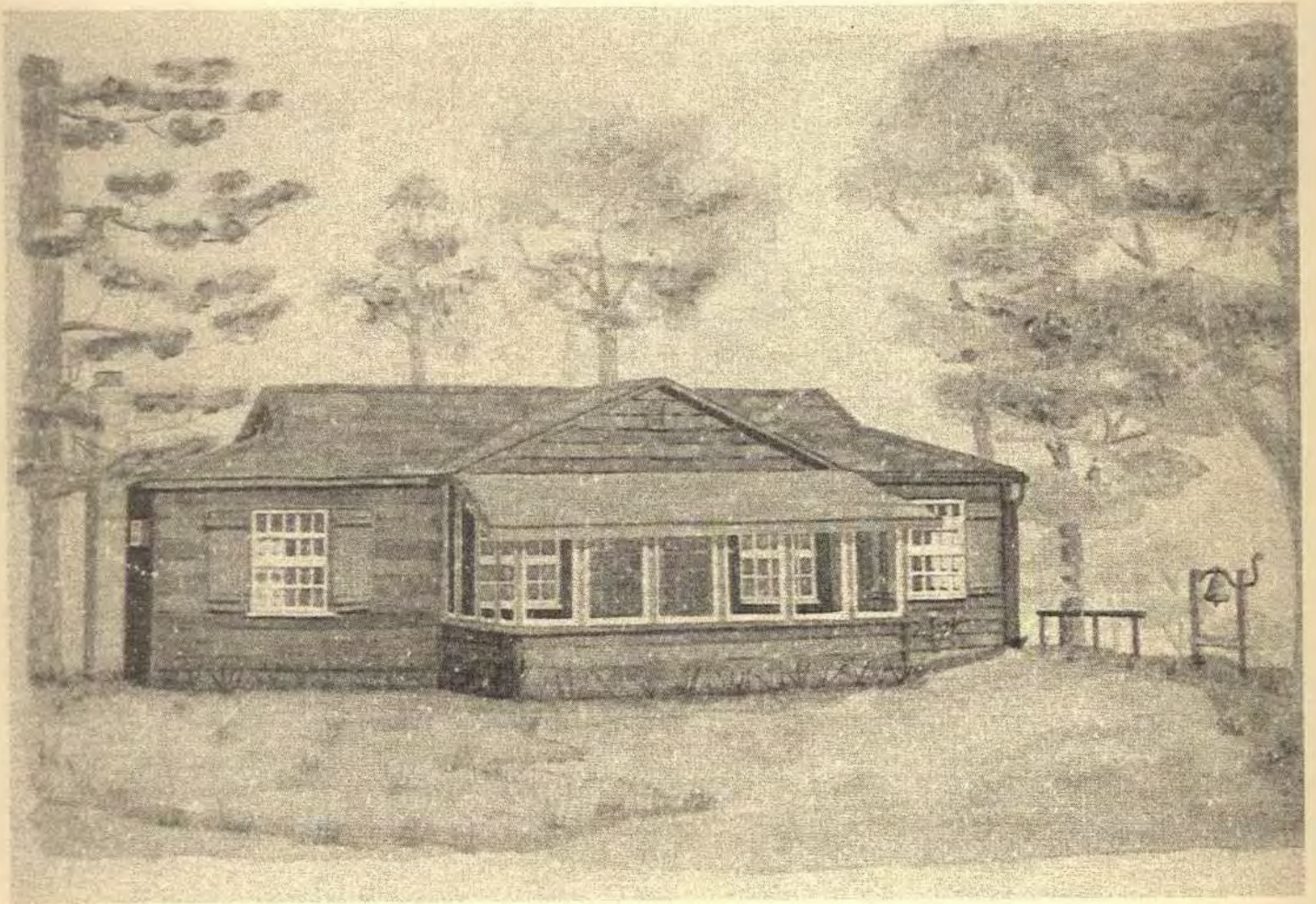


Queen's University Biological Station
Annual Report and Newsletter - 1999



Director: Dr. Raleigh Robertson

Manager: Frank J.S. Phelan

QUBS Annual Report and Newsletter 1999

Errata:

- (i): The following should appear on p. 41 of the report

Dr. Mart Gross - Department of Zoology, University of Toronto, Toronto, Ontario

"Evolutionary and behavioural ecology of fishes"

We are continuing our investigations of the breeding systems of fishes. This year three students worked at QUBS as described below.

Peng Fu - "Fertilization success of individual cuckold male Bluegill sunfish" - M.Sc. thesis

The objective this year was to quantify the fertilization success of individual cuckolders during intrusions into the nests of parental male bluegill. Behavioural observations made at nests estimated the total intrusion frequency and fry were collected for DNA fingerprinting at our Toronto laboratory to estimate cuckold success. By dissection, the average success per cuckold intrusion could be quantified. These data will be compiled with the many years of behavioural study to determine the overall success of cuckolders in the lake, and the factors determining that success.

Assistants: Tracy Michalak and Anna Lawson.

Publications:

Gross, M.R. and J. Repka. 1998. Stability with inheritance in the conditional strategy. *J. Theor. Biol.* 192:445-453.

Gross, M.R. and J. Repka. 1998. Game theory and inheritance in the conditional strategy. *In Game Theory and Animal Behaviour*, L. Dugatkin and K. Reeve (Eds.), Oxford University Press pp. 168-187

Neff, B.D., P. Fu and M.R. Gross. 1999. Microsatellite multiplexing in fish. *Trans. Amer. Fish. Soc.* (in press).

Neff, B.D., P. Fu and M.R. Gross. 1999. Microsatellite evolution in sunfish (Centrarchidae). *Can. J. Fish. Aqu. Scis.* 56:1198-1205.

Neff, B.D., J. Repka and M.R. Gross. 1999. Parentage analysis with incomplete sampling of candidate parents and offspring. *Molecular Ecology* (in press).

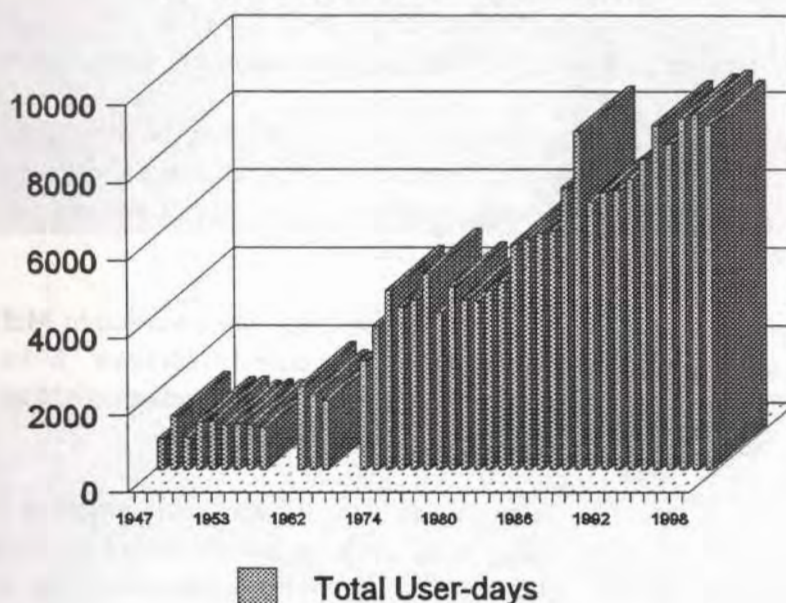
Neff, B.D., J. Repka and M.R. Gross. 1999. Statistical confidence in parentage analysis with incomplete sampling: how many loci and offspring do we need? *Molecular Ecology* (in press).

Introduction

1999 was a very busy year at Queen's University Biological Station. Although 1999 does not boast the highest number of user-days ever, some 8,907 user-days in total were logged (user-day data are displayed in tabular form on pp. 53-54). This is down about 3% from 1998. However, with the constant activity through the fall in the demolition of the old lodge and the start of construction of the new Operations Centre, it seemed very busy indeed.

On average, 43 researchers (professors, graduate students, honours students and assistants) were in residence throughout the summer. Abstracts of 1999 research projects and personnel involved are contained in the following pages (pp.19-50). Use of QUBS has generally been increasing over its 50 year history:

Total User-Days at QUBS - 1947 to 1999



In teaching activities, QUBS hosted 10 modules (11 weeks worth of modules - one of these modules being two weeks in duration) in the Ontario Universities Program in Field Biology (OUPFB). Five of these modules were presented by Queen's instructors, and five by instructors from other institutions. Titles and enrolments for the OUPFB program are found in Tables 1 and 2 (pp.17-18). In addition to the OUPFB modules, Dr. Ed Kott (Wilfrid Laurier University) brought his field course for senior undergraduates to QUBS for two weeks in late summer.

QUBS continues to be in demand for field trips. Trips associated with undergraduate courses at Queen's are an important means of exposing students to natural environments and of engaging them in hands-on study. For many students, this exposure is key to sparking life-long interest in biology, ecology or environmental science. In fall, QUBS hosted only day trips. The usual residential field trips were impossible this year without the use of the lodge. A summary of conference, meeting and field trip use of QUBS in 1999 appears later in this report (pp.51-52).

The Operations Centre

After 12 years of planning and fundraising, our venerable old lodge was demolished and construction of the new Operations Centre started in fall. It is not without some sadness that we watched the old building come down - it has served us well for more than 50 years. However, current and projected uses have outgrown the abilities of the old building and while we fondly salute the old lodge, we heartily welcome the new Operations Centre.

With a combination of donations and grants, the necessary funding for the project was finally in place. The Canada Foundation for Innovation (CFI) and Ontario Research and Development Challenge Fund (ORDCF) each contributed \$341,792.00 to the project. These are matching funds, so an additional \$459,724.00 was raised from donations to achieve the full cost of the Operations Centre (\$1,143,308.00). The generous donations of Mrs. Hilda Pangman were instrumental in achieving the funding target. Contributions were received from many alumni and additively, enabled the matching funds to land the grants for the project. Thanks also to Dr. Allen Keast whose 11th hour contributions to the cause boosted us to the magic number.

The architect, Tom Blood (Nepean) has been working on the project since spring of 1998. Tom has designed a building which is both attractive and functional. His design will complement the rural, lakeside setting. His use of timber framing and as interest elements in the upper level and cedar for siding match the ambience of the station.

Tenders were let in summer of 1999. The contract was awarded to McDonald Brothers Construction of Ottawa, with Gerry McDonald as the general contractor. Mike Finn from Queen's Physical Plant has been overseeing the project. It has been a delight to work with Gerry and Mike on the project.

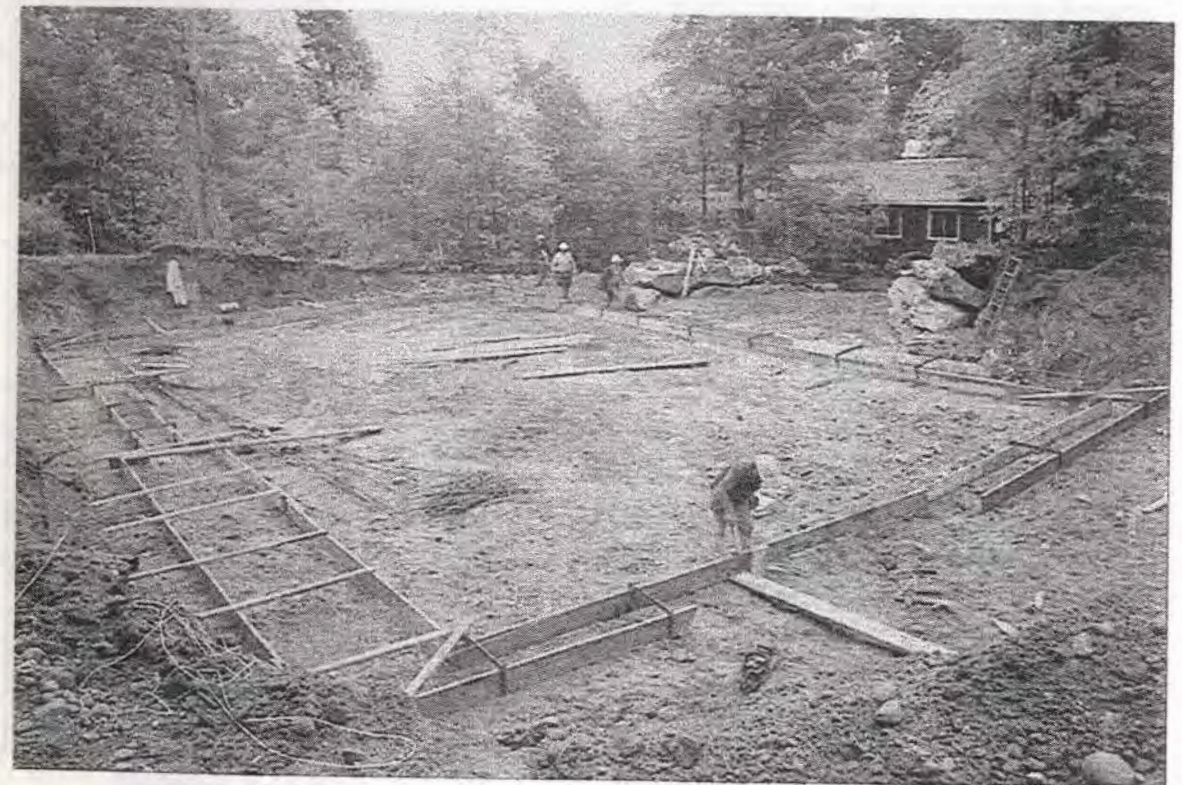
To say farewell to the old building, a "last supper" was held (largely at the urging of Dr. Dave Canvin) on August 28, 1999. Many staff, students, alumni and old friends of QUBS turned out for the event. A BBQ dinner, replete with a few reminiscences about the old building made for a great day. Coupled with a bit of a retirement party for Dr. Dolf Harmsen, the whole affair was one to be remembered.

On their last day, the students and staff of the Wilfrid Laurier field module helped move the furniture out of the old lodge. Thanks to all who helped with this. After the furniture, a week was all we had to shut down services to the old lodge and to remove everything which might be reused. Some of the old building will continue on in the woodwork and bits salvaged by various people. As well, some bits of the old lodge will be reinstalled in the new Operations Centre to give a bit of continuity in the transition from old to new. Reduced to its bones, the old lodge looked pretty forlorn after a week of ripping and tearing. Then it was D-day!

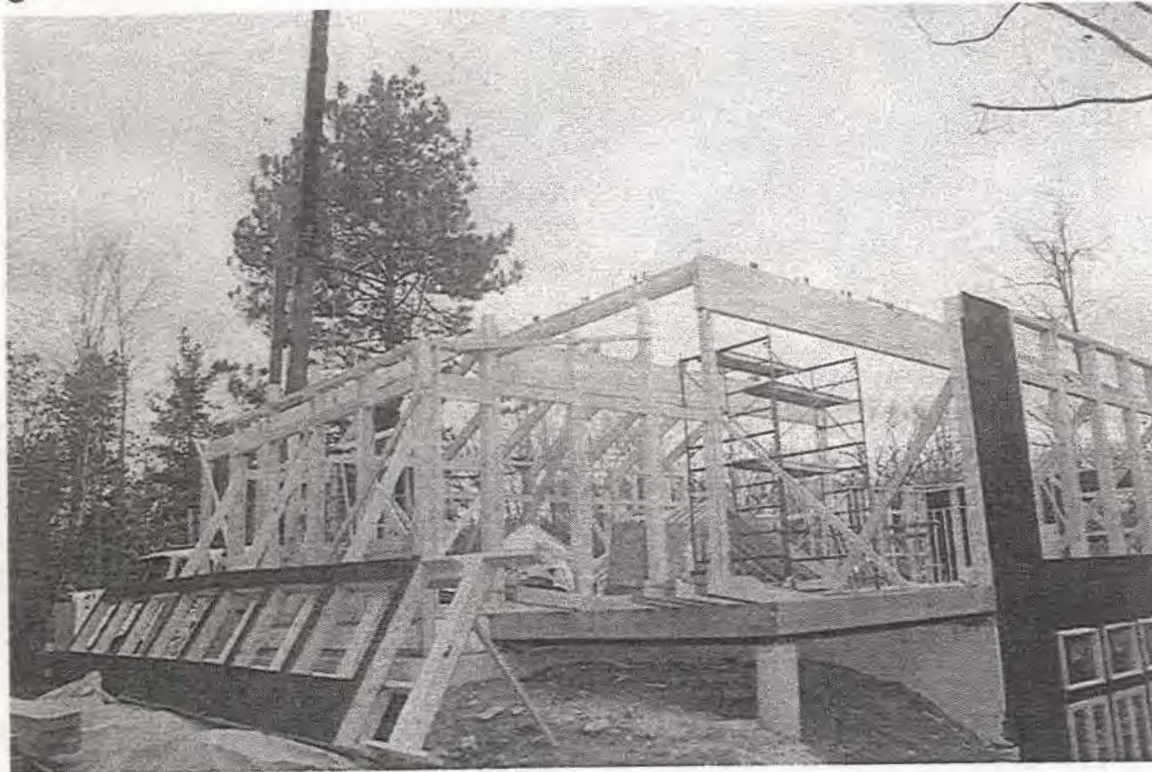
On September 20, 1999, it took only about eight minutes to pull down the old lodge. By day's end, there was little sign of the old building. Without much pause for nostalgia, the very next day excavation for the new building was started. With winter not so very far off, construction forged ahead. By the end of the month, the excavation was completed (after several days of rock-breaking) and the footings were poured. By Thanksgiving, the basement concrete



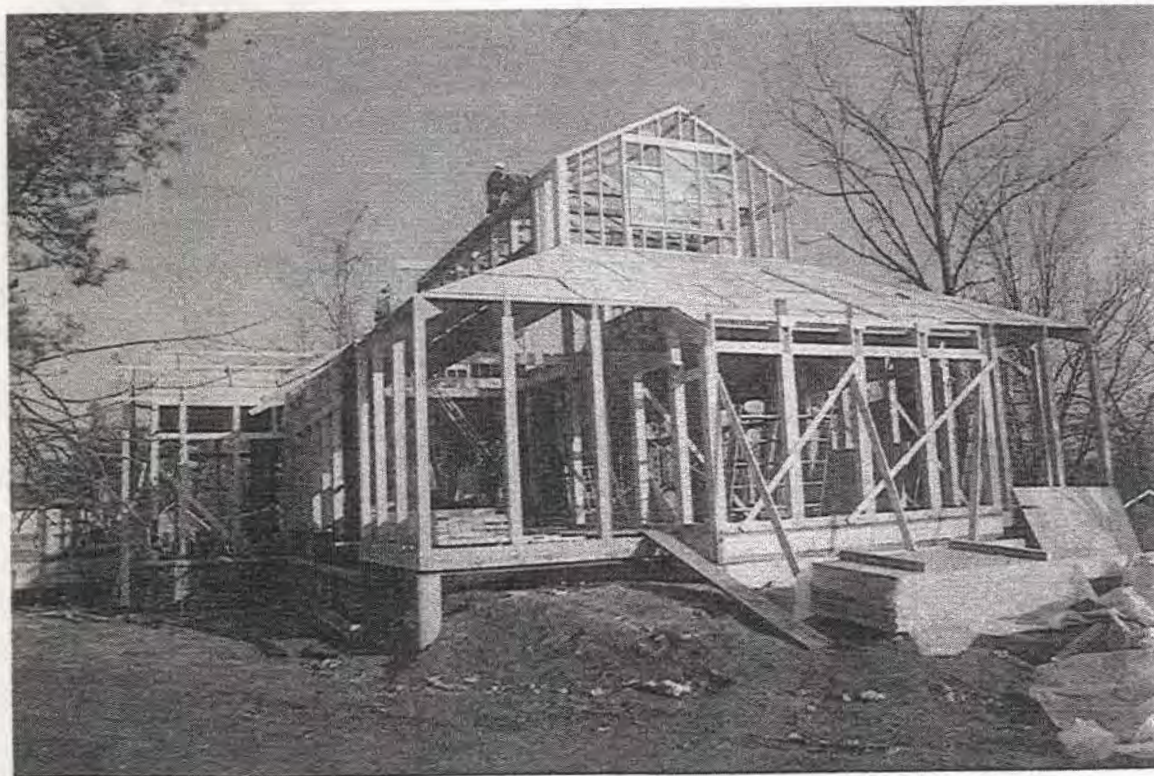
Demolition of old lodge - September 20, 1999



Setting forms for footings - September 29, 1999



Starting timber framing - November 29, 1999



Raising top triangle frames for clerestory - December 1, 1999

walls were in place and the basement was backfilled. At the end of October, the concrete floor was done and the wood framing completed on the lower level. Another month saw the upper floor and walls framed and the timber frame begun. By year's end, the building lacked only the metal roof to finish the framing.

