Agriculture Canada

Research Branch / Direction générale de la recherche

National workshop on bee and pollination research

Atelier national sur la recherche apicole et pollinisation

Canada

National workshop on bee and pollination research

Winnipeg, Manitoba
April 4-5, 1989

Atelier national sur la recherche apicole et pollinisation

Winnipeg (Manitoba)
4-5 avril 1989

Research Branch
Agriculture Canada
1989

Direction générale de la recherche
Agriculture Canada
1989

Produced by Research Program Service

Production du Service aux programmes de recherche

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The dots on the map represent Agriculture Canada research establishments.

Illustration de la couverture
Les points sur la carte indiquent les établissements de recherche d'Agriculture Canada.

FOREWORD

The National Workshop on Bee and Pollination Research was initiated as the result of consultations between the Canadian Honey Council and the Research Branch of Agriculture Canada. Representatives of the Canadian Honey Council, the Canadian Association of Professional Apiculturists and others subsequently accepted the responsibility to serve on an advisory committee to plan the workshop.

The objectives of the workshop were to achieve consensus on research priorities over the next three to five years, to determine where the research might be conducted and to discuss plans for funding the research. The workshop was comprehensive, including a review and discussion of all aspects of bee and pollination research in Canada under three general categories: honey bees, leafcutter bees, and other pollinators.

The research priorities and recommendations agreed to will be helpful in planning research, in making decisions about resource allocations, and in furthering cooperation between those who have a stake in providing the knowledge and technology needed to strengthen the bee and pollination industries in Canada in the years to come.

I wish to thank the many who contributed to the success of this workshop. The spirit of cooperation and the willingness to consider the national scene that prevailed at the workshop are most commendable. Thanks are due to the members of the workshop advisory committee, R. Congdon, D. Dixon, S.C. Jay, W.J. McElheran, R.J.McLaughlin, D. McRory, D. Nelson and C. Sicotte, to the Canadian Association of Professional Apiculturists for hosting the reception prior to the workshop, and to the Ontario Ministry of Agriculture and Food and the Saskatchewan Alfalfa Seed Producers Association for sponsoring delegates to the workshop. A special thanks to Dr. J. Tew, United States Department of Agriculture, who served most effectively as an external reviewer and provided much helpful information and advice to the workshop.

Finally, a very sincere thank you to the three who made exceptional contributions to the success of the workshop; Don Dixon and Cam Jay, Co-chairpersons, whose expert knowledge and organizational and diplomatic skills served us extremely well, and to Barry Fingler who did an excellent job of recording the proceedings and preparing this document.

A.O. Olson
Assistant Deputy Minister, Research
Agriculture Canada

AVANT-PROPOS

L'atelier national sur la recherche apicole et la pollinisation est l'aboutissement de concertations entre le Conseil canadien du miel et la Direction générale de la recherche d'Agriculture Canada. Par la suite, des représentants du conseil Canadian du miel, de l'Association canadienne des apiculteurs spécialisés et d'autres groupes ont accepté l'invitation de se joindre au comité consultatif chargé de la préparation de l'atelier.

L'atelier avait pour objectifs d'atteindre un consensus sur les priorités de recherche pour les prochaines trois à cinq années, d'établir les endroits où la recherche serait menée et de débattre les sources de financement. L'atelier englobait un grand nombre de domaines, notamment l'examen de tous les aspects de la recherche apicole menée au Canada et la pollinisation, regroupés sous les rubriques sur les abeilles à miel, les mégachilles et les autres pollinisatrices.

Les priorités de recherche et les recommandations découlant de l'atelier seront grandement utiles à la programmation de la recherche et à l'impartition des ressources tout en favorisant la coopération entre les personnes chargées de faire progresser les connaissances dans ces domaines et de parfaire les techniques au profit du secteur apicole canadien au cours des prochaines années.

Qu'il me soit permis de remercier tous ceux dont les efforts ont contribué au succès de l'atelier. La coopération était à l'honneur et on a pu constater un empressement fort louable à porter le débat sur la scène nationale. Il nous faut remercier les membres du comité consultatif d'atelier, soit R. Congdon, D. Dixon, S.C. Jay, W.J. McElheran, R.J. McLaughlin, D. McRory, D. Nelson et C. Sicotte, l'Association canadienne des apiculteurs spécialisés qui a offert une réception avant le debut de l'atelier, le Ministère ontarien de l'agriculture et de l'alimentation ainsi que l'Association des producteurs de semences de luzerne de la Saskatchewan qui ont parrainné des délégués. Nos remercions en particulier le Dr. J. Tew du Département américain de l'Agriculture, qui a fait office de critique externe et qui a dispensé des conseils utiles.

Enfin, soulignons la contribution exceptionnelle de trois personnes au succès de l'atelier; Don Dixon et Cam Jay, les co-présidents, qui ont fait profiter leurs aptitudes à l'organisation et leur tact, et celle de Barry Fingler qui s'est chargé du procès-verbal.

Le Sous-Ministre adjoint à la recherche
d'Agriculture Canada

A.O. Olson

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LIST OF PARTICIPANTS/LISTE DES PARTICIPANTS

Co-Chairpersons/Co-présidents

S.C. Jay, Professor, University of Manitoba, Winnipeg, MB
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Recording Secretary/Prise de notes

B. Fingler, Extension Apiarist, Manitoba Agriculture, Winnipeg, MB

Delegates/Délégués

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J. Gruszka, Provincial Apiculturist, Saskatchewan Agriculture, Prince Albert, SK

D. Jones, President, Canadian Alfalfa Seed Council, Oyen, AB

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W. McElheran, Chief, Imports, Animal Health Division, Food Production and Inspection Branch, Agriculture Canada, Ottawa, ON

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C. Prouse, Apiarist and Horticultural Specialist, Prince Edward Island Dept. of Agriculture, Charlottetown, P.E.I.

G. Rank, Professor, University of Saskatchewan, Saskatoon, SK

K. Richards, Research Scientist, Agriculture Canada, Lethbridge, AB

D. Rickard, President, Canadian Seed Growers' Association, Bowmanville, ON (April 5 p.m. only)

D. Rogers, Provincial Apiarist, Nova Scotia Dept. of Agriculture and Mining, Truro, NS

C. Scott-Dupree, Professor, University of Guelph, Guelph, ON

C. Sicotte, Crop Development Officer, Agriculture Development Branch, Agriculture Canada, Ottawa, ON

J. Tew, National Program Leader - Apiculture, U.S. Dept. of Agriculture, Ohio State University, Wooster, OH

P. Van Westendorp, Provincial Apiarist, Alberta Agriculture, Edmonton, AB

W. Wiebe, Director, Crop Protection Branch, B.C. Ministry of Agriculture and Fisheries, Victoria, B.C.

M. Winston, Professor, Simon Fraser University, Burnaby, B.C.

Observers/Observateurs

Y. Martel, Director-General, Research Branch, Eastern Region, Agriculture Canada, Ottawa, ON

F. Rank, Saskatoon, SK

H. Smith, Vice President, Canadian Alfalfa Seed Council, Dugald, MB

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RESEARCH PRIORITIES AND RECOMMENDATIONS

APRIL, 1989

Following is the prioritized list of research recommendations which was unanimously agreed to by the workshop participants at the end of the two day meeting on April 5, 1989. N.B. Only topics within groups are priorized, the three groups are NOT priorized.

A. Honey Bee Research - Priority List (Ranked)

Research Topic	Where To Be Done
1. Mites a) detection (tracheal mite) b) production and maintenance of mite-resistant stock (tracheal mite) c) control products (tracheal and varroa mites) d) production of mite-free stock (queens and bees; both mites) e) economic impact (both mites) f) cultural control (both mites) g) integrated management (both mites)	Agriculture Canada; U. of Guelph; U. of Saskatchewan; Fairview College; U.S.D.A.; private sector
2. Residues in hive products	Ag Canada; U. of Alberta; U. of Saskatchewan
3. Value of bees for pollination	Ag Canada; U. of Guelph
4. Management for self-sufficiency	Simon Fraser U.; provinces
5. Pollination requirements for selected crops	Ag Canada; U. of Guelph; U. of Manitoba; Simon Fraser U.
6. Chemical control of bee diseases	Ag Canada; U. of Guelph
7. Non-chemical control of bee diseases	Ag Canada; U. of Guelph

It is noted that producer involvement has been and will continue to play a major role in research efforts.

B. Leafcutter Bee Research - Priority List (Ranked)

Research Topic	Where To Be Done
1. Pathogens - prevention and control	Ag Canada; U.S.D.A. provinces; industry (associations and producers)
2. Parasites and predators - biology and control	Ag Canada; U.S.D.A.; provinces; industry
3. Causes of mortality of immature bees	Ag Canada; U.S.D.A.; provinces; industry
4. Use of leafcutter bees in other crops	Ag Canada; U of Guelph
5. Management studies	
a) equipment evaluations	Ag Canada; provinces; industry
b) optimum densities of bees	Ag Canada; provinces; industry
c) sex ratios	Ag Canada; provinces; industry
d) combining honey bees and leafcutter bees	Ag Canada; U of Manitoba; provinces; industry
6. Leafcutter Stock Selection	private sector

It is noted that agronomic research within the alfalfa seed industry is equally important to that of leafcutter bee research. The major agronomic concerns have been included for information purposes (Appendix G(2)).

It was suggested that agencies conducting toxicological studies on honey bees should also include similar studies on leafcutter bees.

C. Commodity-oriented Pollination - Priority List (Ranked)

Research Topic	Where To Be Done
1. Tree fruits	U. of Guelph; OMAF; Ag Canada; industry
2. Field crops	
a) oil seeds	U. of Guelph; private sector; U. of Manitoba;
b) forage legumes	Ag Canada

3.	Small fruits	provinces; industry
4.	Greenhouse crops	U. of Guelph; Ag Canada; industry
5.	Special crops	Ag Canada; provinces; private sector
6.	Pollination for sustainable agriculture	Ag Canada

PRIORITÉS DE RECHERCHE ET RECOMMANDATIONS

Avril 1989

On trouvera ci-après la liste des recommandations en matière de recherche selon l'ordre de priorités qui a reçu l'assentiment unanime des participants à l'atelier à la suite de la réunion de deux jours qui s'est terminée le 5 avril.

A. Recherche sur les abeilles - Enumération selon l'ordre de priorité

Sujet de recherche	Endroit
1. Acariens	
a) détection (parasites de la trachée)	Agriculture Canada;
b) production et maintien d'une réserve réfractaire (acariens de la trachée)	U. de Guelph;
c) lutte aux acariens varroa et trachéens	U. de la Saskatchewan; Collège Fairview
d) réserves libres d'acariens (reines et abeilles; deux sortes d'acariens)	Agriculture U.S.A.
e) répercussions économiques (deux sortes d'acariens)	Secteur privé
f) mesures culturales de lutte) (deux sortes d'acariens)	
g) lutte intégrée (deux sortes d'acariens)	
2. Résidus dans les produits des ruches	Ag. Canada; U. de l'Alberta; U. de la Saskatchewan
3. Importance des abeilles la pollinisation	Ag. Canada; U. de dans Guelph
4. Moyens d'assurer l'auto-approvisionnement	U. Simon Fraser; provinces
5. Pollinisation et cultures choisies	Ag. Canada; U. de Guelph; U. du Manitoba; U. Simon Fraser
6. Lutte aux maladies d'abeilles à l'aide de produits chimiques	Ag. Canada; U. de Guelph

7. Lutte aux maladies des abeilles sans l'aide de produits chimiques	Ag. Canada; U. de Guelph

Il importe de souligner l'importance grandissante de la contribution des producteurs aux efforts de recherche.

B. Recherche sur la mégachille (selon l'ordre de priorité)

Sujet de recherche	Endroit
1. Substances pathogènes - prevention et élimination	Ag. Canada; Min. Agr. USA; provinces; secteur (associations et producteurs)
2. Parasites et prédateurs - biologie et programmes de lutte	Ag. Canada; Min. Agr. USA; provinces; secteur
3. La mortalité chez les abeilles immatures	Ag. Canada; Min. Agr. USA; provinces; secteur
4. Utilisation de la mégachille dans d'autres cultures	Ag. Canada; U. de Guelph
5. Études de conduite des élevages	
a) évaluation du matériel	Ag. Canada; provinces; secteur
b) peuplements optimums	Ag. Canada; provinces; secteur
c) nombre de sujets mâles par rapport aux sujets femelles	Ag. Canada; provinces; secteur
d) croisements d'abeilles à miel et de mégachilles	Ag. Canada; U. de Manitoba; provinces; secteur
6. Sélection des stocks de mégachilles	Secteur privé

On notera que la recherche agronomique menée au sein du secteur de la luzerne est tout aussi importante que la recherche entreprise sur la mégachille. Les principales questions touchant à l'agronomie ont été regroupées dans l'annexe (G(2) à titre documentaire.

Une suggestion a été faite à l'effet que les organismes qui mènent des études toxicologiques sur les abeilles à miel pourraient entreprendre des études semblables sur la mégachille.

C. La pollinisation axée sur les produits selon l'ordre de priorité

Sujet de recherche	Endroit
1. Arbres fruitiers	U. de Guelph; Ont. (alim.); Ag. Canada; secteur
2. Grandes cultures a) oléagineux b) légumineuses	U. de Guelph; secteur privé; U. de Manitoba; Ag. Canada
3. Petits fruits	Provinces; secteur
4. Serriculture	U. de Guelph; Ag. Canada; secteur
5. Cultures spéciales	Ag. Canada; provinces; secteur
6. Pollinisation à l'appui de l'agriculture renouvelable	Ag. Canada

M I N U T E S

APRIL 4, 1989

1. Welcome and Introductory Remarks

D. Dixon welcomed everyone in attendance to the meeting and asked the participants to introduce themselves.

D. Dixon indicated that the meeting had been called at the request of Agriculture Canada and the Canadian Honey Council to review the apiculture industries on a historical basis and to determine and prioritize their current research needs over the next 3 - 5 years. It is anticipated that a comprehensive document will arise from this meeting which will outline a clear set of research recommendations for industry and for research and government agencies.

C. Jay reviewed the agenda for the meeting and asked if there were any suggestions for changes. There were no suggested changes.

D. Dixon introduced Dr. Yvon Martel, who welcomed everyone on behalf of the Research Branch of Agriculture Canada. He indicated that as the industries' needs are becoming ever increasing, so are the costs associated with conducting research to meet these needs. It is therefore important that there be close communication and cooperation between the Research Branch, provincial governments, universities, the private sector and producers.

D. Dixon introduced R. Congdon, who welcomed everyone on behalf of the Canadian Honey Council. He indicated that he was pleased that this meeting will not only address the current and future "bee-related" problems but will also address pollination concerns as they relate to beekeeping.

2. Background Information

(A) Five Year State-of-the-Industry Review

1. Honey Bees - P. Van Westendorp provided a 5-year review of the honey bee industry from 1984-1988. Refer to Appendix A(1).

2. Alfalfa Leafcutter Bees - G. Rank provided a 5-year review of the alfalfa leafcutter bee industry from 1984-1988. Refer to Appendix A(2).

(B) Current Bee-Related Research in Canada - Projects and Institutions 1983 - 1988

1. Honey Bees - M. Winston provided a review of honey bee-related research projects in Canada from 1983-1988. Refer to Appendix B(1).

2. Alfalfa Leafcutter Bees - K. Richards provided a review of alfalfa leafcutter bee-related projects in Canada from 1983-1988. Refer to Appendix B(2).

3. Other Pollinators - P. Kevan provided a review of native pollinator research in Canada from 1983-1988. Refer to Appendix B(3).

(C) Recent Apiculture Search Workshops - D. Nelson provided a review of recent apiculture research workshops in Canada dating back to 1970. Refer to Appendix C(1).

3. <u>Educational Requirements and Other Personnel Considerations</u>

D. McKenna reviewed the current status of apicultural education and employment in Canada. He also provided a 5-year projection of the numbers of apiculture graduates and the associated employment opportunities that may or should be available in Canada over this period. A current list of professional apiculturists in Canada is appended. Refer to Appendix D(1).

4. <u>State of the Beekeeping Industry and Related Research in the U.S.A.</u>

J. Tew indicated that there appears to be "hysteria" developing in the U.S. regarding africanized honey bees. U.S.D.A. is attempting to inform and educate, but not excite, the U.S. public about africanized bees. There is also a major industry concern with the public's perception of botulism and its relationship to food products like honey. The National Honey Board has undertaken to prepare itself with educational information about this and other concerns, should they gain widespread media attention and consequently threaten the good reputation of honey.

APHIS (Animal and Plant Health Inspection Service - U.S.D.A.) is currently addressing the concerns related to the regulation of varroa mites through "negotiated rule-making sessions." There has been considerable controversy in some states with regard to permitting known varroa-infested, but treated, colonies into disease-free areas.

The dissemination of accurate and timely information, particularly with respect to africanized bees, is of major concern because most of the U.S. beekeepers do not subscribe to, or read the major journals in beekeeping.

Priorities for research in the U.S. are currently directed toward dealing first with the africanized bee and varroa mite and secondly, with tracheal mites.

U.S.D.A. has formed a technical working group, comprising of persons from APHIS, ARS and Extension Services to plan and coordinate activities with respect to africanized bees.

U.S.D.A. centres of research that are directed toward each of these concerns are:

Weslaco lab - Dr. A. Collins heads research on africanized bees.
Beltsville lab - Dr. H. Shimanuki heads research on parasitic mites of honey bee.

It was felt that cooperative, or joint U.S. - Canadian research into these areas of common concern could probably be arranged.

5. Research Needs and Concerns

(A) Canadian Honey Council - R. Congdon presented the Canadian Honey Council's research needs and concerns. Refer to Appendix E(1).

R. Congdon indicated that the Canadian Honey Council feels that there is an urgent need to hire another federal bee pathologist and a federal honey bee geneticist. The Canadian Honey Council does not believe that it is in the best interests of the beekeeping industry to have bee research centralized in Canada. It may be more beneficial to conduct the research in existing federal facilities across Canada.

(B) Canadian Alfalfa Seed Council - D. Jones outlined the roles of the Canadian Alfalfa Seed Council and presented their research needs and concerns with respect to alfalfa leafcutter bees. Refer to Appendix E(2).

(C) Canadian Seed Growers' Association - A representative was present on the second day of the workshop.

(D) Canadian Association of Professional Apiculturists

1. Provincial Representatives - J. Gruszka reviewed the research needs of provincial representatives. Refer to Appendix E(3). He indicated that funding for research initiatives is difficult to obtain by provincial representatives as research is not defined as one of their mandates (disease control and extension). However, provincial representatives may be able to cooperate with the federal government, universities and industry in undertaking cooperative research efforts; the tracheal mite project conducted recently in La Ronge, Saskatchewan was cited as an example.

C. Prouse indicated that horticulturists should be consulted on varietal testing research, especially where the pollination requirements of the plants are concerned.

2. Research Representatives - D. Nelson reviewed a list of research needs compiled from a questionnaire sent to federal and university researchers in March 1989. Refer to Appendix E(4). He indicated that there appeared to be a general feeling amongst the respondents that the need for tracheal mite research was the most important concern at this time.

6. <u>Recommendations for Research</u>

(A) Honey Bees

1. Disease and Pests (including prevention and control) - B. Fingler presented four research recommendations with respect to honey bee disease and pest control. Refer to Appendix F(1).

   Additional recommendations from the floor included:

   - improved diagnostic procedures for honey bee tracheal mites (previously noted in information supplied by R. Congdon, J. Gruszka).
   - identification of africanized honey bees (previously noted in information supplied by J. Gruszka).
   - non-chemical (inc. integrated management) procedures for the control of honey bee diseases (previously noted in information supplied by R. Congdon).

2. Stock Selection and Breeding (including bee and queen supply) - C. Scott-Dupree presented two research recommendations pertaining to honey bee stock selection and breeding. Refer to Appendix F(2).

3. Management Studies (including behavior) - D. Rogers reviewed a list of recommendations concerning honey bee management and behavioral research. Refer to Appendix F(3). It was decided to address "(1) Self-sufficiency" with respect to overwintering and queen introduction and locating only, because queen rearing, stock improvement, integration and mite resistance have been addressed previously. Also, it was decided to defer discussion of "(4) Pesticide poisoning risk assessment and evaluation of impact" to the area of research of toxic substances affecting bees.

4. Pollination and Plant Related Studies - M. Winston presented three research recommendations related to pollination and plant related studies. Additional recommendations from the floor included:

   - bee attractants
   - crop varietal trials and pollination requirements

   Refer to Appendix F(4).

5. Research on Chemicals Affecting Bees - D. McRory presented several research recommendations for chemicals affecting bees. P. Kevan suggested that pesticide degradation and detection in poisoned bees be added to the recommendations for research in this area. D. McRory and P. Kevan agreed to formalize these recommendations for inclusion to the minutes. Refer to Appendix F(5).

A summary of the preliminary list of research recommendations (not ranked) put forth for honey bees is as follows:

<u>Diseases and Pests</u>

1. Mites

   a) detection (tracheal mite)
   b) economic impact (tracheal and varroa mites)
   c) products for control (tracheal and varroa mites)
   d) cultural control measures (tracheal and varroa mites)
   e) integrated management for control (tracheal and varroa mites)

2. Chemical control of bee diseases

3. Non-chemical control of bee diseases

<u>Stock Selection and Breeding</u>

1. Development and maintenance of honey bee stock resistant to tracheal mites.

2. Production of mite-free Canadian stock (queens/bees).

<u>Management</u>

1. Self-sufficiency

   a) wintering
   b) queen introduction and locating

2. Seasonal management

   a) honey production
   b) pollination

3. Pheromones

   a) swarm prevention and control
   b) queen acceptance

4. Using colony-produced sounds to assess colony status

Pollination and Plant Related Studies

1. National consensus on the value of bees for pollination

2. Pollination requirements of selected crops

3. Nectar production and carrying capacity of selected crops

4. Bee attractants

5. Consideration of bees in varietal trials

Chemicals Affecting Bees

1. Pesticides (risk assessment, impact, degradation and analysis)

2. Pesticide residues in hive products

3. Bee repellents (applied to crops)

B) Leafcutter Bees

K. Richards presented a list of research recommendations for alfalfa leafcutter bees. Refer to Appendix G(1). G. Rank indicated that research into stock improvement of leafcutter bees is needed. D. Murrell added that agronomic concerns, such as seed yield and forage yield evaluations (alfalfa) and soil fertility requirements, especially as related to seed production in alfalfa, are equally as important as leafcutter bee research and should also be considered. A list of agronomic research priorities for alfalfa seed production appears in Appendix G(2).

A summary of the preliminary list of research recommendations (not ranked) put forth for leafcutter bees is as follows:

1. Biology and control of pathogens

   a) chalkbrood
   b) foliar molds

2. Biology and control of parasites and predators

3. Alternative floral sources for leafcutter bees

4. Optimum densities of pollinator for alfalfa

5. Causes of mortality of immature life stages of leafcutter bees

6. Investigation of sex ratios in leafcutter bees

7. Combination effects of honey bees and leafcutter bees in pollinating alfalfa

8. Stock improvement in leafcutter bees

9. Equipment evaluation

   a) shelter design
   b) nesting material

C) Other Pollinators

P. Kevan presented a report entitled "Recommendations for Future Planning in Pollination and Pollinator Biology and Technology." Refer to Appendix H(1).

The workshop recognized the validity of this report and the fact that pollination must be considered on a crop commodity basis and is intrinsically often regional in nature. Pollination research must involve consideration of all potential pollinators.

There was general agreement that this section should therefore be retitled "Commodity-Oriented Pollination".

A summary of the preliminary list of research recommendations put forth for commodity-oriented pollination is as follows:

1. Tree fruits

2. Field crops

   a) oil seeds
   b) forage legumes

3. Greenhouse

4. Specialty crops

5. Sustainable agriculture

Refer to Appendix H(2) for background information to these recommendations.

APRIL 5, 1989

The meeting reconvened at 9:00 a.m.

7. <u>Prioritization of Recommendations</u>

In an effort to prioritize the research recommendations and to determine where the research would best be conducted, the preliminary lists of recommendations within each general research category were reviewed by the participants.

D. Dixon asked if the workshop participants wished to bring forward any additional recommendations or discussion related to the recommendations that had been presented. The participants indicated that they were satisfied that no further discussion was required and that the recommendations fairly represented the wishes of the participants.

D. Dixon indicated that he believed that for the record it was important that the participants formally express their support or rejection of the prioritized list of research recommendations that had been developed by the workshop participants. Accordingly, he asked for a show of hands indicating agreement with the prioritized list of recommendations.

The participants indicated unanimous support for the list of recommendations. The prioritized list appears on pages 4 and 5.

8. <u>Funding and Other Assistance for Research</u>

J. Martens stated that federal funding for research is becoming more restricted and that Agriculture Canada is encouraging a partnership approach to funding research projects. The future prospects for increased levels of funding through the federal Research Branch are poor.

J. Martens indicated that there is a federal program in place called the Research Partnership Support Program which involves a cost-shared arrangement that, in effect, will make a "dollar out of thirty-three cents". Funds for projects would be committed on a one-third basis by each of industry, Agriculture Canada and NSERC. There was concern expressed that the beekeeping industry would not likely be able to provide the desired level of funding for research, because of its rather depressed financial status at present. "In-kind" industry involvement would not be considered to be eligible; funding is required.

D. Jones indicated that a "check-off" levy system for funding research in the leafcutter bee industry has recently been discussed in Alberta. However, the main problem with such a system concerns how to implement it in such a way that it is fair and equitable for everyone.

R. Congdon reiterated the point that the beekeeping industry is currently experiencing serious financial problems with poor honey prices and soft market conditions. Because of these problems, financial backing of research is not likely; beekeepers would be more able to contribute "in-kind", through the use of their equipment, vehicles, etc. Some beekeeper associations have accessed research funds through the Economic and Regional Development Agreement (ERDA).

M. Winston indicated that Simon Fraser University has been able to successfully access provincial funding and that any opportunities for "creative financing" should be explored.

C. Scott-Dupree stated that the University of Guelph has accessed funding through OMAF's Special Projects Program for tracheal mite research. However, this program has been terminated and replaced with three new provincial programs, none of which will provide avenues for apicultural research funding. Applying for NSERC operating grants for any apicultural research is extremely difficult because such research is viewed as applied and is subsequently referred to Agriculture Canada. Agriculture Canada wants to have industry funding in the project proposal and when this is not achievable, the project proposal is not approved. There is a possibility through strategic grants for some projects such as bee breeding, however, it is not likely that the many integrated management proposals would successfully obtain funding.

There was the hope expressed that ERDA would remain available as an avenue of accessing funds for apicultural research. It has been a very valuable means of funding many regional research projects.

Most of the representatives from the Provincial Ministries of Agriculture indicated that provincial funding for research were becoming more difficult to access. Funding of many provincial research projects was being accomplished through ERDA. W. Wiebe indicated that it would be beneficial to identify potential sources of funding for each province.

D. Dixon and C. Jay expressed their thanks to the participants for their input and cooperation in determining research priorities for honey bees, leafcutter bees and other pollinators.

J. Martens and G. Neish expressed their thanks to the participants and to D. Dixon, C. Jay for their assistance in organizing and chairing the meeting and to B. Fingler for recording the minutes.

The meeting adjourned at 4:30 p.m.

PROCÈS-VERBAL

Le 4 avril 1989

1. Mot de bienvenue et préliminaires

M. D. Dixon souhaite la bienvenue à tous et demande aux participants de se présenter.

Il souligne que la réunion a été convoquée à l'instigation d'Agriculture Canada et du Conseil canadien du miel dans le but d'examiner le chemin parcouru jusqu'ici par le secteur de l'apiculture et d'établir les priorités de recherche au cours des 3 à 5 prochaines années. On prévoit que la réunion donnera lieu à la préparation d'un document circonstancié exposant un ensemble explicite de recommandations à l'intention du secteur et des organismes gouvernementaux et de recherche.

C. Jay passe en revue l'ordre du jour et demande s'il y aurait lieu de le modifier. Aucune modification n'est proposée.

D. Dixon présente le Dr Yvon Martel qui souhaite la bienvenue à tous au nom de la Direction générale de la recherche d'Agriculture Canada. Il fait observer que si, d'une part, les besoins du secteur ne cessent de s'accroître, il en va de même des coûts de la recherche entreprise en vue de combler ces besoins. Il importe donc que s'établissent des rapports étroits entre la Direction générale de la recherche, les administrations provinciales, les universités, le secteur privé et les producteurs.

D. Dixon présente R. Congdon qui souhaite à tous la bienvenue au nom du Conseil canadien du miel. Il dit se réjouir que la réunion permettra non seulement de se pencher sur les questions d'actualité et les perspectives d'avenir en apiculture, mais aussi d'examiner les questions de pollinisation dans un contexte d'apiculture.

2. Données documentaires

(A) Examen quinquennal du secteur

1. Abeilles à miel - P. Van Westendorp donne un aperçu de la situation du secteur des abeilles à miel au cours de la période 1984-1988. Voir l'annexe A(1).

2. Mégachilles de la luzerne - G. Rank donne un aperçu de la situation du secteur de la mégachille de la luzerne entre 1984 et 1988. Voir l'annexe A(2).

(B) Recherche sur les abeilles menée au Canada - Projets et institutions 1983-1988

1. Abeilles à miel - M. Winston passe en revue les projets de recherche liés aux abeilles à miel entrepris au Canada entre 1983 et 1988. Voir l'annexe B(1).

2. Mégachilles de la luzerne - K. Richards passe en revue les projets de recherche liés aux mégachilles de la luzerne entrepris au Canada entre 1983-1988. Voir l'annexe B(2).

3. Autres pollinisatrices - P. Kevan passe en revue la recherche sur les pollinisatrices indigènes du Canada menée entre 1983 et 1988. Voir l'annexe B(3).

(C) Ateliers sur la recherche apicole tenus récemment - D. Nelson passe en revue les ateliers sur la recherche apicole au Canada tenus depuis 1970. Voir l'annexe C(1).

3. Niveaux de scolarité et autres questions liées à la dotation

D. McKenna fait le point sur la formation en apiculture au Canada et sur la situation de l'emploi. Il fait part des prévisions quant au nombre de diplômes en apiculture d'ici 5 ans et des possibilités d'emploi qui s'offrent ou devraient s'offrir au Canada au cours de cette période. On trouvera à l'annexe (D(1) une liste à jour des apiculteurs professionnels au Canada.

4. Situation de l'industrie apicole américaine et de la recherche

J. Tew signale qu'il semble qu'une forme d'hystérie collective se fait jour aux États-Unis vis-à vis des abeilles à miel à croisements africains. Le ministère américain de l'agriculture s'efforce d'informer le public en veillant à ne pas soulever les passions. Le secteur apicole s'inquiète fortement de l'opinion qui se répand dans le pulic qu'il y aurait un lien entre certains produits comme le miel et le botulisme. L'office national du miel se tient prêt à entreprendre une campagne d'information sur ce problème et certains autres sujets à controverse, si les médias montent l'affaire en épingle en risquant de discréditer le miel.

L'APHIS (service d'inspections zootechniques et phytotechniques) se penche sur la question de la réglementation des acariens par voie de "séances de réglementation négociée". L'introduction dans des secteurs exempts d'infestations de colonies réputées infestées par la varroase mais ayant été traitées pour l'enrayer a soulevé la controverse dans certains états.

Aux États-Unis, on accorde présentement la priorité en matière de recherche aux abeilles à croisement africain et aux varroas et, en second lieu, aux parasites acariens de la trachée.

Le département américain de l'agriculture a formé un groupe de travail technique composé de représentants de l'APHIS et des services de vulgarisation pour qu'ils planifient et coordonnent les activités liées aux abeilles à croisement africain.

Les centres de recherche américains qui s'occupent de ces questions sont:

Le laboratoire Weslaco où le Dr A. Collins dirige la recherche sur les abeilles à croisement africain.

Le laboratoire de Beltsville où le Dr H. Shimanuki dirige la recherche sur les acariens parasites des abeilles à miel.

On est d'avis que l'on pourrait prendre des dispositions pour que de la recherche concertée ou menée conjointement par les deux pays soit entreprise sur ces questions d'intérêt commun.

5. Besoins et préoccupations en matière de recherche

(A) Conseil canadien du miel - R. Congdon fait état des besoins et préoccupations du Conseil canadien du miel. Voir l'annexe E(1).

Il souligne que le Conseil est d'avis qu'il est urgent que l'on retienne les services d'un autre spécialiste en pathologie apicole et un généticien des abeilles à miel pour le compte du gouvernement fédéral. Le Conseil ne croit pas par ailleurs qu'il y va des meilleurs intérêts du secteur apicole que la recherche apicole canadienne soit regroupée. Il serait peut-être plus utile de mener cette recherche dans les centres fédéraux à travers le pays.

(B) Conseil canadien de la luzerne de semence - D. Jones fait le point sur le rôle du Conseil et présente ses besoins et ses préoccupations en matière de recherche sur la mégachille de la luzerne. Voir l'annexe E(2).

(C) Association canadienne des producteurs de semence - son délégué n'est pas encore arrivé; on l'attend pour la seconde journée.

(D) Association canadienne des apiculteurs professionnels -

1. J. Gruszka passe en revue les besoins des délégués provinciaux en matière de recherche. Voir l'annexe E(3). Il signale qu'il leur est difficile de faire financer leurs recherches car la recherche ne fait pas partie de leurs mandats (éradication des maladies et vulgaristation). Il leur est toutefois possible de mener de la recherche conjointe avec leurs homologues du fédéral, des universités et du secteur. À titre d'exemple, on cite le projet mené récemment à La Ronge en Saskatchewan sur les acariens parasites de la trachée.

C. Prouse fait observer qu'il serait peut-être bon que l'on fasse appel aux horticulteurs pour la recherche sur les essais des variétés, surtout lorsqu'elle porte sur les besoins de pollinisation des plantes.

2. Représentant du secteur de la recherche - D. Nelson passe en revue une liste des besoins en matière de recherche dressée à partir d'un questionnaire expédié en mars 1989 à des chercheurs du fédéral et des universités. Voir l'annexe E(4). Il signale que les répondants sont presque unanimes à déclarer que la recherche sur le parasite de la trachée figure au premier rang de leurs préoccupations.

6. <u>Recommandations en matière de recherche</u>

(A) Abeilles à miel

1. Maladies et parasites (y compris la prévention et la lutte antiparasitaire) - B. Fingler présente quatre recommandations de recherche portant sur les maladies des abeilles à miel et la lutte antiparasitaire. Voir l'annexe F(1).

