# Annual Report
## 2009

Canadian Poultry Research Council
Le Conseil De Recherches Avicoles Du Canada

483 Arkell Road, R.R. #2, Guelph, Ontario, N1H 6H8
(289) 251-2990 fax: (519) 837-3584 email: info@cp-rc.ca

## About the CPRC

The creation of the Canadian Poultry Research Council (CPRC) follows the recommendation of a report commissioned by the Canadian Agri-food Research Council and the Canada Branch of the World's Poultry Science Association. This report assessed the needs and resources of Canada's poultry sector with respect to research, education and technology transfer. It also documented the rapid erosion of both human and physical resources and the loss of federal funding for poultry research.

In response to the concerns and recommendations outlined, the five national poultry organizations met to discuss the need for a national organization devoted to addressing national poultry research concerns. In November 2001, the CPRC was formally established.

The founding members are:

- Canadian Hatching Egg Producers
- Canadian Poultry and Egg Processors Council
- Chicken Farmers of Canada
- Egg Farmers of Canada
- Turkey Farmers of Canada

Each Member elects annually a representative to serve on the CPRC Board of Directors.

## Mission Statement

CPRC's mission is to address its Members' needs through dynamic leadership in the creation and implementation of programs for poultry research in Canada, which may also include societal concerns.

This mission focuses on:

- The coordination and enhancement of a more efficient Canadian poultry research effort.
- Securing additional and matching funding.
- Facilitating the establishment of national poultry research priorities.



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## Message from the Chair

Research is the lifeblood of innovation. Innovation is key to the continued success of the Canadian poultry industry. These tenets are the cornerstones of CPRC's Strategic Plan developed in 2008. This annual report is structured around the main objectives of the Plan and details the steps CPRC has taken in 2009 towards fulfilling its objectives.

Before providing a brief overview or CPRC's activities in 2009, I'd like to take this opportunity to thank CPRC's Directors, Staff and Members for their work, without which none of these activities would be possible. A very special thank you to Dr. Roger Buckland for his tireless efforts with CPRC over the past five years. Dr. Buckland had a significant impact on Canadian poultry research and we wish him all the best on his well-deserved retirement.

CPRC's research programs were expanded in 2009 to include two new projects in the Avian Gut Microbiology program, one in the Environment program, and one in "Novel Feedstuffs". The latter is a program initiated by CPRC in response to an emerging need to find alternatives to current grains that are increasing in price due largely to demands from the energy sector. Details of these projects, and all other research supported by CPRC, can be found in this report.

In 2009, CPRC solicited proposals for new research in the priority areas of "Poultry Behaviour & Welfare" and "Food Safety & Quality". CPRC's Scientific Advisory Committee reviewed these proposals and those approved for support by the Board of Directors were integrated into a Poultry Science Cluster application that was submitted to the federal "Canadian Agri-Science Clusters" initiative. The concept of groups or "clusters" of scientists working in cooperation towards common goals ties in very well with CPRC's efforts towards a more cooperative and coordinated approach to poultry research in Canada.

This cooperative approach is manifest in the poultry welfare cluster that continues to develop under an agreement between the University of Guelph, Poultry Industry Council, Agriculture and Agri-Food Canada (AAFC) and CPRC.

Building a long-term research agenda requires influx of new scientists. CPRC's Postgraduate Scholarship Supplement program is designed to attract bright new students to pursue studies in poultry science. The 2009 supplement was awarded to Shyam Bushansingh Baurhoo at McGill University. You can read about Shyam's work and details of the scholarship supplement program later in this report.

**Jacob Middelkamp**
Chairman

These activities are all part of CPRC's strategy to develop sustainable programs for poultry research in Canada – programs that address the near-term needs of our industry and that build a solid foundation of knowledge from which future innovations will develop. Creation of these programs will require cooperation and partnership among industry funders of poultry research, government, and researchers themselves. CPRC has created a draft "Science Strategy for Canada's Poultry Sector" as a launching point for discussions towards a national strategy. CPRC has already had preliminary discussions with some major funders of poultry research in Canada and looks forward to working with the many organizations across Canada with a stake in poultry research in developing this strategy in 2010 and beyond.

Respectfully submitted,

Jacob Middelkamp, Chairman

CHAPTER 1

# Structuring an organization that is stable and focused on results.

## Board of Directors

The CPRC is governed by a Board of Directors representing each of the five member organizations.

***Jacob Middelkamp***, Chair of CPRC, represents the Chicken Farmers of Canada (CFC). Mr. Middelkamp has been broiler chicken producer in Alberta for the last 13 years. He has been a Director on the Alberta Chicken Producers (ACP) Board for nine years, serving five of those on the Research Committee (three years as Chair) and three on the Quality Committee. He also championed efforts to implement the "On Farm Food Safety Program" on behalf of ACP. Mr. Middelkamp has represented Alberta on the CFC Board for three years, serving two years on the CFC Food Safety Committee and one year on the Finance Committee. He has been a CPRC Director for the last three years. He also serves on the Steering Committee for the Virtual Centre for Poultry Welfare at Guelph.

***Chris den Hertog***, CPRC's Vice Chair, represents the Canadian Hatching Egg Producers (CHEP). Mr. den Hertog has been a broiler hatching egg breeder producer in British Columbia for 15 years. He has also been the president of a residential construction company for the last 28 years. Over his 10-year tenure as a Director at the BC Broiler Hatching Egg Commission (BCBHEC), Mr. den Hertog served on the Finance, Production, and Standards Committees. He has been the BCBHEC Director to CHEP for two years. Mr. den Hertog serves on CHEP's Avian Biosecurity Advisory Committee, Production Committee and Finance Committee. He has been Director to CPRC for five years.

***Erica Charlton*** represents the Canadian Poultry and Egg Processors Council (CPEPC). Ms. Charlton has held the position of CPEPC Technical Director for 3.5 years and is responsible primarily for technical files for the poultry meat processing companies, and occasionally for the egg processor companies, as required. Ms. Charlton acts as industry/government liaison and is the processor industry's single point of contact on technical issues with CFIA and Health Canada. She is the staff lead on the Poultry Operations Technical Committee. Ms. Charlton's exposure to technical aspects of poultry meat inspection and food safety give her a unique perspective on issues relating to the CPRC. Ms. Charlton is a Board member for Canadian Partnership for Consumer Food Safety Education and serves on the Canadian Meat Council Technical Committee, Canadian General Standards Board Technical Committee for Organic Agriculture, and the Turkey Farmers of Canada Live Production Committee.

***Dr. Helen Anne Husdon*** is CPRC's Director representing the Egg Farmers of Canada. Dr. Hudson earned both MSc and PhD degrees in poultry science from the University of Georgia. Her education and experience provide a strong background in laying hen rearing, housing and management Dr. Hudson is currently self-employed as a poultry consultant working mainly for Burnbrae Farms, one of the major commercial egg producers in Ontario. Her 15-year tenure at Burnbrae involves day-to-day farm activities and management of land and properties. Dr. Hudson is Chair of a committee which leads environmental/energy awareness at Burnbrae. Dr. Hudson is actively involved with a number of organizations across Canada relating to poultry research. She is a Director at the Alberta Poultry Research Centre, serves on the Research Committee and HACCP Committee at Egg Farmers of Canada, is a Director of the Poultry Industry Council (PIC) in Guelph, Ontario, is Chair of the PIC Research Committee, and is a member of the Steering Committee for the Virtual Centre for Poultry Welfare at Guelph.

***Roelof Meijer*** is the CPRC Director representing the Turkey Farmers of Canada (TFC). He also serves on TFC's Research Committee. Mr. Meijer is a turkey producer in Alberta and Owner/President of R&M Poultry, R&M Dairy, and Pine Valley Turkey Farm. Mr. Meijer has served on the Alberta Turkey Producers Board for five years. He also served on the Research Committee for the Alberta Dairy Producers, as well as a special committee assigned to improve information transfer between researchers and industry stakeholders.

The CPRC Board of Directors meets several times per year to discuss existing and emerging issues relating to poultry research in Canada. Board meetings are also attended by staff representatives from each of the member organizations. This structure facilitates efficient communication between CPRC and its membership. Operational and financial decisions are subject to CPRC Board approval by majority vote. Whenever required, consultations are first made between CPRC and its members to ensure that CPRC activities are within its mandate and performed in the best interests of the Canadian poultry sector as a whole.

## Scientific Advisory Committee

The Board is supported by a Scientific Advisory Committee (SAC) to aid in the peer review process of all research proposals submitted to the CPRC. The review process adheres to basic principles and guidelines established by the Natural Sciences and Engineering Council (NSERC) regarding potential for conflict of interest and confidentiality of information. SAC consists of five core members that serve 5-year terms. Supplemental reviewers are chosen with expertise specific to the proposals reviewed each year.

## Staffing

As CPRC activities continue to rise, it is increasingly apparent that staff capacity must be increased as well. CPRC Members are reviewing a transition plan that will address CPRC's near-term staffing needs.

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**Scientific Advisory Committee**

***Core members in 2009:***

Dr. Joshua Gong
*Guelph Food Research Centre*
*Agriculture and Agri-Food Canada*

Dr. Doug Korver
*Department of Agricultural, Food and Nutritional Sciences*
*University of Alberta*

Dr. Steve Leeson
*Department of Animal & Poultry Science*
*University of Guelph*

Dr. Fred Silversides
*Agassiz Research Centre*
*Agriculture and Agri-Food Canada*

Dr. Bogdan Slominski
*Department of Animal Science*
*University of Manitoba*

***Supplemental reviewers in 2009:***

Dr. Ruth Newberry
*Department of Animal Sciences*
*Washington State University*

Dr. Juan-Carlos Rodriguez-Lecompte
*Department of Animal Science*
*University of Manitoba*

Dr. Shayan Sharif
*Department of Pathobiology*
*OVC, University of Guelph*

Dr. Andrew Olkowski
*Department of Animal & Poultry Science*
*University of Saskatchewan*

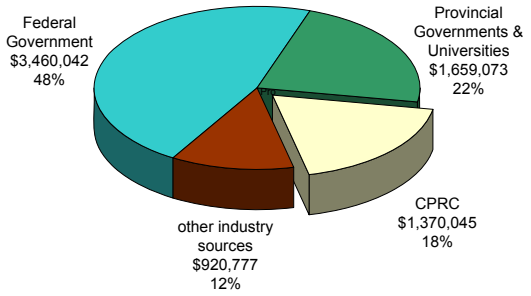
Dr. Hank Classen
*Department of Animal & Poultry Science*
*University of Saskatchewan*

CHAPTER 2

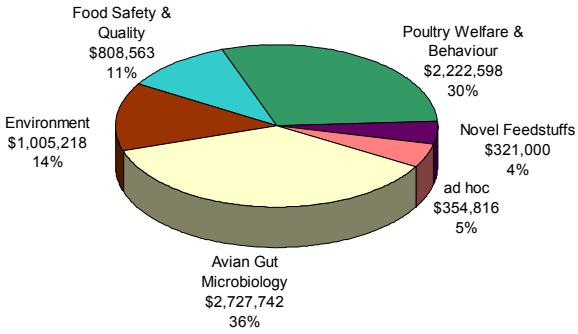
# Leveraging, optimizing poultry research investment in Canada.

One of CPRC's main goals is to help build Canada's capacity for poultry research. To date, CPRC Members have committed almost $1.4 million in support of 26 research projects at universities and federal government laboratories across Canada. Although CPRC's contribution is significant, it only represents a fraction of the overall support for these projects; funds from other sources total over $6 million. That is to say, CPRC dollars have been matched or "leveraged" 4.3:1. Helping secure matching dollars is a large part of CPRC's funding process. Industry dollars (such as those from CPRC) are eligible for matching by a number of sources, such as the Natural Sciences and Engineering Research Council (NSERC) and Agriculture and Agri-Food Canada (AAFC). As a prerequisite for CPRC funding, a project must secure matching funds from these or other sources. In addition to the funding quoted above, the CPRC has committed another $220,000 for 3 proposals that are currently under consideration for matching. These projects will only be funded by the CPRC if they are successful in securing matching funds. These projects could be leveraged for up to a total of $850,000.

**Funding sources for CPRC projects**
(total $7,439,937)




**Research funding by program (all sources)**
(total $7,439,937)




## National Research Strategy

There are several organizations across Canada that fund poultry research. CPRC's goal is not to duplicate the efforts of these organizations by simply becoming another purchaser of research, but instead to work with these organizations to develop a system that will leverage as many industry dollars as possible with other sources. There are many forms that such a system can take. CPRC's approach is to consult with the various funders across the country to better understand their individual processes and gain insight into how a system of national research programs would meet their needs while addressing national research priorities. Consultations have begun and CPRC has already received useful feedback on the potential for developing national research programs. CPRC has drafted a national research strategy document that will be developed in consultation with all stakeholders.

## Science cluster

CPRC's Call for Letters of Intent in 2009 focused on two priority areas:

1. Poultry Welfare & Behaviour
2. Food Safety & Quality – Impact of Poultry Health & Disease

Thirty-two proposals were received and subjected to CPRC's review process, including a scientific review by CPRC's Scientific Advisory Committee and internal review processes carried out by CPRC Members.

Concurrent to this process, Agriculture and Agri-Food Canada (AAFC) announced the Growing Canadian Agri-Innovations Program, including the Canadian Agri-Science Clusters initiative. This initiative is designed to "help key industry-led agricultural organizations to pull together national scientific and technical resources to establish clusters that support innovation for enhanced profitability and competitiveness". The idea is to encourage industry sectors to take an active role in developing a

collaborative, consultative approach to research and innovation strategies. The goals of the Clusters initiative correspond with those of CPRC. The decision was therefore made to integrate proposals approved by CPRC into a Poultry Science Cluster application.

The Poultry Science Cluster focuses on three main research areas of strategic importance to the industry:

1. Enteric diseases of poultry, as impacted by reduced emphasis on the use of feed-borne antibiotics and their potential for impacting human health.
2. Avian Influenza as it affects the poultry industry and its potential for zoonosis and associated societal concerns.
3. Specific aspects of poultry farming that impact bird welfare and related societal issues.

