C. J. Robinson

PROCEEDINGS OF THE

ENTOMOLOGICAL SOCIETY OF MANITOBA

VOLUME 14 1958

THE QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1959

N O T E

The price of the Proceedings to non-members of the Entomological Society of Manitoba is $1.00 per volume. Requests for the exchange of publications and other correspondence concerning the Proceedings should be addressed to:

Entomological Society of Manitoba
c/o Regional Librarian
Canada Agriculture Research Laboratory
Box 322
University of Manitoba
Winnipeg, Manitoba

S. R. Loschiavo
Editor-Librarian.

Proceedings of the

ENTOMOLOGICAL SOCIETY OF MANITOBA

Vol. 14 1958

CONTENTS

CONTENTS

LIST OF MEMBERS

Executive

1957-58

President:
R. M. Prentice
Forest Biology Laboratory
Box 2
University of Manitoba
Winnipeg

Vice-President:
P. H. Westdal
Canada Agriculture
Research Laboratory
Box 322
University of Manitoba
Winnipeg

Secretary:
W. G. Ives
Forest Biology Laboratory
Box 2
University of Manitoba
Winnipeg

Treasurer:
L. D. Nairn
Forest Biology Laboratory
Box 2
University of Manitoba
Winnipeg

Editor:
S. R. Loschiavo
Canada Agriculture
Research Laboratory
Box 322
University of Manitoba
Winnipeg

1958-59

Honorary-President:
A. V. Mitchener
Norwood Apts.
99 Cartier Street
Ottawa 4, Ontario

President:
P. H. Westdal
Canada Agriculture
Research Laboratory
Box 322
University of Manitoba
Winnipeg

Vice-President:
A. G. Robinson
Department of Entomology
University of Manitoba
Winnipeg

Secretary:
W. G. Ives
Forest Biology Laboratory
Winnipeg

Treasurer:
L. D. Nairn
Forest Biology Laboratory
Winnipeg

Editor:
S. R. Loschiavo
Canada Agriculture
Research Laboratory
University of Manitoba
Winnipeg

Members 1958

Allen, W. R. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Askew, W. L. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Barrett, C. F. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Berck, B. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba

Bird, R. D. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Bradley, G. A. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Brooks, A. R. Canada Agriculture Research Laboratory, University of Saskatchewan, Saskatoon, Saskatchewan.

Buckner, C. H. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Butcher, J. W. Entomology Department, Michigan State University, East Lansing, Michigan.

Cole, T. V. Entomology Field Station, Box 627, Brandon, Manitoba.

Cox, G. A. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Eastwood, J. P. Velsicol Corporation, 700 Kellog Avenue, Ames, Iowa.

Ford, L. Production Service, Canada Department of Agriculture, 717 Dominion Public Building, Winnipeg, Manitoba.

Fox, W. B. Chipman Chemicals Ltd., 1040 Lynn Avenue, Winnipeg, Manitoba.

Fraser, G. R. Chipman Chemicals Ltd., 1040 Lynn Avenue, Winnipeg, Manitoba.

Fredeen, F. J. H. Entomology Laboratory, Canada Department of Agriculture, University of Saskatchewan, Saskatoon, Saskatchewan.

Furgala, B. Dept. of Entomology and Economic Zoology, University of Minnesota, St. Paul Campus, St. Paul, Minnesota.

Greaney, F. J. Line Elevators Farm Service, 765 Grain Exchange Building, Winnipeg, Manitoba.

Gurney, A. B. Division of Insects, U.S. National Museum, Washington 25, District of Columbia.

Handford, R. H. Entomology Laboratory, Box 210, Kamloops, British Columbia.

Heron, R. J. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba

Howden, J. S. Green Cross Insecticides, 110 Sutherland Avenue, Winnipeg, Manitoba.

Ives, W. G. H. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Kelleher, J. S. Entomology Field Station, Box 637, Brandon, Manitoba.

Lejeune, R. R. Forest Biology Laboratory, 409 Federal Building, Victoria, British Columbia.

Liscombe, E. A. R. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Loschiavo, S. R. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

McLeod, J. A. Department of Zoology, University of Manitoba, Winnipeg, Manitoba.

Melvin, J. C. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

*Mitchener, A. V. Norwood Apts., 99 Cartier Street, Ottawa 4, Ontario.

Muldrew, J. A. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Nairn, L. D. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Petty, D. J. Plant Protection Division, Canada Department of Agriculture, 722 Dominion Public Building, Winnipeg, Manitoba.

Prentice, R. M. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba

Procter, P. J. Department of Entomology, University of Manitoba, Winnipeg, Manitoba.

Pugh, S. Chipman Chemicals Ltd., 1040 Lynn Avenue, Winnipeg, Manitoba.

Reeks, W. A. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Richardson, H. P. Entomology Field Station, Experimental Farm, Morden, Manitoba.

Robertson, D. R. Provincial Entomologist, Department of Agriculture, Legislative Building, Winnipeg, Manitoba.

Robinson, A. G. Department of Entomology, University of Manitoba, Winnipeg, Manitoba.

Romanow, W. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Singleton, M. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Sinha, R. N. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Smith, D. L. Department of Entomology, University of Manitoba, Winnipeg.

≠ Stansfield, E. J. 917 Riverwood Avenue, Fort Garry, Manitoba.

Sutherland, J. R. G. Shadow Lane, Clark, New Jersey.

Thorsteinson, A. J. Department of Entomology, University of Manitoba, Winnipeg, Manitoba.

Turnock, W. J. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

*Wallis, J. B. 468 Niagara Street, Winnipeg, Manitoba.

Warren, G. L. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Watters, F. L. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Westdal, P. H. Canada Agriculture Research Laboratory, Box 322, University of Manitoba, Winnipeg, Manitoba.

Wighton, D. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

Wong, H. R. Forest Biology Laboratory, Box 2, University of Manitoba, Winnipeg, Manitoba.

---

* Life member.

≠ Deceased.

ENTOMOLOGICAL SOCIETY OF MANITOBA FINANCIAL STATEMENT

FOR YEAR ENDING DECEMBER 31, 1958

Receipts

Balance in Bank, Dec. 31, 1957		$222.04
Members' dues, 1958		151.00
Members' dues, 1959		156.00
Registration 1958 spring meeting		13.50
Registration 1958 fall meeting	17.00	
Sale of tickets for banquet	62.50	79.50
Sale of Proceedings		24.50
Transfer of I.G.P.C.E. account to E.S.M.		118.02
Bank interest		1.70
Cheques outstanding		102.00
		$868.06

Expenditures

1957 cheques outstanding cancelled	$126.00
Subscriptions to Ent. Soc. of Can.	246.00
Spring meeting 1958 expenses	35.21
Fall meeting 1958 expenses	122.40
Banking expenses	9.54
Cost of Proceedings	33.60
Stationery	12.54
Gifts	29.65
Cash on hand	.50
Bank balance on hand Dec. 31, 1958	252.62
	$868.06

Audited and found correct - Jan. 16, 1959

E. A. R. Liscombe

D. R. Robertson

Proceedings of the

ENTOMOLOGICAL SOCIETY OF MANITOBA

A society to foster the advancement, exchange
Vol. 14 and dissemination of entomological knowledge 1958

INTRODUCTION

The membership and Executive spent considerable time discussing the present and future policy regarding the Proceedings of the Entomological Society of Manitoba. The content of the Annual Proceedings has gradually evolved over a period of 14 years and in its present form includes complete manuscripts of research and review papers presented at the spring and fall meetings. These are listed or reviewed in a number of indexing and bibliographic journals. The question arises as to whether we should be satisfied with a mimeographed Proceedings or work towards publications comparable to those of other regional Societies, namely Quebec, Ontario, and British Columbia. Some preliminary steps were taken in 1958 to investigate ways and means of publishing our Proceedings. Two possibilities were considered: (1) Publication of our Proceedings at our own expense, but possibly with the financial support of some outside agencies; (2) incorporating our Proceedings in a larger journal consisting of annual reports from the three regional Societies of the prairie region. The first idea was dropped because of high costs, low membership and little liklihood of outside support. The second idea did not have the complete support of the three regional Societies. Nevertheless, the outgoing Executive recognized the need for further study of the disposition, format and content of our Proceedings. This subject will, no doubt, be given further consideration by the new Executive.

In 1958, Professor Mitchener, one of the founders and most loyal member of our Society, left Winnipeg and has taken up permanent residence in Ottawa. His enthusiastic participation in scientific sessions and business of the Society will be missed for many years to come. Our sincere wishes are extended to Professor Mitchener, who was recently appointed Honorary-President of the Entomological Society of Manitoba.

As Regional Director of the Society, I had the privilege of attending three meetings of the Board of Directors of the Entomological Society of Canada. My most noteworthy impression of these meetings was the truly national spirit which prevails in the parent society.

I wish to express my sincere thanks to all members and particularly to the Executive for their support during the past year.

R. M. Prentice
President

SPRING MEETING

Business Session

The Spring Meeting under the chairmanship of Mr. R. M. Prentice of the Entomological Society of Manitoba was held March 28 in the Entomology Building, University of Manitoba.

Minutes: The minutes of the 1957 fall meeting were read by the secretary who moved the adoption of the minutes as read. Seconded by S. R. Loschiavo. Carried.

Report of the Common Names Committee: H. R. Wong, chairman of the committee, reported that two common names are being submitted to the national committee. He moved the adoption of the report. Seconded by D. Wighton. Carried.

Treasurer's Report: Treasurer L. D. Nairn moved the following report be adopted as read. Seconded by W. R. Allen. Carried.

Financial Statement as of March 27, 1958

Debits

Bank charges	$ 2.04
Receipt book	.50
Total	$ 2.54

Credits

Bank balance, Dec. 31, 1957	$ 96.04
I.G.P.C.E. account transferred to Ent. Society of Manitoba	118.02
Annual dues, 1958	23.00
Total	$237.06
Bank balance	$234.52

The Treasurer reported that $125.00 of the above amount had been transferred to a savings account, where it will earn an interest of 1 3/4 per cent.

Report of the Regional Director of the Canadian Entomological Society: President R. M. Prentice read a report of the Regional Directors. No motions were brought forward, so Mr. Prentice moved adoption of report as read. Seconded by D. R. Robertson. Carried.

Business Arising Out of the Fall Meeting: W. R. Allen reported on the revisions of the constitution as suggested by the committee appointed to study the constitution. Professor A. V. Mitchener suggested changing the revision in Article 7 to read "years" instead of "terms". Motion by W. R. Allen to adopt Article 3 and Article 7 as amended. Seconded by R. J. Heron. Carried.

CONSTITUTION AND BY-LAWS OF THE ENTOMOLOGICAL SOCIETY OF MANITOBA

As revised and approved at the Spring Meeting, April, 1957

Article 1. Title

This Society shall be known as the Entomological Society of Manitoba in affiliation with the Entomological Society of Canada.

Article 2. Object

The object of the Society shall be to foster the advancement, exchange, and dissemination of entomological knowledge.

Article 3. Membership, Dues and Expenditures

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) An annual fee shall be levied from each member as provided for in Section 1 of the By-laws.
d) The Executive shall have the power to meet expenses required in the normal operation of Society business. Such expenditures shall be subject to subsequent ratification at the annual meeting by the majority of the members present.
e) A member who neglects to pay the annual fee 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. The fall meeting shall be considered the annual meeting.

Article 5. Nature of Meetings

The meetings shall be informal insofar as possible.

Article 6. Officers

The Officers of the Society shall consist of Past President, President, President-elect, Secretary, Treasurer, and Editor. The Past-President and President shall be those persons who have most recently completed terms of office as President and President-elect respectively. 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 at the annual meeting and officers so elected shall remain in office until the next annual meeting. The office of President shall not be held by the same member for more than two consecutive years.

Article 8. Alteration of the constitution and By-laws

The constitution 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 a general meeting. By-laws may be changed by a motion approved by the majority of the members present at any 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.

By-laws

1. a) The annual fee for full members shall be $1.00.
   b) A student membership shall be set at one-half the local regional fee.
   c) The fiscal year of the Society shall coincide with the calendar year; fees are payable in advance at the annual meeting.
2. The Regional Director on the Board of Directors of the Entomological Society of Canada representing the Entomological Society of Manitoba shall be that member of the Society holding the office of President during the first year of his term on the Board of Directors.
3. a) A financial statement is to be presented at the first general meeting following the end of the fiscal year.
   b) Two auditors shall be elected at each annual meeting to examine accounts of the current year.

Proposed revisions of constitution to be considered at meeting March 27, 1958

Article 3. Section (e) to be revised to read:

"A member whose annual dues remain unpaid after one year has elapsed from due date shall automatically cease to be a member."

Article 7. to be revised to read:

"Elections shall be held once a year at the annual meeting and officers so elected shall remain in office until the next annual meeting. The Past President, President, and President-elect shall not be re-elected to their respective offices for two successive years."

By-laws

In connection with by-law #2 it should be considered whether the President of the Society should necessarily be the Regional Director representing the Society on the Board of Directors of the Entomological

Society of Canada. As the constitution of this Society now stands only every second president would serve as the Society's representative on the board of the Entomological Society of Canada. Some differences of opinion on this matter were voiced at the fall meeting of the Society.

W. R. Allen
R. J. Heron
February 26, 1958

Discussion of the fact that only alternate presidents would act as regional directors on the board of directors of the Entomological Society of Canada prompted the following motion by D. R. Robertson.

"That the regional director on the board of directors of the Entomological Society of Canada be elected biennially at the appropriate annual meeting of the Entomological Society of Manitoba. The person elected should be an ex-officio of the executive or a member of the executive." Seconded by A. G. Robinson. Carried.

Report of the Editor: S. R. Loschiavo reported for the committee appointed to discuss publication and circulation of the Proceedings. He moved the adoption of the following report.

I am pleased to report that the 1957 Proceedings of the Entomological Society of Manitoba is now ready for publication and should be available for distribution within a few weeks.

We now have a permanent central address for the library of the Society. In the past considerable difficulty was experienced in the consolidation of correspondence and library acquisitions. Mr. Kent Oliver, Regional Librarian in the Canada Agriculture Research Building has agreed to accept all mail on behalf of the Society and to forward it to the current Editor. He further agreed to prepare and maintain a list of all exchange publications and to add to this list all future incoming publications received by him on behalf of the Society. A note was placed in the title page of the 1957 Proceedings to the effect that all requests and correspondence concerning the Proceedings be addressed to:

The Entomological Society of Manitoba
c/o Regional Librarian
Canada Agriculture Research Bldg.
Box 322, University of Manitoba
Winnipeg 9, Manitoba

At an executive meeting held on January 31, 1958 it was decided that the Editor should form a committee to discuss certain items of business affecting the publication and circulation of the Proceedings. This committee consisted of the following members: R. D. Bird, W. R. Allen, A. G. Robinson, D. R. Robertson, R. J. Heron, L. D. Nairn, and S. R. Loschiavo. At a meeting held March 5, 1957 the committee was informed that the president, Mr. R. M. Prentice had written to the Presidents of the Saskatchewan and Alberta Societies inviting them to express their personal opinions on the creation of a regional scientific journal or proceedings intended to serve as a suitable outlet for scientific papers and high quality reviews submitted by members of the entomological societies of the three Prairie Provinces.

The question of obtaining contribution numbers from the Entomology Division for papers published in the Proceedings was deferred until more information was available concerning a regional Proceedings. For the same reason the committee postponed asking the province to undertake the printing of the Proceedings. I might mention here the quotations submitted by two local printing firms to print the Proceedings in 10 point type. The figures are approximate and based on 48 pages.

350 copies	$10.77	and	$9.00/page	respectively
150 copies	$ 9.74	and	$7.50/page	respectively

Pending further action that may affect the future status and form of our Proceedings, the question of the necessity of increasing the number of copies was deferred by the committee. In 1956, 175 copies were printed some of which were distributed to visiting Congress delegates and to members of the International Great Plains Conference of Entomologists. About 30 copies remain. In 1957 we arranged to have printed 125 copies of which 54 will go to members and about 45 to those on our mailing list, leaving a reserve of about 26 copies.

Ways and means of reproducing back issues were discussed. If the Public Printing and Stationery Office was to do this work the cost may be too high. The Canada Agriculture Research Building may acquire a copying machine within a year. The possibility of acquiring this machine for our use should be investigated. The committee decided that presently the cost of reproducing back issues is greater than the economic returns. Since there are no pressing demands for back issues this matter was postponed until we could obtain the free use of a copying machine. In the meantime distribution of scarcer back issues could be restricted to institutions with facilities for extensive circulation.

The cost of the 1957 Proceedings was the same as that of other years, i.e. $1.00 per copy. The University of Nebraska Library was willing to accept 9 back volumes as a broken series for $9.00. We sent this library the 1956 volume gratis on an exchange basis in return for the Nebraska Agricultural Experiment Station and Extension publications. Also in exchange for our Proceedings the Society will receive Entomologie et Phytopatholigie appliquees, a quarterly published by the Entomology Research Department of the Iranian Ministry of Agriculture. Recently in answer to a request by the University of Idaho Acquisitions Library we sent 10 copies of available back volumes for which we will receive $10.00.

Seconded by W. A. Reeks. Carried.

Motions by S. R. Loschiavo: That honoraria be given to Miss L. Veltri for extra stenographic assistance, and to Mr. B. Snead for his co-operation in the successful publication of the Proceedings.

That a vote of thanks be extended to Mr. K. Oliver for his willingness to forward correspondence concerning the Proceedings to the incumbent Editor, and to prepare and maintain a list of all incoming exchange publications for the benefit of the members.

Motion by Professor A. V. Mitchener: That the matter of affiliation of proceedings with the Entomological Societies of Alberta and Saskatchewan can be brought up at the fall meeting. The President to make further effort to determine the possibility of such amalgamation by discussing it with representatives of Alberta and Saskatchewan at the I.G.P.C.E. meeting. Seconded by W. A. Reeks. Carried.

R. M. Prentice then moved that the meeting be adjourned. Carried.

In the evening members attended a social function in the Officer's Mess, McGregor Armouries.

Honorary Luncheon: A Luncheon Meeting was held at the Chicken Rib Restaurant on September 18, 1958 in honor of Professor A. V. Mitchener who was leaving the Province to take up residence in Ottawa. On behalf of the Society, Dr. R. D. Bird presented him with a small statue of a bronzed buffalo as a token of appreciation for his contributions to the Society.

Scientific Business: The scientific session of the spring meeting convened in the Department of Entomology, University of Manitoba on March 28. The session consisted of a film and slide showing chaired by W. A. Reeks and papers by A. V. Mitchener and A. J. Thorsteinson.

ROYAL JELLY, ITS PRODUCTION AND USES

A. V. Mitchener*
Professor Emeritus of Entomology
The University of Manitoba
Winnipeg, Manitoba

For many centuries honey bees in various parts of the world have been renowned for the production of a delicious food called honey and for beeswax, first used in candle making and now in countless other ways. Within the memory of many of us the therapeutic value of honey bee venom, especially for rheumatism, has been a lively topic for discussion. This was followed by a more important, widespread and sustained examination of the value of honey bees as pollinators of many of our fruit, vegetable and field crops. The latest apicultural topic to catch the public attention is the possible value of royal jelly as a remedy for certain human ailments and in the manufacture of cosmetics. This current interest occurs not only in Canada, United States and Mexico, but also in France and Italy and in some South American countries.

Many claims have been made that the use of royal jelly administered in some instances orally and at other times by intramuscular injections, stimulates human appetite, restores muscular strength, strengthens debilitated nerves, activates failing glands and generally creates a feeling of well being to tired and weak persons and even further that its use will cure a number of diseases. The claim is made also that some cosmetic preparations containing royal jelly will turn a dry dull skin into a vital glowing complexion. The makers of one skin cream claim that their preparation imparts moisture, vitamins and

---

* Present address: Ottawa

hormones to the skin and that it may be applied under make-up or as a pack. Most of these claims have not been substantiated by scientific investigations.