Voici d'autres recommandations des délégués:

- méthodes de diagnostic améliorées de la présence d'acariens parasites de la trachée (déjà relevé dans les notes fournies par R. Congdon et J. Gruszka).

- dépistage des abeilles à miel à croisement africain (relevé dans les notes de J. Gruszka).

- méthodes non-chimiques (notamment la lutte intégrée) de lutte contre les maladies des abeilles à miel (relevé dans les notes de R. Congdon).

2. Choix des troupeaux et reproduction (y compris les stocks d'abeilles et de reines) - C. Scott-Dupree présente deux recommandations de recherche ayant trait à la sélection des stocks d'abeilles à miel et à la reproduction. Voir l'annexe F(2).

3. Études sur la conduite des élevages (y compris le comportement) - D. Rogers passe en revue une liste de recommandations ayant trait à la conduite des élevages et à la recherche sur le comportement. Voir l'annexe F(3).

On convient de n'examiner que la rubrique "auto-suffisance", en ce qui a t rait à l'hivernage et à l'introduction des reines et au choix du lieu uniquement, étant donné que l'élevage des reines, l'amélioration des stocks, la lutte intégrée et la résistance aux acariens ont déjà été examinés. On convient de plus de reporter les travaux sur la rubrique (4) intitulée "Evaluation des risques d'empoisonnement aux pesticides et incidences" au moment où l'on étudiera le champs de recherche sur les substances toxiques nuisibles aux abeilles.

4. Pollinisation et études phytotechniques - M. Winston présente trois recommandations de recherche sur le sujet en rubrique. En plus, les délégués suggèrent que l'on se penche entre autres sur:

   - ce qui attire les abeilles
   - les essais des variétés végétales et les besoins en matière de pollinisation

   Voir l'annexe F(4).

5. Recherche sur les produits chimiques nuisibles aux abeilles - Le Dr McRory soumet plusieurs recommandations sur le sujet. P. Kevan suggère que la détection de la dégradation des pesticides chez les abeilles empoisonnées s'ajoute aux recommandations. Ils sont tous deux d'accord pour qu'on les formule officiellement afin de les faire figurer dans le procès-verbal. Voir l'annexe F(5).

Voici le resumé des recommandations présentées en ce qui a trait aux abeilles à miel (classement aléatoire):

Maladies et parasites

1. Acariens

   (a) détection (parasites de la trachée)
   (b) incidence économique (acariens de la trachée et varroas)
   (c) produits pour la lutte antiparasitaire (acariens de la trachée et varroas)
   (d) mesures culturales de lutte (acariens de la trachée et varroas)
   (e) lutte intégrée (acariens de la trachée et varroas)

2. Désherbage chimique pour la lutte contre les maladies des abeilles.

3. Moyens de lutte non-chimiques contre les maladies des abeilles.

Choix des stocks et reproduction

1. Mise en valeur et préservation des stocks d'abeilles à miel présentant une résistance aux parasites de la trachée.

2. Production de stocks canadiens exempts d'acariens (reines et abeilles).

Conduite des élevages

1. Auto-approvisionnement

   a) élevages d'hiver
   b) implantation des reines et choix du lieu

2. Élevages saisonniers

   a) production de miel
   b) pollinisation

3. Phéronomes

   a) précautions contre l'essaimage et sa répression
   b) l'accueil fait à la reine

4. L'évaluation acoustique de l'état de la colonie par les sons qu'elle produit.

Pollinisation et étude des végétaux

1. Unanimité d'opinion au pays sur l'utilité des abeilles à l'égard de la pollinisation.

2. Les besoins de pollinisation de cultures particulières.

3. Production de nectar et taux de chargement de cultures spéciales.

4. Substances qui attirent les abeilles.

5. La prise en compte des abeilles dans les essais des variétés.

Produits chimiques nuisibles aux abeilles

1. Pesticides (évaluation des risques, incidence, dégradation et analyse).

2. Traces de pesticides dans les produits de la ruche.

3. Repulsifs des abeilles (vaporisés sur les récoltes).

B. Mégachilles

K. Richards présente une liste de recommandations de recherche portant sur la mégachille de la luzerne. Voir l'annexe G(1). G. Rank signale la nécessité d'effectuer de la recherche sur les moyens d'améliorer les stocks de mégachilles. D. Murrell ajoute pour sa part que les questions liées à l'agronomie tel le rendement des semences et l'évaluation des rendement des plantes fourragères (luzerne) ainsi que les exigences en matière de fertilité des sols, surtout reliée à la production de graines de luzerne sont d'une importance au moins aussi grande que la recherche sur la mégachille et qu'il faudrait aussi les examiner. L'annexe G(2) contient une liste des priorités en matière de recherche agronomique sur la graine de luzerne.

Voici le résumé de la liste provisoire des recommandations de recherche sur la mégachille mise de l'ayant par les délégués (classement aléatoire):

1. Biologie et lutte contre les substances pathogènes
   a) cellules d'incubation
   b) serre-feuilles

2. Biologie et lutte contre les parasites et les prédateurs.

3. Autres sources florales de mégachilles.

4. Densités maximales de pollinisatrices pour la luzerne.

5. Causes de mortalité chez les nymphes de la mégachille.

6. Étude de la proportion de males et de femelles chez la mégachille.

7. L'effet combiné des abeilles à miel et des mégachilles dans la pollinisation de la luzerne.

8. Amélioration des stocks de mégachilles.

9. Evaluation du matériel
   (a) construction des abris
   (b) matériel de nidification

C. Autres pollinisatrices

P. Kevan dépose un compte rendu intitulé "Recommandations pour une meilleure planification en matière de biologie et des techniques de pollinisation". Voir l'annexe H(1).

Le compte rendu reçoit un accueil favorable et l'on convient que la pollinisation mérite l'étiquette de production spécialisée et qu'elle constitue essentiellement une activité particulière à une région. La recherche doit tenir compte de toutes les pollinisatrices possibles.

On convient que la présente section mérite d'être rebaptisée "Pollinisation axée sur les produits".

La liste provisoire des recommandations de recherche mises de l'avant à l'égard de la pollinisation axée sur les produits se lit comme suit:

1. Arbres fruitiers

2. Grandes cultures

   (a) oléagineux
   (b) légumineuses fourragères

3. Produits des serres

4. Cultures spécialisées

5. Agriculture de conservation

Voir l'annexe H(2) pour plus de renseignements sur les documents de référence à l'appui des recommandations.

Le 5 avril 1989

La réunion reprend à 9h.

7. Priorité à donner aux recommandations

Les participants examinent les listes provisoires des recommandations faites vis-à-vis de chaque domaine de recherche en vue de donner un ordre de priorités aux recommandations en matière de recherche et de préciser les lieux où il conviendrait de mener les recherches. D. Dixon demande aux délégués s'ils souhaitent présenter d'autres recommandations ou débattre des recommandations mises de l'avant. On lui répond qu'on a fait le tour de la question et que les recommandations exprimaient assez bien leurs préoccupations.

D. Dixon souligne qu'il importe que le compte rendu consigne officiellement l'accord des participants ou leur rejet de la liste des priorités de recherche élaborée par les participants à l'atelier. Il demande donc aux participants de signifier leur accord, le cas échéant, par un vote à main levée.

Les participants accordent leur accord unanime à la liste de recommandations.

8. Financement de la recherche et autres formes d'aide

J. Martens fait savoir que les affectations du gouvernement fédéral pour la recherche étaient de plus en plus limitées et qu'Agriculture Canada préconise une formule de co-participation pour le financement des projets de recherche. La perspective d'un accroissement du financement en provenance de la Direction générale de la recherche s'annonce faible. J. Martens souligne qu'il existe un programme fédéral intitulé Programme d'aide à la recherche collaborative comportant des dispositions relatives au partage des coûts faisant en sorte qu'il vous est possible de "tripler votre mise". Les partenaires d'un project s'acquitteraient chacun du tiers du financement, soit le secteur privé, le Programme lui-même et le Conseil de recherches en sciences naturelles et en génie. On craint que le secteur apicole ne puisse disposer des fonds nécessaires en raison de sa faible capacité de financement à l'heure actuelle. Les paiements "en nature" ne suffiraient pas, car c'est de financement dont on a besoin.

D. Jones fait remarquer qu'on a récemment examiné la possibilité d'instituer un mode de prélèvements afin de financer la recherche dans le secteur de la mégachille, en Alberta. Il est toutefois difficile d'en arriver à une formule qui soit juste et équitable pour tous.

R. Congdon souligne à nouveau que le secteur apicole est aux prises avec de graves problèmes financiers en raison du faible prix du miel et d'un marché mou. Dans ces conditions, il est peu probable qu'il puisse appuyer la recherche; la contribution des apiculteurs se ferait plutôt "en nature", en prêtant leurs équipements ou leurs véhicules, par exemple. Certaines associations d'apiculteurs ont pu profiter du programme d'entente pour le développement économique et régional pour financer la recherche.

M. Winston signale pour sa part que l'Université Simon Fraser avait bénéficier des sources de financement provincial et qu'il y aurait lieu d'examiner toutes les possibilités "imaginables" de financement.

C. Scott-Dupree fait observer que l'Université de Guelph s'était vue accorder des fonds pour la recherche sur les acariens de la trachée grâce au Programme de projets spéciaux de l'Agriculture de l'Ontario. Toutefois, ce programme n'a plus cours et a été remplacé par trois nouveaux programmes provinciaux qui ne se prêteront pas au financement de la recherche apicole. Les fonds proviennent du ministère ontarien de l'Agriculture. Il est très difficile de se voir accorder des subventions de fonctionnement du CRSNG parce qu'on y considère la recherche apicole comme de la recherche appliquée et que, dès lors, les demandes sont renvoyées à Agriculture Canada. Agriculture Canada, pour sa part, souhaite que le projet comporte une forme de financement de la part du secteur privé et, en l'absence de celle-ci, on essuie un refus de sa part. Certains projets, tels ceux ayant trait à l'élevage des abeilles pourraient profiter de subventions thématiques. Toutefois, il ne faut pas s'attendre à ce que toutes les propositions portant sur les méthodes culturales bénéficient de subventions étant donné leur grand nombre.

On exprime l'espoir que l'EDER continuera d'être une source possible de financement pour la recherche apicole. Il s'est agi d'un mode indispensable de financement de nombre de projets régionaux de recherche.

Selon la plupart des délégués des ministères de l'agriculture des provinces, il est de plus en plus difficile de faire financer la recherche par les provinces. De nombreux projets de recherche provinciaux sont financés par l'EDER. Selon W. Wiebe il y aurait lieu de recenser les sources possibles de financement dans chaque province.

D. Dixon et C. Jay remercient les délégués de leur participation à l'établissement des priorités de recherche à l'égard des abeilles à miel, des mégachilles et des autres pollinisatrices.

J. Martens et G. Neish remercient tous les délégués et en particulier D. Dixon et C. Jay pour l'aide apportée à l'organisation du colloque et pour avoir assuré la présidence, et, enfin, B. Fingler pour la prise de notes. La séance est levée à 16h30.

BEEKEEPING STATISTICS FOR CANADA

YEAR	NUMBER OF BEEKEEPERS	NUMBER OF COLONIES	PRODUCTION/ COLONY (KG)	TOTAL PROD. X 1000 KG	VALUE OF HONEY & WAX (X 1000)
1984	20,810	704,650	61	43,297	64,935
1985	19,625	691,575	52	36,017	56,928
1986	20,289	702,375	49	34,041	50,796
1987	18,912	720,682	58	39,776	51,961
1988	17,995	623,485	65	36,805	N.A.

BEEKEEPING STATISTICS BY PROVINCE

PROVINCE	YEAR	NUMBER OF BEEKEEPERS	NUMBER OF COLONIES	PROD./ COLONY (KG)	TOTAL PROD. X 1000 KG
British Columbia	84	5,500	59,400	51	3,045
	85	5,450	55,000	37	2,035
	86	5,000	55,000	36	1,996
	87	5,000	55,000	39	2,121
	88	5,300	54,000	32	1,715
Alberta	84	1,650	180,000	70	12,600
	85	1,700	175,500	48	8,424
	86	1,689	190,000	61	10,886
	87	1,463	207,700	58	11,367
	88	1,066	176,103	69	10,297
Saskatchewan	84	1,650	105,000	82	8,610
	85	1,650	105,000	70	7,350
	86	1,800	120,000	54	6,532
	87	1,800	120,000	75	8,659
	88	1,500	100,000	104	10,433
Manitoba	84	1,750	116,000	68	7,888
	85	1,350	120,000	73	8,760
	86	1,300	110,000	73	7,983
	87	1,300	109,000	73	7,911
	88	1,200	88,000	84	7,384
Ontario	84	4,500	110,000	40	4,400
	85	4,500	113,000	38	4,294
	86	6,000	115,000	25	2,869
	87	5,000	120,000	37	4,277
	88	5,000	115,000	30	3,495
Quebec	84	4,200	120,000	53	6,360
	85	3,600	110,000	43	4,730
	86	3,400	100,000	25	2,800
	87	3,300	97,000	50	4,850
	88	3,100	79,000	35	3,150

PROVINCE	YEAR	NUMBER OF BEEKEEPERS	NUMBER OF COLONIES	PROD./ COLONY (KG)	TOTAL PROD. X 1000 KG
New Brunswick	84	550	5,000	36	180
	85	440	4,200	36	151
	86	420	5,000	23	113
	87	420	4,800	41	204
	88	380	5,000	29	147
Novia Scotia	84	800	7,900	27	213
	85	800	8,000	29	232
	86	550	6,300	21	136
	87	550	6,500	37	206
	88	370	5,700	27	155
Prince Edward Island	84	210	1,350	43	58
	85	135	875	43	38
	86	130	875	36	32
	87	79	682	50	34
	88	79	682	41	29

HONEY IMPORTS (KG)

YEAR	FROM US	PERCENT	TOTAL
1984	102,349	52	196,492
1985	116,331	47	246,159
1986	108,000	41	264,000
1987	287,757	74	391,422
1988	N.A.		N.A.

HONEY EXPORTS (KG)

YEAR	TO US	PERCENT	TOTAL
1984	15,607,593	83	18,871,176
1985	13,998,543	81	17,278,234
1986	8,547,000	72	11,843,000
1987	5,969,000	55	10,923,000
1988	N.A.		N.A.

PACKAGE BEE IMPORTS

1984	317,984	-
1985	249,036	-
1986	232,147	-
1987	212,850	-
1988*	14,326	47,126

Imports from Australia and New Zealand only.

P. Van Westendorp
April 4, 1989

The Canadian Alfalfa Leafcutting Bee Industry

G.H. Rank(Dept. of Biology, U of Sask.)

The Canadian alfalfa seed industry is dependent upon the use of the alfalfa leafcutting bee, Megachile rotundata, as a managed pollinator. The unit of trade is the prepupae (cell) which is harvested as a leaf enclosed cocoon.

An analysis of leafcutting bee cells submitted to the Canadian Cocoon Testing Centre (Brooks, Alta) is given in Tables 1, and 2. There is remarkedly little variation in the parameters presented in Table 1 over a five-year period. All three prairie provinces have a similar live prepupae/kg (ave=8692). The main contributor to inviable cells is the category pollen balls. These incomplete cells (ave=15%) are thought not to result from pathogen infection but rather represent seasonally late cell construction and/or result from physical factors such as temperature variations. Parasitized cells (ave=1.3%) result mainly from the chalcid Pteromalus venustus and to a lesser extent from Monodontomerus obscurus. Control of both species is by tight fitting hives and the use of dichlorvos during the early incubation period.

One of the main limiting factors in USA bee propogation is infection by the chalkbrood fungus Ascosphaera aggregata. The incidence of cells infected by chalkboard has increased dramatically in samples from southern Alberta (Table 2). Infection was first noticed in six 1983 samples and has increased to 59% of samples analyzed in 1988. The sporatic and low levels of chalkbrood in Manitoba and Saskatchewan are of concern. However, the industry is spread over a vast area (compared to southern Alberta) which limits spread of the disease to other procedures. In addition, the extensive use of hypochlorite bleaching of cells and hives is recommended as a control measure against chalkbood. The appearance of chalkbrood is one 1988 sample from Manitoba and Saskatachewan after a two year absence indicates the need for continued management practices against this disease.

An overview of the value of the industry is given in Table 3. The only unequivocal data available for industry growth is the number of pedigreed hectares provided by the Agriculture Canada Inspection Directorate. From 1984 to 1988 the total number of pedigreed hectares has increased 59% from 14,142 to 22,537. During this time the industry was relatively constant in Alberta but increased dramatically in Saskatchewan and Manitoba. The total seed and bee value of the industry was estimated as indicated in the foot notes to Table 3. The estimated value has increased 233% over a five year period to result in a 1988 estimated value of $ 22,670,000. It is noteworthy that during the widespread drought of 1988 there was a dramatic increase in dryland production in Manitoba and Alberta. Thus production in the alfalfa seed industry appears to be relatively insensitive to drought stress.

Indirect economic benefits from the alfalfa seed industry include a stable supply of seed for forage varieties required by the livestock and dehydration industries as well as improved soil conservation. There is also a number of western Canadian companies which produce specialized equipment for the leafcutting bee industry: hive boards, solid hives, cell harvestors, bleach treatment equipment (Table 4). Many of these firms export materials into the USA.

The alfalfa seed industry has undergone a rapid rate of growth in the last five years. There is a general feeling that continued successful management of the alfalfa leafcutting bee will result in further expansion of this vital industry.

Table 1

CANADIAN COCOON TESTING CENTRE (BROOKS) DATA

PROVINCE	YEAR	Live Prepupae per kg.	% Live Prepupae	% Immatures Dead Larvae Dead Prepupae	% 2nd Generation	% Parasitized Cells	% Pollen Balls	% Machine Damaged Cells	% Females	Total Samples
ALBERTA	84	8365	76	3.8	0.9	1.0	18.3	-	38	159
	85	8256	74	3.6	1.5	0.8	18.2	1.5	41	172
	86	8074	71	4.5	0.8	1.3	21.0	1.8	36	159
	87	8624	75	2.8	0.5	1.9	16.7	1.4	37	192
	88[1]	8281	75	2.8	1.0	2.5	13.7	3.5	39	173
MANITOBA	84	8856	80	3.6	0.8	0.7	15.2	-	33	42
	85	8008	78	2.8	1.4	1.4	15.9	1.0	37	51
	86	8703	75	5.1	1.2	1.1	17.1	0.8	33	65
	87	8943	79	4.0	1.1	1.4	14.3	0.7	40	97
	88[1]	8551	80	3.9	0.5	2.0	11.6	2.5	39	71
SASK.	84	9215	84	3.1	0.6	0.5	12.6	-	40	57
	85	9115	81	3.6	1.1	0.4	12.9	1.0	42	92
	86	8082	75	5.9	0.8	0.8	17.7	0.0	36	96
	87	9119	75	5.0	1.1	1.4	17.1	0.7	41	89
	88[1]	9079	81	3.5	0.9	1.9	10.7	2.7	35	65
ONTARIO	84	-	79	2.3	-	-	9.9	-	-	3
	85	10,282	79	4.3	3.6	2.3	9.9	1.0	33	9
	86	8455	65	10.4	7.2	1.0	16.8	0.2	34	5
	87	8448	72	6.3	6.9	1.6	12.6	0.9	36	8
	Average	8692	77	4.3	1.8	1.3	14.9	1.3	37	

[1] Based on analyses of samples from 01/11/88 to 31/1/89. Of a total of 436 samples that were received from 1988, analyses on 309 are given here. Cumulative total samples are 1984 (261), 1985(324), 1986 (325), 1987 (386), 1988 (436).

Table 2

CANADIAN COCOON TESTING CENTRE DATA

NUMBER OF SAMPLES WITH CHALKBROOD (*Ascosphaera aggregata*)

PROVINCE		1983	1984	1985	1986	1987	1988[2]
ALBERTA -	Tilley, Rolling Hills	4 (.2-1.5)[1]	21, (.16-1.05)	23 (.2-20)	39 (.18-17.6)	58 (.17-22)	102/173
	Duchess, Rosemary	2 (.2-1.5)	ave = 0.56	10 (.18-14.6)	8 (.17-6.5)	27 (.16-16.8)	(0-26.5)[3]
	Brooks	-		8 (.18-1.2)	10 (.17-5.6)	26 (.16-17.5)	ave. = 1.7
	South of Rolling Hills	-		-	-	3 (.17-1.4)	
MANITOBA	Interlake Region	2 (3-5)	1, (.16)	3	-	-	1/71
SASKATCHEWAN		-	1, (.18)	-	-	-	1/65
ONTARIO		-	-	1 (4.5)	-	-	-

1 % contaminated cells
2 Based on samples received from 01/11/88 to 31/1/89, 127 samples remain to be analyzed.
3 One sample at 26.5% with the next highest at 13.06%

Table 3

ALFALFA SEED AND LEAFCUTTING BEE PRODUCTION

Province	Year	Number of Producers	Pedigreed Hectares[1]	Kg common plus pedigree seed[2]	Seed Value (10^6)[3]	No. of leafcutter bees (10^6)[4]	Bee Value (10^6)[5]	Total Value (10^6)
Alberta	84		5793	-	-	214	1.07	-
	85		5474	2,000,000	4.40	203	1.02	5.42
	86		4811	1,750,000	3.85	178	0.89	4.74
	87		5271	1,250,000	2.75	195	0.98	3.73
	88		5418	1,540,000	3.39	200	1.00	4.39
Manitoba	84	130	3294	909,014	1.90	122	0.61	2.51
	85	130	4736	775,000	1.71	175	0.88	2.59
	86	140	5393	950,000	2.09	200	1.00	3.09
	87	168	6246	1,900,000	4.18	231	1.16	5.34
	88	189	7511	3,000,000	6.60	278	1.39	7.99
Sask	84	74	5055	-	-	187	0.94	-
	85	87	5780	300,000	0.66	214	1.07	1.73 (9.74)[6]
	86	100	7058	1,500,000	3.30	261	1.31	4.61 (12.44)
	87	95	7769	1,700,000	3.74	288	1.44	5.18 (14.25)
	88	124	9608	3,870,000	8.51	356	1.78	10.29 (22.67)

[1] Data from Agriculture Canada Inspection Directorate. [2] Compiled by Agriculture Canada using information from provincial Regional Program Officers. [3] Assuming $2.2/Kg, [4] Assuming 37,000 bees/pedigreed ha. [5] Assuming $50/$10^4$ bees. [3,5] The cumulative values (10^6) for seed-bees are: 1985, 6.77-2.97; 1986, 9.24-3.2; 1987, 10.67-3.58; 1988, 18.5-4.17. [6] Cumulative total values for 1985-88.

Table 4

List of Suppliers to Leafcutter Beekeepers

April, 1988

1. Leafcutter Bee Nesting Equipment

Beaver Plastics Doug Anderson	12150 - 150 St. Edmonton, Alberta T5V 1H5
Honeywood Bee Supplies Tom or Jacquie Taylor	Box 2349 Nipawin, Sask. SOE 1E0
Barry Wolf Enterprises	Box 6 Carrot River, Sask. SOE 0L0
Dalziel Enterprises Gilbert Dalziel	Box 119 White Fox, Sask. SOJ 3B0
Canadian Leafcutter Bee Supply Led Dutiaume	Box 6581 Lorette, Manitoba ROA 0Y0

2. Leafcutter Bee Cell Removers

Pinmatic Ralph Moyer	Box 306 Pinawa, Manitoba ROE 1L0
Glen Person	Canwood, Sask. SOJ 0K0
Dalziel Enterprises Gilbert Dalziel	Box 119 White Fox, Sask. SOJ 3B0
Richard's Prairie Welding Richard Wiens	Box 186 Rosemary, Alberta TOJ 2W0
Ken Arn	Box 295 Kinistino, Sask. SOJ 1H0

3. Bleach Treatment Apparatus for Leafcutter Bee Cells and Euipment

Percy Eggerman	Box 242 Watson, Sask. SOK 4V0

HONEY BEE RESEARCH PROJECTS

The following is a listing of honey bee related projects in Canada from about 1983 through 1988. Three previous Research Workshop Reports (Victoria, B.C., Nov. 1977, Toronto, Ontario, Nov. 1981, and Charlottetown, Nov. 1986) list earlier projects. The projects are arbitrarily listed under the headings of Agriculture Canada, Universities and Provinces. The listing that follows may not be complete as submissions were not received from all apicultural researchers in Canada.

Year	Name	Title
AGRICULTURE CANADA		
(a) **Beaverlodge Research Station**		
1981-1985	T.I. Szabo	Nectar secretion of canola.
1981-1985	T.I. Szabo	Alberta nucleus hive.
1981-1986	T.I. Szabo	Various combs and weight gain.
1981-1984	J.R. Harbo T.I. Szabo	Comparison of I.I. and M.N. queens.
1981-1984	T.I. Szabo	Nectar secretion of dandelion.
1981-1985	T.I. Szabo	Thermology of wintering.
1981-1985	D. Nelson	Evaluation of canola species and varieties for bee forage.
1982-1985	T.I. Szabo H.G. Najda	Flowering, nectar secretion and pollen production of some legumes.
1983-1985	D. Nelson D. McKenna E. Zumwalt	The effect of continuous pollen trapping on sealed brood, honey production and gross income.
1983-1986	T.I. Szabo D.T. Heikel	Solar pollen substitute feeder.
1984-1987	D. Nelson	The effect of short term storage methods on queen weight.
1984-1985	S. Liu D. Nelson M. Collins	Amoeba and Nosema-infected honey bee queens and worker attendants shipped in mailing cages to Western Canada.
1984-1985	D. Nelson	Evaluation of pollination requirements of canola species.

1986-1987	D.L. Nelson	Evaluation of a simple method to weigh queens.
1987	D.L. Nelson	Evaluation of New Zealand queens.
1987	N.H. Low D.L. Nelson P. Sporns	Carbohydrate analysis of western Canadian honeys.
1987-89	ARDSA Comm. & D.L. Nelson	ARDSA indoor wintering project.
1988	D.L. Nelson & ZOECON	Field studies on fluvalinate.
1988	P. Olsen D.L. Nelson D. Rice	Developing an Elisa technique for AFB.
1988	D.L. Nelson	Evaluation of fall feeding and stress factors.
1987	T.I. Szabo	Effect of dry fumagillin feeding on spring Nosema spore counts in overwintered colonies.
1987	T.I. Szabo	Fumigation with SO_2 to control dry fruit moth in honeybee combs.
1987	T.I. Szabo	Mating distance of the honeybee in northwestern Alberta.
1988	T.I. Szabo	Patterns of honeybee colony gain in Alberta.
1988	T.I. Szabo	Effect of honeybee queen weight and air temperature on initiation of oviposition.
1988	T.I. Szabo	Number of spermatozoa in spermathecae of queens aged 0 to 3 years.
1988	T.I. Szabo L.P.Lefkovitch	Honeybee selection and breeding.
1989	T.I. Szabo	Forager trap.
1989	T.I. Szabo	Outdoor wintering of honeybees in multiple-nucleus and 4-colony packs.
1989	T.I. Szabo L.P. Lefkovitch	Breeding: relationship between morphological and colony traits.

1985	T.P. Liu	Fine structure of hypopharyngeal glands from honey bees with and without tracheal mite infection.
1986	T.P. Liu	Testing Tioconazole and related compounds against both Ascophaera apis and Nosema apis.
1986-87	D. McKenna D. Nelson	Evaluation of nuclei wintered indoors with new and old queens and fed or not fed pollen supplement.

(b) **Saint-Jean-sur-Richelieu**

1986	C. Vincent	The effect of pesticides on foraging behavior of strawberry pollinators.

UNIVERSITIES

(A) **Simon Fraser University**

1982-1984	M.W. Winston C.D. Scott-Dupree G.C. Grant G.G.S. King K.N. Slessor	The biology and pheromone-based monitoring of the dried fruit moth.
1983-1986	M.L. Winston C.D. Scott-Dupree E.N. Punnett S.R. Mitchell	The feasibility of package honey bee production in British Columbia.
1983-1986	M.L. Winston K.E. MacKenzie C.D. Scott-Dupree	Diversity and abundance of native bee pollinators and honey bees on berry and fruit crops compared to natural vegetation.
1984-1986	M.L. Winston K.E. Mackenzie M.J. Smirle	The effect of sublethal pesticide exposure on temporal division of labour and longevity.
1984-1985	K.J. Clark	A review of, and survey for, parasitic mites of honey bees in British Columbia.
1985-1987	M.L. Winston L.A. Ferguson	The effects of worker loss, wax, and amount of brood on temporal caste structure in honey bee colonies.
1983-1985	M.L. Winston P.C. Lee	The effect of swarm size on brood production, emergent worker weight, and comb construction in newly-founded honey bee colonies.

1986-1987	M.L. Winston S.A. Kolmes	A quantitative study of the division of labour among worker honey bees in demographically manipulated colonies.
1985-1988	M.L. Winston M.J. Smirle	Inter-colony variation in pesticide detoxication by the honey bee.
1980-	M.L. Winston K.N. Slessor (many others)	Pheromone-based biology and management.
1987-1990	M.L. Winston M. Wyborn P. LaFlamme	Mass overwintering storage of queens.
1987-	M.L. Winston C. Eckert J. Fewell R. Ydenberg P. Schmid-Hempel	Behavioural ecology of honey bee foraging.
1987-	M.L. Winston L. Willis	Mitochondrial DNA and Apini phylogeny.

(B) **University of Saskatchewan**

1986-1989	N. Low P. Sporns	Analysis of enzymes and oligosaccharides in honey.
1986-1989	N. Low P. Sporns	Pollen analysis.
1986-1989	N. Low P. Sporns	Residues of sulfathiazole and fluvalinate in honey.
1988-	N. Low	New honey products (honeyblend).

(C) **University of Alberta**

1986	P. Sporns	Analysis of sulfur and major elements in honey.
1988-1989	P. Sporns	Analysis of sulfathiazole in honey.
1989-1991	P. Sporns	Crystallization control of honey.
1989-1991	P. Sporns	Analysis of Alberta honey composition to aid honey exports.

(D) **University of Manitoba**

1981-1986	R.W. Currie S.C. Jay	Factors affecting the orientation of drone honey bees.
1982-1986	T. Pankiw D. Dixon S.C. Jay	Effect of aerial application of Malathion on honey bee colonies.
1983	S.C. Jay	Disorientation studies of honey bees.
1983-1985	S.C. Jay D. Nelson	Effect of apiary relocation on the orientation of honey bees.
1983	S.C. Jay D. Jay	Pollination studies of kiwifruit.
1983-1985	N. Mohr S.C. Jay	Foraging behaviour of honey bees on Canola.
1983	S.C. Jay	Disorientation studies of bees in New Zealand relative to the sun's position.
1984-1986	S.C. Jay D. Dixon	Management strategies for use with palletized honey bee colonies.
1984-1986	S.C. Jay R. Currie	Pollination studies of faba beans.
1985-1986	S.C. Jay D. Dixon	Nectar secretion studies of selected crops in Manitoba.
1986-1987	S.C. Jay D. Dixon	Orientation and honey production studies of honey bee colonies on pallets.
1987-1988	S.C. Jay D.H. Jay	Pollen nutrition studies using ovary development as a bioassay.
1987-1988	S.C. Jay D.H. Jay	Orientation studies of honey bees in the Southern Hemisphere.
1988	R. Currie	Hybrid Canola pollination studies.

(E) **University of Guelph**

1981-1985	R.W. Shuel B.R. Christie	Selection for ease of tripping and high nectar in alfalfa.
1981-1985	R.W. Shuel D. Murrell	Physiological indices of nectar potential in forage legumes.

1981-1985	R.W. Shuel	Selection for high nectar potential in some agricultural honey plants.
1982-1985	A.R. Davis R.W. Shuel	The secretion of systemic insecticides in nectar and some effects on honey bee development.
1983-1986	G.W. Otis	Effects of worker bee size on behaviour, honey production, and pollination.
1984	P.G. Kevan	Lowbush blueberry pollination.
1984-1985	G.W. Otis G.M. Grant	Effects of inner cover design on winter honey consumption.
1984-1986	P.G. Kevan	A survey of pollinator services.
1984-	P.G. Kevan	Foraging behaviour of bees.
1984-1985	G. Morales G.W. Otis	Effects of hive size on colony demography.
1984-1985	G.W. Otis G.M. Grant	Evaluation of Canadian honey bee stocks.
1984	C.P. Milne K.J. Pries	Honey bee corbicular size and honey production.
1984	C.P. Milne G.W. Friars	An estimate of the heritability of honey bee pupal weight.
1985	A.R. Davis R. W. Shuel	Movement of systematic insecticides into pollen?
1985	A.R. Davis D.F. Boyes G.W. Otis G.M. Grant	Transport of mature queen cells in a portable incubator.
1985	G.W. Otis D. Randall	The influence of genetic relatedness on worker visitation to honey bee larvae.
1985	C.P. Milne	Laboratory tests of honey bee hygienic behaviour and resistance to E.F.B.
1985-1986	C.P. Milne	An estimate of the heritability of the corbicular area of the honey bee.
1985	C.P. Milne	A heritability estimate of honey bee hoarding behaviour.

1986	G.W. Otis P.E.A. Teal M.H. Carter	Gas chromatographic analysis of honey bees infested by tracheal mites.
1986	W. Ramirez G.W. Otis	Developmental phases in the life cycle of <u>Varroa jacobsoni</u>.
1986	G.W. Otis W. Ramirez J. Bath	Have Africanized bees brought tracheal mites to Costa Rica?
1986	A.R. Davis R.W. Shuel	Distribution of ^{14}C-labelled systemic insecticides in royal jelly, queen larvae and nurse honey bees.
1985-	C.D. Scott-Dupree G.W. Otis B.L. Dawicke J.B. Bath	The economic impact of honey bee tracheal mites.
1988-1989	C.D. Scott-Dupree G.W. Otis R. Nauta B.L. Dawicke	Determining the efficacyof four potential miticides for honey bee tracheal mites.
1986	G.W. Otis J.B. Bath C. Garcia	Control of tracheal mites with Bayvarol
1986	G.W. Otis J.B. Bath	Factors affecting migration of tracheal mites into and out of worker honey bees.
1986	G.W. Otis P.E. Teal M.H. Carter	Gas chromatographic analysis of honey bees infected by tracheal mites.
1987-1988	C.D. Scott-Dupree P.G. Kelly	Analysis of New Zealand queens for colony acceptance and reproductive potential.
1987-1988	C.D. Scott-Dupree P.G. Kelly L. Nelson	The longevity of oxytetracycline hydrochloride (Terramycin) in sugar syrup and honey stores of overwintered colonies
1986	P.G. Kevan	The pesticide Dyfonate and honey bees in sweet cornfields.
1989-1990	P.G. Kevan P. Sibley	Pesticide degradation in honey bees.
1988	C.D. Scott-Dupree R. Nauta	The efficacy of Enilconazole in the control of chalkbrood in honey bees.