The scope of the proposal allows for basic research and more near-term, applied studies that will provide both immediate answers and future information for the poultry and food industries, as well as factors impacting consumer wellbeing. Twenty-one scientists working in ten different laboratories will lead the proposed research. The research budget for the cluster totals over $3 million to be spent over three years (2010-2012). Of that total, CPRC has committed $509,669. If the application is successful, funding sources for the cluster will be as follows:

| | |
|---|---|
| Science Clusters Program (federal government) | $1,641,474 |
| Other government sources | $564,580 |
| Industry (CPRC and others) | $809,462 |
| Other sources | $37,500 |
| **Total** | **$3,053,016** |

Results of AAFC's review of the Poultry Science Cluster application are expected in Spring of 2010.

## Poultry welfare cluster for Canada

Dr. Stephanie Torrey is an AAFC Research Scientist who re-located to the University of Guelph as part of the Poultry Welfare Cluster. Dr. Torrey is a trained ethologist. She adds to the animal behaviour and welfare expertise at Guelph and will be working with poultry welfare researchers across the country. For example, Dr. Torrey's proposed research on the welfare effects of feed-restricting broiler breeders is included in the Science Cluster application as a collaborative effort involving scientists from the University of Guelph, University of Saskatchewan and the Scottish Agricultural College.

The welfare cluster has an advisory committee representing each of the parties involved in the agreement to form the cluster: CPRC, Poultry Industry Council, University of Guelph and AAFC. The Committee is involved in ongoing discussions with the University of Guelph towards development of a Chair in Poultry Welfare position. The successful candidate for the position would oversee development of a national program in poultry behaviour and welfare in support of basic and applied research. The current proposal is to create a 10-year position with funds from industry and other sources. After 10 years, the University of Guelph would take over financial support thus creating a permanent position.

As part of the poultry welfare cluster agreement, a PhD Scholarship in Poultry Welfare at the University of Guelph was created. The scholarship was announced in December 2009 with completed applications due March 1, 2010.

CHAPTER 3

# Recognized nationally and internationally for efforts to encourage and support poultry research in Canada.

Recognition of effort is of strategic importance. Potential industry, academic and government partners are much more likely to work with CPRC if they see it as an effective, constructive organization. CPRC continues to build a positive relationship with the Research Branch of AAFC. CPRC's activities are the subject of a regular feature in Canadian Poultry Magazine, whose readership includes virtually every registered poultry producer in Canada, as well as a large proportion of industry stakeholders. CPRC will continue to reach out to funding organizations, universities and government branches through 2010 and beyond.

## Postgraduate scholarship supplement

The future of Canada's poultry sector depends upon a strong, world-class research community. Training future researchers is essential to meet this need. CPRC supports this endeavour in 2 ways. First, nearly all research grants awarded by CPRC incorporate graduate student support. Second, the CPRC has created, in conjunction with the Natural Sciences and Engineering Council (NSERC), a "Postgraduate Scholarship Supplement". The supplement is $7,500 per year. To be eligible, a student must be studying (or planning to study) some aspect of poultry science and hold a NSERC scholarship at the Masters (eligible for one year) or Doctoral level (eligible for up to two years). Applications are due May 1 each year.

NSERC postgraduate scholarships are available on a competitive basis to Canada's best postgraduate students. The purpose of the CPRC Postgraduate Scholarship Supplement is to attract these students to consider a career in poultry science.

The specific objectives of the program are:

- to encourage and support graduate students to carry out research in an aspect of poultry science;
- to build Canada's intellectual capacity in poultry science; and
- to promote graduate research in poultry science at Canadian universities.

The 2009 scholarship supplement was awarded to Bushansingh (Shyam) Baurhoo at McGill University. Shyam is investigating the effect of mannanoligosaccharides (MOS) and lignin on broiler chicken performance, especially in the absence of dietary antimicrobials.

Past winners of the supplement are:

2006 Mohamed Faizal Abdul Careem, University of Guelph
2007 Holly Pizzey, University of Guelph
2008 Megan MacDonald, University of Alberta

For more information on the CPRC PGS supplement, please visit the "Updates" section of the CPRC website

## National Poultry Research Workshop

CPRC is preparing for a national poultry research workshop in Ottawa May 12 and 13, 2010. The purpose of the event is to examine the current state of poultry research in Canada and consider what should be done to address current and emerging issues. Broadly speaking, the workshop will look at where we are and where we need to go.

***Where we are.*** The arena of poultry research in Canada has changed from years past when major emphasis was placed on increasing agricultural productivity. While productivity research remains important, emphasis is shifting towards addressing issues like environmental sustainability, food safety, and poultry welfare. There is also research interest in assessing new market opportunities such as functional foods, industrial products and pharmaceuticals. The research community is tasked with addressing an increasingly broad range of issues yet has limited human, physical and financial resources to do so.

The future success of the poultry industry depends on using our research resources wisely. These resources are dispersed across the country. In many cases, organizations that fund poultry research do so in virtual isolation of other organizations with similar objectives. While scientists are generally better at communicating with others in their field, there are still many opportunities to increase collaboration among individuals and institutions with different, yet complementary expertise.

The federal government clearly agrees with the need for collaboration among scientists and is promoting the formation of "science clusters", or groups of scientists working towards common goals. CPRC submitted a science cluster proposal early this year (funding decisions are expected this spring) that involves more than 20 scientists at ten institutions working together to address agreed upon priority areas. While this collaborative effort is a step in the right direction, it is only a hint of what might be accomplished in the future.

***Where we need to go.*** The workshop in 2010 will give participants the opportunity to review recent research funded by industry and discuss whether intended objectives were met. "Objectives" include not only the direct results of the research, but also consider the training of students and personnel, and whether the cost of the research was money well spent. If the research funded in the past did not have the desired outcome, the process by which future funding decisions are made may need adjustment.

Workshop participants will also re-examine CPRC's research priorities (set in 2005) and adjust them if necessary. These priorities are the base on which national research programs will be developed.

Further to prioritizing what research needs to be done, we need to consider how our limited physical, human and financial resources can be used to maximum effect. There are a number of industry, government and academic organizations that fund poultry research across Canada. Collaboration and coordination among these organizations will maximize the impact of their collective investment. CPRC is facilitating development of a national poultry research strategy that will foster this collaboration. The strategy is being developed in consultation with the various funders of poultry research across Canada. The goal is to create national research programs that are consistent with agreed priorities and to encourage industry and government to invest in the outcomes of the programs. The idea is not to control where individual organizations invest their resources, but rather to encourage them to do so in a manner that avoids unnecessary duplication and maximizes the impact of their investment.

In the face of limited resources and new challenges, we can no longer afford to work in isolation from each other. The best use of our resources and the best chance of success in meeting new challenges will be afforded by working together. An organized collaborative approach to poultry research in Canada will help ensure the future success of our industry. CPRC is working towards that end and looks forward to discussions in May regarding the future of poultry research in Canada.

CHAPTER 4

# Helping to address the real poultry issues of the day.

## Granting Procedures

The CPRC calls for Letters of Intent (LOIs) for priority areas of research each April. This year, researchers were invited to submit grant applications relating to "Poultry Welfare and Behaviour" and "Food Safety and Quality".

Calls for LOIs generally pertain to 2 research priority areas at a time. The priority areas for planned for 2010 through 2011 are as follows:

Date of Call/Priority areas:

| | |
|---|---|
| 2010 | Avian Gut Microbiology<br>Environment |
| 2011 | Poultry Welfare & Behaviour<br>Food Safety & Quality – Impact of Poultry Health & Disease |

With input from academe, government and industry, the CPRC will continually review its research priority list and, if necessary, adjust it to reflect existing and emerging issues of importance to its members. Provided they remain of high importance, the four priority areas listed above will be the subject of future Calls at regular intervals so as to promote continuity in existing research programs.

The CPRC Scientific Advisory Committee (SAC) reviews all LOIs and makes recommendations to the CPRC Directors. Proposals approved for CPRC support must secure matching funds from NSERC, AAFC or other non-industry sources before CPRC funds are released.

## Research Programs

To date, the CPRC is supporting research projects in the following program areas:

1. ***Avian Gut Microbiology:*** The first projects funded under the Avian Gut Microbiology Network (AviMicroNet) program are complete. The resulting research provided many interesting insights into the dynamics of gut microbes in the presence or absence of antibiotics and other feed additives. Results are being shared among industry stakeholders in an effort to improve the understanding of the physiological impact of antibiotics and what the repercussions of reducing their use might be, both for our poultry and the industry as a whole. Two new projects (for a total of eight) were added to the program in 2009 as detailed below.

2. ***Environment:*** This program deals with a wide array of environmental issues ranging from land incorporation of poultry manure, to calcium and phosphorus flow in layers, to workplace exposures to pollutants, to environmental contamination from veterinary pharmaceuticals. A new project was added to the program in 2009 and another is under review with potential funding partners.

3. ***Food Safety and Poultry Health:*** Four projects were funded thus far in the food safety program. Two are complete and two are due for completion early in 2010. The program covers the following subjects: immunization of broiler chickens against necrotic enteritis, immune responses to avian influenza virus in the chicken, development of RNA interference constructs against avian influenza virus, and novel multivalent vaccines for avian health.

4. ***Poultry Welfare and Behaviour:*** Within this program area, five projects are underway covering the impact of ammonia on the welfare of laying hens, improving transport conditions for broilers, alternative methods of euthanizing turkeys, effects of lighting programs on leg weakness in broilers, and improving welfare for beak trimmed hens. Results are expected by the end of 2010.

5. ***Novel feedstuffs:*** There is an emerging need for research on the use of feedstuffs alternative to current grains (especially corn), which are anticipated to increase in price due to demands from the energy sector. The CPRC responded to this situation by calling for LOIs relating to "Novel Feedstuffs" in 2008. One project is underway and two proposals are under review.

6. ***Ad hoc:*** The CPRC also has a mechanism in place whereby it can accept research proposals that do not fit into the main research categories above. Two projects were supported under this program by CPRC as a whole, and one, as detailed below, was supported solely by TFC. The *ad hoc* program allows CPRC Members the flexibility to take advantage of scientific opportunities should they arise and to address acute industry issues as they emerge.

## CPRC-supported projects

Individual projects within each of the above programs are:

***Avian Gut Microbiology***
AMN001
Identification of gut bacteria affected by dietary antibiotics and their roles in the gut immunity of broiler chickens.
*Joshua Gong, Agriculture Canada and Shayan Sharif, University of Guelph*
AMN002
Molecular epidemiology of necrotic enteritis.
*Patrick Boerlin, University of Guelph*
AMN003
Carbohydrase enzyme supplements as growth promoters and modulators of the intestinal microflora of the chicken: The prebiotic and probiotic effect of enzyme hydrolysis products.
*Bogdan Slominski, University of Manitoba*
AMN004
Understanding how Campylobacter jejuni colonizes poultry
*Brenda Allan, VIDO*
AMN023
The use of cyclic-di-GMP, a novel immunotherapeutic and antibacterial molecule in chickens
*Moussa Diarra, AAFC*
AMN024
Investigation into cell-cell signaling in Clostridium perfringens infection for developing a novel disease-control strategy
*Joshua Gong, AAFC*
AMN025
Engineered antibodies and phage products for food safety applications
*Christine Szymanski, University of Alberta*
AMN027
Elucidation of critical characteristics of Clostridium perfringens and pathogen-host-environment interactions defining susceptibility of poultry to necrotic enteritis
*Andrew Olkowski, University of Saskatchewan*

***Environment***
ENV006
Distribution uniformity and emission reduction potential of a precision applicator for surface and sub-surface land application of poultry manure
*Claude Lague, University of Saskatchewan (now at University of Ottawa)*
ENV007
Development of a dynamic model of Ca and P flows in layers
James France, University of Guelph
ENV008
Activity-specific workplace exposures of poultry barn workers
*Ambikaipakan Senthilselvan, University of Alberta*

ENV009
Reducing pollution from veterinary pharmaceuticals in agricultural runoff from poultry manure
*Shiv Prasher, McGill University*
ENV026
Protein-based biomaterials from spent hens
*Jianping Wu, University of Alberta*

***Food Safety & Poultry Health***
FSQ011
Immunization of broiler chickens against necrotic enteritis
*John Prescott, University of Guelph*
FSQ012
Immunology of T cell-mediated immune response to avian influenza virus in the chicken
*Shayan Sharif, University of Guelph*
FSQ014
Development of second generation RNA interference constructs against avian influenza virus
*Serguei Golovan, University of Guelph*
FSQ015
Novel multivalent vaccines for avian health
*Eva Nagy, University of Guelph*

***Poultry Welfare & Behaviour***
PWB017
Engineering, animal welfare and meat quality considerations of broiler transportation in a heated and ventilated vehicle
*Trever Crowe, University of Saskatchewan*
PWB018
Improving welfare for beak trimmed hens through reducing variability and technology transfer
*Hank Classen, University of Saskatchewan*
PWB019
Effect of lighting programs on leg weakness and bird welfare in modern commercial broilers
*Hank Classen, University of Saskatchewan*
PWB020
Evaluation of alternative methods of euthanasia for cull turkeys
*Tina Widowski, University of Guelph*
PWB021
Impact of ammonia on welfare of laying hens, and implications for the environment
*Steve Leeson, University of Guelph*

***Novel Feedstuffs***
NFS028
Distillers dried grains with solubles (DDGS) as a potential source of immunostimulatory and growth promoting activity for poultry
*Bogdan Slominski, University of Manitoba*

***Ad hoc***
UAB005
The impact of timing of protein intake and growth patterns on reproductive efficiency in broiler breeder females.
*Frank Robinson, University of Alberta*
AGA010
Cryopreservation of Canada's remaining avian germplasm
*Fred Silversides, Agriculture & Agri-Food Canada*
CTM022
Use of dietary thyroxine as an alternative molting procedure in turkey breeder hens
*Grégoy Bédécarrats, University of Guelph*

## New research in 2009

***Avian Gut Microbiology***

Bacteriophage have long been touted as a potential alternative to controlling bacterial infections. This special class of virus targets specific bacteria based on surface receptors. Dr. Christine Szymanski is starting a new project at the University of Alberta with collaborators from the National Research Council (NRC) looking at the potential of bacteriophage, or perhaps even small components of them, to control *C. jejuni* populations. This research complements other bacteriophage work underway in Canada and abroad. Dr. Szymanski was awarded a $54,000 grant from CPRC which contributes to funds secured by the research group from the Alberta Ingenuity Fund and NRC.

