting the Dominion Entomological Laboratories in the Prairie Provinces, and it was apparent to me that the entomologist and the plant pathologist are called upon to investigate very similar phenomena.

Up until a hundred years or so ago, the field of biology was regarded as an entity. Specialization in particular branches was uncalled for because it was possible for an individual to become reasonably familiar with the sum total of biological knowledge. This enabled the investigator to preserve a broad point of view and to limit his findings to the fundamental processes affecting all organisms, both plant and animal. As knowledge accumulated, specialization became inevitable and one unfortunate result of this has been that specialists in different branches of biology have become more or less isolated from one another. And yet many of the problems we are required to investigate are so complex that they cannot be solved by the specialist single-handed. Since we cannot abandon specialization, the obvious way out of our difficulty seems to lie in closer association and co-operation between workers in related fields. With this thought in mind, it may be profitable to recall some of the problems in which the entomologist and the plant pathologist share a common interest. I think you will find that there are many of them.

Both entomology and plant pathology began as hobbies -- the collecting and classification of insects and fungi. Plant pathology, a relative newcomer among the branches of applied science, grew out of mycology and, in Britain today, the study of plant diseases is usually referred to as applied mycology rather than as plant pathology. Apparently the early mycologists were not held in very high regard for Fries, the great nineteenth century mycologist, stated that "mycology is one of those despised and neglected studies which bring to their pursuers neither money nor glory". Entomology was probably regarded in much the same light. But today entomology and plant pathology are called upon to deal with economic problems, many of them of national importance. This change in emphasis has occurred in many branches of science. It may perhaps be illustrated by the story of Michael Faraday who, when he was asked by the Prime Minister--"Of what use are induced currents?", replied--"Of what use is a new-born babe?" To this question the Prime Minister is supposed to have answered--"Soon you will be able to tax it". Certainly the findings of entomology and plant pathology have already added greatly to our national wealth.

Taxonomy provides a starting point for much of our work in entomology and plant pathology and the contribution of the taxonomist, whether he be an amateur collector or professional worker, cannot be over-estimated. So it may be of interest to consider for a moment the number of species with which our branches of science are concerned. It seems that the number of insect species greatly outnumbers that of the fungi. It has been stated that some 640,000 species of insects have been described. There are 20,000 known species of insects in the British Isles. It has been estimated that there are over a million species of insects in the world. In other words, insects make up about half of the world's species of living organisms. As regards the fungi, about 200,000 species have been described but many of them are not good species. Something like 40,000 has been suggested as the probable number of species of fungi in the world. But estimates of this kind should not be accepted without question for they are sometimes wide of the mark. Even the great Linnaeus, who described some 6,000 species of plants, 89 of them fungi, must have had a very incomplete conception of the richness of the world's flora for in his Species Plantarum he stated that "I have ascertained by a sufficiently trustworthy calculation that the number of plants in the whole world is far fewer than is commonly supposed, inasmuch as it scarcely contains 10,000." Up to the present some 225,000 species of Phanerogamia alone have been described.

Here in Western Canada, it has been stated that there are probably anywhere from 10,000 to 100,000 species of insects. The vagueness of this estimate suggests that a great deal of systematic work still remains to be done here. Our knowledge of the fungi of Western Canada is far from complete, but we are fortunate in having Professor G. R. Bisby's book <u>The Fungi of Manitoba and Saskatchewan</u>, a very valuable list of the more common species. His list comprises a total of 2,761 species of fungi and bacteria. Of this number 2,638 were found in Manitoba. He estimated the probable total number of species of fungi and bacteria in Manitoba at about 5,000. To the north of us lies a vast territory which, in a biological sense, is practically unexplored. It presents a challenge to Canadian entomologists and botanists.

I have referred to the number of species of insects and fungi with which entomologists and plant pathologists are concerned. What of the actual number of organisms? Here we must deal in astronomical figures. Insects, like fungi, are subject to rapid and extreme variation in number from season to season and this frequently results in epidemic plant diseases and serious insect outbreaks. Here in Western Canada everyone is familiar with the tremendous numbers of rust spores that settle on our grain crops, and with the recurring damage from grasshoppers. It has been estimated that there are some 10^{18} insects in the world. There may be as many as 100,000,000 in and on a single acre of land. Wireworm infestation may reach as high as 10,000,000 to the acre. The numbers of one species of insect may vary as much as 1,000 per cent in a single year. The plant pathologist is concerned with fewer species than the entomologist but he must deal with greater numbers of organisms. In a single gram of Manitoba soil, there may be anywhere from 20,000 to 350,000 spores or bits of fungus mycelium; on a summer's day as many as 100,000 stem rust spores may settle on an area of one square inch in the "rust area" of Manitoba.

The distribution of insects in Nature presents problems very similar to those involved in the distribution of fungi. Some insects are known to travel distances up to 1,000 miles; some are carried far out to sea, or up to altitudes of 14,000 ft. or so. These records have been beaten by the fungi. Rust spores have been found at 14,000 ft., and I believe spores of other fungi have been found at altitudes of 35,000 to 40,000 ft. These observations are of the greatest practical interest to the entomologist and plant pathologist because they throw light on the movement of destructive insects and fungi from one country to another. With the recent introduction of rapid long-distance air transport, there have come increased opportunities for the wide dissemination of pathogenic fungi and insects that may become serious pests or which harbour disease-producing organisms.

You are concerned with a number of insects that are useful to man, such as the honey bee and the silkworm. These and many others are the bases of important industries. The plant pathologist and the mycologist are called upon to study the yeasts which help to make our bread and beer, the mushrooms and other important edible fungi and, more recently, fungi such as Penicillium which produce antibiotics that are used in medicine.

Destructive species are the principal concern of both the entomologist and the plant pathologist. Here in Western Canada there are destructive insect pests such as the wheat stem sawfly, grasshoppers, cutworms, spruce budworm, and species occurring in stored products. Among the destructive fungi, there are the rusts, smuts, root rotting species, and many others which are of tremendous economic importance.

Then there is the question of epidemics, involving rapid increases in populations of fungi and insects. This is one of the most important problems with which we have to deal. Before the introduction of rust resistant varieties, wheat stem rust destroyed an average of 40,000,000 bushels of wheat annually in Western Canada. In epidemic years, the loss reached as high as 100,000,000 bushels. Fungi and insects have on many occasions been responsible for far-reaching economic and social changes. It was the coffee rust, for instance, that ruined the coffee industry in Ceylon about 1868 and led to the planting of tea in that country. Late blight of potatoes, another fungus disease, destroyed the Irish potato crop about 1845, caused widespread famine, and brought about the repeal of the "Corn Laws". It was about this disease that Disraeli wrote, "The mysterious but universal sickness of a single root changed the history of the world." Outbreaks of insects have also been attended by disastrous results. Here in Western Canada it was insects, not fungi, that were responsible for the first serious damage to crops -- an outbreak of locusts which infested the crops of the Red River Settlers and resulted in famine.

The associations between insects, fungi, and other organisms are many and varied. Many insects and fungi are parasitic on man and animals; some insect species parasitize others; fungi may attack insects and cause a high mortality among them; they may also attack other fungi. In some instances, a symbiotic relationship exists between insects and fungi. Many diseases, both plant and animal, are transmitted by insects. Most of us have heard of the Dutch elm disease which is present in the province of Quebec and in the eastern States. This disease is caused by a fungus which is disseminated by insects. Many of the virus diseases of plants are, of course, transmitted by insects. One stage in the life cycle of wheat stem rust involves the intervention of insects, for they are an important agency in transferring nectar and pycniospores from one aecial pustule to another on the barberry, and thereby facilitating the production of new physiologic races of stem rust.

One of the most fruitful fields of research in plant pathology has been that of physiologic specialization. In stem rust of wheat, for instance, some 200 different physiologic races have been identified. These races are alike morphologically but they have strikingly different parasitic capabilities. Unless a variety of wheat possess resistance to all of the races of stem rust that are present in the region where it is grown, it may become severely infected. This same phenomenon of physiologic specialization has been found in other fungi. Indeed, it is the rule rather than the exception in fungi. I believe a comparable condition has been found among insects, and its study is likely to demand greater attention from entomologists who are concerned with questions of biological control or plant resistance.

Another field of research that has contributed to the solution of plant pathological problems is the genetic relationships of fungi. Once it has been established that there are physiologic races of certain fungi, it is important to know if different races will hybridize and produce new races. A very considerable amount of work has been done in this field. The same sort of problems must arise frequently in entomology and their investigation will present opportunities for interesting fundamental work which will contribute towards the solution of important economic problems.

What I have said thus far seems to point to the conclusion that workers in different branches of science will be called upon more and more to co-operate in the investigation of complex problems, because in so many fields their interests merge. As an instance of the type of problem that will require co-operative effort, one might mention the breeding of wheat varieties possessing resistance to sawfly. Already splendid progress in this direction has been made, mainly as a result of the co-operative research of plant breeders and entomologists. But experience thus far indicates that a variety of wheat may be quite resistant in one locality and much less resistant in another. Likewise, it has been found that the sex-ratio of the insect may be influenced by the wheat variety on which it is reared and also by the locality. Obviously there are here a number of problems relating to both insect and host plant that require further investigation. A somewhat parallel situation existed in respect of breeding for resistance to stem rust of wheat before it had been established that there were a great many physiologic races of rust. At that time, the resistance of a variety of wheat was subject to fluctuation from place to place and from season to season, depending upon the races of rust that were present. I am not suggesting that the parallel between wheat stem rust and the wheat stem sawfly is in any sense complete and that the possible existence of races of the insect will explain the varying degrees of resistance that have been observed under different conditions. But the principle is much the same. The practical problem of breeding wheats for resistance to sawfly will require a fundamental study of the genetics and physiology of the insect, as well as of the morphology, physiology, and probably also the biochemistry of the wheat plant. In other words, it is a task calling for teamwork and co-operation between plant breeders, entomologists, geneticists, plant physiologists, plant pathologists, and biochemists. A problem of this kind cannot be solved by specialists working independently of one another. It would be unfortunate if, in undertaking these difficult and complex problems, we were to overlook the very important matter of co-operation. We might then find ourselves in the position of the Australians when they inaugurated their trans-continental railway service -- the first train was made up, distinguished persons were present to celebrate the occasion, the signal was given, and the engine moved off, but the coaches remained standing because some one had forgotten to couple the coaches to the engine. Individual work is important, but there are certain large problems that must be tackled co-operatively. That will require more laboratories and better equipped laboratories, and also more workers.

