Internal Faculty Reassigned Time Award Cover Sheet

ENHANCING NORTHERN MICHIGAN UNIVERSITY'S BIOLOGICAL COLLECTIONS AS RESOURCES FOR BIODIVERSITY RESEARCH AND TEACHING

A proposal submitted to:
NMU Faculty Grants Committee

By

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31 January 2013

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<th>Years at NMU:</th>
<th>1.5</th>
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<td>Total Reassigned Time Requested:</td>
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<td>Semester Requested:</td>
<td>Fall 2013</td>
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<td>Dates of Previous support (indicate if none):</td>
<td>Fall 2012</td>
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Enhancing Northern Michigan University’s biological collections as resources for biodiversity research and teaching

Kurt Galbreath

Abstract

Under this request for 4 credits of reassigned time, I propose to accomplish three primary objectives related to the natural history collections that are housed in Northern Michigan University’s Biology Department: 1) develop protocols for preparing and archiving mammal, parasite, and frozen tissue specimens, 2) establish a digital database (accessible and searchable online), and 3) hire and train student curatorial assistants. Completion of these goals will establish a foundation that is critical to my efforts as a co-Principal Investigator on a project that has been recommended for funding by the National Science Foundation ($225,000 to NMU). This 3-year collaborative project will produce thousands of field-collected specimens, which must be processed and archived to make them maximally useful as a resource for biodiversity research. The tasks outlined in this proposal will allow efficient archiving of specimens in the NMU museum. Key facilities and resources that are necessary for the project are in place, leaving protocol development and student training as major next steps toward a fully operational natural history museum. Success of this project will improve the probability of funding for future NSF grant proposals, and it will enhance our natural history museum capabilities and strengthen inter-institutional contacts. It will also increase student involvement in the collections, which will benefit teaching and research at NMU in ways that extend beyond the scope of the immediate project.
**Introduction** - I am requesting a reassigned time award to facilitate my work as a co-Principal Investigator on the Collaborative & Integrative Inventories of Biomes of the Arctic (CIIBA), a biological survey project that has recently been recommended for funding by the National Science Foundation (NSF; $225,000 dedicated to NMU out of $945,000 total project budget). At the core of this project lie comprehensive field inventories of plants, mammals, and parasites from transects in Siberia and North America, which will produce thousands of biological specimens that must be processed and archived in appropriate natural history museum collections before they can be made available as a resource for diverse studies on the ecology, evolution, and biogeography of northern organisms. My students and I will be making specific contributions to the portion of the work that focuses on mammals and their parasites. With field inventories beginning in Summer 2013, I propose to use reassigned time during the Fall 2013 semester to accomplish three primary objectives: 1) develop protocols for preparing and archiving mammal, parasite, and frozen tissue specimens in NMU’s natural history collections, 2) establish a digital database (accessible and searchable online) for NMU’s mammal and parasite collections, including procedures for data entry and quality control, and 3) hire and train student workers to initiate specimen and data processing. Completion of these objectives will establish infrastructure necessary to fulfill the goals of CIIBA, which is critical for downstream investigations on northern biodiversity.

**Background** – CIIBA is designed to support specimen-based investigations on the biogeography, ecology, and evolution of plants, mammals and parasites from the boundaries of the vast Beringian region, which spans eastern Siberia and northwestern North America and was a zone of intercontinental biotic dispersal during glacial periods of the past few million years (Hoffmann 1984; Sher 1999). The project represents an expansion of the Beringian Coevolution
Project (Cook et al. 2005), which over the past decade contributed to >160 publications on northern diversity but was more limited in its taxonomic and geographic scope. CIIBA will enhance these earlier studies by providing comparative material from key northern regions that lie beyond the traditional bounds of Beringia yet are necessary to interpret Beringia’s influence in structuring patterns of biological diversity across the North. My collaborators and I (including NMU students) will collect specimens that will support both morphological and DNA-based investigations of Beringian species. Comprehensive biological surveys have not been completed for large swaths of the Northern Hemisphere, and CIIBA will improve our understanding of diversity across many of these unstudied regions.