Drs. Andrew Olkowski and Bernard Laarveld of the University of Saskatchewan have initiated research into the characteristics of *Clostridium perfringens*, the causative organism of necrotic enteritis, and the bacterium's interactions with poultry and the environment that define its ability to cause disease. Industry cash from CPRC ($89,402) and in-kind contributions from Lilydale ($17,340) were matched by the NSERC-CRD program to bring the total project budget up to $204,488.

***Environment***

Dr. Jianping Wu at the University of Alberta was awarded a $60,000 grant from CPRC to investigate potential production of biomaterials from spent layer hens. Spent hen disposal remains a significant challenge for the layer industry. Dr. Wu's work may lead to new, environmentally sustainable solutions. His project attracted $232,569 from the Alberta Meat and Livestock Agency (ALMA).

***Novel Feedstuffs***

The prospect of increasing feed costs for the poultry industry prompted CPRC to initiate research into the potential for alternative, less expensive feed ingredients and feed processing technologies. Drs. Bogdan Slominski and Juan C. Rodriguez-Lecompte at the University of Manitoba are looking at distillers dried grains with solubles (DDGS) as a potential source of immunostimulatory and growth promoting activity for poultry.

## Project Status

The following table summarizes the status of CPRC-supported projects, as well as applications approved by the CPRC Directors and for which matching funds are being pursued. Project details are provided in Appendix 1.

| Program | Project leader | Institution | CPRC # | start date | expected end | status |
|---|---|---|---|---|---|---|
| Avian Gut Microbiology /Alternatives to Antibiotics | Gong/Sharif | AAFC/U of Guelph | AMN001 | Nov-04 | Nov-06 | complete |
| | Boerlin | U of Guelph | AMN002 | Nov-04 | Nov-06 | complete |
| | Slominski | U of Manitoba | AMN003 | Jan-05 | Mar-08 | complete |
| | Allan | Vaccine and Infectious Disease Organization | AMN004 | Nov-04 | Dec-07 | complete |
| | Diarra | AAFC | AMN023 | Aug-08 | Mar-12 | in progress |
| | Gong | AAFC | AMN024 | Oct-08 | Nov-10 | in progress |
| | Szymanski | U of Alberta | AMN025 | Jun-09 | May-12 | in progress |
| | Olkowski | U of Saskatchewan | AMN027 | Sep-09 | Sep-12 | in progress |
| Environment | Lague | U of Saskatchewan | ENV006 | Nov-05 | Oct-07 | complete |
| | France | U of Guelph | ENV007 | Nov-05 | Oct-07 | complete |
| | Senthilselvan | U Alberta | ENV008 | Feb-06 | Jun-08 | complete |
| | Prasher | McGill | ENV009 | Jan-06 | Feb-07 | complete |
| | Wu | U of Alberta | ENV026 | Sep-09 | Aug-12 | in progress |
| | Van Heyst | U of Guelph | under review | | | |
| Food Safety & Quality | Prescott | U of Guelph | FSQ011 | Sep-06 | Aug-09 | complete |
| | Sharif | U of Guelph | FSQ012 | Mar-07 | Aug-09 | complete |
| | Golovan | U of Guelph | FSQ014 | Nov-06 | Oct-08 | in progress |
| | Nagy | U of Guelph | FSQ015 | Dec-06 | Nov-09 | in progress |
| | Crowe | U of Saskatchewan | PWB017 | Jan-07 | Dec-10 | in progress |
| Poultry Welfare & Behaviour | Classen | U of Saskatchewan | PWB018 | Apr-07 | Mar-10 | in progress |
| | Classen | U of Saskatchewan | PWB019 | Mar-07 | Feb-10 | in progress |
| | Widowski | U of Guelph | PWB020 | Apr-07 | Dec-09 | complete |
| | Leeson | U of Guelph | PWB021 | Jan-08 | Dec-10 | in progress |
| Novel Feedstuffs | Slominski | U of Manitoba | NFS028 | Oct-09 | Oct-12 | in progress |
| | Anderson | APRI | under review | | | |
| | Classen | U of Saskatchewan | under review | | | |
| Ad hoc | Robinson | U of Alberta | UAB005 | May-04 | Apr-06 | complete |
| | Silversides | AAFC | AGA010 | Sep-06 | Mar-08 | complete |
| | Bedecarrats | U of Guelph | CTM022 | Jun-07 | May-09 | complete |

CHAPTER 5

# Transferring knowledge to the users of poultry research.

CPRC prints a monthly feature in Canadian Poultry magazine. The articles provide updates on recent CPRC activities and often include summaries of completed research projects. The summaries are written in simple language and explain how the projects fit into overall research programs, and how the research relates to the farm. Research results are also provided to the CPRC member organizations who then relay the information directly to their respective members. Results are, of course, published in peer-reviewed scientific journals and shared worldwide throughout the scientific community.

The "Science Strategy for Canada's Poultry Sector" document proposes development of a national technology transfer and commercialization strategy. Canada has communications officers, extension specialists and commercialization managers in place at institutions and organizations across the country. These individuals have the appropriate expertise to recognize pertinent information and can share it appropriately with their target audience. Utilizing this existing expertise and infrastructure is deemed the most efficient way to implement an effective technology transfer and commercialization strategy. CPRC will work with the appropriate organizations to develop such a strategy.

# Financial Statements

For the year ended December 31, 2009

9.

**PARTNERS:**

Ross E. Bairstow, B. Comm., C.A. (Retired)

D. Andrew Smart, B. Math., C.A., C.F.P.

Edward (Ted) L. Smith, B.A., CA, T.E.P.

Sara B. Detweiler, B.B.A., C.A.

**ASSOCIATE:**

Deborah Cronk, H.B.Comm., C.A.

100 Gordon Street

Guelph, Ontario

N1H 4H6

Tel: (519) 822-7670

Fax: (519) 822-6997

Website: www.bssllp.ca

# AUDITORS' REPORT

To the Members of **The Canadian Poultry Research Council:**

We have audited the statement of financial position of **The Canadian Poultry Research Council** as at December 31, 2009 and the statements of fund operations and changes in fund balances and cash flows for the year then ended. These financial statements are the responsibility of the Organization's management. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with Canadian generally accepted auditing standards. Those standards require that we plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In our opinion, these financial statements present fairly, in all material respects, the financial position of the Organization as at December 31, 2009 and the results of its operations, changes in its fund balances and cash flows for the year then ended in accordance with Canadian generally accepted accounting principles.

Bairstow, Smart & Smith LLP

Guelph, Ontario
February 24, 2010

LICENSED PUBLIC ACCOUNTANTS

# THE CANADIAN POULTRY RESEARCH COUNCIL

Statement of Financial Position as at December 31, 2009

| | Operating Fund | Research Fund | Scholarship Fund | Total 2009 | Total 2008 |
|---|---|---|---|---|---|
| ASSETS | | | | | |
| **Current** | | | | | |
| Cash | $ 13,526 | $ 376,153 | $ 2,576 | $ 392,255 | $ 94,188 |
| Research contributions receivable | | 58,928 | | 58,928 | 388,247 |
| Prepaid expenses | 1,436 | | | 1,436 | |
| Interest receivable | 57 | 87 | 35 | 179 | 1,475 |
| Short-term investments (Note 5) | 105,521 | 125,745 | 50,928 | 282,194 | 291,633 |
| Interfund loan (Note 9) | 19,091 | (19,091) | | | |
| | 139,631 | 541,822 | 53,539 | 734,992 | 775,543 |
| Research contributions receivable - long term | | 34,875 | | 34,875 | |
| | 139,631 | 576,697 | 53,539 | 769,867 | 775,543 |
| LIABILITIES AND FUND BALANCES | | | | | |
| **Liabilities** | | | | | |
| Accounts payable and accrued liabilities | 21,959 | | | 21,959 | 5,195 |
| Research grants payable -current (Note 7) | | 145,230 | | 145,230 | 321,284 |
| | 21,959 | 145,230 | | 167,189 | 326,479 |
| Research grants payable - long term(Note 7) | | 241,403 | | 241,403 | 38,000 |
| **Deferred Contributions** (Note 6) | | 152,323 | 53,539 | 205,862 | 258,516 |
| | 21,959 | 538,956 | 53,539 | 614,454 | 622,995 |
| **Fund Balances** | | | | | |
| Internally restricted for research | | 37,741 | | 37,741 | 37,741 |
| Unrestricted | 117,672 | | | 117,672 | 114,807 |
| | 117,672 | 37,741 | | 155,413 | 152,548 |
| | 139,631 | 576,697 | 53,539 | 769,867 | 775,543 |

# THE CANADIAN POULTRY RESEARCH COUNCIL

Statement of Fund Operations and Changes in Fund Balances
For the Year Ended December 31, 2009

| | Operating Fund | Research Fund | Scholarship Fund | Total 2009 | Total 2008 |
|---|---|---|---|---|---|
| REVENUE | | | | | |
| Membership fees | $ 110,000 | $ | $ | $ 110,000 | $ 110,000 |
| Interest | 1,607 | | | 1,607 | 1,493 |
| Contributions | 30,000 | | | 30,000 | 144,002 |
| Contributions (Note 6) | | 203,402 | 15,072 | 218,474 | 7,567 |
| | 141,607 | 203,402 | 15,072 | 360,081 | 263,062 |
| EXPENSES | | | | | |
| Workshops | | | | | 14,581 |
| Meetings | 22,145 | | | 22,145 | 14,929 |
| Insurance | 1,436 | | | 1,436 | 1,197 |
| Interest and bank charges | 118 | | 72 | 190 | 185 |
| Consultants | 34,553 | | | 34,553 | 21,794 |
| Office | 3,266 | | | 3,266 | 1,216 |
| Overhead | 3,999 | | | 3,999 | 3,999 |
| Per diems | 1,125 | | | 1,125 | 2,250 |
| Professional fees | 2,700 | | | 2,700 | 2,050 |
| Management fees | 35,250 | | | 35,250 | 31,333 |
| Telephone | 326 | | | 326 | 289 |
| Website | 364 | | | 364 | 259 |
| Translation | 3,460 | | | 3,460 | 3,006 |
| Poultry Welfare Cluster | 30,000 | | | 30,000 | |
| Avi Micro Net | | 89,402 | | 89,402 | 144,002 |
| Environment | | 60,000 | | 60,000 | |
| Novel Feedstuffs | | 54,000 | | 54,000 | |
| Scholarship | | | 15,000 | 15,000 | 7,500 |
| | 138,742 | 203,402 | 15,072 | 357,216 | 248,590 |
| EXCESS OF REVENUE OVER EXPENSES | 2,865 | | | 2,865 | 14,472 |
| FUND BALANCE - Beginning of Year | 114,807 | 37,741 | | 152,548 | 138,076 |
| FUND BALANCE - End of Year | 117,672 | 37,741 | | 155,413 | 152,548 |

## THE CANADIAN POULTRY RESEARCH COUNCIL

Statement of Cash Flows
For the Year Ended December 31, 2009

| | 2009 | 2008 |
|---|---|---|
| CASH FLOWS FROM OPERATING ACTIVITIES | | |
| Excess of revenue over expenses | $ 2,865 | $ 14,472 |
| Net change in non-cash working capital: | | |
| Research contributions receivable | 294,444 | (231,295) |
| Prepaid expenses | (1,436) | 1,197 |
| Interest receivable | 1,296 | 7,070 |
| Accounts payable and accrued liabilities | 16,764 | (3,714) |
| Research grants payable | 27,349 | (71,283) |
| Deferred contributions | (52,654) | 133,530 |
| | 288,628 | (150,023) |
| CASH FLOWS FROM FINANCING AND INVESTING ACTIVITIES | | |
| Purchase of investments | (282,194) | (649,255) |
| Redemption of investments | 291,633 | 644,988 |
| | 9,439 | (4,267) |
| INCREASE (DECREASE) IN CASH | 298,067 | (154,290) |
| CASH - BEGINNING OF YEAR | 94,188 | 248,478 |
| CASH - END OF YEAR | 392,255 | 94,188 |

## 1. PURPOSE OF THE ORGANIZATION

The Organization is incorporated under the provisions of the Canada Corporations Act and was formed to support the Canadian research effort in Canada's poultry sector. The Organization is exempt from tax under Section 149(1)(e) of the Income Tax Act.

## 2. SUMMARY OF SIGNIFICANT ACCOUNTING POLICIES

**Fund Accounting**

Revenues and expenses related to program delivery and administrative activities are reported in the Operating Fund.

Revenues and expenses related to research activities are reported in the Research Fund.

Revenues and expenses related to scholarship activities utilizing the Canadian Vitamins Settlement proceeds are reported in the Scholarship Fund.

**Revenue Recognition**

The Organization uses the deferral method of accounting for contributions.

Restricted contributions are recognized as revenue in the year in which the related expenses are incurred. Unrestricted contributions are recognized as revenue when received or receivable if the amount can be reasonably estimated and collection is reasonably assured.

Restricted investment income is recognized as revenue in the year in which the related expenses are incurred. Unrestricted investment income is recognized as revenue when earned.

Membership fees are included in income over the membership term.

**Short-term investments**

Given the short term nature of the cash investments held, book value approximates market value and they have been classified as held for trading. Financial assets held for trading are acquired or incurred principally for the purpose of selling or redeeming them in the near term. They are recognized at fair value based on market prices. Gains and losses are reflected in operation for the period in which they arise.

## 3. CHANGE IN ACCOUNTING POLICY

The CICA has issued revisions to Section 4400 which relate to not-for-profit organizations. These changes now allow the optional disclosure of net assets invested in capital assets, require application of Section 1540, "Cash Flow Statements", and require reporting of revenues and expenses on a gross basis in the statement of operations unless not required by other CICA guidance.

A new CICA Section 4470, "Disclosure of Allocated Expenses by Not-for-Profit Organizations", requires certain disclosures when fundraising and general support expenses are allocated to other functions.

The above changes in accounting policies are applicable to years beginning on or after January 1, 2009. Accordingly, the Organization adopted the amended standards for its fiscal year beginning January 1, 2009. The revised standards had no impact on the Organization's financial statements.