SOME RECENT ADVANCES IN THE STUDY OF DIAPAUSE IN INSECTS

R. W. Salt

This paper is not intended to be a complete review of the subject of diapause. It is rather a discussion of certain aspects of the field and particularly of some recent advances that have been made in the past year or two, which have done more, in my opinion, to clarify this complex subject than anything heretofore published. For this reason I am going to omit most of the miscellany which comprises most of our knowledge of diapause, and concentrate on the more fundamental aspects of the problem. First, however, let us consider a few introductory matters.

Insects are poikilothermic or cold-blooded animals, and as such their body temperature depends largely on that of their surroundings or on radiant energy. Their metabolic activity is roughly proportional to temperature within the range usually encountered in nature, which means that temperature plays a very important role in the life of any insect. If this were strictly true, however, insects would not be long on this earth. For insect body temperatures are influenced predominantly by the weather and this is a most uncertain factor. Consider what would happen if insects were inflexibly influenced by temperature. A mild fall would allow development beyond the stage where the species normally has protection against winter cold; or it develops to a stage in which it needs plant food, long since ripened or frozen by an early frost. Even if the winter were passed successfully, a warm sunny day in early spring might result in activity long before food is available.

Fortunately for most insects the phenomenon of diapause acts as a regulatory factor to protect against irregularities in the weather. While temperature fluctuations are the most common and obvious, diapause also protects certain species against drought, excessive moisture, unavailability of host plants or host insects, etc. In a temperate climate such as ours diapause offers a protection which few insect species can afford to be without. Naturally enough in our climate the occurrence of diapause usually serves to carry the species through the winter, and this has given rise to the erroneous belief that many overwintering forms must be frozen before they can resume development in the spring. Most of you will recall statements made in the literature or by your teachers that, for example, grasshopper eggs will not hatch until they have been frozen. This belief has by now, I hope, been relegated to oblivion, but nevertheless let us consider the evidence on which it was based.

Eggs of Camnula pellucida collected in the late summer or fall and kept at room temperatures fail to hatch, whereas eggs exposed to normal winter conditions hatch readily when warmed up in the late winter or spring. It was logical to assume that low winter temperatures had something to do with the situation but unfortunately some of the earlier investigators were carried too far by their imaginations and the power of logic. They assumed that because the temperatures involved were low enough to freeze water they were low enough to freeze grasshopper eggs. This is not the case, actually, for grasshopper eggs undercool far below 0°C. (to approximately -20°C.) and are seldom frozen under natural conditions. Moreover, freezing is invariably fatal. The low fall and winter temperatures do indeed terminate diapause but not by freezing.

The role of low temperatures in terminating diapause has given rise to another assumption, not always borne out by the facts, that the process has a negative temperature coefficient. Because in many cases diapause is broken at low temperatures and not at higher ones does not necessarily mean that the temperature coefficient is negative. In such cases the higher temperatures may lie entirely outside the effective range. Within the effective range the coefficient may be positive, negative or both. Cephus cinctus is an example of an insect which appears to have a positive coefficient throughout the entire range of effectiveness -- from the undercooling point to 10°C. (Salt 1947). Andrewartha (1943), working with eggs of the Australian grasshopper Austriocetes cruciata, found that the western race of this species came out of diapause better at 13.3°C. than at either 10°C. or 6.5°C., while the southern race did better at 10°C. than at either 13.3°C. or 6.5°C. Hodson and Weinman (1945), working with eggs of the forest tent caterpillar, Malacosoma disstria Hbn., found that a temperature of about 2°C. was most effective in breaking diapause. Their data show that the effect was only slightly lessened at 5°, 10° and 15°C., and much more so at -5°C. In this species, then, there seems to be an optimum temperature for diapause elimination, above and below which are less effective temperatures, and indicating negative and positive temperature coefficients, respectively. In searching the literature for data on this topic, however, I found no deliberate attempts to determine the optimum temperature with precision. Rather two or three or four convenient low temperatures were used and the results compared. I suspect that these fell by chance where the coefficient was positive, or where it was negative, or where it was both, on each side of an optimum. I feel also that it is probable that more thorough work would in all cases reveal the type of situation where an optimum temperature of diapause-elimination exists. Furthermore, the location of this optimum temperature, considered in the light of data on moderately-low temperature metabolism, should be of great importance to the study of diapause.

Many workers have naturally compared the activity of diapausing and non-diapausing individuals of the same stage and species. During diapause the metabolism of the insect is usually at a low level and in many cases muscular activity ceases. The usual method of comparison has been to take measurements of oxygen consumption as an indicator of metabolism. Bodine (1929, 1932), working with eggs of the grasshopper <u>Melanoplus differentialis</u>, found that the oxygen consumption per egg increased steadily from the time the egg was laid until it was ready for katatrepsis or revolution. At this time, the embryo entered diapause and the oxygen consumption fell abruptly to a constant low level. After the termination of diapause it once more rose rapidly, up to the time of hatching. Further work by Bodine (1934) showed that the egg's respiration during diapause was insensitive to sub-lethal concentrations of cyanide. In non-diapause eggs treatment with cyanide solutions caused a drop in respiration to the diapause level. In short, metabolism was of two types, cyanide-sensitive and cyanide-insensitive. During active development both types operated; during diapause only the cyanide-insensitive fraction remained in operation. The significance of this will become more apparent later, when we consider some of the recent findings of Williams (1946, 1947a, 1947b). Meanwhile, let us consider Bodine's work more closely. His figures on oxygen consumption were based on the egg as a unit, regardless of the size of the embryo in it. It is only to be expected that as the embryo increases in size it uses more oxygen. If so, and we make the appropriate corrections for size, we are left with two respiratory, metabolic or energy levels -- a low diapause level and a higher developmental level. The former may be thought of as representing a truly basal metabolism, in which the animal is kept alive but is denied the use of energy for cellular division and growth, muscular activity, or any active process. These activities require considerable energy and go on only at the higher metabolic rate.

This seems to be the picture in embryos of Melanoplus differentialis. It is likely that a similar situation exists in many other species of insects, in which the state of diapause is one of quiescent, low-energy-level existence. It is not typical, however, of all diapausing insects. Two exceptions will be familiar to you -- larvae of Loxostege sticticalis and larvae of Cephus cinctus. Using the latter as an example, we have an obligatory diapause in the fully-grown larva. When the developing larva has finished feeding it empties its alimentary tract and after secreting a cocoon-like lining in its "stub", it is prepared for the winter. Because development to the succeeding stage, the prepupa, does not occur until a sufficient conditioning period at low temperatures intervenes, the larva is considered to be in diapause. Its diapause, however, is superficially at least a very different matter compared to that of Melanoplus differentialis, for it remains muscularly active. Cell division is probably lacking during this period; certainly there are no gross indications of growth or morphological change. So we have in this species a diapause condition in which there is muscular activity but otherwise cellular inactivity. The muscular activity is very probably cyanide-sensitive, although this has not been experimentally determined. At any rate, the metabolic rate in the diapause of this and similar species should not be at the low level found in Melanoplus differentialis, nor yet at a high developmental level, but rather in between the two. I have made some oxygen consumption measurements on diapausing Cephus cinctus larvae and they reflect the situation rather well. At first the data were very confusing, but then it was realized that muscular activity was obscuring the picture. The wriggling of diapause larvae is sporadic, so that the amount of oxygen consumed in a respirometer at 27°C. becomes merely an index of the frequency or amount of movement. In order to make comparisons unobscured by movement it is proposed to use temperatures below the threshold of muscular activity, but this work has not yet been carried out.

If one were to review what is known about diapause in the wide variety of insects in which it occurs, I think that two generalizations would become apparent -- first, that diapause in all species appears to be the same basic phenomenon, and second, that its production, duration and elimination are influenced by a wide variety of environmental factors. Most workers in this field, including myself, have studied the effect of this or that factor on diapause, hoping that a large number of such observations will reveal the true nature of the basic phenomenon. So far they have not. In all fairness, however, it should be pointed out that this type of observation has produced much of immediate value to the practical entomologist. As with most scientific research, nevertheless, the long-term view is best served by including a goodly proportion of more fundamental experimentation. This has been done recently, in the subject at hand, by Dr. C. M. Williams of the Biological Laboratories at Harvard University, who has applied novel methods to the problem and has already gone a long way towards its solution. His first paper is still less than a year and a half old, and two further papers are in press at the present time (November 1947). Dr. Williams has kindly granted me permission to review the two unpublished papers and to include a brief account of their contents here. So most of the following will be new to you and will certainly be of interest.

Williams used Saturniid pupae, principally Platysamia cecropia, which have a pupal diapause. This can be broken by chilling the pupae for 1½ months longer at a low temperature. Two types of pupae were therefore available -- chilled, or post-diapause pupae, and unchilled or diapause pupae. Under carbon dioxide anaesthetic chilled and unchilled pupae were grafted together so that they shared the same blood. Diapause was ended in both pupae and they emerged in normal time. Grafted pairs of unchilled pupae, on the other hand, persisted in diapause. This settled the problem of whether diapause resulted from the presence of a development-inhibiting factor or the absence of a development-producing factor. To quote, "If diapause results from the presence of some factor inhibiting development, then such parabiotic combinations should fail to develop by virtue of the diapausing pupa distributing this factor to the chilled individual. To the contrary, if diapause results from the absence of some necessary growth factor, both animals should develop, provided the chilled individual can supply double the minimal amount needed by a single animal." (Williams 1946). The results clearly showed that diapause resulted from the absence of a necessary growth factor. It is interesting to note at this time that the action was not species-specific or even genus-specific, for it was possible to break diapause of *Platysamia cecropia* pupae by joining them to chilled pupae of *Telea polyphemus*. In addition, the sex of the individuals was without significance.