1987	Z. Huang	An <u>in-vivo</u> method of evaluating hypopharyngeal gland activity in honey bees.
1986	Z. Huang G.W. Otis	Effects of larvae on protein synthesis activity of hypopharyngeal glands.
1987	Z. Huang G.W. Otis	Effect of starvation of larval honey bees on worker visitation.
1988-1990	C.D. Scott-Dupree K. Romel	Determination of the sex pheromone of male <u>Galleria</u> <u>mellonella</u>:the greater wax moth.
1988	D. Meisenheimer G.W. Otis	Comb construction by queenright and queenless colonies of honey bees.

PROVINCES

(a) British Columbia

1981-1985	D.M. McCutcheon D. Bates	Overwintering honey bee queens for commercial use.
1981-1985	J. Corner J. Gates F. Calvert	Development of queen rearing techniques.
1981-1985	J. Corner J. Gates F. Calvert	Honey bee stock selection using closed population techniques.
1984-1985	J. Gates	Comparative testing of B.C. developed stock.
1985	M. Wyborn D.M. McCutcheon	Applying fumagillan in dry baker's fondant sugar.
1985-1986	D.M. McCutcheon	Alternate method of depopulating hives.
1986	J. Gates	Using the Jentner queen rearing device.
1986	J. Gates	Pollination survey in Okanagan area of B.C.

(b) **Alberta**

1984	D. Colter	Indoor wintering of five-frame nuclei hives in Peace River, Alberta.
1985	D. Colter	Pesticide degradation rates for Furadan, Decis, Lorsban, and Larvin.

(c) **Saskatchewan**

1982 -	J. Gruszka	Analysis for the presence of oxytetracyline residues in Saskatchewan honey.
1983 -	D. Murrell	The effect of fall and spring protein supplementation on honey bee colonies.
1983-1985	T. Taylor S. Clifford	The feasibility of utilizing Saskatchewan reared honey bee queens in commercial honey production.
1985-1986	J. Gruszka D. Peer	Honey bee tracheal mite project, La Ronge, Saskatchewan.
1986	J. Gruszka	Wintering nucleus hives indoors.
1986-1988	J. Gruszka	Comparison of outdoor wintering wraps.

(d) **Manitoba**

1984	D. Dixon B. Fingler	Environmental monitoring program for the 1983 aerial spraying of malathion to combat Western Equine Encephalitis.
1984	D. Dixon S.C. Jay	Infertile and Nosema infected queen honey bees shipped to Western Canada.
1986	D. Dixon J. Borsa T.A. Gochnauer	Sterilization of comb with gamma radiation.

(e) **Ontario**

1986	D.G. McRory A.R. Davis	Investigation of Africanized bees in Ontario.
1986	D.G. McRory A.R. Davis	Survey of mite fauna in hives in Ontario.

(f) **Quebec**

1986 -	A. Méthot (reporting)	Possibility of controlling A.F.B. using gamma radiation from Cobalt 60.

(g) **Nova Scotia**

1982	L. Crozier	Outdoor wintering of nuclei.
1986	E. Nickerson H. Specht L. Crozier	Indoor wintering of honey bee colonies in Nova Scotia.

1988-89	D. Rogers	Winter wrap trial.
1988	D. Rogers	Practical queen rearing and stock improvement.

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April, 1989

Number of honey bee-related projects

in Canada, 1983-1989

Topic	Agriculture Canada	Universities	Provinces
Honey & Pollen Analysis			
Natural constituents	1	3	
Residue analysis		3	1
New products and processes		2	
Disease/pest			
Surveys, incidence, detection	2	1	2
Effects on bees and colonies	1	4	2
Drugs and treatments	5	2	2
Pest biology		4	
Queens/Stock/Breeding			
Stock comparisons	4	2	
Storage: short and long term	1	1	1
Queen production	3	1	3
Selection		1	3
Behavior/ Management			
Equipment/manipulations	5	4	1
Wintering	4		7
Basic		16	
Bee production		1	
Pollen and supplement-nutrition	1	1	1
Plant/Pollen			
Nectar/Pollen secretion/Production	4	4	
Plant pollination requirements	1	4	
Pollinator diversity & abundance		1	
Foraging behavior		2	
Economic analyses		1	1
Toxic			
Effect on behavior/mortality/devel.	1	3	
Bee detoxification abilities		2	
Application methods		3	3

Apiculture et pollinisation des cultures au Québec

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Si l'on extrapole à partir des études de McGregor (1976), l'apiculture et la pollinisation entomophile devraient occuper une place non négligeable au Québec. Ceci a été implicitement reconnu en 1983 lors d'un colloque organisé à l'Université du Québec à Montréal par la Société d'entomologie du Québec. Toutefois les études économiques exhaustives et à jour sur la contribution des abeilles domestiques et sauvages à l'agriculture québécoise sont actuellement inexistantes. En 1978, la valeur totale à la ferme du miel et des cultures pollinisés par les insectes à 68 millions de dollars (de Oliveira 1983).

Dans ce travail, je brosserai un portrait succint de l'apiculture et de la pollinisation telle qu'elle s'est pratiquée au Québec depuis un dizaine d'années. Il s'agit de présenter les travaux de recherches qui ont été effectués et d'identifier les problèmes qui s'annoncent à l'horizon.

Situation de l'apiculture au Québec

En 1987, il y avait environ 3300 apiculteurs au Québec, soit 99 000 colonies ayant produit 4850 tonnes métriques de miel. En 1988, 103 producteurs (17 269 ruches) étaient assurés par l'assurance récolte pour une valeur d'environ $1700 000.00, ce qui représente une légère hausse par rapport à la situation de 1987. Cette assurance est collective (c'est-à-dire que les prix sont basés sur une moyenne de zone) et non obligatoire. La majorité des producteurs assurés en 1988 étaient de la région de Sherbrooke, Québec, Saint-Hyacinthe et Charlemagne. La Fédération des producteurs de miel du Québec considère qu'un apiculteur sérieux a plus de 50 ruches: il y en a environ 275 au Québec, dont la moyenne de production est environ de 45 kg de miel.

Le cadre légal de l'apiculture québécoise, la "Loi sur les abeilles" est actuellement en revision.

Apiculture et éducation

Au Québec, l'éducation en apiculture et en pollinisation des cultures est déficiente. Dans les Facultés Universitaires d'agriculture soient le Collège Macdonald et l'Université Laval, on n'offre qu'un seul cours d'apiculture. Les Instituts de Technologie Agricole (ITA) de Saint-Hyacinthe et de La Pocatière offrent également des cours de niveau technique. Au Québec, il n'y a présentement aucun cours sur la pollinisation entomophile ou encore sur la pathologie des abeilles.

Recherches

Depuis dix ans, on a effectué passablement de recherches dans les universités québécoises, la plupart du temps avec de faibles ressources humaines et économiques. Le Dr. de Oliveira, de l'Université du Québec à Montréal a supervisé des travaux de plusieurs étudiants de Maîtrise dont le thème portait sur les sujets suivants: 1) la pollinisation du fraisier, du framboisier et du pommier (Pion 1978, Pion *et al.* 1980), 2) l'entomofaune pollinisatrice dans des champs en friche autour d'un village situé au coeur d'une région forestière (Painchaud 1982), 3) l'entomofaune pollinisatrice de biotopes cultivés et non cultivés de la région de Saint-Hyacinthe (Payette 1987), 4) l'effet de pesticides sur les visites des pollinisateurs du fraisier (Brossard 1987), 5) les besoins en pollinisation du fraisier cultivé (Chagnon 1989). Un autre travail de Maîtrise, portant sur l'effet des pesticides sur les abeilles, est en cours. Cette équipe a également fait des recherches sur l'effet des traitements insecticides dans le maïs-grain sur l'activité de l'abeille domestique (Pion *et al.* 1983).

A l'Université Laval, le Dr. J.-M. Perron a supervisé des travaux sur la pollinisation entomophile des bleuetiers nains du Lac Saint-Jean (Morissette 1985). Il a également effectué des travaux sur *Phacelia tanacaetifolia*, plante qui produit beaucoup de nectar dans les conditions rencontrées en U.R.S.S.. D'autres espèces de plantes mellifères, notamment la bourrache médicinale, le mélilot hubam et la gastache ont fait l'objet d'études par cette équipe. A l'heure actuelle le Dr. Perron fait de la recherche en collaboration avec la Station de Deschambault (M.A.P.A.Q.) sur l'activité des colonies. Ces recherches visent à la sélection génétique de colonies plus actives et vigoureuses sous nos conditions.

Au Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (M.A.P.A.Q.), les recherches de M. Marceau de Deschambault portent sur la sélection de reines plus productives sous les conditions québécoises. L'avènement possible des acariens des trachées donne une dimension très importante à ce type de recherches. Le Dr. Méthot (M.A.P.A.Q. à Granby), responsable de la pathologie des abeilles, est d'avis que la recherche en pathologie est déficiente au Québec. La loque américaine, *Bacillus larvae*, est présentement sous contrôle alors que le couvain plâtré, *Ascosphaera apis*, prend de l'importance depuis deux ans. En 1988, chaque nucléus inspecté était scellé avant la livraison en vue de contrer la loque américaine et autres maladies. Par ailleurs, les dangers à craindre sont l'acarien des trachées et la varroase; la présence du *Varroa* et de l'acarien des trachées dans les Etats américains limitrophes au Québec (Vermont, New York, Maine) constitue une menace imminente. L'impact sur l'industrie apicole québécoise sera certainement négatif mais on ne sait dans quelle mesure.

A la Station de Recherches d'Agriculture Canada à Saint-Jean-sur-Richelieu, on a effectué des travaux sur 1) la pollinisation de plusieurs cultivars de fraisiers (Bagnara et Vincent 1988) 2) les différences entre les cultivars au point de vue du contenu en sucres du nectar et en acides aminés du pollen (Grünfeld *et al.* 1989), 3) l'effet des pesticides sur les pollinisateurs et la pollinisation du fraisier (Vincent *et al.* 1989). Il reste à publier des résultats concernant 1) l'effet de l'azinphosméthyle sur les visites des pollinisateurs et la pollinisation, 2) les différences morphométriques des fleurs cultivars de fraisiers, et 3) des résultats concernant le patron de réflectivité des pétales. Nous sommes intéressés à poursuivre des recherches sur l'effet de résidus de pesticides sur le comportement des pollinisateurs du fraisier, tout spécialement chez le fraisier à production continue. La pollinisation des autres petits fruits serait également un sujet d'intérêt, en autant que les ressources le permettent.

Au Collège Macdonald, Khanizadeh et Buszard (1987) se sont intéressés à l'effet de traitements fongicides, notamment le captane et l'Easout, sur la pollinisation du fraisier. Le Dr. Vickery effectue des recherches sur les besoins en hivernation des colonies. Ce type de recherche devient important avec l'avènement probable des acariens des trachées.

Services de pollinisation

En 1988, la Fédération des producteurs de miel du Québec a effectué des études pour établir un coût uniforme pour les services de pollinisation en vergers de pommiers et dans les bleuetières du Lac Saint-Jean. Les prix demandés par ruche en 1988 étaient de $45.00 en vergers de pommier (région de Rougemont) et de $65.00 en bleuetières (région du Lac Saint-Jean). Ces prix ont été calculés en fonction des risques encourus (transport, empoisonnement dû aux pesticides, etc.). Il semble que les producteurs de pommes et de bleuets aient trouvé ces prix exagérés, mentalité qui démontre la faible compréhension des producteurs pour les services de pollinisation. Il convient de souligner que cette attitude n'est pas l'appanage exclusif des producteurs; de nombreux chercheurs ont une vision semblable, ce qui semble être une situation généralisée au Canada.

Conclusion

Comme en témoigne cette brève revue et la liste des publications ci-jointe, l'apiculture et la pollinisation entomophile ont fait l'objet d'une activité remarquable, malgré un sous-financement chronique. Ainsi depuis dix ans, les nombreuses recherches sur la pollinisation du fraisier font du Québec un chef de file mondial en ce domaine. Les programmes d'éducation en apiculture sont actuellement déficients tant aux niveaux techniques et universitaires. Parmi les nombreuses priorités de recherches, mentionnons les traitements préventifs et curatifs contre l'acarien des trachées et la varroase, la contribution des pollinisateurs au rendement des cultures de même que l'effet négatif des pesticides, le diagnostique rapide des maladies des abeilles et le développement de lignées résistantes aux maladies. De l'avis de plusieurs intervenants en apiculture, une étape décisive à franchir en apiculture serait un changement de mentalité des producteurs, des chercheurs (non-initiés), et de ceux qui financent les projets de recherches.

Remerciements

Je remercie A. Méthot, J.-M. Perron, N. Duffy, C. Laniel et D. Sansfaçon pour les informations ayant servies à écrire ce document.

Références

Bagnara, D. et C. Vincent 1988. Role of insect pollination and plant genotype in strawberry fruit set and fertility. J. Hortic. Sci. 63: 69-75.

Brossard, J.-P. 1987. Effet répulsif de quatre insecticides (Ambush, Cymbush, Malathion, Cygon) vis-à-vis l'abeille domestique. M.Sc. Thesis, Université du Québec à Montréal, Montréal, 86 p.

Chagnon, M., J. Gingras et D. de Oliveira 1989. Impact of honey bee visits on the pollination rate of strawberries. J. Econ. Entomol. (in press).

de Oliveira, D. 1983. Importance économique de la pollinisation par les insectes. Ann. Soc. Entomol. Qué. 28: 40-50.

de Oliveira, D., S. Pion et R. O. Paradis 1983. Entomogamie et production du fraisier 'Redcoat', *Fragaria* x *ananassa* Duch., au Québec. Bull. Soc. Entomol. Fr. 88:356-359.

Grünfeld, E., C. Vincent et D. Bagnara 1989. Chemical analysis of nectar and pollen of strawberry flowers by HPLC. J. Agric. Food Chem. 37:290-294.

Khanizadeh, S. et D. Buszard 1987. Effects of the Fungicides Captan and Easout on Strawberry (*Fragaria* x *ananassa* Duch.) Fruit Development. Adv. Strawberry Prod. 6:27-31.

Morrisette, R., A. Francoeur et J.-M. Perron 1985. Importance des abeilles sauvages (Apoidea) dans la pollinisation des bleuetiers nains (*Vaccinium* spp.) en Sagamie, Québec. 30:44-53.

Painchaud, D. 1982. Etude d'une communauté d'insectes pollinisateurs dans les Laurentides. M.Sc. Thesis, Université du Québec à Montréal, Montréal.

Payette, S. 1987. Entomofaune pollinisatrice (Hymenoptera:Apoidae) de la région agricole de Saint-Hyacinthe, M.Sc. Thesis, Université du Québec à Montréal, Montréal, 82 p.

Perron, J.-M. 1983. Les problèmes de pollinisation et de l'apiculture en milieu agricole. Ann. Soc. Entomol. Qué. 28:30-39.

Pion, S. 1980. La pollinisation du fraisier (*Fragaria* x *ananassa* Duch.), du pommier (*Malus pumila* Mill.) et du framboisier (*Rubus strigosus* Michx) par les insectes. M.Sc. Thesis, Université du Québec à Montréal, Montréal, 180 p.

Pion, S., D. de Oliveira et R. O. Paradis 1980. Agents pollinisateurs et productivité du fraisier "Redcoat", *Fragaria x ananassa* Duch. Phytoprotection 61: 72-78.

Pion, S. D. de Oliveira, A. Bélanger et C. Ritchot 1983. Traitements insecticides et activité de l'abeille domestique sur le maïs-grain au Québec. V[e] Symposium International sur la Pollinisation, Versailles, Les Colloques del'INRA No 21, p. 201-208.

Vincent, C., D. de Oliveira et A. Bélanger 1989. The management of insect pollinators and pests in Quebec strawberry plantations, in N. J. Bostanian, L. T. Wilson et T. J. Dennehy (Eds.) Monitoring and Integrated Management of Arthropod Pests of Small Fruit Crops, Intercept Ltd., Dorset, U.K. (in press).

ALFALFA LEAFCUTTER BEE PROJECTS - 1983-1988

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The following research and demonstration projects relative to alfalfa leafcutter bees have been undertaken in Canada during the period 1983-1988. These projects have been conducted by Agriculture Canada, university, and provincial government personnel and by alfalfa seed producer associations. The projects may represent more than one scientific paper, projects which have not been published, or projects which are still in progress.

Ontario

Biosystematics Research Centre

1983-1988 - Dr. John Bissett. Taxonomy and survey of chalkbrood (*Ascosphaera* spp.) in leafcutter bees.
A three-year survey was conducted in the alfalfa seed producing regions of Canada for chalkbrood. Three new species of *Ascosphaera* have been described and descriptions and keys are provided for the eight species previously known.

New Liskeard College of Agricultural Technology

1983-1987 - A. V. Skepasts. Pollination, leafcutter bees, and alfalfa seed production in Northern Ontario.
A demonstration-research project to determine the feasibility of alfalfa seed production. Uses existing bee management and agronomic practices for seed production. Weather during the growing season makes growing the crop a risky business in Northern Ontario.

Manitoba

University of Manitoba

1983-1984 - Dr. S. C. Jay and N. Mohr. Effect of nest replacement on the production of female bees.
There was a reduction in the number of females produced in replacement hives suggesting its neither practical nor economical to replace hives to increase numbers of females. Chalcidoid parasitism was reduced in the replacement hives.

Manitoba Alfalfa Seed Producers Association

1985-1988 - H. Rutherford. Agri-food project to control chalkbrood disease in Manitoba leafcutter bees.

Purpose to survey Manitoba bees for chalkbrood; develop and demonstrate practical techniques for chalkbrood prevention and control; research and identify causes of chalkbrood; develop and demonstrate methods to minimize potential for chalkbrood; and demonstrate decontamination techniques for bees and equipment. Engaged in an intensive education program to clarify misconceptions. Developed an automated dip tank for disinfecting hives with halogen solutions.

1987-1988 - B. Fingler. Cocoon dipping and its effect on leafcutter bee emergence.
Emergence of adults was significantly lower from cocoons dipped in bleach compared to cocoons not dipped.

Saskatchewan

Saskatchewan Department of Agriculture

1987-1989 - D. Murrell. Comparison of shelter designs for leafcutter bee production in parkland Saskatchewan.
A 2-year field study of 7 shelter designs. Temperature, percentage of capped tunnels, cocoon production varied by design, but quality of cells did not vary by design.

1988-1990 - D. Murrell. Comparison of nesting materials commonly used in parkland Saskatchewan.
A 2-year field study to compare the diverse types of nesting materials used in commercial production for productivity, ease of handling, and quality of cocoons.

Saskatchewan Alfalfa Seed Producers Association

1986-1990 - D. W. Goerzen. Leafcutter bee foliar mold research and development of control methods in Saskatchewan.
Surveys bee populations for chalkbrood and foliar molds, identifies and monitors foliar molds, studies causes of bee mortality, determines mold species which may be hazardous to producer health, and tests methods of foliar mold control. Ascosphaera aggregata has not been found at detectable levels, yet a large number of mold, yeast, and bacterial species are common. Paraformaldehyde efficacy is being tested for nest material contaminants.

Private entrepreneurship

1986-1990 - Dr. G. H. Rank. Univoltine strain selection and comparison of strains of leafcutter bees.
Investigating the development and selection of a univoltine strain for Canadian conditions so as to eliminate losses due to this problem through the comparison of foreign strains (French, Spanish).

Alberta

Agriculture Canada - Research Station - Beaverlodge

1984-1986 - Dr. D. T. Fairey and J. A. C. Lieverse. Cell production by leafcutter bees in new and used wood and polystyrene nesting materials.
Cell production and viability in used material was 2-3 times that in new material, irrespective of the type of material.

1983-1988 - Dr. D. T. Fairey, Dr. L. P. Lefkovitch, J. A. C. Lieverse, and B. Siemens. Materials for leafcutter shelters.
Dura Film polyethylene, Lortex III, and Monarflex Ultra were compared as covering materials for shelters and had similar preformance in production of viable cells and sex ratio.

- - Dr. D. T. Fairey and Dr. L. P. Lefkovitch. Shelter designs for leafcutter bees.
Study in progress.

- - Dr. D. T. Fairey and Dr. L. P. Lefkovitch. Stocking rates for leafcutter bees.
Study in progress.

1984-1986 - Dr. D. T. Fairey, Dr. L. P. Lefkovitch, and Dr. D. L. Nelson. Viability of prepupae during extended storage.
More than 50% of the prepupae were nonviable after 417 days of storage at 3-5°C. Survival of emerged adults did not appear to depend on storage time or sex.

- - Dr. D. T. Fairey and Dr. L. P. Lefkovitch. Pollen collection and foraging behavior of leafcutter bees.
Study in progress.

1983-1988 - Dr. D. T. Fairey and Dr. L. P. Lefkovitch. Leafcutter bee, a potential pollinator of single-cut red clover.
Examines the seed yield of plots with and without leafcutter bees and a comparison of the production of bee cells from red clover and alfalfa.

- - Dr. D. T. Fairey and Dr. L. P. Lefkovitch. Floral morphology of clovers.
Study in progress.

- - Dr. D. T. Fairey and Dr. L. P. Lefkovitch. Characterization of pollinating behavior (frequency of foraging, proboscis length) of native and introduced pollinators of clovers.
Study in progress.

- - Dr. D. T. Fairey and Dr. L. P. Lefkovitch. Pollination and reproduction of leafcutter bees on forage legumes.
Study in progress.

Agriculture Canada - Research Station - Lethbridge

1983-1984 - Dr. K. W. Richards and Dr. D. L. Struble. Identification of sex pheromone components of the driedfruit moth, impact of damage and food preference, growth, and development of larvae.
Provides basic information for the development of an effective pest management program including the determination of an economic threshold.

1983-1986 - Dr. H. C. Huang and Dr. K. W. Richards. Verticillium wilt contamination on leaf pieces forming cells for leafcutter bees and the role bees play in the dissemination in alfalfa.
This is the first implication that bees are capable of disseminating plant pathogens in seed crops.

1983-1984 - Dr. K. W. Richards. Comparison of tumblers used to remove debris from cells of the leafcutter bee.
Six designs were compared for removal of debris and predators and operation.

1983-1984 - Dr. B. D. Hill and Dr. K. W. Richards. Use of dichlorvos resin strips to reduce parasitism of leafcutter bee cocoons during incubation.
Information on efficacy on parasite and prepupae, rate of action and some limiting parameters of usage.

1984-1987 - Dr. G. H. Whitfield and Dr. K. W. Richards. Influence of temperature on survival and rate of development of diapausing and non-diapausing _Pteromalus venustus_, a parasite of leafcutter bees.
The laboratory study provides base temperature and degree days of development for predicting emergence and were verified using biophenometers.

1984-1985 - Dr. K. W. Richards. Detection of _Ascosphaera aggregata_ in leafcutter bee larvae in western Canada.
Reports the results of a survey and the confirmed detection of chalkbrood in Manitoba.

1978-1986 - Dr. K. W. Richards. Pollination requirements of cicer milkvetch, _Astragalus_ cicer.
Determines the need for cross-pollination by comparison of open-pollinated and pollinator-excluded plants, length of time flowers are available for pollination, and actual seed yields after harvest.

1983-1987 - Dr. K. W. Richards and Dr. G. H. Whitfield. Effects of temperature and duration of winter storage on survival and period of emergence for leafcutter bees.
Cocoons stored for 22 months at 4 constant temperatures. A five-parameter model of adult emergence for storage and temperature is described. Minimum and maximum storage periods and optimum storage temperature recommended.

1978-1987 - Dr. K. W. Richards. Density, diversity, efficiency and effectiveness of pollinators of cicer milkvetch.
Comparison of pollinators at 2 locations with emphasis on bumble bees, honey bees and leafcutter bees. A theoretical approach (4 parameter model) used to predict the bee populations required to pollinate varying flower densities. Bumble bee colony establishment and reproductive success near fields was determined. Propagation rate and quality of leafcutter bees was determined as excellent.

1985-1986 - Dr. K. W. Richards and Dr. G. H. Whitfield. Emergence and survival of leafcutter bees held at constant incubation temperatures.
A laboratory study of bees from 4 Alberta locations and incubated at 8 constant temperatures. Determines base temperature of development and number of degree-days for emergence and was confirmed using biophenometers. All locations responded similarly to temperatures in the intermediate range of 25-35°C, the range commonly encountered in commercial operations.

1986-1987 - Dr. K. W. Richards and Dr. G. H. Whitfield. Relation of head-capsule width to instar development in larvae of the leafcutter bee.
Quantification and recognition of the different instars are necessary to life-table and stage-specific development and survival studies. Larvae exhibited developmental polymorphism with 77% having 4 instars and 33% having 5 instars.

1986-1988 - Dr. K. W. Richards and P. D. Edwards. Density, diversity, and efficiency of pollinators of sainfoin.
Density of flowers over the season determined. Comparison of pollinator species in rate of foraging (multiple regression models), visitations per raceme, foraging hours per day, and actual density compared to flower density. Theoretical approach used to predict the bee populations required to pollinate varying flower densities.

1986-1989 - Dr. K. W. Richards and Dr. G. H. Whitfield. Development and survival of the life stages of leafcutter bees.
Determines the rate of development and survival of eggs, larvae, and pupae of leafcutter bees at 9 constant temperatures. Uses predictive development models and establishes base temperatures and degree days for each stage.

1986-1990 - Dr. K. W. Richards and Dr. G. H. Whitfield. Establish density of bee cells per unit area of hive and percent survival for each development stage.
Information obtained from release of bees in the field to season end and correlated with degree-day accumulation. Uses the above laboratory information as a basis to provide estimates of population replacement and increase relative to degree-day accumulation.

1983-1991 - Dr. K. W. Richards. Alternate floral sources for leafcutter bees.
Determines the effects (seed yield, seed set) of leafcutter bees as a pollinator on 30 species of forage legume crops (mass-screening stage) to increase seed production.

1987 - Dr. K. W. Richards. (in cooperation with Dr. I. Williams). Pollination requirements and pollinators of lupins.
Research conducted while on transfer of work to Rothamsted Experimental Station, England. Seed carrying capacity of yellow lupins determined. Diversity, density and foraging rate of pollinators of white, yellow, and blue lupins determined. Anthesis, pollen production, and flower dynamics for white lupin established.

1988-1992 - Dr. K. W. Richards. Determine the diversity, density, and foraging rate of pollinators of birdsfoot trefoil. Will predict the number of pollinators required to pollinate varying flower densities. Includes a cultivar evaluation trial for seed production.

1988- - Dr. K. W. Richards and Dr. B. D. Hill Efficacy of fungicides of chalkbrood control.
Preliminary laboratory study to determine rate required to control chalkbrood yet not harm the bees.

1988- - Dr. K. W. Richards. Determine effect on cocoons of dipping them in sodium hypochlorite to disinfect them of chalkbrood and foliar mold spores.
Mortality of cocoons occurred in all treatments where cocoons were dipped in bleach for varying lengths of time and concentrations.

1985- - Dr. W. A. Charnetski. Toxicity of insecticides to leafcutter bees established by three evaluation methods.
Tube chamber, petri dish chamber, and field cages were used and compared to evaluate the toxicity of deltamethrin, trichlorfon, and methoxychlor deposits on alfalfa for adult bees.

1987-1992 - Dr. B. D. Schaber. Determine the composition of nectar from alfalfa flowers from burned and unburned alfalfa seed fields.
The relative quantity of 5 sugars from nectar from alfalfa flowers from spring burned and unburned alfalfa seed fields are being compared.

1987-1990 - Dr. B. D. Schaber. Determine the effect of burning alfalfa seed fields for insect control on mandibular wear of adult bees and ease of cutting leafpieces.
The chemical composition of alfalfa leaves from burned fields differs from that in unburned fields. Mandibles wear more in burned fields than in unburned fields and the ability to cut suitable leafpieces or construct cells may be influenced.

Alberta Alfalfa Seed Producers Association

1986- - Dr. G. H. Whitfield and Dr. K. W. Richards. Control of chalkbrood in leafcutter bees.
Field trials to determine effects of dipping nesting material in sodium hypochlorite and of fungicides on chalkbrood control. Fungicide applied to trap crop for passive transmission to nest. Diagnosis of chalkbrood by x-radiographs improved.

1988- - Dr. K. W. Richards. Control of chalkbrood in leafcutter bees.
Field trials to refine effects of dipping nesting material in in sodium hypochlorite, iodine, and calcium hypochlorite at various concentrations and for varying lengths of time. Various fungicides and methods of application investigated.

University of Calgary

1987-1990 - Ms. Marjorie Horne. Plant specificity in the leafcutter bee.
M. Sc. thesis being conducted at the Lethbridge Research Station on 11 forage crop species. Involves choices of plant species for constructing and provisioning cells and some of the reasons why choices were made.

ADDENDUM TO ALFALFA LEAFCUTTER BEE PROJECTS - 1983-88

Ontario

University of Guelph

1985 - 1989 V. Kucyk and B. Christie on alfalfa seed production in southern Ontario

A project on the effects of row-spacing, seeding rates, pollinator density, harvesting technology on alfalfa seed production. Research indicates great potential for seed and leafcutting bee production.

Ontario Alfalfa Seed Growers' Association

1984 - 1989 Alfalfa seed production in Ontario

This is a grower cooperative project with various demonstrations on working farms from throughout agricultural Ontario. The U. of Guelph project (above) is also part of research sponsored by the OASGA.

P. Kevan
April 4, 1989

RECENT CANADIAN PROGRESS ON THE BIOLOGY, MANAGEMENT AND PROTECTION OF NATIVE POLLINATORS: ca. 1983 - 1988.

by

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INTRODUCTION

Most of the research on pollinators in Canada has been on honey bees and leafcutting bees. Of that work, most concerns the biology and management of the bees, and little concerns their actual pollinating activities and less still encompasses the integration of both botanical and zoological facets of pollination. The recent CAPA reports (1986 to 1988) support that contention with only about 10% of the listed research projects having as their primary concern the subject of pollination.

Outside the realm honey bees and leafcutting bees, very little information is available for crops. Some of the research which does concern crops has other primary concerns, particularly the effects of pesticides on native pollinators (see p. 6). Even though studies of native pollinators on native plants can be most instructive to the pollination of crops (see pp. 7 - 8), the information frequently is not perceived as practically relevant.

Since becoming involved in considerations of conservation in pollination of crops (Kevan 1975a) and native plants (Kevan 1975b), Kevan (U of Guelph) has continued to try to remind the scientific and agricultural community of the value of pollination and pollinator diversity in all ecosystems from the most highly managed agricultural ones to remote and undisturbed wilderness (Kevan and LaBerge 1979; NRCC 1981; Kevan and Baker 1983; 1984; Kevan 1984; 1986a; 1987a, b; 1989 and in preparation "Pollination and Pollinators for Sustainable Agriculture" with A. Clark, Crop Science and V. Thomas, Zoology, U of Guelph).

Particularly relevant to this submission is the published set of papers from The Workshop on Alternative Pollinators for Ontario's Crops held at the University of Guelph, 12 April 1986. The papers presented range from the review by Torchio (USDA, Logan, Utah) of non-honey bee species as pollinators of crops to specific problems of orchards, ericaceous crops, bumblebees, alfalfa, and ginseng. The prefatory remarks by Kevan (1987b) were re-iterated in Canadian Beekeeping (1988) and have pointed up the need for agriculture's and apiculture's taking a broader view of pollination and pollinators. A variety of serious and relatively recent developments, coupled with some chronic problems in the beekeeping industry, have since strengthened the arguements and speak to the need for an appreciation of urgency in pollination of crops in the future (Kevan in press: attached).

Instead of providing a chronological catalogue of projects conducted at various laboratories in Canada, I prefer to present a precis of research on pollinators other than honey bees and leafcutting bees by general topic.

NATIVE POLLINATORS AND CROPS

Blueberries and Cranberries

The greatest body of information is available on lowbush blueberries, and mostly from the Maritime Provinces. Finnamore and Neary (1978) list some 190 species of bees associated with the pollination of this important, although minor, crop. Those researchers are no longer involved in pollination or pollinator research. The research on the effects of Fenitrothion, an O-P insecticide used against spruce budworm in New Brunswick, showed clearly that populations of native pollinators of blueberry were severely reduced on fields near spray applications and that crop reductions followed. That work, plus additional research in Quebec, New Brunswick, and Ontario has been recently reviewed by Kevan (U of Guelph) and Plowright (U of Toronto) as part of the deliberations on the re-registration of Fenitrothion for the control of forest insect pests (Kevan and Plowright in press). One of the important points made by Kevan and Plowright in their report is that very little work has been done in the last 5 to 7 years (see p. 6), despite the recognition that pollination is a component of the ecosystem which is highly sensitive to perturbation by insecticides (NRCC 1981).

Mohr and Kevan (U of Guelph) initiated work on the pollination requirements and native pollinators of lowbush blueberries in northern Ontario (Mohr and Kevan 1987). They concluded that the abundance of native pollinators was probably too low to cause enough pollination on commercially managed blueberry lands in northern Ontario and that honey bees were needed. Unfortunately, that work has been all but suspended for lack of funds.

Recent research on native pollinators of other *Vaccinium* species is sparse. Winston and Graf (1983) and MacKenzie and Winston (1984) (at Simon Fraser U) have published on the abundance and diversity of native pollinators on highbush blueberry, and other berry crops in the Lower Fraser Valley. Their ultimate conclusion is that native bees are probably in too few numbers, and vary too widely in their populations from year to year, to be reliable for economic crop setting. A preliminary survey in along the Lake Erie shore for pollinators of highbush blueberry has indicated large populations of bumblebees, contrary to earlier indications (Mohr and Kevan 1987). Further work will be done this summer (Kevan, U of Guelph).

Research on cranberries from both the Lower Fraser Valley (Winston and Graf 1983; MacKenzie and Winston 1984) and the Muskoka Lakes (Kevan et al. 1984) produced remarkably similar results. Bumblebees are the main native pollinators, but that honey bees, because of their managability, may be more reliable.