## 4. FINANCIAL RISK MANAGEMENT OBJECTIVES AND POLICIES

The Organization's principal financial instruments consist of cash and investments. The main purpose of these financial instruments is to finance and maintain the Organization's operations and research funding. The financial organization has other financial assets and liabilities such as research contributions receivables, interest receivable, accounts payables and accrued liabilities, research grants payable and deferred contributions which arise directly from its operations. The main risks arising from the Organization's financial instruments are interest rate and credit risk.

**a) Interest Rate Risk Exposure**

The Organization's exposure to the risk of changes in market interest rate relates primarily to cash and investments. Financial assets with variable rates expose the Organization to cash flow interest rate risk. All other financial assets and liabilities are non-interest bearing.

**b) Credit Risk Exposure**

Credit risk from cash has a maximum exposure of the carrying amount of this instrument.

**Fair Value of Financial Instruments**

The carrying value of cash, research contributions receivable, interest receivable, guaranteed investment certificates, accounts payable and accrued liabilities, research grants payable and deferred contributions approximate fair values due to the short-term maturities of these instruments.

## 5. SHORT TERM INVESTMENTS

| | 2009 | 2008 |
|---|---|---|
| **Operating Fund** | | |
| Cashable guaranteed investment certificate, interest 2.05%, maturing September 26, 2009 | $ | $ 53,509 |
| Cashable guaranteed investment certificate, interest 1.83%, maturing October 23, 2009 | | 50,000 |
| Cashable guaranteed investment certificate, interest 0.2%, maturing September 26, 2010 | 105,521 | |
| | 105,521 | 103,509 |
| **Research Fund** | | |
| Cashable guaranteed investment certificate, interest 0.2%, maturing September 26, 2010 | 125,745 | 123,220 |
| **Scholarship Fund** | | |
| Cashable guaranteed investment certificate, interest 0.2%, maturing September 26, 2010 | 50,928 | 64,904 |
| | 282,194 | 291,633 |

## 6. DEFERRED CONTRIBUTIONS

Deferred contributions relate to the unspent portion of funding received that is restricted for specific purposes and the unspent portion of the Canadian Vitamins Class Actions National Settlements. Changes in the deferred contributions balance are as follows:

| | Canadian Vitamins Settlement | Research Contributions | Other | 2009 | 2008 |
|---|---|---|---|---|---|
| BALANCE - BEGINNING OF YEAR | $ 67,687 | $ 186,738 | $ 4,091 | $ 258,516 | $124,986 |
| Amount recognized as revenue in the year | (15,072) | (203,402) | (4,091) | (222,565) | (7,567) |
| Amount received related to subsequent years | | 166,981 | | 166,981 | 139,595 |
| Investment income | 924 | 2,006 | | 2,930 | 1,502 |
| BALANCE - END OF YEAR | 53,539 | 152,323 | | 205,862 | 258,516 |

## 7. RESEARCH GRANTS PAYABLE

Research grants payable in the amount of $386,633 (2008- $ 359,284) represent the outstanding amount committed by the Organization to fund researchers in the poultry field. The liability is recorded in the year the grants are awarded by the Organization and is reduced as funds are distributed to the researchers when milestones in the agreement have been fulfilled.

## 8. INTERNALLY RESTRICTED FUND BALANCES

Internally restricted research funds represent the unspent portion of funds transferred from the operating fund to the research fund by the board of directors. These internally restricted amounts are not available for purposes other than research without approval of the board of directors.

## 9. INTERFUND LOAN

The interfund loan is non-interest bearing and there are no terms of repayment.

## 10. CAPITAL DISCLOSURES

The Organization defines its capital as its unrestricted net assets. Internal restrictions on capital are disclosed in (Note 8).

The Organization's objective when managing its capital is to hold sufficient unrestricted net assets to maintain the stability of its financial structure enabling it to focus its efforts on serving its members and to ensure external restrictions for research are sustained.

## 11. COMMITMENTS

The Organization has an agreement with the Poultry Industry Council to provide management services. This agreement automatically renews at the end of each calendar year for a subsequent one year term, unless terminated.

The Organization also has commitments to fund various research projects from its research fund. The timing of fulfillment of these commitments is based upon the researcher obtaining matching funding for each research project, and are estimated to be as follows:

| | |
|---|---|
| 2009 | $234,383 |
| 2010 | 273,526 |
| 2011 | 253,198 |

## SCHEDULE 1 – ADMINISTRATION EXPENSES

| For the year ended December 31 | 2009 | 2008 |
|---|---|---|
| Workshops | | 14,581 |
| Meetings | 22,145 | 14,929 |
| Insurance | 1,436 | 1,197 |
| Interest and bank charges | 118 | 118 |
| Consultants | 34,553 | 21,794 |
| Office | 3,266 | 1,216 |
| Overhead | 3,999 | 3,999 |
| Per diems | 1,125 | 2,250 |
| Professional fees | 2,700 | 2,050 |
| Management fees | 35,250 | 31,333 |
| Telephone | 326 | 289 |
| Website | 364 | 259 |
| Translation | 3,460 | 3,006 |
| **Totals** | **$108,742** | **$97,021** |

## SCHEDULE 2 – RESEARCH EXPENSES BY PROGRAM

(projects underway as of December 31, 2009)

| | Committed | Paid | Payable |
|---|---|---|---|
| Avian Gut Microbiology | $586,304 | $440,901 | $145,403 |
| Environment | $142,237 | $82,237 | $60,000 |
| Food Safety and Poultry Health | $215,731 | $183,731 | $32,000 |
| Novel Feedstuffs | $54,000 | $0 | $54,000 |
| Poultry Welfare and Behaviour | $278,778 | $183,548 | $95,230 |
| Ad hoc programs | $92,995 | $92,995 | $0 |
| **Totals** | **$1,370,045** | **$983,412** | **$386,633** |

## SCHEDULE 3 – RESEARCH COMMITMENTS

(projects approved for CPRC funding that have not yet secured matching dollars)

| | 2009 | 2010 | 2011 | Totals |
|---|---|---|---|---|
| Avian Gut Microbiology | $30,000 | | | **$30,000** |
| Environment | $35,563 | $35,250 | $35,250 | **$106,063** |
| Novel Feedstuffs | $45,775 | $37,661 | $31,938 | **$115,374** |
| Science Cluster | $123.045 | $200,615 | $186,010 | **$509,670** |
| **Totals** | **$234,383** | **$273,526** | **$253,198** | **$761,107** |

# Appendix 1 - Research Project Details

The following projects supported by CPRC are at various stages of completion (see "Project Status" table, page 13). These summaries are posted on the CPRC website and are updated as research results come in.

Up to date project summaries can be found at http://www.cp-rc.ca/research_programs.html

**AMN001**
Identification of gut bacteria affected by dietary antibiotics and their roles in the gut immunity of broiler chickens
*Principal investigators: Joshua Gong, Agriculture and Agri-Food Canada, Shayan Sharif, University of Guelph*
*Co-investigators: Huaijan Zhou, Texas A&M University, Parvis Sabour, Agriculture and Agri-Food Canada, Babek Sanei, Ontario Ministry of Agriculture, Food and Rural Affairs, Jennifer Brisbin, University of Guelph (PhD candidate)*

Funding: $260,000 (CPRC $100,000, PIC $30,000, MII $55,000, NSERC $75,000)
Start date: November 2004
Expected end: November 2006
Interim report received: December 13, 2006
Final report received: April 2008
Status: complete

Background:
There are increasing concerns over the development of bacterial resistance to antibiotics. While it is not clear if the use of antibiotics to prevent infection and promote growth in poultry is a contributing factor, it is clear that antibiotics do have an effect on microbial populations in the chicken gut. It has also been shown that antibiotic use affects development of the chicken's immune system. The objectives of this research project, therefore, were to determine which microbes in the gut are most affected by antibiotics and to determine how these microbial changes affect the immune system.

Research progress:
An experiment was set up in which birds were fed either non-medicated diets or those supplemented with bacitracin (4.4 or 55 ppm) or virginiamycin (11 or 22 ppm). Samples were taken from various regions of the gut at 3, 7, and 14 days and microbial populations were compared. Genetic analysis revealed that many bacterial groups were affected by the presence of the antibiotics used in this study. Effects were most pronounced with virginiamycin. This antibiotic was then used in a trial during which birds fed medicated or non-medicated feed were immunized with several potent antigens designed to elicit an immune response. In most cases, the presence of virginiamycin in the feed did not affect the immune response of the birds, but there were a few specific cases for which immune response was increased. This result is surprising and may provide some insight as to why subtherapeutic levels of antibiotics can improve broiler chicken performance.

Several species of Lactobacillus bacteria were affected by the presence of virginiamycin in this study. Lactobacillus acidophilus has been linked to increased immune response in chickens. Components of this bacterium were therefore used to stimulate chicken immune system cells in the laboratory. The cells responded by increasing expression of several genes relating to immune function. It has been hypothesized that a decreased population of L. acidophilus in the gut due to antibiotic use could have a negative effect on immune function in the bird. Results from this research project suggest, however, that the use of antibiotics such as virginiamycin does not negatively affect immune function in broiler chickens.

Future work:
Work is ongoing to further characterize changes in immune system gene expression in response to antibiotics. This information will be crucial to finding ways to improve the chicken's immune function, both to enhance the effectiveness of currently antibiotics and to perhaps reduce the need for them in the future.

**AMN002**
Molecular epidemiology of necrotic enteritis
*Principal investigator: Patrick Boerlin, University of Guelph*
*Co-investigators: John Prescott, Bruce Hunter, Wayne Martin, Gabhan Chalmers (MSc student), University of Guelph*

Funding: $107,000 (CPRC $70,000, PIC $37,000)
Start date: January 2005
Expected end: November 2006
Interim report received: n/a
Final report received: April 2008
Status: complete

Background:
*Clostridium perfringens* is a bacterium commonly found in the gut of a variety of healthy animals, including chickens. However, it is also linked to necrotic enteritis (NE). There is relatively little information on how NE develops, especially in terms of the role that *C. perfringens* plays and why certain strains of the bacterium can cause the disease. The main objectives of this project were to look at the *C. perfringens* strains present in chickens and compare their diversity both within individual birds and among different birds on commercial broiler farms, and to see if that diversity changes in birds suffering from NE.

Research progress:
The techniques traditionally used to determine strain diversity are very laborious. Dr. Boerlin's team therefore developed techniques that are less work intensive and can be largely automated. These new techniques were used throughout the current project and will part of related studies in the future.

In the first phase of the project, Dr. Boerlin's team looked at the diversity of *C. perfringens* strains in two barns in a commercial broiler farm. It was unexpectedly low. Similar studies in Europe, where antimicrobial use is restricted, show higher strain diversity. Dr. Boerlin suggests that the use of bacitracin on the farms in his study may have skewed the *C. perfringens* population towards a few resistant strains.

Strains isolated from field cases of NE (these birds did not receive antimicrobials) were then compared to those from flocks with no known history of the disease. *C. perfringens* strains from the same NE-positive birds, or from different healthy birds from the same barn, were generally the same genetic type. However, different NE outbreaks were associated with genetically diverse strains. Almost all these isolates tested positive for the NetB toxin, which was recently implicated as a contributing factor in NE. Collectively, these results suggest that an element(s) that can be transferred from one strain to another (such as the *netB* gene) can affect a strain's ability to cause NE.

Samples were also taken from a different research project during which birds were challenged with *C. perfingens* to artificially cause NE. All the strains tested were *netB* positive, but the degree to which they caused disease varied. The implication here is that *netB* may only contribute to NE and that other factors (such as management practices) are involved in development of the disease. Further studies are being planned to determine the effects of different management practices on *C. perfringens* populations.

Publications:
Chalmers, G., S. W. Martin, D.B. Hunter, J.F. Prescott, I. J. Weber, and P. Boerlin. 2008 Genetic diversity of Clostridium perfringens isolated from healthy broiler chickens at a commercial farm. Vet. Microbiol. 127:116-127.

Chalmers, G., S.W. martin, J. F. Prescott, P. Boerlin. 2008. Typing of Clostridium perfringens by multiple-locus variable number of tandem repeats analysis. 128:126-135.

Chalmers, G., H. L. Bruce, D. L. Toole, D. A. Barnum, and P. Boerlin. 2007. Necrotic enteritis potential in a model system using Clostridium perfringens isolated from field outbreaks. Av. Dis. 51:834:839.

**AMN003**
Carbohydrase enzyme supplements as growth promoters and modulators of the intestinal microflora of the chicken: The prebiotic and probiotic effect of enzyme hydrolysis products
*Bogdan Slominski and Gregory Blank, University of Manitoba*

Funding: $327,800 (CPRC $82,900, CBS $78,000, CBS (in kind) $6,000, ARDI $160,900)
Start date: January 2005
Expected end: March 2008
Interim report received: August 2005, November 2007
Final report received: April 2009
Status: complete

Background:
Common poultry diets based on corn, soybean, wheat and other plant-based ingredients have a number of constituents that are poorly digested. The presence of these indigestibles in the gut can serve as a substrate for a range of deleterious organisms. A significant proportion of these indigestibles are referred to as non-starch polysaccharides (NSP). The objective of this project is to use a new generation of carbohydrase enzymes to increase the hydrolysis of NSP and to see if their hydrolysis products promote the proliferation of beneficial bacteria in the gut and help protect poultry from Clostridium perfringens (the causative organism of necrotic enteritis). If successful, the use of carbohydrase supplements could offset the use of antibiotics in poultry feeds..

Research progress
A carbohydrase enzyme mix was tested at a range of concentrations and was shown to significantly depolymerise NSP of soybean meal, canola meal and flax. The ability of the enzymes to decrease the viscosity of flax-based products was also confirmed (high viscosity digesta has been linked to proliferation of pathogenic bacteria in the gut). The NSP hydrolysis products have been characterized. Drs. Slominski and Blank also looked at the effect of enzyme products on the proliferation of C. perfringens in the lab. These lab results did not demonstrate any clear effects, however experiments are now underway to test the effect of the enzyme supplement on the bacterium in the gut. Previous experiments suggest that when birds are fed diets without antibiotics or coccidiostats, enzyme supplementation results in an increase in feed efficiency. The enzymes may also slightly reduce the number of Enterbacteriacea and coliform bacteria in the small intestine and may increase the ratio of lactic acid bacteria to E. coli in the gut (it is hypothesized that carbohydrase hydrolysis products increase acidity in the gut making conditions more suitable to beneficial bacteria such as lactobacilli thereby allowing them to out compete other deleterious bacteria such as E. coli). These results, although promising, likely do not demonstrate the true value of the enzyme supplement. More dramatic benefits of enzyme supplementation are shown when birds are challenged with C. perfringens. Preliminary results indicate that when birds are fed a wheat-based diet, feed efficiency is increased during the grower-finisher phase compared to challenged birds that did not receive the supplement. Overall weight gain was improved for birds on corn-based diets. Similar challenge studies are now underway using a ‘hot’ field strain of C. perfringens known to cause necrotic enteritis in the field..