Williams then reasoned that in all probability one organ or tissue was responsible for the diapause-terminating effect. He therefore removed various organs and tissues from chilled pupae and implanted them singly into diapausing pupae. Again the results were positive -- only one organ had any effect, and it was the brain. Again there was a lack of species- or genus-specificity, for *P. cecropia* was activated by the chilled brains of *Samia walkeri*, *Callosamia promethea* or *Telea polyphemus*. This lack of specific action, however, suggested to Williams that the effect might work through the endogeneous brain of the "host" pupa. Therefore, in subsequent experiments he used diapausing pupae from which the brains had been removed. That the brain alone required the low temperature treatment was demonstrated by implanting integument and other tissues and organs from diapausing into chilled pupae, where they "took root", as it were, and developed simultaneously with the host tissues.

The next step was to remove the brains from chilled individuals at regular intervals. From this, Williams found that in the first 11 days at 25°C., following chilling, the brain was inactive. After the 17th day the loss of the brain meant nothing to the chilled pupa and it developed normally; however, the removed chilled brains were then without effect on diapausing pupae. Further investigation, in which he used a transparent plastic window in each chilled pupa, showed that "each individual achieves threshold activation during an extremely short period, not exceeding a few hours". (Williams 1946). The critical period, 11 to 17 days, therefore indicates the variation among individuals in this respect.

It has been shown by Bounhiol in 1938 and by Piepho in 1940 and 1941 (cited by Williams 1946) that the corpora allata of Lepidoptera inhibit pupation during the larval stage. Williams removed the corpora allata from fourth instar caterpillars of Platysamia cecropia and Telea polyphemus, which then omitted the fifth instar and pupated. The corpora allata were then removed from diapausing pupae and implanted into chilled pupae. The former continued in diapause and the latter developed normally. In view of this and other evidence, Williams concluded that there was no evidence of an inhibitory factor in the diapause of these species.

In a subsequent paper (1947a) Williams investigated the possibility that the action of the brain in terminating diapause was indirect rather than direct. He performed some remarkable surgery on his pupae, dividing them into viable sections and sealing the incised surfaces with plastic cover slips and paraffin wax. He sectioned diapause pupae between the 4th and 5th abdominal segments, and into each fragment of ten viable pairs he implanted chilled brains. All of the anterior fragments developed to the corresponding adult segments but none of the posterior, abdominal fragments developed, even after as long as eight months. By making sections at other levels he found that the thorax was critical, and of the thoracic structures, that it was the prothoracic glands which were the seat of activity. Isolated diapause abdomens, implanted with a chilled brain and prothoracic glands (chilled or unchilled), led to adult differentiation. Some fragments even developed eggs, while most of the internal structures could be dispensed with entirely. No development occurred, however, when the glands were implanted in the absence of a chilled brain.

Having thus identified the two sources of action responsible for the termination of diapause, Williams turned his attention to the probability that endocrine secretions were involved (1947b). He located two groups of neurosecretory cells in the brain which operate together but not singly to produce the brain factor, but the nature of the factor itself remains unknown. Its presence has not been demonstrated in the blood or tissues. Nor, apparently, has the presence of the prothoracic gland factor. The result, however, apart from the mere statement that diapause is terminated, is that the cytochrome system is resynthesized at this time. This is a vital development, for the cytochrome system is necessary for adult differentiation and development.

As a result of these investigations, Williams was able (1947b) to picture the mechanism of diapause somewhat as follows. At pupation the cytochrome system is broken down, leaving the pupa with a residual, cyanide-insensitive metabolism. This provides enough energy for existence but not enough for cellular activity or growth. To obtain this higher energy level, the tissues must resynthesize the cytochrome system, and to do this they require a factor produced by the prothoracic glands. These glands in turn require another factor which is apparently secreted by certain neurosecretory cells in the brain. The brain, furthermore, must be chilled before it is enabled to produce its factor, even though this process goes on most rapidly at higher temperatures.

Earlier, I mentioned the work of Bodine, who demonstrated in <u>Melanoplus differentialis</u> eggs a low-energy-level, cyanide-insensitive metabolism during diapause. Williams' findings fit this situation quite well, for during diapause the grasshopper embryo is quiescent and presumably lacks a cytochrome system. Could the same presumption be made, though, for <u>Loxostege sticticalis</u> or <u>Cephus cinctus</u>, which are muscularly active during diapause? Probably not. In these species one would expect to find an intermediate type of process corresponding to their intermediate type of diapause metabolism. Basically, however, these exceptions are not in conflict with Williams' findings. The mechanism of diapause and its termination may be similar to that found in <u>Platysamia cecropia</u>, but the results are somewhat different. Indeed it seems but another illustration of the point suggested earlier in this paper, that while diapause may be fundamentally the same phenomenon in all species, the factors influencing its production, duration and termination are extremely varied.

<u>Acknowledgment</u>

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Literature Cited

Bodine, J. H. 1929
Factors influencing the rate of respiratory metabolism of a developing egg. Physiol. Zool. 2, (4): 459-482.

__________ 1932
Hibernation and diapause in certain Orthoptera. II. Response to temperature during hibernation and diapause. Physiol. Zool. 5, (4): 538-548.

__________ 1934
The effect of cyanide on the oxygen consumption of normal and blocked embryonic cells (Orthoptera). Jour. Cell. Comp. Physiol. 4, (3): 397-404.

Hodson, A. C. and C. J. Weinman 1945
Factors affecting recovery from diapause and hatching of eggs of the forest tent caterpillar, Malacosoma disstria Hbn. Minn. Agric. Exp. Sta., Tech. Bul. 170.

Salt, R. W. 1947
Some effects of temperature on the production and elimination of diapause in the wheat stem sawfly, Cephus cinctus Nort. Can. Jour. Res. D, 25, (2): 66-86

Williams, C. M. 1946
Physiology of insect diapause: the role of the brain in the production and termination of pupal dormancy in the giant silkworm, Platysamia cecropia. Biol. Bull. 90, (3): 234-243

__________ 1947a
Physiology of insect diapause. II. Interaction between the pupal brain and prothoracic glands in the metamorphosis of the giant silkworm, Platysamia cecropia. Biol. Bull. 93:89-98

__________ 1947b
The endocrinology of diapause. Bull. Biol. France et Belg. (In press)

THE SPECIES CONCEPT

Ruth B. Barker

When we stop to think about it, it is amazing that there are so many kinds of things living on this earth. The extent of organic diversity seems almost beyond belief when we consider that there must be at least a million and a half species of plants and animals. Up to 1935 there had been described 822,765 species of animals, more than half of them insects, and 233,000 plants. When also we consider the fact that individuals are unique, the diversity becomes even more striking (3, 10).

But there is the additional fact of discontinuity of the organic variation. As Dobzhansky (3), outstanding geneticist, says: "If we assemble as many individuals living at a given time as we can, we notice at once that the observed variation does not form a single probability distribution or any other kind of continuous distribution. Instead a multitude of separate, discrete distributions are found. In other words, the living world is not a single array of individuals in which any two variants are connected by unbroken series of intergrades, but an array of more or less distinctly separate arrays, intermediates between which are absent or at least rare. Each array is a cluster of individuals, usually possessing some common characteristics and gravitating to a definite modal point in their variations. Small clusters are grouped together into larger secondary ones, these into still larger ones, and so on in an hierarchical order."

Thus is devised our scientific classification of organisms. The discrete clusters are designated races, species, genera, families and so forth. It is artificial and yet it serves to point up the fact of organic discontinuity.

The theory of evolution represents the greatest generalization advanced in the study of organic diversity. Quoting from Dobzhansky (3) again: "The theory of evolution asserts that the beings now living have descended from different beings which have lived in the past; that the discontinuous variation observed at our time-level, the gaps now existing between clusters of forms, have arisen gradually, so that if we could assemble all the individuals which have ever inhabited the earth, a fairly continuous array of forms would emerge; that all these changes have taken place due to causes which now continue in operation and which therefore can be studied experimentally".

It is through the study of the causes of evolution that the modern concept of species has developed. This is a concept of species that have greater reality in nature than other taxonomic units. It is a dynamic, not a static concept of "subspecies and species as stages in a process of evolutionary diversification", a concept expressed in terms of populations, not of individuals (3).

There have been periods when consideration of the evolutionary development of species was rather out of fashion. It isn't out of fashion today. In fact, to borrow a fashion term, it has the 'new look'. That may require an explanation.

The course and the mechanisms of biological evolution constitute a study that has benefited greatly in recent years from a new and significant trend that has become discernible in biology in the past decade. From excessive specialization, a science of general biology is emerging. As Dobzhansky (5) says, "This extreme compartmentalization of biological knowledge proved fruitful in that it led to an enormous accumulation of factual information; it has been deleterious in so far as it resulted in a lack of understanding between the representatives of the various disciplines [specialized branches] and a consequent lowering of the efficiency of biological research."

In the last few years, various aspects of evolutionary theory have been treated at book length by several students from different points of view. However, all these works show the new trend, some more than others, towards correlating the evidence afforded by various branches of biology -- particularly systematics, genetics and ecology. Dobzhansky has written as a geneticist, Mayr as a systematist, Julian Huxley as a neobiologist or naturalist, Stebbins as a botanist, Simpson as a paleontologist. Equally or more important studies have also been made by H. J. Muller, Sewall Wright, J. B. S. Haldane, R. A. Fisher and many others.

The problem of species has two aspects, their differentiation and their maintenance as separate groups. It was Darwin who started biologists thinking about the agencies which brought about and maintained the diversification of animals and plants into distinct species. Previous to this, evolutionists, drawing mainly on morphological data, were most interested in demonstrating that evolution actually took place and not so much in explaining the nature of the discontinuities in the organic world or the mechanisms through which they originated.

Darwin also provided an incomplete explanation of how evolution works. In brief -- "Organisms vary. Some (at least) of these variations are hereditary. Within a given group, some individuals have more descendants than others. The hereditary variations of these individuals are, therefore, more common in succeeding generations, which tend to evolve in the direction of these variations." This mechanism is not operative in all cases of evolutionary change but it is undoubtedly a widespread mechanism (16).