Orchard Fruit

The next greatest body of information is available from studies on orchards. Boyle-Makowski and Philogene (Ottawa U) first published their findings in 1983. They indicated that several species of native bees were better pollinators of apples in the Niagara Region than were honey bees. They carried more pollen, worked at lower temperatures, and under windier and cloudier conditions. More detailed accounts of their work have been presented in the entomological literature (Boyle-Makowski and Philogene 1985; Boyle-Makowski 1987). Roberte Boyle-Makowski is now at the Agriculture Canada

Research Station, Regina, Saskatchewan and is no longer actively involved in research in pollination. Bernard Philogene is mostly concerned with pesticide science and is at the University of Ottawa.

Although it should be well recognized that native bees are better pollinators of apples, and presumably other orchard trees, than are honey bees, they may not be in large enough numbers to provide an adequate pollination force. Scott-Dupree and Winston (1987) record that 100 species of bees were collected in orchards in the Okanagan Valley during studies in 1984 and 1985. However, they conclude that the total populations of these bees would not be adequate to full pollination of the crop. The populations may be low for a variety of reasons, including nest-site destruction, monocropping and lack of alternative forage, urbanization, pesticides, and competition from honey bees. Research in these areas of applied ecology are much needed.

There have been several casual attempts to use Orchard Bees in Ontario. However, to date these have failed. Serious scientifically conducted trials are needed to assess the potential for these bees in Ontario. The existing literature would indicate a high liklihood of success (Torchio 1987) with potentially great value to orchardists. Osmia lignaria is native to fruit growing regions of Canada and has been collected in orchards in the Okanagan Valley and is known from Ontario. There are two subspecies, O. l. lignaria in the East and O. l. propinqua from the western slopes of the Rocky Mountains west. One grower in Ontario is intending to try Orchard bees this season (1989) and has asked Kevan to help in assessing the bees' performance.

Other fruit

MacKenzie and Winston (1984) and Winston and Graf (1983) report findings for raspberries in concert with those mentioned above for blueberries and cranberries. Kevan (unpublished) has made preliminary investigations into pollination of elderberry. Although he has found that elderberry blossoms deprived of visits by insects set significantly less fruit than those which are open pollinated, the exact nature of pollination requirements of this crop are not clear. Reports in the literature are unreliable. Honey bees do not work elderberry flowers, except when starved for pollen. Kevan's research on vineyard grapes (unpublished) indicate that insect pollination is not needed. However, in wild grapes, which are dioecious (Kevan et al. 1985; 1988) insect pollination, mostly by pollen collecting solitary bees, is important in widely spaced vines which can not be pollinated by wind.

Squash, Gourds, and Pumpkins

Recently the squash or gourd bee Peponapis pruinosa was discovered in large aggregations in Ancaster, Ontario. This bee is essentially monolectic, foraging almost exclusively on various types of Cucurbita pepo. It appears to be a highly efficient pollinator, being active at dawn and for the half-day duration of the day's flowers on the crop (Kevan et al. 1989). Research is underway in Kevan's laboratory to develop a management technology, similar to that used for alkali bees, for the use of P. pruinosa on squashes and their allies on farms in southern Ontario. Despite the potential value for the bee in Canada and the U. S. A. appropriate funding agencies seem disinterested. Co-operator growers, however, have been ready to provide logistic and in-kind support for the work.

Forage Legumes

Most of the research on forage legumes has centered on alfalfa and Megachile rotundata. Other bees, including leafcutting bees should be examined for their potential as legume pollinators. Kucyk (U of Guelph) has obtained cells of other species of Megachile (M. relativa) while using M. rotundata for trials on alfalfa pollination in Elora, Ontario (Kucyk personal communication). Plowright and Hartling (1981) investigated bumblebee pollination in red clover and indicated that the typical behaviour of these pollinators to visit flowers on inflorescences in such a way as to maximize profits from foraging resulted in maximized seed-set. Whether bumblebees can be managed for crop pollination is an open question. Plowright and Laverty (1987) suggest that such a policy would not be useful except under special circumstances. Richards and Fairey and Lefkovitch (Agriculture Canada, Lethbridge, Beaverlodge and Ottawa respectively) are considering native pollinators, particularly bumblebees, as pollinators of various legumes (e.g. cicer milk vetch, sainfoin, clovers).

Pollination in Enclosures

Initial work has been started at the University of Guelph on pollination of selected lines of parsnips by various bees and houseflies (Kevan and Shattuck 1988). Research is planned for similar work on asparagus. However, for both these and other similar research on a variety of minor crops, researchers have been unable to find funding.

PESTICIDES, NATIVE BEES AND POLLINATION

As mentioned above, the amount of pesticide oriented research on pollinators, other than honey bees and leafcutting bees in Canada has been minimal in the last 5 years. Kevan and Plowright (1989) have reviewed the literature. The following list itemizes the recent research in this area.

1. Kevan and Plowright (1989) on a review of the effects of Fenitrothion on pollinators and pollination,

2. Barber and co-workers (Forest Pest Management Institute, Sault Ste Marie) on developing and testing methods of assessing the impact of insecticides used in forestry on forest plant fecudity and on pollinators (bumblebees, solitary bees, other insects),

3. Fudge, Lane, and Associates (St. John's) on the effects of aerially applied fenitrothion on the activity of pollinating insects in Newfoundland. This report is rather inconclusive.

4. Lavalin (Andre Marsan et Associes) to Ministry of Energy and Resources, Quebec on the effects of fenitrothion and aminocarb sprays on pollinators in forests. This report mostly re-iterates existing information,

5. Somer Inc. (Montreal) on the effects of fenitrothion and aminocarb on pollinators and on the fecundity of plants in the forest environment. This is a solid report with results from well-designed experiments showing that fenitrothion is more harmful than is aminocarb and that pollinators and plant fecundity were both adversely affected, especially by fenitrothion. These results are consistent with those from New Brunswick obtained several years earlier by Plowright and co-workers (see Kevan and Plowright 1989).

To the best of my knowledge, only the research at FPMI is now on a continuing basis. The need for a greater understanding of the pollination requirements of the native vegetation of Canada has been pointed out periodically by Kevan (1975a), NRCC (1981), and others. Now some small base of information is available for herbaceous plants of the boreal forest (Barrett and Helenurm 1987; Helenurm and Barrett 1987; and see Kevan and Plowright 1989).

NON-APPLIED RESEARCH ON NATIVE BEES AS POLLINATORS

Bumblebees have made excellent study animals for testing hypotheses regarding foraging theory. Plowright and Laverty (1984) have thoroughly reviewed the literature on the ecology and sociobiology of these fascinating insects. The following is a brief and incomplete listing of Canadian studies on native pollinators, not just bumblebees, which relate to pollination biology to provide a sampler of the types of research being done. They range from those more specific to foraging theory to some more general in nature:

1. Plowright and Hartling (1981) on bumblebees and red-clover (described above),

2. Galen and Plowright (1985a) on nectar and pollen foraging by bumblebees on fireweed,

3. Plowright and Galen (1985) on landmarks and bumblebee foraging efficiency,

4. Galen and Plowright (1985b) on nectar amounts and pollen carryover in fireweed,

5. Laverty (1985), Laverty and Plowright (1988a) on floral complexity and bumblebee learning and manipulation of flowers (Laverty is at U of Western Ontario),

6. Laverty and Plowright (1985) on competition betwen hummingbirds and bumblebees for floral nectar,

7. Laverty and Plowright (1988b) on interspecific relationships between plants with the same pollinators. Laverty is continuing this avenue of research with bumblebees,

8. Harder (U of Calgary) (1985; in press) on floral form and bumblebee anatomy in pollination, resource partitioning, foraging behaviour, especially for pollen, pollen removal rates, transfer, and its implications for plant reproduction,

9. Bell, Lefebvre, Lechowicz, Schoen and co-workers (McGill U) on pollinators foraging behaviour on flowers at different sexual phases (see Bell 1984),

10. Kevan (1986b) on pollinator behaviour and pollination of dioecious plants, especially prairie rose (submitted), wild grapes (Kevan et al. 1985, 1988), native hop tree (Ambrose et al. 1985), Kentucky coffee tree (in preparation), and others,

11. Kevan (unpublished) on the foraging behaviours of large bees on trees,

12. Packer (York U) on bee biology and systematics, particularly on social behaviour of Halictidae and foraging trip durations in relation to nest productivity,

13. Montgomerie (Queen's U) on pollination ecology of spring ephemerals in Eastern deciduous forests, of high arctic plants, and of hummingbird pollination in temperate and tropical plants,

13. Small and Brookes (Biosystematics Research Centre, Agriculture Canada) on

pollination of Medicago and its allies, mostly from a botanical viewpoint,

14. Ambrose (U of Guelph) and Kevan on the breeding biology of rare plants of Ontario in relation to their conservation,

15. Kevan and co-workers on insects as vectors of nectar-inhabiting yeasts, particularly in milkweed (Kevan et al. 1989) and on milkweed pollination in general (Punchihewa 1984),

16. Kevan and co-workers on pollination in Cactaceae, especially Opuntia,

17. Addicot (U of Alberta) on pollination and pollinator biology on Yucca,

18. Carter (U of British Columbia) on foraging behaviour in bumblebees and risk assessment in foraging,

19. Knerrer (U of Toronto) on evolution of sociality in Halictine bees,

20. Owen (U of Calgary) on biosystematics of bumblebees,

REFERENCES

Ambrose, J. D., P. G. Kevan, and R. M. Gadawski, 1985. Can. J. Bot. 63: 1928-1935.

Barber, K. N. 1987. Abstracts of 1987 Ont. Pesticides Advisory Committee, Ont. Ministry of Environment, Toronto.

Barber, K. N. 1988. ibid but for 1988.

Barrett, S. C. H. and K. Helenurm, 1987. Can. J. Bot. 65: 2036-2046.

Bell, G., L. Lefebvre, L.-A. Giraldeau, and D. Weary, 1984. Oecologia 64: 287-294.

Boyle, R. M. D. and B. J. R. Philogene, 1983. J. Hort. Sci. 58: 355-363.

Boyle-Makowski, R. M. D. and B. J. R. Philogene, 1985. Can. Ent. 117: 1509-1521.

Boyle-Makowski, R. M. D., 1987. Proc. ent. Soc. Ont. 118: 125-141.

Finnamore, A. T. and M. E. Neary, 1978. Annls ent. Soc. Que. 23: 168-181.

Galen C. and R. C. Plowright, 1985a. Ecol. Ent. 10: 9-17.

Galen C. and R. C. Plowright, 1985b. Can. J. Bot. 63: 488-491.

Harder, L. D. 1985. Ecology 66: 198-210.

Harder, L. D. 1989. Amer. Nat. (in press).

Helenurm, K. and S. C. H. Barrett, 1987. Can. J. Bot. 65: 2047-2056.

Kevan, P. G. 1975a. Biol. Conservation 7: 301-309.

Kevan, P. G. 1975b. Env. Conservation 2: 293-298.

Kevan, P. G. 1984. Proc. I Regional Symp. Biol. Control, Serdang, Malaysia. Abstract, p. 63.

Kevan, P. G. 1986a. in Biological Control in the Tropics (Hussein and Ibrahim, Eds.), Universiti Petranian Malaysia, pp. 439-452.

Kevan, P. G. 1986b. Prog. IV Int. Cong. Ecol. Abstracts pp. 198-199.

Kevan, P. G. (Editor) 1987. Alternative Pollinators for Ontario's Crops. Proc. ent. Soc. Ont. 118: 109-170.

Kevan, P. G. 1987. Proc. ent. Soc. Ont. 118: 109-110.

Kevan, P. G. 1988. Can. Beek. 14: 79-80.

Kevan, P. G. 1989. Can. Beek. in press.

Kevan, P. G. and H. G. Baker, 1983. Ann. Rev. Ent. 28: 407-453.

Kevan, P. G. and H. G. Baker, 1984. in Ecological Entomology (Huffaker and Rabb, Eds), Academic Press.

Kevan, P. G., D. C. A. Blades, U. Posluszny, and J. D. Abrose, 1988. Vitis

Kevan, P. G., D. Eisikowitch, S. Fowle and K. Thomas, 1989. J. apic. Res. (in press)

Kevan, P. G., R. W. Longair, and R. M. Gadawski, 1985. Can. J. Bot. 63: 2263-2267.

Kevan, P. G., N. A. Mohr, M. Offer, and J. D. Kemp, 1988. Proc. ent. Soc. Ont. 119: (in press).

Kevan, P. G., R. M. Gadawski, S. D. Kevan, and S. E. Gadawski, 1984. Proc. ent. Soc. Ont. 114: 45-53.

Kevan, P. G. and W. E. LaBerge, 1979. Proc. IV Int. Symp. Pollination, Md. Agric. Exp. Stn Special Misc. Pub. 1: 489-508.

Kevan, P. G. and R. C. Plowright, 1989. Fenitrothion and Pollination. in Canada Dept. Env. Publ., Dartmouth, N. S. (in press).

Kevan, P. G. and V. Shattuck, 1988. Can. Beek. 14:

Laverty, T. M. 1985. Ph. D. Thesis, U of Toronto.

Laverty, T. M. and R. C. Plowright, 1985. Oecologia 66: 25-32.

Laverty, T. M. and R. C. Plowright, 1988a. Anim. Behav. 36: 733-740.

Laverty T. M. and R. C. Plowright, 1988b. Can. J. Bot. 66: 173-178.

MacKenzie, K. E. and M. L. Winston, 1984. Can. Ent. 116: 965-974.

Mohr, N. A. and P. G. Kevan, 1987. Proc. ent. Soc. Ont. 118: 149-154.

NRCC, 1981. Pesticide-Pollinator Interactions. Nat. Res. Council of Canada, NRCC 18471. 190 pp.

Plowright, R. C. and L. K. Hartling, 1981. J. appl. Ecol. 18: 639-647.

Plowright, R. C. and T. M. Laverty, 1984. Ann. Rev. Ent. 29: 175-199

Plowright, R. C. and T. M. Laverty, 1987. Proc. ent. Soc. Ont. 118: 155-160.

Punchihewa, R. W. K. 1984. M. Sc. Thesis, University of Guelph.

Scott-Dupree, C. D. and M. L. Winston, 1987. Can. Ent. 119: 735-745.

Torchio, P. F. 1987. Proc. ent. Soc. Ont. 118: 111-124.

Winston, M. L. and L. H. Graf, 1983. J. Brit. Columbia ent. Soc. 79: 14-19.

REVIEW OF PREVIOUS RESEARCH WORKSHOPS

Since 1970 there have been four Apiculture Research Workshops. In each case the workshops were sponsored by Agriculture Canada and the Canadian Association of Professional Apiculturist.

- 1970, Ottawa, Ontario
- 1977, Victoria, B.C.
- 1981, Toronto, Ontario
- 1986, Charlottetown, P.E.I.

There has been a definite shift in the research priorities over the years from wintering and management to control of diseases and pests. This is in part, due to the discovery of Tracheal mites in 1984 and the Varroa mites in 1987 in the U.S. Surveys have identified Tracheal mites in B.C., Alberta, Saskatchewan, Manitoba, and Quebec. A national survey in 1988 did not find any Varroa in Canada. At present, in Canada, there are no registered controls for either of these mites. Thus, the importance of self-sufficiency has come to the fore again. Stock selection for disease and pest resistance has also become a popular topic, which might help solve mite problems. Most areas of research are becoming more integrated in their approach to problems. The one area that has been identified over the years that has received little attention is marketing, but is an area the producers still identify as very important.

SUMMARY OF RESEARCH PRIORITIES OF PAST WORKSHOPS

In 1986 the Apiculture Research Workshop Report listed research priorities under the following areas:

(A) APICULTURE RESEARCH:
- Disease and Pests
- Bee Supply
- Colony Management
- Stock Improvement
- Pesticide - Pollinator Interactions
- Bee botany

(B) INDUSTRY RELATED RESEARCH:
- Marketing Research
- Human Health
- Financial Management.

In 1981 the Apiculture Research Workshop Report listed research priorities under the following areas.

(A) PRODUCTION
- stock selection and breeding
- diseases and pests
- improved colony management

(B) REGULATIONS
- chemicals
- evaluation of pesticides

(C) UTILIZATION
- nectar production and pollination of specific crops
- new nectar and pollen sources

(D) EDUCATION

(E) MARKETING

In 1977 the Apiculture Research Workshop Report listed research priorities under the following areas.

(A) PRODUCTION
- stock selection and breeding
- diseases and pests
- improved colony management

(B) UTILIZATION
- nectar production and pollination of specific crops
- new nectar and pollen sources

(C) REGULATIONS
- chemicals
- evaluation of pesticides

(D) MARKETING

(E) EDUCATION

In 1970 the Apiculture Research Workshop Report listed research priorities under the following areas.

(A) Marketing and product research
(B) management for honey and pollen production
(C) wintering
(D) pollination
(E) honey-producing plants
(F) bee diseases

COMPILED BY
D. L. NELSON

EDUCATIONAL REQUIREMENTS AND OTHER PERSONNEL CONSIDERATIONS APRIL 1989

1. Present Personnel:

   There are twenty-eight professional positions directly associated with teaching, extension, or research in apiculture: (8) at universities; (5 research /teaching positions, 3 technician positions) (5) at federal research stations; (3 scientists, 2 technicians) (11) as either apiarists, assistants or specialist and (4) at the College level.

2. Institutions involved in bee related training programs are:

   Simon Fraser University - Graduate Level Programs M.Sc., M.P.M. PhD.

   University of Manitoba - Graduate Level M.Sc., Ph.D.

   University of Guelph - B.Sc. - Entomology/Apiculture
   M.Sc. and Ph.D. - Apiculture

   Fairview College - one year certificate, Producer Level Training
   Programs also in Tanzania, Nicaragua and the Philippines

The four universities and Fairview College all offer opportunities for foreign as well as domestic students, attesting to the fact that Canada is recognized world-wide for beekeeping expertise.

In addition, these institutions and others, offer a variety of programs on bees and beekeeping, ranging from University and College credit courses to evening courses for the general public. A six week training course runs at Malaspina College, Nanaimo, BC most years.

3. Projections for the next five years show the following number of graduates

B.Sc.	M.Sc.	Ph.D.	Certificate
6	14	6	75

4. During the next five years there should be five positions available.

   3 at the Provincial level M.Sc.
   1 at the University level Ph.D.
   1 at the College level M.Sc.

5. From the responses returned from the industry and professionals, in addition to the above noted vacancies, there should also be an increase of 5 positions at the Research Level - 2 Ph.D., 3 Technicians

6. There is also a great need for general beekeeping education at the public school level, the agricultural diploma level, and particularly at the beekeeper level.

   If we assumed that there are 1200 people involved fulltime in beekeeping in Canada and the average length of their careers in beekeeping is fifteen years, this would mean there may be a need for 80 people a year to enter this industry to just maintain the status quo.

   Thus people entering beekeeping need to gain a proper background and understanding of the industry. Better informed and educated producers will help to lessen the problems we now face and will face in the future.

7. Two provinces, BC and Alberta have Education Committees, which are excellent means of achieving a coordinated approach to the education and extension.

8. A need for some means of coordination and liaison at the federal level was identified; possibly as a federal apiarist.

D. McKenna
April 4, 1989

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CANADIAN HONEY COUNCIL

RESEARCH BRIEF

Winnipeg, Manitoba

April 1989

INTRODUCTION

To understand our current needs and requirements it is necessary to attempt to look forward for the next 5 - 10 years. Our Industry is in very distressed times. We are currently facing the Tracheal and Varroa mites along with the Africanized Bee threat coming from the South. These are compiled with the already serious disease known as chalkbrood and some unidentified viruses along with chemical controls for these mites and other serious pests in the Agricultural Community, such as the upcoming infestation of the Russian wheat midge.

In the past our industry had very few problems and had five researchers. This number has now diminished to three due to government restraint programs. In these very troubled times we do not feel that the three researchers presently employed will be able to address the increase of mite infestations and the possible Africanized Bee, and disease problems, pesticide problems, honey residue problems, etc.

We would like to recommend that Agriculture Canada fully support the existing researchers and that we again ask for the additional six research positions as referred to in the Research Brief presented in 1986

RECOMMENDED POSITIONS AND PRIORITIES

#1 PATHOLOGIST

The research that will be required in the areas of detection and control measures for the Tracheal mite and the Varroa Mite clearly identifies the need of a second pathologist to work in the beekeeping industry. (Appendix 1 page 6, item 1). We also recommend that work be continued on chalkbrood disease, although some promising new developments have occurred.

#2 GENETICIST

As identified in Appendix 1, pages 6, 9 and 10, items 1, 2 and 4, the need for research to find out if present bee stocks are resistant to the Tracheal Mite and the Varroa mite and to possibly import stocks (eggs and semen) that are resistant to these mites. The position could work with the pathologists to develop resistant strains of bees so that less chemicals would be used for disease controls. The geneticist could also work with the bee management researcher to increase production and other desired characteristics.

#3 FOOD CHEMIST

We believe this is of great importance, and has been addressed in Appendix 1, pages 13 and 14, items 1 and 2). Because honey is recognized as a health food and because the industry uses certain chemicals for disease control, etc., and also because in the future new chemicals may be used for disease and/or mites it is very important to ensure our honey remains pure and be considered as a health food. It is essential at this time to determine honey quality to prevent serious problems. There also needs to be more work done on developing new processes and uses of honey, not to mention the increasing need to work with importing countries to ensure we have a product this is marketable in their countries.

#4 BIOCHEMIST

This position is mentioned in Appendix 1, page 11, item 5). The use of pesticides is increasing problems for our industry and we feel more research needs to be done on these chemicals in relation to the pesticide-pollinator interaction under Canadian Conditions. As well this Biochemist could provide the necessary expertise for other researchers in apiculture research projects.

#5 BEE NUTRITIONIST (Number 5 and 6 are of equal importance)

Because there is a desire in the Honey industry to become more self-sufficient in the supply of our own bees (Appendix 1, page 8, item 2) there is an increased need to provide better nutrition to colonies in the way of alternate pollen feed. We need to develop pollen substitutes and be able to feed colonies under Canadian conditions.

#6 PLANT PHYSOLOGIST AND POLLINATION EXPERT

This position is identified in Appendix 1, page 12 & 13, item 6 & 7). This also is a very important area of research not only to evaluate nectar and pollen producing plants but also to work closely with plant breeders to develop new varieties of crops that produced more honey and pollen.

FURTHER RECOMMENDATIONS

The industry feels that it is not necessary to have all the researchers located in one central location but may rather be more beneficial if they were able to work in areas that already have existing facilities that would house the researcher and their support staff.

Bees generally do not mix well, in the areas of plant and animal research and the bee researchers might be better off in a separate facility. There is a need to have a separate budget that's not associated with, or controlled by, a local Research Station. Their mandate is a national one, and is much impeded by the current organization of the research Branch. It should be recognized that apiculture researcher's need for such services as telephone, travel and information dissimination differs from that of other researchers serving local regions. There might be just cause to join honey bees with other beneficial insects and form a new facility for Beneficial Insects. This concept is one that is prevalent in other countries, in particular the U.S.A. and most EEC countries.

It is further recommended that a master plan be developed for apiculture research in Canada that will include all interested parties and provide direction for the various research agencies and interested participants. This, we feel, would provide the industry with the most effective use of facilities, available personnel and financial resources.

The past history of apiculture research has led us to believe that there exists a dire need for long range planning and co-orination. It is our conviction that the lack of such a plan has resulted in less research funding committments by all levels of governments in Canada.

Appendix 1

RESEARCH PRIORITIES AND RECOMMENDATIONS FROM THE CANADIAN HONEY COUNCIL - APRIL 4, 1989.

We strongly recommend the following research priorities and recommendations. Some of this comes directly from the Research Review of 1986. These are listed in order of priority to our industry at this time. One must bear in mind that over the past two years, although the priorities are much the same, that the ones of top priority have just come onto the scene, and history can repeat itself.

A. <u>APICULTURE RESEARCH</u>

1. DISEASES AND PESTS

a) Acarapis woodi and Varroa Jacobsoni

These two mites are presently in the United States and will expand into Canada with time. The Tracheal mite has already been spotted in most provinces. The detection method presently used is very costly to the provinces and also not very accurate. The control of these mites is also a top priority to Canadian Beekeepers. Eradication is the present means of control for Tracheal. If a real infestation of these mites happens, then we will have to look at some means

of controlling these mites. Residual effects of all chemicals used should be tested.
Also there is a need to try to find genetic stock (eggs and semen) that demonstrates resistant to the mites. This may be able to be imported into Canada from Europe.
Also testing for mite resistance of the present strains of Canadian bees.

b)A program for selection and maintenance of resistant stocks should be developed and written up so that any breeder or beekeeper could apply practical means to test and improve their own strains.

Recommendations

That researchers presently working on priority diseases and pests be encouraged to concentrate their efforts on the Tracheal and Varroa mites.

That the second pathologist when hired, have a diverse background and be capable of working on most, if not all, of the diseases and pests. In addition, that research scientists employed by institutions be provided with appropriate technical assistance.

Consideration should be given to the consolidation of a research team at a university with the aim of developing an integrated approach to disease and pest control in honey bees.

2. BEE SUPPLY

There is a need for research and development involving the future supply of early queens, package bees and nuclei. Because of the unique climate in Canada, replacement bees are required each spring. The closure of the Canadian Border to the importation of bees from their traditional market, the United States, has left the Canadian Beekeeper in desperate need for alternate sources of early queens, package bees and nuclei. Provincial development and extension personnel are active in technology transfer in queen, package bee and nucleus production. The problem of early queen availability could be solved by a successful, cost effective method of overwintering large quantities of queens. A high Tech method of detecting the queen in the hive.

Recommendations

Queen overwintering research and High Tech method of queen detection be conducted at universities (as is presently being carried out at the Simon Fraser University), Agriculture Canada and the beekeeper level. Funding - partial federal, provincial and private.

Extension and development personnel in the provinces continue activities in technology transfer in the fields of queen, package bee and nucleus production.

The beekeeping community continue to explore and evaluate additional alternate sources of bee supply.

Study mating biology and basic bee genetics to facilitate stock development.

3. COLONY MANAGEMENT

Development of methods to have parasite free replacements available each year through chemical or cultural control, ie chemical treatment of nucleus hives prior to overwintering.

Further research into overwintering

There is a continued need for applied and basic colony management research with an aim to improved production efficiency.

Recommendations

Research on colony management should be encouraged at the Agriculture Canada, University, and provincial levels using cooperative and demonstration projects that directly involve beekeepers: e.g., method of developing parasite free replacement bees, wintering methods, colony management for honey production and pollination, "high tech" beekeeping, queen bee introduction, swarm prevention and population dynamics. That researchers come up with a method of maintaining mite free bees by either chemical or cultural control.

The remaining research priorities that have been identified (e.g. bee nutrition, phagostimulants in pollen, pheromones and their applications etc.) require more fundamental approaches that can be best addressed by researchers at universities and government institutions.

The existing personnel and resources need to be increased to meet these research priorities.

4. STOCK IMPROVEMENT

There is a need to have some safe method of distributing genetic material to beekeepers, especially as more and more domestic sources of queens are suspected of having mites
There is a need for improvement of stock and testing of presently available bee stock. Regional differences occur and must be considered in such programs.
The increasing incidence of mites and bee diseases and concern over bee poisoning in pollination situations. Development of bee stocks resistant to disease could solve some of these problems. Increases in honey yield may be

necessary to increase profitability and provide future stability to the industry.

Recommendations

Test currently available stock on a regional basis for honey production, wintering ability and disease resistance. Much of this should be done at the beekeeper level in consultation with apiculturists based on a set of defined criteria.

Selection of stock for resistance to mites, disease, pesticides and a safe method of distributing genetic material be conducted by Agriculture Canada.

Study mating biology and bee genetics to assist in solving problems of early queen availability.

5. PESTICIDE - POLLINATOR INTERACTIONS

Field toxicity tests, sublethal effects of pesticides

Methods to repel bees from spray areas

Further research into integrated pest management and pesticide-pollinator interactions with emphasis on protection of domestic and wild pollinators and a bee safe healthy agricultural environment.

Recommendations

Conduct field toxicity tests of insecticides under Canadian conditions at provincial institutions, universities, or Agriculture Canada.

Conduct studies on both chemical and technical methods of repelling bees from areas in which insecticides are being applied.

Develop better methods to protect bees during insecticide application. Research be done by Agriculture Canada, Universities and beekeepers.

Study sublethal effects of pesticides on honey bees and other pollinators.

6. BEE BOTANY

A Canadian Study should be done on the Economic significance of beekeeping to agriculture. At the present time, all studies available are from the United States or Europe. In the United States, it is stated in Appendix 11 that pollination values to the country are 68 times the value of pollination fees. In Canada we do not charge pollination fees in all provinces and therefore feel that a Canadian indepth study should be done of the direct and indirect value of pollination to Canada. A data base is lacking to determine the economic significance of beekeeping.

A propogation study of plant species to determine floral sources should be conducted.

Recommendations

Establish a co-ordinated approach to research in this field and obtain continued financial support.

Additional funding and staffing be provided to determine the economic significance of bees to the agricultural sector and to determine floral sources.

7. ENVIRONMENTAL MONITORING

Research using bee and pollen samples for the establishment of current levels of environmental contaminants (similar to the work of Dr. Bromenshenk of University of Montana.) This data can be used to reduce potential for harm to bees or other organisms from hazardous materials. In situations such as the installation of a waste treatment facility, data collected before operation of the facility can be used to determine whether the facility is in compliance with safety codes and to monitor for problems.

B. INDUSTRY RELATED RESEARCH

1. MARKETING RESEARCH

Canada presently produces more honey than we consume and traditionally we were very dependent on the United States as a market for our excess honey. With the United States market fading out of the picture due to the impact of their loan and buy-back programs, Canadians are forced to find new markets for their excess product. Canadians recognize the vast potential that marketing research has in our industry, we believe that there are two major needs in marketing research:

i)There is a need for diversification in our marketing strategy, in both domestic and export markets and there is a need for development of innovative uses of honey and other hive products, including container development and the use of honey in food products.

ii) Marketing research is beyond the scope of our apiculture specialists, but we encourage and strive to facilitate cooperative work with other agencies and departments.

<u>Recommendations</u>

The federal government should make funds available to the beekeeping industry as well as providing access to facilities and expertise so that the industry, as a whole, can pursue new product and market development.

The federal government should assist the beekeeping industry by initiating studies on new techniques for determining floral sources of honey.

2. HUMAN HEALTH

There is a need to determine the cause of medical problems resulting from exposure to dead bees in wintering structures.
Human health may also be affected by chemicals used in beekeeping.
Research into the medical and nutritional benefits of honey and other hive products such as pollen.
Research into detection of chemical contaminants in honey and effective wide scale sampling methods.

Recommendations

Alert the medical profession to this problem and actively encourage research on health hazards.
A medical specialist and a nutritional specialist may be

essential to this type of project. Agriculture may gave to fund the research if professionals are interested and available but lack the financial resources.

3. FINANCIAL MANAGEMENT

As a result of increased costs of production, low honey prices and marketing problems, Canadian beekeepers are experiencing no profit margins and therefore, financial hardships resulting in the loss of many commercial beekeepers.

Our apiculture specialists and beekeepers are not usually trained in the area of financial management. We need to work closely with farm management specialists and other specialists to develop these programs and to assist in their transfer to, and use by beekeepers.

<u>Recommendation</u>

Comprehensive financial planning and management systems need to be developed that address the specific and unique needs of Canadian Beekeepers.

Appendix 11

Cornell Study Analyzes U.S. Honey Bee Pollination

THE VALUE of increased U.S. agricultural crop yield and quality achieved by honey bee pollination was $9.7 billion in 1985, according to a research study conducted by Cornell University. The study was conducted under a trust fund established by the National Honey Board with the USDA's Economic Research Service.

The value of honey bee crop pollination is 68 times the combined sum of all pollination fees paid to beekeepers (estimated at $60.9 million per year) and the cost of the federal honey price support program ($80.8 million in 1985), the study reported.

According to the study, more than two million colonies of honey bees are rented annually for crop pollination, a number which is considerably higher than any previously published estimate.

"Many of the colonies are used on two different crops in the same year, and a small number even pollinate three," the study reported. "Thus, about one million colonies are involved, almost one-third of all beekeeper-managed colonies in the United States."

Many U.S. agricultural crops, including almonds, apples, melons, alfalfa, plum/prunes, avocados, blueberries, cherries, cucumbers, pears, sunflowers and cranberries, are dependent upon or derive increased yields from honey bee pollination. The study notes that acreage and/or production have been increasing markedly over the last 20 years for many of the major crops that benefit from honey bee pollination.

The study, conducted by Willard S. Robinson, Richard Nowogrodzki and Roger A. Morse of the Department of Entomology at Cornell University is the most current effort quantifying the value of pollination services.

According to the USDA's Economic Research Service, approximately one-third of the human diet is directly or indirectly benefited by honey bee pollination.

taken from American Bee Journal Volume 129 no 3 March 1989

UPDATE INFORMATION

THE CANADIAN BEEKEEPING INDUSTRY

The rapid expansion, in the Canadian Beekeeping Industry, that began in the early 1970's and peaked in the years 1984, 1985 and 1986 with approximately 700,000 colonies, has now started a downward trend with 606,421 colonies in 1988.

The estimated value of the beekeeping industry, based on honey and beeswax sales at the producer level has also leveled off in recent years, partly as a result of less colonies and partly due to the general reduction in the wholesale price for honey. The beekeeping industry also contributes to the price for honey. The beekeeping industry also contributes to the agricultural economy through the provision of insect pollination, resulting in increased seed and fruit production of several crops. The monetary result of this pollination is difficult to estimate, but is usually considered to be valued at several times the value of the honey and beeswax produced.

Inputs into the honey bee industry originate from labor, utility services, feed, construction, credit, pharmaceutical, petroleum, machinery and equipment industries. As the honey is prepared for domestic and export markets it supports a number of secondary industries including those involved in processing, packing, marketing and transportation.

Alberta, Saskatchewan and Manitoba continue to be the centers of production in the Canadian Beekeeping Industry. In 1988, the three prairie provinces accounted for approximately 75% of the total Canadian honey crop (page 21).

Beekeepers have several potential markets for the honey they harvest:

1. Direct sales to consumers -- Beekeepers may pack honey in consumer containers and sell it directly to the public. This market is particularly important to beekeepers that are located close to large population areas and to beekeepers that harvest relatively small amounts of honey.