A circular driveway provides the approach up the hill to the main entrance of the new building. The split-level entrance and large staircases provide ready access to both levels of the Operations Centre. This two-level, year-round building which will provide much improved central services for all QUBS users. The upper level consists of two screened porches, a glass porch, a dining room, servery and kitchen. This level is built with a clerestory which admits light at the top of the building and allows hot air to exit. The design is very open, bright and airy. The lower level provides a new conference room, office space, computer rooms, washrooms, laundry room, mechanical room and two storerooms. One can walk out of the lower level doors straight into the upper level of the Brown Lab. The architect has done a great job of linking this new building with the existing buildings, roads and walkways of the station.

As this is written, the building nears completion. A ribbon-cutting and celebration of the new building is in the planning stages for mid-summer.

Crabbe Donation

Lloyd and Jean Crabbe of Newboro have donated a piece of property with the shell of a house to Queen's. The property is adjacent to the Bracken Tract, situated along the Mon O'Kel Road. Transfer of the property took place in November of 1999. The 1.5 acre parcel comes with a house (The Birdbox) designed and built entirely by Mr. Crabbe. The house is built atop an old foundation left from the mining activities at the iron mine situated in the middle of the Bracken Tract. Using this foundation and the links to the existing septic system, Mr. Crabbe started to build the house. The "Birdbox" refers to the clever trompe l'oeil at the eaves, where Mr. Crabbe has mimicked a martin house.



In concordance with Queen's policy, an environmental assessment of the property was conducted by the Analytical Services Unit at Queen's. There was no chemical contamination of the property by the previous mining activities. The property will be managed as part of the Bracken Tract. Because of its location, it was deemed important to secure this property and to consolidate it into the larger tract.

The Crabbes were thanked by the University at a reception held at the Faculty Club in fall. All of us at QUBS would also like to thank the Crabbes for their generous gift.

Bracken Donation

George and Margaret Bracken of Smiths Falls continued in their generosity toward the university through the donation of another piece of property. With the donation of the Crabbe property, the Brackens still held a 1.5 acre parcel fronting the Mon O'Kel Road, situated between the Crabbe property and the existing house to the north. In December of 1999, the Brackens transferred ownership of this property to Queen's. This property, along with the Crabbe property will be managed as part of the Bracken Tract and consolidates QUBS ownership of the parcels along the access via the Mon O'Kel Road.

We heartily thank George and Margaret for their continued generosity toward QUBS and Queen's.

Domtar Donation

Early in 1999, Dr. Peter Hodson (Department of Environmental Science) had arranged a donation of equipment to Queen's from Domtar (Ste. Anne de Bellevue, Quebec). It seems that Domtar had decided to close their monitoring division and dispose of the equipment. Dr. Hodson, having had close connection with Domtar's biologist during field courses focussed on the St. Lawrence River, mentioned that a transfer of the equipment by donation to Queen's could be mutually beneficial. In preliminary discussions with QUBS staff, it seemed that some of the gear might be of benefit to QUBS. Frank went with Dr. Hodson to inventory the equipment and earmark that of interest to Queen's. In early spring, Frank and Floyd joined a convoy with Dr. Hodson's crew to load the equipment and bring it back to Queen's. The equipment list was lengthy and included a mobile lab (a 5 ton truck with self-contained lab), technical equipment, sampling gear, boats, motors, generators, fish tanks etc. Of this gear, a large boat, motor and trailer, a work boat and two generators were destined for QUBS. We thank Domtar for their gift of equipment. It will assist us in achieving the mandate (to provide opportunities for teaching and research in the field) of the biological station.

NSERC MFA Grant

In early 1999, announcements were made by NSERC of the latest awards under the Major Facilities Access Grant (MFA). MFA recognizes the value of shared facilities and support of research. With the diversity of users at QUBS and the volume and quality of research at QUBS, NSERC recognizes QUBS' contributions to research through this grant. QUBS was awarded a three-year grant of \$66,150 per year. This grant will pay the Assistant Manager's (Floyd Connor)

salary and benefits and half of a Maintenance Assistant's (Rod Green) salary. The grant may also provide an annual contribution to shared costs of utilities.

QUBS has received this grant (or its precursor, the Infrastructure Grant) for 16 years. The acknowledgement of excellence of research and training implicit in the award is a feather in the cap of the station. The grant itself permits the hiring of staff which benefits all QUBS users.

NSERC Equipment Grant

In November of 1998, QUBS staff and several of its Principal Investigators prepared and submitted to NSERC a proposal for funding for a "Global Positioning System (GPS) and geographic information system (GIS) for Queen's University Biological Station". The intent was to upgrade QUBS systems, as many researchers at QUBS are now counting on the ability to collect precise spatial data both rapidly and reliably. The proposal was fully funded, with \$45,130 awarded in the spring of 1999.

With these funds, and with consultation and help from Jeff Dawson and Jason Pither (both graduate students at Queen's and users of QUBS), the list of equipment purchased included GPS equipment for field use and a computer to anchor the developing GIS at the field station and some peripherals for the computer to enable data input and output.

The GPS equipment included a Pathfinder ProXRS with TSC1 datalogger, antenna, backpack, and software, two GeoExplorer II hand units and Pfinder Office 2.11 software for computer handling of GPS files generated.

The computer equipment included a Dell 410 Workstation computer (dual 450 MHz processors, two 9-Gb hard drives, 512 Mb RAM) with a 21" flat-screen high-resolution monitor, Zip drive, CDRead/Write/Rewrite, and tape backup, an Epson Stylus Color large-format printer, and an Epson Expression 836XL large-format color flatbed scanner.

Dr. Roland Tinline of Queen's Geography Department has been most supportive of our endeavors in this area, and with the blessing of AutoDesk has provided us with a copy of AutoCAD with which to edit and manage our GIS files.

The new components of the system have meshed nicely with the old, to produce a very effective and well-integrated system. Use of the GIS/GPS equipment was high in 1999, and will probably continue to increase over time.

Wes and Dorletta Curran Scholarship

Recently, QUBS alumni, including Dr. Ted Brown and Al and Marg McBurney, among others, felt that the role of the Currans in the field station was not receiving the attention that it should (Wes Curran was the founding Director of the field station, and Dorletta, Wes' wife, was instrumental in the early years of the station). To recognize the Currans, and as a tribute to their efforts on behalf of generations of students at QUBS, the Wes and Dorletta Curran Scholarship was established. The scholarship is available to support the work of a student each year at QUBS, with emphasis on aquatic studies.

This year was the first year of the award, with Agnes Kliber the first recipient. Agnes is pursuing her undergraduate degree at Queen's, and doing an undergraduate thesis on the reproductive ecology of Columbine, *Aquilegia canadensis*.

History Project

QUBS staff recognize a need to know the history (human, geological and ecological) of QUBS properties, as an important part of developing land management plans. At the same time, there is great interest among our neighbours in the history of the area. Sue MacLatchie, one of our neighbours on Lake Opinicon, has local heritage as a hobby or, perhaps, an avocation. Sue has agreed to assist us in developing a history of the area. Dr. Smol (Queen's - Biology) and his crew at PEARL (Paleoecological Environmental Assessment and Research Lab) have been working on various lakes in the vicinity of QUBS, including the "Back Lakes" of the Pangman Tract. For their work, an understanding of past history, including perturbations, is vital to understanding the profiles they uncover in their research. Thus, a mutual interest history project was conceived. The group includes those mentioned above, with Celine Muis coerced into coordinating activities of the group. Also involved are Francine Forrest, Kim Neill, John Glew, Tammy Karst and Joanne Little from Smol Labs Inc. and Dr. Euan Reavie (formerly of Smol Labs Inc., now at University of Toronto).

Seminars

Raleigh and Frank organized the seminar program for 1999. A full list of speakers and topics appear later in this report (p. 55). This program facilitates information exchange among QUBS users and sparks a great deal of valuable discussion. It is an important means of gaining input from other researchers, especially for undergraduate and graduate students working on their own research topics. Suggestions for speakers and topics are always welcome.

Open House

The annual Open House was held on Sunday, July 11 in 1999. Some 500 visitors toured the displays of research! The response this year was amazing and in no small part due to the efforts of all the QUBS regulars whose hard work in preparation of displays, and in serving as hosts to our visitors, made this event remarkable this year.

The 1999 version of the Community Newsletter (eighteenth edition) was distributed in early July to 1,000 households and cottages in the vicinity of Chaffey's Lock, Elgin and Perth Road Village. The newsletter keeps our friends and neighbours abreast of activities at QUBS, even if they are unable to attend the Open House.

Both of these initiatives are vital to maintaining close contact with the neighbouring community of QUBS, for without support of the community, opportunities at QUBS would become more restrictive.

Renovations and Additions

In 1999, much time and attention was directed at preparations for the construction of the Operations Centre in fall. Nevertheless, there were a series of improvements made to various facilities at the field station this year. Among these were:

1) Proper storage was created for the growing technical equipment related to GIS and GPS. Storage shelving was built and installed in the Collections Room of the Brown Lab for this gear.

2) In late summer, the shingles were removed from Basswood Cabin. Some of the sheathing and fascia were replaced and the building reroofed.

3) Another of the old "Bunkie Junior" cabins was removed to be replaced by the new and improved version. This year, old Cabin 2 was removed and a new Cabin 2 was ready for early summer occupancy.

4) With the aquarium being intensively used as a serpentarium for the last few years, the demand for water from the paired lake pumps has been reduced. Therefore, the system was redesigned to utilize the smaller pump system (which used to supply the Tankhouse) when water demand is low, yet when demand is high, a quick switch can be made back to the high-volume pumps in the lower Boathouse.

4) The antique water pump for the Trilab finally gave up the ghost (it is suspected that it was the original pump). It was replaced with a new jet pump and a captive air tank in summer.

5) During the rock-breaking required for the new Operations Centre, a huge volume of fractured marble had to be relocated. Some was used for retaining walls, and some was used to fill beside and behind the workshop to make a pad extension. It has been used as a place to store our tractor implements behind the shop.

6) As a continuation of efforts to reduce erosion by foot traffic and runoff, the path to the Boathouse was fitted with landscape ties, forming broad steps. These steps, backfilled with stone are pretty effective in controlling erosion on the pathways.

7) In summer, the old winter road used by the homesteaders at Lindsay Lake was reopened. This trail now links the Mica Mine Fields (East Field 2) and the Lindsay Lake Road, allowing yet another means of access to the lakes without increasing the traffic through the bird study areas of the Lindsay Lake Road.

8) In late summer, a garage door was installed in the Crabbe House, to finish the shell of the "Birdhouse" adjacent to the Bracken Tract (see details under Crabbe Donation). To do this, the cement skirt of the old mine building was cut away and the door installed (easier said than done).

9) In early summer, in the interest of safety, cautionary road signs were placed at the entrance to the QUBS road and at all sharp turns.

10) In summer, repairs were made to the boardwalk to Cow Island where the beavers had chewed the planks.

11) In late winter, a sander was purchased to aid in the maintenance of the QUBS access road. This sander will be mounted in the back of the QUBS work truck. It has its own engine, hopper, conveyor and spreader. It can be operated from the cab of the truck. Frank used this kit on his own truck last winter and it was a huge time-saver and ensures safe access during icy conditions.

Field Safety

Queen's University is in the midst of developing a comprehensive field research safety policy and well as guidelines for safety in field research. It is unclear just how this might impact policies and procedures at QUBS, but it is fair to say that QUBS will be expected to fully adhere to the principles and guidelines established. A draft of the Queen's documents is currently being

circulated for comment, so the finalizing of the policy and guidelines is not far off.

Watercraft Safety

It will soon be necessary for motorboat operators to have proof of proficiency. This proof is supplied after successfully completing a safe boating course or passing a test on safety, regulations and rules of the road. To ensure that QUBS users have a basic understanding of these issues, a familiarization exercise and test was devised by QUBS staff for all outboard motorboat users. This procedure is merely an interim measure - soon, QUBS boat operators will have to comply with the impending legislation (all operators of power watercraft under 4 m in length will require proof of competency by September 15, 2002).

All-terrain Vehicle Safety

Recognizing the need for operator competency in boats, it was realized that operators of ATVs should also be competent. Therefore, a familiarization with use of ATV and a test of operator competency was devised before anyone was able to use the station ATV. In addition, safety helmets were purchased and provided to users.

Naturalist Workshop

In 1999, as in 1998, no Naturalist Workshop activities were undertaken. It was decided not to offer a Naturalist Workshop program to avoid competing with lodge replacement and construction of the new Operations Centre. It is expected that this outreach program will be back on track for 2000. In its absence, the demand for and inquiries about the program have been overwhelming. For 2000, a SWEP grant has been secured to hire an Outreach Coordinator at QUBS. This person will, among other duties, assist QUBS staff in planning workshops for summer and fall.

Station User Fees

The fee schedule for 1999 appears on the last page of this report. Fees have been increased by about 2.5% in an effort to keep pace with the consumer price index.

Theses and Publications

An updated list of theses and publications is included as an *Appendix* to this report. Principal investigators should review this carefully to ensure that their efforts and efforts of their students are properly represented. This compendium is important as a reference database and is useful to QUBS users. In addition, it is an aid to documenting the importance of QUBS as a site for teaching and research.

In an attempt to keep our listing of theses and publications emanating from work carried out at QUBS as current as possible, please submit citations as soon as available. In

addition, copies of theses should be forwarded to QUBS for the library (we will have them bound as necessary). Reprints of publications would be appreciated.

Parks Canada- Rideau Canal

Doug Stewart (Superintendent of the Rideau Canal), on behalf of Parks Canada - Rideau Canal, has provided QUBS with complimentary passes for both of our pontoon boats (floating classrooms) for 1999, continuing a pattern of generosity going back many years. Mr. Stewart and Parks Canada are to be thanked for this generosity. These passes facilitate access to many study lakes along the Rideau Canal and provide a wide range of research and teaching opportunities at no cost to QUBS personnel. In 1999, access to Sand, Indian, Clear, Newboro and Upper Rideau Lakes permitted a variety of interlake comparisons.

Acknowledgements

Thank you to Floyd Connor (Assistant Manager), Roger (Rod) Green (Maintenance Assistant), Sara Burtch, Terri Castle, Marg Phelan, Juile Burt and Deborah Heintzman (Food Service Staff) for their efforts on behalf of QUBS. It is the effort and dedication of all of our staff, no matter in what capacity, that contributes to the overall success of the field station.

Crafts Night

It seems that there is keen interest in craft activities among QUBS users and friends. Once a week through the summer of '99, an informal group met in the Brown Lab to engage in a variety of crafts (eg. painting, knitting, crochet).

Cover

The cover is from a watercolour of the old lodge done by Marg Phelan. This image graced the front of a special edition T-shirt or sweatshirt produced by QUBS regulars in 1999 to commemorate the old building.

Geographic Information System Project

In 1999, funds were available to provide staff to work on advancing the establishment of a Geographic Information System (GIS) at QUBS. A government grant through SWEF enabled the hiring of one student, while a partial contract with the Fowler Herbarium plus a Curriculum Development grant from Dr. Peter Boag (Head, Department of Biology at Queen's) provided support for a second student plus funds for production of teaching materials related to the GIS. Below are direct contributions from: 1) Jason Pither, a graduate student at Queen's with experience in GIS and Global Positioning System (GPS) hardware and software and 2) Celine Muis, an undergraduate at Queen's, working under the SWEF grant.

Jason Pither

The summer of 1999 was somewhat of a technical transition year for QUBS. NSERC provided funding to purchase high-end equipment for the researchers' computing needs (see above - NSERC Equipment Grant). At the beginning of the summer, with the help of Floyd Connor, I assembled a workstation environment that will see QUBS well into this next century (well, at least 5 years anyway!). Together with the GIS software and recently acquired high-precision GPS equipment, QUBS now has the capacity for the acquisition and analysis of ecological data at levels of accuracy that were unimaginable five years ago.

As the designated "tech" at the station, my duties during the summer consisted primarily of assisting various researchers with their computing, GIS (with the help of Celine Muis), and GPS needs. For example, I designed a GPS data dictionary for the Ecological Land Classification protocol; I helped instruct on the use of GPS during a field course; and I produced instructional material for the use of the various new software and equipment (still in progress).

The highlight of my summer was starring with Celine Muis in an educational video on using GIS and GPS in ecological research. Celine and I worked together on the script for weeks for this 15 minute video (including creating some cool graphics for the video). Queen's TV came to QUBS, and filmed the video in one day... be sure to see it in an Ecology lab near you, and spot the Gnome!

During my own time, I continued research (starting during my M.Sc.) into the asymmetry of the wings of a resident damselfly, *Calopteryx maculata* (Beauvois). Confirming and adding to results obtained in Nova Scotia, I found that these damselflies consistently have longer right wings than left. This consistency in "directional asymmetry" is a relatively rare finding according to the literature. The research has been submitted to the Canadian Journal of Zoology for review.

Celine Muis

The land classification map project of the QUBS property, which was originally launched in the summer of 1998, was continued this year with a combination of funding. The goal of this project is to create a complete digital map of the biological diversity of all 2000 ha of the QUBS property. This land classification map has and will continue to serve as an important tool for the understanding of the QUBS biological landscape. This understanding is essential for decision-

making regarding land management of the property.

This summer, with the help of Floyd Connor, I mapped sections of the QUBS property with the station's new high-precision Global Positioning System (GPS) equipment. Furthermore, I classified all sections of the property according to Ontario's new Ecological Land Classification system protocol. With the assistance of Jason Pither, I incorporated spatial data into a Geographic Information System (GIS). We organized all the map data into the AutoCAD map software package. The result of this work included a more detailed, yet still incomplete (this will probably always be a work in progress, as new information will need to be added each year), biological map of the station property. My other duties at the station included the completion of a basic guide for GPS data collection and GIS use and the production of an educational video with Jason Pither about the uses of GPS and GIS in ecological research.

The Weather Report

To provide fundamental information to users, QUBS operates an electronic weather data collection and computerized file service at the Biological Station. In 1999, this system underwent significant maintenance and upgrading and is now ready to collect quality weather data for several more seasons and to deliver it quickly in response to requests from researchers.

On 23 March 1999, the anemometer was removed and returned to Campbell Scientific for replacement of the main bearing and for calibration. It was reinstalled on 14 April 1999, and should now provide another year or two of maintenance-free service.