Publications:
Jia, W., B.A. Slominski, H.L. Bruce, G. Blank, and O. Jones. 2009. Effects of diet type and enzyme addition on growth performance and gut health of broiler chickens during sub-clinical Clostridium perfringens challenge. Poult. Sci. 88: 132-140.

Jia, W., B.A. Slominski, H.L. Bruce, G. Blank, and O. Jones. 2009. Enzyme addition facilitates the post-disease compensatory growth of broiler chickens challenged with Clostridium perfringens. Canadian Journal of Animal Science (Submitted Feb. 13, 2009).

Wang, X., G. Blank, and B. Slominski. 2009. Growth of Clostridium perfringens and background microbiology in ligated small intestine segments from broiler chickens fed wheat/soybean/canola meal- or wheat/soybean/canola meal/flax-based diets without or with enzyme supplementation. Poult. Sci. (to be submitted).

**AMN004**
Understanding how Campylobacter jejuni colonizes poultry
*Brenda Allan, Vaccine & Infectious Disease Organization*

Funding: $100,000 (CPRC)
Start date: November 2004
Expected end: December 2007
Interim report received: April 18, 2007
Final report received: January 2009
Status: complete

Background:
*Campylobacter jejuni* is the leading cause of bacterial gastroenteritis in humans in North America. In poultry, the bacterium resides in the gut without detriment to the bird. Poultry products contaminated with the bacterium are implicated as a source of human infection. The long-term goal of this research program is to decrease or eliminate the level of *C. jejuni* in poultry by vaccination. The first step towards achieving this goal is to better understand the mechanism by which this bacterium colonizes the avian gut.

Research Progress
It has been shown that some strains of *C. jejuni* are more adept at colonizing the avian gut than others. The proposed research aims to identify the factors which contribute to these differences. One approach is to introduce random genetic mutations into lab strains of the bacterium and test for their virulence. Differences in ability to colonize can then be correlated with specific genetic differences. The researchers first proposed the use of Sequence Tagged Mutagenesis (STM) to introduce and assess the mutants. However, during the planning stage, another group of scientists began a very similar project using the same technology. Rather than duplicate this effort, Dr. Allan decided to utilize Recombination-based In-Vivo Expression Technology (RIVET), which, at least in other organisms, can detect genes missed by STM. Unfortunately, Dr. Allan's group was unable to clear some technical hurdles (mainly associated with plasmid construction) necessary to make use of the RIVET method. As a result, the project took a different tack: to screen cattle, poultry and human samples for *C. jejuni* and compare isolates for the relative frequencies of various genes thought to be involved in virulence.

Forty-nine samples from cattle and 50 from humans were screened for the presence of 14 putative virulence genes (as indicated in the literature). Results of this screen were compared to results on poultry samples tested under a different project.

Results:
All putative virulence genes were detected in 20% of the samples. Approximately 60% of the samples were positive for all the genes, except for *virB11*. No differences were found between cattle and human samples. Although several genes were found less often in poultry samples, there were no clear differences in gene frequency among cattle, human or poultry samples. These results suggest that cattle may serve as a reservoir for strains of Campylobacter that colonize both poultry and humans.

Future work:
Some *C. jejuni* isolates have many putative virulence genes, while others have few. These 2 classes of strains will be tested for their ability to colonize chicks. Two animal models will be used:

In the *Standard Model*, all birds will be orally challenged with the appropriate dose of *C. jejuni* in a 0.5 mL volume. Colonization of the birds will be monitored by culturing cloacal swabs on Karmali Medium (Bacto) and growing under microaerophilic conditions. Five birds in each group will be tested for colonization by *C. jejuni* before the group was challenged. Birds will be maintained for seven days after challenge then euthanized by cervical dislocation. Ceca will be aseptically collected for quantitative assessment of colonization on day 7.
The *Horizontal Transfer Model* will assess the ability of *C. jejuni* to colonize orally challenged birds and unchallenged birds that are placed in contact with them. Only 20% of the birds will be challenged and marked for identification. All birds will be treated as described above. The use of the two models assesses the full range of colonization potential and will discriminate between different mutants.

This work may lead to information useful in determining what factors are involved in gut colonization by C. jejuni.

Publications:
Hannon SJ, Taboada EN, Russell ML, Allan B, Waldner C, Wilson HL, Potter A, Babiuk L, Townsend HG. Genomics-based molecular epidemiology of Campylobacter jejuni isolates from feedlot cattle and people in Alberta, Canada. J Clin Microbiol. 2008 Nov 26

**UAB005**
The impact of timing of protein intake and growth patterns on reproductive efficiency in broiler breeder females
*Principal investigator: Frank Robinson, University of Alberta*
*Research team: Rob Renema, Martin Zuidhof, Ali Pishnamazi (PhD), Nicholas Wolanski (MSc), Felicity Dennis, Nigel Davidson (technicians)*

Funding: $149,400 (CPRC $19,000, AARI $90,000, Aviagen $35,000, Aviagen (in kind) $5,400)
Start date: May 2004
Expected end: April 2006
Interim report received: n/a
Final report received: June 2008
Status: complete

Background:
There is a large variation in laying performance of commercial broiler breeder chickens, both among strains and among different producers. Careful management decisions are required, especially during sexual maturation, to maximize egg production. This project builds on years of work done at the University of Alberta towards a better understanding of the interaction between protein intake and reproductive efficiency in broiler breeders. This work has been especially enlightening as it creates profiles of these interactions for individual birds rather than looking at whole flock responses.

The overall objective of this research program is to determine the impact of varying protein intake patterns of broiler breeder females during the growth phase on carcass traits and reproductive potential and use this information to create a growth profile that can help predict future performance.

Specific Objectives are:
To examine how the timing of increases or reductions in dietary protein affect growth and breast muscle deposition. This will determine if more heavily fleshed birds maintain breast muscle tissue at the expense of egg production.
To characterize the physiology of the reproductive response (reproductive maturation, egg production traits, duration of fertility and hatchability) under normal and alternative protein intake conditions.
To use early and standard photostimulation ages to identify how protein intake patterns during rearing impact reproductive readiness.
To identify early indicators of metabolic and reproductive dysfunction. Can markers such as relative chick body weight, breast muscle fleshing, age at sexual maturity, and ovarian morphology be used to effectively predict reproductive potential?
To trace changes in weight and fleshing measurements of all birds in commercial broiler breeder flocks and to relate these changes to the health, livability and reproductive status of birds at the end of lay. Is there an ideal juvenile growth profile for long-term reproductive effectiveness in a commercial setting?

Research progress:
The main research flock related to this experiment consisted of 600 Ross 308s and 600 708s. During their growth phase, the birds were fed either a standard breeder ration or one that was 3% higher or 3% lower in dietary balanced protein (rations were balanced in the top 14 amino acids to avoid confounding results from limiting amino acids). The high or low protein rations were fed over 1 of 4 time periods: 1-7, 7-13, 13-19 or 19-25 weeks. Feed allocation was the same in the three feeding treatments. Birds were fed ad libitum for 2 weeks, then were on a 5 of 7-day feed restriction program, then fed daily from 17 weeks of age on. Various measures were taken throughout the experiment (body weight, external carcass characteristics, breast yield, fad pad weight, liver weight, reproductive development). As expected, the 308s were heavier overall and the 708s produced a higher percentage of breast yield. There were only minor diet effects on the birds prior to sexual maturity. At 17 weeks, a subset of birds was moved to individual cages. The 308s reached sexual maturity earlier. It was unexpected that changes to dietary protein during the 1 to 7 wk period (when early frame size set) and during the 19 to 25 wk period (when reproductive tract developing) did not affect reproductive or carcass traits at sexual maturity. Carcass traits at sexual maturation were most affected by changes in dietary protein during the 13 to 19 wk period. The 7 to 13 wk dietary protein level influence on subsequent ovary traits at sexual

maturity is the earliest demonstration of nutrition on the ovary – which is normally immune to changes prior to 14 wk of age. Although statistically significant, the differences were not large. The importance of the results exist in the fact that a 3% change in dietary protein can continue to have an effect long after the point in rearing it was given. These results suggest that feeding a high protein diet during the growth phase may not be necessary for good reproductive development.

The true impact of a treatment is on the long-term reproductive traits – egg and chick production. Dietary protein levels had minor effects on egg production. Neither the total eggs laid nor the number of settable eggs was significantly influenced by diet. Feeding the LOW diet to young pullets (1-7 wks) led to production of the most small eggs. Feeding the HIGH diet later on (13-19 wks), especially close to sexual maturity (19-25 wks), resulted in the lowest fertility. Both the 308s and the 708s performed well on the standard diet. Ultimately chick production was reduced by altering the dietary protein during rearing. This effect was most pronounced early in lay. Hatchability in early production (31 to 42 wk of age) was 89% in control birds vs. 82% and 85% in HIGH and LOW dietary balanced protein groups, respectively. Birds receiving additional protein at some point during the rearing phase ultimately produced 8 fewer chicks than hens on the standard diet Control treatment.

In a related trial, chicks were fed ad lib for either 1 or 3 weeks. Growth curves thereafter were designed to merge the 2 groups by 10 weeks of age. As expected, the 3WK group initially gained much more weight, but upon being feed restricted virtually matched the other group in all respects, including apparent reproductive development, by the end of the trial (16 weeks). Flock uniformity was better for the 1WK group, presumably due to the easier transition into feed restriction and less competition for feed from aggressive birds. The pullets were photostimulated at 17, 19, 21 or 23 weeks. As expected, stimulating birds later resulted in delayed onset of sexual maturity, but these birds matured more quickly than those photostimulated early. Flocks stimulated later came into lay most consistently and had larger early eggs. These results suggest that more mature birds can better respond to photostimulation cues.

Data were also collected on 2 commercial breeder flocks from hatch to end of lay. Chick size had little correlation to production traits while measurements at 9 weeks were more predictive. On average, lighter birds had fewer large yellow follicles (LYFs) in their ovary and a higher percentage of them were out of lay. Everting the cloaca, as is done during artificial insemination, was used to indicate if a hen was laying or not. Heavy birds, on the other hand, tended toward more LYFs (too many LYFs can result in double-yolked eggs and other reproductive problems).

Future work:
The results continue to be analyzed in the context of the overall breeder physiology program. As the broiler breeders of the future continue to improve their growth and breast muscle deposition potential, protein delivery may start to play a more important role and warrant rethinking how we grow our breeding stocks. This project has identified some of the issues we will face.

**ENV006**
Distribution uniformity and emission reduction potential of a precision applicator for surface and sub-surface land application of poultry manure

Principal Investigator: Claude Laguë, P.Eng., Ph.D., Adjunct Professor, Department of Agricultural and Bioresource Engineering, College of Engineering, University of Saskatchewan (Dr. Laguë is currently Dean and Professor, Faculty of Engineering, University of Ottawa)
Collaborators: Joy Agnew, P.Eng., M.Sc., Ph.D. candidate, Department of Agricultural and Bioresource Engineering, College of Engineering, University of Saskatchewan. Hubert Landry, P.Eng., Ph.D., Project Leader, Prairie Agricultural Machinery Institute

Funding: $504,743 (CPRC $12,935, NSERC/AAFC $25,866, Universities of Saskatchewan and Ottawa $55,500, NSERC (IRF) $60,000, PAMI (in kind) $21,800, SAFRR $103,318, ACAAF $225,324)
Start date: November 2005
Expected end: October 2007
Interim report received: September 14, 2006
Final report received: January 2008
Status: complete

Background:
The main objective of this project was to engineer a precision land applicator adapted to a variety of solid and semi-solid manures (including poultry manure) and other organic fertilizers. The performance goals of the applicator included application and subsurface incorporation in a single pass, uniform distribution, and low odour and greenhouse gas emissions.

Research Progress:
Several improvements were made to the original prototype applicator that had been previously developed by the University of Saskatchewan, especially the design of an innovative subsurface application system adapted to solid manure products. A flexible auger system was developed to feed manure into a tube that injects the material directly behind a disk opener. Another disk closes the trench, effectively incorporating the manure.

Results:
Not only does the new prototype incorporate manure, it distributes it very uniformly. Uniformity of distribution, measured using beef cattle manure compost (similar in physical characteristics to poultry manure), was demonstrated by a coefficient of variation (CoV) of approximately 7% (CoV gives an indication of how evenly manure is applied – the smaller the number, the more uniform the manure is spread. CoV's for commercial solid manure spreaders typically range from 30% to 110%. A spinner-type spreader broadcasting poultry manure over a 40 ft width has a CoV of about 50%).

The current prototype (with 6 injectors) requires an estimated 72 kW (~100 hp). By comparison, spreaders with vertical or horizontal beaters require about 40 kW (~55 hp), while spinning disc type spreaders require about 60kW (~80 hp). Although a larger tractor is required, manure is simultaneously spread and incorporated, which represents time and energy savings versus separate spreading and incorporating operations.

When the prototype is adjusted to achieve maximum coverage of material, subsurface application of solid manure will significantly reduce odour emissions. There is, however, a trade-off in that greenhouse gas ($CO_2$, $CH_4$, $N_2O$) emissions increase with injection - the increase is about 30% for solid manure injection compared to surface application and about 45% for liquid manure injection compared to surface application.

Publications:
Karmakar, S., C. Laguë, J. Agnew and H. Landry. 2007. Integrated decision support system (DSS) for manure management: A Review and Perspective. Computers and Electronics in Agriculture 57: 190 - 201.

Laguë, C., J. Agnew, H. Landry, M. Roberge and C. Iskra. 2006. Development of a Precision Applicator for Solid and Semi-solid Manure. Applied Engineering in Agriculture 22 (3): 345 – 350.