2. Direct sales to retail outlets -- Some beekeepers pack honey in approved containers and sell their product directly to food stores.

3. Sales to honey co-operatives -- Some beekeepers have chosen to join and ship their honey to co-operatives that have been established for the purposes of processing, packing and marketing the honey of their members.

This market is particularly important for many beekeepers in the three prairie provinces where approximately 40% of the honey harvested is marketed through the Manitoba Co-operative Honey Producers Ltd. and the Alberta Honey Producers Co-operative Ltd.

TABLE 1. Estimates of the Number of Beekeepers and Colonies of Bees, Production and Value of Honey and Wax in Canada,(1) by Province, 1987 and 1988 with Five-year Averages, 1982-1986

Province and year	Beekeepers Apiculteurs	Colonies	Honey - Miel Average yield per colony(2) Rendement moyen par colonie(2)	
	number nombre		pounds livres	kilograms kilogrammes
Prince Edward Island				
Average 1982-1986	181	1,165	92	42
1987	79	682	110	50
1988P	83	721	90	41
Nova Scotia				
Average 1982-1986	706	7,280	64	29
1987	400	5,600	81	37
1988P	370	5,700	60	27
New Brunswick				
Average 1982-1986	522	4,660	74	33
1987	420	5,000	90	41
1988P	380	5,000	65	29
Québec				
Average 1982-1986	3,900	113,000	86	39
1987	3,300	97,000	110	50
1988P	2,700	88,000	44	20
Ontario				
Average 1982-1986	4,540	112,600	75	34
1987	5,00h	115,000	82	37
1988P	5,000	115,000	67	30
Manitoba				
Average 1982-1986	1,540	113,000	155	70
1987	1,250	109,000	160	73
1988P	1,200	88,000	185	84
Saskatchewan				
Average 1982-1986	1,700	103,600	155	70
1987	1,700	115,000	166	75
1988P	1,500	100,000	230	104
Alberta				
Average 1982-1986	1,662	179,400	126	57
1987	1,480	193,000	132	60
1988P	1,140	150,000	151	69
British Columbia				
Average 1982-1986	5,570	56,000	94	43
1987	5,000	58,500	78	35
1988P	5,300	54,000	70	32
CANADA				
AVERAGE 1982-1986	20,321	690,785	117	53
1987	18,629	698,782	125	57
1988P	17,673	606,421	129	58

(1) Does not include Newfoundland.
(2) Figures based on the commercial beekeepers' survey.
P Preliminary figures.
Note: 1 pound = 0.453 592 37 kilogram; 2,204.622 pounds = 1 metric tonne.

BEE AND POLLINATION - RESEARCH WORKSHOP
WINNIPEG - APRIL 4TH AND 5TH, 1989

CANADIAN HONEY COUNCIL - RESEARCH NEEDS AND CONCERNS

1. Diseases and Pests

A. Parasitic Mites

1) Improved detection methods. ie: Eliza, etc.
2) Development of genetically resistent stocks of bees through screening of existing stocks and/or importation from areas where known resistance occurs.
3) Research into Chemical Controls, residual and efficacy testing required.
4) Management and Cultural Controls.
5) Development of an integrated approach to mite control.

B. Diseases - Continued research into the control of established diseases: i.e. chalkbrood, A.F.B., E.F.B., Sacbrood, Nosema, etc.

2. Colony Management and Bee Supply

A.) There is a continued need for applied and basic colony management research with an aim to improve production and efficiency.

B.) Continued activities in research and technology transfer in the fields of Queen, Package Bee, and Nuc production.

3. Stock Improvement

Continued development of Genetic lines that incorporate the desired characteristics of high production, overwintering, disease resistance, and at the same time, maintain genetic diversity.

4. Pollination

A. Pesticide - Pollinator Interactions

- Field toxicity tests, sublethal effects of pesticides.
- Methods to repel bees from spray areas.
- Further research into integrated pest management and pesticide - pollinator interactions with emphasis on protection of domestic and wild pollinators and a bee safe healthy agricultural environment.

4. Pollination (cont'd)

B. - That a study be done to identify the value to Canadian Agriculture of direct and indirect pollination by honey bees.

Recommended Positions

At no time in the history of Canadian Beekeeping has the industry faced such a variety of complex problems. It is imperative that adequate researchers, both in the form of personal and funding be provided for research and development. Research done or not done will have long term and lasting effects on the viability of the Canadian Beekeeping interests and it's ability to provide hive products and meet pollination needs.

A. Pathologist

The research that will be required in the areas of detection and control measures for the Tracheal mite and the Varroa Mite clearly identifies the need of a second pathologist to work in the beekeeping industry. (Appendix 1, page 69, item 1) We also recommend that work be continued on chalkbrood disease, although some promising new developments have occurred.

B. Geneticist

As identified in Appendix 1, pages 69, 72 and 73 items 1, 2 and 4, the need for research to find out if present bee stocks are resistant to the Tracheal Mite and the Varroa mite and to possibly import genetic material which exhibits resistance to these mites. The position could work with the pathologists to develop resistant strains of bees so that less chemicals would be used for disease controls. The geneticist could also work with the bee management researcher to increase production and other desired characteristics.

C. Plant and Pollination Expert

This position is identified in Appendix 1, pages 75 and 76, item 6 and 7. This also is a very important area of research not only to evaluate nectar and pollen producing plants, but also to work closely with plant breeders to develop new varieties of crops that produced more honey and pollen.

D. Bee Nutritionist

Because there is a desire in the Honey industry to become more self-sufficient in the supply of our own bees, (Appendix 1, page item 2), there is an increased need to provide better nutrition to colonies in the way of alternate pollen feed. We need to develop pollen substitutes and be able to feed colonies under Canadian conditions.

E. Food Chemist

We believe this is of great importance, and has been addressed in Appendix 1, pages 76 and 77 items 1 and 2. Because honey is recognized as a health food and because the industry uses certain chemicals for disease control, etc., and also because in the future new chemicals may be used for disease and/or mites, it is very important to ensure our honey remains pure and be considered as a health food. It is essential at this time to determine honey quality to prevent serious problems. There also needs to be more work done on developing new processes and uses of honey, not to mention the increasing need to work with importing countries to ensure we have a product that is marketable in their countries.

F. Biochemist

This position is mentioned in Appendix 1, page 74 , item 5. The use of pesticides is increasing problems for our industry and we feel more research needs to be done on these chemicals in relation to the pesticide-pollinator interaction under Canadian Conditions. As well, this Biochemist could provide the necessary expertise for other researchers in agriculture research projects.

All existing research facilities should be utilized. A centralized approach to federal research is not required.

RESEARCH PRIORITIES - CANADIAN ALFALFA SEED COUNCIL

- Submission to National Workshop on Bee and Pollination Research

April 4, 5, 1989, Winnipeg, Manitoba

INTRODUCTION

The Canadian Alfalfa Seed Council is a producer organization which was incorporated in 1981. The various roles of the Council are the following:

- to promote the development and adoption of sound alfalfa seed and leafcutter bee production practises in Canada.
- to provide a national forum for discussing alfalfa seed and leafcutter bee concerns by sponsoring the Annual Canadian Alfalfa Seed School.
- to further the interests of the Canadian alfalfa seed and leafcutter bee industry by establishing communication links with other relevant producer, extension, research and regulatory agencies.
- to direct the operation of the Canadian Leafcutter Bee Cocoon Testing Centre at Brooks, Alberta.
- to facilitate communication between alfalfa seed organizations in Canada and elsewhere.
- to serve as a coordinating body for the dissemination of information of importance to the alfalfa seed and leafcutter bee industry.

RESEARCH PRIORITIES

1. TITLE: Chalkbrood Disease Control in Alfalfa Leafcutter Bees

BACKGROUND: Some research on chalkbrood disease has been conducted in the United States and in Manitoba and Alberta; however, ongoing research into the biology and control of this disease is urgently needed. The impact of chalkbrood on leafcutter bee populations in the U.S. is evident. Producers in the U.S. average an approximate 50% reduction in leafcutter bees annually due to this disease. Comparatively, Canadian producers generally experience a 1.5-fold increase in bee reproduction annually. Although not currently widespread throughout Canada, there have been recent, isolated cases of chalkbrood disease in leafcutter bee stocks that have exceeded 20% infection levels. Further research is needed in the biology and control of this fungal disease in an effort to maintain healthy Canadian leafcutter bee stocks for domestic and foreign markets.

RECOMMENDATION: Conduct research in the biology and control of chalkbrood disease in an effort to reduce and/or eliminate its presence in Canadian leafcutter bee stock.

WHERE: Agriculture Canada Research Station, Lethbridge

WHEN: 1989

2. TITLE: Foliar Mold Control in Alfalfa Leafcutter Bees

BACKGROUND: The occurrence of foliar molds in leafcutter bee nesting material is of perennial concern to producers. These molds, depending upon the species and their relative abundance, may greatly reduce levels of viable cells. Also, several mold species pose potentially serious health hazards to humans. Investigations into foliar mold control have been conducted since 1986 by the Saskatchewan Alfalfa Seed Producers' Association (SASPA) through funding received by the Economic Regional Development Agreement (ERDA). The current project is scheduled for completion in 1989. Research is required to further assess new methods of foliar mold control and to investigate the occupational health concerns related to these molds.

RECOMMENDATION: Conduct research to identify foliar molds, assess their impact on leafcutter bees and humans and examine existing and new methods of mold control for efficacy and effect on bees.

WHERE: Work is currently being conducted by SASPA (W. Goerzen). This research should continue through this producer organization in Saskatchewan.

WHEN: 1990

3. TITLE: Parasite Control in Alfalfa Leafcutter Bees

BACKGROUND: The control of parasites, especially *Pteromalus venustus*, has been researched in Alberta, Manitoba and Saskatchewan. Current levels of parasitism in leafcutter bees in Canada range from 0 - 19.5%. The use of Vapona (dichlorvos) to control these parasites during incubation may soon be in jeopardy, subject to an Environmental Protection Agency (U.S.) evaluation of this product.

RECOMMENDATION: Investigate alternative chemical and other means of parasite control (ie. "heat-shock" treatment) to reduce parasite levels in Canadian leafcutter bee stock.

WHERE: Agriculture Canada Research Station, Lethbridge or University of Saskatchewan or University of Manitoba.

WHEN: 1989

4. TITLE: Reduction of Pollen Ball Incidence in Alfalfa Leafcutter Bees

BACKGROUND: Over the past several years, levels of pollen balls (ie. cells containing no eggs on cell provisions and/or cells containing larvae which have died in very early development) in leafcutter bee stock have been increasing, reaching levels as high as 37% recently. The reasons for this occurrence are not well known but have been attributed to such things as heat stress, poor nutritional value of cell provisions and pesticide residues in leaf and food material.

RECOMMENDATION: Investigate the cause of pollen balls in leafcutter bees, in an effort to reduce and/or eliminate their presence.

WHERE: Canadian Leafcutter Bee Cocoon Testing Centre, Brooks and Agriculture Canada Research Station, Lethbridge

WHEN: 1989

5. TITLE: <u>Factors Determining Male-Female Ratio in Alfalfa Leafcutter Bees</u>

BACKGROUND: Since the female leafcutter bee is largely responsible for the effective pollination of alfalfa, it is important to maximize their numbers in leafcutter bee stock. Sex ratios commonly range between 20% - 50% female. Earlier research conducted in this area investigated the effects of nest tunnel length, nest tunnel width and early nest removal from shelters on the sex ratio of leafcutter bees.

RECOMMENDATION: Further investigate factors which may effect the sex ratio in leafcutter bees in an effort to maximize female numbers.

WHERE: Canadian Leafcutter Bee Cocoon Testing Centre, Brooks and Provincial Alfalfa Seed Producer Associations.

WHEN: 1989 - 1993

6. TITLE: <u>The Use of Leafcutter Bees as a Pollinators of Other Crops</u>

BACKGROUND: Approximately 95% of Canada's single-cut red clover seed is produced in the Peace River region of Alberta. In addition, approximately 33% of all forage seed (grass and legume) is grown in this region. Research is currently being conducted in Canada on the use of leafcutter bees on red clover, alsike clover, birdsfoot trefoil, sainfoin, milk vetch and (hybrid) canola.

RECOMMENDATION: Further investigate the feasibility of using leafcutter bees to pollinate other crops requiring insect pollination.

WHERE: Agriculture Canada Research Station, Beaverlodge

WHEN: 1989 - 1993

7. TITLE: <u>Combining Honey Bees and Alfalfa Leafcutter Bees for the Pollination of Alfalfa</u>

BACKGROUND: It has long been suggested that combining honey bees and alfalfa leafcutter bees in various ratios might greatly improve the seed set in alfalfa. Presumably this suggestion arises from the idea that the leafcutter bees would first trip the alfalfa flower and that "follow-up" visits of honey bees would enhance pollination.

RECOMMENDATION: Evaluate combinations of honey bees and alfalfa leafcutter bees in various ratios in an attempt to improve seed set in alfalfa.

WHERE: Agriculture Canada, Beaverlodge or University of Saskatchewan, Saskatoon or University of Manitoba.

WHEN: 1990 - 1993

8. TITLE: <u>Evaluating Leafcutter Bee Stocking Rates for the Pollination of Alfalfa</u>

BACKGROUND: In recent years, fluctuations in the availability and price of both leafcutter bees and alfalfa seed has created a need for further information about stocking rates for leafcutter bees. This information could be used by the producer when determining whether to increase (or decrease) bee densities on a given alfalfa field.

RECOMMENDATION: Investigate various stock rates of leafcutter bees on alfalfa in an effort to determine an "economic threshold" value for bees/acre.

WHERE: Coordinated by Canadian Alfalfa Seed Council, in cooperation with Provincial Alfalfa Seed Producer Associations.

WHEN: 1989 - 1993

Other research concerns include:

a) the need for the evaluation of various shelter designs for bee productivity and bee quality.

b) the need for the evaluation of commercially available nesting material, particularly the polystyrene and styrofoam nesting media, for ease of handling, bee productivity and bee quality.

c) the need for the evaluation of native insect pollinators as a means of increasing legume seed production.

The Canadian Alfalfa Seed Council feels that these other research concerns are best addressed on a regional basis, as climatic, geographic and management factors differ between the various provinces. Research on these concerns should be conducted in each seed producing province. Council is pleased that Dorothy Murrell, Saskatchewan Agriculture, has been and will continue evaluating various shelter designs and nesting materials for leafcutter bees in Saskatchewan.

The Canadian Alfalfa Seed Council strongly believes that technology transfer is vital to the well-being of the alfalfa seed and leafcutter bee industry in Canada. It is important that as technical information on any aspects of alfalfa seed or leafcutter bees becomes available, it be both accessible to producers and presented in a format that is meaningful to producers. Newsletters and other publications, seminars, field days and surveys are all important vehicles for this dissemination of information and their continued use is encouraged by Council.

The Canadian Alfalfa Seed Council gratefully acknowledges the cooperation, support and work in this industry of Agriculture Canada, Alberta Agriculture, Saskatchewan Agriculture, Manitoba Agriculture, and the three prairie Alfalfa Seed Producer Associations. Council also wishes to thank the Technical Advisory Committee (currently comprised of Barry Fingler, Chairperson, Manitoba Agriculture; Dorothy Murrell, Saskatchewan Agriculture and Dr. Ken Richards, Agriculture Canada) for their advice and assistance. It is hoped that the current, good working relationship that exists now between the Council and these organizations and individuals will continue and strengthen in the future.

Respectfully submitted,

Doug Jones, President
Canadian Alfalfa Seed Council

Research Needs and Concerns

CAPA - Provincial Apiculturists

Members of the Canadian Association of Professional Apiculturists who are provincial representatives have, as their mandate, responsibilities for disease control and extension. The recent introduction of two new mite pests to North America and the recent closure of the border to the importation of American packages and queens has resulted in changes to our priorities to respond to the needs of the industry.

In canvassing the provincial representatives there was general agreement that the research priorities established in Charlottetown in 1986 are still valid and that the ranking at that time is still appropriate.

Diseases and Pests

Provincial representatives unanimously agree that their major concerns at present are mite pests and that research needs to be done on several fronts:

1. Mite Diagnostic Methods

   All provinces are either having to deal with mite infestations or need to improve the accuracy of the sampling and surveying methods currently being used to ensure the ability to discover mite infestations at an early stage. The current methods of discovery are inadequate in that they are very expensive, time consuming and do not offer a high degree of accuracy at low level infestations. Alternate methods need to be researched immediately to solve this problem.

2. Mite Control Methods

   Regardless of whether or not one believes that the current eradication schemes will be successful or not, there is a need to develop mite control methods to be used in co-operation with eradication schemes or instead of eradication schemes should the mites become widespread. Research needs to be conducted, under Canadian conditions, with regard to chemical treatments and genetic selection to determine if mite-resistant strains of bees can be developed for general use.

3. Africanized Bee Diagnostic Methods

   Although the arrival of the Africanized bee at the Canada-U.S. border is still some years away, it is recognized that we may soon need to be able to recognize the Africanized bee. It is felt that perhaps the Biosystematics Research Institute in Ottawa could train someone in the methods that are currently used to detect Africanized bees and that this training could eventually become available to provincial apiculturists.

Although disease and mite pest control is a provincial mandate, we feel that the research initiatives that need to be undertaken are beyond the scope and mandate of any particular provincial apiculturist. We would recommend that this research be conducted at the national level, either by Agriculture Canada or by a university and that the techniques which are developed be made available to the various provincial jurisdictions across Canada.

Extension

Provincial representatives in Eastern Canada have identified technology transfer and self-sufficiency as high priorities. Self-reliance has become even more important now that the border has been closed and as the industry attempts to stay free of the varroa mite.

Although the extension mandate is a provincial responsibility, there can be a role for federal participation in technology transfer and in attaining some of the research priorities, identified at Charlottetown, which could be addressed in on-farm demonstration projects or co-operative projects with commercial beekeepers, but would need a source of funding.

There is a general feeling among provincial representatives that more and more has been expected of them by the industry in terms of research. Funding for research initiatives is and continues to be difficult for provincial representatives in that it is not clearly defined as one of their mandates (disease control and extension). Provincial representatives can co-operate with federal and university research facilities in those provinces where they exist. In the provinces where no such co-operation is available, funding for co-operative research with industry can produce significant results. Unfortunately, until the profitability returns to the beekeeping industry, a source of funding is required.

Prepared by:

John Gruszka
Provincial Apiculturist

RESEARCH PRIORITIES FROM RESEARCH PERSONNEL AND PROVINCIAL ASSOCIATIONS

(A) RESEARCH PERSONNEL

Based on a questionnaire sent to federal and university researchers the research priorities are listed below. (see appendix 1 for complete summary)

1) Disease and pests with a strong emphasis on tracheal mites.
2) Stock selection and breeding with emphasis on tracheal mite resistance.
3) Pollination.
4) Chemicals used in beekeeping.
5) Colony management
6) Pesticide and herbicide evaluation under Canadian conditions.

(B) PROVINCIAL ASSOCIATIONS

Priorities from three provinces, Ontario and British Columbia and Alberta are listed below:

ONTARIO

A) Honey bees

1) Marketing research; test marketing and consumer preferences.
2) Re-establish two research positions in Ottawa in bee pathology and bee biology **or** establish two research chairs at the University of Guelph in the same areas.
3) Import stock resistant to parasitic mites.
4) Colony management; queen identification and location and queen and nuc production and wintering.
5) Detection methods for regulatory personnel and beekeepers for Varroa, tracheal mites, AFB, and nosema.

B) Pollination

1) Determine pollination requirements in apples of dwarf and semi-dwarf species, as well as in solid block plantings.
2) Determine pollination requirements and economic benefits for canola, red clover, and soybeans under Ontario conditions.
3) Determine pollination requirements and economic benefits for sour cherries.
4) Compare efficiency of honey bees to leafcutting bees as pollinators of alfalfa under Ontario conditions.

BRITISH COLUMBIA

1) Development of honey bee tracheal mite (H.B.T.M.) resistant stock.
2) Testing of menthol and other chemicals for controlling H.B.T.M.
3) Development of faster, better methods of H.B.T.M. identification.

ALBERTA

1) Tracheal mite control using menthol - and efficacy.
2) Tracheal mite control - management techniques.
3) Overwintering technology
4) Breeding strains resistant to tracheal mites.

Compiled by
D.L. Nelson
March, 1989

CANADIAN RESEARCH PRIORITIES FOR HONEY BEE AND POLLINATION RESEARCH

Based on the questionnaire sent to Federal and University Research Personnel in March 1989 the following priorities were identified.

(A). RESEARCH PRIORITIES

1. Diseases and Pests
2. Stock Selection and Breeding
3. Pollination of Specific Crops
4. Chemicals used in Beekeeping Industry
5. Improved Colony Management Methods
6. Evaluation of Pesticides and Herbicides Under Canadian Conditions

(1). DISEASES AND PESTS

1. Acarine Disease
2. Varroa Disease
3. Chalkbrood Disease
4. Nosema Disease
5. Sacbrood-like Disease
6. African Bee

(2). STOCK SELECTION AND BREEDING

1. Disease Resistance
2. Wintering Ability
3. Honey Production
4. Pollination Behaviour
5. Queen Rearing at Beekeeper Level
6. Docility
7. Longevity

(3). POLLINATION OF SPECIFIC CROPS

1. Crop Requirements for Pollination
2. Level of Pollinators for Specific Crops
3. Alternate Pollinators for use on Specific Crops

(4). CHEMICALS USED IN BEEKEEPING INDUSTRY

1. New Chemicals for Disease Control
2. Residue Concerns
3. Honey Removal

(5). IMPROVED COLONY MANAGEMENT METHODS

1. For Wintering
2. For Package Bee and Queen Production
3. Honey Production
4. For Pollen Production

(6). EVALUATION OF PESTICIDES AND HERBICIDES

1. Pesticides for use against bee mites
2. Pesticides that are harmful to bees
3. Herbicides that are harmful to bees

HONEY BEE DISEASES & PESTS - INCLUDING PREVENTION AND CONTROL

1. **TITLE:** The Development and Registration (if necessary) of control products for the honey bee brood disease chalkbrood (*Ascosphaera apis*)

   BACKGROUND: Chalkbrood can be a serious brood disease in some Canadian honey bee operations. In recent years at least one chemical control agent has shown some promise for the control of this disease.

   RECOMMENDATION: In cooperation with interested chemical companies, conduct research for the purpose of developing registered products for the control of chalkbrood disease in honey bees.

   WHERE: University of Guelph

   WHEN: 1989

2. **TITLE:** The Development and Registration (if necessary) of control products for the honey bee parasites *Varroa jacobsoni* and *Acarapis woodi*

   BACKGROUND: These parasites are threats to the Canadian beekeeping industry and have the potential to cause significant economic losses. Efficacious and economic control options need to be developed before these mites become widespread in the Canadian beekeeping industry.

   RECOMMENDATION: In cooperation with interested chemical companies, conduct research for the purpose of developing registered products for the control of these parasitic mites.

   WHERE: Agriculture Canada, Beaverlodge
University of Guelph

   WHEN: 1989

3. **TITLE:** The Economic Impact of Honey Bee Parasitic Mites under Canadian Conditions

BACKGROUND: The honey bee parasites, Varroa jacobsoni and Acarapis woodi are becoming widespread in North America. It is probable that both of these parasites will eventually become endemic to the Canadian beekeeping industry.

RECOMMENDATION: Research is required to study the biology and determine the economic impact on beekeepers of these two mites under Canadian conditions.

WHERE: Agriculture Canada, Beaverlodge
University of Guelph

WHEN: Research should be initiated immediately (1989), perhaps in conjunction with studies related to the development of mite control procedures.

4. **TITLE:** Investigation of Gamma Radiation to Sterilize Honey Bee Equipment for the Control of Honey Bee Brood Diseases

BACKGROUND: There is a growing concern about the use of antibiotics and fumigants for the control of honey bee brood diseases. An economic, non-chemical control means may offer a useful alternative to traditional methods of control and reduce concerns related to antibiotic residues in honey. Gamma radiation has had some limited use in other countries for this purpose.

RECOMMENDATION: In cooperation with AECL, research be initiated to evaluate the efficacy and applicability of gamma radiation for honey bee disease control.

WHERE: AECL, Pinawa

WHEN: 1990

B. Fingler
April 4, 1989

STOCK SELECTION AND BREEDING

1. TITLE: Selection and Maintenance of Mite Resistant Bee Stock

BACKGROUND: Acarapis woodi, otherwise known as the honey bee tracheal mite, has now become firmly established in the United States. In addition, the provinces of Manitoba, Saskatchewan, B.C., and Quebec have had to deal with the depopulation of large numbers of honey bee colonies which have been infested with this parasitic mite. The results of research in Canada and the U.S. indicates that A. woodi is an economically devastating pest of honey bee colonies in temperate climates of North America. At present, honey bees cannot be imported to Canada from traditional sources in the U.S. and, as a result of this, much of Canada still remains mite-free. However, it is certain that the honey bee tracheal mite will become established here, and should survive wherever there is beekeeping.

While it is important that Canadian apiculturists work toward obtaining registration of safe, efficacious miticides for treating mite-infested colonies of bees, it is agreed that chemical controls will prove to be only short-term solutions to the problems. The long-term solution to the problem of tracheal mites will be through normal and artificial selection of genetic stocks which are resistant to this devastating parasite.

RECOMMENDATION: It is recommended that a bee breeding program be initiated to develop tracheal mite resistant stocks of bees suitable for Canadian beekeeping and climatic conditions. The objective of a breeding program would be to establish a population of bees resistant to tracheal mites from several European sources. Rapid success in obtaining bees resistant to tracheal mites can be anticipated because several lines of evidence suggest that bees in Europe are highly resistant to mites. The establishment of a mite-resistant Canadian bee stock would be accomplished by importing eggs of mite-resistant European stocks, rearing them into queens, and instrumentally inseminating them with semen imported from the same European locations. This diverse population of European bees would be maintained initially at a quarantined site by use of the CLOSED BREEDING POPULATION (CBP) technique. In a CBP, it is possible to maintain a relatively small group of colonies for 25 - 50 years without substantial reduction of brood viability. This is accomplished by annually replacing the queen of each colony with a daughter queen instrumentally inseminated with semen from drones of all the colonies in the population. It is possible to select for certain desirable characteristics (i.e. overwintering ability, honey production) within the CBP as well, by replacing more of the queens with daughters reared from the best colony or by inseminating more daughter queens with semen from drones of the best colony. Once CBP is established, evaluation of colonies headed by daughter queens for resistance to tracheal mites will commence. This will be done by introducing these queens into colonies known to be infested with tracheal mites. The daughter queens, proving to be the most resistant to tracheal mites, will be used to replace their mothers. As soon as the new stock of Canadian mite-resistant bee is out of quarantine, distribution of breeding stock to beekeepers would begin for their evaluation and use in queen rearing operations. In this way, genes for mite-resistance could be widely introduced to Canadian bee populations in a few years.

Established lines of mite-resistant bees will be maintained and monitored for purity using restriction fragment length polymorphism (RFLP).

WHERE: University of Guelph (Drs. C. Scott-Dupree & G. Otis)
Fairview College (D. McKenna)
University of Saskatchewan (Dr. G. Rank)

Interest in participating in a bee breeding program has been expressed by Dr. T. Szabo, Agriculture Canada, Beaverlodge, Alberta. However, at the time of this research workshop, discussions of the breeding program with Dr. Szabo have been minimal.

WHEN: The bee breeding program would be a co-operative undertaking between the institutions listed above. The project should be initiated immediately, however, actual commitment to the proposed program will hinge on obtaining additional funding sources at the institutions over a 5 year period.

2. TITLE: Mite Free Production of Canadian Bee Stock

BACKGROUND: Self sufficiency in Canada is possible only with the support of a domestic queen rearing industry. However, the process of this industry is ultimately threatened by the introduction of parasitic mites into Canadian beekeeping operations. Steps must be taken to ensure that beekeepers can remain confident that the queens they purchase from Canadian producers are free of parasitic mites.

RECOMMENDATION: We recommend that research be initiated to investigate methods of producing and shipping queens that are free of parasitic mites.

WHERE: Agriculture Canada, Beaverlodge
Fairview College
U.S.D.A.

WHEN: This project should be initiated immediately.

C. Scott-Dupree
April 4, 1989

AMERICAN BEE JOURNAL VOL 122(5): 350, 351, 354, 355

A Closed Population Breeding Program for Honey Bees

by ROBERT E. PAGE, JR.,[1] ERIC H. ERICKSON, JR.,[1] and HARRY H. LAIDLAW, JR.[2]

Bee Breeding Past and Present

TRADITIONALLY, honey bees have been bred by the annual or biennial selection of one to several superior performing queens that are used as breeder queens for the next generation (season). Daughters are raised from these queens and allowed to naturally mate with a random assortment of drones from colonies in the area. This method of breeding has, in some cases, led to an improvement in the average performance of the colonies produced. However, those instances where there have been significant genetic improvements are probably few. This is the result of not having sufficient control over the queen matings or the genetic composition of the drones in the drone congregating areas where matings take place.

With the development of instrumental insemination came the ability to control matings. Beekeepers had looked forward to dramatic improvements in honey bees stocks with the use of instrumental insemination. Instead, it became evident that the honey bee genetic mechanism of sex determination places serious constraints on breeding. Upon inbreeding, this sex determination mechanism results in reduction in the viability of worker brood in colonies, a characteristic called "shot brood." It also results in high variability in brood viability among queens when one or very few drones are used for instrumental insemination of each queen, and thus limits the beekeeper's ability to select superior queens.

The first use of instrumental insemination was directed toward production of inbred lines and crossing these lines to produce interline hybrids. The USDA Laboratories in Baton Rouge, Louisiana, and at Madison, Wisconsin began hybrid bee breeding and stock testing programs in 1943. Instrumental insemination made it possible to control worker brood viability of the interline hybrid queens by crossing them with lines that, in combination, yielded 100 per cent viable brood (i.e. have different sex genes). This method did meet with some apparent success, though not well documented, and a few superior performing hybrids were produced; however, not all hybrids proved to be superior.

Should "Africanized" bees become established in the queen and package bee producing areas of the southern and western United States, closed populations may prove to be of paramount importance as African gene free reservoirs for future reselection programs.

Other major difficulties precluded the adoption of breeding specific combining hybrids by most commercial queen breeders and production beekeepers. These problems were primarily the unsuitability of the hybrid production queens as breeders and the necessity for the queen breeders to maintain low viability inbred lines. In order to produce a truly superior hybrid, many lines needed to be selected, maintained, and tested. Unfortunately, these lines were easily lost and often irreplaceable. As a consequence, interest in breeding inbred lines and production of specific combining hybrid bees has dwindled.

Honey bee breeders have been unable to adopt methods of mass selection and line breeding used by plant and other animal breeders because of the limitations imposed by the mating behavior of queens and the sex determination mechanism of honey bees. Breeding systems must be devised that either greatly reduce inbreeding, (such as previously tried circular breeding schemes) or that identify specific sex genes and guarantee high viability of the worker brood produced by the commercial queens. A new system, breeding within closed populations, is outlined below.

Closed Population Selective Breeding

A closed population is a breeding population that is free from the uncontrolled introduction of genetic material. These populations may be maintained by complete geographic isolation or by instrumental insemination. The principle difficulty in the use of closed populations has been in knowing how many colonies, or lines, must be maintained to keep inbreeding effects to a point where worker brood viability will remain at an acceptably high level, but yet still have a small enough number of colonies or lines to be economically manageable. These questions went unanswered until the recent work on the population genetics of sex determination by Woyke (1976), Yokoyama

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[2] Department of Entomology, University of California, Davis, CA 95616.

and Nei (1979), Cornuet and Aries (1980), and especially Kubasek (1980), Page and Marks (1982), and Page and Laidlaw (1982a,b). These studies have given us some idea of the minimum numbers of colonies necessary for closed populations, and the types of mating systems to use in order to make genetic improvement and still maintain high viability.

In this paper, we present a model breeding program that is founded on closed population hypotheses, including the pooling of semen. These hypotheses were initially advanced by H. H. Laidlaw, based on cooperative work with a California queen breeder in the 1970's (unpublished), and are augmented by the work of Kubasek (1980), Page and Marks (1982), and Page and Laidlaw (1982a,b). Its purpose is to guide beekeepers in improving the commercial value of queens produced, and in economically maintaining desirable germ plasm.

Breeding Program

A large breeding population, high genetic variability, and continuous, gradual selection are the principle components that must be optimized in a closed population breeding program. However, economics will dictate how well these optima are met by setting limits on the number of colonies (queens) that make up the breeding population and consequently how many queens can be tested each year. Our model program represents a minimum estimate of the necessary size of a breeding population utilizing a specific mating system, method of queen insemination, and queen selection.

Twenty-five queens from genetically diverse sources are selected, marked, introduced into colonies (with excluded entrances) and genetically combined into a closed base breeder queen population. Computer simulations (Page and Marks 1982; Page unpublished, see figures 1-3) have shown that good brood viability can be expected in a closed population of 25 breeder queens (colonies) after 10 years (generations) if each of the 25 queens is replaced by one of her daughters, and these lineages are continued each generation. In fact, after 10 generations there is about a 95% chance that the average worker brood viability of queens in this population will be at least 85 per cent. With 35 colonies these results are expected for 20 or more generations. This queen-daughter replacement (supersedure) system results in a decrease in the rate of loss of sex genes and brood viability when compared to a population where replacement queens are selected without regard to lineage (random). With a random selection system the probability of high (85 per cent) brood viability is greater than 95 per cent for only 6 generations.

An equal number of daughters and many drones are reared from each of these 25 queens. The semen from an equal number of drones from each queen is collected and pooled using the method of Kaftanoglu and Peng (1980b) and then homogenized. This pooled semen is used to inseminate each new daughter queen and should result in each queen being effectively mated to a very large number of drones representing a very large sample of the entire closed population gene pool.

Use of pooled, homogenized semen (homogenization of semen has not yet been demonstrated but will be tested) has the hypothetical advantage of eliminating any variation among colonies resulting from the chance mating of the queen and makes selection for general combining ability of queens (a desirable characteristic for breeder queens) likely. Queens that produce eggs that have "rare" sex genes are identified by their higher than average worker brood viability. This identification provides some control over the loss of sex genes and the subsequent loss of brood viability in this population (see further discussion below).

An effort must be made to insure the survival of the 25 queens constituting the breeding population. If any of these queens are lost during the year they should, if possible, be replaced by one of their own daughters. These daughters should be inseminated by a random sample of any drones available in the breeding colonies at that time. If a daughter replacement cannot be provided, a daughter of one of the surviving queens is substituted.