The gland system associated with the head end of the honey bee consists of hypopharyngeal, postcerebral, mandibular, postgenal and thoracic glands. Meckel (1846) first discovered two pairs of glands in the head cavity of the adult worker honey bee according to Ribbands (1953). The function of the anterior of these glands was not surmised for another 25 years, Fischer (1871). Schiemenz (1883) and others later confirmed Fischer's belief that these glands, now known as the hypopharyngeal glands, are the source of bee milk which is known to be fed at least in the early larval stages of the queen, worker and drone. This bee milk is also secreted and fed by nurse honey bees, to the queens and to the drones. Each coiled gland consists of approximately 500 or more small cellular bodies each of which is attached by a short neck to a duct which opens on the suboral plate of the hypopharynx, Snodgrass (1956). When dissected and distended each gland is about one and one-half times as long as the whole body of the worker honey bee. Hypopharyngeal glands are absent in the drones and vestigial in the queens. They are fully developed in the young or nurse worker honey bees whose function it is to feed all larvae as well as the adult queens and drones. In newly emerged adult worker honey bees, the hypopharyngeal glands are small and empty. Apparently workers must include pollen in their diet before their hypopharyngeal glands become fully developed. Haydak (1957) reported that the hypopharyngeal glands developed in the newly emerged worker until the fifth day, when they appeared to be mature; this maturity continued until the workers were at least 15 days old when they began to degenerate in some individuals. About one-half of the workers he examined at 38 days of age had degenerated hypopharyngeal glands. Fully active glands, however, were found in some workers 69 days old. In overwintered honey bees even older individuals 187 days old, had active glands when examined.

Ribbands (1953) makes a distinction between bee milk and royal jelly, a name first used by Perez (1884). The former is the secretion fresh from the glands of the nurse honey bee fed to the young larvae of all castes and to the queens and the drones. Royal jelly is the bee milk found in or taken from queen cells. This distinction should be remembered in the discussion which follows.

Royal jelly is a paste-like substance with an acid reaction and a distinctive pungent aroma. Its color has been variously described as white, milky-white, creamy, milky-gray or grayish-white. Perhaps these color variations are due to the different sources of the food of the nurse honey bees. Different authors have described its taste as mild, sharp, acrid, bitter or cheese-like.

Townsend and Lucas (1940) were perhaps the first in Canada to make a chemical analysis of royal jelly. Their interest was fostered by Dr. Banting of insulin fame. They divided royal jelly into four fractions, namely, (1) ether-soluble (2) water-soluble and dialysable (3) water-soluble and non-dialysable and (4) water insoluble. They stated that fraction one appears to consist of an organic acid or mixture of acids and "there is some evidence that fraction one contains the physiologically active material responsible for sexual development of the queen bee". Their work and that of others indicated the presence of a sex hormone.

Various researchers have analyzed royal jelly with surprisingly varying results. These differences may be due to different methods of obtaining samples of royal jelly for analysis and of making the analysis or they may be due to differences in food eaten by the nurse honey bees. An average of the analyses made by five different workers showed a moisture content of 65.3 per cent and 34.7 per cent dry matter. The dry matter contained fat, carbohydrates, protein, nitrogen, phosphorus, sulphur, ash (mineral) and undetermined material. Johanasson (1955) shows that in analyses of royal jelly made by several researchers the fat content varied from 1.73 to 13.55 per cent; the carbohydrate from 8.3 to 29.15 per cent; the protein from 9.0 to 45.0 per cent; the nitrogen from 2.24 to 4.45 per cent and the ash from 0.70 to 4.06 per cent. Of the vitamins found in royal jelly, pantothenic acid ranked first and this was followed by nicotinic acid. Other vitamins found were thiamine, riboflavin and pyridoxine. Haydak and Palmer (1938) found no vitamin E in royal jelly. Johansson (1955) states that of the 28 amino acids of importance to the protein chemist, 20 have been found in royal jelly. Quantitatively, royal jelly has a similar amino acid content to whole milk, egg or liver. Traces of pollen have been found in royal jelly, but they are believed to have been there by accident. Willson (1955) states that McCleskey and Melampy in 1939 found royal jelly to be bactericidal in its action and for that reason does not spoil under hive conditions. Willson's paper is an excellent review and should be read by anyone especially interested in royal jelly.

It has long been known, Schirach (1770), that both queens and workers are derived from the same kind of egg. The two castes or forms do differ, however, not only in size and structure, but also instinctively and physiologically. The queen is larger than the worker. Her mouth parts are shorter and not suitable for gathering nectar and she has no functional pollen baskets. Her ovaries and spermatheca are well developed while the ovaries of a normal worker are undeveloped. Her sting is curved and has very few barbs. Instinctively she remains in the hive except when on mating flights early in life and seldom uses her sting except on another queen. She is fed by nurse honey bees with bee milk only and is capable of metabolizing enough of that remarkable food to enable her to lay her own weight or more of eggs in a day and continue to do so for many successive days. The worker honey bee, on the other hand, has mouth parts well suited for gathering nectar and water and a honey stomach for holding liquids until she returns to the hive. Wax glands are fully developed on the undersides of segments four, five, six and seven of the abdomen. The barbed straight sting of the worker is well developed for effective defence. Instinctively workers perform during their life spans, many duties inside and outside of the hive, including brood rearing, gathering nectar, pollen, water and propolis, and generally looking after the welfare of the colony. There are other differences but the ones mentioned will serve to differentiate between the queen and the worker although each is a female honey bee. Our present information derived from the results of many researchers is that these differences are largly, if not entirely, the result of differences in the food fed to the larvae beginning between the second and third day of their larval lives. Larvae destined to become queens are supplied with an abundance of bee milk throughout their larval lives. It should be stated here as a reminder, that honey bees have four stages in their life histories namely, egg, larva, pupa and adult and that the immature honey bee of each caste is fed only in the larval stage. At approximately the end of the fifth day of the larval period both queen and worker cells are sealed. The bee milk supplied to the queen larvae is never restricted. In many instances more food is supplied than the larva requires resulting in some being left over in the cell when pupation takes place. Larvae destined to become workers are fed with an excess of bee milk for between two and three days, but thereafter their food is more restricted, Nelson and Sturtevant (1924). Queen breeders use larvae not more than two days old for grafting in their commercial breeding work. At the time the worker larval food is restricted it is also changed and thereafter includes honey or nectar and variable amounts of pollen grains from the stomachs of the nurse honey bees. This latter food is supplied progressively until the end of the larval stage.

The remarkable changes already mentioned that take place in the development of those larvae which develop into queens have been responsible for the more recent interest in the potency of bee milk and royal jelly upon which queen larvae are fed throughout their existence. These substances are also thought to be responsible for the greatly extended life span to several years of the adult queen over that of the adult worker which normally lives up to eight months. The possibility of the existence of something in royal jelly which, when used by humans would improve the health, welfare and longevity of mankind has aroused considerable interest in various parts of the world.

Smith (1957 a) carried out a detailed study of the causes of dimorphism in the honey bee under hive conditions and more particularly under laboratory conditions. He could detect no apparent differences in the hatching or initial feeding of queen and worker larvae. He was able to rear queens from (1) fresh royal jelly, (2) royal jelly which had been in the refrigerator for at least six months, (3) royal jelly which had been frozen for at least one year and (4) lyophilized royal jelly which had been stored in a refrigerator for at least 17 months. He found that air dried royal jelly at room temperature was darkened and that it failed to promote larval growth for more than one day. He found that the queens and the workers could be reared in other than their normal hive positions. He disproved the theory that limitations of space for developing larvae might have something to do with dimorphism. He found that there was a change in the food given to worker larvae during the third and fourth day with an increase in the amount of pollen given as development continued. He concluded, "It appears that food quality and total food intake are both important factors in female dimorphism. However, total intake is not necessarily dependent upon available food. The mechanism by which queens and workers are differentiated is still to be explained".

Smith (1954) used a commercial method of producing royal jelly in quantity. He confined the queen in a lower brood chamber beneath a queen excluder. Above the queen excluder he placed a super containing combs of honey, but with no brood. Immediately above he placed a super containing combs of open brood, pollen and nectar. Additional supers for the storage of honey were added under the top brood chamber as the season advanced. Larvae from about 18 to 24 hours old were grafted into artificial queen cells and arranged along three bars on a single otherwise empty frame and placed in the top brood chamber. This was done daily for three days; on the fourth day the frame containing the oldest larvae was removed and the royal jelly extracted by suction and stored immediately in a refrigerator. As soon as the royal jelly had been removed from the three bars on a particular frame the cells were grafted again and the frame returned to the colony. The nurse honey bees in any colony were at all times tending from 120 to 135 queen cells. At weekly intervals frames of sealed brood were removed from the top brood chamber and replaced with frames of eggs and unsealed brood from the brood chamber below the queen excluder.

Smith (1957 b) said that in 1957 they produced in the Department of Apiculture at Guelph, 40 pounds of royal jelly from 36 colonies by the system outlined. He estimated that it would require from 16 to 18 man hours per day to operate 36 colonies. In a 42 day period from June 20 to July 31, 1957 they produced 9997 grams (approximately 22 pounds) of royal jelly from 36 colonies. They collected the royal jelly in pieces of glass tubing about one inch in diameter and from six to eight inches long. A cork which could be pushed up inside the tube was fitted in one end of the glass tube and the royal jelly collected through the open end by air suction. When the tube was full a piece of 100 mesh nylon bolting cloth was placed firmly over the open end and the cork then pushed upward forcing the royal jelly through the nylon cloth to strain it. This removed any small bits of wax and improved the appearance of the royal jelly. It was then placed in one ounce jars and stored at 0°F in the deep freezer. Dr. Smith's production of approximately 352 ounces of royal jelly required an estimated 756 man hours; at $2.00 per hour it would cost for wages alone approximately $4.25 per ounce.

Chauvin (1956) reported that 200 kilograms (approximately 440 pounds) of royal jelly were collected in France in 1955. He reported that, "the quality of the product may be determined by physical tests among which the measurement of its conductibility is especially interesting and enables one to easily detect any addition of honey; the examination of the drug is completed by a microscopic study; the colour of the jelly in alkaline solution, the determination of the numbers and size of the exuviae enable to determine whether the jelly was collected within the prescribed dates and with the necessary care".

The proper collection and preservation of royal jelly is obviously very important if it is to retain its inherent qualities for queen development and possible therepeutic use. It has been shown by Smith (1957 a) that fresh royal jelly, frozen royal jelly, refrigerated royal jelly and lyophilized royal jelly are each capable of being used to rear queens. His work indicates some of the methods that may be used to preserve royal jelly for as yet undetermined periods of time and is an important contribution to science. The best method of preserving royal jelly is a matter yet to be determined.

The claims from different parts of the world that royal jelly has had beneficial effects on ailing mankind have been received with much skepticism because many of these claims have not been based upon the findings of scientific investigations. Willson (1957) has brought together much recent information on researches carried on in France especially by Dr. Remy Chauvin, Director of the French Government Apicultural Experiment Station at Bures - sur - Yvette, and his associates. These reputable researchers confirm the claims that it affects human glands, is effective for certain ills of the aging, in neuropsychoses and in nutrition. Dr. Chauvin reports on work done by Dr. H. Destrem, University of Bordeaux, that it stimulates the appetite and brings about a state of euphoria (well-being). A rise in the blood pressure of those suffering from low blood pressure was noted from its use, but no increase in blood pressure occurred in those suffering from high blood pressure. When taken orally the results seemed almost as satisfactory as when taken by injection in those people suffering from neuropsychoses. One researcher who used injected doses of 15 to 30 milligrams says that it took doses four times larger when administered orally to effect equally good results. Willson (1957) also gives some details of work done in Italy where vitamin B_{12} was reported for the first time in royal jelly. Three doctors of the University of Florence treated 42 children, aged from seven and one-half years down, suffering from malnutrition, with varying doses of royal jelly preserved in various ways. In every case, "when royal jelly treatments were given, a gain in weight was made irrespective of the age of the patient or the size of the dose or form of royal jelly used". They confirmed the findings of French investigators that royal jelly tends to stimulate the appetite. Willson reports on work done by a number of Italian doctors and those interested should read his article with the details.

Considerable interest has been created recently in the use of royal jelly among the manufacturers of cosmetics. In an article in Todays Health published by The American Medical Association, Chicago, in August 1955, the Secretary of the Committee on Cosmetics reviewed some of the claims made for the use of royal jelly in cosmetics and then said, "Whether or not it contains estrogenic hormones is not definite". A further comment was made to the effect that "favorable effects of royal jelly would be due to the vitamin B complex. At the moment there is no sound reason for thinking that this chemical will favorably affect the skin when applied topically".

Full page advertisements by two prominent manufacturers of cosmetics appeared in the October 1957 issue of Vogue magazine published in New York. In each advertisement royal jelly was featured as affording beauty benefits of a rather fantastic nature. Royal jelly in unstated amounts is used in face creams, liquids and lip sticks. The claim is made in one advertisement that it, "gives it a cling that almost makes you forget touch-ups! and all the while Royal Jelly is blessing your skin with its incredible beauty benefits". A third cosmetic manufacturer had an advertisement in the September issue of the same magazine.

A note under New Products in the Manufacturing Chemist published in London, England in July 1957 states, "a skin cream containing Royal Jelly (a jelly-like secretion upon which queen bees feed) has been placed on the market under the name Apiella Royal Jelly Skin Vitalizer by F. Farthing and Co. Ltd. The makers claim that this preparation imparts moisture, vitamins and hormones to the skin applied under make-up or as a pack. Apiella is packed in 2 oz. jars and retails at 2 guineas".

The writer in Winnipeg in March 1958 located a face cream containing royal jelly in a 1 7/8 ounce jar priced at $10.00 per jar. A four ounce container of a liquid cosmetic formulation sold at the same price. A one ounce jar of colored fluid makeup was priced at $3.75. Each contained royal jelly in an unstated amount. A one ounce cream preparation made in France containing royal jelly was available at $10.00.

At another retail location in Winnipeg, royal jelly in honey was on sale for oral use. A six ounce jar containing 1500 milligrams of royal jelly was priced at $8.00, while a larger 12 ounce jar containing 6085 milligrams of royal jelly was priced at $19.00. Sixty tablets each containing 50 milligrams of royal jelly along with other ingredients in stated amounts was another available form at $8.00.

To the writer it is evident that much has been learned about the composition and effects of royal jelly but much more research is needed. Wherein lies the magic of this product in producing queen honey bees? Further information is needed on the composition of royal jelly. Apparently some scientific background has been established supporting its therepeutic value for certain human ailments, but much more research is needed especially in North America. Claims have been made for it in the manufacture of cosmetics and it is being advertised and sold under these claims. Here again basic research is needed. Beekeepers may have something of great importance to humans and again they may not. The whole field should be investigated thoroughly on a scientific basis. If future findings are in accord with popular claims, a new field of production will open up for the specialist in apiculture.

I am especially indebted to Dr. M. V. Smith, Department of Apiculture, O.A.C., Guelph, Ontario for permitting me to study his unpublished Ph.D. thesis listed among the references at the end of this paper. He has made an outstanding contribution to our knowledge of royal jelly. I am also indebted to him for other favors through correspondence.

REFERENCES

Chauvin, R. 1956. La gelée royale - sa récolte et son rôle thérapeutique. Tenth International Congress of Entomology. Montreal (Abstract).

Fisher, G. 1871. Ueber die Funktion der Speicheldrüsen der Biene nach Schiemenz. Eichstadt. Bienenztg.

Haydak, M. H. 1957. Changes with age in the appearance of some internal organs of the honey bee. Bee World.

Haydack, M. H. and L. S. Palmer. 1938. Vitamin E content of royal jelly and bee bread. J. Econ. Ent. 31(5): 576.

Johansson, Tage S. K. 1955. Royal Jelly. Bee World 36: Nos. 1, 2.

Meckel, H. 1846. Cited by Ribbands (1953).

Nelson, J. A. and A. P. Sturtevant. 1924. The rate of growth of the honeybee larva. Bull. U. S. Dept. of Agric. No. 1222: 1 - 24.

Ribbands, C. R. 1953. The behaviour and social life of honeybees. Bee Research Association Limited. London.

Schiemenz, P. 1883. Ueber des Herkommen des Futtersaftes und die Speicheldrüsen der Biene nebst einem Anhange uber das Riechorgan. Z. wiss. Zool. 38: 71 - 135.

Schirach, A. G. 1770. (Natural history of the queen of the bees). Leipzig? French transaltion.

Smith, M. V. 1954. Some facts about royal jelly production. Gleanings in Bee Culture. 82(12): 714 - 715.

Smith, M. V. 1957 a. Some aspects of development and differentiation in the female of the honey bee (Apis mellifera L.), and its use as a test animal to assess the biological activity of royal jelly. A thesis presented to the Faculty of the Graduate School of Cornell University towards the degree of Doctor of Philosophy.

Smith, M. V. 1957 b. Personal correspondence.

Snodgrass, R. E. 1956. Anatomy of the honey bee. Comstock Pub. Associates, Ithaca, N. Y.

Townsend, G. F. and C. C. Lucas. 1940. The chemical nature of royal jelly. Biochem. Jour. 34: 115 - 1162.

Willson, R. B. 1955. Royal jelly: a review. American Bee Journal. 95 (9) (10).

SOME IMPRESSIONS OF THE SYMPOSIUM ON "INSECTS AND FOOD PLANTS", WAGENINGEN, NETHERLANDS, MAY 1957

A. J. Thorsteinson
Professor of Entomology
The University of Manitoba
Winnipeg, Manitoba

Black and white and colored slides were shown of the scenes in Holland and prominent personalities encountered by the speaker during his participation at this stimulating Symposium.

Additional slides were shown of some of the delegates from abroad at the Tenth International Congress of Entomology, Montreal, August, 1956.

ANNUAL MEETING

Business Session

The annual meeting of the Entomological Society of Manitoba was held November 27-28, 1958, in the main conference room of the Agriculture Building, University of Manitoba, Winnipeg. The meeting was opened by the President, R.M. Prentice who announced that Mr. G.P. Holland, Ottawa, would meet in the afternoon with Federal Entomologists and Forest Biologists, in the library of the Canada Agriculture Research Laboratory for informal discussions regarding the reorganization of the Department of Agriculture.

Minutes: In the absence of the Secretary, Mr. W.G. Ives, who was inadvertently detained out of town, minutes of the last meeting were read by P. H. Westdal and adopted as read on a motion by P. H. Westdal, seconded by T. V. Cole.

Business Arising Out of Minutes:

1. Mitchener motion re amalgamation of proceedings of Entomological Societies of Manitoba, Saskatchewan and Alberta.

Mr. Prentice read letters from Riegert of Saskatchewan and Ball and Hocking of Alberta. The idea apparently had been met with favorable consideration but neither Society felt that it was feasible at the present time. Mr. Prentice suggested that the matter be turned over to the new executive.

Report of the Editor: S. R. Loschiavo gave the following report.

One hundred and seventy copies of the 1957 Proceedings of the Entomological Society of Manitoba were printed of which 100 were sent out according to our mailing list. Some were sold and a few were given as complimentary copies. About 60 copies are on hand.

At least five papers are available for publication in the 1958 volume of the Proceedings. Suitable papers that were not presented at the Spring or Fall Meetings will be considered for publication in the 1958 Proceedings. Authors may submit their manuscripts to me or to the incoming Editor Librarian.

Exchange of publications was arranged with two institutions in the past year. In answer to requests several available copies of back volumes of the Proceedings were sent out at $1.00 per copy. During the past year Mr. Oliver and I catalogued all our accumulated publications in the Society's Library. New material is catalogued as it arrives.

Considerable discussion took place regarding contribution numbers for papers published in the Proceedings. Opinions expressed ranged from those who felt the Proceedings had outlived their usefulness and should be dropped to those that felt that the Proceedings were very useful and provided an outlet for articles that could not be published elsewhere.

It was suggested that the limited distribution of the Proceedings and the fact that they were not printed were the main reasons for the reluctance of the authorities to grant contribution numbers. Mr. Holland felt that the limited distribution was the important factor and suggested that perhaps an abstract could be published in the Proceedings and the paper published elsewhere.

In answer to a question raised by Dr. Bird, Mr. Loschiavo reported that cost of printing 350 copies would be about $400.00. Mr. Holland reported that the British Columbia Report of the Proceedings was supported by a grant from the Government supplemented by advertisements. The cost was about $300.00 per year. In the ensuing discussion it was suggested that the Provincial Government and Grain Companies be approached regarding support and that the possibility of sustaining memberships from Industry be investigated.