Diverse research questions may be addressed by specimens collected through this project. For example, exploration of co-evolutionary dynamics between plants, mammals, and parasites offers a way to test hypotheses that relate to historical processes that shaped communities across the Northern Hemisphere (Hultén 1937; Abbott and Comes 2003; Hoberg and Brooks 2008; Hoberg et al. 2012). In addition, CIIBA collections will establish critical baselines against which the effects of environmental change may be assessed over time. Such baselines provide a tool to detect losses of native organisms or additions of invasive species that could negatively impact ecosystems and the services that they provide to humanity (Chapin et al. 2006; Diaz et al. 2006).

**Project description** – Biological inventories completed under CIIBA will yield thousands of mammal and parasite specimens. For the project to provide a maximally utilized resource for biodiversity research, specimens must be processed and archived in accessible natural history museum collections, and specimen data must be available online. Many mammal and parasite specimens (and associated frozen tissues) collected under CIIBA will be archived in the natural history collections here at NMU to serve as permanent physical records of diversity to
which other data will be linked (e.g., collection date and locality, DNA sequence data, publication records). However, we currently lack established protocols for processing specimens and tracking data, and none of NMU’s biological collections are logged in a fully accessible museum database system.

I am working to build the required infrastructure here at NMU for processing and databasing mammal and parasite specimens. For example, mammal skeletons are typically prepared as museum specimens using dermestid beetle larvae to clean the flesh from bones, and in Fall 2012 I established a dermestid colony on campus that is now being managed by NMU students. Likewise, I have prepared space, equipment, and materials in my lab for slide-mounting and identifying parasite specimens. Further, with the support of other faculty curators in the Biology Department, I have secured an invitation for NMU to join the Arctos museum database network. Arctos is a centrally managed museum database system that is used by many large and small university museums and offers sophisticated database tools (e.g., online accessibility, data security, advanced searching and reporting). Because the cost of servers, data storage, and technical support are shared by network members, the over-all cost for a small museum such as NMU’s is a fraction of what it would be if we were to manage our own system.

With these facilities and resources coming on line, I am ready to begin developing protocols for preparing, archiving, and databasing mammal, parasite, and frozen tissue specimens, and training student curatorial assistants. With over a decade of experience working in natural history museums, including the University of Alaska Museum, Cornell University Museum of Vertebrates, and Western Washington University Herbarium, I am well-versed in the methods required to complete this project. Further, the successful completion of all objectives
undertaken during my Fall 2012 reassigned time period demonstrate my track record of productivity (see attached final report).

**Objective 1 – Develop museum protocols:** Procedures must be tested and documented for a) subsampling mammal and parasite tissues for DNA-based applications, b) organizing and tracking tissue samples in an ultra-cold (-80°C) frozen archive, c) preparing and accessioning mammal voucher specimens (e.g., skins, skeletons), d) slide-mounting whole parasites for species identification and morphological studies, and e) tracking all data associated with tissue and voucher specimens. Thus, a key outcome of this award will be a document outlining museum procedures for the mammal, parasite, and frozen tissue collections.

**Objective 2 – Establish a digital online database:** To fulfill the requirement that all specimens collected under CIIBA must be archived in fully databased and accessible collections, I will initiate the process of databasing NMU’s mammal and parasite collections within Arctos. I will establish procedures for data entry by student workers to ensure that data remain linked to voucher specimens and are transcribed accurately from field records into digital format.