On 16 December 1999, the many sensor leads were all disconnected from the 21X weather micro-computer and it was sent off for inspection, calibration, and upgrading. It needed new programmable chips ("PROM's") to make it Y2K compliant, so these were installed. Servicing was completed in January, and the system was running again by 20 January 2000. The gap in data from 16 December to 20 January was regrettable but unavoidable.

As our weather data base has spanned an increasing number of years, and as more QUBS users have requested these data, it has become clear that some streamlining of the system was in order. Until autumn of 1999, most data were simply in "raw" form, and summaries were created and provided by QUBS management upon request. Nearly all requests are for data summarized in daily or hourly intervals, so summaries have been prepared for these two intervals for all data collected since the 21X micrologger was first installed in November of 1991. Blocks of these data a year or two in length can be sent immediately to users upon our receipt of an e-mail request. For those researchers wanting repeated and reliable access to the complete data set since 1991, we are newly able to offer a CD (for which we may have to charge a nominal fee). The hope is that, at least by its second or third edition, this CD will not only contain all the raw and summarized weather data collected at QUBS between November 1991 and December 1999, but will also be self-explanatory and that its "weather journal" notes on weather, Lake Opinicon ice, weather station operation, and biological phenomena will prove interesting and useful.

E-mail requests, and requests for the Weather CD, are welcome.

QUBS Properties

For records-keeping purposes, this section of the Annual Report will list uses of properties, management activities and changes pertinent to specific areas. Entries will be made corresponding to particular tracts of land.

GIS Mapping

Work continues on the development of a Geographic Information System for QUBS. Data collected using Global Positioning System equipment are continually being added to the database. With the efforts of Celine Muis and Jason Pither, the configuring of the system proceeded apace in 1999. Jason and Celine set up the new computer, scanner and GPS receiver and developed training materials for all QUBS users. Mapping of physical features of QUBS properties (trails, roads, shorelines and conspicuous features) continues. With the help of Celine, a start was made toward developing an Ecological Land Classification system to aid in the mapping of habitat features.

There continues to be difficulty in reconciling survey and metes and bounds descriptions of properties with on-site GPS data. Hopefully, this can be eventually resolved, so as to provide the best location information possible to QUBS users.

Over time, a fully functional GIS will develop. This database will enable an overall management plan for QUBS properties.

Hughson Tract

The Hughson Tract was used for studies of Tree Swallows, Eastern Bluebirds, Golden-winged Warblers, damselflies, dragonflies, butterflies, water mites, vegetation productivity, Columbine, Ragweed, secondary succession, land management, Black Rat Snakes, Northern Water Snakes, Garter Snakes, Ribbon Snakes, Pumpkinseed Sunfish and the possible effects of bismuth on vegetation in 1999.

Dr. Weatherhead and his students continue to use the snake pens constructed at the back of the S.R. Brown fields, just at the east side of Lindsay Lake Pond.

The various bird box grids were used intensively by Dr. Raleigh Robertson and his students in work on cavity-nesting birds (Tree Swallows and Eastern Bluebirds). Dr. Bart Kempenaer's collaborative work on Tree Swallows also made good use of the nest box grids.

The New Barn field plots used by Dr. Aarssen and his students were roto-tilled in fall. The Lane Sargent Field was bushhogged but was too wet in late fall to be tilled.

In conjunction with Tim Demmons' management plan for Golden-winged Warblers, some of the field edges were left untrimmed, retaining a 5 metre border in which succession will produce a gradual transition from field to forest, seemingly the type of habitat preferred by these birds. Jamie Beauchamp monitored these edges as part of a study of land management practices to enhance biodiversity.

Haying of the open fields was done by Bob Butterill and David Hughson. David has been using the Horse Barn to store some of this hay.

Bonwill Tract

In 1999, The Bonwill Tract was used for studies of Cerulean Warblers, Golden-winged warblers, vegetation productivity, land management, damselflies, dragonflies, water mites, Black

Rat Snakes, Northern Water Snakes, Garter Snakes and Ribbon Snakes. In addition, the Canadian Wildlife Service Forest Bird Monitoring Plots were visited by Floyd Connor and Dr. Allen Keast, and the Ontario Ministry of Natural Resources (Eric Boysen - Kemptville) maintains several Growth and Yield Plots flanking the Bedford Road.

Jim Barton did some trail management to keep the walking trails open.

Haying of the open fields was done by Bob Butterill.

John M. Cape-Charles Sauriol Environmental Studies Area

The Cape-Sauriol Tract was used for studies of dragonflies, damselflies, water mites, Largemouth and Smallmouth Bass, Yellow Perch, Sunfish production, fish sperm, Black Rat Snakes and Pontederia pollinators in 1999.

In late summer, a heritage-minded group travelled to the mine sites flanking Pothole Lake.

Hilda and John B. Pangman Conservation Reserve

In 1999, the Pangman Reserve was used for studies of Cerulean Warblers, Golden-winged Warblers, Bluebirds, Least Flycatchers, Columbine, land management, Black Rat Snakes, Northern Water Snakes, Garter Snakes, Ribbon Snakes, dragonflies, damselflies, water mites, Largemouth Bass, Northern Pike, fish communities and paleolimnology.

Warner Lake continues to be a site of intensive study on Largemouth Bass populations. Frank Phelan, Dr. David Philipp and students have individually PIT-tagged most of the male bass in the lake and are conducting a multi-year study of bass populations. The lake has been posted as a research lake and closed to fishing. In Lindsay Lake, a similar study has been started on Northern Pike.

Lake surveys, including fish community composition, were continued in 1999 for Lindsay, Long, Garter, Round and Poole Lakes. Dr. Allen Keast, Dr. Ed Kott (Wilfrid Laurier), Dean Fitzgerald (University of Windsor) and Frank Phelan started a fish survey on Long Lake using a variety of capture gear. The outpost cabin on Long Lake greatly facilitated this work. QUBS has boats on all of the lakes in the Pangman Reserve to enable collections of all kinds.

The suite of small lakes is also of interest to paleolimnologists documenting climate change and forest structure changes in the past. Researchers involved in studies there include members of the John P. Smol lab at Queen's.

In summer, a work party cleared the roadways and trails to maintain easy access. The old winter road (as described by George Hughson) was reopened to provide an alternate access from the Mica Mine Field to the Lindsay Lake Road. The trail starts at the far end of the Mica Mine Field (East Field 2), proceeds through a small field (this will be called the Winter Road Field), and parallels the swale before meeting the Lindsay Lake Road halfway between the Lindsay Lake Pond and the Boundary Field.

The Lindsay Lake Road continues to be a popular place for nature walks with various groups.

Bracken Tract

The Bracken Tract was used for studies of Tree Swallows, Eastern Bluebirds and vegetation productivity in 1999.

In fall, the property was intensively used by students in Geology 221 (Geological Field Methods). Doug Archibald had the students determine the stratigraphy of the surficial sediments

with soil augers and conduct a magnetometer survey to determine the contact zone between the background gneiss and the magnetic gabbro which holds the magnetite. This work is of interest since the area used to be home to a very successful iron (magnetite) mine.

The donation of the Crabbe property by Lloyd and Jean Crabbe and a building lot by George and Margaret Bracken consolidated this tract where it fronts the Mon O'Kel Road.

Maurice Hutchings is permitted to graze cattle on this tract. In exchange, Maurice keeps an eye on the property.

Moore's Tract

In 1999, the Moore's Tract was used in studies of Black-capped Chickadees, vegetation productivity, secondary succession, butterflies, water mites, Garter Snakes and Ribbon Snakes.

Dr. Ralph Morris made use of the Moore's Tract in fall as a study site for small mammals during his field course.

Preliminary discussions with Dr. Gerry Wyatt, who owns the property immediately to the west of the Moore's tract, indicated that there used to be a walking trail through the property, along the ridgetops from the Wyatt property to the Indian lake Road. Reopening this trail would improve access to the interior of the property.

Table 1: Summary of enrolments in the Ontario Universities Program in Field Biology in 1999 (QUBS courses highlighted)

Course	Instructor	Affiliation	Module	Weeks	Location	B	C	G	M	O	Q	To	Tr	Wa	We	Wi	Y	Other	TOTAL
1a	Kevan	Guelph	Pollination Ecology	2	Mexico	0	0	4	0	0	0	0	2	0	1	2	1		10
2	Handford	Western	Desert Ecology	2	Arizona	1	1	0	0	1	3	1	1	0	3	1	0		12
3	Arnason	Ottawa	Intro. to Tropical Ecosystems	2	Costa Rica	1	0	2	0	6	1	0	0	0	2	0	1		13
4	Ratcliffe	Queen's	Acoustic Communication - Birds	1	QUBS	1	1	0	1	2	3	1	0	0	1	0	1		11
5	Quinn	McMaster	Atlantic Tropical Ecology	2	Brazil	0	1	0	3	0	3	2	0	0	3	0	2		14
6	Middleton	Brock	Disturb.-dominated Ecosys.	2	Argentina	0	0	0	0	0	4	0	0	0	0	0	1		5
7	Fahrig	Carleton	Ecology of Southern Florida	2	Florida	0	0	0	0	0	1	2	0	0	1	0	2		6
9	McGowan	Toronto	Marine Biology	2	HuntsmanMSC	1	1	0	1	1	3	13	0	0	0	0	1		21
10	Yezerniac	Queen's	Behavioural Ecology - Birds	1	QUBS	1	2	0	0	1	2	0	1	0	0	1	1		8
11	Otis	Guelph	Field Entomology	2	Virginia	0	1	8	1	0	2	0	0	0	1	0	2	8	23
12	Fox	Trent	Kawartha Highlands Ecosys.	2	Peterborough	0	2	0	0	1	1	2	4	1	1	0	0		12
13	Gaston	Ottawa	Community Ecology	2	QCI - BC	0	0	1	0	0	0	0	0	0	1	0	1		3
14	Conlan	Carleton	Marine Invertebrates	2	HuntsmanMSC	0	2	0	0	1	1	5	0	0	2	0	1		12
15	Currie	Toronto	Biodiversity of IndoChina	2	Vietnam	0	0	0	1	0	2	7	0	0	1	0	0		11
16	Stutchbury	York	Forest Songbird Ecology	1	Pennsylvania	0	0	0	0	0	1	0	0	0	0	0	4		5
18	Gillespie	Guelph	Ecology of Iceland	2	Iceland	0	0	5	0	0	0	1	0	0	0	0	0	15	21
19	McQueen	York	Eutrophication & Zooplankton	1	QUBS	1	1	0	0	2	2	0	0	0	0	0	6		12
20	Shore	York	Plant Reproductive Ecology	1	QUBS	0	0	0	0	0	1	1	0	0	0	0	0		2
21	Eckert	Queen's	Evolutionary Ecology - Plants	1	QUBS	0	1	0	0	0	5	1	0	2	0	0	1		10
22	Shetsinger	Queen's	Applied Environmental Ecology	2	QUBS	1	0	1	0	1	5	1	1	0	1	0	0		11
23	Hodson	Queen's	Methods in Ecotoxicology	2	Cornwall	0	0	0	0	1	7	1	0	0	0	0	1		10
24	Nudds	Guelph	Field Ecology	2	Algonquin	0	0	13	0	0	1	2	0	1	0	0	0		17
25	Ballantyne	Guelph	Marine Biology	2	HuntsmanMSC	0	0	19	0	0	0	1	0	0	0	0	0		20
26	Carleton	Toronto	Arctic Ecosystems	2	Manitoba	1	1	0	0	0	1	8	0	1	1	1	2		16
27	Miller	Western	Alpine Ecology	2	Alberta	0	0	0	0	0	2	1	0	1	4	1	1		10
28	Zimmerman	Toronto	Lake Ecosystems	1	Algonquin	0	0	1	0	1	0	3	0	0	0	4	2		11
29	Gunderman	McMaster	Insect Taxonomy/Ecology	1	QUBS	0	0	0	2	0	2	0	0	1	0	0	2		7
30	Pringle	McMaster	Systematics - Flowering Plants	1	QUBS	0	0	0	0	0	3	1	0	0	0	0	1		5
31	Francis	Queen's	Bird Migration and Ecology	2	Port Rowan	0	1	0	2	0	4	2	1	1	1	0	1		13
32	Bailey	Western	Freshwater Ecology	2	Algonquin	1	1	0	1	0	0	0	1	1	4	1	1		11
33	Owen	Western	Experimental Marine Biology	2	HuntsmanMSC	0	0	0	0	0	2	0	0	2	3	0	1	1	9
34	Ferris	Toronto	Biogeochemical Processes	1	Deep River	1	0	0	0	1	0	7	0	0	0	0	1		10
35	Roots	Toronto	Photography for Ecologists	1	Algonquin	1	0	1	1	0	1	6	1	3	1	1	3		19
36	Barton	Waterloo	Terrestrial and Aquatic Biology	2	Algonquin	2	0	0	0	1	3	2	1	5	0	0	2		16
37	Morris	Brock	Small Mammal Ecology	1	QUBS	0	0	1	1	0	4	1	0	0	0	0	3		10
38	Smol	Queen's	General Limnology	1	QUBS	1	0	0	0	0	1	0	0	0	0	0	2		4
40	Kolasa	McMaster	Tropical Ecology	2	Jamaica	0	0	0	5	0	3	0	0	0	1	0	0		9
41	Williams	Toronto	Tropical Marine Biology	1	West Indies	0	0	0	0	0	2	5	0	0	0	0	5		12
					# students	14	16	56	19	20	77	76	13	19	33	12	53	24	
					# student-weeks	21	27	109	33	33	127	126	24	32	64	18	74	48	

B=Brock C=Carleton G=Guelph M=McMaster O=Ottawa Q=Queen's To=Toronto Tr=Trent Wa=Waterloo We=Western Wi=Windsor Y=York

Table 2: Summary of credits earned in the Ontario Universities Program in Field Biology in 1999

	B	C	G	M	O	Q	To	Tr	Wa	We	Wi	Y	Other	Total	
														Student-Weeks	Half-Course Credits
Total Student-Weeks Not at QUBS	15	22	106	29	26	94	119	21	29	61	17	57	48	644	322
Total Student-Weeks at QUBS	6	5	3	4	7	33	7	3	3	3	1	17	0	92	46
Total Student-Weeks in Field Modules	21	27	109	33	33	127	126	24	32	64	18	74	48	736	
Total Half-Course Equivalents in Field Modules	10.5	13.5	54.5	16.5	16.5	63.5	63	12	16	32	9	37	24		368

B=Brock
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Wi=Windsor

Q=Queen's
Y=York

13% of credits in entire program earned at QUBS in 1999
(22% in 1998; 18% in 1997; 25% in 1996; 26% in 1995; 21% in 1994)

26% of Queen's credits earned at QUBS in 1999
(40% in 1998; 33% in 1997; 45% in 1996; 34% in 1995; 39% in 1994)

I: Research conducted by Queen's University Personnel in 1999

Dr. Lonnie Aarssen

"Plant Ecology and Evolution"

Viviane Paquin - "Allometric gender allocation in ragweed (*Ambrosia artemisiifolia* L.). " - M.Sc. thesis.

Cultivated field plots in the New Barn field were used for an experimental study involving *Ambrosia artemisiifolia* designed to test hypotheses for allometric gender allocation in plants (size-dependent allocation to male versus female reproductive function): The objectives are: (1) To compare the patterns of plastic allometry in gender allocation when size variation is a result of variation in neighbour effects versus variation in soil resource levels. We predict that variation in size, measured as height, resulting from variation in neighbour effects will generate allometric gender allocation consistent with the 'pollen dispersal' hypothesis (increasing maleness with increasing height), whereas variation in size, measured as biomass, resulting from variation in soil resources will generate allometric gender allocation consistent with the size advantage and time commitment hypotheses (increasing maleness with decreasing size). (2) To examine how plastic allometry varies with age (development) and to examine how developmental allometry varies with environment. Various combinations of ages and environments can produce plants of the same size. Is gender allocation a function of size, regardless of age or environment? Or is gender allocation a function of the interaction between development and environment regardless of size? If the latter is true, then it may not be generally possible to predict gender allocation based on size alone. In this case, allometric gender allocation should be interpreted not as a 'size-dependent' effect per se, but rather as an effect dependent on 'age X environment'. (3) To test the 'time commitment' hypothesis which predicts that plant size is negatively correlated with both maleness and mortality rate. This relatively recent hypothesis has never been tested. The results are forthcoming.

Assistants: Robert Laird, Danush Viswanathan

Robert Laird - "Is the productivity of vegetation higher when it contains more species?" - B.Sc. thesis.

Recent studies have suggested that higher species richness causes higher productivity within vegetation. We predict however that variation in productivity between quadrats within natural vegetation is more closely related to variation in species composition than to variation in species diversity; i.e., a quadrat will generally have high productivity because it contains productive species, not because it contains many species. Does this effect depend on the recentness of disturbance or the time of the season that harvest is taken? Because plants do not choose where they emerge, local diversity and species composition (within 1 m² quadrats) will vary naturally and randomly due to chance in recently disturbed plots. Local diversity and species composition however will change with time after disturbance, as competition excludes certain species from certain sites within the habitat. This study was carried out using three adjacent plots within the Lane Sargent field at QUBS, all originally sown in 1972 with a hay mixture of timothy

grass and red clover: (a) low disturbance: - mown once per year (for hay) for the past 27 years (since 1972). (b) medium disturbance: - as in (a) but also cultivated two years earlier (in 1997) and 5 years earlier (in 1994). (c) high disturbance: - as in (a) but also cultivated once each year for the last 5 years (starting in 1994). All above ground vegetation within quadrats was harvested, separated according to species, dried and then weighed. Multiple regression analyses will be used to test which of the following independent variables is the best predictor of total productivity (total dry weight biomass) per quadrat: species richness per quadrat, species evenness per quadrat, soil fertility per quadrat, harvest date (early season, mid season, late season), and plot disturbance level (low, medium, high). The results are forthcoming.

Assistant: Danush Viswanathan

Dr. Peter T. Boag and Dr. Steven C. Loughheed.

James Austin - "Geographic, historical and ecological correlates of population genetic structure in the bullfrog, *Rana catesbeiana*." - M.Sc. thesis.

Anecdotal evidence suggests that bullfrog populations are declining throughout Ontario and across their natural range, although they remain common and widespread. In SW Ontario where approximately 60% of the total wetland area have been lost, bullfrog populations are noticeably rare. Such anthropogenic influences are evident throughout North America, and continued habitat loss is likely to continue; therefore, understanding and identifying the processes that shape genetic structure is germane to the future of this and other wetland species.

Beginning in 1998, with the logistic support of QUBS, we began sampling bullfrog populations from a nested set of drainages, as well as from across a larger regional scale centered on southern Ontario. Using microsatellites developed specifically for this species we are asking: 1) Does genetic differentiation among neighbouring populations reflect dispersal solely via aquatic habitat corridors or is dispersal a simple function of geographic distance irrespective of the nature (aquatic vs. terrestrial) of intervening habitat? 2) Over what geographic scale (spanning 10s to 100s of km) does significant inter-population genetic differentiation occur in bullfrogs? Future work will expand this geographic scale to address fundamental questions about the role of scale, history, and geographic barriers to gene flow. The empirical examination of genetic structure and gene flow over multiple spatial scales in bullfrogs will provide a unique and theoretically valuable perspective on the influences guiding evolutionary potential of amphibian species.