It was moved by W. J. Turnock, seconded by W. A. Reeks that the new executive invetigate the possibility of a new format and financial support for a printed journal. Carried.

The Editor's report was adopted on a motion by S. R. Loschiavo, seconded by W. Romanow.

Treasurer's Interim Report - L. D. Nairn: The treasurer did not give a complete report but he stated that cash on hand as at November 28 was $159.84.

Report of the Regional Director: The regional director, R. M. Prentice discussed some of the important minutes arising from the Annual Business Meeting and the two meetings of the Board of Directors at Guelph, Ontario:

Report of Treasurer: A statement of the cash position of the Entomological Society of Canada prepared by W. S. McLeod showed receipts over disbursement as of October 15, 1958, to be $7,811.83. Of this total, $3,064.71 was represented in a Savings Account and $4,747.12 in a Current Account. At the meetings, W. S. McLeod discussed ways and means of investing these funds at a much higher rate of interest than is now being obtained. At the final meeting of the Board of Directors, the treasurer was authorized to invest up to $5,000.00 in government bonds.

Affiliation with a National Biological Society: R. Glen reviewed the development and aims of the National Biological Society, The Canadian Society of Wildlife Biologists, and the Canada Federation of Biological Societies and also the services provided by the Agriculture Institute of Canada to organizations affiliated with it. The organizations that might be expected to provide a national voice for biology were the last two and the Royal Society of Canada. R. H. Wigmore read a letter of November 18, 1957, and a resolution of October 27, 1958, from R. W. Salt, Co-ordinator of the Canadian Insect Physiologists Group, recommending that the Society join the Federation; the physiologists preferred to join through the Society rather than as a separate group. After considerable discussion, on motion of R. Glen and J. Marshall, it was recommended that the subject of joining the Canadian Federation of Biological Societies be given special study during 1958-59, that the Executive Committee have the available information on the constitution of the Federation and other relevant matters assembled and distributed to all members of the Society, and that the directors representing the regional societies encourage study of the question, explain questions that arise, see that their Societies form some opinion, and report to the Board before the annual meeting in 1959. It was agreed that, for the Entomological Society of Quebec, the available information be provided also in French.

Editorial Board: H. H. J. Nesbitt had met with the President of the Society and two members of the Editorial Board concerning a provisional draft of editorial policy for The Canadian Entomologist. Some of the suggestions were: that only papers of lasting interest in entomology be accepted; that only papers by members of the Society be accepted; that every paper be examined by an anonymous referee for factual content and generalizations, that comments on presentation be made by the Editor, and that all comments be referred to the author; that every paper be accompanied by an abstract; that the references be listed in a regular form; and that scientific notes and comments be accepted. G. P. Holland referred to the fact that most of the 1958 issues of the journal had been two or three months late and mentioned that the printer for the Proceedings of the Congress was very satisfactory. It was agreed to recommend to the incoming board that, in naming the new editor, it be made clear that he and the Editorial Board, in consultation with the Executive Committee, should have a free hand in formulating editorial policy and in printing of The Canadian Entomologist.

Resignations and Appointment of Officers: W. R. Thompson resigned as editor of The Canadian Entomologist and R. H. Wigmore resigned as secretary of the Entomological Society of Canada. The following officers were appointed for 1959:

Editor	E. G. Munroe
Secretary	L. L. Reed
Treasurer	W. S. McLeod
Sustaining Membership Convener.	L. A. Roadhouse

Gifts to Retiring Officers: The Board recognized the indebtedness of the Society to W.R. Thompson and R.H. Wigmore for their long and faithful services as Editor and Secretary, respectively. On motion of F. O. Morrison and R. M. Prentice, it was agreed that the Executive Committee be authorized to expend up to about $75.00 in purchase of a suitable gift of appreciation for each of the two officers.

Annual Meeting, 1959: Mr. Nelson and Dr. Smith explained the usual organization of annual meetings of the Entomological Society of America, and expressed strong hope that the programs of the societies meeting jointly at Detroit in 1959 (Entomological Society of America, Entomological Society of Canada, and Entomological Society of Ontario) would be completely integrated. Dr. P. Oman will be President of the Entomological Society of America who would be attending the annual meeting of the Entomological Society of America at Salt Lake City this fall meet with the Board of the American Society at the Hotel Utah, November 30, concerning plans for the joint meeting.

Papers to be delivered at the joint meeting will be assembled by the program chairman into six sections. Titles and abstracts (limited to 50 words) will be required by September 1. The program will be put into galley form at the Washington office, checked by the Program Committee, and published in the September issue of the Bulletin of the Entomological Society of America. Separates of the program will be available and can be supplied to the Entomological Society of Canada at about $35.00 per hundred copies. The time for presentation of contributed papers will be limited to 10 minutes, with two minutes for discussion.

The joint meeting will be held from November 30 to December 3. About 650 members of the American Entomological Society were expected to attend, and about 150 members of the Entomological Society of Canada. A common registration fee of $5.00 was suggested.

Three evenings will be taken up with the banquet, the mixer (smoker), and a showing of movies and slides. Business sessions of the three societies will be held separately and concurrently. There will be no charges for meeting rooms.

It was agreed that Mr. Nelson and W. S. McLeod collaborate in checking the mailing lists of the American and Canadian Societies to avoid duplication in the distribution of programs. Programs should be sent to all members of the Entomological Society of Canada in advance of the meeting, at the expense of this Society.

Dr. Smith suggested that, for the various committees set up in connection with the joint meeting, the Canadian Society appoint members to work with committee members representing the American Society. He also suggested that the Entomological Society of Canada prepare scientific and technical exhibits, which are an important feature of annual meetings of the Entomological Society of America.

These general proposals for the joint meeting were approved by The Board. A.G. McNally thought the proposals would be very acceptable to the Entomological Society of Ontario.

Honorary Membership: The question was raised as to whether the Entomological Society of Manitoba should consider sponsoring Professor A. V. Mitchener as an honorary member of the Entomological Society of Canada.

It was noted that one of the qualifications was that a candidate should be an international figure. This brought forth the suggestion that perhaps the qualifications should be changed since this was a Canadian Society and not an international one.

It was moved by W. A. Reeks and seconded by R. D. Bird that the incoming executive ask Dr. Thorsteinson to investigate Prof. Mitchener's case and bring in a report to the next meeting. Carried.

Mr. Holland suggested that the Entomological Society of Manitoba should not overlook Mr. J. B. Wallace as a candidate because of his contributions as an outstanding amateur.

Report of the Nominating Committee - R. J. Heron:

Honorary President	- A. V. Mitchener
Past President	- R. M. Prentice
President	- P. H. Westdal
President elect	- A. G. Robinson
Secretary	- W. G. Ives
Treasurer	- L. D. Nairn
Editor	- S. R. Loschiavo
Regional Director	- P. H. Westdal
Auditors	- E. A. R. Liscombe
	- D. R. Robertson

Mr. Heron pointed out that his committee had named Professor Mitchener to the office of Honorary President, inconstitutionally, but had done so because Professor Mitchener had never held office even though he had largely fathered the Society.

In response to a call for nominations from the floor it was moved by A. J. Thorsteinson, seconded by R. Liscombe that nominations cease. Carried.

Meeting adjourned.

In the evening of November 27, a dinner meeting for members and their wives was held at Chan's Restaurant. Mr. G. P. Holland as guest speaker gave an interesting and stimulating talk illustrated with colored slides on his collecting trip to New Guinea, Australia, and the Fiji Islands.

Scientific Business

The scientific session of the fall meeting convened in the main conference room of the Agriculture Building, University of Manitoba on November 27, 1958. Topics of regional and general interest were discussed by J. A. Muldrew, W. A. Reeks, R. Sinha, and P. D. Gupta. Dr. R. M. McGinnis, Cereal Breeding Section, Canada Agriculture Research Laboratory, Winnipeg, led the discussion on J. A. Muldrew's paper and Dr. F. J. Greaney, Line Elevators Farm Service, Winnipeg, acted as discussion leader on R. Sinha's paper.

GENETIC ASPECTS OF INSECTICIDE RESISTANCE

J. A. Muldrew
Research Officer
Forest Biology Laboratory
Winnipeg

I INTRODUCTION

Insecticides have not been used against forest insect pests to the same extent as against pests in the fields of agricultural, household and medical entomology. This is probably the main reason why the appearance of insecticide-resistant species of forest insects is not yet a major problem in forest entomology.

I am currently investigating the problem of the development of resistance in the larch sawfly to one of its parasites - the ichneumonid Mesoleius tenthredinis. The eggs of the parasite deposited within the bodies of the host larvae become encapsulated by phagocytic blood cells which inhibit the embryonic development of the parasite. In Ontario, the Prairie Provinces, and the Lake States, the larch sawfly encapsulates a fairly high proportion (roughly 80 per cent) of the eggs deposited. In Newfoundland, New York State, and British Colubmia, however, less than five per cent of the parasite eggs are encapsulated. There is evidence which indicates that Mesoleius was highly successful in Manitoba and adjacent areas for a period following its introduction in 1910-11. The development of this resistance to the parasite may be a selection process whereby the susceptible elements in the population are progressively eliminated and if so, it may be analagous to the development of resistance to insecticides by many pests. To compare the larch sawfly resistance to Mesoleius with insecticide resistance, the literature on the genetics of insect resistance to chemicals was examined.

II HISTORY

The acquired resistance of insects to insecticide action was first observed with the San Jose scale and lime-sulfur sprays by Melander in 1914 and with California red scale and HCN fumigation by Quayle in 1916. The profound significance of the appearance of these rather insignificant forms was at first ignored by all save a few students of population genetics (Dobzhansky, 1941; Smith, 1941). Since the first report that houseflies in northern Sweden did not respond as expected to DDT in 1946 (Wiesmann, 1947), several hundred similar instances have been noted involving numerous species and many of the newer insecticides. The sudden dominance of these resistant forms threatened the usefulness of insecticides as basic weapons in the conquest of insect-borne diseases and agricultural enemies. Review papers by Brown (1958 c), Metcalf (1955) and others present many well-authenticated examples of resistance. The genetics of insect resistance to chemicals has been reviewed by Kitzmiller (1953), Grayson and Cochran (1955), Milani (1954, 1956), Crow (1957) and Brown (1958 c, 1959).

III DEFINITION OF TERMS

All living organisms can carry on their vital functions in the presence of a chemical up to a concentration that depends on the chemical, the species, the stage in life history, etc. This is termed tolerance. Any increase in this normal tolerance associated with selective breeding from individuals that survive exposure to such things as extreme temperatures, abnormal food, etc., is termed vigor tolerance. It is a non-specific improvement in the physical and biochemical condition of the insect.

Resistance denotes the added ability to withstand an insecticide acquired by breeding from those individuals which survive exposures to that particular toxicant insufficient to wipe out the whole colony. It usually extends to some degree to allied compounds. Resistant strains are able to tolerate doses of toxicants which would prove lethal to the majority of individuals in a normal population of the same species. The total ability of an insect to withstand an insecticide is the sum of vigor tolerance and true resistance but in highly resistant strains the vigor effect is relatively very small (Hoskins and Gordon, 1956). Brown (1958 c) has suggested that for pre-existing resistance, such as that of the boll-weevil for DDT, the word "refractoriness" be used and he uses "tolerance" to mean the same as the "vigor tolerance" of Hoskins and Gordon, i.e. increases in LD_{50} of approximately five times or less.

When a resistant strain is selected from a population the regression line relating percentage mortality and dosage becomes flatter as the LD_{50} increases indicating a heterogeneous population with respect to resistance to the insecticide. With more intensive selection the LD_{50} increases still further and the regression line becomes steeper again as the population becomes homogeneous for resistant individuals. A small movement of the line to the right with no change in slope indicates vigor tolerance.

IV ORIGIN OF RESISTANCE

There are two different, though not mutually exclusive, explanations of the role of the poison in the development of resistance:

(1) Preadaptation - Genetic differences in resistance are present in the population before the application of the insecticides, and the poison acts as a selective agent favoring the resistant genotypes.

(2) Postadaptation- The change to resistance is physiological and does not depend on the genetic constitution, of if the change is genetic, it is induced directly by the poison.

Entomologists have almost universally accepted the preadaptive explanation on the basis of the following evidence: (a) the repeated failure to demonstrate directly acquired resistance to insecticides. Beard (1952) found that Galleria larvae that survived doses of DDT, nicotine, or pyrethrum were made the more susceptible to doses given one week later. Similar results were obtained for Musca by Hadaway (1956). It has been found with Pediculus (Cole et al, 1956), Musca (Harrison, 1952), and Drosophila (Luers, 1953) that resistance in laboratory populations increased in successive generations only if the levels of DDT applied were sufficient to cause some degree of mortality; (b) the failure to demonstrate that insecticides increase the mutation rate. Luers (1953) and Pielou (1952) exposed Drosophila to DDT and gamma-BHC and found no increase in the mutation rate of recessive lethals in the X-chromosome; (c) the failure to attain any appreciable change in resistance from selecting within inbred or isogenic lines. There is no reason to think that direct effects of the insecticide would be any less effective in isogenic than in heterogenous strains (Merell and Underhill, 1956).

Genetic analyses of Drosophila and Musca offer no evidence for extra-chromosomal inheritance of resistance. With the exception of the sex-linked gene for HCN resistance in Aonidiella, the genes for resistance are characteristically autosomal. In *Blatella germanica* induced DDT-resistance shows some maternal effect, attributable perhaps to delayed phenotypic expression, in that the F_1 always resembles the female parent more closely than the male in reciprocal crosses (Cochran *et al*, 1952; Crow, 1957).

Ordinarily evolution is so slow that changes within a human lifetime cannot be seen in wild species but the development of resistance to insecticides constitutes an important exception to this and perhaps is the best proof of the effectiveness of natural selection yet obtained. The evidence supports the view that the insecticide acts as a powerful selective sieve for concentrating resistant mutants that were present in low frequencies in the original population. The appearance of DDT-resistant houseflies in widely separated parts of the world supports the view that such mutants occur frequently in natural populations. On the other hand, because of marked variation in the type and degree of housefly resistance in various localities in Denmark, Keiding (1953) has suggested that the geographical distribution of genes influencing resistance varies considerably even in an area as small as Denmark. This indicates that selection within any limited group will reveal only the resistance that was potentially available in the group.

In the case of the California red scale, which developed a resistance to cyanide sprays, the evidence indicates that the relative proportions of the resistant and susceptible forms depends on an equilibrium which is related to the frequency of fumigation. Evidently, infrequent fumigations enable the susceptible race to increase to such proportions between fumigations that it becomes the dominant race; but with frequent fumigations, the numbers of "susceptibles" are kept low relative to the resistant race which breeds more slowly but has a better chance of being alive after fumigation. It is believed that in the absence of fumigation, the susceptible race is superior or it would not have been dominant (Smith, 1941).

V MANNER OF INHERITANCE OF RESISTANCE

A. Difficulties in the Genetic Analyses of Resistance

Major genes are those which are readily identifiable because of the pronounced effects of their individual functions whereas polygenes (or multiple genes) are those whose individual contributions to phenotypic differences are small and may be obscured by the effects of the genotype as a whole and by the influences of environment.

It is difficult to distinguish monogenic from polygenic factors except in Drosophila. It is customary in quantitative characters to assume that any trait that does not lead to Mendelian segregation is polygenic. Crow (1957) defines polygenic as any number of factors larger than can be individually identified, which may mean only a few though the number is usually assumed, often without warrant, to be large enough to permit statistical manipulations based on a normal distribution (Lerner, 1954).

A single factor, if it has highly variable expression, can appear to be polygenic. Such a factor can be very easily misinterpreted in a trait like resistance where the individual response is all or none. Analysis of such characters is especially difficult (Schultz and Redfield, 1951). Milani (1956) pointed out that some examples of resistance that at first appeared polygenic in origin were found with closer study and using purer strains to be monofactorial.

The best method of isolating a major factor is by repeated backcrossing with selection (Wright, 1952, p. 28). For example, if resistance can be maintained with mild selection over several generations of backcrossing to a susceptible strain, there is probably a major gene. Busvine (1953) starting with a strain resistant to both DDT and BHC was able to separate DDT resistance from BHC resistance with rather mild selection, indicating that very few genes were involved, although different genes were involved with respect to these two chemicals. Perhaps the best evidence for polygenic inheritance would be the repeated failure to isolate a major gene by repeated backcrossing.

B. Manner of Inheritance in Various Genera

(1) Drosophila - Certain natural mutant strains have shown considerable tolerance to DDT although they had never been exposed to this insecticide (Kikkawa, 1953). Field collected strains subjected to DDT pressure for 40 or more generations have usually shown less than a ten times increase in tolerance (Crow, 1954; King, 1954, 1955 b). Both the natural and the developed tolerance extend to other insecticides (Kikkawa, 1953; Tsukamoto, 1955; Bartlett, 1952). It is generally agreed that Drosophila has developed a vigor tolerance only and not true resistance. This tolerance has been much studied, however, since a precise genetic analysis is possible.

Most of the investigators who have worked on the tolerance of Drosophila adults have concluded that they were dealing with polygenic systems (Oshima and Hiroyoshi, 1955, 1956; Crow, 1957; Merell and Underhill, 1956). King and Somme (1958) subjected two DDT-tolerant strains of D. melanogaster separately to chromosomal analysis. In the case of each line, an LD_{50} was obtained for flies from every one of the 27 possible combinations of the three large chromosome pairs; homozygous non-tolerant, heterozygous and homozygous tolerant for each pair. The non-tolerant chromosomes were taken from the control stock from which the tolerant lines had been developed by selection. They found that the factors for tolerance were located on each of the three chromosomes and that their apportionment among the three was not the same in the two lines. The fact that the relative potency of the three pairs of chromosomes differed between the two tolerant lines indicates that there are several factors on each. They could not conclude that among the chromosomes with which they worked a single set might not have been isolated which would have shown the major portion of tolerance to segregate as a single gene but they believe that if the original population had contained such a gene, it would have become fixed as the basis for tolerance in each subpopulation.

Ogaki and Tsukamoto (1953) found tolerance to both DDT and BHC in D. melanogaster to be attributable to a single gene which they were able to localize in a given region of chromosome II but they were measuring larval tolerance, which seems to differ genetically from tolerance in the adult. King (1958) reported that adult flies from a line selected successfully for larval tolerance are not necessarily tolerant. On the other hand, lines which have been selected for adult tolerance usually display high larval tolerance, thus there are at least two kinds of heritable larval tolerance, one associated with adult tolerance and one entirely separate from it.

(2) California red scale - Dickson (1941) tested over 100,000 of these scales for resistance to cyanide and found the data to be in excellent agreement with a sex-linked resistance factor without dominance. The females are resistant (RR), intermediate (Rr) or susceptible (rr), and the heterogametic males are either resistant (R) or susceptible (r). It was found that susceptible strains usually contain a small proportion of highly resistant females suggesting that by selection of this part of the population it should be relatively easy to change a susceptible into a resistant strain. From five susceptible strains subjected to selection by fumigation only two became typically resistant and these did so in a relatively few selections. It was concluded that the resistant genes must be linked to an essential biological function for them to become predominant in the population (Lindgren and Dickson, 1945).

(3) Houseflies - Work with houseflies has been hampered by lack of basic knowledge of housefly genetics, and additional confusion has resulted from the criteria used for evaluation of resistance; typically rate of paralysis, i.e. "knockdown", and mortality. There is some evidence that these two factors may be independently controlled genetically. Harrison (1951) showed that resistance to knockdown in an Italian strain is controlled by a simple Mendelian inheritance involving a single recessive gene allele. Harrison (1954) repeated the hybrid crosses and obtained the 24-hour mortalities for different doses of DDT. There were no clear-cut Mendelian ratios in the F_2 generation but a heterogeneity in response greater than that of either parent. Harrison (1953) concluded that in this strain resistance to kill was multifactorial in origin and that knockdown-resistance and kill-resistance were inherited in different ways.

Milani (1954, 1955) studied another Italian strain that was characteristically kill-resistant, but many of which were not knockdown-resistant. The results of crosses of this strain with a susceptible one showed that knockdown-resistance derived from a single recessive gene. Milani concluded that in heterozygotes this gene had no penetrance for knockdown-resistance but a partial penetrance for kill-resistance. He went on to show (1956, 1958) that the results obtained by Harrison for kill-resistance could be explained on the basis of a single gene.