**Objective 3 – Train student workers:** I anticipate that undergraduates from NMU will participate in field collections in Summer 2013, and salary support available through CIIBA will permit students to be hired during subsequent semesters to assist in specimen and data processing. During the Fall 2013 semester I will devote considerable time to student training and oversight as museum procedures are developed, tested, and refined. My goal is to establish a team of well-trained undergraduate personnel who will be able to contribute to new employee training in subsequent semesters. Several students already act as volunteer curatorial assistants in the museum, indicating that there will be strong interest in paid curatorial positions.
Justification – The proposed project will dramatically enhance the existing natural history collections at NMU by increasing student involvement, improving specimen curation, and making museum data accessible to the broader scientific community for the first time in the museum’s history. These improvements are critical for my research program as they will facilitate the successful completion of my role in CIIBA (important for future NSF funding) and allow me to build a specimen-base here at NMU that will provide a foundation for future student research projects. Students will benefit by developing skills in curatorial techniques, and they will have opportunities to become involved in my research program through collections-related activities (e.g., field expeditions, specimen preparation and identification). Better curation and data accessibility will also make it easier to use the collections as resources for teaching, which is part of the core mission of the museum. Further, the collection management protocols and database system established under this project will pave the way for parallel improvements in other natural history collections at NMU (e.g., birds, invertebrates, plants), leading to broader impacts within the Department. Finally, by joining Arctos, NMU will immediately establish a connection with several other universities that are part of the network (e.g., University of Alaska, University of California Berkeley, University of New Mexico), and researchers from around the world will be able to access our specimen records, potentially fostering new inter-institutional connections and collaborations. Thus, this project promises to strengthen NMU’s presence within the scientific community at large.

Methods - To develop museum collection protocols I will identify and outline key steps involved in preparing and accessioning specimens into the NMU museum (see Objective 1 above). These procedures will be developed in collaboration with student employees and in consultation with colleagues at other natural history museums. Major resources required for
processing specimens and data are already in place, including the dermestid colony for cleaning mammal skeletons, slide-mounting materials and microscopes for preparing parasite specimens, ultra-cold freezers for archival storage of tissues, and computers for working with the Arctos database, which is accessed via a web browser and therefore requires no special software or equipment. Specimens to be processed will be collected under IACUC authorization #204.

**Timetable - September 2012** – Develop preliminary collection manual; Launch mammal/parasite/frozen tissue database; Train students in specimen processing and database use; Begin specimen/data processing

**October/November 2012** – Oversee student processing of specimens and data; Evaluate and refine collection procedures with student input

**December 2012** – Complete collection manual; Oversee student workers

**Reassigned time** - I am requesting 4 load credits of reassigned time for this project. With this amount of time it is realistic to expect to meet the ambitious goals of the project, but a smaller time reassignment will limit my ability to complete the work. I will be developing an organizational and procedural framework for the museum where none currently exists, and identifying and addressing all of the issues that relate to this complex undertaking will require multiple iterations of evaluation and refinement. Further, student training and oversight will represent a sustained time commitment over the course of the semester as it is essentially an open-ended task. As students gain skills and confidence in one set of tasks (e.g., data entry and mammal specimen preparation) I will extend their training to other more challenging areas (e.g., parasite mounting and species identification). A museum’s value depends on the quality of its data, so I must ensure that all student curatorial assistants are highly capable of not only completing their own work, but also training future student workers.
Literature Cited


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University of Alaska Fairbanks Wildlife Biology MS 2002  
Illinois Wesleyan University Biology BS 1997

Academic positions
2011 – present  Assistant Professor, Northern Michigan University  
2008 – 2011  Research Associate, Western Washington University

Publications
Five most closely related to proposed project (of 15 peer-reviewed publications):
Five other significant publications:


Synergistic Activities
(i) Student training: 1) Currently serving on 3 graduate committees; 2) Have mentored or trained several high school, undergraduate, and graduate students on field mammalogy and parasitology methods, molecular laboratory techniques, and/or the use of phylogeographic and systematic tools.

(ii) Curriculum development: 1) Produced online teaching materials for various courses at Cornell University and Northern Michigan University; 2) Participated in the NSF-funded Transforming Undergraduate Education in Science (TUES) Active Learning project at NMU to develop and teach active learning curricula in key biology courses.