**ENV007**
Development of a dynamic model of Ca and P flows in layers
*James France, University of Guelph*

Funding: $60,180 (CPRC $20,060, NSERC/AAFC $40,120)
Start date: November 2005
Expected end: October 2007
Interim report received: July 31, 2006
Final report received: January 30, 2008
Status: complete

Background:
The main objective of this project was to develop a mathematical model to describe and predict calcium (Ca) and phosphorus (P) flows in layer chickens. A functional model would help industry (producers, nutritionists etc.) make dietary and management decisions to optimize Ca intake and reduce P excretion in manure. This process has the potential economic impact of saving dietary input costs while maximizing layer productivity and will help mitigate the environmental impact of commercial layer production.

Research progress:
The first step in this project was to perform a literature review to collect relevant data regarding the interactions of Ca and P in layers. Data collected were entered into a database that was used to develop a model of Ca and P flow in layers. Using data from the literature, the research team was able to enter variables into the model and accurately predict outcomes that matched those measured in real experiments. There were few data representative of Canadian field conditions in the literature, however, so the model was not tested as vigorously as the research team hoped. Based on tests that were performed, it is anticipated that the model will serve as a useful tool to help the industry adjust layer diets and make management decisions that will optimize Ca intake and minimize P excretion in layer manure.

Publications:
Kebreab, E., J. Dijkstra, R. P. Kwakkel, S. Leeson, H. Darmani Kuhi, R. S. Diaz and J. France. 2008 Development and evaluation of a dynamic model of calcium and phosphorus metabolism in layers. Submitted to J. Poultry Science.

**ENV008**
Activity-specific Workplace Exposures of Poultry Barn Workers
*Principal investigator: A. (Sentil) Senthilselvan, University of Alberta*
*Co-investigators: Irene Wenger, Nicola Cherry, John Feddes, Jerry Beach, University of Alberta*

Funding: $33,726 (CPRC $11,242, NSERC/AAFC $22,484)
Start date: February 2006
Expected end: March 2008
Interim report received: n/a
Final report received: July 2008
Status: complete

Background:
There are relatively few data available on the exposure of poultry workers to environmental contaminants. The purpose of this study was to log the amount of time poultry workers spend on various activities on farm and to measure their exposure to environmental contaminants (respirable dust, ammonia, CO2). Exposures were compared between layer and broiler operations throughout production cycles at different times of the year

Research Progress:
During a previous study, poultry workers completed questionnaires designed to determine the amount of time they spent on various farm activities. Workers were also fitted with Personal Environmental Sampling Backpacks to measure contaminant (dust, ammonia, relative humidity, carbon dioxide) exposure during these activities. In all, there were 17 layer operations and 16 broiler operations visited. Broiler farm visits occurred at different times of the year and layer visits occurred at various stages of the flocks' production cycles. Data from point exposures were linked to activity diaries to estimate total exposures for the workers.

Dust (<10µm) levels overall were higher in broiler barns than in layer barns. There was no season difference in dust levels in the broiler barns, but they were higher in the layer barns during the winter than the summer.

Relative humidity (RH) was generally higher in broiler barns than layer. There was no season difference in RH in the broiler barns, but it was higher in the layer barns in the summer than in the winter.

Carbon dioxide levels were higher in the broiler barns vs. layers, and were higher in the winter vs. summer for both types of operations.

There was no season difference in temperature in the layer barns while the broiler barns were warmer in summer than in the winter.

As the broilers aged, dust levels increased, but there were no changes in ammonia, CO2 or RH. There were no layer flock age effects on any of the contaminants measured.

All stated objectives were met. In addition to the measurements outlined above, the project was intended to suggest measures to protect poultry workers from potential environmental health hazards. Surprisingly, the study suggests that ammonia exposures did not exceed the 25ppm Time Weighted Average Threshold Limit Value (the TLV of a chemical substance is a level to which it is believed a worker can be exposed day after day for a working lifetime without adverse health effects, according to the American Conference of Governmental Industrial Hygienists (ACGIH)). The authors did point out, however, that the sampling equipment used has a time lag and may have underestimated ammonia levels since the workers were in the barns for relatively short periods of time. Similar to ammonia, measured CO2 levels did not exceed the 5,000ppm TWA TLV. The authors do recommend that poultry workers use N95 or comparable respirators while working in their barns to mitigate adverse effects of respirable dust.

Related Publications:
Kirychuk SP, Dosman JA, Reynolds SJ, Willson P, Senthilselvan A, Feddes JJ, Classen HL, Guenter W. Total dust and endotoxin in poultry operations: comparison between cage and floor housing and respiratory effects in workers. J Occup Environ Med. 2006 Jul;48(7):741-8.

Wenger, I.I., Ouellette, C.A., Feddes, J.J.R., and Hrudey, S.E. 2005. The Design and Use of the Personal Environmental Sampling Backpack (PESB II) for Activity-Specific Exposure Monitoring of Career Pig Barn Workers. Journal of Agricultural Safety and Health. 11(3):315-324

**ENV009**
Reducing pollution from veterinary pharmaceuticals in agricultural runoff from poultry manure
Principal investigator: Shiv Prasher, McGill University
*Co-investigators: Xin Zhao, McGill University, Ciro Ruiz-Feria, Texas A&M University*

Funding: $114,000 (CPRC $38,000, NSERC/AAFC $76,000)
Start date: January 2006
Expected end: December 2007
Interim report received:
Final report received: April 2008
Status: complete

Background:
This project was aimed at investigations into the fate and transport of veterinary pharmaceuticals (VPs) in soil and water. There has been relatively little work done in this area, especially specific to Canadian conditions. More information is required to determine the extent to which VPs persist in agricultural soil and runoff, and what risks are posed by their presence.

Research progress:
Manure from Quebec poultry farms feeding one of 3 coccidiostats (monensin, narasin and salinomycin) was applied to soil at 10 Mg/ha (~4.5 ton per acre). The soil was previously free of poultry manure for 10 years. Specially designed devices, known as lysimeteres, were used to track the movement of these VPs through the soil and into ground water. Rainfall was simulated to represent the 50-year maximum in the area over 3 months (July to September). Soil samples were collected from the surface and at three depths (0.1, 0.3, 0.5m), and leachate (water runoff) was collected 0.9m below the surface throughout the experiment.

Monensin persisted at various soil depths for over 60 days. At the surface, it decreased from 16.1 mg/kg on day 0 to 1.54 mg/kg on day 60. At other depths, monensin levels initially increased, and then decreased. The pharmaceutical was detected at all four soil sampling depths from day 7 through day 60. A small amount of monensin was also observed in drainage waters from day 3 to day 15. At the soil surface, narasin levels declined from 11.08 mg/kg on day 0 to 0.036 mg/kg on day 30, while below the soil surface and in drainage water, it only persisted until day 15. Salinomycin at the soil surface, initially at 8.5 mg/kg dropped to 0.72 mg/kg by day 3, and was undetectable thereafter. While below the soil surface, salinomycin only remained detectable until day 7 it remained detectable in drainage water until day 60, where its concentration (1.56 mg/L) was greater than that of either monensin (0.34 mg/L) or narasin (0.32 mg/L). It appears that whereas monensin could persist in soil over a longer period, salinomycin is more mobile and may present a greater threat to water resources. Studies are also underway to investigate the effect of VP-manure on the half-life of commonly used herbicides. Initial results indicate that half-lives of three herbicides (atrazine, metolachlor, and metribuzin) increased with the presence of VPs in soil. One of the primary mechanisms of pesticide degradation in soil is microbial degradation and the presence of VPs in soil may be affecting microbial survival in soil. However, more work needs to be done in this area before any concrete conclusions can be drawn.

Future work:
It took longer than expected to develop and refine techniques for VP extraction. The objective of testing the project's data against a mathematical model was therefore not achieved in the expected timeframe. This work is, however, currently underway. It is hoped that information gathered during ongoing work will lead to Best Management Practices designed to mitigate any negative effects of VPs in the environment.

Publications:
Soma, V., S.O. Prasher, R.M. patel, C.A. Ruiz-Feria, and X. Zhao. 2008. Fate and transport of monensin in soil. Manuscript under preparation. Transactions of the ASABE.

Soma, V., S.O. Prasher, R.M. Patel, C.A. Ruiz-Feria, and X. Zhao. 2008. Movement of narasin in soil and water: a lysimeter study. Manuscript under preparation. Agricultural Water Management.

Soma, V., S.O. Prasher, R.M. Patel, C.A. Ruiz-Feria, and X. Zhao. 2008. Leaching of salinomycin from poultry manure into soil and groundwater. Canadian Biosystems Engineering.

Fan, M, S.O. Prasher, and R.M. Patel. 2008. Effect of poultry manure pharmaceuticals on persistence of agricultural herbicides in soil. Transactions of the ASABE.

**AGA010**
Cryopreservation of Canada's Remaining Avian Germplasm
*Fred Silversides, Agriculture and Agri-Food Canada*

Funding: $69,000 (CPRC $34,500, AAFC $34,500)
Start date: September 28, 2006
Interim report received:
Final report received: July 27, 2007
Status: complete

Background:
In 1946 there were 300 breeders of poultry in Canada. Today, 90% of the broiler chickens in North America and 90% of layers worldwide come from 2 breeder companies each; none of these companies is Canadian owned. Many genetic lines at institutions and research facilities across the country have also been dropped. According to a 2005 survey of institutions at Agriculture and Agri-Food Canada (AAFC) and the Faculties of Agriculture and Veterinary Medicine, only 5 institutions still carry genetic stocks, representing 33 lines of chickens in 23 different populations. These stocks of live birds are at continual risk from disease and budget cuts. There needs to be an economical way to address this drastic reduction in the genetic diversity of poultry stocks in Canada.

Freezing and storing semen, as has been used to preserve genetic stocks in other agricultural species, does not work well with poultry. Furthermore, the large size and fragility of the avian egg prevents any attempts to freeze its genetic material. Although freezing and storing cells from undifferentiated embryos has met with some success, the procedure to reconstitute flocks is technically difficult. Dr. Silversides and his team suggest an alternative procedure. They have demonstrated that ovarian tissue can be collected from day-old chicks and transferred to recipient chicks. They have also shown that testicular tissue can be transplanted from one chick to another resulting in live offspring once the recipient reaches sexual maturity. The implication of these results is that these tissues can be collected from chicks of genetic interest and frozen for long-term storage. When there is a need to regenerate flocks, the tissues can then be thawed and transplanted to recipient chicks that, upon reaching sexual maturity, can be bred to produce offspring with the genetic makeup of the transplanted tissue.

Research progress:
The aim of this project was to freeze the gonads of 120 individuals from each population of chickens currently kept at AAFC and university facilities across Canada, with the eventual goal of recuperating offspring from each flock. Thus far, tissues from 1558 individuals representing 18 populations from 3 institutions were frozen. Unfortunately, due to hatching problems, enough material was collected from only 3 populations (there needs to be a certain number of individuals recuperated per line to produce enough birds in a flock to avoid inbreeding problems). Attempts have not been made to regenerate flocks from any of these frozen tissues.

Future work:
Dr. Silversides and his team will continue to freeze gonadal tissue from lines of birds across the country. Although the proof of concept of recuperating flocks from frozen gonads has been established, Dr. Silversides notes that long-term institutional commitment is required to form a fully functional gene bank.

Related publications:
Silversides, F. G., Shaver, D. McQ. and Song, Y. 2007. Pure line laying chickens at the Agassiz Research Centre. Animal Genetic Resources Information 40: 79-85.

Song, Y. and Silversides, F. G. 2006. The technique of orthotopic ovarian transplantation in the chicken. Poult. Sci. 85: 1104-1106.

Song, Y. and Silversides, F. G. 2007. Offspring derived from orthotopic ovarian transplants in chickens. Poult. Sci. 86: 107-111.

Song, Y. and Silversides, F. G. 2007. Heterotopic transplantation of testes in newly hatched chickens and subsequent production of offspring via intramagnal insemination. Biol. Reprod. 76: 598-603.

Song, Y. and Silversides, F. G. 2007. Production of offspring from cryopreserved chicken testicular tissue. Poult. Sci. 86: 1390-1396.

**FSQ011**
Immunization of broiler chickens against necrotic enteritis
*John Prescott, University of Guelph*

Funding: $96,813 ($33,981 CPRC, $62,832 NSERC/AAFC)
Start date: September 2006
Expected completion date: August 31, 2009
Interim report received: July, 2007
Final report received: November 2009
Status: complete

Background:
The long-term goal of this project is to develop a means of protection against Necrotic Enteritis (NE) in broiler chickens alternative to the antimicrobials currently used in the industry. The issue of increasing bacterial resistance to antimicrobials is of major concern to the Canadian poultry industry; alternative means to control important disease such as NE would have significant impact.

Research progress:
Despite its prevalence, there is relatively little known about immunity to NE. Dr. Prescott's team has made significant advances in understanding of the subject. They first showed that it is possible to confer resistance to NE by oral infection with virulent strains of C. perfringens. "Virulent" strains are those capable of producing disease. A number of proteins secreted by these strains were shown to elicit immune reactions. Among these proteins were alpha-toxin (AT) and others which are given the short names FBA, GPD, HP and PFOR. Intramuscular immunization with these proteins revealed all could protect birds from mild challenge. AT, HP and PFOR could protect against more severe challenge. Alpha toxin has historically been considered in the literature as the most important factor causing NE. However, more recent work from around the world is casting some doubt on the importance of its role in causing disease. Dr. Prescott's work further suggests that certain secreted proteins, in addition to AT, are involved in immunity to NE.

With this information in hand, Dr. Prescott and his team set sights on developing a NE vaccine that could deliver one or more of these proteins, or at least fragments of the proteins that elicit an immune response. They reasoned that an effective NE vaccine would deliver these protein fragments or "antigens" directly into the intestine. There are existing Salmonella vaccines that do just that. Dr. Prescott decided to start with one of these vaccines and modify it so it could confer resistance to Clostridia in addition to Salmonella. A number of such vaccine vectors were constructed and tested.