If more than one or two breeders queens are lost in any year, the population is expanded to 30 queens (colonies) the following year by rearing an additional daughter from each of five queens selected from the surviving breeders. These selected queens are chosen at random or by some predetermined criteria. The breeding population is reduced back to 25 queens

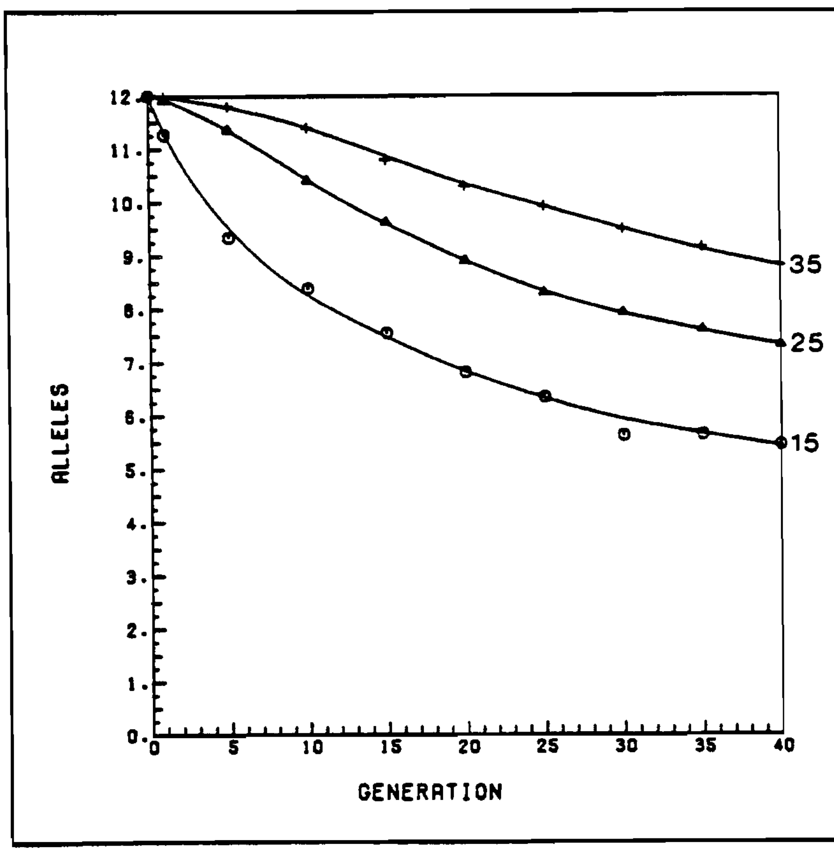

Figure 1. The loss of sex genes (alleles) in closed populations of 15, 25, and 35 breeder queens, as determined by computer simulation. Each breeder queen mates with 10 drones and is replaced by one of her own daughters each generation. It is assumed that the initial breeder queens were chosen from a large, open mating, natural population that has 12 sex genes, and that each queen mated with 10 different drones. These results are based on 200 replicate simulations of generations 1 through 20 and 150 replicate simulations of generations 21 through 40 (Page, unpublished).

by eliminating the additional breeder queens after drones are reared from them and inseminations are made the following season. Wide fluctuations in the number of breeding queens from year-to-year results in a more rapid loss of sex genes and overall genetic variability. As an alternative, 30 breeder colonies may be established initially and maintained to compensate for the possible loss of queen lines during the life of the program.

Stock Testing and Selection

At least three or four daughter queens of each queen mother are reared, inseminated, and placed in field colonies for evaluation. From these a single replacement daughter for each queen mother is selected based upon how well the daughter colony performs. Queen mother colonies should be maintained throughout the test period for insurance against the accidental loss of daughter test queens.

Selection of breeder queens is a matter of personal judgment and preference by the bee breeder and is consonant with the breeding goals. Selection effort is concentrated on only a few of the most important characteristics, but observations are made on several others that may help in deciding between queens that are equally desirable otherwise. In most cases, some characteristics considered important are already present in the stock to an acceptable degree and it is only necessary to guard against their loss.

In any case, selections are made according to well defined criteria that are established early in the breeding program and which remain constant in meaning. Descriptions of colonies are recorded in such a way they can be readily analyzed (Laidlaw 1979).

Natural selection will also aid in this selection program by eliminating test colonies that don't perform well. This is an added advantage since this population is selected for geographical specificity. Brood viability of individual breeder queens is considered if a loss of sex genes becomes evident by a loss in brood viability in the population. Breeder queens having higher than average brood viability are chosen to contribute a larger number of drones to inseminate the next generation of daughter queens, thereby further slowing the loss of brood viability in this population.

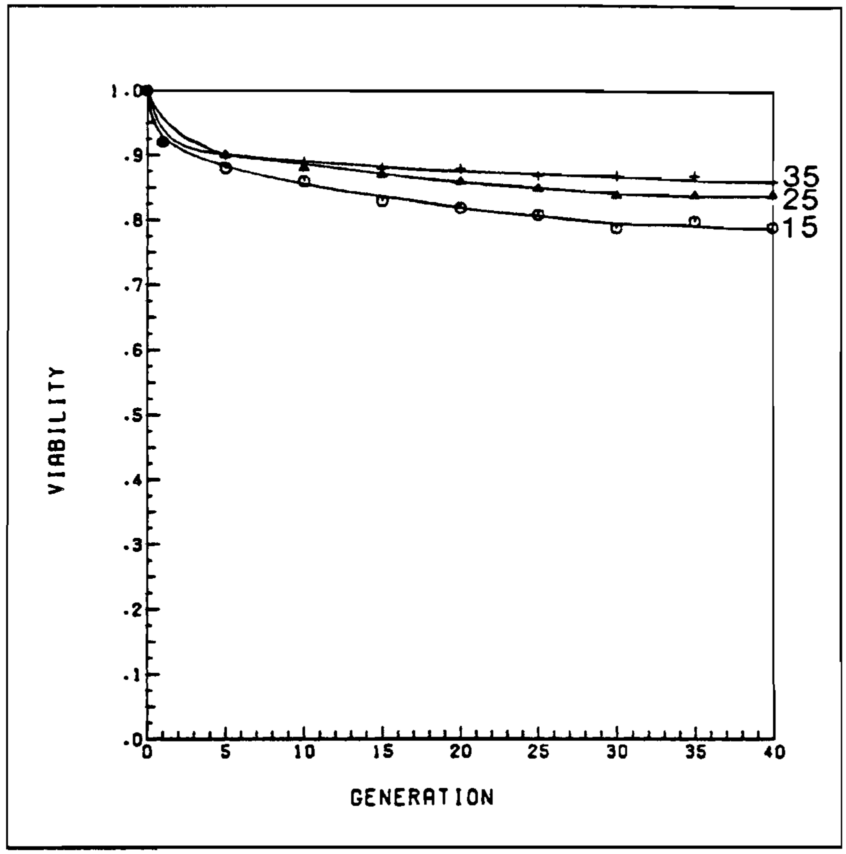

Figure 2. The loss of brood viability in closed populations of 15, 25, and 35 breeder queens (see caption, figure 1).

Discussion

Computer simulations (Kubasek 1980; Page and Marks 1982; Page unpublished) verify and demonstrate the potential usefulness of closed populations for stock maintenance and selective breeding. Field testing, as outlined in this paper, is needed to delimit the utility of such a program. Those of us at Madison plan to begin testing this program beginning in the spring of 1982. We expect that this approach to bee breeding will produce high quality queens that will be acceptable as commercial breeders and that the quality of this stock will be maintained economically for many years. The methodology of closed population breeding is simple enough that, with minimum equipment investment, many bee breeders may establish and conduct such a program. Others may incorporate a similar program utilizing natural, but isolated, queen matings. Queens with genotypes showing superior general combining ability may be used as commercial queen mothers. Daughters may be produced, naturally mated, and used in commercial colonies. The integrity of the closed breeding population, however, must remain intact.

Closed populations may serve as reservoirs of germ plasm within the United States from which genetic material may be selected for specific needs such as gentleness, disease resistance, resistance to acarine or Varroa mite infestation, winter hardiness, etc. Here at Madison we are presently researching the physiological bases for winter hardiness and plan to use this information in our breeding program. Should "Africanized" bees become established in the queen and package bee producing areas of the Southern and Western United States, closed populations may prove to be of paramount importance as African gene free reservoirs for future reselection programs.

ACKNOWLEDGMENTS

This work has been funded by the North Central States Bee Research Facility, United States Department of Agriculture, Agricultural Research Service and the Agricultural Development Systems Project, Arab Republic of Egypt — University of California — United States Agency for International Development.

REFERENCES

Cornuet, J.-M. and F. Aries. 1980. Number of sex alleles in a sample of honey bee colonies. Apidologie 11: 87-93.

Kaftanoglu, O. and Y.-S. Peng. 1980a. A new syringe for semen storage and instrumental insemination of queen honeybees. J. Apic. Res. 19: 73-76.

Kaftanoglu, O. and Y.-S. Peng. 1980b. A washing technique for collection of honeybee semen. J. Apic. Res. 19: 205-211.

Kubasek, K. J. 1980. Selection for increased number of sex alleles in closed populations of the honey bee. An investigation via computer simulation. Un-

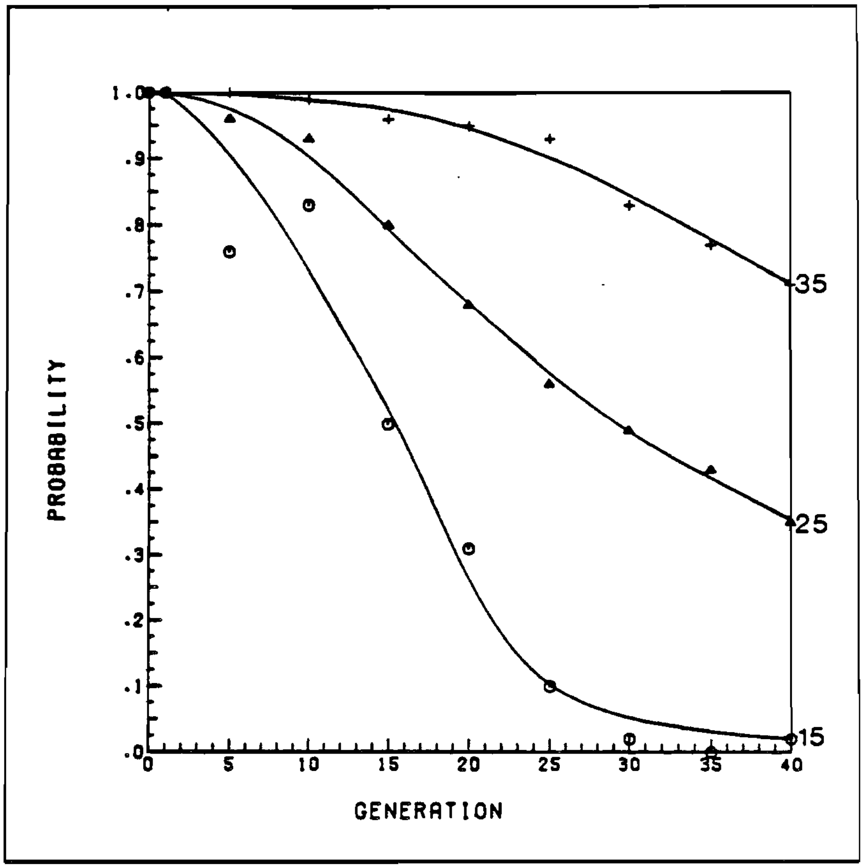

Figure 3. The probability that the average brood viability in closed populations of 15, 25, and 35 breeder queens will be AT LEAST 85% for each generation. These probabilities were determined directly from the replicated simulations (see caption, figure 1).

published Masters Thesis. Louisiana State University.

Laidlaw, H. H., Jr. 1979. Contemporary Queen Rearing. Dadant and Sons. Inc. Hamilton. Illinois.

Page, R. E. and H. H. Laidlaw. 1982a. Closed population honey bee breeding I. Population genetics of sex determination. J. Apic. Res.: in press.

Page, R. E. and H. H. Laidlaw. 1982b. Closed population honey bee breeding II. Comparative methods of stock maintenance and selective breeding. J. Apic. Res.: in press.

Page, R. E. and R. W. Marks. 1982. The population genetics of sex determination in honey bees: random mating in closed populations. Heredity. 48: 263-270.

Woyke, J. 1976. Population genetics studies on sex alleles in the honeybee using the example of the Kangaroo Island bee sanctuary. J. Apic. Res. 15: 105-123.

Yokoyama, S. and M. Nei. 1979. Population dynamics of sex-determining alleles in honey bees and self-incompatability alleles in plants. Genetics. 609-626.

SUMMARY & PRIORIZATION OF

MANAGEMENT & BEHAVIORAL STUDIES RECOMMENDED

-Prepared by Dick Rogers, Apiculturist, N.S.D.A.M.-

1) Self-sufficiency:

   a) Queen rearing, stock improvement, integration
   b) Overwintering
   c) Mite resistance
   d) Queen introduction and locating.

2) Seasonal Management systems for:

   a) Honey production
   b) Pollination.

3) Use of pheromones in colony management:

   a) Swarm prevention/control
   b) Queen acceptance.

4) Pesticide poisoning risk assessment and evaluation of impact.

5) Pollen substitutes.

6) Monitoring of colony noise to determine colony status.

HONEY BEE MANAGEMENT AND BEHAVIORAL STUDIES NEEDED

NEW BRUNSWICK - ONE RESPONDANT

1) Cost efficient management systems for honey production and pollination:

- To be initiated and conducted in near future by university, federal/provincial governments, and beekeepers.

2) Queen rearing, stock selection, and overwintering:

- There is a need to improve stocks generally and a need to overwinter queens for use in early spring;

- To be initiated and conducted in near future by university, federal/provincial governments, and beekeepers.

3) Methods for more successful queen introductions:

- Reduce queen losses by increasing acceptance (pheromone studies, methods of release) and by reducing supersedure (better queens to start with);

- To be initiated and conducted in near future by university, federal/provincial governments, and beekeepers.

HONEY BEE MANAGEMENT AND BEHAVIORAL STUDIES NEEDED

NOVA SCOTIA

1) Seasonal management and wintering for self-sufficiency:

   - .To stabilize industry and reduce risk of pest/disease introductions,
   - .Integration of queen rearing and stock improvement in overall management; overwintering of queens and nucs,
   - .Conduct immediately by N.S. Government.

2) Specific management techniques for honey production and pollination:

   - .Colonies for pollination need to be managed differently than colonies designated for honey production,
   - .Pollination - strength standards, efficient moving, number of colonies required by crop, conditioning for reduced stress, value/benefits of bees by crop,
   - .Honey production - site assessment (e.g. potential and carrying capacity of site), when to prepare for winter and does this conflict with fall or late nectar flows,
   - .Conduct in near future by N.S. government in cooperation with C.A.P.A. and Agriculture Canada.

3) Use of pheromones in colony management:

   - .Improve queen acceptance; swarm control/prevention,
   - .Low priority - university and Agriculture Canada.

4) Relationship between colony noise frequency and colony status:

   - .May be useful for assessing colony status on site or remotely via electronics/computers,
   - .Low priority - university and Agriculture Canada.

HONEY BEE MANAGEMENT AND BEHAVIORAL STUDIES NEEDED

NEWFOUNDLAND - ONE RESPONDANT

1) Improved methods of overwintering:

- Methods and schedules to reduce losses in climates as experienced by Newfoundland and Cape Breton (N.S.),
- Timing of fall feeding; type of packing; stock selection for overwintering ability,
- Conduct by Newfoundland beekeepers in cooperation with Newfoundland Government and Agriculture Canada.

2) Seasonal management for northern climates:

- Shorter summers and types of forage require different management than recommended elsewhere,
- Timing for spring and fall feeding, splits, population management, winter preparation, etc.
- Conduct by Newfoundland beekeepers in cooperation with Newfoundland Government and Agriculture Canada.

HONEY BEE MANAGEMENT AND BEHAVIORAL STUDIES NEEDED

BRITISH COLUMBIA - TWO RESPONDANTS

1) Queen rearing and stock improvement through selection:

   .It appears possible to develop stock resistant to honey bee tracheal mites and Varroa mites; general benefits would include improved honey production, overwintering ability, others;

   .Must obtain funding to maintain selected stock for distribution,

   .Initiate immediately; conducted by Agriculture Canada and University of Guelph.

2) Methods for self-sufficiency:

   .Could become net exporters of bees; stabilize industry; provide economic viability,

   .Develop and improve overwintering of queens and bees, methods of integrating bee/queen production in overall apiary management,

   .Initiate immediately; Agriculture Canada (at Simon Fraser University and/or University of Manitoba) and provinces.

3) Use of pheromones in colony management studies:

   .Swarm prevention and other studies,

   .Lower priority unless directly related to high priority studies,

   .Simon Fraser University.

4) Methods for more successful queen introductions:

   .Reduce queen losses by increasing acceptance (pheromone studies, methods of release), and by reducing supersedure (better queens);

   .To be initiated and conducted in near future by university, federal/provincial governments, and beekeepers.

5) Pollen substitutes:

   .Need for low cost, readily available, more acceptable substitutes.

HONEY BEE MANAGEMENT AND BEHAVIORAL STUDIES NEEDED

ONTARIO - TWO RESPONDANTS

1) Methods for rapid location of queens:

- Verify queen presence in nucs and packages and locate queens in hives for requeening,
- Microchip technology; chemical labelling(?),
- Agriculture Canada in cooperation with U.S.D.A.;

2) Use of pheromones in requeening:

- To eliminate need to find queen,
- Induce balling prior to queen cell introduction,
- Conduct in near future at University of Guelph.

3) Pesticide poisoning risk assessment and evaluation of impact:

- Assess risk of poisoning in sweet corn; determine toxicity of wood preservatives used on hive equipment and on wood chips in smokers; methods to quantify impact on colonies in suspected poisoning cases.
- Conduct in near future at University of Guelph (Dr. Kevan).

4) Selection of stocks resistant to honey bee tracheal mites:

- Chemicals not the long-term solution,
- Import larvae and semen from resistant (?) stocks in Europe,
- Conduct at University of Guelph and/or Agriculture Canada at Beaverlodge,
- Gard sends his regards to everyone!

POLLINATION AND PLANT RELATED STUDIES: 1990-1995

prepared by: Mark L. Winston
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1) Nectar Production of Selected Crops

Background: The quantity and quality of nectar produced by various crops and varieties under the diverse environmental conditions in Canada are largely unknown. This information is important to a) facilitate the use of good nectar-producing varieties by growers, b) allow beekeepers to determine how many colonies a given area of crop could sustain (i.e. "carrying capacity"), and c) assist beekeepers in making decisions about moving on to and off of crops. This research should be ongoing, as new crops and varieties are regularly introduced across Canada. Currently, field crops are of particular interest because of the high realized or potential honey production from those crops.

Recommendation: Evaluate the nectar secretion and carrying capacity of selected nectar yielding field crops under various environmental conditions.

Where and When: The Universities of Manitoba and Guelph, various Provincial Ministeries of Agriculture, and a new Agriculture Canada position; ongoing.

2) Crop Pollination Requirements

Background: The pollination requirements of numerous crops and varieties are not understood, particularly in high-value crops such as fruit trees and berries, but also in canola, red clover, soybeans, and others. For example, in Ontario alone there is a need to examine the pollination requirements of dwarf apples, red clover (for seed production), soybean varieties, and sour cherries. Across Canada there is a lack of data collected under diverse Canadian conditions concerning the number of hives required and hive placement for most bee-pollinated crops. Also, the efficiency of honey bees compared to other bee species has received almost no attention.

Recommendation: Research concerning crop pollination requirements be initiated on selected crops which are known or thought to benefit from bee pollination.

Where and When: A new Agriculture Canada position should be created to coordinate and conduct this research, possibly centered at the University of Guelph; ongoing.

3) National Consensus on Importance of Bees for Pollination

Background: Adequate data concerning the economic importance of bees for crop pollination are not available, but are crucial to justify and plan the research outlined above.

Recommendation: A survey be conducted to determine the economic impact of honey bees on crops across Canada.

Where and When: Agriculture Canada; immediately.

4) Bee Attractants

Background: Honey bee pheromones have recently shown potential as attractants for use on bee-pollinated crops. Various commercial and potentially commercial blends need to be tested on different crops under Canadian conditions.

Recommendation: Research be initiated to test honey bee pheromones as attractants for bee-pollinated crops.

Where and When: SFU, 1989 - 1992

POLLINATION AND PLANT RELATED STUDIES

TITLE: Regional Crop Varietal Trials and Pollination Requirements

BACKGROUND: Agriculture Canada and the provinces routinely conduct yield trials on numbered or newly named varieties to assess their yield potential in that particular region. These yield trials are used by extension workers as a basis for regional variety recommendations. Often, the yield data is highly variable due to the random approach to pollination requirements. Published data does not note whether the yield results represent the true potential of the variety under ideal pollinating conditions. In addition, published variety descriptions often fail to note whether the variety has special pollination requirements.

RECOMMENDATIONS:

* research workers should provide information on pollinating conditions during the variety trial when reporting yield data.
* research workers should attempt to provide ideal pollination conditions so that the optimum yield of a variety can be properly assessed.
* published variety descriptions should note any special pollination requirements, if any.

WHEN AND WHERE: Immediately, at locations where crop varietal research is being conducted.

Chris Prouse
April 4, 1989

RESEARCH ON CHEMICALS AFFECTING BEES

1. **TITLE:** The development of information on the effects of various pesticides on honey bee colonies

   BACKGROUND: Pesticides used to control harmful insects also may have devastating effects on honey bee colonies. Each chemical will have greater or lesser effect depending on its application.

   RECOMMENDATION: Research be funded to develop information on how the bees are being affected, i.e. direct drift, contaminated nectar or pollen, etc., and develop recommendations on how to prevent or minimize damage of the pesticide application. Also, develop risk assessment information and impact data.

   WHERE: At the research institution with the closest proximity to the particular problem, i.e. Guelph, for pesticide problems with honey bees near sprayed sweet corn fields.

   WHEN: As problems develop.

2. **TITLE:** Pesticide Residues in Hive Products

   BACKGROUND: Pesticides of various types have opportunities to enter hive products either through management practices or accidentally from the surrounding environment.

   RECOMMENDATION: Research should be conducted to determine if measurable residues occur in hive products where it becomes apparent that there may be exposure even if the practice has been generally accepted by the industry, i.e. using wood preservatives on bottom boards so that adjustments can be made to management practices before an unacceptable residue problem in the product develops in commercial trade.

   WHERE: At the institution best equipped to handle the residue analysis.

   WHEN: These will be low cost projects which will need attention as they become apparent.

3. **TITLE:** Methods of repelling bees from sprayed areas.

BACKGROUND: When pesticide is applied in the environment, it would be desirable to have a method to repel the bees from the sprayed crop so that harmful effects would be minimized.

RECOMMENDATION: Where spray problems occur, attention to repellent methods be given research assistance to overcome the problem.

WHERE: Wherever a pesticide problem is investigated if such a strategy is applicable.

WHEN: In conjunction with pesticide problems.

Doug McRory
April 4, 1989

4. **TITLE:** Residue breakdown in field-weathered and stored bees

BACKGROUND: One problem with pesticide detection in killed pollinators, honeybees, is the speed with which the toxic substances break down. Little is known about this subject, yet it would be very useful to be able to indicate what levels of toxin honey bees had encountered at the time of their death. That could be related to known values for LD_{50}, LD_{95}, probit slopes, hazard values, etc., and the cause of death assessed.

RECOMMENDATION: Research be done on the rate of breakdown of pesticides in field-weathered, stored, refrigerated and frozen poisoned bees.

WHERE AND WHEN: University of Guelph with pesticide testing laboratory start up - grant pending (Kevan and Sibley)

P.G. Kevan
April 4, 1989

RECOMMENDATIONS FOR RESEARCH FOR ALFALFA LEAFCUTTER BEES

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Historically the alfalfa leafcutter bee and legume seed production research in Agriculture Canada (West) has been conducted under the forage commodity program and should continue so. Over the past 10 years several reviews of the forage program have been conducted with a major emphasis during 1988. Recent recommendations to the Directors of the Western Region relative to leafcutter bee and forage seed production (pollination) research which impact on this workshop include: Lethbridge Research Station will be the primary site for work on alfalfa seed production (all aspects), including leafcutter bee management and disease control. Beaverlodge Research Station to maintain strength in seed production, especially of forage grasses and of legumes other than alfalfa, to continue strong commitment to evaluation of foreign cultivars for the export seed market, and to strengthen work on management practices for export seed markets. Lethbridge and Saskatoon Research Stations to continue breeding legume forages (alfalfa), but Swift Current Research Station to discontinue breeding legume forages (alfalfa) yet continue as a cultivar evaluation site. Melfort Research Station to continue weed control in alfalfa seed production.

RESEARCH PRIORITIES FOR THE NEXT 5 YEARS

These priorities have been established in consultation with the Alberta, Saskatchewan, and Manitoba Alfalfa Seed Producers Associations and with relevant researchers.

1. BIOLOGY AND CONTROL OF PATHOGENS, WITH EMPHASIS ON CHALKBROOD FUNGI

Background:

Chalkbrood fungi, *Ascosphaera aggregata*, is the most serious disease threatening leafcutters bees in Canada and the USA. *Ascosphaera* species infect the larvae of many bee species or are saprophytic on pollen-nectar provisions. *A. aggregata* is not the same species commonly encountered in honey bees. Leafcutter bee larvae become infected after consuming cell provisions contaminated with *Ascosphaera* spores.

The disease was first reported from Lovelock, Nevada, in 1973 and has rapidly spread and become most severe in the western United States where losses of more than 65% of bees have been recorded. The high level of bee losses from chalkbrood has made the USA increasingly dependent on the importation of replacement bees from Canada; estimated to be 150-300 million bees per year (value $750K-$3M per year.)

Chalkbrood was confirmed to be in Canada in 1982 in Manitoba. Since then it has spread to Alberta, Saskatchewan, and Ontario and the incidence of the disease has increased each year. In Alberta, for example, in 1983, the fungus was found in 7 samples of cells at levels below 1%; in 1984, 21 samples averaged 1%; in 1985, 41 samples averaged 2% with a high of 14.6% infection; in 1986, 47 samples ranged from 0.17% to 17.6%; in 1987, 85% of beekeepers had chalkbrood which ranged from 0.17% to 22%; and in 1988, 90% of beekeepers had chalkbrood which ranged from 0.17% to 26.5% of total production.

Because of the high sporulation rate of infected larvae, the many modes of dispersal of the fungus, the high potential for increased infection levels in bee larvae, and the general susceptibility of Canadian bees to the disease, Canadian beekeepers (unanimous priority concern from the three prairie Alfalfa Seed Associations) are greatly concerned about significant losses of bees due to chalkbrood. There is a danger that alfalfa seed production in Canada and the USA could be significantly reduced due to the lack of disease-free replacement leafcutter bees.

Present commercial practices for control of chalkbrood in leafcutter bees include sterilizing the nesting material by dipping (manual or automated) in calcium or sodium hypochlorite, which, at times may reduce the incidence of the disease by 75%. Loose cells are also dipped to reduce spore loads. Other practices include removing cells from nesting medium and tumbling them (Canadian loose-cell system), or phasing bees out of contaminated solid nesting boards (United States only), or dry heat treatment of nesting material. Although these practices have provided some control, they have not achieved the level of control sought by leafcutter beekeepers and alfalfa seed producers. With the enormous spore load carried by bees emerging from contaminated nesting materials, merely the provision of new or sterilized nesting material is undoubtedly inadequate for disease control.

Other pathogens such as bacteria, yeasts, viruses, and plant foliar molds (several species) are believed to be or known to be involved in mortality of immature stages or adult bees. The identity, incidence, biology, effects on immature or adult bees, and control of these pathogens are relatively unknown. The plant foliar mold project in Saskatchewan has identified many of the prevalent molds, common yeasts, and some bacterial isolates occuring saprophytically on pollen provisions or in cells, from dead bee larvae or adults or from nesting materials and has provided some information on incidence, biology, and control.

Dr. Mark Goettel, an insect pathologist, has recently joined the staff of the Lethbridge Research Station and part of his responsible is pathogens of leafcutter bees. The Alberta, Saskatchewan, and Manitoba Alfalfa Seed Producer Associations have indicted a need for additional research on pathogens, especially chalkbrood.

<u>Recommendation for research</u>:

a. Determine and monitor the distribution of *A. aggregata* in Canada.
b. Assess the morphometric and genetic variability of *A. aggregata* throughout its range and identify and describe other *Ascosphaera* spp.
c. Develop a laboratory bioassay system to compare susceptibility among bee operations, virulence among fungus populations, and susceptibility to fungicides.

d. Investigate the role of other microorganisms in association with chalkbrood (e.g. synergism, antagonism) through both in vitro and in vivo studies.
e. Study the pathogenesis of chalkbrood with particular emphasis on elucidating the differences between "sporulating" and "non-sporulating" forms of the disease.
f. Identify and determine the efficacy of candidate fungicides for control.
g. Continue to determine, monitor incidence on bees and humans, and test existing and new methods of control for plant foliar molds in Saskatchewan.

Where and when research conducted:

a. The Canadian Leafcutter Bee Cocoon Testing Centre on an ongoing basis receives and diagnoses samples of bee cells for quality (eg. live, dead, parasitized, sex ratio, etc) and the presence of chalkbrood fungi from beekeepers across Canada. The Lethbridge Research Station (Drs. Mark Goettel, Ken Richards, Dan Johnson) in collaboration with the Cocoon Testing Centre is developing a computer program (geographical incidence survey and spacial statistics) that will allow the systematic analysis of the quality of the bee cells and specifically of chalkbrood incidence and distribution each year. For this program to be successful, it will be necessary for beekeepers from across Canada to continue submitting samples of their current year's production regardless of the incidence of chalkbrood. Commence spring, 1989.
b. A collaborative project among scientists at the USDA Bee Biology and Systematics Laboratory, Logan, Utah, (Dr. John Vandenberg), Biosystematics Research Centre, Ottawa (Dr. John Bissett), University of Alberta and Lethbridge (Dr. M. Goettel) has bee initiated to study the biology and distribution of chalkbrood in North America. This study will attempt to identify genetic variability within A. aggregata and to describe new species. In this context, all samples containing chalkbrood or any abnormal cadavers found at the Cocoon Testing Centre are being sent to Lethbridge. Provincial apiculturists and extension entomologists are asked to send leafcutter bee cadavers infected with chalkbrood to Dr. Mark Goettel in Lethbridge for initial diagnosis. Commence spring, 1989.
c. A laboratory bioassay system is being developed at the Bee Biology and Systematics Laboratory, Logan, Utah (Dr. John Vandenberg) and will be used at Lethbridge once operational. Commence spring, 1989.
d. The possibility of a collaborative project between scientists at the University of Alberta and at Lethbridge (Dr. M. Goettel) is being investigated to study the role of other microorganisms in association with chalkbrood. This may extend to cooperative research with the USDA Carl Hayden Bee laboratory in Tucson, Arizona (Dr. M. Gilliam).
e. A study of the pathogenesis of chalkbrood is being initiated at Lethbridge Commence fall, 1989.
f. A study to evaluate candidate fungicides for control of chalkbrood will continue with cooperation of industry at the Lethbridge (Drs. M. Goettel, Bernie Hill, and K. Richards). Commence spring 1989.
g. Continue the Saskatchewan based study (as long as funding lasts; D. W. Goerzen, Saskatchewan Alfalfa Seed Producers Association) on plant foliar molds and as many other associated causes (bacteria, yeasts) of mortality of immature stages and adults as possible.

2. BIOLOGY AND CONTROL OF PARASITES AND PREDATORS

Background:

At the present time there are 21 species of pest insect associated with the leafcutter bee with the chalcid wasps, especially Pteromalus venustus the most common. Prior to 1984, mortality attributable to parasites or predators accounted for less than 1% of the total bee population across Western Canada. However, since that time the percentage has increased slightly each year with the average loss in 1988 being 2.3% (range 0-14.5%). This increase may be due to several simultaneously occuring factors: increased numbers of first time (inexperienced) beekeepers who are not aware of the potential for rapid population increase of parasites or of the diverse methods of control available; carelessness on the part of experienced beekeepers in implementing appropriate control measures; unseasonably warm summer weather conducive for reproduction of parasites; diverse types of unproven nesting materials being used; and increased numbers of beekeepers in the parkland regions who acquire various types of pest insects first as they tend to have higher than average numbers of native bees and their associated pests in their operations.

The basic biology of some of the main parasites and predators is known. For example for Pteromalus venustus the mating strategy, base temperature and degree-days for development and survival at various temperatures for diapausing and non-diapausing forms is known. This removes the guess work of predicting when appropriate control measures should be implemented. Development, survival, rate of growth, number of instars, preferred food, impact of damage, and sex pheromone components for the dried-fruit moth are known.

Various control procedures can be implemented in the loose-cell system of management. These include proper hive construction and usage of nesting materials, black (ultraviolet) lights over water-detergent baths, vacuuming, and tumbling. Sprays, baits, fly strips, paints, oil baths, or grease are marginally effective in controlling chalcid wasps and other pest insects. The use of insecticide vapor strips (dichlorvos, Vapona) in incubators is effective in controlling chalcid wasps. However, these strips are under considerable environmental pressure including human health in the United States and may be deregistered in the near future.

Studies on the biology and control of parasites and predators of leafcutter bees have been an integral part in the development of the loose-cell system of management in the Lethbridge program and shall continue to be so. Dr. D. S. Yu, insect parasitologist, will join Lethbridge in a term position in May, 1989 and may become involved in some biology studies. The Alberta, Saskatchewan, and Manitoba Alfalfa Seed Producer Associations have indicated a need for additional research on the biology and control of parasites and predators.

Recommendation for research:

a. Continue studies on the basic biology of the main chalcid parasites and selected predators so as to enhance our success at control.
b. Investigate chemical and other means of parasite and predator control which will not harm bee populations.

Where and when research conducted:

a. Laboratory cultures of the main chalcid parasites are maintained at Lethbridge for biological studies. Additional biological studies will be initiated in the fall, 1989 by Dr. K. W. Richards and possibly Dr. D. S. Yu.
b. Facilities from previous chemical (dichlorvos) control studies, chalcid parasite and bee populations are available at Lethbridge and additional studies will be initiated once possible compounds are identified by Drs. K. W. Richards and B. D. Hill.