(iii) Collections development: 1) Made significant contributions of mammal, plant, and parasite voucher specimens and frozen tissues to the University of Alaska Museum, Cornell University Museum of Vertebrates, Museum of Southwestern Biology, Western Washington University Herbarium, and US National Parasite Collection through participation in 8 major field expeditions in Alaska, China, Siberia, and Intermountain West of North America since 1999; 2) Currently leading efforts to curate the natural history collection of Northern Michigan University and develop it as a resource for teaching and research.

(iv) International collaboration: 1) Built relationships with biologists from Russia, France, Britain, and Canada through collaborative field expeditions; 2) Recommended by the National Science Foundation to receive funding support for field collections in Russia and Canada during 2013-2015 field seasons.
Kurt Galbreath

Diversity, evolution, and biogeographic history of northern parasites

Fall 2012 Reassigned Time Award

Project summary: For this reassigned time award I proposed to complete and submit two manuscripts to peer-reviewed journals. These manuscripts explore aspects of my research on the diversity and evolutionary history of tapeworms of the genus Arostrilepis, a widespread and complex assemblage of parasites associated with northern small mammals (e.g., voles and lemmings). Work on these writing projects also allowed me to further develop collaborative relationships with multiple research groups in the US, Russia, and Lithuania. I requested a reassigned time award to facilitate my contributions to the preparation of the manuscripts, which included data analysis, writing, preparing figures, and navigating the submission and editorial process.

Results: The major result of the first manuscript prepared during the award period was the discovery and description of three new species of Arostrilepis tapeworms. This manuscript also presented the first examination of evolutionary relationships among all described species within the genus, and it outlined our current understanding of major biogeographic patterns for the group across Asia and North America. The second manuscript showed that a particular Arostrilepis species (A. tenuicirrosa) has a vast distribution that spans Eurasia, yet it exhibits little morphological or genetic structure across that huge range. This implies that the species acquired its current distribution relatively recently (e.g., since the last ice age ended ~10,000 years ago). Relationships among A. tenuicirrosa populations and evidence from the fossil record for hosts suggest a recent post-glacial expansion westward into Europe from an East Asian point of origin.

Products: The following two manuscripts were submitted as planned, fulfilling the goals of the project:


Further, the manuscript submitted to the journal Zootaxa has completed the review process and is now in press, with publication planned for later in 2013 (see attached first page of page
proofs). The submission to Acta Parasitologica is currently in review. Related products associated with these papers include several DNA sequences that were submitted to the globally accessible GenBank database for use by other investigators (accession numbers JX392029- JX392050, JX104762- JX104773). Also, the two projects represented by these papers have strengthened connections between my research program and those of Eric Hoberg (US National Parasite Collection), Arseny Makarikov (Institute of Systematics and Ecology of Animals, Russian Academy of Sciences) and Vytus Kontrimavicius (Institute of Ecology of Nature Research Centre, Lithuania). Stronger ties will play an important role in facilitating planned future collaborative efforts.

In addition to the above products, I used available time during the Fall 2012 semester to establish a colony of dermestid beetles here at NMU. Though not a part of the original reassigned time proposal, this dermestid colony will play an important role in my research program and therefore was a valuable product to emerge from this award. The colony is being used to clean skeletons of specimens that I will collect in the field as I pursue my research on northern mammals and their parasites. It is also available to other faculty and students in the Biology Department who need to prepare specimens for research or teaching purposes. The colony represents an especially important resource for the continued development and growth of the natural history museum collections housed in the Biology Department. Currently 4 undergraduate students are participating in the day-to-day management of the colony, giving them opportunities to gain experience in specimen curation and mammalogical methods.