Dr. Chris Eckert

"Ecology and Evolution of Plant Reproductive Strategies"

Chris Herlihy - "Reproductive assurance and the evolution of self-fertilization in wild columbine, *Aquilegia canadensis*" - Ph.D. thesis

The evolution of self-fertilization from outcrossing is one of the most commonly trod evolutionary pathways in flowering plants, yet there is a lack of empirical data concerning the

ecological and genetic selective factors associated with this transition. Self-fertilization will be advantageous when it provides a means to ensure seed set when pollinators and/or potential mates are scarce (reproductive assurance), yet may be costly if self-fertilized ovules could have been used instead for outcrossing (seed discounting). The consequences of self-fertilization in terms of reproductive assurance and seed discounting were studied in 12 populations of wild columbine (*Aquilegia canadensis*) around QUBS in 1999, and in 9 of these populations in 1998. Wild columbine has a well developed mechanism of self-fertilization, where the anthers curl forward as the flowers develop, ending up in close proximity to the stigmas, resulting in self-pollination. The capacity for within flower self-pollination can be eliminated by removing the anthers before they begin to shed pollen. The seed set and amount of self-fertilization can be compared between these emasculated (E) flowers and intact (I) control flowers. As predicted by hypotheses of reproductive assurance, removing the capacity for within-flower self-fertilization decreased the number of seeds produced, indicating that outcross pollination is insufficient, and that self-pollination provides reproductive assurance by increasing seasonal seed set. However, molecular genetic analysis of the mating system showed that there was substantial self-fertilization in E flowers, indicating that large amounts of self-fertilization occur via transfer of pollen between flowers on the same plant (geitonogamy), resulting in severe costs associated with seed discounting. These data, combined with previous results indicating very strong inbreeding depression indicate that overall, automatic self-fertilization results in a net fitness loss in these populations.

Assistant: Michael Bhardwaj.

Agnes Kliber - "Factors affecting inter-floral variation in reproductive allocation in *Aquilegia canadensis*" - B.Sc. Thesis

How an organism allocates finite resources has been a central question in evolutionary ecology. It is hypothesized that individuals partition limited nutrients and energy in a manner that ultimately increases the likelihood of passing its genes on to future generations. A common observation in sequentially flowering plants is a decline in allocation to reproductive structures (flowers, pollen, ovules, seed) across a single flowering season. Furthermore, seed set declines between proximal fruits (located closest to resources) and those that are located more distally. My project proposed to look at this pattern of allocation in *Aquilegia canadensis* (wild columbine), a native perennial that invests strongly in floral development (4-8 large red flowers with nectar spurs) and exhibits a sharp decline in allocation to all reproductive traits, especially seeds (>90%) between early-formed and later-formed flowers. Specifically, I am addressing two questions: 1) What proximate factors affect resource allocation to reproductive traits? and 2) Are there any selective factors that favour this decline pattern? Using field manipulations I tested pollen abundance, resource availability and architectural constraints as possible proximate factors causing lower seed set in late flowers. I also looked at herbivory rates and mating systems of flowers across the flowering season to determine whether they can function as strong selective pressures favouring early-flower maturity. Preliminary results indicate that temporal variability in pollen availability does not explain the low seed number in later flowers while resource stress increases selective abortion of late fruit. Herbivory damage was greatest on flowers that opened later in sequence. Higher seed set in early flowers may be, therefore, an adaptive strategy to capitalize on the higher survival probability of early flowers.

This research was supported by the **Wes and Dorletta Curran Scholarship** in Biology.

Publications:

Eckert, C.G., M.E. Dorken and S.A. Mitchell. 1999. Loss of sex in clonal populations of a flowering plant, *Decodon verticillatus* (Lythraceae). *Evolution* 53: 1079-1092.

O'Connell, L.M. and C.G. Eckert. 1999. Differentiation in sexuality among populations of *Antennaria parlinii* (Asteraceae). *International Journal of Plant Science* 160:567-575

Routley, M.B., K. Mavraganis and C.G. Eckert 1999 Effects of population size on the mating system in a self-compatible, autogamous plant, *Aquilegia canadensis* (Ranunculaceae). *Heredity* 82: 518-528.

Dr. Rudolf Harmsen, Professor Emeritus and **Dr. Suzanne Blatt**, Post-doctoral Fellow.

"Secondary succession in an abandoned hay field in southeastern Ontario"

Secondary succession in abandoned hayfields has been assumed to follow a predictable and linear pathway from grass species through to climax forest. Further, the final species composition is determined by local climatic and geomorphic characteristics. This view of succession does not account for herbivory, by either invertebrate or vertebrate species. The permanent plots established in 1975 and monitored yearly for plant, invertebrate and vertebrate species have shown otherwise. Contrary to the general theory, succession within our plots neither progressed in a linear fashion, nor resulted in a predictable species composition. A theoretical model of succession to include herbivory has been formulated and generates results consistent with our observations. Further analysis of the data to determine the influence of invertebrate and vertebrate herbivory, while accounting for climatic and geomorphic characteristics, on succession pathways is currently in progress.

Assistants: Mary-Beth Savage, Shauna Sellers, Monica Guzkowsky and Dirk Zuidema

Jim Karagatzides (Queen's U. Dept. of Geography) with **Dr. Len Tsuji** (Dept. of Environmental Science, University of Toronto at Scarborough)

"An examination of the potential effects of bismuth shotgun pellets on soils and plants of southern Ontario hardwood forests and wetlands"

Bismuth has been proposed as a non-toxic alternative to replace lead shot pellets. However, while bismuth is used as a treatment for ulcers, little research has been undertaken on its potential impact to plants, soil and wildlife. Furthermore, on-going acid deposition may lead to mobilization of bismuth in terrestrial and aquatic ecosystems. In 1999, we established long-term monitoring plots in a sugar maple forest and marsh at QUBS. In each environment, 24 plots were established and given one of four treatments: bismuth, acidifying agent (ammonium sulphate

pellets), bismuth plus acidifying agent, controls. Bismuth pellets were applied at average rates presented in the literature for current rates of lead pellets in the environment: 50 pellets per m² for upland forests and 200 pellets m² for wetlands. We will examine the change (before vs after treatment comparisons) in soil chemistry (pH, bismuth and other elements), vegetation biomass and chemical status of wetland and forest herbs, and tree ring increment growth and chemistry.

Dr. Allen Keast

"Comparisons of Lake and Stream Fish Communities in Eastern Ontario"

A feature of freshwater fish systems is the striking contrast in the communities of lakes and streams: in species composition, use of habitat, division of living space, body size of the fish species, life history parameters and utilization and subdivision of food resources. Ontario is remarkable in two ways: the great diversity in types of lakes and streams and the recency of the assemblages (post-glacial, maximum age in present form only 8-10,000 years. Recently, QUBS has added the Pangman Conservation Reserve to its landholding, property which contains a series of small lakes and beaver ponds. This property offers new study sites for comparisons within the wider Ontario framework.

I have proceeded with reworking data from a series of graduate student theses, reinterpreting data in terms of newer theoretical aspects and quantifying the features of additional water bodies. The data are being related to changes along the length of streams and ecologies relative to measured resource bases. In the immediate area of QUBS, two extremes, one represented by sluggish, weedy and silted systems (Cooligan and Jones Creeks) contrast with the second, with high gradients and rapid flow (Shelter Valley and Medway Creeks). In the Medway, changes in species composition along the system are striking: entrance drainages have only 5 or 6 fish species, while the first permanent ponds a few kilometers below have 17 species (70% species turnover). Species also differ between these ponds and gravel riffle sites a few kilometers below (44% turnover). Overall, between the headwaters and the impoundments found near the mouth of the creek show a full 80% species turnover. The species (and their age) classes quantitatively relate to prey types in the various habitats, with chironomid eaters and herbivores being prominent according to food availabilities.

The dominance of large-bodied fish in lakes (including Lake Opinicon) and limitation to small-bodied fish in small streams have broad implication to prey and resource use: these have been quantified and related to foraging theory. Indeed, in stream and beaver ponds, larger prey like odonate nymphs and small fish go unharvested and underutilized. The proportion of biomass and absolute measures of biomass of fish in different trophic levels in stream and pond communities as compared to lakes indicate that the food webs and energy flow systems are very different. Attempts are being made to develop such data into quantitative frameworks.

Back in the '60s, when interspecific competition and its role in the structure of communities was a major area of research, and prevalent theory operated on the basis of species fitting tightly into communities because of well-defined and predictable space use and feeding ecology, the great ichthyologist Peter Larkin jolted his colleagues in stating that fish were really quite plastic in diet and use of habitat. Implications of this statement have never been fully explored. In newer synthesis, I have taken up this theme with a series of specific questions: Just how plastic are fish species? Are some more plastic than others? How does adult diet relate to

age-specific diet? Where diets differ between water bodies, is this a result of differing availability of food or is the presence/absence of competing species of importance? What are the implications of different suites of cohabitators? Survey work on these questions continues.

Dr. William Leggett, Dr. Jim Garvey and Dr. Tom Herra

"Searching for general recruitment mechanisms in sunfishes"

For many taxa including fish, variable recruitment from earlier to later life stages during the first year of life drives variability in adult abundances. Identifying critical recruitment "bottlenecks" is a challenge for ecologists and resource managers interested in forecasting community responses to perturbations. Conventional wisdom holds that cohort strength of fish is regulated (i) during egg and larval stages in marine systems and (ii) during juvenile stages in freshwater ones. To determine if the latter view is valid, Jim Garvey, Tom Herra, and Bill Leggett explored mechanisms underlying first-year survival of centrarchids (sunfish and largemouth bass) in Lake Opinicon, Ontario during May 1998 through May 1999. An intensive survey of stage-specific survival of age-0 sunfish in Lake Opinicon revealed that survival depended on interactions during multiple, interdependent life stages. Declining temperatures during early spring and depletion of energy reserves by small/young individuals during winter reduced survival of pelagic larvae and littoral juveniles, respectively. When managing widely distributed species, both plastic life history responses to the environment and interdependencies among life stages must be considered, rather than focusing on the responses of isolated life stages. Early growth and survival of fishes in northern lakes may largely be regulated by seasonal abiotic factors; these early events have important effects on later life stages.

Dr. Bob Montgomery

"Sperm Evolution in Fish"

For the past few years we have been studying the behaviour and morphology of fish sperm to get some insight into the factors that influence the evolution of sperm, especially sperm competition. In 1999 Stephen Casselman continued this work by gathering data on the production, movement patterns, and longevity of sperm from a variety of fish species. We completed our studies comparing sperm traits among the different mating types of bluegills (*Lepomis macrochirus*) and have found that sneakers and female mimics have no sperm characteristics that would put them at a competitive advantage with parentals. Thus the evolution of alternative reproductive tactics in this species has not been accompanied by any evolution of sperm traits in the face of intense intraspecific sperm competition. We are still analyzing data for an interspecific comparison. In 2000 we will continue our comparative studies at QUBS.

Assistant: Stephen Casselman

Publications:

Yezerinac S.M., Gibbs, H.L., Briskie, J.V., Whittam, R. and R. Montgomery 1999 Extrapair paternity in a far northern population of Yellow Warblers *Dendroica petechia*. *Journal of Avian Biology* 30:234-237

Leach, B. and R. Montgomery 2000 Sperm characteristics and their influence on sperm competition in bluegills (*Lepomis macrochirus*). *Behavioural Ecology and Sociobiology* (in press).

Frank Phelan - Queen's University Biological Station

"Fisheries Apprenticeship Program"

For the last several years, students have been employed under an agreement with the Ontario Ministry of Natural Resources. The Fisheries Apprenticeship Program provides field experience in sampling methods and an exposure to field research for students in the program. At the same time, OMNR obtains ongoing sampling and monitoring of lake trout and fish communities in select lakes at low cost. This mutually beneficial arrangement forges links between QUBS and OMNR and between students and potential employers in fisheries management.

In 1999, a Spring Littoral Index Netting (SLIN) for lake trout was done in early summer on Big Rideau Lake. In August, a Nearshore Community Index Netting (NSCIN) of the fish community in Lake Opinicon was done. These samples continue the monitoring started by the Rideau Lakes Fisheries Assessment Unit, now defunct.

Matthew Coombs was hired for the full summer under this program. For most of the summer, Matt worked as a research assistant with Frank's and Dave Philipp's crew studying Largemouth and Smallmouth Bass. During the SLIN netting, Geof Hall was invaluable. During the NSCIN, Steve Griffin helped out.

Assistants: Matthew Coombs, Geof Hall, Steve Griffin

Dr. Laurene Ratcliffe

"Acoustic communication and mate choice in birds"

In 1999, we completed our investigation of female-female mating competition in chickadees (Scott Ramsay) and began experiments on long-distance signalling of mate quality cues (Eavesdropping - Dan Mennill; Song fidelity - Peter Christie). The 1992-99 data base on female extra-pair choice also allowed us to test whether extra-pair copulations (EPCs) are associated with a tendency to divorce, and whether females seek EPCs from nearest-neighbours. Honours' student Amy MacDougall analysed the relation between chickadee social rank and blood parasite levels in both wintering and breeding populations, and discovered that QUBS chickadees are essentially parasite-free! The final field season studying Hidden Leks in least

flycatchers (Scott Tarof) focussed intensively on sampling for molecular parentage analyses, while Honour's student Jeff Bos compared the competitive abilities of males breeding solitarily versus those joining breeding clusters. Finally, in a continuing collaboration with Queen's Psychology Department, PhD student Leslie Phillmore studied transmission characteristics of chickadee calls, and effects of distance on birds' abilities to discriminate individuals.

Scott M. Ramsay - "Mating tactics of female black-capped chickadees, *Poecile atricapillus*"
- Ph.D. thesis

Scott's thesis investigates factors determining female chickadee success in mating competition, including 1) individual resource-holding potential (RHP), 2) prior residency, and 3) nest placement. Having completed all his field work in 1998, Scott devoted most of the 1999 season to running molecular analyses of parentage and offspring sex ratios, using the QUMEL facilities. He also carried out a large-scale analysis of female-initiated divorce and extra-pair mate choice with the aid of Ken Otter (PhD 96) and Dan Mennill (MSc in progress). Scott's results demonstrate clearly that relative status (social rank) in female chickadees reflects intrinsic variation in individual quality; thus females do not acquire social rank from their mates. Female rank predicts success at acquiring high-quality mates; while most females are socially faithful, divorce and extra-pair matings appear to reflect separate strategies to obtain good genes.

Scott Tarof - "Sexual and natural selection in least flycatchers: why do breeding birds cluster?" - Ph.D. Thesis.

Least Flycatchers (*Empidonax minimus*) are insectivorous migratory suboscines that defend all-purpose territories. Pairs aggregate in clusters on the breeding grounds. This strong aggregative behavior is unique among other socially monogamous passerines, however no study has explicitly investigated Least Flycatcher settlement patterns or possible ecological and/or social explanations for clustering. My research exemplifies the emergence of a new perspective on avian settlement patterns.

Rather than explaining clustering of territories by resource distribution alone, I test the view that aggregative behavior is a consequence of mating strategies employed by males and females by examining four main hypotheses for avian clustering. The hidden lek hypothesis holds that socially monogamous birds aggregate in response to the pursuit of extrapair copulations (copulations outside the social partnership, or EPCs). The material resources hypothesis suggests birds cluster in response to discontinuities in resource distribution (vegetation, food). The predation hypothesis suggests clumped nesting may be an adaptive response to reduce predation risk. The conspecific attraction hypothesis proposes that individuals seek out and benefit from breeding in close proximity to conspecifics, independent of resource distribution. This is the first test of the hidden lek hypothesis in a socially monogamous bird, and the first genetic mating system study for Least Flycatchers.

My objectives are to (1) describe settlement dynamics in Least Flycatchers, and (2) examine the adaptive significance of clustering. Most of my fieldwork has been completed (1997-1999) at QUBS and will conclude this May. Samples for molecular work have been collected and paternity assignments are underway.

Cluster Dynamics

My first objective was to describe cluster formation. I monitored arrival dates of males and females each day in May, recording settlement patterns, cluster configuration and pairing success. I mapped territories and nest locations using the Global Positioning System during the breeding season ($n = 75$ territories). Daily visits enabled confirmation of territory residency and pairing status of all singing males. I examined 5 clusters in 1997 (2-20 territories/cluster), 2 clusters in 1998 (9-33 territories/cluster), and 6 clusters in 1999 (2-11 territories/cluster). Clusters were distinct units separated by adjacent unoccupied habitat and were comprised of small territories at densities up to 13 territories/ha. Territory boundaries were always contiguous. Territory size ($x = 0.14$ (0.09 ha)) was consistent across years. Clusters grew radially. Although clustering was common, males sometimes settled solitarily; 11/89 (12%) in 1997, 7/93 (8%) in 1998 and 34/104 (33%) in 1999. Solitary males were significantly less likely to pair than were clustered males, although arrival of solitary males overlapped that of females. To my knowledge, no other study has found solitary territorial male Least Flycatchers to this extent. Consequently, this summer I will collect additional data on cluster dynamics, with particular emphasis on solitary male distribution, providing a 4-year data set on settlement patterns with which to examine explanations for clustering.

Are Clusters 'Hidden' Leks?

My second objective was to examine explanations for clustering. I am testing the hidden lek hypothesis at the behavioral and genetic levels. This hypothesis proposes that socially monogamous birds cluster for EPCs, just like lekking species cluster for promiscuous copulations with multiple mates. Classical leks, where males cluster at display sites and compete for matings with visiting females, are characterized by male clustering, female pursuit of copulations, no female-required resources other than sperm, no paternal care, intense male-male competition, and a skew in male mating success. The difference between classical and 'hidden' leks is that in the latter clustering is disguised by territoriality and biparental care. However, these features of socially monogamous mating systems do not preclude the possibility that such systems could resemble leks.

I use data on mating behavior and male song performance to assess the hidden lek hypothesis at the behavioral level. Using microsatellites developed as part of this project, I will identify extrapair sires and correlate extrapair paternity with male morphology, age, and mating behavior to assess the extent to which clusters resemble leks at the genetic level. I predict males to cluster in uniform habitat and display to neighboring females for EPCs. I also predict a skew in realized reproductive success, with one or a few preferred males siring the majority of nestlings in a cluster. I have mist-netted and banded 78 adults and collected morphology and age data, and took DNA samples from the brachial vein of adults and offspring. I quantified mating behavior and male song performance during focal watches of 51 breeding pairs. EPCs (x (SE)) were common in 1997 [1.8 (0.3/hr. ($n=19$ pairs, range 0-7))], 1998 [2.5 (0.4/hr. ($n=20$ pairs, range 0-10))], and in 1999 [1.0 (0.3/hr. ($n=12$ pairs, range 0-5))], supporting the prediction that Least Flycatchers cluster and seek EPCs. EPCs sometimes involved mixed-sex groups (of 4 or more birds) and typically ended in highly aggressive chasing and fighting, similar to behavior observed on leks. Male-male competition was intense and males sang up to 3000 songs/hr., presumably to attract mates. Such display behavior is similar to the behavior of lekking males advertising to visiting females. Seven of 135 incursions onto focal territories were by neighboring females, and females solicited EPCs while on-territory. Female receptivity to EPC is central to the hidden lek hypothesis.

I investigated three alternative hypotheses for clustering, as outlined in my introduction. Preliminary analysis of extensive vegetation sampling data ($n = 256$ plots) do not detect differences in vegetation features. Insect data remain to be analyzed. I am using nesting success data collected over the past 3 years from clusters of varying size to test the prediction that clustering reduces rates of predation. Behavioural data on 'cooperative' mobbing by multiple pairs of Least Flycatchers supports the predation hypothesis. If Least Flycatchers cluster in response to each other, clusters should be experimentally inducible and should shift between years, independent of habitat features. A pilot study performed in 1999 suggested that clusters might be successfully created experimentally. Clusters are episodic between breeding seasons.