3. ALTERNATE FLORAL SOURCES FOR LEAFCUTTER BEES

Background:

The usefullness of leafcutter bees on legume forage crops other than alfalfa, for seed production has been inadequately investigated. Early studies (1970) have been completed at the University of Guelph (diverse plant species and birdsfoot trefoil). Later some commercial usage has been attempted in Saskatchewan (sweet clover, sainfoin), British Columbia (white clover), and Alberta (fenugreek, canola). Experimentally we have used leafcutter bees successfully on commercial fields of sainfoin, cicer milkvetch, and canola and 30 species of perennial and annual legume forages. At Beaverlodge Research Station leafcutter bees have been used successfully on single-cut diploid red clover, diploid alsike clover, and canola in the greenhouse.

Internationally, the bees propagated well and produced seed on white clover and red clover seed fields in Denmark and France, on sainfoin in the USSR, on cucumbers in Poland, on tomato in Denmark, and were observed to visit 49 plant species in another study in Poland. In the United States several studies have been conducted on soybeans, hybrid carrot, ladino clover, birdsfoot trefoil, and sweet clover. Most of the above Canadian and international studies have subjective recommendations and observations concerning bee density, efficiency, and hours of foraging, yet lack comparative objective studies of various pollinators, especially honey bees.

There is increasing evidence from South and Central America that the positive pollination effects by honey bees on diverse crops will be diminished with the arrival of Africanized honey bees. There is also concern that the recent arrival in North America of the tracheal and Varroa mites will reduce the population of forager honey bees available to pollinate crops. Thus, it becomes increasingly important that leafcutter bees and other native pollinators be evaluated as alternate pollinators on as many crops as possible. Also the honey bee is not always the most suitable pollinator (slower visitor from flower to flower or reduced seed production per pod) for a number of forage legumes.

Recommendations for research:

a. Continue determining the effects of leafcutter bees as a pollinator on 30 species of forage legume crops (mass-screening stage) to increase seed production.

b. From the above mass-screening stage choose likely candidate legume forage species and determine the diversity, density, and foraging rate of various pollinators (comparison of leafcutter bee versus honey bee). This information will aid seed growers in their choice of pollinator and through the use of a pollination model can predict the bee population required to pollinate varying flower densities.
c. Determine some of the plant specificity factors for legume forage crops which influence the provisioning and construction of leafcutter bee cells.
d. Determine whether or not some legume forage crops can support (provide adequate leaf sources or quantity and quality of pollen and nectar) leafcutter bee populations.
e. Determine the floral morphology of clovers and their suitability for pollination by a diversity of pollinators.

Where and when for research:

a. Analysis and summation of 3 years of data determining the seed set effects of leafcutter bees on 30 legume forage crops is continuing at Lethbridge by Dr. K. W. Richards.
b. One of the likely candidate legume forage species from the mass-screening stage is birdsfoot trefoil. Plots have been established at Lethbridge and the first year of data will be obtained in spring 1989. At Beaverlodge, Dr. D. T. Fairey is continuing to obtain information on the pollinating behavior (frequency of foraging, proboscis length) of leafcutter bees and native bees on single-cut red clover and alsike clover.
c. Studies initiated by M. Horne of the University of Calgary on plant specificity for leafcutter bees should continue until completed by spring, 1990.
d. Studies on the reproduction of leafcutter bees at Lethbridge on birdsfoot trefoil and at Beaverlodge on single-cut red clover and alsike clover should continue until completed.
e. Floral morphology studies on clovers will continue at Beaverlodge by Dr. D.T. Fairey.

4. OPTIMUM POLLINATOR DENSITIES FOR ALFALFA WITH RELATIONSHIPS TO SEED YIELD AND THE ECONOMICS OF BEES AND SEED.

Background:

As pollen transfer may limit alfalfa yields it is important to know the population of bees required to achieve adequate pollination. Reliable assessments based on observations are difficult to obtain because of the problem of comparing pollinator populations and seed yields affected by other factors, e.g. flower fertility, soil, weather, and insect pests, and because the alternative method of caging areas of alfalfa can affect plant performance.

The population of bees required to achieve adequate pollination of alfalfa is assumed to be the population that would visit most of the flowers. This requirement can be justified for alfalfa because of the necessity to maximize seed setting through cross-pollination for obtaining a more uniform crop for harvest. It must be realized that even if all flowers on a plant were pollinated, not all of them would produce seed. The genetic potential may not be realized because of certain physiological deficiencies, unfavorable weather conditions, water availability, and imperfect seed harvesting techniques.

Recommendation from Canada, the United States, and foreign countries on the number of leafcutter bees required per unit area of alfalfa for maximum pollination have been highly variable and there is a distinct lack of concensus. In Canada the recommended number has tended to increase as more bees became available in the country (e.g. 1964-3000 bees/5 acres, 1984-30000 bees/acre).

When Canada began exporting significant quantities of excess bees the issue arose as to whether is was economical to sell excess bees or retain them and use them on seed fields and increase yields. The economics of the scenarios to either sell or retain bees has not been addressed.

The situation involving alfalfa is relevant to most other crops in Canada. Some aspects of the research of Dr. D. T. Fairey, Beaverlodge on other legume forage crops may be applicable. The Alberta and Manitoba Alfalfa Seed Producer Associations have indicated a need for research on pollinator numbers and economic thresholds in alfalfa.

Recommendations for research:

a. Determine the number of alfalfa flowers per hectare from different plant densities available for pollination during the summer.
b. Determine the actual population of bees foraging on the different plant densities and the resultant seed set.
c. Use a theoretical approach to determine the probability of an individual flower being pollinated under various leafcutter and alfalfa flower densities.
d. Once the above information has been generated, determine the economic threshold whether to increase bee densities on a given seed field or to sell excess bees.

Where and when for research:

a. Plots of different plant densities will be established at Lethbridge and will be sampled to determine flowers per area during the summer. This basic research will also be applicable to pest insect management studies to help determine the threshold for control of pests. Establishing a sampling method which is efficient in time usage and statistically reliable to remove most of the variability will be a challenge. Cooperative project K. W. Richards and B. D. Schaber to establish plots spring, 1990.
b. From the above plant density plots the densities of foraging leafcutter bees and seed yields will be determined. At Lethbridge, commence, 1991.
c. Using the flower density data and other bee and flower data obtained from the above experiments, the theoretical model used on cicer milkvetch, sainfoin, birdsfoot trefoil, and lupins will be used to derive values predicting bee populations.
d. Once the experimental data has been obtained and analysed, C. Weber, economist, Lethbridge will model the various scenarios involving bees, seed yields, and marketing strategies.

5. CAUSES OF MORTALITY OF IMMATURE LIFE STAGES

Background:

Samples submitted by beekeepers from across western Canada since 1970 to the Canadian Cocoon Testing Centre indicate a gradual increase in the quality of bees produced. The average number of live bees per kilogram increased from 7200 in 1970 to 8580 in 1988. The percentage of live cocoons had increased from 59% in 1970 to 78% in 1988, while the percentage of incomplete cells had decreased from 38% in 1970 to 20% in 1983 (22% in 1988). These productivity indicators show that beekeepers are incorporating new and recommended procedures into their operations. Over the years, mortality of immature stages (mainly eggs, first or second instar larvae) has ranged from 5% to 55%. This mortality has been due to biological, management, and environmental factors.

Some of the biological factors (e.g. chalkbrood fungi, plant foliar molds, yeasts, bacteria, parasites and predator) causing mortality of immature stages are being addressed above. Several other factors (e.g. nutrition, competition, genetics, second generation, shelter designs, nesting materials, pesticides, and temperature) have been suggested in the Canadian and world literature as contributors to mortality. Definitive studies for many of these factors are lacking. Alberta, Saskatchewan, and Manitoba Alfalfa Seed Producer Associations have indicated a need for research on causes of mortality for immature stages.

Recommendations for research:

a. Complete the laboratory project on determining the rate of development and survival of eggs and larvae at 9 constant temperatures. This study provides base and upper threshold temperature and degree-days for development and quantifies the effect of temperature on development and survival.
b. Complete the field study establishing the density of bee cells per unit area of hive and the percent survival of each development stage and relate these to degree-day accumulation (temperature).
c. Compare current commercially used shelter designs for productivity and quality of cells.
d. Compare current commercially used nesting materials for productivity and quality of cells.
e. Using geographical incidence survey and spacial statistics programs determine the effect of location in Canada on quality of bee cells with special reference to mortality of immature stages.

Where and when for research:

a. The data has been obtained and analysis and modelling has begun at Lethbridge by Dr. K.W. Richards and Dr. G.H. Whitfield.
b. The field data has been obtained for 2 studies and analysis will begin once the above laboratory study is complete. At Lethbridge by Dr. K. W. Richards and Dr. G. H. Whitfield.
c. Complete the current studies on shelter design comparisons by D. Murrell, Saskatchewan Agriculture and Dr. D. T. Fairey, Beaverlodge. These studies although not related, may indicate, in part, the role shelter design plays in mortality of immature stages.

d. Complete the current studies on nesting material comparisons by D. Murrell, Saskatchewan Agriculture and Dr. D. T. Fairey, Beaverlodge. These studies although not related, may indicate, in part, the role nesting material plays in mortality of immature stages.

e. This recommendation is related to 1a. above (chalkbrood fungi). Historical data available since 1970 at Lethbridge and later from the Cocoon Testing Centre will provide the basis of this project. The data is from representative samples of bee cells submitted by beekeepers from across western Canada. At Lethbridge, Drs. K. W. Richards, M. Goettel, and D. Johnson. Commence, fall 1989.

OTHER RESEARCH CONCERNS:

Several other topics for research have been suggested by the Alfalfa Seed Producer Associations and researchers. However, considering available experienced personnel, limited resources which will not expand, the continuing need for related agronomy based studies (e.g. weed and insect control, soil fertility) in legume forage seed production, and the urgency of some of the above priority issues in the country, these topics should be of lesser concern.

- Is inbreeding of bee populations resulting in lower bee productivity? Are there any long term effects happening (inbreeding depression) and what might be their consequences?

- What are the effects of light irrigation on the quantity and quality of nectar secreted in alfalfa flowers and how will leafcutter bees respond?

- Determine the influence of soil fertility on nectar secretion and crop attractiveness in alfalfa and other legume crops and the addition of some trace elements (e.g. boron, sulphur) for increased seed production. (Partly covered by R. Horton, Melfort Research Station).

- What are the effects of repeated sterilization of nesting materials with halogen compounds, especially sodium hypochlorite, on productivity and quality of cells?

- Evaluate strains of bees for genetic difference (univoltinism, chalkbrood resistance, flight-temperature threshold, foraging behavior). (Partly covered by G. Rank, University of Saskatchewan, and in French studies where Canadian bees have been evaluated.)

- Investigate protocols commonly used in biotechnology and honey bee breeding for possible use in strain development of leafcutter bees.

- Investigate additional factors which may effect the sex ratio in bees and develop a better biological understanding of these factors.

- What are the effects of combined populations of honey bees and leafcutter bees on seed set of alfalfa?

- Evaluate native pollinators for pollination purposes. (Partly covered in 3b. above.)

- Increase seed yield evaluations of alfalfa cultivars and increase the importance of seed yielding ability in breeding programs and in the registration process.

RECOMMENDATIONS FOR RESEARCH FOR ALFALFA LEAFCUTTING BEES

TITLE: Stock Improvement of Leafcutting Bees

BACKGROUND: Refer to attached paper by G.H. Rank and F.P. Rank (1989).

RECOMMENDATION: A. Basic Biology and Molecular Biology
- karyotype and chromosomal gel separations
- genome complexity
- RFLP's (restriction fragment length polymorphisms)

B. Strain Specific RFLP's
- regional strain differences
- univoltinism (later emergence for chalcid control)
- chalkbrood tolerance of European strains
- monitoring any superior strains identified by Ag Canada (tolerance to foliar molds, sex-ratio, pollen ball incidence).

C. Honey Bee Program
- RFLP's associated with qualitative traits (Africanized honey bee, varroa and tracheal mites)
- monitoring of Closed Breeding Program
- marking of quantitative traits (honey production, overwintering)

WHERE AND WHEN: U. of Saskatchewan, collaboration with Simon Fraser U. for molecular biology and U. of Guelph for honey bee stock improvement and Ag Canada for leafcutting bee traits.

G. Rank
April 4, 1989

DIAPAUSE INTENSITY IN A FRENCH UNIVOLTINE AND A SASKATCHEWAN COMMERCIAL STRAIN OF *MEGACHILE ROTUNDATA* (FAB.)

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Can. Ent. 121: 141–148 (1989)

Abstract

The relative diapause intensity of a French univoltine and Saskatchewan commercial strain of the alfalfa leafcutting bee, *Megachile rotundata* (Fab.), was evaluated over a 3-year period. Prepupae from both strains underwent diapause development at 10°C for different time periods. Diapause intensity was estimated by scoring days to emergence after initiating incubation at three different times in each of the 3 years: fall incubation (immediate post harvest); winter incubation; and spring incubation. In all comparisons made, the univoltine strain had a significantly increased diapause intensity compared with the commercial strain. We concluded that diapause intensity was heritable and that this stable difference between strains could provide the basis for a selected line with increased univoltinism under field conditions.

Résumé

L'intensité relative de diapause d'une souche française univoltine et d'une souche commerciale de Saskatchewan de l'abeille mégachile *Megachile rotundata* (Fab.), a été étudiée pendant 3 ans. A 10°C, le développement de diapause des deux souches a duré des périodes différentes. L'intensité de diapause a été estimée en comptant les jours précédant l'émergence après la mise en incubation à trois moments différents pour chacune des 3 années: automne (juste après la récolte); hiver; et printemps. Dans toutes les comparaisons, la souche univoltine a montré une intensité significativement plus élevée de diapause que la souche commerciale. On a conclu que l'intensité de diapause était héréditaire et que la stabilité de la différence entre les souches pourrait servir de base pour la sélection en faveur de l'univoltinisme en conditions naturelles.

Introduction

The alfalfa leafcutting bee, *Megachile rotundata* (Fab.), is widely used as a managed pollinator of alfalfa. This species originated in Eurasia and has been introduced into many countries (Parker 1982). The continued use of *M. rotundata* in different geographic areas may result in the natural selection of specifically adapted strains with altered diapause characteristics. To date there has been very little documentation of heritable differences between locally adapted strains, although Hobbs and Richards (1976) state that natural selection in Lethbridge, Alta., over an 8-year period reduced nondiapausing (second generation) bees of *M. rotundata* from 25 to 4.6% of cocoons.

Under conditions of field management, *M. rotundata* shows a variable emergence of the progeny of the spring generation. The portion of prepupae that do not enter diapause can exceed 40% when reared at Logan, UT (Parker 1979). These nondiapausing bees are referred to as a second generation and generally drift away from their shelters because of the sparseness of alfalfa bloom at the time of emergence (Tepedino and Parker 1986). Krunic (1972) found that cells from the earliest completed tunnels produced an increased percentage of second-generation bees.

Hobbs and Richards (1976) selected against bivoltinism over a 3-year period and produced strains with less than 1% second generation under field conditions at Lethbridge, Alta. They referred to the selected strain as univoltine in contrast with the unselected strain which produced approximately 5% second-generation bees. Leafcutting bees imported from Canada produced up to 77% second-generation bees when reared in France (Tasei and Masure 1978; Tasei 1982). Univoltine strains of leafcutting bees native to France (Toe 1987) and Spain (Asensio 1982) produced virtually no second-generation bees under their field conditions. In a recent comparison of French univoltine and Canadian bees, Toe

(1987) reported that the flight temperature of the French strains was 1.4°C less than the Canadian strain. Canadian bees were observed to fly later in the afternoon but were more restricted in their use of different plant species as pollen sources. The French strain also had different allelic frequencies for nonspecific esterases and lactate dehydrogenase compared with the Canadian strain. When the Spanish leafcutting bee was introduced into Logan, UT, it continued to show a univoltine phenotype (Parker 1982). Reciprocal crosses between Spanish and American strains identified a maternal effect for the univoltine trait (Parker and Tepedino 1982). Preliminary genetic analyses suggested that univoltinism was incompletely dominant and under polygenic inheritance (Parker and Tepedino 1982).

Field emergence of the univoltine strain cannot be effectively evaluated in Canada as our climatic conditions result in a low (approx. 5%) percentage of second-generation bees (Hobbs and Richards 1976; Krunic 1972). Thus we have evaluated the diapause intensity (Danks 1987) of French univoltine and Canadian commercial strains after different chilling times over a 3-year period. Under our experimental conditions, the French strain showed the consistent increase in diapause intensity expected of a trait under genetic control.

Methods and Materials

Bee Strains. The univoltine strain was obtained from J.N. Tasei (INRA, Lusignan, France) in 1983. This strain originated as a wild-trapped population from the region of Barbezieux in Charente (Toe 1987). One thousand cells were quarantined in Saskatoon, Sask., and reared in isolation from commercial bees. The absence of feral populations in the Saskatoon environs precludes the use of field cages (Parker and Tepedino 1982) to maintain strain purity. By 1985, successive population increases at isolated field sites resulted in a sufficient population for diapause intensity evaluation. The commercial strain was obtained from a producer near Prince Albert, Sask. These bees originated from successive increases under commercial conditions over a 10-year period. It is assumed that any migration into this population (approx. 5 million bees) from other commercial operations had a minimal effect on gene frequency because of the large size of the resident population.

Field Sites. All field sites were within a 40-km radius of Saskatoon and locations were changed in each of the 3 years. In any given year, bee strains were placed greater than 2 km, but within 5 km, of each other, in as identical locations as possible. In 1985 and 1986, plots were placed on dry land where alfalfa stands were managed as forage crops. In 1987, plots were placed at the edge of a pivot irrigation system used to irrigate a forage crop of alfalfa. In each year only one field site was used for any strain. One shelter was used for every 1.6 ha. Ten hives (30 000 tunnels) were used per shelter to accommodate approximately 20 000 bees per hectare. Under these conditions neither nesting sites nor pollen or nectar provisions limited population increase.

Bee Management. Univoltine bee incubation was initiated 3 days earlier than commercial bee incubation so that emergence times were approximately synchronous. Cocoons harvested from the previous year were incubated at 30°C (60% RH) until approximately 20% of females emerged. Then bees of both strains were placed in the field on the same day using identical 122 cm by 244 cm plywood shelters and 100 board polystyrene hives. Dates for placement in and removal from the field for both strains in 1985, 1986, and 1987 were 25 June and 11 August, 30 June and 25 August, 21 June and 22 August, respectively. After removal from the field, hives were incubated (5°C above ambient in 1985 and at 25°C in 1986 and 1987) to allow complete spinning of cocoons prior to harvest. Hive incubation dates for 1985, 1986, and 1987 were 12 August to 6 September, 25 August to 13 September, and 23 August to 13 September, respectively. Hives were then harvested and cells were either directly incubated at 30°C (fall incubation) or stored at 10°C to allow the maximum rate of diapause development (Krunic and Hinks 1972) for winter and spring incubation experiments.

Evaluation of Diapause Intensity. Diapause intensity has been defined (Danks 1987) as "the time required under given conditions before some measure of the end of diapause is observed (usually completion such as emergence or reproduction)." Adult emergence times from cells (cocoons containing prepupae) were used as a measure of diapause intensity. Cells of commercial and univoltine strains were incubated at 30°C and 60% RH and daily emergence time was determined for each of three seasonal periods: (*i*) fall incubation — initiated in September immediately after fall harvest of cells; (*ii*) winter incubation — initiated in December; and (*iii*) spring incubation — initiated in April. Population sizes varied from 200 to 2000 cells depending upon the year and time period being evaluated. Strain-dependent emergence always resulted in unequal numbers of emergent bees. Thus all data were analyzed as an analysis of variance with unequal sample size.

Results and Discussion

The 1986 emergence patterns for fall, winter, and spring incubation are given in Figures 1, 2, and 3, respectively. For both strains an increased chilling time resulted in a more synchronous and earlier emergence. The winter emergence pattern gave the best definition of the difference in diapause intensity of the two strains. A three-way analysis of variance of the 1985, 1986, and 1987 winter emergence pattern is given in Table 1. All main and interactive components were significant. However, the main source of variability was attributed to differences between strains with a mean emergence date of 46.8 for the univoltine strain (1807 bees) and 36.6 for the commercial strain (1881 bees). The 1986–1988 mean emergence times for both sexes at each of the three incubation periods are given in Table 2.

Fall Incubation. Prepupae for these experiments were not chilled at 10°C prior to incubation but were used immediately after harvest. Emergence occurred over a wide range, from 3 to ca. 70 days (Fig. 1). Incubation beyond 70 days resulted in sporadic and low emergence. We arbitrarily terminated incubation on day 67 in 1986, and on day 87 in 1987. The univoltine strain had an increased diapause intensity as univoltine male emergence was delayed by approximately 7–10 days and female emergence by 11–14 days compared with the commercial strain (Table 2). The difference in emergence within sexes between strains (e.g. 42.8 versus 35.5 for 1986 males and 47.9 versus 36.3 for 1986 females) was significant. In addition, an increased percentage of univoltine cells remained in diapause. Thus on day 67 (1986), 56.6% of univoltine cells had not emerged compared with 40.1% of commercial cells. Values for 1987 on day 87 were 32% of univoltine and 4.6% of commercial cells. Prepupae that undergo development are viable at 10°C for up to 19 days (Rank and Goerzen 1982). As the development period is approximately 25 days, emergence prior to day 25 presumably results from prepupae that broke diapause prior to incubation at 30°C. Comparison of diapause intensity under these conditions is still a valid and useful parameter as it is defined only on the basis of the average days to emergence. However, removal of bees that emerged prior to day 25 from the analysis still resulted in a significantly different emergence pattern between the two strains (Table 2).

Winter Incubation. At the time of winter incubation, cells had undergone diapause development at 10°C for ca. 12 weeks. In all 3 years the univoltine strain showed an increased diapause intensity compared with the commercial strain (Table 2). The difference in emergence time was greatest in 1985 where the increased univoltine average emergence times were 13 days for males and 17 days for females. In 1986 and 1987 values were 8–9 days for males and 10–14 days for females.

Spring Incubation. The prolonged cold storage (ca. 30 weeks) prior to spring incubation resulted in a much reduced emergence time (Table 2) and highly synchronous emergence (Fig. 3). Even after this long period of diapause development, an increased diapause intensity of univoltine bees was maintained. Although the later emergence of the univoltine

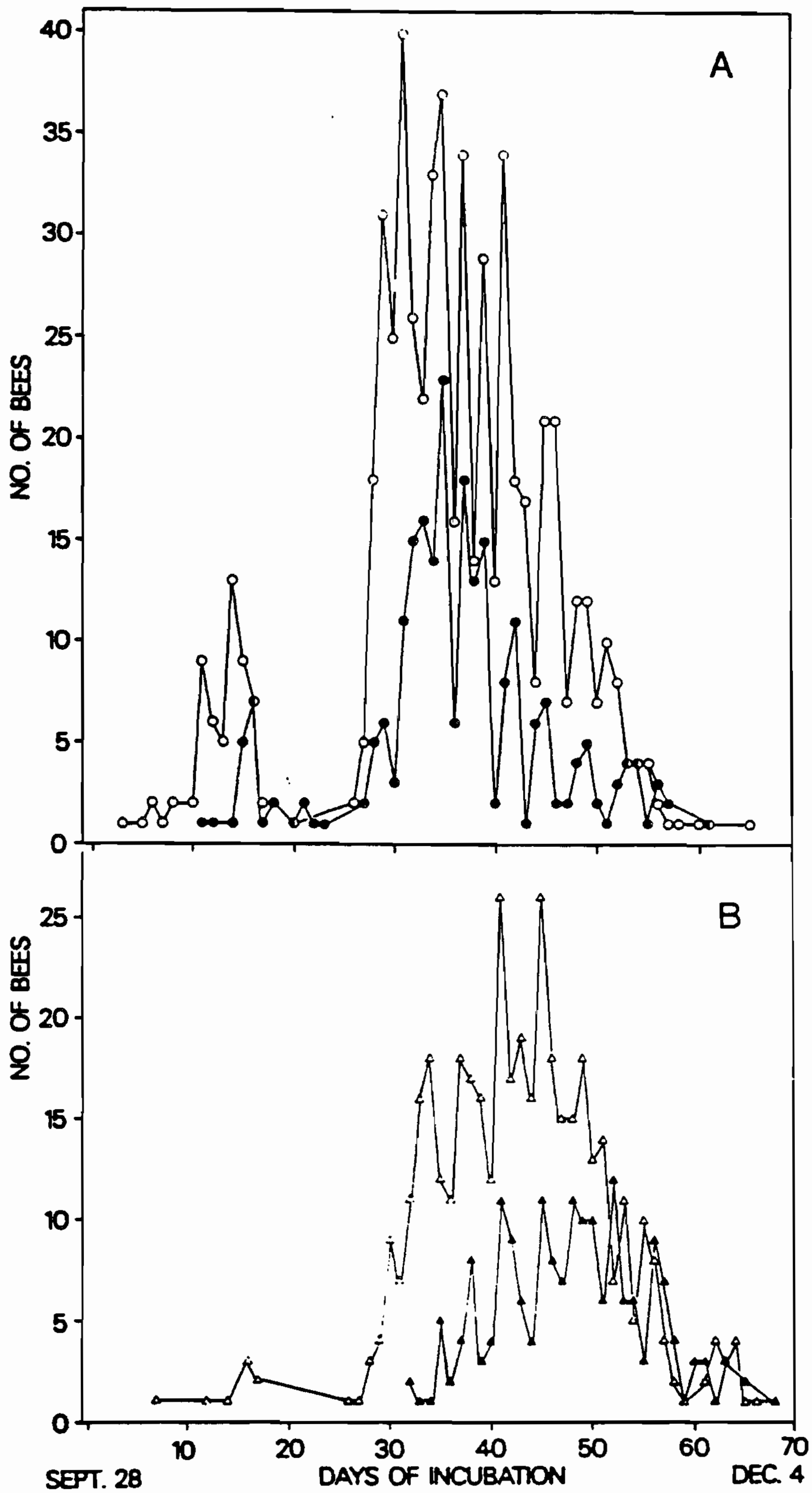

FIG. 1. Emergence pattern of 1986 fall incubation. (A) Commercial strain — males (○), females (●). (B) Univoltine strain — males (Δ), females (▲).

strain was only ca. 2–5 days for males and 4–6 days for females, these differences were highly significant.

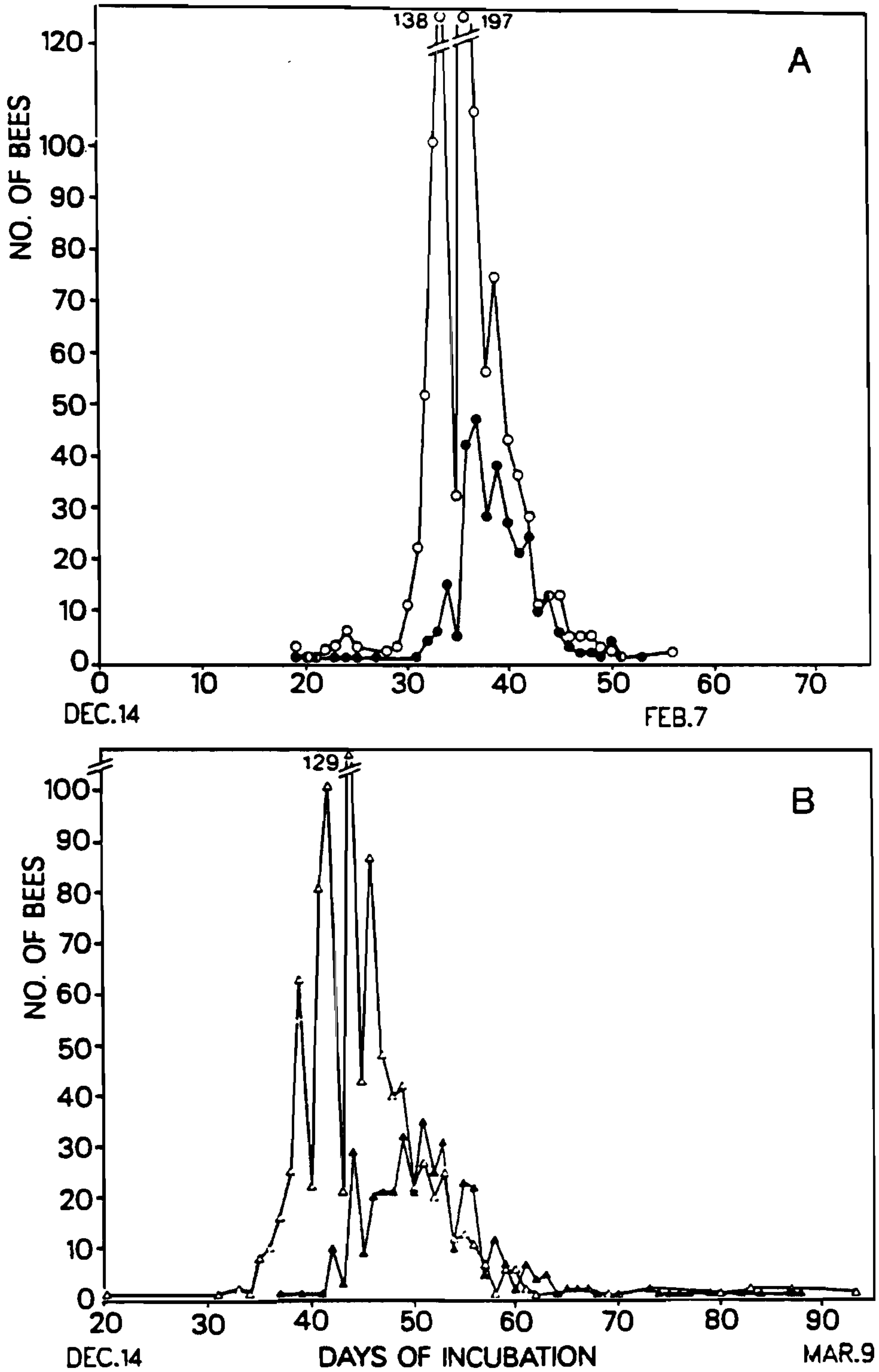

FIG. 2. Emergence pattern of 1986 winter incubation. (A) Commercial strain — males (○), females (●). (B) Univoltine strain — males (Δ), females (▲).

Increased Diapause Intensity of Univoltine Females. The sex × strain interaction (Table 1) results from the late emergence pattern of univoltine females. The differences between univoltine male and female winter emergence for 1985, 1986, and 1987 were 7.6, 6.9, and 6.8 days, whereas comparable values for the commercial strain were 3.9,

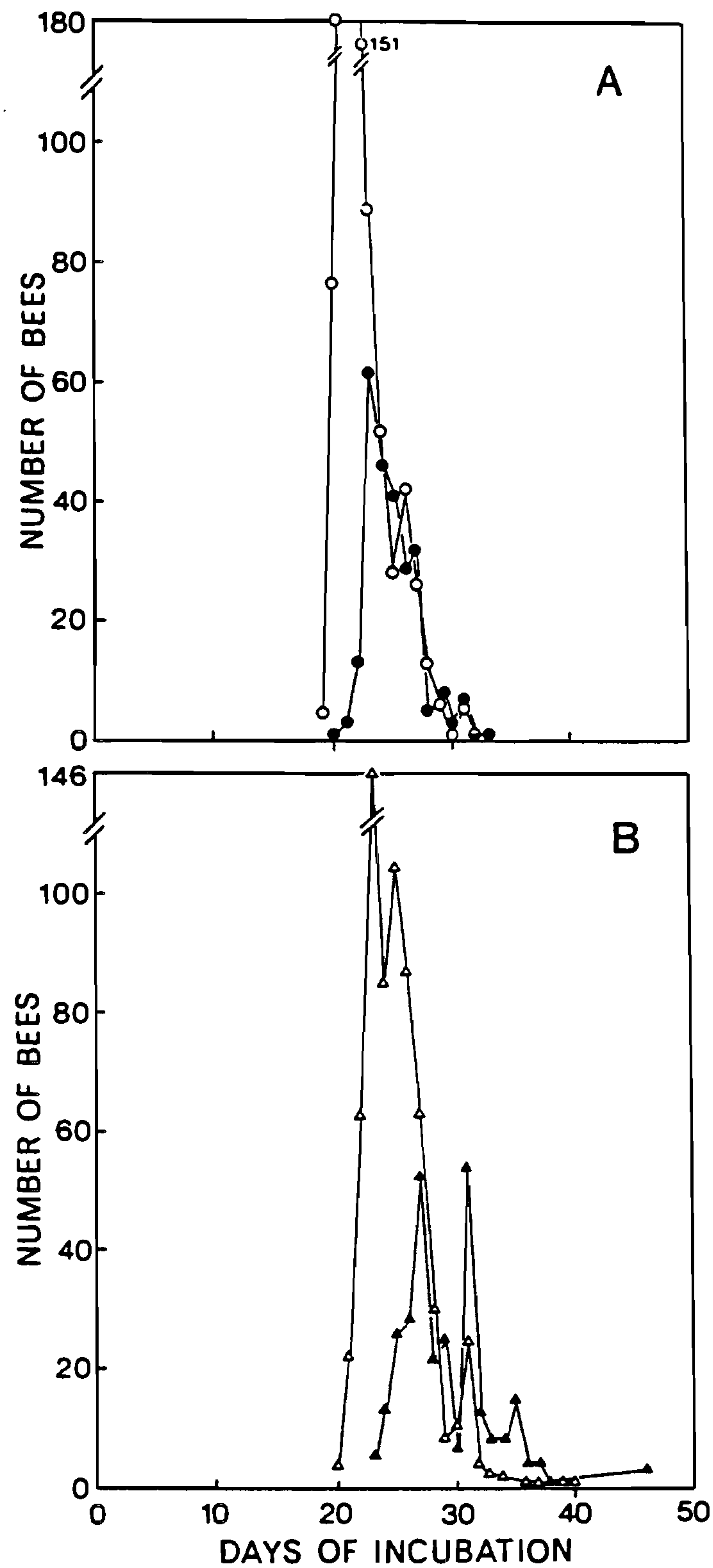

FIG. 3. Emergence pattern of 1986 spring incubation. (A) Commercial strain — males (○), females (●). (B) Univoltine strain — males (Δ), females (▲).

2.9, and 4.2 days (Table 2). Thus the average difference in emergence of sexes is approximately twice as large for the univoltine strain (average = 7.1 days) compared with the commercial strain (average = 3.5 days).