It was Darwin's theory of natural selection that influenced biological research so greatly after 1859. This was an explanation of adaptation in nature, particularly progressive adaptation. "The organisms likely to have more descendants are those whose variations are most advantageous as adaptations to their way of life and to their particular environment. Thus evolution is likely to move in the direction of greater or more nearly perfect adaptation" (16). However, Darwin did not believe that natural selection was a complete explanation of evolution -- he recognized that parts of the process were still mysterious. His natural selection theory was based on two happenings in nature, the details of which were quite unknown -- the origin of new variations in animals and plants and the perpetuation of these by heredity. There were no reliable methods at that time by which these two problems could be studied but since the rediscovery of Mendel's principles in 1900, the science of genetics has developed such methods.

There is general agreement among present-day biologists that the geneticists have identified the materials of evolution. These are discrete changes in the hereditary mechanism which has its physical basis in the germ plasm of the sex cells. The germ plasm is made up of discrete particles known as genes which are organized into united groups called chromosomes. Chromosomes occur in sets, one or more of which are present in every cell that is to grow into an organism. These chromosome sets as a whole, with all their constituent parts, determine what the organism will become as it grows.

As Dobzhansky (3) explains it: "Gene changes called mutations are the most obvious source of evolutionary changes and of diversity in general. Next come the changes of a grosser mechanical kind involving rearrangements of the genic materials within the chromosomes. It seems probable at present that such rearrangements may at least entail changes in the functioning of the genes themselves (position effects), since the effects of a gene on development are determined not only by the structure of that gene itself but also by that of its neighbors. Finally reduplications and losses of whole chromosome sets, called polyploidy, are important as evolutionary forces, especially among some plants. Mutations and chromosomal changes arise in every sufficiently studied organism with a certain finite frequency, and thus constantly and unremittingly supply the raw materials for evolution."

It should be noted that when new species are formed by selection of gene-mutations it is a relatively slow process. A sudden origin of a new species by gene-mutation is impossible in practice because races of a species and, to a still greater extent, species of a genus, differ from each other in many genes. They usually also differ in chromosome structure.

The rate of gene-mutation, as a source of heritable variation, may differ in different types. It is possible that in certain species the rate may vary cyclically to a considerable extent or may vary between species. "The rate of mutation may then be a limiting factor of evolutionary change, condemning some forms to stability, stagnation or eventually extinction" (11). Little is known about mutation-rates. However, the few that have been investigated are all of the same general order of magnitude. The mutation-rate will vary with temperature because of the effect of temperature in increasing the number of generations in all except warm-blooded animals. According to Worthington (17), this has the interesting implication that the rate of evolution in the tropics is more rapid than in colder regions.

The second source of change, structural change in the chromosome, is usually less important than gene-mutation in producing variations.

The third source of change mentioned earlier which has to do with multiplication of the chromosome complement is called polyploidy. It is the one method existing in nature of causing what Dobzhansky (3) calls "cataclysmic emergence of a new species". Species formation through polyploidy occurs mainly as a result of hybridization of two previously existing species. Among plants, this amazing happening is common in Angiosperms where hermaphroditism is the rule, rare in Gymnosperms. It has been of great evolutionary and taxonomic importance in plants. However, it is very rare in higher animals because it interferes with the sex-chromosome mechanism. It is necessarily associated with optional or obligatory self-fertilization or with apogamy.

The mechanisms of species formation so far mentioned, the mutations, to use the term in the wider sense, are on the first level of the evolutionary process. Once produced, mutations are injected into the genetic composition of the population where their further fate is determined by other forces. On the next level the mechanisms of selection and of isolation play their parts in evolution.

It seems generally conceded "that there is no evidence of a direct adaptation in the process of mutation; that the organism is not endowed with providential ability to respond to the requirements of the environment by producing hereditary changes consonant with these requirements. At the individual level, the changes produced are determined primarily by the structure of the organism itself, which is, of course, the result of a historical process in which the environment has played a part. But the historical process, the moulding of the hereditary variation into racial, specific, generic and other complexes, is due to the action of the environment through natural selection and other channels-----" (3).

Currently, students of various branches of biology are in disagreement as to the roles of selection and the various forms of isolation in the evolutionary process. However, their lack of agreement is not in the recognition of the various factors involved, but in differences of emphasis placed on the importance of each factor.

According to the geneticist, Dobzhansky (3), "isolation (apart from the accidental fixing of new combinations of genes already present) is powerless to effect differentiation without mutation and, in most cases, without selection." Julian Huxley (11) regards selection, isolation and intrinsic factors (including mutation and hybridization) as of equal importance in micro-evolution.

The role of isolation in evolution forms one of the most interesting studies in nature.

Isolation is an essential factor in bringing about taxonomic divergence. What is more, "a knowledge of the genetic machinery involved has shown, as Wright (18, 19) and Muller (13) stress, that, granted a normal rate of mutation and degree of variance, it actually promotes differentiation". Many classical systematists emphasized the results of geographical isolation but there are other forms of isolation that can be equally effective. These are ecological, physiological and genetic isolation. Sometimes genetic and physiological isolation develop as a result of geographic isolation -- they are thus interrelated to a certain degree.

Geographical isolation will be discussed first. By the action of geographical isolation, groups of individuals are debarred from breeding because they live in different geographical regions and hence never meet. Mayr (12) considers it extremely important in producing divergence. Dobzhansky (3), on the other hand, calls it only a temporary measure which may or may not lead to a permanent segregation of the groups so isolated. "Any species has a tendency to expand its range and forms now living in separate regions may eventually come together. If no intrinsic physiological isolating mechanisms have developed, their interbreeding will begin and the originally separate groups will fuse together, especially in the area where the distribution regions overlap".

Geographical isolation may have every degree of completeness. A river may effectively isolate the populations on its two banks, but the effect will clearly depend on the size of the river. Equally clearly it will depend on the biological properties of the populations concerned: large birds will be less likely to be isolated than smallish mammals (though very small mammals may more easily be transported across the river on logs or in boats). Geographical isolation may be effected in many ways.

For land forms, the isolating barrier may be the sea, as for island forms or the fauna of different continents; lakes; rivers, as mentioned above; deserts; mountain ranges. (The unique fauna of Australia, which developed in ocean-made isolation, is a good example.) For aquatic forms, the barrier will in general be land. Land-locked lakes are here the equivalent of islands and barriers like the Isthmus of Panama in the Miocene, the equivalent of an ocean between two continental land faunas. Distance alone may promote geographical isolation, but it will never produce complete discontinuities (11).

Geographical isolation has received more study than other kinds, so that some general points on its effects may be mentioned. First of all, where isolation is relatively or quite complete and the isolated population small, the 'Sewall Wright' effect will produce a certain degree of random, non-adaptive change. "Any mutations which are selectively more or less neutral can spread through the population with great rapidity, and useless or even slightly unfavorable recombinations have an opportunity, denied to them in large groups, of becoming the predominant type owing to mere chance. This accidental non-selective change may with time reach any extent" (11). Additional random difference will often be introduced by initial sampling effects, the colonizers of new areas not being average representatives of the species. Both of these effects make it evident that the total amount of diversification will be greater for a species broken up into numerous isolated populations than if it were spread over a continuous area (18).

A well-known example of initial sampling effects acting on a highly variable population is found in the snail genus, Partula, on the Society Islands. H. E. Crampton (2) described a situation there where the snails live in the bottoms of steep-sided mountain valleys and can cross the bare knife-edge ridges between the valleys only with difficulty. Consequently almost every valley has its own distinctive type or range of types of Partula. At the same time, the birds and most plants of Tahiti show no such diversification valley by valley, because isolation of these forms was not effected by such physical barriers.

Sometimes it is possible to use geographic and geological knowledge to establish the time at which isolation took place and from that to calculate the rate of evolution. These studies have indicated that rates in different forms are highly variable.

An example, used by Huxley (11) to illustrate this point, is from the work of C. T. Regan (14). "The barrier between the Pacific and the Atlantic fish faunas constituted by Central America came into being probably in the early Miocene, some 25 million years ago. Some of the fish on the two sides of the isthmus show only sub-specific divergence, but the majority have differentiated into pairs of well-marked species"(11).

Again from Huxley (11): "The islands off the north of Scotland, including the Faeroes and Iceland, cannot have received their present fauna before the end of the Ice Age, some 15,000 years ago; yet numerous well-marked sub-species have evolved on them." Sometimes the rate of change may be very rapid, as described by H. L. Jameson (10) in the case of an island population of house-mice which showed distinct adaptive colour differences from those of the mainland within 100 to 120 years.

The most important point to remember about geographic variation is that the sub-species produced this way may be thought of as species-in-the-making. However, this applies to a limited number only. Some will remain as sub-species, or become extinct. But many undoubtedly diverge until they become new species.

Ecological isolation has not received as much study as georgraphical isolation. Very few cases of ecological species are known but there are numerous examples of sub-species having this origin. According to Mayr (12), in the same geographic district there may exist two very similar forms in two different ecological niches or under the influence of two different sets of ecological factors. Morphological differences may be more or less constant but perhaps slight. Yet they are not merely individual variants because the difference is one of habitat. These ectotypes have been described in plants, insects, snails, fish and mice and a number of other groups. Dice (6) has found two sub-species of the mouse, <u>Peromyscus</u> that are separated only by their preferences for woodland and for open country. Salisbury (15) gives instances of ecological species as well as sub-species in plants.

Proof that ecological isolation plays a part in evolution is shown by cases where a type is, in one region only, represented by a number of different species (or even genera) filling different ecological niches. An example of this sort is described by Worthington (17) among the fish of typical British river. "In any watershed", he explains, "even where no geographical barriers exist, there are numerous ecological barriers which prevent mixture of faunas". Thus "the river can be divided into a series of overlapping zones, inhabited by trout, grayling, coarse fish such as roach, perch, tench, etc., in several subzones and finally the estuarine zone with such fish as flounders living side by side with freshwater species. In such a case specific ecological requirements limit each fish to its particular zone". It is also obvious that there is no sharp distinction dividing ecological isolation and geographical isolation in these circumstances. It should be noted, however, that Mayr (12) attaches little validity to the ecological race concept, attributing variation originally to geographic isolation.

Physiological isolation, according to Huxley (11), is seen most diagrammatically in the physiological races of various parasites and phytophagous insects which may remain remarkably distinct and yet show a bare minimum of morphological difference. In some cases they will refuse to cross, or will yield infertile offspring, so that they deserve the title of species. If they have not been so designated as yet, it is because, in the past, morphological difference has been the decisive criterion of species-difference and not much has been done by way of experiment, breeding tests or cytological examination.