My study is a fresh examination into potential explanations for the propensity to cluster. My findings most strongly support the hidden lek hypothesis, although clustering could also be attributable to reducing predation. This project will enhance our understanding of how mating opportunity can lead to a re-interpretation of what constitutes preferred breeding habitat for birds.

Assistants: Heather Ducharme, Jeff Bos, Nicole Vreeswyk

Daniel Mennill - "Female Eavesdropping in the Black-capped Chickadee" - MSc thesis

The 1999 field season was the first year of my investigation of female eavesdropping and extra-pair partner choice in the Black-capped Chickadee (*Poecile atricapillus*). In January I individually banded 165 birds at 10 feeding stations around the Station Point. Throughout February and March I established winter flock dominance hierarchies by observing chickadees interact at experimental feeders. To assess whether females eavesdrop on the vocal interactions of territorial males I performed a playback experiment to 13 dyads of high and low-ranking neighbours during the breeding season. I used two interactive playback treatments to demote high-ranking males and promote low-ranking males. I then assessed whether females preferentially forayed into the territories of playback-promoted males using radio telemetry and observational tracking on the morning following playback treatments. I also tested whether eavesdropping females sought extra-pair copulations from playback-promoted males using microsatellite analysis to determine patterns of mixed paternity in 26 nests.

Analyses of male responses to interactive playback indicate that high and low-ranking males respond differently to aggressive and submissive playback treatments. While evidence from behavioural observations showed no strong changes in the behaviour of eavesdropping females following playback treatments, results from paternity analysis demonstrate that females may choose extra-pair partners by eavesdropping on their performance in vocal contests. In upcoming field seasons I will expand my investigations of female eavesdropping, male singing behaviour, and communication networks in the Black-capped Chickadee.

Assistants: Meaghan Cunningham, Amy MacDougall, Nicole Vreeswyk

Peter Christie - "Song structure and mate choice at a distance in Black-capped Chickadees" - M.Sc. Thesis

I began my first field season in 1999 in my effort to determine whether fine structure in the songs of male black-capped chickadees might provide distant listening females with clues to male quality. In particular, I was interested in determining whether song structure contains indicators of

male status (that is, his social rank in the linear dominance hierarchies of winter flocks) and whether these indicators might become easier or more difficult to discriminate when heard across distances through the forest. A secondary question asked whether song structure was individually distinctive across broadcast distances. The 1999 season provided a chance to get acquainted with QUBS and its well-known resident population of chickadees. It also provided a preliminary run at some of the recording and transmission work I will be repeating in the coming spring. Early days involved recording the dawn chorus of singing males. I then selected and digitized 10 songs each from the choruses of eight males. These were selected to represent socially dominant and subordinate flockmates from four winter flocks. I then broadcast the songs through the early morning forest at the Lindsay Lake trail and re-recorded them at 11 distances between 5m and 120m. A structural analysis of these recordings suggests song structure may provide cues to social status and identity, but songs recorded at short and long broadcast distances are more reliable than songs recorded at middle distances where reverberation effects are the most acute. The coming season will provide a larger, more statistically reliable sample. Other efforts during my season at QUBS involved recording the "faint fee-bee" nuptial feeding calls of males returning with food to their incubating mates. I began trials of a playback experiment (that will be continued in the coming season) to explore whether females can distinguish the calls of their mate from the calls of male strangers. A hurried and harried start to the season was facilitated considerably by Dan Mennill, who provided ideas, skills and all the social dominance data collected during his many cold, cold hours of winter observations at chickadee feeders.

Assistants: Dan Mennill, Amy MacDougall, Nicole Vreeswyk.

Jeffrey Bos - "Advertisement, aggression and settlement patterns in the Least Flycatcher" - B.Sc. Thesis

This project compares the competitive ability of male least flycatchers (*Empidonax minimus*) breeding out of earshot of neighbouring males ("solitary") versus those breeding in territorial clusters. I compared basal song advertising rates of unpaired solitary and clustered males, and measured their aggressive behaviour during settlement. Solitary and clustered males were observed for 30 min before and during a song playback challenge which simulated neighbour settlement. Results show that solitary males advertise at significantly lower basal rates prior to a challenge, yet are capable of mounting sustained aggressive responses that are not significantly different in intensity than those of clustered males. My results, in combination with morphometric and age data on solitary and clustered males (S. Tarof, unpubl.), allow us to reject the hypothesis that solitary breeders are competitively inferior to males breeding in clusters.

Amy MacDougall - "The effects of parasite load on the behaviour and social rank of the Black-capped Chickadee (*Poecile atricapillus*)" - B.Sc. Thesis

Black-capped chickadees are resident, socially monogamous birds exhibiting biparental care. Females are choosy in their selection of mates, potentially selecting them for their "good genes", including genes providing resistance to parasites. If parasitic infection is costly to a host, differences in behaviour may be observed between parasitized and non-parasitized birds. These differences may be seen in relative position in social dominance hierarchies, song output in the dawn chorus, or nestling provisioning ability. This thesis investigates the relationships between

blood parasite load and social rank, song production, and parental feeding rates in the black-capped chickadee. Individuals of a wild chickadee population at QUBS were observed through the winter to determine social hierarchies. Through the breeding season, behavioural data and song recordings were collected. Individuals were captured in both seasons to obtain blood samples for parasite analysis. Preliminary results suggest that this population is free from parasitic infection of common avian blood parasites (0 parasites observed in 84 adult samples). My thesis topic has evolved to examine effects of parasites in Pine Siskins (*Carduelis pinus*) from a population at Tioga Pass, CA. Analysis of the siskin data is currently being performed, and will determine if endoparasites exert selective pressures on the host population.

Assistants: Dan Mennill, Nicole Vreeswyck, Peter Christie

Leslie Phillmore (Department of Psychology) and Scott Ramsay - "Distance and individual recognition by calls in Black-capped Chickadees and Zebra Finches."

This year we extended previous work aimed at understanding how birds estimate the distance of calling individuals and how they distinguish one individual from another. In previous work we used the fee-bee song of black-capped chickadees; this year we added chick-a-dee calls to the protocol. In February, we spent three days at QUBS recording calls from individuals in the banded population. By using these birds, we were able to tap into the existing database of information about each of the individuals we recorded. Over the course of the three days we made 15 hours of recordings taken within 5 metres of the calling birds. On two mornings in late September, we set up in the forest at the Pangman Reserve to make distance degraded recordings of the calls we had recorded in February. In addition to re-recording the chickadee calls, we also made distance degradation recordings of zebra finch (*Taeniopygia guttata*) calls. The degraded calls are currently being used in operant experiments with captive chickadees and zebra finches in the Psychology Department at Queen's, to test their ability to use different cues to assess distance and the identity of the caller.

Dr. Raleigh J. Robertson

"Behavioural Ecology and Conservation Biology of Birds."

Our research efforts in 1999 focused on behavioural ecology studies of Tree Swallows and Eastern Bluebirds, as well as studies that have conservation implications for the declining Cerulean and Golden-winged Warblers.

Wally Rendell, having finished field studies on Tree Swallow clutch size evolution, designed a study to examine the role of food supply on egg and clutch size in Eastern Bluebirds. Wally initiated the study in April, and Gillian Glenn-Worrall continued the work through the breeding season, while Wally turned his attention to finishing his Ph.D. thesis. Bart Kempenaers, now at the Max Planck Institute in Germany, brought a crew consisting of Angelika Poesel, Agnes Tuerk, Cheryl Bishop and Kim Carter to examine various aspects of sperm competition in Tree Swallows.

On the Cerulean Warbler studies, Jason Jones, with assistance from Sergio Harding, completed the final field season for his Ph.D. on Cerulean habitat relations. Jenn Barg, with help

from Ryan DeBruyn and Ben Risk, started field work for her M.Sc. on female Cerulean use of habitat. Tim Demmons, working with Bill McLeish, continued his work on Golden-winged Warblers, focusing on aspects of predation and the adaptive significance of nesting on edges. Jamie Beauchamp, with assistance from Erin, also worked on edge habitats for his B.Sc. thesis, examining bird community structure in relation to edge habitat manipulations on various Queen's research tracts.

Paul Hamel and his research assistant, Chris Woodsen visited QUBS and worked with our Cerulean crew for several days in June. Paul has been very helpful, initially for Lisa Veit's work, and now with Jason and Jenn's continuing work.

Jesus Vargas, University of Campeche, Mexico, visited QUBS for several weeks to gain experience with warblers in breeding habitat. Jesus proved to be a very skilled nest finder and we enjoyed his involvement in the field.

Jason Jones - "Habitat selection and disturbance response in a peripheral population of Cerulean Warblers (*Dendroica cerulea*)." - Ph.D. Thesis

Over the last thirty years, researchers have become concerned with observed declines in regional breeding populations of almost one-third of Neotropical migrant landbirds. A species of special concern is the Cerulean Warbler (*Dendroica cerulea*). Throughout much of its range, this species is experiencing precipitous declines; estimates derived from Breeding Bird Survey data show regional declines of as much as 3.4% per year from 1966-1987. In sharp contrast to continental trends, recent research indicates that eastern Ontario is home to a sizeable population of Cerulean Warblers that is experiencing relatively high reproductive success. The overall goal of my thesis is to explore the demographic, behavioural and ecological factors regulating the eastern Ontario Cerulean Warbler population.

Reproductive success of our study population is beginning to climb back towards pre-Ice Storm 1998 levels. After a dismal season in 1998 (8% nest success), our study population enjoyed ~45% nest success with two-thirds of the territorial pairs successfully rearing young. Concurrently, the birds have significantly shifted the locations of their nests. Nests in 1999 were significantly higher and further out on branches than in the previous 3 years of this study. Also, pairs appeared to be avoiding gaps in the forest canopy when selecting their nest-sites. As part of the effort to assess how the habitat disturbance resulting from the 1998 Ice Storm affects our population, I collaborated with Jennifer Barg on a series of behavioural watches in which we documented how the male and female used available foliage when moving to and from the nest-site. Preliminary analyses suggest that those nests with medium levels of vegetation surrounding the nest are the most successful. The unpredictable loss of habitat resulting from the ice storm has afforded me the opportunity to examine the relationship between site fidelity, habitat quality and habitat selection in Cerulean Warblers and will provide insight into the relative importance of the physical and social features that drive avian habitat selection.

I'd like to extend a special thank-you to the land-owners who graciously allowed me to work on their property - Rhonda Elliott, Turid Forsyth, David Hahn.

1999 Collaborators and Assistants: Jennifer Barg, Ryan DeBruyn, Sergio Harding, Ben Risk, Jesus Vargas

Jenn Barg - "Intra-territory habitat use and behavioural ecology of Cerulean Warblers during the breeding season" - M.Sc. Thesis

I began my graduate studies at Queen's hoping to study spatial use and behaviour of female Cerulean Warblers. The summer of 1999 provided me a great learning experience on the ways of female Cerulean Warblers, and on the frustrations of not being able to go about what you set out to do. While we had great success at detailing behavioural time budgets for females, they were too difficult for us to follow with the naked eye. Therefore, female spatial use questions will remain for another day, another observer.

However, we simultaneously collected detailed spatial use patterns of male Cerulean Warblers, and this will form the basis of my thesis. By examining habitat use patterns on the territory scale, we can build on our knowledge of habitat needs for this species. This will nicely complement the research of Jason Jones, whose questions have involved habitat use on larger scale.

My work during the summer of 2000 will focus on male Cerulean Warbler spatial use within the territory, and I will continue detailing female time budgets during incubation and nestling feeding.

1999 Collaborators and Assistants: Ryan DeBruyn, Sergio Harding, Jason Jones, Ben Risk and Jesus Vargas.

Tim Demmons - "Use of forest-field edges by Golden-winged Warblers" - M.Sc. Thesis

The 1999 field season was the third year that Golden-winged Warblers (*Vermivora chrysoptera*) have been studied at QUBS. Golden-winged Warbler populations are in decline throughout their breeding range, likely due to breeding habitat loss and hybridization with a closely related species, the Blue-winged Warbler. The QUBS population is at the northern extreme of the Golden-winged Warbler/Blue-winged Warbler hybrid zone, and is one of the few remaining areas without sympatric breeding Blue-winged Warblers.

In 1999, our nest searching effort was increased, and we were able to find 29 Golden-winged Warbler nests. Following fledging or depredation, extensive vegetation measurements were taken at nest sites and random sites. Golden-winged Warbler nest sites were located on forest-field edges with significantly more shrubby growth than random sites along the same edges. Also, preliminary results suggest that nest cover does not affect nest predation.

Based on the results of our nests site selection data, we also conducted an artificial nest study to investigate the effects of edge structure on nest predation at forest-field edges. Data analyses are pending, but it appears that within one landscape type, forest-field edge structure has little effect on nest predation intensity.

Special thanks to Raleigh J. Robertson, William J. McLeish, Jamie and Erin Beauchamp, Jesus Vargas, Turid Forsyth, Kelly Pageau, Frank Phelan, Heather McCracken, Celine Muis, and all others who were kind enough to help out with this project.

Assistants: William J. McLeish, Jamie and Erin Beauchamp, Jesus Vargas

Gillian Glen-Worrall - "Patterns of egg mass variation and incubation in eastern bluebirds (*Sialia sialis*)."

During the summer of 1999, I worked as a research assistant on a collaborative project involving Wally Rendell and RJR, and funded in part by NABS. From April to July, we banded and measured adult and nestling bluebirds, measured egg masses, and determined hatching order for the 33 pairs of bluebirds nesting in artificial boxes around QUBS. Wooden trays were also constructed beside half of these boxes, with mealworms and raisins being supplied daily as food supplements for these pairs.

The purpose of the study was to determine egg mass variation in eastern bluebirds. Studies of egg mass in altricial birds reveal intra-clutch variation, often with a predictable pattern. For example, in tree swallows, the last laid egg is significantly larger than the first, while the opposite is true in the pallid swift. Furthermore, average egg mass may differ so considerably between individuals within a population that average egg mass for some females may be only 60-70% that of the heaviest average egg mass in a population.

Differences in average egg mass within a clutch often correlates positively with female body size. Furthermore, differences in egg size may reflect a female's opportunity to secure the necessary energy for egg production before and during laying. Through the food supplementation experiment, such energetic constraints may have been lessened. Alternatively, patterns of egg size and laying sequence could reflect an evolved attempt to modify hatching asynchrony, and therefore nestling size hierarchies. For example, by laying a small, or large, last egg, females could increase, or decrease, respectively, hatching asynchrony. By marking and weighing each egg on the day it was laid, and then determining hatch order and time, we were able to observe any patterns.

Jamie Beauchamp - "Land management strategies for enhancing biodiversity"

Queen's university is implementing a long term land management plan which is attempting to increase the quality of forest edge habitat for the local bird community. Sections of edge between forest and hay field are being excluded from future mowing. This will allow for the growth of a shrubby zone between the forest and the field, which should result in an increase in bird diversity and maybe the breeding success of these birds. I censused the bird community and sampled the vegetation around these fields in order to 1) collect data which will form the baseline for future research, 2) make predictions for future change in the bird community, and 3) to identify problems and make suggestions.

Assistant: Erin Beauchamp

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Demmons, T. D. 1998. Parental care and nest site selection by Golden-winged Warblers. B.Sc.H Thesis. Department of Biology, Queen's University, Kingston, Ontario.

Rendell, W.B. 1999. Evolution of clutch size in tree swallows: trade-offs during reproduction, age-specific fecundity and survivorship. Ph.D thesis. Department of Biology, Queen's University, Kingston, Ontario.

Dr. John Smol

"Establishing development guidelines for lake watershed management in southeastern Ontario using a multi-proxy paleolimnological approach"

Investigators: Kimberley E. Neill, Francine Forrest, E.D. Reavie, J.L. Little and John P. Smol

Kimberley E. Neill & E. D. Reavie - "Paleolimnological reconstructions using subfossil Chironomidae (Diptera) and Diatoms (Bacillariophyceae) as indicators of deepwater dissolved oxygen depletion and nutrient levels in two Southeastern Ontario Lakes"

Increased lake productivity resulting from cultural activities such as land clearance and cottage development can cause an increase in nutrient levels and a subsequent decrease in deepwater dissolved oxygen (DO). Depleted deepwater DO is a serious problem because it can result in the displacement and death of benthic fish and invertebrates, and cause the release of toxic substances, such as heavy metals and phosphorus from the sediment. This study demonstrates that taking a multi-proxy paleolimnological approach to reconstructing past lake conditions can provide a holistic understanding of past environmental lake conditions. In our study, diatom remains (siliceous algae) were used to reconstruct past nutrient levels, and subfossil midge (Chironomidae, Diptera) larvae provided proxy historical data to reconstruct deepwater DO levels. The main objectives of our paleolimnological research were to determine and compare pre- and post-settlement nutrient and deepwater DO regimes in the recently undisturbed Round Lake (on the QUBS Pangman Conservation Reserve) and a moderately culturally disturbed lake (Hambly Lake) over the past ca. 200 years, and to propose realistic mitigation and management guidelines for these lakes.

Prior to human settlement, the diatom and chironomid assemblages indicate that the nutrient conditions in Round Lake were oligotrophic and deepwater DO was high. With the onset of cultural development surrounding the lake, there were shifts in both assemblages indicating that there was an increase in nutrient levels and a subsequent decrease in deepwater DO. The high nutrient levels and hypoxic conditions during cultural development may have resulted from disturbances such as logging, mining and railroad construction surrounding Round Lake. The land surrounding Round Lake has now been converted into the Pangman Conservation Reserve and cultural development activities are no longer taking place within the catchment. Final shifts in the diatom and chironomid assemblages indicate that the nutrient and deepwater DO conditions have returned to pre-cultural development conditions.

In Hambly Lake the post-settlement changes in diatom and chironomid assemblages are subtle despite moderate cultural disturbance within the catchment. We concluded that this lake has had relatively high nutrient levels and is naturally anoxic for the past ~200 years.

In terms of lake management, the recent conversion of the Round Lake catchment to conservation reserve has contributed to the restoration of nutrient and deepwater DO levels to conditions similar to those prior to cultural development, demonstrating the resilience of this lake system. In contrast, Hambly Lake's nutrient and deepwater DO levels have not been greatly affected by moderate levels of cultural activity. Hence, mitigation efforts to decrease nutrient levels or increase deepwater DO levels will likely not be effective, as this lake had naturally high nutrient levels and low

deepwater DO conditions. This study demonstrates that chironomids are robust paleolimnological indicators and can be used in conjunction with diatoms and other proxy data to develop a holistic understanding of how lakes like these respond and recover from varying degrees and types of cultural disturbance.

Francine Forrest – “A paleolimnological comparison of trophic state responses to canal construction and other disturbances: A comparison of several lakes within the Rideau Canal System” - M.Sc. thesis

Diatom-inference paleo-techniques are being used to reconstruct total phosphorus in Indian, Big Rideau, Lower Rideau and Otter lakes located along the Rideau Canal System. This information is useful for making lake management decisions, as it can be used to distinguish human-induced trophic shifts from natural variability. Additionally, this study will compare trophic state responses of these lakes to canal construction and other anthropogenic disturbances over the last ~200 years. A detailed investigation is warranted, as past paleolimnological studies have found differing responses to these disturbances, particularly those associated with canal construction. Paleolimnological evidence from Lake Opinicon and Sand Lake suggests that shallow macrophyte-dominated lakes experienced minimal changes in trophic status associated with the time of canal construction, whereas, deep mesotrophic to eutrophic lakes (i.e. Upper Rideau Lake) experienced significant changes in diatom assemblages.