Salmonella vaccines expressing FBA and HP were able to protect chickens from NE challenge. These chickens produced antibodies to antigens from both Salmonella and Clostridia. Dr. Prescott's team wanted to increase the level of protection and also wanted to test a vaccine that expressed AT. The researchers made a number of modifications to the vaccine system. They fine-tuned the protein fragments expressed by the vaccine, increased the production levels of the antigens and changed the backbone of the vaccine vector. Disappointingly, the modified AT vaccine only protected birds from moderate challenge. The HP-based vaccine protected them from more severe challenge, but protection levels were not as good as in previous experiments. Neither protected birds from Salmonella infection. Further studies showed the genetic modifications weakened the vaccine strain rendering it less effective..

Future work:
Although disappointing, these results revealed important information on vaccine design. Dr. Prescott's team is now using this information to better define the parameters for development of a successful NE vaccine based on improved Salmonella vaccine carriers that can also deliver other antigens. A successful multivalent vaccine approach such as this will have significant impact on both food safety and poultry health.

**FSQ012**
Immunology of T cell-mediated immune response to avian influenza virus in the chicken
*Shayan Sharif, University of Guelph*

Funding: $359,400 (CPRC $59,800, PIC $60,000, NSERC/AAFC $239,600)
Start date: March 2007
Expected end: February 2009
Interim report received: December 2007
Final report received: August 2009
Status: complete

Background:
The long-term objective of this project is to develop effective, broad-spectrum vaccines against avian influenza (AI) virus. There is relatively little known about the chicken's immune response to AI virus infection. The immediate objectives of this project, therefore, are to identify the molecular determinants that confer immunity to the virus and identify the immune system cells that see these determinants. The project is also aimed at determining the dynamics of immune system cells in response to AI virus infection and to elucidate the genetic pathways that control that response. A better understanding of the immunology of AI is required before rational control strategies can be developed.

Research progress:
The direction of this research program is ever-evolving as more information about AI and potential measures for its control are gained worldwide. There are a number of approaches to AIV vaccines under development, such as inactivated viral vectors expressing AIV antigens, naked DNA or recombinant proteins. There are even a few commercially available (not in Canada) AIV vaccines. None of the approaches or vaccines thus far are without their shortcomings. We need to know more about the biology of AIV to develop more efficient control measures.

Studies on the chicken's immune response to AIV infection suggests that antibodies produced against AIV HA antigens are the most important in eliciting a protective response. NA antigens elicit production of neutralizing antibodies that appear to reduce virus shedding from infected individuals, and may have a synergistic protective effect as well. Dr. Sharif wants to produce a vaccine that presents one or both of these antigens (and perhaps as well immune system molecules such as cytokines). Dr. Sharif worked with Eva Nagy at Guelph to construct fowlpox virus (FPV) vectors expressing AIV proteins (HA, NA etc.). Two HA sequences from Canadian H5N1 isolates were integrated into the system, but the resulting vector was not stable. Dr. Sharif's team therefore adapted an *in vitro* protein expression system to produce the antigens. Their intent is to use the antigens to stimulate AIV-specific T-cells *in vitro*. In order to do so, they need a line of these cells that is stable in culture. Dr. Sharif has developed cell lines before and has established proof-of-principle on using reticuloendothelial virus (REV) to transform a cell line. Assays were developed that measure a number of these cells' responses (e.g. expression of cytokine genes, transcripts of cytokine genes, pathway signals etc.).

Parallel to the studies described above, Dr. Sharif's group looked at immune responses to commercial vaccines that are based on FPV. (little is known about responses to recombinant FPV). They immunized immune-defined chickens with rFPV vectors expressing HA antigen from H5 AIV. Spleen cells from these birds were treated in vitro with a range of small protein fragments of the HA antigen. They identified a peptide that could elicit an increase in cytokine expression. This immune trigger or "epitope" appears to be conserved among various H5 AIVs. The epitope is not, however, immunogenic in chickens on its own, but could elicit a low T-cell response when introduced with adjuvants. This epitope may be used to broaden the immune response and therefore protective effect of future vaccines.

Future work:
The information gained from this research adds to the overall understanding of the chicken's response to AIV infection. The research group identified a molecular determinant within the HA antigen that will serve in future studies as a candidate vaccine against high path AIV.

**FSQ014**
Development of second generation RNA interference constructs against avian influenza virus
*Serguei Golovan, University of Guelph*

Funding: $76,500 (CPRC $25,200, NSERC/AAFC $50,400)
Start date: November 2006
Expected end: October 2009
Interim report received:
Final report received:
Status: in progress

Background:
Poultry is in continuous contact with a great variety of viruses, and while they are resistant to the majority, they are harmed by a few, resulting in significant economic losses. Recent events have demonstrated that avian influenza is a constant threat to poultry industry worldwide. Avian influenza not only results in significant monetary loss for the poultry industry, but also represents a serious risk to human health. The possibility
of another worldwide influenza pandemic is now taken very seriously. At the first sign of avian influenza outbreak, millions of birds have to be destroyed and an embargo on import of poultry products from the affected country is implemented. It is almost impossible to eliminate natural reservoirs of avian influenza virus in wild migratory birds that show no visible symptoms yet can easily spread the pathogenic virus strains across the borders. Vaccination is only partially effective due to rapid antigenic drift of targeted epitopes of influenza virus. Conventional breeding has not produced highly resistant and commercially acceptable varieties. As the virus depends on the host cellular machinery for its propagation, preventing access to this machinery in the cells might block viral replication and interrupt the infection cycle. This project aims to develop RNAi molecules highly efficient against avian influenza virus. The development of this technology might lead to treatments that prevent avian influenza infection, and production of influenza-resistant poultry. The proposed research will also improve the understanding the role natural RNAi plays in protecting poultry from viral infection.

**FSQ015**
Novel multivalent vaccines for avian health
*Eva Nagy, University of Guelph*

Funding: $276,750 (CPRC $96,750, NSERC/AAFC $180,000)
Start date: December 2006
Expected end: November 2009
Interim report received: September 2007
Final report received:
Status: in progress

Background:
Infectious diseases caused by a host of pathogens constantly threaten the poultry industry. As part of the arsenal of prevention and control measures, there is a need for more effective vaccines. The goal of this research to create a biological platform for the production of effective vaccines that protect flocks from more than one pathogen at a time and, when used to infect birds, can be distinguished from that of naturally occurring viral infection in the field. This is an ambitious project that endeavours to use molecular biology to create a vaccine vector based on the fowl adenovirus (FadV-9) that can deliver genes of interest (such as those coding for pathogenic virus antigens) to the bird thereby eliciting an immune response against those antigens

Research Progress:
Results have not yet been approved for public release

**PWB017**
Engineering, animal welfare and meat quality considerations of broiler transportation in a heated and ventilated vehicle
*Trever Crowe, University of Saskatchewan*

Funding: $1,229,757 (CPRC $90,000, NSERC/AAFC $800,000, PIC $23,300, CFOS $80,000, ACP $30,000, AFAC $10,000, SCIDF $55,425, Lilydale (in kind) $141,032)
Start date: January 2007
Expected end: December 2010
Interim report received: October 2007
Final report received:
Status: in progress

Background:
Transport of broiler chickens represents a major welfare challenge to the poultry industry. Temperature and humidity levels in commercial transport vehicles are highly variable, which can expose some or all of the birds to undue stress. Previous research at the University of Saskatchewan demonstrating this variability has led to the development of a prototype broiler transport trailer with active heating and ventilation capable of much better environmental control than commercial trailers currently used. The purpose of this project is to measure and compare differences in temperature and humidity between the prototype and commercial trailers in a range of environmental conditions typical of Canadian winters. The effects of temperature and humidity extremes on the welfare of the bird will also be examined.

Research progress:
Activities thus far include recruitment of personnel, development of protocols, completion of funding applications and equipment acquisition. Fifteen field trials have been performed under ambient conditions ranging from –27oC to 13oC. Many data have been collected covering such parameters as trailer temperature, trailer humidity, body core temperatures, and shrinkage during transport. Dr. Crowe's team is also looking at and adjusting air flow patterns through the prototype trailer to optimize humidity control; there is a possibility that controlling humidity will allow the birds to better tolerate low temperatures with less need for auxiliary heat. Data have also been collected on over 750 carcasses, which will be used to establish the effects of environmental effects on meat quality.

Future work:
There have already been many data collected with several more field trials planned. Future studies using environmental chambers will help determine the low ambient temperature threshold during which broilers can safely be transported.

**PWB018**
Improving welfare for beak trimmed hens through reducing variability and technology transfer
*Hank Classen, University of Saskatchewan*

Funding: $162,375 (CPRC $60,253, NSERC $102,122)
Start date: April 2007
Expected end: March 2010
Interim report received: January 2008
Final report received:
Status: in progress

Background:
Beak trimming is commonly performed on layers, breeders and turkeys to minimize feather pecking and cannibalism in commercial flocks. The practice has come under scrutiny, however, because of associated pain, both immediate and chronic. While there remains some question as to the amount, or even presence of, chronic pain resulting from beak trimming, it is clear that acute pain can be minimized by trimming beaks less aggressively and doing so when the chicks are young. Achieving this end in the commercial setting, however, is difficult as chicks vary in size for which semi- or fully automatic equipment cannot properly adjust. The objectives of this project are:

1. To establish the degree of variability in beak trimming in commercial flocks
2. To determine the causes of this variability and develop methods to minimize it (perhaps by sorting eggs, and therefore chicks, by size and calibrating trimming equipment according to a specified size range)
3. To develop Standard Operating Procedures and training programs to be used by personnel performing beak trimming

Several strains of layer chicks will be monitored immediately after various trimming techniques to assess acute pain, as well as long-term (to approximately 40 weeks of age) to determine if any experience chronic pain or inferior performance due to beak trimming. The economic impact of any long-term effects will also be considered.

Research progress:
Visits to commercial farms are planned for February and March 2008. Chicks from commercial hatcheries trimmed using infrared light or a hot blade are being raised at the University of Saskatchewan and observations are being collected (expected completion in July). Laser-trimmed chicks are no longer available Western Canada so provisions have been made to obtain some from the U.S. Results are expected from these chicks in June 2009.

**PWB019**
Effect of lighting programs on leg weakness and bird welfare in modern commercial broilers
*Hank Classen, University of Saskatchewan*

Funding: *$241,037(CPRC $52,214, NSERC/AAFC $158,223, Lilydale (in-kind) $30,600)*
Start date: March 2007
Expected end: February 2010
Interim report received: January 2008
Final report received:
Status: in progress

Background:
Previous research suggests that lighting programs that include a period(s) of darkness are a simple way to improve broiler welfare. This research project aims to provide information on the impact of various darkness patterns, initiated at various ages, on leg weakness in broilers. Another objective of this project is to develop a simple method of assessing leg weakness on farm. Specifically, the objectives of this project are:
To define the importance of length of continuous darkness on leg weakness and production traits in broilers
To establish the effects of age of initiating extended darkness on leg weakness and broiler productivity
To determine if gait scoring represents an accurate measure of leg pain
To evaluate the use of force plate technology in assessing leg weakness
To establish the relationship of behaviour to leg weakness
To model the economic effects of implementing lighting programs with extended darkness

Research Progress:
The first experiment towards achieving objective 1 is complete with a second underway. Ross x Ross 308 broilers were subjected to various lighting programs. Data were collected on body weight, feed consumption, mortality (frequency and cause), and behaviour (at 32-24 days of age), gait score, footpad condition and meat yield. Many data have been tabulated and analyzed. Video (behaviour) records have not been observed yet. Towards objective 4, a force plate system has been designed with testing and calibration work planned for January or February 2008. Work towards achieving objectives 2, 3 and 6 are planned for subsequent phases of the project.

**PWB020**
Evaluation of alternative methods of euthanasia for cull turkeys
*Principal investigator: Tina Widowski, University of Guelph*
*Co-investigator: Pat Turner, University of Guelph*
*Collaborators: Bruce Hunter, University of Guelph; Penny Lawlis, OMAFRA; Lloyd Weber, LEL Farms*

Funding: $75,579 (CPRC $25,193, NSERC/AAFC $50,386)
Start date: April 2007
Expected end: October 2009
Interim report received: August 2008
Final report received: December 2009
Status: complete

Background:
Over 20 million turkeys are produced annually in Canada. As with all animal production systems, it is inevitable that some birds will become injured or diseased and under these circumstances, euthansia is necessary to reduce suffering. In Canada, the current recommended euthanasia methods for turkeys on farms include blunt force trauma and cervical dislocation (Codes of Practice for Care and Handling of Farm Animals, CARC 2003). The American Veterinary Medical Association also considers manual cervical dislocation to be an acceptable method for small birds, and the Canadian Council on Animal Care considers mechanical cervical dislocation to be an acceptable method for large birds. Until now, no scientific studies have been conducted to determine which methods are most effective for rapidly rendering turkeys insensible, and this is the most important criterion for determining the humaneness of a method. Additionally, even when a method may be considered to be humane, it may be aesthetically unacceptable and therefore difficult for a stockperson to perform. This project investigated the effectiveness of the Zephyr, a pneumatic non-penetrating captive bolt for euthanasia of cull turkeys and compared measures of insensibility and the degree brain lesion caused by the Zephyr to the other physical methods of euthanasia.

Research progress:
The experiments were conducted on commercial farms, using commonly accepted methods for determining loss of consciousness and time of death, and they were performed only on birds deemed to require euthanasia. The carcasses of the birds were then brought back to the laboratory where necropsy, radiographic and histological techniques were used to quantify and compare the degree of brain trauma resulting from the different methods. Results indicated that the Zephyr was a highly repeatable and effective method for euthanasia of birds in all of the weight classes tested, and the researchers are now looking to have the device manufactured and made available for commercial use. Results also indicated that although blunt force trauma may be aesthetically displeasing, it is in fact, a humane method for killing turkeys. However, results also suggest that the methods used for cervical dislocation, particularly by mechanical means (cervical crushing) do not render birds unconscious immediately and any recommendations for their use need to be reconsidered. This project has provided important science-based information for improving animal welfare on farms.