Most of the instances where polygenic inheritance has been reported are based largely on the gradual acquisition of resistance and the absence of clear-cut monofactorial ratios (D'Allessandro et al, 1949 (knockdown-resistance); Bruce and Decker, 1950; La Face, 1952; Crow, 1952; March, 1952; Norton; 1953; Pimental et al, 1954; Reed, 1954). Norton for example, found no differences in the pattern of resistance transmission from crosses of two resistant strains or between resistant and susceptible strains. Resistance of the F_1 generation in all cases was intermediate between that of the parents and was maintained at a constant level for 10 successive filial generations. Successive backcrosses to resistant or susceptible parents progressively increased or decreased the resistance.

Recent work has indicated the presence of a single autosomal dominant gene for high resistance to DDT. Two laboratory strains of houseflies have been shown to carry this gene, one studied by Maelzer and Kirk (1953) and the other studied by Lichtwardt (1956). The stock of Maelzer and Kirk was a mixture of 50% weakly tolerant specimens and 50% entirely resistant individuals. Crosses of the weakly tolerant specimens with a susceptible strain gave a roughly intermediate F_1 and a more wide-ranging F_2 in which approximately two per cent approached the highly resistant strain in resistance. Crosses of the resistant specimens with susceptible flies gave an F_1 which was uniformly resistant and an F_2 showing Mendelian segregation but with susceptible flies in excess of the expected. They concluded that the single dominant gene or its alleles could be, in general, the primary genetic mechanism for high resistance in field populations, and that other factors, although present, would contribute to a lesser type of resistance. Maelzer and Kirk believe that this was because the flies homozygous for the resistant gene had reduced fertility. They were unable to maintain a stock homozygous for strong resistance.

King and Sømme (1958) admit that these workers have demonstrated the presence of a single segregating factor producing high resistance. They point out, however, that the evidence also suggests that this single factor may be a complex which under certain circumstances may remain intact through two generations but which may also be broken up by recombination as indicated by the results of tolerant X susceptible crosses, or synthesized as indicated by the results of the resistant X susceptible crosses. They stress that the data supporting major gene control do not show that differences in mean resistance to DDT between sizable, randomly breeding populations can be explained by a difference between the two populations in the frequencies of two alleles at a single locus.

Lichtwardt (1956) concluded that the DDT-resistance of a laboratory strain was due to a single dominant gene allele. Lichtwardt, Bruce and Decker (1955) showed that the DDT-resistance in wild housefly populations of Illinois was due to a similar single gene allele. They found that sex evidently modified the penetrance of the DDT-resistant gene, since males were more susceptible than females per unit body weight. They also concluded that other genetic factors could contribute to the weaker type of resistance. Apparently in the absence of the main gene houseflies can develop only moderate DDT-tolerance due to minor polygenes, but in the presence of the main gene these polygenes act as modifiers enhancing the resulting strong DDT-resistance (Brown, 1959). Lovell and Kearns (1956) demonstrated that the inheritance of the DDT-resistant gene parallels the inheritance of DDT-dehydrochlorinase content, the heterozygotes having a content intermediate between the homozygous resistants and the homozygous susceptibles.

Crow (1957) believes that DDT-resistance in houseflies is probably not the same in various strains: "occasionally there is a single mutant that confers a high level of resistance, but it is likely that there is a great deal of polygenic variability as well, and the accumulation of several such factors in one strain may result in a high level of resistance, although this has not been demonstrated to date". Merell and Underhill (1956) believe that different populations of the same species may become resistant by different genetic mechanisms--depending on whether the genes originally present which increase the chances of survival in the presence of DDT are polygenes, a single dominant, recessive genes or a combination of these.

(4) Resistance in Mosquitos - Davidson (1956) crossed a dieldrin-resistant strain of *Anopheles gambiae* with a susceptible strain and obtained results consistent with Mendelian segregation of alleles of a single gene of incomplete dominance. In untreated areas of West Africa as many as 12 per cent of the mosquitos may be heterozygous for this gene (Hamon *et al*, 1958). Application of dieldrin or BHC for one to three years can change the population to over 90 per cent homozygotes (Armstrong *et al*, 1956). Davidson (1958) also studied the DDT-resistance of *Anopheles sundaicus* and concluded that it is due to a single gene allele. Coker and Busvine (1957) reported that studies on *Aedes aegypti* indicated that DDT-resistance is due to a single gene allele.

DDT-tolerant strains of *A. atroparvus* were found to have a far greater frequency of chromosomal inversions than the normal. Selection with DDT increased the frequency of inversion heterozygotes (D'Allesandro *et al*, 1958). Brown (1959) suggested the possibility that these inverted sections of chromosome could simulate a single gene, the new gene position effects thus stabilized on them making for resistance.

(5) Resistance in Spider Mites - In two *Tetranychus* species, Taylor and Smith (1956) studied crosses between resistant and susceptible strains for malathion. Their results are consistent with the interpretation that resistance is a result of a single dominant factor.

VI THE PROCESS OF SELECTION FOR RESISTANCE

Selection programs have shown that there is a lag extending through a few to many exposed generations during which resistance increases but little. When LD_{50} levels are plotted against the successive generations the curve is usually sigmoid with the period of rapid increase occurring approximately between the tenth and twentieth generations, (Decker and Bruce, 1952). March and Metcalf (1952), applying gamma-BHC pressure to a strain of *Musca*, found the rapid increase took place between the 30th and 40th generations. The lag may be partly due to a kinetic effect depending on the abundance of the resistance factors. If there is no dominance the rate of change is proportional to $q(1-q)$ where q is the frequency of the resistance gene. The rate of change and also the variability of the population attributable to this gene reach a maximum when half the population have it. At higher frequencies the rate of change and variability both decrease but this is likely to happen only if resistance depends on one or at most a very few genes. It will not occur if the resistance genes carry or are linked with such harmful effects that a balance is reached between their benefits in protecting from the toxic chemical and the weakening which they cause. This may be the explanation for the many cases where intensive selection of houseflies for DDT-resistance failed to reduce the heterogeneity of response (Hoskins and Gordon, 1956; Robertson, 1955).

It has been suggested (Brown, 1959; Milani, 1956, 1958) that the long latent period is one during which modifier genes (those which alter the expression of other genes) are accumulated, incompatible genes are eliminated and the genotype as a whole is prepared for the gene allele that produces strong resistance.

The rate of progress by selection ordinarily depends on both the selective intensity and the amount of heritable variance in the population. Pimental et al (1953) found for Musca that resistance developed faster when the selection pressure was high and Bruce and Decker (1950) found that resistance was accelerated when larval pressure was added to adult pressure on Musca. Merrell and Underhill (1956) found with Drosophila that if the selective dosage was halved the increase was greatly reduced and if it was reduced to one tenth, the increase was inhibited. Resistance in Musca has developed rapidly in the field, usually two years after the introduction of DDT and one year after the introduction of BHC, chlordane, or dieldrin (Brown, 1958a). Where resistance is of polygenic origin, and if the selection pressure is too intense in laboratory studies, the absolute number of survivors may not be large enough to maintain the genetic variability (King, 1955; Crow, 1957).

VII FACTORS ASSOCIATED WITH RESISTANCE

A. Morphological

Wiesmann (1947) found a resistant strain of fly in Sweden distinguished from susceptible flies by stiffer tarsal bristles, wider tarsal segments, and thicker cuticle and intersegmental membranes of the pulvilli. Bigelow and Le Roux (1954) found distinct morphological differences between three resistant and four susceptible strains in the ratio of the width to length of the second abdominal sternum, and the widths of terminal antennal segment to the frons. Morrison (1957) determined the width-length ratio of the second abdominal sclerite for 19 different strains and found that the nine lowest were all susceptible strains. One of these strains, however, was actually DDT-resistant (Brown, 1958 c). Barber et al (1948) reported that puparia of a resistant strain of flies were larger than those of susceptible flies. Resistance has also been associated with a broken costa (Lichtwardt et al, 1955), black abdominal sclerites (Lichtwardt, 1956) or reticulation of the posterior transverse vein (Milani, 1955).

March and Lewallen (1950) concluded that the differences in tarsal segments between a resistant and a susceptible strain were neither uniform enough nor large enough to be attributable to any morphological differences resulting from DDT-resistance. Sokal and Hunter (1955) measured about 1,000 flies from 5 resistant and 4 susceptible strains of the housefly. They measured 16 characters and computed 4 ratios and found that DDT-resistance was not correlated with any of these. To explain the absence of a common morphological correlate they postulate that different genetic systems conferring resistance have evolved each with different morphological correlates. The characteristics found associated with resistance must derive from other genes either linked or accidentally associated with the resistance genes (Brown, 1958 b). March and Lewallen (1956) compared four susceptible and five resistant strains of the housefly by means of paper chromatography of fresh tissue extracts. They found no differences that could be directly correlated with susceptibility or resistance. Instead, the differences seemed to be correlated with origin of the strain.

B. Biological Factors and Reversion

The extent of correlation between adaptive value and resistance in insects is an important question in determining the rate of reversion of resistant strains (i.e., the return to susceptibility with relaxed selection). "Adaptive value" here refers to the ability of a given genotype, relative to that of other genotypes, to transmit their genes to future generations (Lewontin, 1955). Since the genes causing insecticide resistance were at low frequency in the population before the insecticides began to be applied, it must ordinarily be true that they are to some extent disadvantageous; otherwise they would have been common. Therefore the selection for resistance should ordinarily involve the replacement of the original genes with resistance factors, that, in every respect except insecticide resistance, are deleterious from a survival standpoint. One should then expect that when the culture is grown in the absence of the insecticide it will return to susceptibility. This return may, of course, be very slow if the factors are only mildly disadvantageous. Hoskins and Gordon (1956), however, point out that since many species are highly tolerant (or refractory) towards chemicals that are harmful to others, defense mechanisms need not be deleterious.

(1) Evidence indicating resistant strains have a lower adaptive value.

In houseflies the length of the larval period has been found to be longer in some resistant strains than in comparable susceptible strains (Bruce, 1949; Pimental *et al*, 1951; Decker and Bruce, 1952). Others have found that the total developmental time from egg to adult was longer in resistant than in susceptible strains. McKenzie and Hoskins (1954) found that selection of the latest-emerging houseflies increased the average DDT-resistance of a culture without any exposure to DDT and its analogs and selection of the earliest emergents decreased it. The late-pupating substrain, however, was not resistant to lindane, aldrin, dieldrin and pyrethrins. Bochnig (1956) found that three DDT-tolerant strains of *Drosophila* were about 15% heavier than normal, had larger head and wing measurements, and showed longer larval periods.

Milani (1954) observed during crossing experiments that the average fecundity of houseflies was higher in cultures obtained from females of a susceptible strain and lower in females of a resistant strain. He pointed out, however, that inbreeding brings about a fall in fecundity and the reduction in fecundity in resistant strains is due in part to excessive homozygosis (Milani, 1956). Maelzer and Kirk (1953) found that low fertility was associated with the single pair of alleles that controlled high resistance to DDT in the houseflies they studied. Barbesgaard and Keiding (1955) obtained evidence for a resistant strain of housefly that a lethal gene was linked to the resistant gene. Lichtwardt *et al*, (1955) counteracted a tendency of their inbred DDT-resistant lines of houseflies to die out by selecting for fertility and hardiness. Two such strains, although weak and rather infertile, when crossed produced large and hardy F_1 offspring.

Sokal and Hunter (1954) studied eight strains of *Drosophila* with low larval resistance to DDT and found that three strains tended to pupate at the periphery of the medium. They were able, however, to break this correlation by simultaneously selecting for the opposites in these two characters (Sokal, 1956). Grayson (1954) reported for a strain of *Blatella germanica* resistant to chlordane that fewer nymphs per female and also per egg case were produced in comparison to a strain of susceptible roaches. Body weight was also lower for the resistant strain.

(2) Evidence indicating no correlation between resistance and adaptive value.

A number of workers have been unsuccessful in their attempts to correlate degree of resistance with such factors as duration of the egg, larval, pupal and adult stages; number of eggs laid and per cent hatch; average weight of pupae and adults; sex ratio; pre-oviposition period; survival within the life cycle; susceptibility to heat and cold, etc. (March and Lewallen, 1950; Pimental *et al*, 1951; Gagliani, 1952; Babers *et al*, 1953). Other workers have found variations between strains in such characters but these differences were not correlated with resistance. Norton (1953) found that longer than normal life cycles in flies were not necessarily associated with insecticide resistance and concluded that the associations were purely coincidental reflecting the response of the individual strain to its environment. Varzandeh *et al*, (1954) made a rather intensive study of the biological characteristics of three susceptible and four resistant strains of houseflies and concluded that the inheritance of the factors associated with vigor was independent of the factors associated with resistance. Many factors varied considerably between strains, for example egg production differed by as much as 300 per cent but they found that such characters were correlated with general vigor rather than resistance. Knapp and Knutson (1958) found there are innate differences between populations of houseflies that are not necessarily correlated with resistance. Two susceptible strains collected on ranches 110 miles apart in Kansas produced 24.3 and 49.8 offspring per female parent respectively.

Brown (1958 c) has emphasized that reversion due to superior adaptive value of susceptibles in relation to resistant members in an insecticide free environment applies only to competition within a strain; if resistant strains as a whole are compared with susceptible strains there are no consistent differences in their bionomics.

Knutson (1959) studied changes in field populations of houseflies following repeated applications of dieldrin and found that the number of adult progeny produced per female was statistically greater (42) than the prespray figure (36). Adult progeny per female in laboratory populations of houseflies ranged between 148 and 330. Afifi and Knutson (1956) found that the F_1 survivors of dieldrin application produce more eggs than normal but not the F_2 and F_3 generations. Hunter *et al* (1958) found that the potential adult offspring for females of a susceptible strain treated with sublethal doses of DDT was 18% above that of the controls whereas the females of a resistant strain treated similarly produced 34% fewer potential adult offspring than untreated females.

Bøggild and Keiding (1958) compared the adaptive value of resistant and susceptible strains having the same origin by rearing mixed cultures. They started with equal numbers of eggs of each strain and later separated the adult flies on the basis of time required for knock-down on a DDT-treated surface. They found that under conditions of severe competition (high densities) the DDT-resistant strain clearly survived better.

Bøggild and Keiding believe that the conflicting results obtained with respect to the relative fitness of resistant and susceptible flies indicate that correlations of lower fitness with resistance are due to linkage (the disadvantageous genes occurring in the same linkage group(s) as the resistance gene(s) rather than pleiotropy (i.e., multiple effects of a single genetic factor). Alternative explanations may be that the associations may be accidental or due to selection for fitness to the breeding procedure in the laboratory (see Sokal and Hunter, 1958). The adaptive value of small, isolated, laboratory populations may also change due to inbreeding or random genetic drift. When the environment of two genotypes is changed their relative adaptive values may be changed or even reversed since the adaptive value is a function of the environment. Ideally, comparison studies should be carried out in a natural environment with field-collected insects from the same area. One of the reasons why the postulated inferior adaptive value of the resistant strains as compared to that of the susceptible strains has not been commonly demonstrated in field and laboratory studies may lie in the fact that it is not necessary for a favoured variant to have a large selective advantage if it is to spread in the population. The selective advantage may be so small that it cannot be measured by any experiment since a very large number of individuals would have to be tested to give data having statistical significance. With a small selective advantage the favored variant may take a considerable period of time to become prevalent in the population and yet the rate of change might be rapid in relation to the magnitudes of most evolutionary changes. However, after frequencies have become established in different populations, it may then be possible to measure the survival values that the evolutionary process has brought about. Under artificial selection, divergencies may be detected much more rapidly (Allee et al, 1949).

(3) Stability of resistance

(a) Field strains. When selection for resistance is accompanied by a great deal of natural selection for general fitness, the only kind of resistance factors that would become frequent in the population would be those that cause very little reduction in fitness. Because of the much greater possibilities of favorable linkage (of resistance factors with those controlling vital functions) in large natural populations, reversion of resistance arising in the field is less likely than among laboratory populations and when it does occur the return to susceptibility would be expected to be very slow (Hoskins and Gordon, 1956). Brown (1956 a) points out that reversion under field conditions may often be mainly due to genic dilution with surrounding untreated populations.

Complete homozygosity throughout the entire strain may be essential if the resistance level is to be maintained, for if there are many heterozygotes present their superior fitness will prevent them from being eliminated by selection alone (Crow, 1957).

King (1950) recorded that every one of 14 samples of houseflies collected in various parts of the U. S. A. declined in DDT-resistance during laboratory culture, with usually an abrupt decrease during the first and second generation. Other instances of field strains of houseflies reverting after being introduced into laboratory rearing are cited by Pimental et al, (1950), Harrison (1950) and Keiding (1953). The Bellflower strain collected in southern California in 1948 maintained its resistance for 35 generations (March, 1952), but during the subsequent 8 months a subcolony of it showed a marked decline in resistance (Norton, 1953).

California red scale resistant to HCN fumigation has been known since 1916 and has shown no evidence of reversion and the area infested by the resistant strain has continued to increase even after the virtual abandonment of fumigation (Quayle, 1938).

(b) Laboratory strains. Selection in uncrowded laboratory cultures where there is little natural competition may produce highly resistant flies but they may be very poor specimens for natural survival otherwise. Laboratory populations, theoretically, would revert to susceptibility much more rapidly than field populations. The studies to date, however, have shown that the rate of reversion varies greatly with different strains and is apparently dependent upon the degree to which adaptation to the toxicant has progressed and hence to the homogeneity of the resistant strain (Norton, 1953).

Pimental et al (1953) found that a highly resistant strain of housefly, after 20 generations free from DDT selection, declined to one eight-hundredth of the initial level with females and to one seventeen-hundredth with males. There are some examples of laboratory strains not revertint in the absence of the insecticide (Bruce and Decker, 1950; Norton, 1953; Lichtwardt et al, 1955). D'Alessandro et al, (1951) isolated a strain that maintained its resistance to DDT and chlordane for at least 43 generations. Laboratory-reared HCN-resistant California red scale has maintained its resistance without fumigation for more than 150 generations, equivalent to more than 40 years in natural state (Lindgren and Dickson, 1945; Crow, 1957).

King (1958) studied tolerant strains of Drosophila that showed slow reversion to susceptibility; one strain being approximately three times as tolerant as the control at F_{24}.

Crow (1954) found that there was no perceptible decrease in the tolerance of certain strains of Drosophila after three years of rearing in the absence of selection. Since the strains had been selected under conditions of severe 'natural' selection, Crow believes that it is to be expected that only tolerance factors of near normal viability would be selected and he concluded that the tolerance factors in his population were very nearly neutral. On the other hand, Oshima (1958) ran a similar experiment using Japanese strains of Drosophila and concluded from his results that the tolerance factors had entered into new kinds of balanced combinations with other factors acting as viability modifiers and that formerly deleterious factors had become favourable ones. Crow had tested this hypothesis by comparing the reversion rates of hybrids between two tolerant strains with those of hybrids between tolerant and susceptible strains. They hybrids showed no measurable regression as would be expected if there had been integrative combinations in the two populations (almost certain not to be identical) that had been broken up by recombination in the hybrids (Crow, 1957).

Robertson (1957) reported that exposure of the arrhentokous parasite Macrocentrus ancylivorous Rohw. to DDT in each of 10 successive generations increased the level of tolerance to four times that of the initial stock at F_{19}. In the F_{30} to F_{71} generations, when only females were exposed to DDT, the level of tolerance fell to 7 times its initial value. When, beginning with the F_{72} generation, the parasite was reared for 13 generations without exposure to DDT, tolerance fell to its initial level. Females were more DDT-resistant than males.

(4) Restoration of resistance

With resistance factors that are only slightly detrimental, i.e. the type likely to be found in natural populations, reversion to susceptibility should be slow. Furthermore, if the population does return to susceptibility it may require a long time for the genes to be carried below a certain frequency, just as it often takes a long time to accomplish the early part of the increase in resistance. This is because selection in either direction is slow when the gene is rare. Therefore a susceptible population that has once been resistant is likely to increase rapidly in resistance when the insecticide is again applied. This has frequently occurred in laboratories where a population that had lost some resistance was quickly built up to its former level by a few generations of selection (Busvine, 1956; Harrison, 1952; Perry and Hoskins, 1951). Keiding (1956) found that since 1950 nearly all strains of resistant houseflies in Denmark have been reverting to susceptibility but experimental spraying with DDT in 1955 brought resistance back in four weeks.