In a recent paper, Freeman (8) points out that "many closely allied but distinct species may be more readily recognized by what they do, and not, as many believe, by differences in anatomy".

Many examples of genetically isolated species have been discovered by breeding tests or cytological examinations when they could not be recognized by morphological differences. Genetic isolation may arise in many ways and produce biological change in populations. Chromosome-mutation may isolate small portions of the hereditary outfit from the rest and thus provide a basis for the selective divergence of two types, the original and the mutated. Gene-mutation has the same effect and is probably more important because it is more frequent. Polyploidy or chromosome-multiplication, mentioned before as a factor in evolution, can produce genetic isolation suddenly at one step. But when geographical and physiological isolation work to produce genetic isolation, their effects are gradual.

Little agreement now exists among authors as to definitions and terminologies used for the various kinds of isolation in nature. Dobzhansky (3) recognizes only two major kinds, the geographical and the physiological which he subdivides into ecological, seasonal and a number of isolations that are essentially genetic. Huxley (11) speaks of geographical, physiological, genetical and ecological isolation. Mayr (12) stresses geographical isolation and greatly discounts ecological. He also uses the term biological isolation almost in the same sense as Huxley's physiological isolation. In short, it is a very confusing situation because frequently one author's illustration of divergence brought about by a certain kind of isolation could, in the hands of another author, be an equally good illustration of another kind of isolation. This happens because the illustration chosen almost never is the result of only one kind of isolation, but of a complex where several kinds grade into each other or are intrinsically related.

With reference again to the paper by Freeman (8), the problem being discussed concerns the necessity of determining the exact species-status of closely related economic insects. The spruce budworm complex, taken as an illustration, involves a form feeding on spruce and a form feeding on jack pine. Morphological differences are slight but constant and there are behaviour differences. Whether two distinct species are involved must be determined by field investigations of behaviour to see if there is reluctance to hybridize or, in other words, to see if they tend to maintain themselves as independent populations. This problem involves the effects on species-development of geographical, as well as ecological isolation, physiological, and possibly genetic isolation.

Of the three great factors in producing differentiation in nature (mutation, isolation and selection), selection remains the least understood. It might be in order to review some of the various explanations of how it works.

Darwin's natural selection theory of adaptation in nature did not remain long unchallenged by other evolutionists. One of the main lines of attack was that natural selection is a purely negative process. It destroys but does not create. It eliminates disadvantageous variations but does not explain how advantageous variations arise. Of course, Darwin never intended that natural selection be taken as the whole story of evolution, but these serious objections caused disillusionment among students who began to believe that a mechanistic interpretation of evolution was doomed to failure. There was a noticeable swing back to the belief in a supernatural cause to evolution - not in the sense of divine establishment of the natural laws of evolution but in the sense that the laws themselves were supernatural. (16)

Then the geneticists explained the nature and the origin of hereditary variations and in the first excitement of the exploration of a new field, they tried to solve the problem of adaptation by simply abolishing it. Since the mechanism of change involved mutations arising at random, then geneticists said new types of plants and animals arise at random also.

However, to be fair to the geneticists this denial of the reality of the problem of adaptation was neither universal nor endured for long.

One result of the acceptance of random mutation as the mechanism of evolutionary change and at the same time the acceptance of either adaptation or something that looks very much like it in nature, led to the emphasis of another principle - pre-adaptation. Simpson (16) says: "The essence of this principle is that structural or physiological peculiarities, although arising at random, may prove to be suitable or useful in the environment of the organism or in some other environment available to it. For instance, animals living in fresh water may by mutation become tolerant of salty water and then spread into brackish streams or into the sea because they now can; or animals living on a forest floor may undergo mutations enabling them to climb and then may take to the trees for refuge".

Goldschmidt (9) supports an extreme form of pre-adaptation theory. There is little doubt that adaptive change occurs and must be considered in formulating a theory of evolution, but it cannot be accepted as a complete explanation because basically it proceeds by random, accidental or unsystematic processes.

The palaeontologist, Simpson (16), is one of the men engaged in a movement now going on to bring all the present facts and theories on the problem of adaptation together. This movement has resulted in what he calls a new synthetic theory of evolution and it embraces the work of many authors. That is, it recognizes the hereditary mechanism of random mutation and recombination. But it also recognizes that since adaptation is so common in nature as to be nearly universal, there must exist a process in nature that is capable of generating a high degree of improbability as R. A. Fisher (7) has put it, or in other words, of assuring that a result that is genetically extremely improbable will nevertheless become usual. This force, according to the synthetic theory, is natural selection but it is natural selection understood in a new way. It is not merely a negative process of elimination of the unfit but a positive creative process.

According to Simpson (16), the process is complicated but essentially selection acts positively by increasing the number of favorable or adaptive combinations. It thus greatly increases the chances not only of favorable genes but also of favorable combinations of genes. It also acts to prevent dispersal of favorable arrangements of genes and increases their frequency in the population. In addition, a very small selective advantage is enough to insure that favorable genetic systems will be increased in frequency. By this action there appear and spread genetic systems and, therefore, organisms that would never have existed under uncontrolled random mutation and recombination. In this sense, selection is creative.

But this interpretation of selection is by no means generally accepted to the exclusion of the theory of natural selection in the Darwinian sense of elimination of the unfit. This is shown by a recent paper by Baily (1). He states that both morphologically and physiologically unfit organisms may occur and that, although the two aspects are closely related, it is more likely to be the physiologically unfit that are eliminated by natural selection. There is no evidence of the cause of extinction of ancient animals in their morphology since some resemble present forms. We do not know their physiology, but the most likely explanation of their extinction is that a new element in the environment arose suddenly and those animals were physiologically unadapted to it. He gives, as an illustration, a present-day animal that is becoming extinct - the California condor. This bird has keen vision and great strength which gives it a long flight period, but it is too fastidious about its food - it eats only freshly killed meat. In addition, the young take a long time to develop and progeny are thus infrequent. The condor is unadapted physiologically but not necessarily unadapted morphologically.

Some of the aspects of the roles of mutation, isolation and selection in evolution having been given, the following quotation from Wright, as used by Dobzhansky (3), seems an appropriate summing up of their interaction. "The most general conclusion is that evolution depends on a certain balance among its factors.

There must be gene mutation, but an excessive rate gives an array of freaks, not evolution; there must be selection, but too severe a process destroys the field of variability and thus the basis for further advance; prevalence of local inbreeding within a species has extremely important evolutionary consequences, but too close inbreeding leads merely to extinction. A certain amount of cross-breeding is favorable, but not too much. In this dependence on the balance, the species is like a living organism. At all levels of organization, life depends on the maintenance of a certain balance among its factors."

As soon as you attempt an exact definition of species, you become aware of the complexity of views held by various specialists. There are as many definitions as authors and probably most of them are at least partly true. This very lack of agreement on definition is, of course, a reflection of differences in the emphasis placed on certain events in nature by specialists in the various fields of biology. (This same reason explains, to some extent, their lack of agreement on the origins of species.)

Among older writers, Huxley (11) says, the conception of species was an organism which was non-fertile with another species. It is true that the nearest approach to a positive criterion of species is failure to interbreed or produce fertile offspring. But it is meaningless in apogamous forms and as a negative criterion it is not applicable as many obviously distinct species, especially of plants, yield fertile offspring when interbred.

According to Huxley (11), there has been "reluctance among general biologists to accept the fact that species have a greater reality in nature, a greater degree of objectivity, than higher taxonomic categories. According to such objectors, all taxonomic units are equally artificial and are merely useful fictions". But workers who come into close contact with the problem, museum workers and experimental taxonomists, who are applying genetic and ecological analysis to the study of groups in nature, come to other conclusions. "By them, species are seen in the majority of cases to be definable as distinct self-perpetuating units with an objective existence in nature, and therefore on a different theoretical footing from genera or families or other higher categories, which are not definable in this concrete way."

Dobzhansky (3) says that species are the most stable units in taxonomic practice as compared with infra-specific categories, such as variety or sub-species or supra specific ones, such as genus, subfamily or family. He regards sub-species and species as stages in a process of evolutionary diversification. Huxley agrees with this dynamic concept of species but says that there is no single cirterion of species. He says: "Morphological difference; failure to interbreed; infertility of offspring; ecological, geographical or genetical distinctness - all of these must be taken into account, but none of them singly is decisive."

According to Huxley (11), "species may be regarded as natural units in that they are groups which (a) have a geographical distribution-area, (b) are self-perpetuating as groups, (c) are morphologically (or in rare cases only physiologically) distinguishable from other related groups and (d) normally do not interbreed with related groups, in most cases showing partial or total infertility on crossing with them (though neither the lack of crossing or of fertility is universal)." Species resemble sub-species in regard to (a), (b) and (c), but differ with regard to (d).

Huxley (11) also remarks that species may differ markedly in regard to their size and in the degree of difference from related species. The species-concept can not apply to all groups. There are a number of exceptions and border-line cases. It breaks down in regard to hybrid swarms and in regard to apogamous forms, also in various plants which exhibit reticulate instead of divergent descent, such as the willows, _Salix_. It also breaks down with regard to man who exhibits a peculiar form of reticulate descent consequent upon extreme migration.

There are other border-line cases, but the fact remains that the majority of cases show no intrinsic difficulties. As Huxley (11) expresses it: "Either a group exhibits no or negligible interbreeding with related groups and is sharply marked off as an entity, or else it exhibits geographical replacement in regard to other very closely similar groups, and if its range abuts on that of any of these, the two interbreed freely. In other words, most groups are either definitely species or sub-species."

The term species still remains the most suitable for the distinct groups which cause the discontinuities in nature. Huxley continues: "These discontinuities are not permanent; traced back into the past, they always converge; traced forward, any single group may again undergo fission and diverge. But the time during which the discontinuities remain complete is far greater than that during which they are partial; and accordingly the number of 'good species' is far greater than that of difficult border-line cases."