**PWB021**
Impact of ammonia on welfare of laying hens, and implications for the environment
*Steve Leeson and Tina Widowski, University of Guelph*

Funding: $458,499 (CPRC $51,118, NSERC/AAFC $305,666, Novus $60,000, Ajinimoto $41,715)
Start date: January 2008
Expected end: December 2010
Interim report received:
Final report received:
Status: in progress

Background:
Atmospheric ammonia is known to impact bird health and that of poultry workers. Ammonia is a breakdown product of uric acid, which is the main nitrogenous component of avian urine. Consequently, the more uric acid excreted, the greater the potential for ammonia release. To date, the main mechanism to control environmental ammonia levels in layer barns has been by adjustment to the ventilation air flow. There is now concern about the contribution of animal agriculture to ammonia release into the atmosphere, and so this option is likely going to be curtailed and/or regulated in the near future. The goal of this research program is to quantitate ammonia release from caged layers relative to various nutritional and intervention strategies and assess layer welfare in terms of any physiological changes to the bird, as well as test the layers voluntary aversion to, or acceptance of, graded levels of atmospheric ammonia.

**CTM022**
Use of dietary thyroxin as an alternative moulting procedure in turkey breeder hens
*Gregoy Bédécarrats, University of Guelph*

Funding: $61,650 ($27,125 Canadian Turkey Marketing Agency, $3,700 Hybrid Turkeys (in kind), $30,825 NSERC (not yet confirmed))
Start date: June 2007
Interim report received: August 2007
Final report received: October 2009
Status: complete

Background:
Molting is a natural process of many wild birds that occurs after the breeding season. During molt, most feathers are replaced, bone structure is remodelled, and the immune system is rejuvenated. The female reproductive system regresses and is repaired during molting, which temporarily stops egg production. After molting, birds are in essence recharged and physiologically ready for another breeding season. This process is key to the long-term reproductive success of wild avian species.

In the commercial setting, the natural cues that trigger molting are not present, plus commercial breeding stocks have been genetically selected for production cycles that extend far beyond those of their natural cousins. However, egg production does gradually decrease to the point where a flock is no longer economically viable. Turkey breeder stocks are generally replaced at this point. This approach works within the industry only when replacements are in sufficient supply. In times when supply is cut off, such as when bird movement restrictions are imposed during a disease outbreak, alternative means to maintain fertile egg production in the industry may be needed. Molting is a procedure that could be used to 'reset' a flock and gain a second production cycle after the first has ended.

Traditional methods of molting commercial poultry involve severe water and feed restriction. While effective, these methods have serious animal health and welfare concerns and are discouraged in Canada. As an alternative, it has been shown that adding the hormone thyroxine to a chicken's diet can induce molting. Dietary thyroxine mimics the hormonal changes that occur naturally during molt and thus helps to artificially trigger a molt without the need to restrict feed or water. The objective of this project was to determine if this method could be adapted for use in turkeys.

Research progress:
Several trials on small flocks of commercial turkey breeders were performed that showed thyroxine could indeed be used to induce molting in turkeys. The researchers then determined the minimum dose required to do so. Induction of molting alone, however, does not do the industry much good if the birds are unable to begin a new production cycle after molting. Drs. Bédécarrats and Renema determined that a period of reduced day length (achieved with artificial lighting) was required in addition to the thyroxine to completely reset the birds' reproductive tract thus allowing them to start a new production cycle. After testing several combinations of thyroxine doses and lighting programs, the researchers concluded the preferred method of molting turkeys is to supplement their feed with 20ppm thyroxine and reduce photoperiod to six hours for 12 weeks. After this treatment, day length is increased back to 14 hours and the flock returns to lay in about eight weeks.

Future work:
The methods developed provide the turkey industry with a means to extend the productive life of breeder flocks in times when replacements are not readily available, without adversely affecting animal welfare.

While the preferred method described above is effective, it is likely to be expensive on a commercial scale. A more commercially viable procedure might use a cheaper, more readily available source of thyroxine (the researchers suggest the possibility of using iodinated casein as a thyroxine precursor). The study also suggests that the treatment could incorporate a shorter holding period if sufficient thyroxine is present, which would bring the flocks back to lay sooner. Fine-tuning the methods may result in new management practices for modern turkey producers.

**AMN023**
The use of cyclic-di-GMP, a novel immunotherapeutic and antibacterial molecule in chickens
Principal investigators: Moussa Diarra, Agriculture and Agri-Food Canada and François Malouin, Université de Sherbrooke
*Collaborator: Brian Talbot, Université de Sherbrooke*

Funding: $223,954 ($60,002 CPRC, $163,952 AAFC)
Start date: August 2008
Expected end: March 2012
Interim report received:
Final report received:
Status: in progress

Background:
The objective of this project is to demonstrate the usefulness of cyclic-di-GMP, a novel immunotherapeutic molecule, for the prevention of infections by microbial pathogens in chickens. These molecules have been shown to protect mice from bacterial challenge (S. aureus) and elicit varied immune system responses. Human immature dendritic cells in culture also show responses to the presence of c-di-GMP. The responses demonstrated in these and other studies suggest that c-di-GMP is a novel immunostimulant that could be used to protect poultry from bacterial infections and as a new adjuvant for vaccines against poultry pathogens.

Specific objectives are to demonstrate the ability of c-di-GMP to enhance host immunity and to provide proof of concept for their use in chicken production to replace antibiotherapies and antibiotic-based growth promoters. The project will look at the effect of c-di-GMP on the immune response to IBDV vaccination in broiler chickens, on gut microflora and emergence of resistant bacteria, and on the control of *Clostridium perfringens* in broiler chickens.

**AMN024**
Investigation into cell-cell signalling in Clostridium perfringens infection for developing a novel disease-control strategy
Principal investigator: Joshua Gong, Agriculture and Agri-Food Canada
*Collaborators: Mansel Griffiths and John Prescott, University of Guelph*

Funding: $180,500 ($60,000 CPRC, $63,000 AAFC, $57,500 SCIDF (not yet confirmed))
Start date: October 2008
Expected end: November 2010
Interim report received:
Final report received:
Status: in progress

Background:
*Clostridium perfringens* causes necrotic enteritis (NE), a common enteric disease of birds. NE occurs when *C. perfringens* overgrows and dominates the flora in the intestine and produces a high level of α-toxin. This toxin was considered to be a major virulence determinant associated with the disease, however this theory was recently called into question. NE in poultry is currently controlled by prophylactic use of antibiotics in feed. The continued emergence of antibiotic-resistant bacterial pathogens in both humans and food animals, however, represents a potentially severe negative impact of this common practice. The increasing public anxiety has spurred research into non-antibiotic alternatives for controlling the disease. One of the recent significant discoveries in microbiology is bacterial communication and its mechanism through cell-cell signalling (quorum sensing). Quorum sensing has a role in the regulation of a wide variety of physiological processes, especially the production of virulence factors which are important during pathogen bacterium-host interactions. In *C. perfringens*, for example, quorum sensing is involved in regulating production of several toxins, including α-toxin. This information came from studies on a human isolate of *C. perfringens*. Dr. Gong and his team will be looking at *C. perfringens* in the chicken in an attempt to answer the following questions: 1) Does the quorum sensing occur in the chicken intestine? 2) How much is it involved in the toxin production by *C. perfringens* and NE development in the intestine? 3) Can an effective strategy be developed to control NE by blocking the signalling (so-called quorum quenching)?

**AMN025**
Engineered antibodies and phage products for food safety applications
Principal investigators: Christine Szymanski, University of Alberta
*Roger MacKenzie, National Research Council*
*Jamshid Tanha, National Research Council*
*J. Christopher Hall, University of Guelph*

Funding: $1,324,000 ($54,000 CPRC, $1,000,000 Alberta Ingenuity Fund, $270,000 NRC)
Start date: June 2009
Expected end: May 2012
Interim report received:
Final report received:
Status: in progress

Background:
In the past decade, the protein therapeutics market, led by monoclonal antibodies, has rapidly expanded to annual sales of approximately US$20 billion. Most protein therapeutics currently on the market are for the treatment of cancer, but there is huge potential for protein therapeutics to expand into other areas such as infectious diseases. Most approved protein drugs are extremely costly full-length antibodies so there is a pressing need to develop less expensive alternatives. This proposal follows a growing trend in the protein therapeutics industry away from whole antibodies and mammalian expression systems. In applications in which only the antigen binding function is required, single-domain antibodies (sdAbs) and surrogate antibodies such as the receptor binding domains of bacteriophages (PRBDs) are attractive alternatives. Plant expression of such molecules has the potential to greatly reduce cost and give high value agricultural products. The proposed work builds on preliminary data that have established proof-of-principle for the concept that oral administration of *Campylobacter jejuni*-specific pentameric sdAbs (pentabodies) and *Salmonella enterica* serovar *Typhimurium*-specific PRBDs, can reduce the levels of chicken colonization by these organisms. This represents a reduction-at-source approach to decreasing the incidence of food-borne illness. For *C. jejuni*, the specific pentabodies will be engineered for improved protease resistance and thereby lowering the dose levels required. Dr. Szymanski and colleagues have also recently obtained the first genome sequence for a *C. jejuni* bacteriophage. The PRBD of the phage has been identified and will be cloned, engineered and over-expressed for chicken studies to evaluate its efficacy in terms of reducing *C. jejuni* colonization levels.

**ENV026**
Utilization of protein-containing agriculture waste and by-products for adhesive development.

*Principal investigator: Jianping Wu, University of Alberta*

*Co-investigator: Mirko Betti, University of Alberta*

Funding: $292,569 (CPRC $60,000, Alberta Livestock and Meat Agency $232,569)
Start date: September 2009
Expected end: August 2012
Interim report received:
Final report received:
Status: in progress

Post-production laying hens have historically been processed for use in food products such as soups and further processed meats, however this market has declined. Spent hens have also been processed in a variety of feedstuffs for animal diets, but there are growing concerns over the safety of using animal byproducts in animal diets. With few viable markets, spent hens are often disposed without being utilized.

The objective of this project is to look at the potential use of spent hens as bioproducts for industrial applications rather than for use as food or feed. The goals of the project are to (1) develop an efficient and simple method of protein recovery from spent hens by using high pH extraction, low pH precipitation on minced spent hens, (2) study the effects of extraction conditions of the functionalities of proteins, (3) investigate the effect of different treatments on the features of protein-based adhesive.

**AMN027**
Elucidation of critical characteristics of *Clostridium perfringens* and pathogen-host-environment interactions defining susceptibility of poultry to necrotic enteritis.

*Principal investigators: Andrew Olkowski and Bernard Laarveld, University of Saskatchewan*

*Collaborators: Manuel Chirino, Chris Wojnarowichz, University of Saskatchewan*

Funding: $204,488 (CPRC $89,402, NSERC $97,746, Lilydale (in-kind) $17,340)
Start date: September 2009
Expected end: September 2012
Interim report received:
Final report received:
Status: in progress

The pathogen commonly associated with necrotic enteritis (NE) in poultry is *Clostridium perfringens* type A. Although as causative organism these bacteria have been defined relatively well, there are considerable gaps in knowledge on their specific characteristics. Recent research provides evidence that alpha toxin is not a major factor (if any) in etiology of NE. Recent findings provide a new model for future research to unravel the previously unknown molecular mechanisms involved in the lesion development, and to characterize novel virulence factors that appear to play a crucial role in the development of this disease. The long-term objective of this study is to define the factors and mechanisms generated by *C. perfringens* that on one hand play a crucial role in the initiation of the necrotic lesion, and on the other hand force the host system to generate self-destructive enzymes that further perpetuate tissue degeneration leading to necrotic enteritis.

**NFS028**
Distillers dried grains with solubles (DDGS) as a potential source of immunostimulatory and growth promoting activity for poultry

*Principal investigator: Bogdan Slominski, University of Manitoba*
*Co-investigator: Juan C. Rodriguez-Lecompte, University of Manitoba*

Funding: $321,000 (CPRC $54,000, PIC $39,000, NSERC $174,000, Canadian Bio-Systems Inc. $45,000 plus $9,000 (in-kind))
Start date: October 2009
Expected end: October 2012
Interim report received:
Final report received:
Status: in progress

It is estimated that the ethanol plants in Canada will generate 1.3-1.4 million tonnes of corn and wheat DDGS destined for animal and poultry feeding per year. In order to derive maximum value from these co-products, their natural advantage as feed ingredients must be presented to the poultry industry. The principal investigator has been involved in extensive research on chemical and nutritive evaluation of corn and wheat DDGS and nutrient availability data development for poultry and swine. What has not yet been considered is the fact that, as co-products of brewer's yeast (Saccharomyces cerevisiae) fermentation, DDGS will contain a significant quantity of components beneficial for gut development and health and effective in immune system stimulation. Because of their immunomodulating activity, it is thought that they may serve as alternatives to antibiotics for both growth promotion and disease resistance in poultry production.

The objective of this research is to investigate the effect of corn and wheat DDGS vs. yeast-derived products on growth performance, gastrointestinal tract development, and immune system function in broiler chickens. Any potential synergistic effect of these additives and the use of enzyme technology to modify and/or to release the active carbohydrate components from the yeast cell wall structure will also be investigated.

## Appendix 2 – Acronyms used

| | |
|---|---|
| AAFC | Agriculture and Agri-Food Canada |
| ACGIH | American Conference of Governmental Industrial Hygienists |
| ACP | Alberta Chicken Producers |
| AI | Avian Influenza |
| ALMA | Alberta Meat and Livestock Agency |
| AviMicroNet | Avian Gut Microbiology Network |
| BCBHEC | BC Broiler Hatching Egg Commission |
| Ca | Calcium |
| CFC | Chicken Farmers of Canada |
| CHEP | Canadian Hatching Egg Producers |
| CoV | Coefficient of Variation |
| CPEPC | Canadian Poultry and Egg Processors Council |
| CPRC | Canadian Poultry Research Council |
| DDGS | Distillers dried grains with solubles |
| EFC | Egg Farmers of Canada |
| LOIs | Letters of Intent |
| LYFs | Large Yellow Follicles |
| MOS | Mannanoligosaccharides |
| NE | Necrotic Enteritis |
| NSERC | Natural Sciences and Engineering Council |
| NSP | Non-Starch Polysaccharides |
| P | Phosphorus |
| PIC | Poultry Industry Council |
| PRBDs | Receptor Binding Domains of Bacteriophages |
| RH | Relative Humidity |
| RIVET | Recombination-based In-vivo Expression Technology |
| SAC | Scientific Advisory Committee |
| sdAbs | Single-domain Antibodies |
| STM | Sequence Tagged Mutagenesis |
| TFC | Turkey Farmers of Canada |
| TLV | Threshold Limit Value |
| VPs | Veterinary Pharmaceuticals |