A transfer function, recently developed from 64 lakes within southern Ontario, will be applied to the down-core diatom data to reconstruct past lake-water [TP] (Reavie & Smol, in press). This study will further explore the discrepancy of trophic responses between lakes of varying morphometry and macrophyte growth.

Publications:

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II: Research by non-Queen's Personnel in 1999

Dr. Mark Forbes - Department of Biology, Carleton University, Ottawa, Ontario

“Parasitism and phenotypic plasticity in invertebrates and other organisms.”

The conceptual framework of my research is life history theory and how it applies, in particular, to parasite-host-stress interactions and to intraspecific variation in ecology and behaviour. My research at the Queen's University Biological Station has included: developing and testing theory of insect-parasite interactions, developing and testing ideas about stress-fitness relations (and the use of deviations from symmetry as indicators of stress or fitness), and testing evolutionary models on the maintenance of phenotypic plasticity versus polymorphism in insect populations.

Dr. Brian Leung - “Fluctuating asymmetry as an index of environmental stress and fitness”. Carleton University, PDF Cambridge, UK

Brian uses mathematical models and empirical tests to investigate whether deviations from bilateral symmetry can be used as indices of environmental stress and/or fitness of organisms. He uses damselflies and mites as model organisms for empirical tests. Over the last few years, Brian also examined whether nutritional stress influenced susceptibility of damselflies to their ectoparasitic mites, and/or accounted for the incidence of damselfly phenodeviants (individuals that lacked normal wings). QUBS is an important collection site for such laboratory tests.

Assistants: Chris Yourth, Dean McCurdy

Chris Yourth - “Ecological immunology of *Lestes* damselflies”. - B.Sc. thesis

Chris tested a fundamental assumption of emerging theory on ecological immunology, namely, that those species most susceptible to colonization or intensity of parasitism should invest more in immunological responses. Through Chris' work, we know that a species of *Lestes* damselflies most susceptible to attachment by *Arrenurus planus* mites is also most likely to invest in melanization responses (which render mite feeding tubes dysfunctional). However, prevalence or intensity of parasitism does not easily predict ordering of responses in three other species. One possibility is that early-emerging species are less likely to devote melanin resources to immune responses. Rather these species use these resources for thermoregulation.

Kit Muma - “Resistance to *Arrenurus planus* mites by *Sympetrum* dragonflies” - Research Associate and Lecturer, Ithaca College, Ithaca, New York

This past year, Kit examined costs to resistance in *Sympetrum* dragonflies. She studied two species of hosts, *S. obtrusum* which is totally susceptible to *Arrenurus planus* mites and *S. internum* which has a unique resistance mechanism among odonates (apparently aggregating haemocytes at the site of formation of the mite's feeding tube). Kit hopes to ascertain return rates

for lightly- and heavily parasitized dragonflies of both species to address whether heavily-infected individuals might show reduced survivorship. Her studies have implications for understanding constraints on generalist parasites.

Publications:

Leonard N.J., Forbes, M.R. and R.L. Baker. 2000. Effects of *Limnochares americana* (Hydrachnida: Limnocharidae) mites on life history traits and grooming behavior of its damselfly host, *Enallagma ebrium* (Odonata: Coenagrionidae). Can. J. Zool. (in press).

Leung, B., Forbes, M.R. and D.T. Houle. 2000. Fluctuating asymmetry as a bio-indicator of stress: comparing efficacy of analyses. Amer. Nat. (in press).

Forbes, M.R., Muma, K.E. and B.P. Smith. 1999. Parasitism of *Sympetrum* dragonflies by *Arremurus planus* mites: host co-existence lessens parasite-host conflict. Int. J. Parasitol. 29: 991-999.

Leung, B., Baker, R.L. and M.R. Forbes. 1999. Grooming decisions by damselflies, age-specific colonization by water mites, and the probability of successful parasitism. Int. J. Parasitol. 29:397-402.

Drover, S., Leung, B., Forbes, M.R., Mallory, M.L. and D.K. McNicol. 1998. Consequences of Lake pH and Aluminum Concentration for Developmental Stability of the Water Strider, (*Rheumatobates rileyi*) (Hemiptera: Gerridae). Can. J. Zool. 77:157-161.

Leung, B. and M.R. Forbes. 1998. The evolution of virulence: A stochastic simulation model examining parasitism at individual and population levels. Evol. Ecol. 12:165-177.

Theses:

Hecker, K.R. 1999. Testing for sex biases and morph biases in parasitism of zygopterans (Odonata) by gregarines (Eugregarinidae). M.Sc. thesis, Carleton University. 72pp

Leonard, N.J. 1998. Ectoparasitism of Odonate hosts: host response to parasitism and host sex biases in parasitism. M.Sc. thesis, Carleton University. 91pp.

Leung, B. 1999. Assessing and developing the use of fluctuating asymmetry as a bioindicator of environmental stress and quality of organisms. Ph.D. thesis, Carleton University. 232pp.

Yourth, C.P. 1999. Mite ectoparasitism of lepid damselflies: susceptibility and suitability of different species, sexes, and ages of hosts. Unpublished Hons. thesis, Carleton University. 31pp.

Dr. Michael Fox - Environmental and Resource Studies Program and Department of Biology, Trent University, Peterborough, Ontario

"Genetic Determinism vs Phenotypic Plasticity in Pumpkinseed Sunfish Life Histories"

The long term objectives of my research are to explain the high degree of life history variation exhibited by pumpkinseed (*Lepomis gibbosus*) populations. I initiated an experiment in 1995 to determine the extent to which life histories converge when individuals from early and late maturing populations are reared in a common environment. Mature individuals from five Ontario populations (including Lake Opinicon) had been transplanted to artificial ponds at Cornell University. The offspring produced in 1995 were sampled in June, 1998, and it was found that the age and size at maturity differences in the wild populations occurred in the ponds as well.

In May of 1999 juveniles from the Opinicon population were removed from the original ponds and transplanted into two other ponds. The experiment will continue over several years through the progeny of these individuals, to determine the degree of phenotypic plasticity in age and size at maturity.

In addition to this experiment, I am continuing to monitor life history traits of four pumpkinseed populations on an annual basis to provide long term data on annual variability of these traits. One of the four populations is that of Lower Poole Pond, located on QUBS property near the Opinicon Cemetery.

Assistants: Tom Pratt, Scott McCairns

Publications:

Mercer, J.L., M.G. Fox, and C.D. Metcalfe. 2000. Changes in benthos and three littoral zone fishes in a shallow, eutrophic Ontario lake following the invasion of the zebra mussel (*Dreissena polymorpha*). Lake and Reserv. Manage. (in press).

Bertschy, K.A., and M.G. Fox. 1999. The influence of age-specific survivorship on pumpkinseed sunfish life histories. Ecology 80: 2299-2313

Reid, S.M., M.G. Fox, and T.H. Whillans. 1999. Influence of turbidity on piscivory in largemouth bass (*Micropterus salmoides*). Can. J. Fish. Aquatic Sci. 56: 1362-1369.

Dr. James Fullard - Department of Zoology, Erindale College of University of Toronto, Mississauga, Ontario

"Neurobiology of Moths and Butterflies"

James Fullard & Nadia Napoleone

"Diel flight periodicity and the evolution of defensive sensory adaptations in the Macrolepidoptera"

We used the 24-hour flight actograms of 68 species of Nearctic Lepidoptera representing 10 earless and seven eared families to determine the diel flight periodicity (DFP) of these insects. Most species tested exhibited mixed diel preferences (flight during day and night hours) with few being exclusively nocturnal. Only the Papilionoidea (butterflies) and Hesperoidea (skippers) are exclusively diurnal, supporting the hypothesis that this trait has resulted from their lack of ultrasound-sensitive ears that provides auditory defence against aerially-foraging, insectivorous bats. In those taxa with mixed diel preferences (i.e., most moths), eye size increases significantly with the degree of nocturnal flight, results that differs from those reported for other insects. Eyes of large, exclusively nocturnal species increase more with wing span than those of diurnal species suggesting that large, night-flying species face greater threats from visually-hunting, nocturnal predators. A similar trend was seen for the eyes of earless moths compared to those of eared species. Eared, noctuid moths exhibit the highest tendency to fly during both day and night, a trait we suggest results from their possession of both visual and auditory defences. Earless moths are almost completely nocturnal and may be constrained to the night by their trait of reduced flight, a behaviour that although provides protection against bats, would be a liability against diurnal, visually-hunting predators.

Assistants: Kathleen Pendlebury, Briann Dawson, Alessandro Mori, Tarah Harrison and Vicki McDermott

James Fullard, Kathleen Pendlebury & Briann Dawson

"Function of the Vogel's organ in Nymphalid butterflies"

The Vogel's organ is a tympanal structure located at the base of the forewing in certain nymphalid butterflies (especially those of the subfamily, Satyrinae). Although it resembles an ear, a function to which it has repeatedly been attributed, no field data exists as to its auditory role. The functions of insect ears are either as anti-predator defences (e.g., for detecting the echolocation calls of bats) or for intraspecific social signals (e.g., calling or courtship calls). Using the near-infra-red videorecording methods described above we taped the 24 hour flight patterns of six species of local satyrines to determine whether these butterflies reveal any nocturnal flight that would expose them to bats. These actograms indicate that satyrines do not fly at night and probably do not use their Vogel's organs as anti-bat ears. We also video-taped interactions between males and females to see if there were any sexual acoustic signals used during mating. Finally, we performed a series of flight experiments using individuals with intact and ablated Vogel's organs to test whether the structure is used as a sensor controlling flight direction or wing position. The results from these studies are still under analysis.

Assistants: Alessandro Mori and Tarah Harrison

"Colony rearing of the dogbane tiger moth, *Cycnia tenera*"

As in past years, we raise and maintain a colony of tiger moths for research that is conducted in the Erindale laboratories at the University of Toronto. *Cycnia tenera* is an unusual moth species in that it is equipped with sound-producing structures (tymbals) on the sides of its thorax. The sound that are produced resemble those of cicada but differ in their almost completely ultrasonic character. The sounds can be elicited from adults by either touching them or by playing simulations of bat echolocation signals to them. This has allowed us a conveniently model for studying the sensorimotor integration of an insect to two forms of stimuli: tactile and acoustic. The experiments are conducted with adult moths that emerge from pupae prepared from the colonies we raise every summer at QUBS. These colonies are developed from the eggs of wild-captured females that we hatch and grow the larvae on local populations of dogbane. A percentage of wild-raised individuals are released to encourage the natural propagation of this species.

Assistants: Kathleen Pendlebury, Briann Dawson, Alessandro Mori and Tarah Harrison

Publications:

Fullard, J.H. and Dawson, J.W. 1999. Why do diurnal moths have ears? *Naturwissenschaften* 86:276-279.

Surlykke, A., Filskov, M., Fullard, J.H., Forrest, E. 1999. Auditory relationships to size in noctuid moths: bigger is better. *Naturwissenschaften* 86:238-241.

Yack, J.E., Scudder, G.G.E. and Fullard J.H. 1999. Evolution of the metathoracic tympanal ear and its mesothoracic homologue in the Macrolepidoptera (Insecta). *Zoomorphology* 119:93-103.

Dr. Bart Kempenaers (Research Center for Ornithology of the Max Planck Society, Seewiesen, Germany) and **Dr. Raleigh J. Robertson** (Department of Biology, Queen's University)

"Extra-pair Paternity and Reproductive Behaviour in Tree Swallows"

Tree swallows show extraordinary levels of sperm competition: more than half of all the offspring produced in a given season are fathered by extra-pair males and a nest often contains offspring of more than two fathers. Our previous work showed that floater males, which are common in the population, are reproductively active. Floaters have similarly sized testes and produce similar amounts of sperm compared to residents. Paternity analysis using microsatellite markers showed that floaters father offspring. However, we still know very little about the characteristics of males that make them more or less successful in sperm competition. Testosterone is known to be involved in sperm production and in aggressive behaviour. We implanted some males with testosterone to compare copulation behaviour and paternity between T-males and a group of placebo-implanted males.

The high levels of extra-pair paternity in combination with evidence that females have

considerable control over who they copulate with, leads to the question how females benefit from being promiscuous. A previous study showed that hatching success was higher for females with extra-pair offspring than for strictly monogamous females. Hatching failure might result from infertility or from early embryo mortality (e.g. as a consequence of genetic incompatibility). We investigated the presence of sperm and holes in the perivitelline layer around the egg and compared normal clutches with eggs that did not develop after four days of incubation. The results show that a lack of sperm able to penetrate the egg membrane cannot be the cause of hatching failure.

This project was conducted in collaboration with Dr. Raleigh J. Robertson, who kindly provided organizational assistance.

Assistants: Cheryl Bishop, Kim Carter, Gillian Glen-Worrall, Angelika Poesel, Agnes Turk

Publications:

Kempenaers B., Lanctot R.B. & Robertson, R.J. 1998. Certainty of paternity and paternal investment: an experimental approach. *Anim. Behav.* 55: 845-860.

Kempenaers B., Congdon B., Boag P. & Robertson R.J. 1999. Extrapair paternity and egg hatchability in tree swallows: evidence for the genetic compatibility hypothesis? *Behav. Ecol.* 10: 304-311.

Peer K., Robertson R.J. & Kempenaers B. 2000. Reproductive anatomy and indices of quality in male tree swallows: the potential reproductive role of floaters. *Auk* 117: 74-81.

Kit Muma - Ithaca College, Ithaca NY

"What is the cost of being a good host? *Sympetrum* spp. dragonflies parasitized by *Arrenurus planus* water mites"

Over half of all organisms are parasitic during at least one phase of their life-cycle. The relationship between a host and its parasites is a constant battle. Host species are under selective pressure to develop resistance to parasites and a parasite species in turn is under selective pressure to evolve mechanisms to counter that resistance. This phenomenon is known as the co-evolutionary arms race. Water mite larvae are parasitic on insects; mites attach to hosts as they emerge from the water and engorge by sucking bodily fluids from the host. The objectives of this study were to compare two closely-related species of dragonflies that are regularly parasitized by water mites. Mites were able to successfully form stylostomes (feeding tubes) and engorge when attached to *Sympetrum obtrusum* dragonflies. In contrast, mites that attached to *S. internum* dragonflies could not form stylostomes and instead of engorging, they shriveled up and died. *S. internum* appears to have won the evolutionary arms race (Forbes et al. 1999). I hypothesized that there would be no difference in survivorship or fecundity between lightly and heavily parasitized individuals of the resistant species of host. In contrast, I expected that heavily parasitized hosts of the susceptible species will have reduced survivorship and/or fecundity. I

marked over 1000 dragonflies with individual wing markings and recaptured 125. Of 72 marked female *S. internum* dragonflies, only 6 returned to the study site. Even with the low return rates, this is a model system for studying the development of resistance by insects, and the influence of differential susceptibility to parasitism on relative contribution of species to the host/parasite community.

This research was supported by a Summer Grant for Faculty Research awarded by the Provost at Ithaca College.

Collaborators: Dr. Bruce P. Smith - Ithaca College, Dr. Mark Forbes, Carleton University

Assistants: Jen Moran, Chris Yourth

Publications:

Forbes, M.R., Katherine E. Muma, Bruce P. Smith 1999. Parasitism of *Sympetrum* dragonflies by *Arrenurus planus* mites: maintenance of resistance particular to one species. *Int. J. Parasit.* 29:991-999.

Dr. Lawrence Packer - Department of Biology, York University, Toronto, Ontario

"Behaviour of *Dufourea nova-angliae* in artificial arenas."

I have been comparing the behavioural repertoires of Halictine bees in relation to their social behaviour. Species in which there is a reproductive division of labour tend to interact aggressively, those that are communal act cooperatively and those that are solitary exhibit intermediate levels of both types of behaviour.

The subfamily Rophitinae is the basal clade within the family and all species for which nests have been found are solitary. So far my studies of these bees has shown that their behavioural repertoire is unique in that they appear "not to know" how to interact with other individuals and either run backwards and forwards avoiding one another or freeze.

Jessica Janjic - "Behaviour of the bee *Dufourea nova-angliae*" - M.Sc. thesis

In 1999 research on *Dufourea nova-angliae* was conducted at QUBS. This species is oligolectic on *Pontederia*. Five pairs of bees were collected and observed in circle tubes. Although the data from this study have not been analysed, these bees had a repertoire of behaviours more commonly found in the social halictines than other Rophitines. This is an interesting result and may provide some behavioural evidence for the paraphyly of this subfamily with respect to the remaining subfamilies of Halictidae.

Dr. David P. Philipp - Center for Aquatic Ecology, Illinois Natural History Survey and **Frank Phelan** - Queen's University Biological Station

"Long-term monitoring of Largemouth and Smallmouth Bass Reproductive Success"

How year to year variation in mating and reproductive success impacts recruitment has not been determined for many species of fish. To address that issue in largemouth and smallmouth bass, we have been monitoring the reproductive activities of those species at several sites within Lake Opinicon, including four islands and two km of shoreline. These habitats have been surveyed annually during the spawning period by visual swims using a mask and snorkel. Data collected included the location of the nest, depth, assessment of mating success, size of parental male, and duration of parental care for each male, as well as the occurrence of hook-wounds from angling. In this way, we determine the success or failure of each male in raising a brood, allowing us to calculate total fry production for each site each year. Those data will then be correlated with year class strength one and two years later

Assistants: Julie Claussen, Cory Suski, Jana Svec, Jim Ludden, Katie Deters, Matthew Coombs

"Conservation Zones as Management Tools"

Current regulations in Ontario prohibit angling for nesting bass while they are spawning and guarding their young. Existing regulations, however, permit angling for other game fish such as northern pike. As a result, it is possible to inadvertently hook a nesting male bass while legally angling for northern pike. Catching and releasing male bass can lead to an increase in their nest abandonment, and a concomitant decline in reproductive success within a waterbody. Over time this can affect not only bass population size structure, and but also the quality of a bass fishery within a lake. One alternative management strategy that may prove effective at preventing the inadvertent angling of male bass is a peer-enforced, voluntary bass conservation zone. This conservation zone, when properly enforced, can reduce harmful angling levels, and can lead to an increase in nesting success. Current research to assess the efficacy of those programs is being conducted on six nearby lakes (Loughborough, Bob's, Sand, Devil, Buck, and Wolfe) and is attempting to design a protocol that uses littoral zone characters, shoreline features, and topographical maps to predict areas preferred by nesting bass. Once developed, this protocol would allow lake associations and local residents to establish bass conservation zones using readily available and easily recognizable cues.

Assistants: Julie Claussen, Jim Ludden, Cory Suski, and Jana Svec

Jana Svec - "Reproductive Ecology of Smallmouth Bass" - MSc. Thesis.

Currently there is some debate among fisheries biologists whether or not smallmouth bass recruitment is influenced by population-level reproductive success. To address that question, the reproductive success of individual nesting male smallmouth bass has been followed in a portion of the Mississippi River, southeastern Ontario, Canada as part of a long term study. Data so far have shown a positive correlation between the number of smallmouth bass fry produced in a year

(reproductive success) and the strength of that resulting year class one and two years later (recruitment). Smallmouth bass have also shown a high incidence of nest-site fidelity in the Mississippi River, with many males returning to the exact same nest site year after year. Understanding the underlying mechanisms influencing various aspects of the reproductive ecology of smallmouth bass may lead to better management and conservation of the species.