The fact that groups show fertile intercrossing when artificially or secondarily brought together does not disprove their right to be styled species. The basis of decision must be the facts of nature, that is, the fact of their separate existence as self-perpetuating units together with either a reduction or absence of fertility on intercrossing <u>or</u> a certain empirically evaluated degree of morphological or physiological characters. (11)

Mayr (12) concurs in this view of species to the extent that he states "the one criterion of specific distinctness in geographically isolated forms is genetic isolation in nature". But a criticism of this statement is that it cannot be tested by mating experiments, but only by very difficult transference experiments, to see whether two forms would freely interbreed in nature.

As for a species-concept, Mayr (12) says that there are as many concepts as there are students of speciation. To a systematist, the species is only one of a number of systematic categories and in his discussion of species he will concentrate on methods of distinguishing species from sub-species and from other species. To a student of evolution, or, more exactly, a student of speciation, "the species is a passing stage in the stream of evolution". He is primarily interested in the dynamic qualities of species.

The first difficulty in making an attempt at a species definition is that, as Mayr (12) says, "we are confronted by the paradoxical incongruity of trying to establish a fixed stage in the evolutionary stream". In true evolution, there will be all kinds of species, incipient species, mature species, and incipient genera. The second difficulty in defining species arises out of the great diversity of kinds of species in nature. Mayr (12) believes we are justified in wondering whether the species of birds, of corals, of protozoa and of intestinal worms are the same kind of evolutionary phenomena. He states that the species-concept that prevails at the present time in any given taxonomic group depends more on the degree to which this group is known taxonomically than on any other factor.

There is an additional factor contributing to the great diversity of kinds of species. As mentioned before, the main types of speciation are those due to geographical isolation, ecological isolation, physiological isolation and genetic isolation. Each main type, according to Huxley (11), tends to produce different types of speciation. For example, ecological isolation will be more likely to produce sex-recognitional specific characters than will geographical isolation. Physiological isolation, as in phytophagous insects and parasites, will tend to promote a relatively large degree of physiological difference. Genetic isolation is likely to leave two related groups similar both physiologically and morphologically for a long time since both groups inhabit a similar environment.

We must conclude that the modern species-concept, although greatly changed from the Darwinian concept of species, is not yet fully formed. It is emerging out of the study of speciation as carried on by students in every field of biology. It will emerge more quickly if the study can be made co-operatively.

REFERENCES

1. Baily, J. L. Jr. A contribution to the theory of evolution by natural selection. Am. Nat. 75: 213-30. 1941.

2. Crampton, H. E. Studies on the variation, distribution and evolution of the genus Partula. Publ. Carnegie Inst. Wash. Nos. 228, 410. 1916, 1932.

3. Dobzhansky, Theodosius. Genetics and the origin of species. Columbia Univ. Press, New York. 1937.

4. ________. Speciation as a stage in evolutionary divergence. Am. Nat. 74: 312-21. 1940.

5. ________. Introduction In Systematics and the origin of species by Ernst Mayr. Columbia Univ. Press, New York. 1942.

6. Dice, L. R. Speciation in Peromyscus. Am. Nat. 74: 289-98. 1940.

7. Fisher, R. A. The genetical basis of natural selection. Oxford. 1930.

8. Freeman, T. N. The taxonomic and economic approach to an entomological problem. Ann. Report Ont. Ent. Soc. 77: 8-9. 1946.

9. Goldschmidt, R. B. The material basis of evolution. Yale Univ. Press, New Haven. 1940.

10. Jameson, H. L. On a probable case of protective colouration in the house mouse. J. Linn. Soc. (Zool.) 26: 465. 1898.

11. Huxley, J. S. Towards the new systematics. In The new systematics, ed. by J. S. Huxley, pp. 1-46. Clarendon Press, Oxford. 1940.

12. Mayr, Ernst. Systematics and the origin of species. Columbia Univ. Press, New York. 1942.

13. Muller, H. J. Bearings of the '*Drosophila*' work on systematics. In The new systematics, ed. by J. S. Huxley, pp. 185-268. Clarendon Press, Oxford. 1940.

14. Regan, C. T. Biologia Centrali-Americana: Pisces. 1906-08.

15. Salisbury, E. J. Ecological aspects of plant taxonomy. In The new systematics, ed. by J. S. Huxley, pp. 329-340. Clarendon Press, Oxford. 1940.

16. Simpson, G. G. The problem of plan and purpose in nature. Scientific Monthly. 64, No. 6. 1947.

17. Worthington, E. B. Geographical differentiation in fresh waters with special reference to fish. In The new systematics, ed. by J. S. Huxley, pp. 287-302. Clarendon Press, Oxford. 1940.

18. Wright, Sewall. Breeding structure of populations in relation to speciation. A__. Nat. 74: 232-48. 1940.

19. ______. The statistical consequences of Mendelian heredity in relation to speciation. In The new systematics, ed. by J. S. Huxley, pp. 161-163. Clarendon Press, Oxford. 1940.

APPENDIX I

The annual spring meeting of the Entomological Society of Manitoba was held in the Dominion Forest Insect Laboratory at the University of Manitoba on Tuesday, April 22nd, 1947, at 9:30 a.m. In the absence of Dr. B. N. Smallman, Mr. R. R. Lejeune, Vice-President, took the Chair. Those present were: Mr. R. R. Lejeune, Dr. R. D. Bird, Mrs. W. S. Barker, Messrs. B. Berck, B. Filuk, W. C. McGuffin, J. McLintock, C. A. S. Smith, D. S. Smith, H. Westdal and W. S. McLeod, Secretary-Treasurer.

The minutes of the meeting of November 19th, 1946, were read. It was moved by Mr. D. S. Smith and seconded by Mr. McLintock that these be adopted.

<u>Carried</u>

It was moved by Mr. McLeod and seconded by Dr. Bird 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."

<u>Carried</u>

The Treasurer read a financial report which showed a balance of $26.94 on hand. It was moved by Mr. McLeod and seconded by Mr. D. S. Smith that this report be accepted and that the expenditure of $6.40 for stencils for the Proceedings be thereby approved.

<u>Carried</u>

The Chairman announced that one of our senior members, Professor A. V. Mitchener, who had been absent from the Department of Entomology, University of Manitoba, for several months during the winter on account of illness, had suffered a heart attack on Sunday, April 20th, and was resting quietly at home. The members present at this meeting were unanimous in expressing their sincere sympathy, an expression in which they were joined by a visiting entomologist, Mr. G. Shirley Brooks. It was moved by Mrs. Barker and seconded by Mr. Berck that a bouquet of flowers be sent to Professor Mitchener as an expression of good wishes on behalf of the entire membership. <u>Carried unanimously</u>

Mr. McGuffin, speaking on the work of publishing the second volume of the Proceedings of the Entomological Society of Manitoba, reported that the mimeographing of the manuscript had been unavoidably delayed but that the volume should be ready for mailing in the very near future. It was moved by Mr. McGuffin and seconded by Mr. McLintock that the three stenographers who had done so much work in the preparation of this publication, Misses K. Ostapchuk, V. Shewchuk and S. Dougall, should each be given a box of chocolates as a token of our appreciation.

Carried

It was moved by Mr. C. A. S. Smith that the Secretary forward a letter of thanks to Mr. N. C. McKay, Director of Extension, Department of Agriculture, Province of Manitoba, for his kind cooperation and assistance to the Society in the publication of the Proceedings.

Carried

It was moved by Mr. McGuffin and seconded by Mr. Berck that the Constitution as changed or amended be included annually as an Appendix to the Proceedings.

Carried

Correspondence from Dr. J. A. Munro, expressing regret at his inability to attend the meeting, and from Mr. C. R. Douglas, requesting a list of common names for insects of Manitoba, was read. A lengthy discussion on common names of insects and on the availability of information concerning the insects of this Province followed. It was moved by Mr. Berck and seconded by Dr. Bird that a committee be appointed to co-ordinate a project on the listing of the insects of Manitoba, the Committee to include a member from each entomological unit in the Province.

Carried

Mr. McGuffin nominated Mr. McLintock and Dr. Bird to organize such a Committee and to appoint members of the Society to act on this Committee as required. Moved by Mr. Berck and seconded by Mr. D. S. Smith that nominations cease.

Carried

It was moved by Dr. Bird and seconded by Mr. McGuffin that the Entomological Society of Manitoba extend an invitation to the International Great Plains Conference of Entomologists to meet in Manitoba in 1948, provided that it proves possible to secure accommodation for such a Conference at Clear Lake or elsewhere in Manitoba.

Carried

Mr. Lejeune was requested to investigate the availability of accommodation at Clear Lake at his earliest convenience and to report to the Executive.

The next item of business was the annual election of officers. The Chairman expressed appreciation of the splendid work done by Dr. Smallman during his two years in office but it was explained that, according to the Constitution, he was not eligible for re-election.

Mr. Lejeune was nominated by Mr. C. A. S. Smith for the office of President. Moved by Mr. McGuffin, seconded by Mr. D. S. Smith that nominations cease.

Carried

Mr. C. A. S. Smith was nominated by Dr. Bird for the office of Vice-President. Moved by Mr. D. S. Smith, seconded by Mr. McLintock, that nominations cease.

Carried

Mr. McLeod was nominated by Mr. C. A. S. Smith for the office of Secretary-Treasurer. Moved by Mr. Berck, seconded by Dr. Bird, that nominations cease.

Carried

Mr. McGuffin was nominated by Mr. McLintock for the office of Editor-Librarian. Moved by Dr. Bird, seconded by Mr. C. A. S. Smith that nominations cease.

Carried

Some time was devoted to a discussion of the program for the fall meeting. Many excellent suggestions were made, all of which were noted by the Executive.

Further discussion on the work of the Committee to list the insects of Manitoba followed. It was agreed that this would be a work of great magnitude and usefulness. It was suggested that, in order to make a start on the project, any member who happened to be in possession of any check list of insects of Manitoba should forward a copy to Dr. Bird or Mr. McLintock. It was agreed that the central file of information should be designed in such a way that it might one day contain many details on the location, dates, seasonal range, food plants, etc. of the individual species.

Moved we adjourn at 11:45 a.m.