Table 1. Analysis of variance of emergence times for the winter incubation experiments of 1985, 1986, and 1987*

Strains	DF	*F* ratio	*PR>F*
Strain	1	3404	<0.0001
Sex	1	599	<0.0001
Year	2	76	0.0001
Strain × sex	1	92	0.0001
Strain × year	2	25	0.0001
Sex × year	2	3	0.0327

*Total number of observations was 1807 univoltine and 1881 commercial bees.

In view of the relative strain differences that were maintained under variable environmental conditions (Table 1, strain × year interaction) and developmental stages (Figs. 1, 2, 3, Table 2), we are confident that the trait of diapause intensity is heritable. Our results support the work of Parker (1982) and Parker and Tepedino (1982) on the heritability of voltinism in American and Spanish bees. Because of the requirement for field reproduction of this species, we have not been able to evaluate the underlying genetic basis for increased diapause intensity. Nevertheless, our results are qualitatively similar in that increased diapause intensity would be expected to result in a decreased second generation under field conditions.

Factors that have selected for different diapause intensities in bees from Barbezieux and those from Prince Albert are obscure. The most obvious difference in the two populations is that the French strain increased under natural conditions in a southern latitude (45.5°N) whereas the Saskatchewan population was managed artificially in a cooler, more northerly latitude (52°N). We presume that lack of suitable pollen and nectar sources exerted strong selection pressure against any emergent second generation in France. Under Saskatchewan management conditions, cells are artificially removed from the field to prevent loss from second generation. This would have the effect of removing selection pressure against second generation and would be anticipated to select for the related trait of reduced diapause intensity that we have documented.

Table 2. Average emergence times during the fall, winter, and spring incubations of univoltine and commercial bees in 1985, 1986, and 1987*

		Average days to emergence			
		Univoltine		Commercial	
Year	Incubation period	Males	Females	Males	Females
1986	Fall	42.8 (43.2) †	47.9 (47.9)	35.5 (38.1)	36.3 (38.4)
1987	Fall	45.1 (45.1)	54.0 (54.0)	35.3 (36.0)	40.5 (40.8)
1985	Winter	43.0	50.6	30.0	33.9
1986	Winter	45.4	52.3	36.3	38.6
1987	Winter	42.5	49.3	34.7	38.9
1985	Spring	23.8	26.9	21.3	22.9
1986	Spring	25.0	29.1	22.6	24.9
1987	Spring	28.9	33.8	24.0	27.5

*Treatment means within sexes of the two different strains were compared by a one-way analysis of variance. For each of the eight incubation periods the probability of a chance difference in mean emergence date between males and females of the two different strains was <0.0001.

†Values enclosed by parentheses are average days to emergence exclusive of any emergent bees prior to day 25.

Acknowledgment

We thank Cedric Gillott for helpful discussions and for assistance with preparation of the manuscript. Financial support of the Saskatchewan Agricultural Development Fund was greatly appreciated.

References

Asensio, E. 1982. Leaf cutter bee management in Spain: problems of parasitism. pp. 77–79 *in* Rank. G.H. (Ed.), Proceedings of the First International Symposium on Alfalfa Leafcutting Bee Management. Univ. of Saskatchewan, Saskatoon, Sask.

Danks, H.V. 1987. Insect Dormancy: An Ecological Perspective. Biological Survey of Canada, Ottawa. p. 17.

Hobbs, G.A., and K.W. Richards. 1976. Selection for a univoltine strain of *Megachile (Eutricharaea) pacifica* (Hymenoptera: Megachilidae). *Can. Ent.* **108**: 165–167.

Krunic, M.D. 1972. Voltinism in *Megachile rotundata* (Megachilidae: Hymenoptera) in Southern Alberta. *Can. Ent.* **104**: 185–188.

Krunic, M.D., and C.F. Hinks. 1972. The effect of temperature and of temperature pretreatment on diapause and on the synchronization of adult emergence in *Megachile rotundata* (Hymenoptera: megachilidae). *Can. Ent.* **104**: 889–893.

Parker, F.D. 1979. Alfalfa leafcutter bee: origin of female and its influence on diapause. Proc. IV Int. Symp. Pollination. *Md. Agric. Exp. Sta. Spec. Misc. Publ.* **1**: 269–272.

——— 1982. Introduction of alfalfa leafcutting bees to new areas and selection development. pp. 198–211 *in* Rank, G.H. (Ed.), Proceedings of the First International Symposium on Alfalfa Leafcutting Bee Management. Univ. of Saskatchewan, Saskatoon, Sask.

Parker, F.D., and V.J. Tepedino. 1982. Maternal influence on diapause in the alfalfa leafcutting bee (Hymenoptera: Megachilidae). *Ann. Ent. Soc. Am.* **75**: 407–410.

Rank, G.H., and D.W. Goerzen. 1982. Effect of incubation temperature on emergence of *Megachile rotundata* (Hymenoptera: Megachilidae). *J. econ. Ent.* **75**: 467–471.

Tasei, J.N. 1982. Status of *Megachile rotundata* F. in France. pp. 239–246 *in* Rank, G.H. (Ed.), Proceedings of the First International Symposium on Alfalfa Leafcutting Bee management. Univ. of Saskatchewan, Saskatoon, Sask.

Tasei, J.M., and M.M. Masure. 1978. Sur quelques facteurs influençant le développement de *Megachile pacifica* Panz (Hymenoptera, Megachilidae). *Apidologie* **9**: 273–290.

Tepedino, V.J., and F.D. Parker. 1986. Effect of rearing temperature on mortality, second-generation emergence, and size of adult in *Megachile rotundata* (Hymenoptera: Megachilidae). J. econ. Ent. **79**: 978–977.

Toe, L. 1987. Variations intra-spécifiques chez l'abeille *Megachille rotundata* (F.): Comparaisons morphologique, écoéthologique et biochimique de deux souches: une Canadienne et une Française. Ph.D. thesis, Université de Poitiers.

(Date received: 26 July 1988; date accepted: 19 December 1988)

PRIORITIES IN AGRONOMIC RESEARCH FOR ALFALFA SEED PRODUCTION

Besides research in leafcutter beekeeping, the alfalfa seed industry has many agronomic concerns which require ongoing research programs in order to develop solutions. The agronomic aspect of this industry must be given as high a priority as is the leafcutter beekeeping aspect.

1. **TITLE:** Soil Fertility Requirements for Optimum Seed Production

BACKGROUND: Fertility recommendations exist for alfalfa forage production, but these are not appropriate for seed production. No recommendations exist for seed production.

RECOMMENDATION: At present this lack of information has begun to be addressed through Saskatchewan Agriculture Development Fund grants via the Saskatchewan Alfalfa Seed Producers' Association to Russ Horton, Forage Agronomist at the Melfort Research Station. Fertility recommendations must be developed for different seed-growing regions and soil types, under dryland and irrigation. Micro-nutrient studies must be included.

WHERE: Agriculture Canada, Melfort
Other Research Stations with existing forage fertility programs

2. **TITLE:** Weed Management and Control in Alfalfa Seed

BACKGROUND: Weeds are often difficult to control in perennial crops such as alfalfa seed. There is only a limited number of registered herbicides for use in alfalfa seed. New weed problems are surfacing for which there are no known or registered control agents.

RECOMMENDATION: Ongoing weed control programs, such as those at Melfort and Lethbridge Research Stations, must be maintained and continued. New herbicides with some potential must be tested as they become available.

WHERE: Agriculture Canada Research Stations across the prairie provinces; provincial departments of Agriculture; producer associations.

3. TITLE: Insect Pest Mangement in Alfalfa Seed

BACKGROUND: Control recommendations exist for the common pests of alfalfa seed. Economic threshold information is still somewhat lacking, as are predictive models. In addition, there is concern that biological control programs formerly in existence at Saskatoon Research Station be continued.

RECOMMENDATION: Studies on economic thresholds for the common alfalfa seed insect pests, and early monitoring as a predictive tool, are necessary to aid growers in spray application decisions. Biological control studies should be continued.

WHERE: Agriculture Canada; provincial departments of Agriculture, producer associations.

4. TITLE: Seed and Forage Yield Evaluations

BACKGROUND: There is concern among seed growers that not enough is known about seed yield of both existing and new cultivars. Potential varieties are traditionally tested extensively for forage yield but not for seed yield.

RECOMMENDATION: Variety trials for both new and existing cultivars should be maintained at existing Agriculture Canada locations, and location number should be increased. Seed yield evaluations should be included in all forage yield trials. Seed yield information should be included in variety registration applications.

WHERE: Agriculture Canada Research Stations, universities

D. Murrell
April 5, 1989

RECOMMENDATIONS FOR FUTURE PLANNING IN POLLINATION AND POLLINATOR BIOLOGY AND TECHNOLOGY

by

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University of Guelph
Guelph, Ontario, N1G 2W1

1 April, 1989

PREAMBLE

I wish to set forth a number of points of varying degrees of contentiousness to stimulate discussion of pollination and pollinators in relation to their use, management, protection and study. It is not my intention to cause discomfort, but to play a little mischief as an imp's advocate.

The most important point which needs to be recognised is that

POLLINATION IS A KEY-STONE PROCESS WHICH LINKS THE PRODUCTIVITY OF THE PLANT AND ANIMAL KINGDOMS IN ALMOST ALL TERRESTRIAL ECOSYSTEMS FROM THOSE IN HIGHLY MANAGED AGRICULTURAL SETTINGS TO THE MOST REMOTE WILDERNESS.

and that

THE VALUE OF POLLINATION TO AGRICULTURE AND TO NATURE FAR EXCEEDS THE VALUE OF HIVE PRODUCTS FROM HONEYBEES

From those points, I submit a series or propositions for consideration.

1. The pollination biology of crops, or of any plants, can not be adequately addressed by scientists without both botanical and zoological understanding.Thus, pollination biology should be studied by scientists from both zoological and entomological viewpoints working together, or by truly interdisciplinary individuals, or both.

2. Pollination biology from the botanical standpoint requires an understanding of: a) plant breeding systems and their diversity
   b) floral anatomy and morphology at the gross and microscopic level
   c) the nature and diversity of floral rewards to pollinators
   d) the nature and diversity of floral attractants to pollinators
   e) the biology of pollen
   f) the nature of reproductive allocation in plants
   g) the assessment of the quality and quantity of seeds and fruits resulting from pollination
   h) plant biosystematics, evolution, and phylogeny.

3. Pollination biology from the zoological viewpoint requires an understanding of: a) the role of floral anatomy at both the gross and microscopic levels in directing pollinator behaviour
   b) the importance of floral rewards in the lives of pollinators
   c) ecophysiology, behaviour, and nutritional requirements of pollinators
   d) the reproductive biology of pollinators
   e) the diversity and abundance of pollinators and their general bionomics
   f) pollinator biosystematics, evolution, and phylogeny

4. For pollination of crops, two additional areas of expertise are needed:
   a) for the botanically minded, in plant breeding and
   b) for the zoologically minded, in apiculture.

5. Many crop scientists and horticulturalists know almost nothing about the pollination of the crops with which they work and know even less about pollination biology and pollinators.

6. Many apiculturalists, and especially beekeepers, view honey bees (some acknowledge the value of leafcutting bees) as the only pollinator worth attention for agriculture and there are exaggerated claims on the value of honey bees to agriculture in Canada and the U. S. A. Nevertheless, the honey bee must be acknowledged as the most valuable pollinator for agriculture world-wide and in Canada because of its managability and familiarity.

7. There is a huge untapped resource of native bees which may have huge potential value for crop pollination. Bees other than honey bees which have been successfully used for crop pollination are those which have been scientifically studied and are biologically fairly well understood (e.g. the alkali bee, alfalfa leafcutting bee, orchard bees, and a few others). The choice of those bees for study of their economic potential came about through examination of naturally occuring pollinators on the crops in question.

8. There is very little funding for research on alternative pollinators for use on crops in Canada, and almost none on native bees.

9. It is unrealistic to segregate pollination biology according to the type of pollinator when it is the pollination requirements of the plants which are the primary concern. The segregation according to pollinator type should be done after the pollination requirements of the plant are understood. Honey bees are useful pollinators because they are opportunists and generalists (and for the reasons noted above) not because they are necessarily the best pollinators.

10. The true relative values of honey bees, other managed pollinators, and native pollinators are not properly understood for agricultural crops nor for the native vegetation. The importance of pollinator diversity is not appreciated in terms of sustainable agriculture nor in terms of conservation of managed or natural ecosystems.

11. The beekeeping industry in Canada is in serious difficulty because of depressed honey prices on the world and domestic markets and the imminent threat of mite-caused diseases which will seriously impact pollination of Canadian crops.

12. In the future, Canadian agriculture will have to produce high quality to crops to compete with those which will be imported under Free Trade with the U. S. A. Proper pollination will be required to assure that the best possible crops are grown in Canada for the domestic and export markets.

13. Information on the pollination of crops grown in Canada is seriously and variously flawed by

a) being dated,
b) originating outside Canada,
c) possibly being inappropriate to Canadian conditions and crop varieties,
d) being inapplicable to new crop varieties and cultivation methods,
e) having no foundation in rigorous testing and being anecdotal,
f) being inconclusive after scrutiny of the literature,
g) inadequate recognition of the value, or lack thereof, of the reported information,
h) the value of native pollinators having been mostly discounted,
i) being outright wrong.

The list of problems associated with the body of knowledge of pollination of Canadian crops and native plants could be expanded. However, the facts are that there is much more unknown about pollination and pollinator biology in Canada than there is known, and that the state of knowledge for crops grown in Canada is only marginally better than is the state of knowledge for native plants.

RECOMMENDATIONS

The following is a list of recommendations of what needs to be done to overcome these deficiencies. I feel that it is not appropriate to set forth suggestions on specific projects on pollination and native pollinators at this time. I hope that I have generated the view that pollination and pollinator biology are in such general disarray in Canada that the first need is for an assessment of current knowledge, given the immediate problems, and co-ordination on how research might be directed.

DIRECTION AND CO-ORDINATION OF RESEARCH IN POLLINATION AND POLLINATOR BIOLOGY

1. The establishment of a network of researchers in pollination and pollinator biology to include apiculturalists, entomologists, botanists, crop scientists, horticulturalists, ecologists, ethologists, biosystematists, and so on in Canada. Some ideas which should be instituted are
   a) an electronic mail network such as BEE-L now operational on BITNET
   b) a semi-annual newsletter
   c) a national workshop

These three ideas could be a direct outcome of these meetings. I volunteer to take on responsibilities a) and b) from the University of Guelph, and will co-ordinate the National Workshop to be held at the University of Guelph if funding can be found. I suggest that Agriculture Canada be approached to sponsor such a workshop.

2. The establishment of a National Centre for expertise in pollination to include scientists and practitioners as noted above and to co-ordinate the national networking initiative noted above. The location of the National Centre or "Pollination Bank" should be in an area of diverse agriculture and at an institution with broad expertise in crop sciences, horticulture, botany, entomology, and apiculture, and close to institutions with other scientists working in pollination related fields. The University of Guelph would be a most appropriate and logical choice. It is suggested that Agriculture Canada support that initiative both financially and in policy.

The mandate of the Pollination Bank would be to develop pollination technology for various crops by research conducted directly by the Bank and by supporting and co-ordinating regionally appropriate projects. Such projects might include:
 a) development of honey bee management for pollination of dwarf, semi-dwarf and trellis grown fruit-trees in various parts of Canada,
 b) development of pollinator management for greenhouse grown crops,
 c) development of pollination technology for specialized problems in plant breeding, hybrid seed production, and crop selection,
 d) research and development on pollination of crops new to Canada, e.g. ginseng, peanuts, evening primrose, etc.,

e) rigorous examination of existing recommendations on pollination and pollinator requirements of crops grown in Canada,
f) native pollinators on small fruits
g) biosystemic surveys of native pollinators and elucidation of the biology of those with potential for crop pollination or in conservation,
h) bionomical studies of alternative pollinators for various crops under national and regional conditions, e.g. of alfalfa leafcutting bees in eastern Canada, of orchard bees in British Columbia and in eastern Canada, of squash bees, etc.
i) the assessment of the importance of native pollinators to natural ecosystems for conservation of wild-life, native vegetation, and rare or endangered plants,
j) the development of methodologies for the preservation of pollinators for sustainable agriculture, sustainable development, and conservation under the broad philosophy of wise environmental stewardship.

EACH ONE OF THE TOPICS LISTED ABOVE WOULD FORM THE BASIS FOR A RESEARCH PROJECT ON ITS OWN. EACH TOPIC NEEDS INVESTIGATION AND AN INVESTMENT OF FUNDING. IT WOULD BE MORE EFFICIENT TO ACCOMMODATE THE ABOVE IN A CO-ORDINATED FASHION AND WITHOUT REFERENCE TO PARTICULAR TYPES OF POLLINATORS.

Such centres of expertise in pollinator and pollination biology exist in Holland and the U.S.A. where they serve national needs. In Holland The Research Centre for Insect Pollination and Beekeeping is supported by the government, trade and industry, and from the horticultural and beekeeping sectors. That centre involves itself in projects other than in pollination, including projects on pesticide safety for bees, but has, as its name indicates, recognized the greater value of pollination than of honey bee products.

In Canada, a national centre would naturally bring about a focus to pollination biology nationally, but would not have as its aim the directing of research appropriate to regional or local needs. The centre would strive to promote such research and provide an information base which individual or teams or researchers would use. The co-ordination of effort in a critical facet of applied ecology is long overdue. Without doubt, the creation of a national Pollination Bank would be seen by the scientific community in agriculture and in biology in general as an event of international significance which would further promote Canadian expertise for its global reputation and status in international development.

CROP POLLINATION AT THE CROSS-ROADS:

I. THE IMMEDIATE PROBLEMS

by

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Pollination in Canada stands at a cross-roads. It is well recognized that the value of honeybees, the most manageable of pollinators, for pollination far exceeds the value of all hive products (honey, bees' wax, etc.) combined. For example, the value of the Canadian apple crop has been estimated at about $90 million which is nearly twice the value for hive products. It is estimated that about 75% of apple pollination is carried out by honeybees and the rest by other pollinators. For all crops together, the figure of $1.2 billion worth has been indicated to be dependent on bee pollination in Canada.

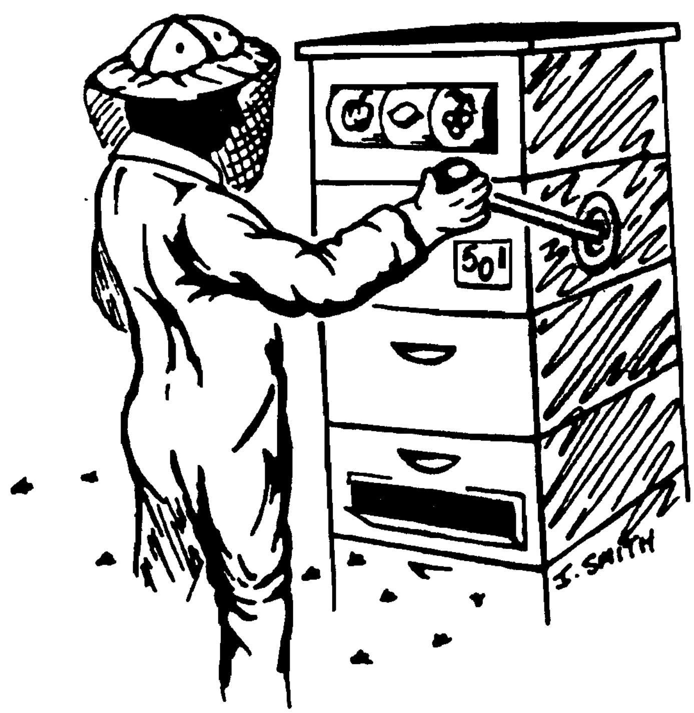
The paramount importance of honeybees has come about for several reasons. Their long association with humans, their great managability, the large amount of research on their activities and value as pollinators, and the demise of native pollinators in the wake of modern agriculture with insecticides and monoculture has made the honeybee the mainstay of pollination in agriculture, not just in Canada but in all temperate and sub-tropical countries. But agriculture in Canada seems to have assumed a cavalier attitude to pollination, honeybees, and other pollinators and many growers take pollination for granted. At the present time pollination faces serious threats to its well-being. Growers must come to appreciate their sources of pollinators, their importance, and the grave consequences of not understanding and not acting on the issues that face pollination in fruit production and in agriculture generally. The intent of this article, and following articles is to point to the present difficulties and potential problems of the future, and to provide back- ground with which to make decisions for management and research priorities.

POLLINATION PROBLEMS IN THE NEAR FUTURE

The reasons that pollination in Canada is at a cross-roads and needs to be understood by fruit-growers are several. Some concern the beekeeping industry and as such are of indirect concern, but with serious implications to fruit growers. Others concern "the state of the art" in crop pollination and its technology, and attitudes about that. Finally, very soon there will be the the need for fruit growers in Canada to produce competitively in free trade with the U. S. A. impinges on pollination.

First: Financial Problems in Beekeeping.

The beekeeping industry in Canada is in serious financial trouble. Commercial beekeepers are finding it increasingly difficult to make ends meet because of the very low price of honey on domestic and world markets. Most professional beekeepers in Canada do not make their incomes from



pollination services. Rental of bee hives for pollination reresents only a small part, if any, of most beekeepers incomes. Only in the Okanagan Valley in British Columbia is pollination the life-blood of apiculture. Mechanisation in the beekeeping industry most certainly has helped, but the basic needs of attending to hives and managing bees is not amenable to intensive machine operation. Beekeeping is a labour intensive agricultural operation. In that general respect, beekeeping, which has had a decrease in the number commercial operations, is similar to many facets of agriculture. However, the ramifications may be more far reaching as the number of honeybees available for pollination declines.

Second: Mite Diseases.

Beekeeping in Canada is threatened by two extremely serious diseases of honeybees which are plaguing the United States. Those diseases are caused by the trachael mite, which enters the breathing tubes of adult bees and debilitates them to greater or lesser amounts, and *Varroa* mite, which is a parasite of the brood and adult bees. Control measures for those diseases are being developed, but whatever the methods, they will add to the complexity and cost of beekeeping. A further, and more distant threat is that of the Africanized bee, which is fast moving north through Mexico, having started in Brazil about 33 years ago. It is a highly defensive bee, readily attacking perceived threats to the colonies, and is difficult to manage. Once the mite diseases become established, as they surely will by natural movement of bees across the border and by actions of irresponsible beekeepers, beekeeping in Canada will become a more sophisticated undertaking than it has been in the past. Then, running efficient operations on a commercial scale will cost more. The cost of pollination services, as they become scarcer and more needed, will rise.

Evidence from Israel, where a cantaloupe crop was lost because of the demise of honeybees from Varroa disease, and concern for declining availability of pollination services in Maine and New York, point up the probable validity of the concerns noted above.

Third: Changes in Beekeeping Geography.

The increased complexity that is to be expected will carry with it a greater reliance on chemical treatments for mite control, and a need for greater diligence on the part of beekeepers. For both reasons, the demography of the beekeeping community will likely change. It is expected that many hobbiests, who make up the diffusely scattered and large majority of Canadian beekeepers, may find beekeeping to become too much trouble and for some the chemicals may be unacceptable. Those people will abandon their hobby, so reducing the availability of such a wide-spread pollinating force. Wild colonies of honeybees will die out. Free honeybees for pollination may become much scarcer than they are at present and fruit growers may find themselves much more dependent on pollination services than they thought they were.

Fourth: Pollination Science in Canada.

There is very little information on the pollination requirements of crops, with a few exceptions, under Canadian conditions. Much of the information which is used in Canada comes from Europe and the U. S. A.. Much of that information is out of date, some is non-scientific, some is merely long-cited but unsubstantiated opinion, and some is simply wrong. In short, there is no substantial body of reliable information which can be applied to Canadian agriculture, new crops, new varieties of crops, new planting or cropping practices, etc. whether or not honeybees or other, alternative, pollinators are considered. These issues are especially germain to the fruit growing industry because of the lack of information on pollination requirements in orchards of semi-dwarf trees, trees grown in trellises, new varieties, and new fruit crops being grown, or with potential, in Canada.

Fifth: Free Trade.

Free-trade with the U. S. A. seems to be just around the corner and agriculture is part of the bargain. The quality and quantity of insect-pollinated crops imported into Canada from the U. S. A. attests to American ability to produce quality and quantity. There is fairly heavy emphasis on research into crop pollination in the U. S. A. by comparison with that in Canada. In the U. S. A., regional, national, and international expertise in pollination is part of the management package for fruit crop production. Even so, in the U. S. A. mite diseases have already caused the sounding of an alarm for fruit pollination in at least Maine and New York, and the threat of the Africanized bee to reliable pollination is being seriously and scientifically examined.

Sixth: Attitudes to Pollination.

A curious attitude that pollination is not a problem seems to pervade some facets of Canadian agriculture. However, there seems to be little evidence to show that insect pollinated crops (e.g. stone and pome fruits, oil-seed crops, forage legumes, some vegetables, etc.) in Canada are producing to their maximum quantity and quality. Apple producers sometimes state that pollination is not their problem, thinning the crop

is. That view may not be the best for maximizing crops. It is well known that the king blossom tends to set a bigger, better formed fruit than the lateral blossoms. The most profitable yields come from maximizing pollination of the king blossoms. It follows that one can not discuss "too much pollination" until it has been shown that orchards are producing the best possible and maximm number of fruit. In Canada, is pome fruit production at such a high level that no improvement can be made through better pollination and pollinator management?

An equally curious view sometimes implied in beekeeping discussions is that honeybees are all that are required, the special case of alfalfa is usually conceded, and alternative pollinators represent a threat to the industry. Orchard bees have been shown to be excellent pollinators of pome fruit, but have not been investigated seriously in Canada. The management and use of alternative pollinators offers interesting opportunities for beekeepers. It is they, after all, who are the most well informed in the art of keeping bees and could readily diversify their operations in pollination, even into specialty pollinators such as orchard bees.

In Canada, the view that "pollination problems have not been encountered" may be correct. However, that view probably reflects only that the problems have not been recognized and not that they do not exist now or will not in the future.

The effects of the issues raised above, namely:

1). financial difficulties in the beekeeping industry,

2). the presence of bee diseases knocking at the national border,

3). the expected need for greater sophistication and expenses in the beekeeping industry to tackle diseases, 4). the probable decline in the number of beekeepers (commercial and hobbiest) with the simultaneous decline in the number and general availability (often free) of colonies for pollination,

5). the lack of relevant and locally applicable information on the pollination requirements of many crops, including fruits

6). problems in the appreciation of the value and need for pollination in in fruit production and in agriculture generally, and

7). the forthcoming need for Canadian agriculure to be more efficient in the face of free trade with the U. S. A. with its greater level of expertise

all conspire against the adequacy of present knowledge and technology in pollination.

The future appears to be far from certain and does not appear bright. However, dark clouds have silver linings. Through with decisive action on the research front to address the problems for beekeeping and pollination that face Canada fast progress can be made. The huge body of world information on fruit pollination and honeybees can be applied and modified, through experimental research, to the Canadian situations. Research on alternative pollinators can be stepped up and broadened for application in Canada. Information on the pollination requirements of fruit plants grown in Canada can be synthesized, evaluated, and used to direct investigations atuned to national and regional needs.

The first step to action is the recognition of a problem. The next step is an examination of the problem with a view to possible solutions. In this essay, the problem has been set forth, with reasons for its being, and a sneak view of the nature of the solutions has been given. In following articles, more details will be presented on honeybee management for pollination, the value and use of alternative pollinators, and the pollination requirements of Canadian crops.

COMMODITY-ORIENTED POLLINATION

The following commodity areas have national significances and opportunity for improvement, or contribution for pollination research.

1. Tree Fruits
2. Field Crops - Oil Seeds
   Forage Legumes
3. Small Fruits
4. Greenhouse
5. Specialty Crops
6. Sustainable Agriculture

1. **TITLE:** Tree Fruit Pollination

BACKGROUND: Bees are recognized as excellent pollinators of fruit trees throughout Canada. However, research on bees for pollination has been sporadic and almost all has been on apples. Orchard bees (Osmia) may have immense potential but have not been research in Canada. They forage at lower temperatures, under windier, wetter and cloudier conditions than do honey bees and they distribute themselves widely in orchards. Native bees share these same positive traits as pollinators in the changeable spring weather when orchards bloom. Research in the U.S.A. has indicated that as few as 256 female orchard bees/acre can adequately pollinate apple orchards. Management and husbandry techniques have been worked out for orchard bees, but need adapting and fine-tuning to Canadian conditions. Other native pollinators need investigating to assess their roles as orchard pollinators and the potential for encouraging their populations. The use of all pollinators, including especially honey bees, needs to be assessed in orchards under new means of cultivation and design, e.g. dwarf and semi-dwarf trees, trellis-grown trees, solid block plantings, etc. The percent of king-blossom set is of critical importance for the crop value and management programme on apples. The role of insects on self-compatible cherries needs to be assessed.

RECOMMENDATION: Research on the relative importance and potential of various pollinators for orchard trees. Research would be on pollinator densities, hive or domicile placing, domicile design, bee management, native bee bionomics and encouragement as reflected through the quality and quantity of the crops.

WHERE: To start at the University of Guelph on apples in Ontario and later to transfer findings for research in Quebec, Maritimes, and B.C.

WHEN: As soon as possible

2. TITLE: Field Crops (Oilseed Pollination)

BACKGROUND: Preliminary trials in Ontario have indicated that cross-pollination by honey bees improves the quantity and quality of seed yield from canola, _Brassica_ _napus_. Varietal trials are lacking and on the one variety tested, more work is needed. Seed germinability was raised from about 80% to over 90% in bee-pollinated plants vs. pollinator-excluded plants, yet the generally held view is that _B_. _napus_ does not benefit from cross-pollination.

Hybrid seed production through the use of CMS and SI lines offers exciting potential for increased yields. However, obtaining hybrid seed at practical prices requires the use of special pollination technology to assure seed-set and the genetic integrity of the hybrid seed. The use of various pollinators needs to be tested in various conditions of enclosures, greenhouses, and field production and in reference to the mechanisms of floral constancy which have caused difficulty for crop breeders working with other _Brassica_ crops.

RECOMMENDATION: That the use of pollinators for yield production of _B_. _napus_ be thoroughly researched in terms of seed quantity, quality, and germinability. That a reliable pollination technology be developed for hybrid seed production.

WHERE AND WHEN: University of Guelph in collaboration with canola seed producers and developers of hybrid seed and with growers. Grant pending for hybrid seed part.

Other Oilseed Crops - also need investigation along the same lines for yield production. Soybean varieties differ in their pollination requirements for maximum yields. S.C. sunflowers produce better when cross-pollinated, etc. These sorts of research are not being conducted in any comprehensive and co-ordinated manner in Canada, yet make up a large part of our agricultural export potential.

TITLE: Field Crops (Forage Crops)

BACKGROUND: The report by Richards on alfalfa and the listing of the projects related to that serves as excellent background to this problem. The concerted and co-ordinated research conducted by Agriculture Canada on forage crops in western Canada needs to be paralleled in eastern Canada. Research on the potential for alfalfa seed production in Ontario has produced most promising results. Other crops in need of investigation are birdsfoot trefoil, various clovers, etc.

RECOMMENDATION: That research be supported on pollination of forage legumes in eastern Canada to parallel, in a more modest way, that done in the west. The work should start on alfalfa and red clover for various agricultural uses including crop rotation, plough-down manure, soil rehabilitation and nitrification, and forage.

3. **TITLE:** Small Fruits

BACKGROUND: The pollination requirements of small fruits are understood to greater or lesser extents. Blueberries require cross-pollination, the story on strawberries is not straight forward because of the diversity of breeding systems in the crop. Elderberries are not understood, etc. In short, there is much that needs to be worked out for small fruits as to which pollinators are the best, which can be managed or encouraged, and what the needs are of the plants for pollination.

RECOMMENDATION: Horticulturalists working with various small fruits should team up with pollination biologists to work out the problems, as applicable, noted above. Particularly important is the need for information on varieties to carry statements of pollination requirements based on commercial scale plantings in the region(s) for which the variety is intended.

WHERE: At various horticultural research stations, federal and provincial.

WHEN: As soon as possible.

4. **TITLE:** Greenhouse Crops

BACKGROUND: The use of bees in greenhouse pollination is well established in Europe and Japan. In Canada, little is known about the management of pollinators for greenhouse crops. Recently, in Europe, honey bee management techniques have been developed for greenhouse tomato pollination. These are saving the industry large sums of money. Although greenhouse crop production in Canada is a small industry in agriculture, there is a need to maintain competitive efficiency. Crops for which technology should be research and developed are tomatoes, melons, bell peppers, vegetable and flower seed production.

RECOMMENDATION: Research on developing technology for insect pollination management for efficient and reliable production of greenhouse crops such as tomatoes, melons, bell peppers, vegetable and flower seeds.

WHERE AND WHEN: To be initiated at the University of Guelph with collaboration from Ag Canada Harrow and OMAF Vineland.

5. **TITLE:** Specialty Crops

BACKGROUND: A number of specialty crops are grown in Canada but little is known about their pollination requirements (e.g. ginseng, evening primrose, borage, peanuts, asparagus, vegetable and flower seeds).

RECOMMENDATION: Collaborative research between horticulturalists and pollination biologists be conducted to elucidate the pollination requirements of the crops and how best to manage pollinators to maximize crop production for quantity and quality.

WHERE: University of Guelph

WHEN: As soon as possible.

6. **TITLE:** Pollinators for Sustainable Agriculture

BACKGROUND: The beekeeping industry is facing difficult times and the future for pollination looks bleak. However, before the advent of extensive monocropping and agricultural chemical use, native pollinators were in abundance and were probably responsible for a greater proportion of pollination of entomophilous crops than at present. The diversity and abundance of native pollinators on agricultural land needs to be investigated and efforts made to restore, at least in part, that segment of the ecosystem.

RECOMMENDATION: Research be undertaken to survey the wild pollinators of various crops, especially orchard trees, forage legumes, and small fruits with a view to determining their bionomics as that relates to pollination and to elucidating their nesting and forage requirements. From that vantage it may be possible to take some for possible "domestication" and possible for others to be encouraged through farm and rural land management practices. A pollinator systematist be hired at BRC or at a univesity.

WHERE: National co-ordination through interested ecologists and systematists throughout Canada.

WHEN: As soon as possible.

P.G. Kevan
April 4, 1989