Brown (1959) points out that rapid restoration of reverted strains indicates that although the main gene becomes scarce during reversion, the modifier genes survive in good quality. He suggests that "some of these modifying genes may be suitable alternative genes which may counteract the genetic weakness often found to accompany the development of inbred homozygous DDT-resistant houseflies. Thus these new gene complexes may confer tolerance to different groups of insecticides, and may explain the unusual readiness of strains once DDT-resistant to develop BHC-resistance or dieldrin resistance. To this extent these genes have more than one effect and are pleiotropic".

C. Negatively-correlated cross-resistance

Ogita (1958) discovered that the DDT-resistant gene on chromosome II of Drosophila confers enhanced susceptibility to phenylthiourea. Selection with PTU would presumably result in an increase in DDT susceptibility. Ascher and Kocher (1954) discovered that a DDT-resistant strain of housefly at Basle was more susceptible than a normal strain to stomach poisoning by inorganic salts of bromine. Selection pressure with diisopropyl-tetrachlorophosphate applied for three generations on a DDT-resistant strain containing 5 per cent of susceptible individuals transformed it into a DDT-susceptible strain (Kearns, 1957). Brown, (1959) believes that "in these pairs of compounds negatively-correlated as to cross-resistance lies a great hope for the future solution of the resistance problem".

REFERENCES

Allee, W. C., A. E. Emerson, O. Park, T. Park, and N. P. Schmidt. 1949. Principles of animal ecology. W.B. Saunders Co., Philadelphia.

Afifi, S. E. D. and H. Knutson. 1956. Reproductive potential, longevity and weight of house-flies which survived one insecticidal treatment. J. Econ. Ent. 49: 310-313.

Armstrong, J. A., V. Ramakrishna and C. D. Ramsdale. 1956. Unpublished, in working documents WHO/Mal/182 and WHO/Insecticides/52, 10 pp.

Ascher, K. R. S. and C. Kocher. 1954. Enhanced susceptibility of a highly resistant strain of house-flies to ingestion of potassium bromide. Experientia (Basel), 10: 465-466.

Babers, F. and J. Pratt, Jr. 1951. Development of insect resistance insecticides. II. A critical review of the literature up to 1951. U. S. Dept. Agr., Bur. Entomology, Plant Quarantine, Publ. E-818.

Babers, F. H., J. Pratt, Jr. and M. Williams. 1953. Some biological variations between strains of resistant and susceptible house flies. J. Econ. Ent. 46: 914-915.

Barber, F., O. Starnes and E. Starnes. 1948. Soap Sanit. Chemicals 24 (11): 120-121, 143.

Barbesgaard, P. and J. Keiding. 1955. Crossing experiments with insecticide-resistant houseflies. Vidensk. Medd. fra. Dansk naturh Foren. 117: 83-116.

Bartlett, B. R. 1952. A study of insecticide resistance in strains of <u>Drosophila melanogaster</u> Meig. Canada. Ent. 84: 189-205.

Beard, R. L. 1952. Effect of sub-lethal doses of toxicants on susceptibility of insects to insecticides. J. Econ. Ent. 45(4): 561-567.

Bigelow, R. S. and E. J. Le Roux. 1954. Distinct morphological differences between DDT-resistant and non-DDT-resistant strains of the housefly, <u>Musca domestica</u> L. Can. Ent. 86(2): 78-86.

Bochnig, V. 1956. Entwicklungyphysiologische und biometrische Untersuchungen an DDT-sensiblen und resistenten Stämmen von <u>Drosophila melanogaster</u>. Z. indukt. abstamm. - u. Vereb Lehre. 87:694-707.

Bøggild, O. and J. Keiding. 1958. Competition in house fly larvae. Experiments involving a DDT-resistant and a susceptible strain. Oikos 9(1): 1-25.

Brown, A. W. A. 1958 a. The spread of insecticide resistance in pest species in Interscience Publishers, Advances in pesticide research, vol. 2, New York.

Brown, A. W. A. 1958 b. Present status and future outlook of resistance of insect vectors of disease to insecticides. Proc. Tenth Internat. Congress Ent. Vol. 2 (1956): 187-196.

Brown, A. W. A. 1958 c. Insecticide resistance in arthropods. WHO Monogr. Ser. 38. Geneva.

Brown, A. W. A. 1959. Inheritance of insecticide resistance and tolerance. (in press).

Bruce, W. N. 1949. Latest report on fly control. Pest Control. 17:7, 28.

Bruce, W. N. and G. Decker. 1950. House-fly tolerance for insecticides. Soap and Sanit. Chemicals. 26:122-5, 145-7.

Busvine, J. R. 1953. Forms of insecticide-resistance in houseflies and body lice. Nature. 171: 118-122.

Busvine, J. R. 1956. Normal resistance-levels of Anopheles gambiae to various insecticides. Nature. 177: 533-534.

Cochran, D. G., J. M. Grayson and M. Levitan. 1952. Chromosomal and cytoplasmic factors in transmission of DDT resistance in the German cockroach. J. Econ. Ent. 46(6): 997-1001.

Coker, and J. R. Busvine, 1957. MS in preparation.

Cole, M. M. et al. 1956. Further studies on resistance of human body lice to insecticides. J. Econ. Ent. 50: 556-559.

Crow, J. F. 1952. Some genetic aspects of selection for resistance. Nat. Acad. of Sciences. N. R. C. Publ. No. 219: 72-75.

Crow, J. G. 1954. Analysis of a DDT-resistant strain of Drosophila. J. Econ. Ent. 47: 393-398.

Crow, J. F. 1957. Genetics of insect resistance to chemicals. Annual Rev. Ent. 2: 227-246.

D'Alessandro, G. et al. 1949. Sulla resistenza delle mosche al DDT. Sicilia med. 6: 5-16.

D'Alessandro, G., M. Mariani, and M. Gagliani. 1951. La resistenza al DDT della M. domestica si attena nel corso della generazioni allevate in assenza dell' insetticida. Boll. Soc. ital. Biol. sper. 27: 1746-1747.

D'Alessandro, G., G. Frizzi and M. Mariani. 1958. Ulteriori ossevazioni sui rapporti fra ordinamenti cromosomici e resistenza al DDT in Anopheles atroparvus: Riv. Parassit: 19: 67-72.

Davidson, G. 1956. Insecticide resistance in Anopheles gambiae Giles: a case of simple Mendelian inheritance. Nature 178: 861-863.

Davidson, G. 1958. Insecticide resistance in Anopheles sundaicus. Nature (Lond.) 180: 1333-1335.

Decker, G. C., and W. N. Bruce. 1952. House fly resistance to chemicals. Amer. J. Trop. Med. and Hyg. 1: 395-403.

Dickson, R. C. 1941. Inheritance of resistance to hydrocyanic acid fumigation in the California red scale. Hilgardia. 13(9): 515-522.

Dobzhansky, T. 1941. Genetics and the origin of species. 2nd. ed. Columbia Univ. Press, N.Y.

Gagliani, M. 1952. "The duration of the larval cycle in strains of Musca domestica L. sensitive and resistant to DDT." Boll. Soc. Ital. Biol. Sperim. 26: 326-8.

Grayson, J. M. 1954. Nature of insect resistance to chemical poisons. Va. Acad. Scie. (n.s.) 5: 241.

Grayson, J. M. and D. G. Cochran. 1955. On the nature of insect resistance to insecticides. Virginia J. Sci. 6: 134-143.

Hadaway, A. B. 1956. Cumulative effect of sub-lethal doses of insecticides on house-flies. Nature (Lond.) 178: 149-150.

Hamon, J., M. Eyrand and S. Scales. 1958. Bull. Soc. Path. Exot. 51: 42-47.

Harrison, C. M. 1950. DDT-resistant house-flies. Ann. Appl. Biol. 37: 306-309.

Harrison, C. M. 1951. Inheritance of resistance to DDT in the house fly, Musca domestica L. Nature (Lond.) 167: 855-856.

Harrison, C. M. 1952. DDT resistance in an Italian strain of Musca domestica. Bull. Ent. Res. 42: 761-768.

Harrison, C. M. 1953. DDT resistance and its inheritance in the house fly. J. Econ. Ent. 46: 528-530.

Harrison, C. M. 1954. Genetical aspects of DDT-resistance in the house-fly. R. C. Ist. Sup. Sanità, Suppl., pp. 235-252.

Hess, A. D. 1953. Current status of insecticide resistance in insects of public health importance. Amer. J. Trop. Med. and Hyg. 2: 311-317.

Hoskins, W. M. and H. T. Gordon. 1956. Arthropod resistance to chemicals. Annual Rev. Ent. 1: 89-122.

Hunter, P. E., L. K. Cutkomp and A. M. Roklaila. 1958. Reproduction in DDT- and diazinon-treated flies. J. Econ. Ent. 51(5): 579-582.

Kearns, C. W. 1957. quoted in Brown, A. W. A. Insecticide resistance in arthropods. Geneva.

Keiding, J. 1953. Development of resistance in the field and studies of inheritance. Trans. Ninth Intern. Contr. Entomol. 2:340-345.

Keiding, J. 1956. Resistance to organic phosphorus insecticides of the house-fly. Science, 123: 1173-1174.

Kikkawa, H. 1953. The genetics of resistance to insecticides in Drosophila. IV. Parathion resistance and general considerations. Jap. J. Genet. 28: 171.

King, J. C. 1954. The genetics of resistance to DDT in Drosophila melanogaster. J. Econ. Ent. 49: 387-393.

King, J. C. 1955 a. Integration of the gene pool as demonstrated by resistance to DDT. Amer. Nat. 89: 39-46.

King, J. C. 1955 b. The genetics of resistance to insecticides. In: Annual Report, Cold Spring Harbor, N.Y. 1954-55. pp. 33-35.

King, J. C. 1956. Evidence for the integration of the gene pool from studies of DDT resistance in Drosophila. Cold Spring Harbor Symp. Quant. Biol. XX: 311-317.

King, J. C. 1958. Some light on population dynamics provided by lines of Drosophila melanogaster selected for resistance to DDT. Proc. Tenth Int. Congress of Ent. (1956) 2: 811-893.

King, J. C. and L. Somme. 1958. Chromosomal analyses of the genetic factors for resistance to DDT in two resistant lines of Drosophila melanogaster. Genetics 43(4): 577-593.

King, W. V. 1950. DDT-resistant house-flies and mosquitos. J. Econ. Ent. 43: 527-532.

Kitzmiller, J. B. 1953. Mosquito genetics and cytogenetics. Rev. bras. Molar. 5: 285-359.

Knapp, F. W. and H. Knutson. 1958. Reproductive potential and longevity of two relatively isolated field populations of insecticide susceptible houseflies. J. Econ. Ent. 51(1): 43-45.

Knutson, H. 1959. Changes in reproductive potential in houseflies in response to dieldrin. (in press).

La Face, L. 1952. Sul comportamento ereditario della resistenza ad alcuni insetticidi in Musca domestica. Riv. Parassit. 13: 57-60; R. C. Ist. sup. Sanitã, 15: 376-380.

Lerner, I. M. 1954. Genetic Homeostasis. John Wiley & Sons. Inc. New York.

Lewontin, R. 1955. The effects of population density and composition on viability in Drosophila melanogaster. Evolution. 9: 27-41.

Lichtwardt, E. T. 1956. Genetics of DDT resistance of an inbred line of house fly. Jour. Heredity. 47(1): 11-16.

Lichtwardt, E. T., W. N. Bruce and G. C. Decker. 1955. Notes on the inbreeding of house flies. J. Econ. Ent. 48(3): 301-303.

Lindgren, D. L. and R. C. Dickson. 1945. Repeated fumigation with HCN and the development of resistance in the California red scale. J. Econ. Ent. 38: 296-299.

Lovell, J. B. and C. W. Kearns. 1956. Inheritance of ability to synthesize DDT-dehydrochlorinase and its relationship to DDT-resistance in the housefly. Bull. Ent. Soc. Amer. 2, No. 3, pp. 17-18.

Luers, H. 1953. Untersuchung zur Frage der Mutogenitat des Kontaktinsektizids DDT an Drosophila melanogaster. Naturwiss. 40: 293.

Maelzer, D. A. and R. L. Kirk. 1953. A preliminary study of the genetics of DDT resistance in house flies. Aust. Jour. Biol. Sci. 6(2): 244-256.

March, R. B. 1952. Summary of research on insects resistant to insecticides. In: National Research Council. Conference on Insecticide Resistance and Insect Physiology, Dec. 8-9, 1951. Publ. No. 219, pp. 45-53.

March, R. B. and L. L. Lewallen. 1950. A comparison of DDT-resistant and non-resistant house flies. J. Econ. Ent. 43: 721-2.

March, R. B. and L. L. Lewallen. 1956. Paper chromatography of fresh tissue extracts of susceptible and insecticide-resistant strains of the house fly Musca domestica L. Annals of the Ent. Soc. of Amer. 49(6): 571-575.

March, R. B. and R. L. Metcalf. 1952. Insecticide research for the control of resistant house-flies. Pest Control, 20(4): 12-18.

McKenzie, R. E. and W. M. Hoskins. 1954. Correlation between the length of the larval period of Musca domestica L. and resistance of adult flies to insecticides. J. Econ. Ent. 47(6): 984-992.

Melander, A. L. 1914. Can insects become resistant to sprays? J. Econ. Ent. 7: 167-172.

Merell, D. J. and J. C. Underhill. 1956. Selection for DDT resistance in inbred, laboratory, and wild stocks of Drosophila melanogaster. J. Econ. Ent. 49(3): 300-306.

Metcalf, R. L. 1955. Physiological basis for insect resistance to insecticides. Physiol. Revs. 35(1): 197-232.

Milani, R. 1954. Mendelian inheritance of knock-down resistance to DDT and correlation between knock-down and mortality in Musca domestica L. Riv. Parassit. 15: 513-542. Sel. sci. Papers Ist. sup. Sanità. 1: 176-212 (in English).

Milani, R. 1955. Comportamento ereditario dei caratteri knock-down-resistance (kdr) e plexus (plx) in Musca domestica L. R. C. Ist. sup. Sanità, 18: 889-897.

Milani, R. 1956. Ricerche genetiche sulla resistenza degli insetti alla azione delle sostanze tossiche. Riv. Parassit. 17: 233-246. 18: 43-60.

Milani, R. 1958. Some aspects of genetic research on insecticide resistance. Riv. Parassit. 18: 199-202.

Morrison, F. O. 1957. The ratio of the width to the length of the second abdominal sternite of the house-fly. J. Econ. Ent. 50: 554-556.

Norton, R. J. 1953. Inheritance of DDT tolerance in the house fly. Contrib. Boyce Thompson Inst. 17: 105-126.

Ogita, Z. 1958. A new type of insecticide. Nature. 182: 1529-1530.

Ogaki, M. and M. Tsukamoto. 1953. Genetical analysis of DDT resistance in some Japanese strains of Drosophila melanogaster. Botyu-Kagaku. 18: 100-104. (English resume. 103).

Oshima, C. 1958. Studies on DDT-resistance in Drosophila melanogaster. J. of Heredity. 49(1): 22-31.

Oshima, C. and T. Hiroyoshi. 1955. Drosophila Information Service. 29: 152-153.

Oshima, C. and T. Hiroyoshi. 1956. Genetic studies of resistance to DDT and nicotine sulfate in Drosophila virilis. Botyu-Kagaku. Bull. Inst. Insect Control. 21: 65-70.

Perry, A. S. 1958. Factors associated with DDT-resistance in the house fly Musca domestica L. Proc. Tenth Internat. Congress of Ent. (1956). 2: 157-172.

Perry, A. S. and W. M. Hoskins. 1951. Detoxification of DDT as a factor in the resistance of house-flies. J. Econ. Ent. 44: 850-857.

Pielou, D. P. 1952. The nonmutagenic action of p-p'-DDT and -hexachlorocyclohexane in Drosophila melanogaster Meig. (Diptera: Drosophilidae). Can. Jour. Zool. 30(6): 375-377.

Pimental, D. and J. E. Dewey. 1950. Laboratory tests with house-flies and house-fly larvae resistant to DDT. J. Econ. Ent. 43: 105.

Pimental, D., J. E. Dewey and H. H. Schwardt. 1951. An increase in the duration of the life cycle of DDT-resistant strains of the house fly. J. Econ. Ent. 44: 477-481.

Pimental, D., H. H. Schwardt and J. E. Dewey. 1953. Development and loss of insecticide resistance in the house fly. J. Econ. Ent. 46: 295-298.

Pimental D., H. H. Schwardt and J. E. Dewey. 1954. The inheritance of DDT resistance in the house fly. Ann. Ent. Soc. Amer. 47(1): 208-213.

Pratt, J. J. and F. H. Babers. 1953. The resistance of insects to insecticides. Some differences between strains of house flies. J. Econ. Ent. 46: 864-873.

Quayle, H. J. 1916. Univ. Calif. J. Agr. 3: 333-358.

Quayle, H. J. 1938. The development of resistance to hydrocyanic acid in certain scale insects. Hilgardia. 11(5): 183-210.

Quayle, H. J. 1943. The increase in resistance in insects to insecticides. J. Econ. Ent. 36: 493-500.

Reed, J. K. 1954. Factors affecting the resistance of houseflies to insecticides. (Doctoral thesis, Iowa State College, Ames, Iowa).

Robertson, F. W. 1955. Selection response and the properties of genetic variation. Cold Spring Harbor Symp. Quant. Biol. XX Population Genetics: 166-177,

Robertson, J. G. 1957. Changes in resistance to DDT in Macrocentrus ancylivorus Rohw. (Hymenoptera: Braconidae). Can. Jour. Zool. 35: 629-633.

Schultz, J., and H. Redfield. 1951. Interchromosomal effects on crossing over in Drosophila. Cold Spring Harbor Symp. Quant. Biol. 16: Genes and Mutations: 175-198.

Smith, J. S. 1941. Racial segregation in insect populations and its significance in applied entomology. J. Econ. Ent. 34(3): 1-13.

Sokal, R. R. 1956. See discussion at end of paper by Kind, J. C. 1956. - Cold Spring Harbor Symp. on Quant. Biol. XX: 311-316.

Sokal, R. R. and P. E. Hunter. 1954. Reciprocal selection for correlated quantitative characters in Drosophila. Science 119: 649-651.

Sokal, R. R. and P. E. Hunter. 1955. A morphometric analysis of DDT-resistant and non-resistant house fly strains. Ann. of the Ent. Soc. of Amer. 48(6): 499-506.

Sokal, R. R. and P. E. Hunter. 1958. Environmentally caused fluctuations in quantitative characters of Drosophila. Proc. Tenth Internat. Congress of Ent. (1956). Vol. 2: 843-854.

Taylor, E. A. and F. F. Smith. 1956. Transmission of resistance between strains of two spotted spider mites. J. Econ. Ent. 49(6): 858-859.

Tsukamoto, M., and T. Hiroyoshi. 1956. Further studies on the mode of inheritance of resistance to nicotine sulfate in Drosophila melanogaster. Botyu-Kagaku. 21: 71-76.

Varzandeh, M., W. N. Bruce and G. C. Decker. 1954. Resistance to insecticides as a factor influencing the biotic potential of the housefly. J. Econ. Ent. 47: 129-134.

Wiesmann, R. 1947. Untersuchungen über das physiologische Verhalten von Musca domestica L. verschiedener Provenienzen. Schweiz. Ent. Gesell. Mitt. 20: 484-505.

Wiesmann, R. 1955. Der heutige Stand des Insektizid-Resistenzproblems. Mitt. Biol. Bundesanstalt f. Land u. Forstwirthschaft. 83:17-37.

Wright, S. 1952. Quantitative Inheritance. pp. 5-42. Her Majesty's Stationery Office, London, England.