Assistants: Jim Ludden, Cory Suski, Matthew Coombs, Kate Deters, Matthew Deters, Josh Snyder, Stacy Snyder, Julie Claussen, John Epifanio.

Cory Suski - "Linking reproduction to conservation efforts for the largemouth bass and smallmouth bass" - MSc. Thesis.

A productive bass fishery can attract large numbers of non-resident anglers and can be a major economic benefit for that local area. As part of a long-term research project, the movements, site fidelity, reproductive success and nesting characteristics of largemouth bass were studied in an attempt to determine how biotic and abiotic factors combine to influence their reproductive success and their angling vulnerability. In addition, experiments were performed that showed that brood loss to predation, which occurs while a male is absent from his nest, is the primary reason for nest abandonment in nesting bass following a catch-and-release angling event. The results of these studies can be used to direct the placement and development of voluntary bass sanctuaries as an alternative management tool that can be used to protect nesting bass.

Assistants: Matthew Coombs, Jim Ludden, Frank Phelan, and Jana Svec

Publications:

Tranquilli, J. V., R. D. Fields, C. A. Toline, and D. P. Philipp. 2000. The effectiveness of three molecular techniques to detect genetic variation in the bluegill *Lepomis macrochirus*. Transactions of the American Fisheries Society (in press).

Dr. Peter Sale - Department of Biological Sciences, University of Windsor, Windsor, ON

"Fisheries and Aquatic Studies"

Dean Fitzgerald - "Growth, survival, and bioenergetics of young Yellow Perch in temperate lakes" - Ph.D. Thesis

This project is contributing information and understanding on factors shaping the growth and survival of young-of-the-year (YOY) yellow perch (*Perca flavescens* Mitchell) among lake types within the Great Lakes basin. Of particular interest is the pattern of YOY perch cohort growth and overwinter survival among lakes and years. Both short- and long-term (>10 y) data are being used to answer these questions. Short-term data on YOY perch has been collected from within numerous small (800-1000 ha), large (>10,000 ha), and basins of Great Lakes (>100,000

ha) during 1997 and 1998. Long-term data are being used for one replicate lake within each lake-size category. During 1997 and 1998, the patterns of growth and survival observed for Lake Opinicon, a small-lake replicate, were similar to other lakes considered in this study. Overall, intraspecific competition and temperature appear to be the primary determinants of growth and survival among lake types for young perch in the Great Lakes basin.

Dr. Bruce Smith - Biology Dept., Ithaca College, Ithaca, NY 14850.

"Water mite parasitism of Aquatic Insects"

I. "Systematics of *Arrenurus* spp. water mites"

Arrenurus is a very large and common genus, with almost 1000 described species worldwide and about 60 species found in the region of QUBS. Species of this genus are defined by morphology of adult males, while most females and larvae are undescribed and unidentifiable. One of my long-term projects has been to associate the two genders and larvae of these species, making it easier to conduct ecological and behavioural studies on these organisms. During the summer of 1999 I continued my efforts to identify larvae of species of the subgenus *Arrenurus*, which are especially difficult to distinguish. Species of this subgenus parasitize odonates, and make for an especially useful system for studying host/parasite interactions. The difficulty identifying mites has been a limiting factor in past studies. In past years there have been intensive surveys made by myself and others, yet in summer 1999 we discovered larvae of at least three species new to science.

Assitant: Jennifer Moran

II. "Behavior, Ecology, and Evolution of host/parasite interactions"

Collaborative studies with Kit Muma and Mark Forbes continue, investigating host/parasite interactions. Parasitism by *Arrenurus planus* mites and the consequences of presence or absence of immune responses in *Sympetrum* spp. dragonflies continues as one focus of attention. A second avenue of investigation was the possible relationship between parasitism by *Limnochares aquatica* mites and the presence of two flight "morphs" (phenotypes) of *Gerris comatus* water striders. More detailed accounts are provided under project descriptions by my collaborators

Jennifer Moran - "Parasitic growth of larval mites on damselflies and dragonflies"

One would expect a trade-off in host/parasite relationships as to how much a parasite can take before harming the host, and therefore the parasite itself. A logical prediction would be that degree of larval engorgement of *Arrenurus* spp. mites on Odonata (dragonflies and damselflies) would be related to size of the host species. Also, it has been speculated that loading the abdomen would have a greater effect upon the balance of the host (thus impairing flight) compared to the same load upon the thorax. Therefore, it is predicted that parasitic species attaching to the host's thorax may engorge to larger volumes than species attaching to the host's

abdomen. In this study, 272 larval mites representing 21 *Arrenurus* species were removed from 17 different species of Odonata, and volume of engorgement was calculated for each parasite species. There was significant differences among mite species in larval engorgement: species in the *americanus* group typically grew to volumes 8-12 that of an unfed larva, the *superior* and *pinguisomus* species groups grew 20-35 times their original volume, and *Arrenurus planus* grew over 130 times their original volume through larval feeding on the host. Degree of engorgement was not consistent with host species, type of host (damselfly vs. dragonfly), or location on host. However, closely related species engorge to similar sizes, implying that degree of engorgement best correlates with phylogenetic relationships among mite species

Publications:

Forbes, M.R., Muma, K.E., Smith, B.P. 1999. Parasitism of *Sympetrum* dragonflies by *Arrenurus planus* mites: host coexistence and maintenance of species resistance. *International Journal for Parasitology*. 29:991-999.

Smith, B.P. 1999. Loss of larval parasitism in parasitengonine mites. pages 125-136 in *Ecology and Evolution of the Acari*, edited by J. Bruin, L.P.S. van der Geest, M.W. Sabelis. Kluwer Academic Publishers b.v.

Dr. Patrick Weatherhead - Department of Biology, Carleton University, Ottawa, Ontario

"Long-term studies of snakes"

In 1999 the long-term projects on both black rat snakes and northern water snakes were maintained through the efforts of the students currently conducting thesis work of these species (see below).

"Laying order and sibling competition in red-winged blackbirds (*Agelaius phoeniceus*)"

Recent evidence from several species of birds suggests that females vary the amount of testosterone in eggs with laying order to influence the outcome of sibling competition in the nest. A pilot study was conducted in 1999 to assess whether laying order affecting sibling competition in red-winged blackbirds. Encouraging results from this study make it likely that this problem will be pursued further in 1999.

Assistant: Stephanie Doucet

Gabriel Blouin-Demers - "Thermal ecology of the black rat snake (*Elaphe obsoleta*) in a cool temperate environment" - Ph.D. Thesis.

This project was initiated in 1996 to continue the long-term ecological and demographic study of black rat snakes at QUBS and to undertake a detailed investigation of the spatial ecology

and thermoregulatory behaviour of this species. Black rat snakes are at the northern limit of their range in eastern Ontario and close to the northern extreme of snake distributions. Black rat snakes thus experience high thermoregulatory costs in Ontario (cool temperatures, short active season, etc.). General models in thermal biology predict that species experiencing such high thermoregulatory costs should not invest substantial effort in thermoregulation and thus should have fluctuating body temperature profiles. Species that experience fluctuating body temperature profiles are also expected to demonstrate maximum performance under a broad range of body temperatures. These predictions have never been adequately tested using septentrional snake species. The central goal of my research is to understand the ecological factors affecting body temperature selection (foraging, reproduction, ecdysis) and how the preferences influence habitat use to gain insight into the thermoregulatory strategies of black rat snakes. I use temperature-sensitive radio-telemetry to document body temperature selection, habitat use, and movement patterns.

Assistants: Heather McCracken, Alissa Moenting, and Catherine Verreault

Kelley Kissner - "Maternal influences on offspring quality in northern water snakes, *Nerodia sipedon*" - Ph.D. Thesis.

A female's fitness is intimately related to the survival and reproductive success of her offspring. Consequently, a female may be expected to manipulate the quality of her offspring in ways that maximize her fitness. There are two general ways in which a female could influence the quality of her offspring. First, a female may control who she mates with or her number of mates. Second, a female may influence the quality of her offspring by varying their phenotype. I am using a combination of experimental and correlational approaches to determine the potential that exists for female northern water snakes (*Nerodia sipedon*) to influence the quality of their offspring, and the extent to which females exploit this potential to vary offspring quality adaptively to enhance their own fitness. Offspring quality is measured as overwinter survival of neonatal water snakes. Survival of neonates is monitored using individuals maintained in outdoor enclosures, complete with ponds and hibernacula, located in the Hughson tract.

Assistants: Sophie Sommerer, Patrick Begin, Stephanie Doucet

Sophie Sommerer - "Offspring sex ratio variation in eastern garter snakes and northern ribbon snakes" - MSc thesis

Natural selection favours parents that invest equally in offspring of each sex, thus explaining sex ratios of 1:1 found in most populations. In those populations whose sex ratios are not biased, an individual female might benefit from producing an excess of either sons or daughters. Studies of several snake species have shown that mothers appear to adjust the sex ratio of their offspring in response to their circumstances at the time of reproduction. I am using two local, live-bearing snake species to determine whether females are able to manipulate litter sex ratios adaptively. I have recorded measurements of maternal size, and will determine whether females adjust the sex ratios of their offspring according to their size at ovulation (the time at which sex is determined). I have also gathered detailed measurements of offspring characteristics to determine whether sexual dimorphism observed in adults is obvious at birth, as

well as to establish whether offspring size and performance characteristics are related to maternal size.

Assistants: Kelley Kissner, Patrick Begin, Stephanie Doucet

Publications:

Blouin-Demers, G., K. A. Prior and P. J. Weatherhead. 2000. Patterns of variation in spring emergence by black rat snakes (*Elaphe obsoleta obsoleta*). *Herpetologica* (in press).

Blouin-Demers, G., K.J. Kissner, and P.J. Weatherhead. 2000. Plasticity in preferred body temperature of young snakes in response to temperature during development. *Copeia* (in press).

Brown, G. P. and P. J. Weatherhead. 2000. Thermal ecology and sexual size dimorphism in northern water snakes, *Nerodia sipedon*. *Ecological Monographs* (in press).

Kissner, K.J., G. Blouin-Demers, and P.J. Weatherhead. 2000. Sexual dimorphism in malodorousness of musk secretions of snakes. *Journal of Herpetology* (in press).

Loughheed, S. C., H. L. Gibbs, K. A. Prior and P. J. Weatherhead. 2000. Hierarchical patterns of genetic population structure in black rat snakes (*Elaphe obsoleta obsoleta*) as revealed by microsatellite DNA analysis. *Evolution* (in press).

Weatherhead, P. J. and K. W. Dufour. 2000. Fledging success as an index of recruitment in red-winged blackbirds. *Auk* (in press).

Weatherhead, P. J., K. W. Dufour, S. C. Loughheed and C. G. Eckert. 2000. A test of the good-genes-as-heterozygosity hypothesis using red-winged blackbirds. *Behavioral Ecology* (in press).

Brown, G. P. and P. J. Weatherhead. 1999. Factors affecting growth and sexual size dimorphism in northern water snakes (*Nerodia sipedon*). *Copeia* 1999: 723-732.

Brown, G.P. and P.J. Weatherhead. 1999. Female distribution affects mate searching and sexual selection in male northern water snakes (*Nerodia sipedon*). *Behavioral Ecology and Sociobiology* 47: 9-16.

Brown, G.P. and P.J. Weatherhead. 1999. Demography and sexual size dimorphism in northern water snakes, *Nerodia sipedon*. *Canadian Journal of Zoology* 77: 1358-1366.

Prosser, M. R., H. L. Gibbs and P. J. Weatherhead. 1999. Microgeographic population structure in the northern water snake, *Nerodia sipedon*, detected using microsatellite DNA loci. *Molecular Ecology* 8: 329-333.

Weatherhead, P.J. 1999. Sequential mating patterns suggest extra-pair mating is not part of a mixed reproductive strategy by female red-winged blackbirds. *Proceedings of the Royal*

Society of London B 266: 1027-1031.

Weatherhead, P. J., G. P. Brown, M. R. Prosser and K. J. Kissner. 1999. Factors affecting neonate size variation in northern water snakes, *Nerodia sipedon*. Journal of Herpetology 33: 577-589.

Weatherhead, P. J., G. P. Brown, M. R. Prosser and K. J. Kissner. 1998. Offspring sex ratio variation in northern water snakes, *Nerodia sipedon*. Canadian Journal of Zoology 76: 2200-2206.

Summary of Conference, Meeting and Field Trip Use of QUBS in 1999

Organizer	Function	Number of Participants	Duration
Kathy Marocco (Amherstview Public School)	Skills Development and Counselling	12	Feb 1-3
Dr. S. Koh (York U - Biology)	Plant Ecology Field Trip	8	Feb 12-14
Andrea Stuparyk (Queen's - QPID)	Queen's Program in International Development Workshop	20	March 12-14
Jamie Clark (Queen's - English)	Creative Writing Workshop	13	March 20-21
Caroline Seto (Queen's - ENSC)	Environmental Education Field Trip	42	April 28-29
Dr. Ron Weir (FON)	Federation of Ontario Naturalists Field Trip	14	May 30
Sarah Hammond (Queen's - SD)	Science Discovery Organizational Meeting	4	June 30
Sarah Hammond (Queen's - SD)	Science Discovery Field Trip	12	July 7
Sarah Hammond (Queen's - SD)	Science Discovery Field Trip	16	July 22
Sarah Hammond (Queen's - SD)	Science Discovery Field Trip	13	August 4
Sarah Hammond (Queen's - SD)	Science Discovery Field Trip	13	August 18
Dr. Ed Kott (Wilfrid Laurier U. - Biology)	WLU Biology Field Course	17	Aug 29-Sept 11
Reg Genge (St. Lawrence College)	Environmental Technology Field Trip	20	September 18
Reg Genge (St. Lawrence College)	Civil Engineering Field Trip	20	September 19
Sylvat Aziz (Queen's - Art)	Art Students Field Trip	14	September 22
Doug Archibald (Queen's - Geology)	Geology 221 (Geological Field Methods) Field Trip	40	Sept 22-23
Dr. Peter Boag (Queen's - Biology)	Biology 302 (General Ecology) Field Trip	69	September 25
Dr. Peter Boag (Queen's - Biology)	Biology 302 (General Ecology) Field Trip	64	September 26

Organizer	Function	Number of Participants	Duration
Jeff Ruttan (Bell H.S. - Nepean)	Science Students Field Trip	30	September 29
Jeff Ruttan (Bell H.S. - Nepean)	Science Students Field Trip	30	September 30
Dr. Peter Boag (Queen's - Biology)	Biology 302 (General Ecology) Field Trip	73	October 2
Dr. J. Smol (Queen's - Biology)	Biology 335 (Limnology) Field Trip	43	October 2
Dr. Peter Boag (Queen's - Biology)	Biology 302 (General Ecology) Field Trip	71	October 3
Dr. J. Smol (Queen's - Biology)	Biology 335 (Limnology) Field Trip	38	October 3
Janice Aarssen-Bruyns (Prince Charles P.S.)	Grade 3 Field Trip	42	October 12

Documentation of Use of QUBS in 1999 - User-Days

User	Supervisor	Post-Doc	Graduate Student	Assistant	TOTAL
INTERNAL (QUEEN'S) RESEARCH					
Aarssen	10	0	30	35	75
Boag	0	0	1	1	2
Eckert	15	0	104	137	256
Friesen	1	0	0	3	4
Harmsen	15	30	0	59	104
Karagatzides	0	0	5	2	7
Keast	99	0	0	0	99
Leggett	0	3	0	3	6
Montgomerie	5	0	0	51	56
Phelan	n/a	0	0	108	108
Ratcliffe	8	0	247	305	560
Robertson	101	0	311	579	991
Smol	1	0	6	10	17
Tufts	1	0	7	9	17
Total Internal	256	33	711	1302	2302
EXTERNAL RESEARCH					
University of Toronto					
Fullard	57	0	71	129	257
Gross	0	0	69	125	194
Carleton University					
Forbes	27	0	0	189	216
Weatherhead	107	0	479	513	1099
Illinois Natural History Survey					
Philipp	69	0	134	211	414
Max Planck Institute					
Kempnaers	58	0	0	270	328
Virginia Commonwealth University					
Epifanio	48	0	0	0	48
Ithaca College					
Smith	64	0	0	69	133
Trent University					
Fox	1	0	0	1	2
York University					
Fenton	0	0	3	9	12
Packer	4	0	4	0	8
University of Windsor					
Sale	0	0	9	9	18

Documentation of Use of QUBS in 1998 - User-Days (continued)

User	Supervisor	Post-Doc	Graduate Student	Assistant	TOTAL
Total External	435	0	769	1525	2729
Total Research User-Days	691	33	1480	2827	5031
% Queen's	37	100	48	46	46
% Non - Queen's	63	0	52	54	54

USER-DAYS IN TEACHING ACTIVITIES	1985
CONFERENCE AND FIELD TRIP USE	322
OTHER*	1569
GRAND TOTAL USER-DAYS IN 1999	8907**

(* QUBS staff, family and their visitors are not included, nor are construction workers involved in the demolition and rebuilding of the central building)

(** down 3% from 1998)

Seminars 1999

- Wednesday, June 2: Graduate Student seminars I
Peng Fu - "Sperm competition in fishes"
Gabriel Blouin-Demers - "Black Rat Snake Ecology and Conservation Biology"
Tim Demmons - "Ecology and management of Golden-winged Warblers"
Dan Mennill - "Mate Choice in Black-capped Chickadees"
Jason Jones - "Conservation Biology of Cerulean Warblers"
Cory Suski - "Nesting biology and population biology of Largemouth Bass"
- Wednesday, June 9: Graduate Student seminars II
Scott Tarof - "Clustering in Least Flycatchers"
Chris Herlihy - "Outcrossing vs. selfing in Wild Columbine"
Chris Yourth - "Mite parasitism of aquatic insects"
- Wednesday, June 16: Graduate Student seminars III
Faye Thompson - "Floral longevity and outcrossing in Wood Lilies"
Jenn Barg - "Behavioural ecology of Cerulean Warblers"
Sophie Sommerer - "Reproductive ecology of Garter and Ribbon Snakes"
Kelley Kissner - "Reproductive ecology of Northern Water Snakes"
- Wednesday, June 23: Undergraduate student seminars - "Snapshots of research 1999"
Jeff Bos - "Settlement patterns in Least Flycatchers"
Jennifer Moran - "Growth of parasitic mites on damselflies and dragonflies"
Ryan DeBruyn - "Habitat characteristics of the local Cerulean Warbler populations"
Amy MacDougall - "Parasite loads and social rank in Chickadees"
Agnes Kliber - "Inter-floral variation in reproductive allocation in Columbine"
- Tuesday, June 29: Dr. John Casselman - Research scientist, Ontario Ministry of Natural Resources, Lake Ontario Section, Glenora, Ontario
"Climate, fish and fisheries"
- Wednesday, July 14: Dr. Paul Hamel - US Fish and Wildlife Service, Center for Bottomland Hardwoods Research, Southern Hardwoods Laboratory, Stoneville, Mississippi
"What I wish I knew about Cerulean Warblers"

Fee Schedule for 2000

Board Charges - Meals only

\$460/month/person	-no obligation for chores
\$315/month/person	-includes obligation for chores on a rotating schedule

Accommodation Charges - Housing only

\$18/month/person	-dormitory (White House or Curran Cottage)
\$36/month/person	-small cabin (Cabins 1, 4, 5, 6, 7, 11)
\$72/month/person	-medium cabin (Cabins 2, 3, 8, 9, 10, 13, 14)
\$95/month/person	-large cabin (Cabins 12, 15 and White House Apartment)
\$135/month/person	-Cottage (Keast, Earl, Sumac or Maplewood)

Room and Board Rates for Short-term Visitors

\$200/person	-weekly R&B for field courses - includes a lab fee
\$27.50 day/person	-24 hr. room and board
\$4.25	-breakfast or lunch only
\$8.00	-dinner only
\$10.50/person	-overnight accommodation - academic purposes
\$21/person	-overnight accommodation - non-academic purposes

NOTE - Fees for groups and conferences are negotiated directly with the Manager or Director

Boat Rental

\$225/month, \$100/week	- includes maintenance from normal use - gas and oil not included
\$45/day	- includes gas and oil for one day rental

NOTE - Fees for use of pontoon boats are negotiated directly with the Manager or Director

Bench Fees

\$5.00/day	- non-Queen's staff or major researcher (M.Sc. or Ph.D. candidate, project coordinator or Post-Doctoral Fellow)
\$1.75/day	- each non-Queen's assistant

NOTE - If sufficient funds are not available, bench fees may be waived or reduced upon written application to the Director.