**Further research:** The two manuscripts completed for this project establish an important foundation for future investigations of northern parasite diversity. We now have a relatively complete understanding of species-level diversity within the *Arostrilepis* complex, which includes more than a dozen species. This taxonomic framework is critical for understanding the biogeographic and co-evolutionary histories in this group, which hold promise to yield novel insights into patterns and processes of diversification and community assembly across the Northern Hemisphere. Further, our study of rangewise patterns of genetic structure in *A. tenuicirrosa* (described in the paper submitted to Acta Parasitologica) establishes testable hypotheses that will be evaluated in my lab using other broadly distributed *Arostrilepis* species and molecular tools. This specimen-based research will involve both new field collections in North America and Asia and lab-based molecular genetic analyses.

**Grants:** Though preparing a grant application was not one of the tasks that I proposed to accomplish during my reassigned time period, I did apply for (and win) the Scott Holman Research Award of $4000 in Fall 2012. I also applied for an internal Faculty Research Grant (pending). Further, I received notification that a collaborative National Science Foundation grant on which I am a Co-Principal Investigator is recommended for funding (RUI-Integrated
Inventory of Biomes of the Arctic with Western Washington University and University of New Mexico; $945,000 total, $225,000 of which will come to NMU). This NSF grant will support field work by me and my students in Asia (2 seasons) and North America (1-2 seasons).

**Budget:** Completion of the work proposed for this reassigned time award required no expenses.
Parasite diversity at the Holarctic nexus: species of *Arostrilepis* (Eucestoda: Hymenolepidae) in voles and lemmings (Cricetidae: Arvicolinae) from greater Beringia

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Abstract

Previously unrecognized species of hymenolepidid cestodes attributable to *Arostrilepis* Mas-Coma & Tenora, 1997 in arvicoline rodents from the greater Beringian region and western North America are described. Discovery and characterization of these tapeworms contributes to the recognition of a complex of cryptic species distributed across the Holarctic region. Three species are proposed: *Arostrilepis gulyaevi* sp. n. is named for cestodes in *Myodes rafocanus* from the Republic of Buryatia, southeastern Siberia and from the Khabarovskiy Kray, Chukotka Autonomous Okrug, and Magadanskaya Oblast’, Russian Far East (western Beringia); *A. cooki* sp. n. is named for cestodes in *Myodes gapperi* from British Columbia, Canada and Montana, USA; and *A. rauschorum* sp. n. is named for cestodes in *Microtus oeconomus*, *M. lenticularis*, and *M. pennsylvanicus* and *M. xanthognathus* from the Brooks Range, Seward Peninsula, north-central interior, and Arctic coastal plains of Alaska (eastern Beringia) and Montana, USA. Consistent with recent studies defining diversity in the genus, the form, size, and spination (pattern, shape and size) of the cirrus sac are diagnostic; species are further distinguished by the relative position and length of the cirrus sac, and arrangement of the testes. Assessment of genetic data from the cytochrome b gene of mitochondrial DNA complements differentiation of this complex based on morphological attributes and confirms known species diversity within the genus. New data for geographical distribution and host specificity of known *Arostrilepis* spp. indicate that 3 of 12 recognized species have Holarctic distributions extending across Beringia. These include *Arostrilepis beringiensis* (Kontrimavichus & Smirnova, 1991) in lemmings (species of *Lemmus* and *Synaptomys*), A. cf. *janickii* Makarikov & Kontrimavichus, 2011 in root voles (*M. oeconomus*) and *A. macrocirrosa*
MEMORANDUM

TO: Kurt Galbreath
   Biology Department

FROM: Brian Cherry, Ph.D.
      Assistant Provost/IACUC Administrator

DATE: October 2, 2012

RE: Application to use Vertebrate Animals
    Application # IACUC 204
    Approval Period: 10/02/2012 - 8/01/2015

The Institutional Animal Care and Use Committee has approved your proposal to use vertebrate animals in research for “Comparative Phylogeography of Northern Mammals and Their Parasites; Museum-based Mammal Collecting in Michigan's Upper Peninsula” by designated member and full committee review.

If you have any questions, please contact me.

ljc