WHAT FOREST MANAGEMENT IN MANITOBA MAY LEARN FROM AERIAL SPRAYING IN NEW BRUNSWICK

W. A. Reeks
Officer-in-Charge
Forest Biology Laboratory
Winnipeg

Aerial spraying in this instance refers to spraying against the spruce budworm, Choristoneura fumiferana (Clem.). So much has been written on the control of the budworm by aerial spraying that for this statement it has been necessary to select only the most recent references and those that may have some bearing on future budworm situations in Manitoba. Forest management no doubt can benefit from the results of many spraying operations, but those conducted in New Brunswick are singled out because they covered a long period and large area.

The aeroplane has about a 40-year history in spruce budworm work. It was first used on budworm surveys in 1920 by Swaine (7). Swaine also introduced the use of aircraft aerial dusting operations against the spruce budworm in Nova Scotia. This was in 1927. Since then aerial spraying against the budworm has become commonplace, with operations having been carried out in Ontario, Quebec, and New Brunswick, as well as the states of Maine, Washington, and Oregon.

During a trip to New Brunswick in October, 1958, I had the opportunity to attend a meeting of delegates representing the Division of Forest Biology, Forest Protection Ltd., industry, and entomologists from Maine and the U.S. Forest Service. The general opinion was that the New Brunswick spraying operation was an outstanding success, but it was recognized that all the problems relating to the importance of spraying are not solved. I gained the opinions of some foresters outside the meeting that we no longer may fear destruction of forests resulting from budworm attack. The most optimistic of these think we can meet future budworm threats with insecticides. This is a dangerous attitude, as learned by orchardists. Their philosophy years ago was that spraying should be designed to give complete mortality of insect pests regardless of the effect on beneficial organisms. As a result, more and more spray applications were required each year. Then a gradual change came about, with the general concepts being: (1) Spraying programs should be complementary to control by natural factors; and (2) the need for spraying should be contingent on the requirements of individual orchards. Similarly, aerial spraying against the spruce budworm should be complementary to, and not a substitute for, good forestry practices; also, the need for spraying a forest must be contingent on the silvicultural consideration of the watershed or region to be treated.

THE NEW BRUNSWICK PROGRAM TO 1958, INCLUSIVE

Spraying techniques have been covered in several excellent papers, among them those of Balch (1) and Webb (10). A discussion of techniques in this brief report is largely confined to changes that have been affected from time to time.

In 1952, the spray formulation consisted of 1 lb. of DDT in one U.S. gallon of oil solvent, with the aircraft delivering about one gallon per acre. From 1953 to 1958 the dosage was cut in half by doubling the swath width. The reduced dosage, although less effective, was adequate to protect a good deal of the current foliage of infested trees, thereby keeping the trees alive. It also ensured treatment of a larger area at the same cost. A limited amount of spraying was done twice in one season, using the lighter dosage two to three weeks apart. This caused higher larval mortality, but two applications are recommended only for stands of high value. Insecticides other than DDT were tested on a small scale in 1958. These were DDD, Korlan, and Sevin. Results on the effect of these on the spruce budworm and fish were not available in official publications at the time of writing.

A new technique in flying was adopted in 1953. This was the practice of flying in pairs, which ensured better aerial inspection of the spray planes, better coverage, and better protection of the pilots.

Spray assessment was initially carried out by the use of a wide distribution of spray cards impregnated with an oil-soluble dye. Examinations of these after spraying in 1952 indicated excellent coverage. As the spray program enlarged, the spray assessment was done largely by aerial inspection.

The biological assessment was done by aerial inspections, ground surveys of defoliation in sprayed and unsprayed areas, and measurement of egg populations. The latter gave a good indication of the severity of defoliation that should be expected the following year.

The total area sprayed (including areas resprayed) amounted to about 22,000 square miles from 1952 to 1958 inclusive. To attain this objective 14 airstrips and many service roads had to be constructed. The largest single operation was carried out in 1957, when about 8,100 square miles were sprayed with 200 spray planes.

The spraying operation in 1958 was especially significant because, for the first time, the area sprayed (4,100 sq. mi.) almost equalled the total area moderately to severely attacked (4,800 sq. mi.).

The notable features of the 1958 infestation following spraying, as reported by Webb (unpublished report) were the relatively scattered and discontinuous nature of heavy feeding and a decided recession of the outbreak from the extreme boundaries of light, moderate, and severe attack reached in southern New Brunswick in 1956 and 1957. Final surveys in 1958 showed relatively light egg populations and only small areas of imminent high mortality. Active infestations by the end of the year were confined to two relatively small areas in the centre of the Province, and it is unlikely that spraying will be continued in 1959.

PRESENT TRENDS IN EFFECTIVENESS OF SPRAY PROGRAM

Although the spraying program has probably ended, considerable work remains before its effectiveness will be fully evaluated. Long-term studies will be carried out to show the delayed effects of spraying on the budworm and its parasites and to determine the degree of recovery of sprayed trees.

When the idea of spraying in New Brunswick was conceived in 1951, there were many antagonists. Some of their objections now have been removed because of present trends in results. A few of these trends are discussed as follows:

Cost of Spraying not Prohibitive

The cost of the 7-year spraying program, approximately $11,000,000 was shared by the Government of Canada, and the Government of New Brunswick. Under this arrangement of financing, the cost of spraying is not prohibitive. Tree mortality to date in the sprayed areas has been generally light, whereas Webb (unpublished report) showed that mortality of balsam fir on unsprayed check areas was virtually complete by the end of 1958 in many of the mature and overmature types, and approached 50% of all fir stems 2 inches d.b.h. (diameter breast high) and over for the range of stand types and age conditions. It would appear that the pulp and paper industry would now have difficulty in supplying mills with raw material if the spraying program had not been carried out.

Many factors affect cost, and an important one is the degree of continuation of susceptible forest stands. This is especially true in Manitoba, where susceptible stands of balsam fir are discontinuous and not often an important component of the forest. Completed forest inventories in three sections of Manitoba show that balsam fir makes up about 3 to 14 per cent of the total tree species (softwoods and hardwoods). Because of the scattered nature of susceptible stands in this Province, many air strips and long access roads would be required for a spraying operation. This would undoubtedly raise the cost above that of similar operations in New Brunswick, where stands are more continuous. Spraying in Manitoba would be considered only where values of threatened stands are extremely high.

Effectiveness of Spraying not Constant

The spraying operation should start when the majority of the larvae are in the fourth instar to ensure maximum larval mortality. At this stage, however, considerable feeding will have already occurred on the new foliage, and a primary objective in New Brunswick was to give maximum protection to current growth. In practice, spraying generally started with the flush of new shoots of balsam fir (10).

Naturally, in a large operation timing may not be perfect. This factor, as well as uneven dispersion, weather conditions, and possibly other factors as yet unexplainable, caused differences in effectiveness from year to year. In 1956, for example, the spraying was less effective than in previous years. In contrast, the estimated mean percentage of population reduction in areas spraying for the first time in 1958 was 79% and the loss of current foliage was 35%; the check area showed 70% loss of current foliage.

Because of the uneveness of effective spraying, some stands may have to be sprayed two or three times. Generally a single application is adequate to keep the trees alive.

If spraying were to be ever carried out in Manitoba, presumably it would be on a small scale. A requisite would be to determine the objective, i.e. whether to strive for maximum larval mortality by late spraying or maximum protection of current foliage by early spraying. Probably the former objective would be preferred depending on the size of the operation.

Spraying may not extend "Normal" Period of Outbreak

"Will spraying extend the normal outbreak period by eliminating the mortality factor of starvation or by producing a strain of budworms that is resistant to DDT?" This question frequently was heard early in the spraying program. The New Brunswick outbreak in the first quarter of this century lasted about 10 years. The present outbreak also has lasted about 10 years so there is no evidence that spraying extends the outbreak period.

Actually, there is no such thing as "normalcy" in expressing the duration of an outbreak. Outbreaks in central Canada have lasted up to 20 years, depending upon the extent of susceptible stands and degree of dispersion (5). I do not think that anyone engaged in budworm spraying believes that application of poisons actually will shorten an outbreak period.

Spraying may not Reduce Effectiveness of Natural Control

There is no evidence that natural control factors have been adversely affected by spraying. Webb (unpublished report) has shown that one species of parasite was at least as abundant, proportionately, on sprayed plots as in unsprayed areas. The same species showed an increase in percentage parasitism from less than 10% in 1957 and earlier years to 50% in 1958. Another species consistently showed the highest parasitism occurred in sprayed plots the year following spraying.

Effect of DDT on Wildlife and Fish

Apparently the spraying operation did not appreciably affect populations of birds and mammals.

Populations of some species of aquatic species, especially caddis flies, have been greatly reduced in sprayed areas, and recovery is likely to be slow. This, in turn, undoubtedly has had some effect on fish, but the present picture is confusing. Studies by the Fisheries Research Board of Canada in 1954 indicated that one-year-old salmon were seriously affected by spraying. It was feared that the killing of fingerlings and parr each year would reduce the population of grilse and salmon returning from the sea three years later. Whether this happens apparently is yet to be proved, because salmon catches in all or most of the New Brunswick waters were reported to have reached record numbers in 1958.

Investigations on tolerances of salmon to DDT are being carried out in the east and west under controlled and field conditions. The allowable content of DDT in streams is likely to be fixed upon termination of these investigations.

Manitoba has an important fish resource. We lack knowledge of the abundance and species of the aquatic insect fauna that form the diet of our principal fish species. Unfortunately, some aquatic fauna that are important to fish are objectionable to tourists in the Whiteshell. More should be known about our fauna and their tolerances to insecticides before aerial spraying is seriously considered in Manitoba.

THE FUTURE OF AERIAL SPRAYING IN MANITOBA

The results of spraying reviewed above apply to only one insecticide in a specific region under Maritime conditions. Use of another insecticide would require repetition of the entire investigation from the spray assessment to the biological assessment. New insecticides are likely to replace those that were considered satisfactory over the past decade. It is equally possible that some well established insecticides will be replaced by plant growth regulators. Recent studies in the Department of Entomology (9), University of Manitoba, showed that the pea aphid did not multiply normally on beans that had been treated with a plant growth regulator, maleic hydrazide. This result has broad implications. Through the eventual use of plant growth regulators it may be possible to break synchronization of the spruce budworm with pollination or bursting of buds of balsam fir. If the development of balsam fir could thus be delayed to make it coincide with that of black spruce, possibly balsam fir would become less attractive to the budworm. This is a line of investigation that the economic entomologist of the future should find rewarding.

No aerial spraying has been done in Manitoba during the present outbreak. What will be the policy of the Province in the event of future outbreaks? This question is now considered from the standpoint of probabilities of other outbreaks and susceptibility of future stands.

The history of the budworm helps us to predict future outbreaks. Infestations in Manitoba from 1937 lead me to believe that we have been dealing with three independent outbreaks, as follows: (1) The Namew Lake outbreak, active since 1950, with indications of continuing beyond 1958; (2) The Spruce Woods outbreak, beginning about 1939 and extending to 1958 or later; and (3) the Southeastern Manitoba outbreak, lasting from about 1953 to 1958 or possibly 1959. The first two are believed to be independent of the last because they showed different trends in annual fluctuations and nature of stands affected. The Southeastern outbreak, although consisting of many widely separated infestations, seems to have arisen by dispersion of adults originating from Ontario. This outbreak may be considered as part of a much larger one that centered in Ontario and lasted for at least 20 years.

Other outbreaks have been reported in Minnesota from about 1912 to 1918 (4) and in northwestern Ontario as far as the present Manitoba-Ontario Border, starting about 1866 (2). Although no studies in Manitoba have been undertaken to show specifically the possible occurrence of early outbreaks, the growth pattern of balsam fir and white spruce from many stands has been examined. As yet we have been unable to see evidence of outbreaks early in this century or the last. However, a more critical study in more areas may show that the 1866 outbreak extended into Manitoba.

Opinions on the susceptibility of forest stands to budworm attack vary, mainly because of confusion in the meaning of "susceptibility" and "vulnerability". Morris (6) shows the difference between these two terms. He considers that susceptibility refers to all factors that promote the release of the budworm population from its endemic level, and its rapid attainment of pressure and momentum. Once an outbreak gains momentum, all susceptible stands, regardless of the content of spruce and fir, may be severely attacked. "Vulnerability" refers to the vulnerability of a stand to mortality after it is attacked.

There is a general feeling in Manitoba that balsam fir is increasing in the eastern part of the province. Also, trends in forest succession following the present outbreak in Ontario showed a consistent increase in the proportion of balsam fir as compared with the original stand (3). Ghent (3), nevertheless, feels that any trends in succession following budworm outbreaks must be determined on a regional basis. It is clear from Turner's (8) and Ghent's (3) work that the mortality of balsam fir in northern Ontario is correlated with the percentage of total basal area contributed by the balsam fir component of the stand. Very general observations support a similar conclusion for Manitoba.

Because of the high fir content in the regeneration of northwestern Ontario, it is not unreasonable to expect another major outbreak near the end of the century. If such an outbreak shows the same westerly extension as the last two, many white spruce-balsam fir stands in southeastern Manitoba are likely to be susceptible, with the most vulnerable being those high in fir content. The decision to spray in Manitoba would then be based largely on the cost of operation in relation to the value of the stands and whether spraying would be carried out simultaneously in Ontario. A requisite to future spraying will be a better appreciation of the succession of tree species following stand deterioration from old budworm attacks and cutting.

REFERENCES

1. Balch, R. E. The spruce budworm and aerial forest spraying. Canadian Geographical Journal. 45(5): 201-209. 1952.

2. Blais, J. R. The recurrence of spruce budworm infestations in the past century in the Lac Seul Area of northwestern Ontario. Ecology 35(1): 62-71. 1954.

3. Ghent, A. W., D. A. Fraser, and J. B. Thomas. Studies of regeneration in forest stands devastated by the spruce budworm I. Evidence of trends in forest succession during the first decade following budworm devastation. Forest Science 3(2): 184-208. 1957.

4. Graham, S. A. and L. W. Orr. The spruce budworm in Minnesota. Tech. Bull. 142. Univ. Minn. Agr. Exp. Stn. 1940.

5. Greenbank, D. O. The role of climate and dispersal in the initiation of outbreaks of the spruce budworm in New Brunswick - The Role of Dispersal. Can. Jour. Zool. 35: 385-403. 1957.

6. Morris, R. F. A review of the important insects affecting the spruce-fir forest in the Maritime Provinces. For. Chron. 34(2): 159-189. 1958.

7. Swaine, J. M. A survey of our forests from the air. Agr. Gazette of Canada 8: 20-22. 1921.

8. Turner, K. B. The relation of mortality of balsam fir <u>Abies balsamea</u> (L.) Mill., caused by the spruce budworm <u>Choristoneura fumiferana</u> (Clem.), to forest composition in Algoma Forest of Ontario. Publ. 875, Dept. Agr., Ottawa. 1952.

9. Thorsteinson, A. J. Insect Research. Farm Facts, 3(3): 1. 1958. Dept. of Univ. Extension and Adult Education, Univ. Man. 1958.

10. Webb, F. E. Developments in forest spraying against spruce budworm in New Brunswick. Pulp and Paper Mag. of Canada, Woodlands Review. Convention Issue. 1958.

HEATING AND DETERIORATION OF BULK GRAIN

STORED IN FARMS OF MANITOBA

R. N. Sinha
Entomology Section
Canada Department Agriculture Research Laboratory
Winnipeg

INTRODUCTION

The problem of heating and deterioration of bulk grain stored on farms has been a matter of considerable concern to the farmers of certain regions in the province of Manitoba since 1950. Invasion of grain by insects, mites, and storage fungi is directly responsible for the loss of grain kept in defective and unsuitable storage places since these pests do not cause serious damage to dry grain stored in proper places. From 1950 above-average harvests filled up most of the normal storage places on the farms. After the introduction of the quota system the farmer was obliged to store more grain on his farm and had to convert machine shops, barns, school buildings, dance halls, old unused bins, etc. to storage places. Many of these buildings were unsuitable for long-term storage of grain, because of water-leakage through the roof or walls, damp and unclean floors, or poor ventilation. Under these conditions, the temperature and the water content of the grain increased and, consequently, the grain became vulnerable to attack by molds, insects, and mites. Grain stored in these places for a few years provided an environment conducive to the growth of these organisms which then became firmly established as serious economic pests.

EXTENT AND NATURE OF LOSSES

No comprehensive study of the loss due to grain heating has been made but reports from agricultural representatives in different areas of the province indicate that heating occurs on many farms in Manitoba. Nineteen agricultural representatives reported in questionnaires that only 108 cases of heating bulk grain were brought to their notice by the farmers in their areas during 1956 and 1957. Most complaints during 1956-57 came from farmers residing in the agricultural districts of Beausejour, Holland, Morris, Neepawa and Portage la Prairie. The quantity of grain involved in each case ranged from 800 to 13,000 bushels. Personal interviews with agricultural representatives, commercial grain handlers and farmers revealed that the number of unreported instances of heating grain on farms far exceeds that of the reported ones.

During the crop year 1957-58, 3,431 carloads of wheat, oats and barley passing through Winnipeg were graded "Rejected Mixed Heated" (less than 10% heated kernels) or "Rejected Sample Heated" (more than 10% heated kernels) because of heating. The economic loss resulting from the deteriorated quality of the heated grain is modestly estimated at nearly one million dollars.

Deterioration in stored grain is characterized by mustiness, reduced germinability, lowered milling quality, presence of germ damaged "sick" grain and heated kernels.

MATERIALS AND METHODS

This study is based on approximately 1,000 samples taken from grain stored in 9 bins at Brunkild, Lowe Farm, Miami, Oak Bluff, and Rosebank in Southern Manitoba between November, 1957, and May, 1958. Wheat and oat samples each weighed 150 g. and 200 g. respectively.

A circular plot, 9 feet in diameter, was chosen to cover most of the surface area of each bin. Each plot was divided into 3 consentric circles 3, 6, and 9 ft. in diameter. Four sample points, each 90 degrees apart were chosen on each circumference. Temperature at each point was measured with copper-constantan thermocouples in conjunction with a potentiometer (Rubicon Co., Philadelphia, Serial No. 68684). Samples were taken with a torpedo probe at depths of 6 inches, 1, 2, 3, 4, 5, and 6 ft. depending upon the depth of the bulk. Each sample was analysed for (i) water content, measured with a dielectric moisture meter (Halross Instruments Corporation, Ltd., Winnipeg, Manitoba, Model No. 919, Serial No. 157014), (ii) germinative ability, tested by incubating on wet filter paper, (iii) species and number of microorganisms, observed by plating the seeds on wet filter paper and incubating for 5-7 days, (iv) species and number of insects and mites, separated from grain by using small Berlese funnels equipped with 100 watt electric lamps.

CHARACTERISTICS OF SOUND GRAIN IN SMALL BULKS

Sound grain in bulks of 800 to 10,000 bushels may be characterized by the following conditions:

(1) Physical. The three factors indicating the physical condition of bulk grain are summarized (Oxley, 1948) as follows: (i) the thermal conductivity of the grain, (ii) the water absorbing power of the grain which causes it to assume an equilibrium of water content depending on the relative humidity of the air, (iii) the porous granular nature of bulk grain. These factors become more important as the size of the bulk grows. Babbit, (1945) has mentioned that the daily and annual variation of temperature in Canada (Port Arthur, Ont.) do not appreciably affect grain beyond 6 ft. from the surface. The present observations in Manitoba are in agreement with those of Babbit (1945) with regard to variation of temperature in farmers' bins, especially during the winter when the temperature gradient becomes steep. This results in faster translocation towards the cooler surface thus causing uneven distribution of water content of the grain at different levels. However, during the summer in Manitoba the temperature variation in the grain does not normally exceed 11°C. and it remains more or less uniform at different parts of a 1,000 bushel bulk of grain stored in a bin, usually 4 to 8 ft. in depth.

(2) Biotic

(a) Flora: (i) Fungi: Sound, stored grain retains externally, as well as internally, field fungi, many of which appear to be harmless to the seed (Machacek et al, 1951). The extent of infestation of the seed by these fungi in a sample of sound grain often gives an indication as to the condition of the bulk grain. The following are the three major fungi found in wheat, oats, and barley on the farms in Manitoba.

Alternaria: This was the most common fungus associated with a majority of seeds taken from more than 500 samples of wheat, oats, and barley.