Provincial Sales Tax

P.S.T. is applicable to oil used in boats, to photocopies and Fax.

Goods and Services Tax

G.S.T. is applicable to charges for boat rental, direct sales (e.g. equipment) and all charges for room and board from casual users.

Queen's University Biological Station List of Theses

Ph.D. THESES:

Updated March 8, 2000

- AGBETI, M.D. 1993. Comparison of seasonal succession of phytoplankton in two lakes with different mixing regimes. Ph.D. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- AIKEN, R. 1980. The role of acoustic signalling in the aggregating and mating behaviour of *Palmarcorixia nana* Walley (Hemiptera: Corixidae). Ph.D. thesis. Department of Zoology, Erindale College of University of Toronto, Mississauga, Ontario.
- BARCLAY, R. M. R. 1981. Interindividual use of echolocation calls: Eavesdropping by the Little Brown Bat, *Myotis lucifugus*. Ph.D. thesis. Department of Biology, Carleton University, Ottawa, Ontario.
- BOHONAK, A.J. 1998. Dispersal and gene flow in freshwater invertebrates. Ph.D. thesis. Department of Ecology and Systematics, Cornell University, Ithaca, New York.
- BROWN, G. P. 1997. Sexual size dimorphism and demography, thermoregulation and mating activity of northern water snakes (*Nerodia sipedon*). Ph.D. Thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- BROWN, J. A. 1983. A comparative study of behavioural ontogeny in four species of centrarchid fish. Ph.D. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- CAVALCANTI, R. B. 1981. Nest desertion: Theory and tests of its adaptive significance in birds. Ph.D. thesis, Department of Biology, McGill University, Nontreal, P.Q.
- CONRAD, K.F. 1991. Allocation of reproductive effort in Eastern Phoebe (*Sayornis phoebe*). Ph.D. Thesis. Department of Biology, Queen's University, Kingston, Ontario.
- COTE, Isabelle M. 1993. The evolution of sociality in fishes with emphasis on the role of parasites. Ph.D. Thesis, Department of Zoology, University of Toronto, Toronto, Ontario.
- DUFOUR, K.W. 1997. Symmetry, quality and sexual success in red-winged blackbirds. Ph.D. Thesis. Carleton University, Ottawa, Ontario.
- ECKERT, C.G. 1993. The evolutionary maintenance of a sexual polymorphism in clonal *Decodon verticillatus* (L.) Ell. (Lythraceae). Ph.D. thesis. Department of Botany, University of Toronto, Toronto, Ontario.
- ELRIFI, I.R. 1986. Processes during nitrogen-induced photosynthetic suppression in N-limited microalgae. Ph.D. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- EPP, G.A. 1989. Field experiments on interspecific plant interactions during succession in two abandoned hayfield plots. Ph.D. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- FORBES, M.R.L. 1991. Parasites and reproductive success of male hosts: competing hypotheses and tests with *Enallagma* damselflies and parasitic mites. Ph.D. thesis, Department of Zoology, University of Toronto, Toronto, Ontario. 196 pp.
- FOX, M.G. 1989. The effects of resource limitation and population density on prey consumption and population dynamics of young-of-the-year walleye in pond culture. Ph.D. thesis, Department of Biology, Queen's University, Kingston, Ontario.

- FULLARD, J. H. 1979. Auditory components in the defensive behaviour of certain tympanate moths. Ph.D. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- FULTHORPE, R.R. 1990. Survival, activity and transfer of a bacterial catabolic transposon in an aquatic system. Ph.D. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- GOTCEITAS, V. 1987. Microhabitat selection by bluegills (*Lepomis macrochirus*) avoiding predation. Ph.D. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- GROSS, M. R. 1980. Sexual selection and the evolution of reproductive strategies in sunfishes (*Lepomis*: Centrarchidae). Ph.D. thesis, Department of Biology, Univ. of Utah.
- HITCHCOCK, C.L. 1992. Social caching by black-capped chickadees. Ph.D. thesis. Department of Psychology, University of Toronto, Toronto, Ontario.
- KINDLER, P.M. 1990. Role of 11-ketotestosterone, testosterone and prolactin in the expression of reproductive behaviors by male bluegill. Ph.D. thesis. Department of Animal Sciences, University of Illinois, Champaign, Illinois.
- KRAMER, H.G. 1982. The song patterning of song sparrows *Melospiza melodia* in relation to territorial defense. Ph.D. thesis, Department of Biology, McGill University, Montreal, Quebec.
- LEUNG, B. 1999. Assessing and developing the use of fluctuating asymmetry as a bioindicator of environmental stress and quality of organisms. Ph.D.thesis, Carleton University, Ottawa, Ontario. 232pp.
- LONKER, S. 1979. Conditions of metamorphism in high grade pelites from the Frontenac Axis, Ontario, Canada, calculated from experimental and theoretical equilibria. Ph.D. thesis, Department of Geological Sciences, Harvard Univ.
- MEEK, S.B. 1991. Parental investment and the maintenance of monogamy in Eastern Bluebirds *Sialia sialis*. Ph.D. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- MENARD, G. 1986. A genetic approach to the study of morphometric variation in marsh and upland red-winged blackbirds. Ph.D. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- MURPHY, S.D. 1993. The occurrence and consequences of heterospecific pollen transfer: Allelopathic pollen in *Phleum pratense* L. (Poaceae) and the *Hieracium* L. aggregate (Asteraceae). Ph.D. Thesis, Department of Biology, Queen's University, Kingston, Ontario.
- OTTER, K.A. 1996. Female reproductive strategies in the Black-capped Chickadee: Their influence on male and female reproductive success and honesty in male advertisement. Ph.D. Thesis. Department of Biology, Queen's University, Kingston, Ontario.
- PRIOR, K.A. 1997. Conservation biology of black rat snakes: Ecological, demographic and genetic approaches. Ph.D. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- PROCTOR, H. 1991. Evolution of sperm transfer in water mites. Ph.D. thesis. Department of Zoology, Erindale College of University of Toronto, Mississauga, Ontario.
- PROSSER, M.R. 1999. Sexual selection in Northern Water Snakes, *Nerodia sipedon sipedon*: Examination of the mating system and correlates of male reproductive success using microsatellite DNA markers. Ph.D. thesis. McMaster University, Hamilton, Ontario.
- RENDELL, W.B. 1999. Evolution of clutch size in tree swallows: trade-offs during reproduction, age-specific fecundity and survivorship. Ph.D thesis. Department of Biology, Queen's University, Kingston, Ontario.

- SHUTLER, D. 1991. Dynamics of territory acquisition by red-winged blackbirds. Ph.D. Thesis. Department of Biology, Carleton University, Ottawa, Ontario.
- SMITH, Bruce P. 1983. Water mite parasitism of mosquitoes. Ph.D. thesis, Department of Zoology, University of Toronto, Toronto, Ontario. 172 pp.
- STUDD, M.V. 1987. Alternative strategies of allocation of reproductive effort in Yellow Warblers. Ph.D. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- VANDER KLOET, S.P. 1971. The North American Blueberries revisited: A taxonomic study of *Vaccinium* section *Cyanococcus* Gray. Ph.D. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- WHITTINGHAM, L.A. 1992. Male parental care and nesting success in red-winged blackbirds. Ph.D. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- WIEDENFELD, D.A. 1988. Ecomorphology and foraging behavior of the yellow warbler, *Dendroica petechia*. Ph.D. thesis. Department of Biological Science, Florida State University
- YEZERINAC, S.M. 1995. Extra-pair mating in yellow warblers: sexual selection and reproductive strategies. Ph.D. thesis. Department of Biology, Carleton University, Ottawa, Ontario.
- 39 PhD Theses
- M.Sc. THESES:**
- AMUNDRUD, J. R. 1970. Ecological interrelationships of the larvae of Perciform fish in Lake Opinicon, Ontario. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- ARNOLD, S. 1986. Reproductive patterns of darters (*Percidae: Etheostomati*): Female mate choice and patterns of allocation of reproductive effort. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- BALLANTYNE, P. K. 1976. Sound production during agonistic and reproductive behaviour in the Pumpkinseed (*Lepomis gibbosus*), the Bluegill (*L. macrochirus*) and their hybrid sunfish. M. Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- BALL, S. 1994. Costs of antipredator behaviour of larval Chironomidae. M.Sc. thesis. Department of Zoology, Erindale College of University of Toronto, Mississauga, Ontario.
- BARCLAY, R. M. R. 1978. Vocal communication and social behaviour of the Little Brown Bat, *Myotis lucifugus* (Chiroptera: Vespertilionidae). M.Sc. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- BARRY, F.E. 1991. Sexual size dimorphism of northern water snakes *Nerodia sipedon*. M.Sc. Thesis. Department of Biology, Carleton University, Ottawa, Ontario.
- BERTSCHY, K. 1997. The influence of age-specific survivorship and growth on pumpkinseed (*Lepomis gibbosus*) life histories. M.Sc. thesis. Watershed Ecosystems Program, Trent University, Peterborough, Ontario.
- BLANCHER, P. J. 1978. Habitat distribution of the Eastern Kingbird (*Tyrannus tyrannus*): The influence of intraspecific competition. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- BOOTH, D. 1984. Energetics, feeding and growth in year II bluegills (*Lepomis macrochirus*) relative to season. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.

- BOTTOMLEY, E.Z. 1983. The effect of root uptake by *Myriophyllum spicatum* L. on temporal and spatial distributions of bioavailable phosphorus in a littoral sediment. M.Sc. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- BROWN, K. E. 1977. Feeding and growth performance of Yellow Perch (*Perca flavescens*) in relation to differing backgrounds of resources and potential competitor species. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- BROWN, S. R. 1952. Some aspects of lake soils in relation to the productivity of a lake. M. A. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- BURNHAM, J.C. 1998. The contribution of seeds and turions towards population growth and persistence of *Hydrocharis morsus-ranae* L. M.Sc. Thesis. Department of Botany, University of Guelph, Guelph, Ontario.
- CARGNELLI, L. 1995. Male reproductive behaviour and recruitment in Bluegill Sunfish (*Lepomis macrochirus*: Centrarchidae). M.Sc. Thesis, Department of Zoology, University of Toronto, Toronto, Ontario.
- CHEK, A.A. 1991. Mate guarding in Tree Swallows. M.Sc. Thesis. Department of Biology, Queen's University Kingston, Ontario.
- CHRISTIE, C. 1988. Surficial diatom assemblages as indicators of lake trophic status. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- CLARK, K. L. 1978. The selective advantages of Yellow Warblers (*Dendroica petechia*) nesting in interspecific aggregations. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- CLARKE, S. E. 1979. Comparison of courtship sequences in parental and hybrid sunfish (*Lepomis* spp.): Evidence for a behavioural isolating mechanism. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- CLAUSSEN, J.E. 1991. Annual variation in the reproductive activity of a bluegill population: effect of clutch size and temperature. M.Sc. thesis. Department of Zoology, University of Toronto, Toronto, Ontario.
- COLEMAN, R. 1986. Parental investment theory: Tests in bluegill sunfish (*Lepomis macrochirus*: Centrarchidae). M.Sc. thesis, Department of Biology, Simon Fraser University, Burnaby, British Columbia.
- COMPLAK, J. A. 1982. Relationship between lake type and the performance (growth, body condition, feeding patterns) of four littoral zone fish species. M. Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- COOK, W.J. 1991. The parasitism of dragonflies by the water mite *Limnochares americana* Lundblad (Acari:Parasitengona: Limnocharidae). M.Sc. thesis, Department of Biology, University of New Brunswick, Fredericton, New Brunswick. 97 pp.
- COUTTS, R. A. 1972. The development of a technique to determine insect species from stomach contents and feces of some bats. M.Sc. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- CRAIG, S. R. 1976. Seasonal development of structure in two macrophytic communities in Lake Opinicon, Ontario. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- CURTIS, C. 1946. The soils of the Queen's University Biology Station. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.

- DANYLCHUK, A.J. 1993. The relationship between body size and reproductive patterns pumpkinseed (*Lepomis gibbosus*). M.Sc. thesis, Watershed Ecosystems, Trent University, Peterborough, Ontario.
- DAWSON, J.W. 1995. A neurophysiological description of the central pattern generator underlying sound production in two species of tiger moths (Lepidoptera: Arctiidae). M.Sc. Thesis. Department of Zoology, University of Toronto, Toronto, Ontario.
- DEACON, L. I. 1984. A comparison of growth, reproduction and habitat utilization in two populations of pumpkinseeds, *Lepomis gibbosus*, M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- DUCKWORTH, G. A. 1978. Adaptive aspects of spawning in female small-bodied fish from Jones Creek and Lake Opinicon, near Kingston, Ontario, Canada. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- DUNLOP, C. 1987. A comparison of antipredator behaviour in two populations of the Banded Killifish (*Fundulus diaphanus*). M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- ECKERT, C.G. 1985. The law of battle and polygyny in the red-winged blackbird. M.Sc. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- EMBORSKY, S. J. 1971. Feeding and growth of the Bluegill sunfish (*Lepomis macrochirus* Rafinesque) in Lake Opinicon, Ontario. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- EPP, G. 1986. Attributes of competitive ability and local coexistence in two different-aged hayfields. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- FEE, F. 1998. Variability and correlations among reproductive and nonreproductive traits in four spider species. MSc thesis. Department of Biology, Queen's University, Kingston, Ontario.
- FERGUSON, H.L. 1996. Thermal and temporal variability of spawning populations of largemouth and smallmouth bass: a comparative ecological study. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- FESSENDEN, T. 1990. Mating patterns in the soldier beetle, *Chauliognathus pennsylvanicus*. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- FOTHERINGHAM, J. R. 1995. Ecological influences on song structure and singing behaviour of wood warblers (Parulinae). MSc thesis, Queen's University, Kingston, Ontario.
- FOWLOW, K. 1994. Structural studies along the Perth Road shear zone, Frontenac Terrane, Southern Ontario. M.Sc. thesis, Department of Geology, Miami University, Oxford, Ohio.
- FULLARD, J. H. 1976. A preliminary study of sounds produced by arctiid moths. M.Sc. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- GARGA, N. 1996. Aposematism in water mites (Acari: Hydracarina): a predator defense mechanism, a phylogenetic hold-over and protection from damaging light. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- GERRISH, N. 1981. Some aspects of the selection of odonate host species by *Arrenurus* water mites (*Acari hydrachnellae*) in Lake Opinicon, Ontario. M.Sc. thesis, Department of Zoology, University of Toronto, Toronto, Ontario.

- GRANT, J. W. A. 1980. Territoriality, reproductive success and mate choice in the Johnny Darter (*Etheostoma nigrum* Rafinesque). M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- GRIFFIN, S. 1998. Floral fluctuating asymmetry: experimental studies of its effects on plant reproductive success and pollinator behaviour. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario
- GROTEN, H.F. 1990. The social aspects of place learning in the feeding behaviour of bluegill sunfish (*Lepomis macrochirus*). M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- HAMR, J. 1978. Detection and discrimination on insect flight sounds by the big brown bat (*Eptesicus fuscus*) (Chiroptera: Vespertilionidae). M.Sc. thesis, Department of Biology, University of Guelph, Guelph, Ontario.
- HARKER, J. M. 1976. Prey selection relative to availability and size: A comparison of the feeding of four inshore fish assemblages, Lake Opinicon, Ontario. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- HARRISON, T.M. 1983. Patterns of feeding and habitat use by little brown bats, *Myotis lucifugus* (Chiroptera: Vespertilionidae), over and around Lake Opinicon, Ontario. M.Sc. thesis, Department of Biology, Carleton University, Ottawa, Ontario.
- HECKER, K.R. 1999. Testing for sex biases and morph biases in parasitism of zygoterans (Odonata) by gregarines (Eugregarinidae). M.Sc. thesis, Carleton University, Ottawa, Ontario. 72pp.
- HENDERSON, J.B. 1986. The European skipper (*Thymelicus lineola*): population ecology and herbivory in an old-field community. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- HILDER, B. E. 1983. The territorial system of *Nannothemis bella* (Anisoptera: Libellulidae). M. Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- HOYLE, J.A. 1986. The comparative feeding ecology of two top piscivores, Northern Pike (*Esox lucius*) and Largemouth Bass (*Micropterus salmoides*). M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- HURLY, A. P. 1982. Female competition in Red-winged Blackbirds. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- IRWIN, D.L. 1992. The cost and benefit of apical dominance: Growth responses of five herbaceous species to shoot apex removal. M.Sc. Thesis. Dept. of Biology, Queen's University.
- JORGENSEN, C. R. 1966. The annual reproductive cycle in six Lake Opinicon fishes: *Lepomis macrochirus* x *gibbosus* (hybrid population), *Ambloplites rupestris*, *Pomoxis nigromaculatus*, *Percina caprodes*, *Perca flavescens*, and *Esox lucius*. M. Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- JUSTUS, J. 1995. Sexual selection and fluctuating asymmetry in a condition-dependent fish ornament (Pumpkinseed Sunfish: *Lepomis gibbosus*). M.Sc. thesis, Department of Zoology, University of Toronto, Toronto, Ontario.
- KARST, T.L. 1996. Paleolimnological analyses of lake eutrophication patterns in Collins Lake and Lake Opinicon, southeastern Ontario, Canada. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.

- KIEFFER, J.D. 1991. Learning and individual variation in the foraging behaviour of sunfish. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- KONKLE, B. 1987. Artificial substrates as indicators of food limitation in sunfishes (Centrarchidae). M.Sc. thesis, Department of Zoology, Erindale College of University of Toronto, Mississauga, Ontario.
- KRISTENSEN, D. 1996. An assessment of the songbird habitat quality of red pine plantations in eastern Ontario. M.Sc. thesis. Department of Biology, Queen's University, Kingston, Ontario.
- KROGH, T.E. 1961. The titaniferous magnetite deposit of the Newboro District. M.Sc. Thesis, Department of Geology, Queen's University, Kingston, Ontario.
- LEFFELAAR, D. 1983. Reproductive strategies in the Tree Swallow, *Tachycineta bicolor*. M.Sc. thesis, Department of Biology, Queen's University, Kingston, Ontario.
- LEMPRIERE, C.S. 1990. Plasticity in the chickadee call of wintering flocks of Black-capped Chickadees (*Parus atricapillus*). M.Sc. Thesis. Department of Biology. Queen's University, Kingston, Ontario.
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