R. R. Lejeune,
Chairman.

W. S. McLeod,
Secretary-Treasurer.

APPENDIX II

A business meeting of the Entomological Society of Manitoba was held in the Forest Insect Laboratory at the University of Manitoba at 9:30 a.m. on September 24, 1947. Those present were: Mr. R. R. Lejeune, President, Professor A. V. Mitchener, Dr. R. D. Bird, Dr. B. N. Smallman, Mrs. W. S. Barker, Messrs. B. Berck, G. Shirley Brooks, H. Fyfe, J. McLintock, D. J. Petty, C. A. S. Smith, D. S. Smith, J. B. Wallis, H. Westdal, H. R. Wong and W. S. McLeod, Secretary-Treasurer.

It was moved by Dr. Bird and seconded by Mr. McLintock that the minutes of the meeting of April 22, 1947 be adopted.

Carried

The work of the Committee for the listing of the insects of Manitoba was then briefly reviewed. Dr. Bird reported that some progress had been made in the Brandon Laboratory on the Lepidoptera and that some file cards had already been prepared. Mr. McLintock reported that the mosquitoes of the Province had been done and that Mr. Holland of Kamloops has information on the fleas of Manitoba which he would gladly place at our disposal. Mrs. Barker stated that some of this work was also being carried on in the Forest Insect Laboratory. Professor Mitchener made the suggestion that certain orders be allocated to members of the Society or to laboratories or departments for their special attention.

The Meeting next turned its attention to the subject of the proposed organization of an Entomological Society of Canada. In introducing the subject, the Chairman read the Memorandum dated November 23, 1945, which had been received some time ago from Mr. W. A. Ross of Vineland.

In this Memorandum and in subsequent discussion it had been suggested that local entomological societies might approach their respective Provincial Governments to see if financial support for the proposed national Society might be secured. Dr. Smallman reported on behalf of the Manitoba Executive that a Brief to the Minister of Agriculture and Immigration for the Province of Manitoba had been prepared (included as Appendix III). The Brief had been submitted to Mr. N. C. MacKay for his criticisms and suggestions but Mr. MacKay had not yet had time to consult with the Executive. Dr. Smallman then read the Brief and stated that it was hoped to have a report on the Minister's reply for the next business meeting of the Society.

During the early part of September, a proposed Constitution for the Entomological Society of Canada had been drawn up by the Executive and the Manitoba members of the Committee on National Entomological Organization. This proposed Constitution had been mimeographed and mailed to all members of the Society. It was suggested that the Secretary read one by one the articles of the proposed Constitution and the Comments pertaining to each Article and that opportunity for discussion be given after each Article. With the exception of a period of one hour during which the meeting adjourned for lunch, this discussion was continued until mid-afternoon. (The proposed Constitution and Comments, as amended in view of the opinions expressed by the meeting, will be found in Appendices IV and V.)

It was moved by Professor Mitchener and seconded by Mr. Brooks that the meeting express its commendation of the work done by the Executive and Manitoba members of the Committee on National Entomological Organization.

Carried

Having terminated the discussion of the proposed Constitution, the meeting devoted some time to a discussion of the I.G.P.C.E. which is to meet at Clear Lake, Manitoba, in August of 1948 as the guests of the Entomological Society of Manitoba. Professor Mitchener moved and Dr. Bird seconded that Mr. Lejeune be appointed Secretary of the Conference.

Carried

A letter from Professor Ozburn of Guelph to Dr. Smallman suggesting affiliation of the Entomological Society of Manitoba with the Entomological Society of Ontario, was then read. It was the opinion of the meeting that we appreciate the invitation but that there seems little point in affiliating at the present time, at least until we see what may be accomplished in the organization of an Entomological Society of Canada.

Moved we adjourn at 3:30 p.m.

R. R. Lejeune,
Chairman.

W. S. McLeod,
Secretary-Treasurer.

APPENDIX III

Memorandum to:

The Honourable D. L. Campbell
Minister of Agriculture and Immigration
The Province of Manitoba

This brief is submitted on behalf of the Entomological Society of Manitoba with the purpose of informing the Minister of a proposal to establish an Entomological Society of Canada and to ascertain whether such a Society may hope to receive a measure of support from the Province of Manitoba.

In 1945, the Entomological Society of Manitoba was constituted for the purpose of facilitating the exchange of information among professional and amateur entomologists working in the Province. The entomological services operative in the Province and represented in the local Society embrace almost every field of entomological interest--teaching, apiculture, medical entomology, plant quarantine, and insect pests of field crops, forests, gardens and stored products. The Entomological Society of Manitoba has proved to be of great value to its members and, through them, to the community which they serve. Copies of the Proceedings of the Entomological Society of Manitoba for 1945 and 1946 are attached.

The need for such local organizations has been felt in other parts of Canada and other entomological societies are active in British Columbia, Ontario and Quebec. It is a natural development, therefore, that a proposal for a national organization should come forward.

The benefits from a national organization that will accrue to the members of the Manitoba Society and that may be expected to be reflected in their services to the Province are summarized herewith:

(1) The establishment of a national Canadian Journal of Entomology to provide a unified outlet for scientific papers and reports on all phases of entomological work in Canada.

(2) Access to the valuable library now in possession of the Entomological Society of Ontario which will be donated to the national society.

(3) Opportunity for discussion, and personal contact with other Canadian entomologists through the medium of annual meetings alternating between Eastern and Western Canada.

(4) Strengthening of the present Entomological Society of Manitoba by its affiliation with the national organization.

(5) Attraction of amateur entomologists whose valuable work is to be encouraged by the national organization.

In Canada, the science of entomology is universally associated with the public service. It is reasonable, therefore, that entomologists should seek governmental support in the establishment of an organization designed to improve their services. In the past, the Entomological Society of Ontario has been assisted by the Ontario Government by a grant amounting to as much as $1,000. per annum for the purpose of publishing their Annual Report, and by provision of office and library space. The Entomological Society of British Columbia has also received financial assistance from the Province for the publication of an annual report. The Entomological Society of Manitoba acknowledges assistance from the Province in the publication of its Proceedings.

The National Committee for the formation of an Entomological Society of Canada proposes to approach the Dominion Government and the Provincial Governments for financial support. The Province of Ontario has already promised to transfer to the national organization the support it formerly gave to the Ontario Society. Only by similar assistance from the other provinces will it be possible to achieve the object of an Entomological Society of Canada.

The financial requirements of the proposed Society are not yet known. Our purpose in submitting this brief is to ascertain whether a request for financial assistance will meet with a sympathetic hearing from the Minister of Agriculture and Immigration of the Province of Manitoba.

Respectfully submitted,

W. S. McLeod,
B. N. Smallman.

Members,
The National Committee

R. R. Lejeune, President,
C. A. S. Smith, Vice President.

The Entomological Society
of Manitoba.

APPENDIX IV

Suggested Constitution for the Entomological Society of Canada

Article 1: Name

(a) The Society shall be known as the Entomological Society of Canada.

Article 2: Headquarters and Library

(a) The headquarters and the library of the Society shall be located at Guelph, Ontario.

Article 3: Objects

(a) to serve as a learned society for the advancement of the science of entomology in Canada

(b) to establish a library of entomology

(c) to develop outlets for the publication of entomological material

(d) to foster the exchange of information on entomology.

Article 4: Affiliation

(a) The Entomological Society of Canada shall consist of an association of provincial or regional entomological societies. Entomological societies in any part of the Dominion of Canada may secure affiliation with the Entomological Society of Canada by a written application to the Secretary of the national body, the said application to be signed by the President and Secretary of the local society.

(b) Local societies which affiliate shall adopt a name which shall characterize them as being branches of the national organization; e.g. The Entomological Society of Manitoba shall adopt the name, "Entomological Society of Canada, Manitoba Branch."

Article 5: Membership

(a) Amateur and professional entomologists may secure membership in the Entomological Society of Canada only by virtue of their membership in a local society which has affiliated with the Entomological Society of Canada.

(b) Members of a local society shall be considered to be in good standing as long as they observe all the rules and regulations of the local society, with the understanding that membership shall be considered to have lapsed when an individual, having received due notice, has failed to pay his annual fees for two consecutive years. Loss of membership in the local society shall automatically bring about loss of membership in the Entomological Society of Canada.

Article 6: <u>Fees</u>

(a) The Treasurer of each local society shall be required to remit annually to the Treasurer of the Entomological Society of Canada on behalf of each paid up member of the local society a fixed fee as determined by the National Executive.

(b) Each local society may levy upon its own members an amount over and above the amount of the total national fee as it sees fit, this being retained by the local treasurer for the maintenance and expenses of the local society.

(c) Libraries or organizations and persons not wishing to join a local society affiliated with the Entomological Society of Canada or not residing in Canada may subscribe to the official journal of the Entomological Society of Canada by payment to the national Treasurer of an amount equal to the fixed fee determined by the National Executive.

Article 7: <u>Officers</u>

(a) The direction of the affairs of the Entomological Society of Canada shall be in the hands of a Board of Directors. Qualified members of the Entomological Society of Canada in each province of the Dominion shall elect one Director to the Board to represent the local or locals in that province. Two or more provinces may unite to elect one director if those provinces are organized as a region.

(b) Directors of the Entomological Society of Canada shall be elected for a term of two years. At the first meeting of the Board of Directors it shall be decided that approximately half of the members of the Board shall accept an initial term of one year only so that in future there will be an election of Directors from approximately half of the provincial or regional groups in each year.

(c) The Directors shall from amongst themselves elect annually a President and a Vice-President. Other officers, including Editor, Members of the Editorial Board, Secretary, Treasurer, Auditors, etc., shall be appointed annually by the Board of Directors in any way that may seem appropriate to them. Such appointed officers shall have no vote in matters being decided by the Board unless they are also directors.

(d) Officers of the Society may accept re-election or re-appointment for successive terms in the same office.

Article 8: Meetings

(a) The Entomological Society of Canada shall hold an Annual Meeting at such time and place as shall be determined a year ahead by the Board of Directors. This annual meeting shall be held in the East and the West of Canada on alternate years and shall, whenever possible, be held at the invitation of provincial or regional societies which shall act as hosts for the annual meetings.

(b) The Directors shall meet at the time of the regular Annual Meeting but may also call special meetings when necessary.

Article 9: Nature of Meetings

(a) Local societies affiliated with the Entomological Society of Canada shall continue to have full control of their own local meetings.