Helminthosporium sativum Pamm., King & Bakke: This species was quite common in all bins containing grain stored for more than one year.

Cladosporium: Cladosporium was present in a number of seeds (7 to 48% per sample) in nearly all samples taken from bins containing wheat, oats, and barley.

Machacek et al (1951), from their study extending over a period of seven years, also found that infestation of wheat, oats, and barley by Alternaria is more serious in Manitoba than in any other province of Canada (see Table I).

Table I. Comparative abundance of some of the more common fungi found in surface-sterilized seed from the seed-inspection District Manitoba (taken from Machacek et al, 1951).

Fungi	Wheat	Oats	Barley
Alternaria	68.68	66.76	75.65
Helminthosporium sativum	3.62	2.51	4.99
Helminthosporium teres	0.11	0.01	2.90
Helminthosporium avenae	0.01	0.94	0.01
Fusarium	0.72	2.13	.38
Cladosporium	0.10	0.56	0.47
Pullularia	0.19	1.10	0.87
Nigrospora	1.46	2.76	1.52

(ii) Bacteria: The bacterial count of a sample of dry and sound wheat stored for a year showed yellow chromogenic bacteria, 45 x 10^3/g. at the dilution of 10^{-3}. James (1955) has also found that yellow chromogenic bacteria predominate in dry wheat grown in Western Canada. Perhaps this chromogen represents an epiphyte of a wide variety of plants named Bacterium herbicola aurenum Duggeli (James et al, 1946).

(b) Fauna: Various Arthropods often occur sporadically in sound grain when stored for some time. To determine the kind and the number of insects and mites in a bulk of grain stored for more than a year, three bins each containing approximately 1,000 bu. of wheat, oats or barley, were sampled during the summer of 1958; ninety-one samples each spaced one foot apart, were taken from each bin during June and July, 1958, at Miami and Rosebank, Manitoba.

Ninety-one samples of wheat contained 3 adult Cephalonomia waterstoni (Gahan) - a parasite of the rusty grain beetle, Cryptolestes ferrugineus Steph., 1 adult Lathridius bergrothi Reitt., 2 adult psocids, Lepinotus reticulatus Endl., 55 adult and immature hairy mites, Glycyphagus destructor (Schr.), 3 adult Laelaptid mites, Echinolaelaps glasgowi (Ewing), 1 Oribatid mite and 2 other unidentified mites. Approximately 90% of the kernels in all samples germinated. The temperature of the bulk grain varied from 7° to 12°C. while the water content was 12.1 to 14.1%.

Samples of barley contained 1 adult of the confused flour beetle Tribolium confusum Duval, 3 larvae of C. ferrugineus, 4 nymphs of L. reticulatus, 8 adults of Staphylinid beetles, 2 thrips and 12 adult and immature forms of G. destructor. Most of these seeds germinated. Temperature ranged from 12.8° to 17.8°C. and water content from 11.8 to 13.5%.

Samples of oats contained enormous numbers of adult and immature forms of G. destructor, as many as 1480 mites being counted in a 150 g. sample. Infestations of mites were restricted to patches 2 ft. below the surface. Echinolaelaps glasgowi also occurred sporadically. The germinability of a large majority of the seeds was retained. The temperature ranged from 11° to 20°C. and the water content from 11.5 to 14.4%.

CHARACTERISTICS OF HEATING GRAIN IN SMALL BULKS

Hot spots in stored grain are usually reported during the winter in Manitoba. The physical and biotic conditions found in bulks of 1,000 to 10,000 bushels of heating grain are described as follows:

(1) Physical: Uneven distribution of temperature and water content is an important physical characteristic of hot spots in stored grain. Grain along the periphery of the hottest area of the bulk is usually tough or damp. Tough and damp grain also is found on a crusted surface.

(2) Biotic

(a) Flora: (i) Fungi: Several species of storage fungi associated with stored grain are found within a typical hot spot. The following major fungi were recorded:

Aspergillus flavus Link.: This yellow-green colored fungus is one of the most widespread species in hot spots. It was found in more than 50% of dead seeds per sample in wheat, barley, and oats where temperatures ranged from 20° to 50°C. It occurred in large quantities in grain of 13.5 to 17% water content. Insects did not feed on laboratory cultures of this fungus maintained in Czapek's medium.

Aspergillus glaucus Link.: This blue-green species of fungus was less abundant than A. flavus. Generally, tough or damp grain heating at 20° to 38°C. was heavily infected with this fungus. All the samples of dry grain at 26° to 35°C. and having 13 to 14.4% moisture was heavily infested with A. glaucus. Insects such as the foreign grain beetle, Ahasverus advena Waltl. and C. ferrugineus could thrive in laboratory-reared cultures of this fungus.

Penicillium melinii Thom.: This is a blue-green fungus. When plated in potato sugar agar or Czapek's agar in the laboratory a yellow ring forms around the periphery of the colony. This fungus was most typical of the flora associated with dead or injured kernels in heating grain. Penicillium melinii was recorded in large numbers in samples of grain having 8.8 to 26.1% water content at 14° to 53°C. Heaviest infection was indicated by the attack of almost every kernel in each of 36 samples of wheat having 12.8 to 21% water content at 25° to 39°C. It is interesting to note that the heavy infection of P. melinii was associated with a correspondingly heavy infestation of insects such as A. advena and C. ferrugineus.

Absidia: This is a white fungus which, when reared in Czapek's agar in the laboratory, looks like spider web. This fungus was associated with dead seed especially where the temperature ranged from 19° to 44°C. and the water content from 13.8 to 19%. Samples of grain containing Absidia also showed heavy infection of P. melinii and A. flavus.

Actinomycete (?): This fungus was recorded from the kernels of 48 samples of dead oats which probably had a previous history of heating and cooling. At the time of sampling, the grain temperature ranged from 21° to 53°C. and water content from 8.8 to 12.8%. The fungi P. melinii and A. flavus and the insects A. advena, C. ferrugineus, Xylocorus sp., and Anthicus floralis (L.) were predominant in grain infected with Actinomycete.

(ii) Bacteria: The sample of heated wheat collected 3 inches beneath a crust of germinating wheat showed white bacteria, the number being 32 x 10^8 viable bacteria per gram at 10^{-7} dilution.

(b) Fauna: Cryptolestes ferrugineus was most abundant and typical of the arthropods found in hot spots in Manitoba. Three hundred and thirty-six samples collected at different depths in seven bulks of heating and deteriorating wheat and oats on 3 farms in Manitoba showed the presence of the following mites and insects arranged in order of abundance in number: Glycyphagus destructor, Cryptolestes ferrugineus, Ahasverus advena, Cephalonomia waterstoni, Echinolaelaps glasgowi (Ewing), Lepinotus reticulatus Endl., Cheyletus eruditus (Schr.), Xylocorus sp., Anthicus floralis (L.), Lathridius bergrothi Reit., Enicmus minutus (L.), Coninomus constrictus (Gyll.), Tribolium confusum Duv.

1. Cryptolestes ferrugineus - An ecological niche favorable to the multiplication of C. ferrugineus was indicated by the presence of an average of 142 larvae per 150 gram sample of tough wheat ranging from 36° to 40°C. No larvae were found below 9°C. and above 49°C., nevertheless adults were collected at -10°C. and as high as 53°C. Large numbers of adults and larvae of C. ferrugineus were found in early stages of heating at 11° to 15°C. However, considerably more insects were found in advanced stages of heating at temperatures ranging from 21° to 45°C. Further rises in temperature reduced their number indicating that the optimum condition for multiplication of this species lies within this range. Larvae of C. ferrugineus were recorded in grain of 8.9 to 27% water content, but large numbers of larvae were found in localized spots where the water content of the grain appears to be a major factor in the growth and decline of a colony of C. ferrugineus in heating bulk grain. Experiments in the laboratory showed that at room temperature adults of C. ferrugineus fed and survived on mycelia and spores of P. melinii, A. glaucus, and Alternaria plated in Czapek's agar but failed to reproduce.

2. Ahasverus advena - This was the predominant species among the fungus-feeding insects infesting grain in hot spots. Two hundred and eighteen insects were collected from a sample of 185 grams of damp and tough oats infected with Actinomycete (80% of totals), P. melinii (68%), A. flavus (32%), and Absidia (12%). None of the seeds in this sample germinated. Adults of A. advena occurred at temperatures ranging from -2° to 47°C., and larvae from 7° to 42°C. Optimum breeding seemed to occur between 23° to 40°C. in dry, tough or damp grain which had been heavily infected by P. melinii and A. glaucus. Laboratory observations on this beetle revealed that it could successfully breed and complete its life history in about a month at room temperature (about 25°C.) or at 30°C. and 90% relative humidity on Penicillium melinii and Alternaria plated in Czapek's agar or potato sugar agar.

3 to 5. Xylocorus sp., Anthicus floralis, Coninomus constrictus - Dry, tough or damp grain, previously invaded by Penicillium, Aspergillus, Actinomycete, and Absidia is vulnerable to the attack of these insects which often occur together. This grain is usually found at 31 to 34°C. and seldom germinates. The presence of these species in appreciable number indicates that the grain is in the final stage of deterioration.

PROBABLE CAUSES OF HEATING AND DETERIORATION

This account of normal and deteriorating farm-stored grain shows that numerous factors are responsible for heating and deterioration of stored grain. My observations of heating grain and a review of the literature revealed the following facts.

A steep gradient of temperature is created along the outer layer of bulk grain which is in contact with cold air during the winter. As a result, translocation of water vapor from warmer areas to the periphery of the bulk begins by a convection current (Anderson et al., 1943). Also, small localized areas several feet beneath the surface become hotter than surrounding areas due to the metabolic heat produced by insects. Wilson (1946) observed this phenomenon in his studies with Rhizopertha in bulk wheat. That storage fungi contribute to this local heating has been demonstrated by Gilman and Barron (1930). The creation of small hot spots inside the bulk is accompanied by greater accumulation of water vapor in the area by the metabolic water given out by insects (Agrawal et al, 1957) and fungi (Milner et al, 1947). Fairbrother (1929) showed that the farm practice of blending different lots of grain of different water content, to attain an average water content within the grade limit, was not successful; the grain originally high in water content after blending, had a higher water content than the theoretical average. Christensen (1957) pointed out that the highest water content prevailing in any considerable portion of the bulk for some time was the critical factor in the growth of fungi and ultimate grain deterioration. An average water content for the entire bulk, recommended for safe storage does not always give protection from growth of storage fungi. Moreover, in some granaries water leaks through the wall cracks or the earthen floor. Sometimes farmers thresh and store combine-harvested grain containing high water content. Slight rise in temperature and the water content of the intergranular air by some of the causes mentioned above provides conditions suitable for the germination of certain fungi and breeding of certain insects and mites. Heat is produced by the respiration of the rapidly growing fungi and fast breeding insects and mites; many insects and mites feed on fungi that may contribute to the increase in the rate of their multiplication. Some insects and mites may carry the mycelia and spores of fungi to different parts of the bulk where the proper environment has already been created. Oxley and Howe (1944), Wilson (1946), Solomon (1953) and others have shown that the aggregation of insects in areas of good food supply and optimum temperature and water content abruptly raises the temperature of the grain creating a hot spot. A self accelerating process begins; a rise in temperature and often water content of the grain due to the presence of insects and fungi causes an increase in their rate of metabolism; this leads to greater multiplication of the organisms themselves and to additional heat production.

ACKNOWLEDGEMENT

I am grateful to the following members of the Division of Botany and Plant Pathology, Canada Department of Agriculture Research Laboratory, Winnipeg: Mr. H. A. H. Wallace who analyzed a large number of samples for fungi; Dr. J. E. Machacek for identifying the species of Penicillium and Aspergillus; Dr. W. A. F. Hagborg for identifying the bacterial content in certain samples of wheat.

I am also indebted to Mr. R. A. Sellen for technical assistance during this work.

REFERENCES

Agrawal, N. S., C. M. Christensen, and A. C. Hodson. 1957. Grain storage fungi associated with the granary weevil. Jour. Econ. Ent. 50(5): 659-663.

Anderson, J. A., J. D. Babbit, and W. O. S. Meredith. 1943. The effect of temperature differential on the moisture content of stored wheat. Can. J. Res., C. 21: 297-306.

Babbit, J. D. 1945. The thermal properties of grain bulk. Can. J. Res. F. 23: 388-401.

Christensen, C. M. 1957. Deterioration of stored grain by fungi. Bot. Rev. 23: 108-134.

Fairbrother, R. H. 1929. The influence of environment on the moisture content of wheat and flour. Cereal Chem. 6: 379-395.

Gilman, J. C., and D. H. Barron. 1930. Effects of molds on temperature of stored grain. Plant Physiol. 5: 565-573.

James, N. 1955. Yellow chromogenic bacteria on wheat, I. Quantitative studies. Can. J. Microbiol. 1: 271-274.

James, N., J. Wilson, and E. Stark. 1946. The microflora of stored wheat. Can. J. Research, C, 24: 224-233.

Machacek, J. E., W. J. Cherewick, H. W. Mead, and W. C. Broadfoot. 1951. A study of some seed-borne diseases of cereals in Canada,

II. Kinds of fungi and prevalence of diseas in cereal seed. Sci. Agr. 31: 193-206.

Milner, M., C. M. Christensen, and W. F. Geddes. 1947. Grain storage studies. IV. Wheat respiration in relation to moisture content, mold growth, chemical deterioration, and heating. Cereal Chem. 24: 182-199.

Oxley, T. A. 1945. The spontaneous heating of stored cereals. Roy. Coll. Sci. Journ. 15: 71-80; reprinted in Milling, 1946, 106 (18), 380, 382, 384.

Oxley, T. A. 1948 a. The scientific principles of grain storage. 103 pp. The Northern Publishing Co. Ltd., Liverpool.

Oxley, T. A., and R. W. Howe. 1944. Factors influencing the course of an insect infestation in bulk wheat. Ann. Appl. Biol. 31:76-80.

Solomon, M. E. 1953. The population dynamics of storage pests. Trans. IXth Int. Congr. Ent., Amsterdam, 2: 235-248.

Wilson, F. 1946. Interaction of insect infestations, temperature, and moisture content in bulk-depot wheat. Bull. Coun. Sci. Industr. Res., Australia, No. 209, 31 pp.

EDUCATION AND RESEARCH IN INDIA

P. D. Gupta
Visiting Research Fellow
Department of Entomology
University of Manitoba
Winnipeg

I am very grateful for the privilege of addressing members of the Entomological Society of Manitoba on the subject of Education and Research in India. In spite of my limitations, I readily agreed when you suggested to me to speak at this meeting since it flashed into my mind that this will provide an opportunity when facts could be placed before you as to the endeavours, the Government and the people of India are making in the field of education with a view to wipe out illiteracy and raise the standards of higher education and research within the shortest period possible.

I take this opportunity to express my thanks to the University of Manitoba for the grant which enabled me to come here and to offer my sincere gratitude to Professors Thorsteinson and Robinson and to the other members of the Entomology Department for their kind hospitality, encouragement and co-operation. I assure that the memories of my visit to Canada will be ever cherished and I shall carry to my countrymen an impression of close understanding and good feeling the people of Canada have for us.

India is a secular democratic state having adult franchise for all her citizens. The preamble to the Constitution enshrines the resolve of the people of India to secure for all citizens:

> Justice, social, economic and political;
> Liberty of thought, expression, belief, faith and worship;
> Equality of status and of opportunity;

and to promote among them all, Fraternity assuring the dignity of the individual and the unity of the Nation.

The Constitution guarantees every citizen his/her Fundamental Rights, viz. the right to equality, the right to freedom, the right against exploitation, the right to freedom of religion, cultural and educational rights, the right to property and the right to constitutional remedies.

It is essential that people must be educated to derive the maximum benefit from such a liberal and all embracing Constitution which treats every individual as the real backbone of the society and guarantees, without distinction of caste, creed, race or sex, equal right to an adequate means of livelihood.

It may not be inappropriate to remark that ours is an old civilization which had a great set back due to numerous causes including foreign rule for about a thousand years. In 1947, the infant independent India was left with serious problems of feeding and clothing a teeming population of about 380 million semistarved and half naked people from want of proper sanitation and medical aid.

The people and their elected representatives took up the challenge and an all out effort has since been made to build up a new and prosperous India. Andrew Carnegie's dictum "Educate the people and poverty will take care of itself" has been accepted as an article of faith with us and our energy is being directed to achieve this goal. The following table will give some idea as to literacy, the increase in the number of institutions and students and total expenditure on education during 1951 to 1961.

Year	Literacy	Number of Institutions	Number of Students	Total Expenditure in crores of Rupees
1951	16.5%	0.29 million	26.5 million	125
1956	23%	0.37 million	40 million	190
1961 (target)	33%	0.46 million	55 million	300

It may be desirable to give some idea about the primary and secondary schooling before discussing the higher education imparted in the universities and technical institutions.

PRIMARY EDUCATION

We have only a few pre-primary or nursery schools for children below 5 to 6 years of age but people are growing conscious of the utility of these institutions and their number increased from 330 in 1951 to 630 in 1956, although these are all located in big cities alone.

Since the population of juveniles in India is quite high (24.8% of the total population), it is in the fitness of things that greater emphasis is laid on primary education. There are usually two types, the ordinary and the basic elementary schools. Since basic system is the accepted pattern, the ordinary elementary schools will be gradually converted into basic ones. The basic system sets out an activity curriculum in which learning is correlated with the physical and social environment of the children and also with productive activities like spinning, weaving, gardening, carpentry, leather work, book craft, domestic craft including cooking, sewing, house management etc.

An all Indian Council of Elementary Education has been set up and it is proposed to have an early implementation of free compulsory elementary education for all the children up to the age of 11 years; 63% of the children of age group 6 to 11 years will be in these schools by 1961 while every one of them should be going to school by 1966.

SECONDARY EDUCATION

Secondary education leading to High School certificate, almost equivalent to the senior cambridge of British system, was considered sufficient for the elite of urban population and served as a passport for most of the coveted clerical positions regarded as white collar jobs. During 1931 as few as 10 thousand students appeared for the examination as compared to 180 thousand in 1958 from U.P. which is one of the largest States in India. The few secondary schools called High Schools were limited to the cities and district headquarters but an enormous increase in their number during the 11 years of independence has brought these within reach of the rural population and the High School Certificate in itself is now no guarantee for any position.

Since the secondary stage in education serves as terminal stage for the largest number of students, the Secondary Education Commission recommended that the existing schools be converted into multipurpose types with the aim of making the system a self-contained and complete stage up to the age of 17. The schools offer instruction in compulsory subjects, viz. languages, social studies, general science and craft in addition to a course in either science, technology, commerce, agriculture, fine arts, home science or humanities. Plans are already in progress to provide facilities for free education for all the children up to the age of 17.

Previously not more than a dozen Public Schools could be counted in the whole of India. The education in these institutions was so expensive that only the sons of the very rich could afford the luxury. Now the Government of India has opened these schools to the rich and poor alike by offering paid scholarships for brilliant students from the families of low income groups.

HIGHER AND UNIVERSITY EDUCATION

Post-secondary education is imparted through arts and science colleges, professional colleges, (medical, engineering, agricultural, veterinary, etc.) universities, research institutions and special educational institutions.

In certain States like U.P., the Board of High School and Intermediate Education continues to supervise the courses of study during the first two post-high school years, and holds Intermediate examinations. In most of the other States, the Board is responsible for secondary education up to High School only and the students enter the university or the colleges directly under the control of the universities. The recommendation of the Government of India that "out of the 4 years a student has to spend after the present high school to get his Bachelor's degree, one year be added to the secondary stage to be called Higher Secondary School and a three year degree course be instituted at the Universities", is being gradually implemented, bringing a uniform system throughout the country.

Arts and Science colleges numbering 712 in 1956 impart training to the students who are fortunate enough to enter them. These institutes are independent in their internal management but are under the supervision of the affiliating university with regard to curricula, standard of teaching, appointment of qualified teachers and other academic matters. Some of the arts and science colleges offer courses leading to the highest academic degree and are more or less miniature universities short of power to hold examinations to confer degrees.

There are 37 universities divided into three different types, viz. affiliating, affiliating and teaching, and residential and teaching. The first type are fast disappearing as these have started offering facilites for teaching and research, especially at the graduate level. The affiliating and teaching type predominate, having the largest number of alumni and some of the oldest universities belong to this category. Most of the younger universities are, however, of the residential and teaching type; each being a unitary organization undertaking teaching at all levels and having control in all respects over the colleges under their jurisdiction.

The Inter-University Board, an advisory body, provides a forum for the discussion of common problems, maintenance of uniform standard and for the mutual recognition of degrees and diplomas. The University Grants Commission, an autonomous statutory body, was constituted in 1956 to look after most of the matters connected with higher education including the determination and co-ordination of standards and facilities for study and research. It makes appropriate grants to different universities for implementation of development schemes.

The universities are fully autonomous bodies having complete freedom from State control. Each university has its own administrative machinery comprising the governing body (court or senate), the academic council, and the executive council. The vice-chancellor (President in North American Universities) is the academic as well as the executive head and holds office for one or two terms of 3 to 5 years. Most of the universities have four to five faculties but some of the larger ones each have 8 to 9. The Dean of each Faculty is appointed from amongst the Chairmen (Heads) of the Departments constituting the faculty, either by rotation in order of seniority or by election. The office does not carry an additional emolument and it is not a life appointment. The Faculty of Science is separate from that of Arts.

Admission to the universities is made strictly on merit on the basis of marks obtained, either at the last public examination of in specially written competitive entrance examinations conducted for the purpose, particularly for the faculties of medicine, engineering and veterinary medicine. Admission to the professional colleges (faculties) and to the faculty of science is much more difficult since the number of applicants is very high. In medicine and in engineering about 15% of the applicants find admission while the rest have to either continue in the faculty of science or give up studies. There is both an upper as well as a lower age limit for admission to these institutions.

The syllabi and courses are framed by a Board of Studies in each subject which have to be finally approved by the Board of Faculty and the Academic Council. The courses are fairly rigid in the faculties of Science, Agriculture and Law and the candidate does not get much choice of subjects. We have only full courses; the system of giving half courses was tried in our university at Lucknow but had to be abandoned. English is the medium of instruction in most of the colleges and all the Universities especially at the graduate level although an attempt is being made to replace English gradually by the national or one of the regional languages at the undergraduate level.

In most of the Indian Universities, research can be pursued only after a student obtains the masters degree which is the minimum qualification for registration. The student must have a thorough knowledge of the fundamentals before he is allowed to specialize. Dissertations in one branch of a major subject are discouraged at the graduate level. In zoology for example, the graduate student has to write 8 papers and appear in 2 laboratory examinations during his stay of two years. Generally, students securing first or high second class marks in their masters work are allowed to do research.

Most of the universities follow the British model and have a three grade system for teaching staff in the time scale of Rupees, 3600/- -- 240/- -- 6000/- for Lecturers, 6000/- -- 300/- -- 9600/- for Readers, and 9600/- -- 600/- -- 15000/- for Professors. The scale of pay in the affiliated arts and science colleges is somewhat lower than in the professional and technical institutions. The salaries in teaching and research institutions are, however, low compared to those of civil services and business executives, and efforts are being directed to remove the disparity in their incomes.

The parents have to support the education of their sons/daughters unlike the students in North America who earn and learn. Fees have to be paid and there are not many scholarships, fellowships and assistantships even at the graduate level. There is an acute problem of providing suitable employment to the educated young men because most of them do not like to go to rural areas while there are not a sufficient number of white collar jobs. The student is obliged to go in for higher degrees postponing the day of graduating in the hope of becoming better qualified to compete for the few positions advertised by the government or private organizations. Rapid industrial development, full exploitation of the countries natural resources, and a change in the attitude of young men towards the values of life are likely to take us out of this unfortunate position.

PROFESSIONAL COLLEGES

Most of the professional institutions like medical, agricultural, veterinary, engineering, pedagogical colleges constitute faculties of the university to which they are affiliated but quite a few of the institutions imparting training in these fields remain independent and award only diplomas or certificates. Instances are not lacking where some of these professional colleges have been given the status of a University, e.g. College of Engineering, Roorkee; Indian Agricultural Research Institute, New Delhi; and Indian Veterinary Research Institute, Izatnagar.

A number of institutions impart training in industrial subjects like mining and metallurgy, chemical engineering, ceramics, textile, sugar, and oil technology, etc. These are either independent or government sponsored bodies which award diplomas and associateships.

RESEARCH INSTITUTES

A number of specialized institutes offer only research facilities but no graduate courses leading to masters degrees. These centres of learning attract students from all over India and even from other Asian countries to pursue a research career in their specific fields. The Palaeobotanical Institute, Lucknow; Indian Institute of Science, Banglore; Indian Statistical Institute, Calcutta; Tata Institute of Fundamental Research, Bombay; Institute of Social Science, Bombay; and Shri Ram Institute for Industrial Research, Delhi are some of the examples of purely research institutions which have endowments and are liberally financed by the federal and state governments.

A number of All Indian Bodies like the Council of Scientific and Industrial Research, Indian Council of Medical Research and Indian Council of Agricultural Research, tender advice, co-ordinate activities, and finance and supervise scientific projects besides maintaining several research institutes.

The Council of Scientific and Industrial Research has already set up a chain of 21 National Research Laboratories (Physical, chemical, roads, buildings, electronics, salt, mining, biochemistry, food, leather, drugs, etc.) located in different parts of the country where both fundamental and applied researches are carried out.

The Indian Council of Medical Research fosters and co-ordinates medical research in the country. Some of the research institutes in the field of medicine and public health doing specialized work are the Indian Institute of Hygiene and Public Health, Tata Institute of Cancer Research, King Institute of Preventive Medicine, Patel Chest Institute, Haffkine Institute, Pasteur Institute, Malaria Institute, etc.

The Indian Council of Agriculture Research sponsors research in both agriculture and animal husbandry. It finances and co-ordinates research projects in the colleges and universities as well as in institutes and laboratories maintained by the state and federal governments. Indian Agricultural, Indian Forest, Indian Veterinary, Indian Dairy, Indian Lac, Central Rice, Central Potato, Central Cotton, Central Sugarcane Research Institutes and Central Marine and Central Inland Fisheries Research Stations along with a number of smaller research laboratories for specific commodities like coconut, tobacco, oil seeds, areca nuts, etc. constitute the main centres of research in their respective fields. Departments like the Zoological, Botanical and Geological Surveys of India maintain extensive museums, Zoological and Botanical gardens and in addition to their survey work provide facilities for training and research to those interested in systematics and ecology.

Quite a few departmental research stations and institutes like the Hydraulic Research Station, Railway Research Centre, Navigational Research Centre, etc. have been set up by different ministries to advise them on their specific problems.

Care has been taken that there is no lopsided development of education and the students are encouraged to take part in sports and cultural Activities. A National College of Physical Education, Councils of sports at the Centre and in the States of Rajkumari Sports coaching scheme provide suitable facilities for the training of young men besides holding seminars, popularizing norms of physical education and awarding scholarships and fellowships for higher studies. Liberal grants are given to Sports Federations to modernize their equipment and help them participate in international games and sports. In order to develop the qualities of leadership and discipline in the youth, Senior, Junior and Girls divisions of National Cadet Corps have been established in some of the secondary schools and colleges and in all the universities by the Army, Navy and the Air Force.

Since Indian independence was attained sufficient attention has been paid to the programmes catering to the recreational, cultural and emotional needs of the youth so that their enthusiasm is directed into proper channels. The holding of annual youth leadership camps and inter-university youth festivals, establishment of youth hostel associations, organizing labour and social service schemes and providing travel concessions and financial assistance to young men for tours are some of the endeavours made in this direction.

Fine arts, painting, sculpture, music, poetry, literature, etc. have been given their due share in the scheme of education. Suitable scholarships and fellowships are awarded to the students interested in some of these fields and they are provided with all the facilities to receive proper and systematic training of the highest order. Lalit Kala Academy, Sangeet Natak Academy and Sahitya Academy established during 1953 and 1954 are some of the highest institutions devoted exclusively to the development and promotion of study and research in subjects like painting, applied arts, sculpture, music, dance, drama, poetry, Indian literature etc. Besides offering facilities for training and research, the Academies initiate surveys, hold seminars and conferences, arrange displays of exhibits, establish international contacts and bring out publications.

EDUCATION AND RESEARCH IN ZOOLOGY IN GENERAL AND ENTOMOLOGY IN PARTICULAR

Now it may be desirable to deal at some length the subject in which all of us are vitally interested. It is unfortunate that only a casual attitude has been shown towards the Biological Sciences in India as is quite evident from the fact that out of 46 only 7 Biologists were elected to the presidential chair of the largest Scientific Body, viz. the Indian Science Congress Association. It does not require special mention that research in zoology, especially in the applied branches like entomology, parasitology, fisheries, genetics etc. has to make major contribution in an agricultural country like ours which has alarming forest and irrigation insufficiencies and enormous food problems clamouring for solution through improved animal husbandry, dairy farming and progressive fisheries' policy.

Although ample evidence exists that interest in animal life was keenly evinced by our people from ancient times, yet we are indebted to the British scientists for the development and growth of the science of zoology in its present form. Unfortunately much progress could not be made in spite of the fact that the study of the subject is so fascinating and useful, probably because the knowledge remained confined to the seats of learning and could not diffuse even to the person of general culture much less to the common man. No effort was made to make the subject popular or to enlist the active co-operation of the people by bringing home to them the benefits from its study through the organizations of natural history societies, museums, aquaria, zoological gardens, and agricultural and animal husbandry exhibitions.

The routine teaching consisted mostly of reporting facts from text-books written in foreign countries; even the animals for dissection and mounting were imported. Agassiz' dictum, "Study 'nature' and not books alone" is now being emphasized to create real interest in the subject. Memoirs on Indian types and text books are being written and the syllabi and courses of study revised and re-orientated. With a shift on emphasis from 'form to function' and from 'qualities to quantities', the methods belonging to the exact sciences of physics, chemistry and mathematics are now being increasingly applied to the study of zoological problems and it is changing from a purely descriptive to analytical and experimental science. Only a beginning has been made towards the study of the science of modern genetics and the newer disciplines of comparative physiology, biochemistry, biophysics, histopathology, bio-ecology, etc. We are still far behind in the development of zoology and it is likely to take some years to catch up. We hope to receive your blessings, good will, help and active co-operation for speedier progress.

MARINE ZOOLOGY AND FISHERIES

Although the new marine and inland fishery stations at Mandapam and Calcutta, the centres at Trivandrum and Krusadi Islands, and the aquaria at Madras and Bombay have opened up opportunities for advanced studies in fisheries, these can play only a minor role for instructions in marine zoology in general. A number of students from the up country do not get an opportunity to have a look at the sea even after taking a Master's degree in Zoology although they spend about half their time in studying marine animals. Recently there has been increasing interest in the advancement of oceanographic studies. The power fishing project of the central government is providing opportunities for marine work both on the applied and fundamental aspects. With regard to limnological studies, we are concerned more with problems of rivers and tanks rather than those of lakes and are gradually preparing for the day when, on completion of multipurpose river projects, vast inland aquatic resources will become available for exploitation.

PARASITOLOGY

Until recently the study of Protozoa, Helminth parasites and insects, like that in other branches of zoology, was confined to systematics and morphology. New lines of teaching and research have been introduced at certain centres like the Universities of Lucknow, and Delhi and the investigations on larval stages and life histories, histopathology, and physiology of Helminth parasites are likely to provide clues for effective control measures against these worms. Experimental studies have demonstrated that certain worms having morphological differences but recovered from different hosts are really phenotypic rather than genotypic, e.g. the metacercaria of the same species of Fasciola when fed to guinea pigs, rabbits, cattle and pigs produced adults possessing differences sufficient to justify them as separate species. A contribution is thus made towards a proper understanding of the concept of the so called 'species'. We have, however, hardly begun a study of phytonematology, but it is being realized that greater attention should be paid to this important branch.

ENTOMOLOGY

In spite of the fact that the geographical and climatic diversities have bestowed on us a wide variety of terrestrial habitats, each presenting biological problems of special interest, and that the majority of our centres of research in the natural sciences are situated in places where unrivalled facilities exist for carrying out projects in terrestrial ecology, no serious effort has been made to investigate the bio-ecology of the tropical forests and high mountains. The existing natural facilities for making original observations on wild life, especially of insects, birds and mammals have not been utilized at all.

Since independence, the value of the study of entomology in our daily life is being appreciated and it is fully realized that research in Entomology has to play an important and honorable part in projects concerning industry, agriculture, animal husbandry, silviculture, and prevention of diseases. Fletcher, Lefroy, Afzal Husain, Ramkrishna Ayyar, Pruthi and Ram Chandra Rao will ever be remembered as pioneers in the field of entomology in India.

Entomology forms a full independent subject in all the Agricultural Colleges even at the graduate level but is generally taught as a branch of zoology in most of the science colleges and the universities. In some universities students are encouraged to take this subject as a part of a "special group" for their master's degree.

Facilities for advanced study and research are provided at the agricultural, Veterinary and medical colleges; zoology departments of the universities; departments of agriculture and forestry of the State and Central governments; Zoological Survey of India; Forestry Research Institute; and Indian Agricultural and Indian Veterinary Research Institutes. The distinction and rivalry between the so-called pure and applied fields of entomology are fast disappearing and there is closer co-operation between the various institutions devoted to the study of insects. Although we are short of properly trained systematists, emphasis is shifting towards the studies of insecticides, biological control, ecology, population dynamics and such other problems concerning insects.

An extension service of the Agriculture department in the States provides free advice to the farmers who are still indifferent and regard pests and plant diseases as natural calamities against which they consider themselves powerless. The Plant Protection and Quarantine Directorate established a few years ago under the central government keeps vigilance, helps research and offers assistance.

Only a few organized attempts have been made to study Apiculture and honey is mostly collected from the hives of wild bees in nature. Except for meagre efforts to combat mosquitoes, house flies and a few obnoxious insects injurious to poultry and cattle, adequate attention has not been paid towards proper and systematic study of insect vectors responsible for deterioration of health in humans and live stock.

In the end, I must apologize for my shortcomings and offer my grateful thanks for the patience and sympathy with which you listened to me.

APPENDIX

ADDITIONS TO THE LIBRARY OF THE ENTOMOLOGICAL SOCIETY OF MANITOBA

The following list contains the names of authors and/or titles of publications received in exchange for the Proceedings since the publication of the list appended to Volume 13 of the 1957 Proceedings.

1. Annales de la Société Entomologique du Québec, Vol. 2, 1956.

2. Annales de la Société Entomologique du Québec, Vol. 3, 1957.

3. Annuaire de la Faculté d'Agriculture et de Sylviculture de l'Université de Skoplje (Jugoslavia), Vol. 10, 1956-57.

4. Bey-Bienko, G. J. Tettigoniiden aus Iran (Orthoptera), No. 5. Stuttgarter Beiträge zur Naturkunde. Stuttgart, Germany, 1957.

5. Bollettino dell' Istituto di Entomologia Della Universitá Degli Studie di Bologna, Vol. XXII, 1957.

6. Collinet, C. Le sort des Tenebrio molitor L. qui atteignent le stade nymphal dans des milieux nutritifs artificels. II. Fertilité des adultes. Bull. Soc. R. Sci., Liege, 26: 381-386, 1957.

7. Collinet, C. Contribution à l'étude de la variabilité individuelle chez Tenebrio molitor. I. Variabilité à différents stades. Bull. Soc. R. Sci. Liege. 27: 258-265, 1958.

8. Duchateau, Gh. et M. Florkin. A survey of aminoacidemias with special reference to the high concentration of free amino acids in Insect hymolymph. Arch. Internat. Physiol. Biochim., 66, 18 pp., 1958.

9. Faber, Albrecht. Über den Aufbau von Gesangsformen in der Gattung Chorthippus Fieb. (Orthoptera)... Stuttgarter Beiträge zue Naturkunde, Stuttgart, No. 1, 1957.

10. Faber, Albrecht. Über parallele Abänderungen bei Lautäusserungen von Grylliden... Stuttgarter Beiträge zur Naturkunde, Stuttgart, No. 2, 1957.

11. Florkin, M. Biochimie et évolution animale. Actes Sci. Helvétique Sci. Nat. Neuchâteal, pp. 35-53, 1957.

12. Hatch, Neville H. The Beetles of the Pacific Northwest. Part II: Staphyliniformia. (University of Washington publications in biology, Vol. 16).

13. Huot, L. et J. Leclercq. Nutrition protidique chez Tenebrio molitor L. I. Influence de l'etat physiologique des larves sur leur comportement dans des milieux nutritifs carancés. Arch. Internat. Physiol. Biochim. 66: 270-275, 1958.

14. Huot, L. et J. Leclercq. Nutrition protidique chez Tenebrio molitor L. II. Notion d'optimum protidique. Arch. Internat. Physiol. Biochim. 66: 276-281, 1958.

15. Huot, L. et J. Leclercq. Besoins protidiques chez les larves de Tenebrio molitor (race G.). Arch. Internat. Physiol. Biochim. 66: 120-121, 1958.

16. Jeuniaux, Ch. Purification of a streptomyces chitinase. Biochem. J. 66, 29 pp. 1957.

17. Jeuniaux, Ch. et M. Florkin. Contributions à la Biochimie du ver à soie. I. Influence de diverses conditions expérimentales sur l'élaboration de la soie et sur la croissance. Arch. Internat. Physiol. Biochim. 66, 1958.

18. Jeuniaux, C. Les enzymes d'origine épidermique au cours du phénomène de la mue chez les Insectes. Actes Soc. Linneenne Bordeaux, 97, 8 pp.

19. Kettner, F. W. et J. Leclercq. Mission E. Jansenns et R. Tollet en Grece (Juillet - Aôut 1953) 15e note- Hymenoptera - Apidae solitaires. Bull. Ann. Soc. R. Ent. Belgique. 93: 74-80, 1957.

20. Leclercq, J. La sort des Tenebrio molitor L. qui atteignent le stade nymphal dans des milieux nutritifs artificels. I. Durée de la vie larvaire et poids nymphaux. Bull. Soc. R. Sci. Liege, 26: 369-380. 1957.

21. Lindner, Erwin. Ostafrikanische Bombyliidae (Dipt.) Stuttgarter Beiträge zur Naburkunde, Stuttgart, No. 3, 1957.

22. Plant Protection. Published by the Institute for Plant Protection. Belgrade (Jugoslavia), Nos. 38, 39-40, 41-42, 1956 to 1958.

23. Pest Infestation Research. Department of Scientific and Industrial Research. Reports of the Pest Infestation Research Board and Reports of the Director of Pest Infestation Research. 1947 to 1956 inclusive.

24. Proceedings of the Entomological Society of British Columbia, Vol. 55. 1958.

25. Recherches Agronomiques. Published by the Ministère de l'Agriculture de la Province de Québec. Le conseil des Recherches Agricoles, No. 1, Juin 1947 - Avril 1957.

26. Recherches Ageonomiques. Published by the Ministère de l'Agriculture de la Province de Québec. Sommaire des résultats, No. 2, 1948 - 1957.

27. Sabrosky, C. W. East African Milichudae (Diptera) Stuttgarter Beiträge zue Naturkunde, Stuttgart, No. 4, 1957.

IN MEMORIAM

Edmund John Stansfield died unexpectedly at the Winnipeg Grace Hospital on February 26, 1959. Our membership knew him as a regular attender and participant in the meetings of the Society and as a zealous and able exponent of organized, modern mosquito control. Mr. Stansfield was born in England and lived in Australia as a young man before coming to Canada. He graduated from the University of Manitoba and farmed at Atwater, Saskatchewan. In 1948, he joined the mosquito control organization in Winnipeg and in 1951 became Field Manager. He is known for his work in the emergency of the 1950 flood and for his long service with the St. John's Ambulance Association.

Mr. Stansfield's keen and progressive approach to mosquito control in metropolitan Winnipeg remains an inspiration to all of us who are associated with this work. Only a few days before his untimely death he visited the Department of Entomology to discuss plans for the 1959 operations. He had great faith in the potential contribution of entomological research in the present and future of mosquito control. His own insight into the biological aspects of his work was worthy of his high degree of practical competence. He was a loyal and active member of the Entomological Society of Manitoba.