(b) The agenda of the Annual Meeting of the Entomological Society of Canada shall be drawn up by the Board of Directors who shall bear in mind the wishes of the local societies which they represent.

Article 10: Amendment of the Constitution

(a) The Constitution may be altered or amended at any time by an approving vote by ballot of two-thirds of the votes cast by members in good standing. Such alterations or amendments must be made by a local society or the Board of Directors by notice of motion which shall have been sent to all members. A period of six months shall be allowed for the return of the ballots.

APPENDIX V

Comments on Articles of the Proposed Constitution (as found in Appendix IV)

Note: Comments are numbered to agree with the Article in the Constitution with which they are concerned.

Comments on Article 1:

The discussion on this point emphasized that our members feel very strongly that the proposed Entomological Society of Canada should be in the nature of a learned society and that all possible precautions should be taken to prevent it from becoming merely another professional society.

Comments on Article 2:

Our members expressed the opinion that it is more or less unimportant to us whether Guelph or Ottawa happens to be chosen as the headquarters of the national society.

Comments on Article 3:

(c) The Manitoba Society feels that sufficient consideration has not been given by the Ontario group to the difficulties of financing and editing an adequate scientific journal. We are also inclined to believe that the Ontario group, on further consideration, may be less inclined to attempt the publication of a journal which will "embrace.................. all phases of Entomology." We, therefore, make the following suggestions in the hope that they will stimulate a closer study and a better understanding of the problems that are involved in this item.

We suggest that the Canadian Entomologist be continued as a publication under the same name but with its editorial policy modified so as to include the publication of:

(1) the material now published in the Canadian Entomologist

(2) the three types of material suggested in the Toronto Memo, namely:

(i) the material heretofore published in the Ann. Rep. Ent. Soc. Ont. and of other provincial and regional groups

(ii) brief news notes on the meetings of regional groups

(iii) naturalists' notes and notes of general interest

(3) a section of abstracts of all Canadian research papers and publications on entomological subjects

We further suggest that if the Entomological Society of Canada considers that there should be a unified outlet for the publication of research papers prepared by Canadian entomologists it might make arrangements to publish several issues annually of the Zoological Section of the Canadian Journal of Research. This policy would give us time to build up experience in estimating the volume and quality of Canadian papers suitable for such a publication and would be regarded only as an interim measure leading toward the eventual publication of a Canadian Journal of Entomology.

We feel that the name "Canadian Journal of Entomology," should be carefully reserved for use when the time is ripe for the publication of a periodical that will take its rightful place in entomological literature. It is proposed that, when the decision is made to embark on the publication of this Journal, the Canadian Entomologist should continue its policy of abstracting all Canadian papers on entomological subjects. We feel that this service will be of great value to workers all over the world.

Comments on Article 5:

(a) This article in the Constitution is designed to ensure the fulfillment of one of the purposes of the Entomological Society of Canada which, as we see it, is to promote the formation of local entomological societies and to strengthen them whenever possible. If this purpose is to be attained there should be no means by which an individual can evade his duty to support a local and yet secure the full benefits of the Society. See also Article 6 (c) which permits an individual to subscribe to the Journal without joining a local society and without claiming any of the benefits of membership.

Comments on Article 6:

The members voted in favour of charging the same fees to entomologists in other countries as are charged to Canadian members, in opposition to the suggestion from Eastern Canada that individuals and organizations in other countries be permitted to subscribe to the publications of the Society at a reduced rate.

The suggestion that student entomologists be permitted to join local entomological societies without paying the extra fees for membership in the national society or for subscription to the national publications, was supported unanimously.

Comments on Article 7:

(a) If Article 7 (a) is accepted by the National Society at the time of formal organization, there will be four Directors elected, one each from Quebec, Ontario, Manitoba and British Columbia. We may confidently hope for at least an increase of one due to the formation of a Maritime Branch and possibly others will also follow. A Board of four or five Directors is not large but should be large enough to conduct the affairs of the Society with the assistance of appointed officers.

The suggestion that each local society elect its own Director was made and promptly rejected.

(c) This item in the constitution was the cause of much discussion and all members were not in agreement. The item as it stands in the Constitution, was finally approved by a vote of 6 to 4.

(d) Our Society visualizes the proposed Entomological Society of Canada as a device for drawing together and unifying a number of local societies, each of which is to preserve a large measure of local autonomy. If this is so, then there is a distinct need for continuity in the National Executive (i.e. the Board of Directors). Thus it becomes undesirable that the term of office of a Director, especially if he happens to be the National President or Vice-President, should be terminated by the Constitution. We believe that Directors whose services are unsatisfactory will be eliminated by the local societies of their province in the elections which must be held every second year.

Comments on Article 8:

(a) Our members feel very strongly that the Constitution must provide for alternation of meetings between the East and the West. It was our suggestion that the Manitoba-Ontario border be taken to mark the division between eastern and western Canada.

(b) It was suggested that the following be included as a by-law: "In a meeting of the Board of Directors a quorum shall consist of not less than two-thirds of the number of elected Directors."

This item brought forth considerable discussion of the financial problems that will be faced by a national society. The only recommendation made, however, was that the expenses of the Directors of the Entomological Society of Canada incurred in attending the annual meeting should be paid out of the treasury of the national society.

Comments on Article 10:

(a) It was the opinion of the meeting that this procedure would permit a thorough discussion of such motions in local meetings in each province or region during the six months allowed for the return of the ballots.

APPENDIX VI.

The regular fall meeting of the Entomological Society of Manitoba was held at the University of Manitoba on Tuesday, November 11, 1947. A brief business meeting was called to order at 9:30 a.m. Those present were: Mr. R. R. Lejeune, President, Professor A. V. Mitchener, Dr. R. D. Bird, Mrs. W. S. Barker, Messrs. S. Filuk, H. Fyfe, J. McLintock, C. A. S. Smith, D. S. Smith, J. E. Wallis, H. Westdal, H. R. Wong and W. S. McLeod, Secretary-Treasurer.

The minutes of the meeting of September 24, 1947, were read and adopted.

It was moved by Professor Mitchener that the Secretary write a letter to Mrs. G. S. Brooks, expressing our sympathy for her in the loss of her husband, George Shirley Brooks, a member of this Society. Seconded by Mr. C. A. Smith. Carried Unanimously

Mr. C. A. S. Smith reported that the Brief prepared by the Executive had been submitted to the Honourable D. L. Campbell, Minister of Agriculture and Immigration for Manitoba. The Honourable Mr. Campbell had requested the Executive to discuss the matter with him and had given a very sympathetic hearing but was unable to give any assurance of financial assistance from Provincial Government funds.

Mr. Lejeune, who had just returned from the Annual Meeting of the Entomological Society of Ontario, reported on meetings of the full Committee on National Entomological Organization which had been held in Guelph at that time. He stated that it appears to be impossible to proceed immediately with the formation of an Entomological Society of Canada because of the magnitude of the financial problem. Prince Edward Island was the only Province which had promised that a constribution would be made. Members from Ontario, Quebec and Manitoba were unable to give definite assurance of financial assistance from provincial funds. No statement was forthcoming from British Columbia. Officers of the Dominion Government had stated their belief that such a national Society should stand on its own feet and should not expect a federal grant. It had, therefore, been decided that entomological societies should continue on the present basis for at least another year. Dr. W. R. Thompson, Editor of the Canadian

Entomologist, had expressed his determination to expand and improve this publication, however, and it was decided that the Committee on National Entomological Organization should continue its efforts. It was also reported that several entomologists had expressed their approval of the Proceedings of the Entomological Society of Manitoba and the type of work which is being done by this Society.

It was moved by Professor Mitchener that this Society strongly support the formation of an Entomological Society of Canada in the near future, either with or without a national publication but with such a publication as one of its ultimate aims. Seconded by Dr. Bird. <u>Carried</u>

It was moved by Mr. Wallis and seconded by Mr. McLintock that the Treasurer be authorized to make necessary expenditures in connection with the luncheon plates for guest speaker and stenographer and the tips for the waitresses at the noon luncheon on this day. <u>Carried</u>

It was moved that the business meeting be adjourned at 10:10 a.m.

R. R. Lejeune,
Chairman.

W. S. McLeod,
Secretary-Treasurer.

APPENDIX VII

The Constitution of the Entomological Society of Manitoba

Article 1. Title

This Society shall be known as The Entomological Society of Manitoba.

Article 2. Objects

The objects of the Society shall be:

(a) to foster the exchange of information on entomology

(b) to further the dissemination of entomological knowledge.

Article 3. Membership and Dues

(a) Any person interested in entomology may become a member on application in writing to the Secretary of the Society.

(b) A member may withdraw from the Society upon giving notice in writing to the Secretary.

(c) Levies or dues of amounts necessary for the operation of the Society may be made from time to time, as circumstances dictate, at the discretion of the executive and subject to the approval of a majority of the members present at a regularly called meeting.

(d) Small items of expense, not exceeding five dollars, which may be incurred during periods between meetings, may be met by the Secretary-Treasurer with the approval of other members of the Executive. Such expenditures must be ratified at the next regular business meeting by a majority of the members present.

(e) A member who neglects to pay the annual levy for two consecutive years shall automatically cease to be a member.

Article 4. Meetings

Meetings shall be called each year by the President at times and places suitable to the majority of the members.

Article 5. Nature of Meetings

The meetings shall be informal insofar as possible.

Article 6. Officers

The officers of the Society shall consist of a President, a Vice-President and a Secretary-Treasurer. These three officers shall constitute the executive with full power to act on behalf of the Society within the bounds of the constitution and to appoint committees as necessary.

Article 7. Elections

Elections shall be held once a year and officers so elected shall remain in office for a period of 12 months or until such time as another election has been held. The office of President shall not be held by the same member for more than two consecutive years.

Article 8. Alteration of the Constitution

The constitution and by-laws may be altered or amended at any official meeting of the Society with the approving vote of three-fourths of the members present and in good standing. Such alterations must be made by notice of motion which shall have been sent to the Secretary and a copy of such forwarded to all members at least two weeks before the general meeting.

Article 9. Minutes

The preparation and custody of the minutes shall be entrusted to the Secretary who shall also hold all books and records.