An annual compilation of research publications enabled by the Canadian Museum of Nature

Canadian Museum of Nature Research Review 2018

canadian museum of nature
nature
musée canadien de la nature

Canada

ABOUT THE CANADIAN MUSEUM OF NATURE

The Canadian Museum of Nature is the national museum of natural sciences for the second largest country in the world, an Arctic nation with the world's largest coastline.

The mission of the Museum is to make the vision of a sustainable future a reality. As current environmental changes such as greenhouse gas emissions, species extinctions, loss of natural spaces, and their causal factors run counter to this vision, the Museum's mission is one of inspiring change.

The Museum is one of many national natural history museums and like-minded organizations in the scientific community working to provide the foundation required to foster the change required to "save the world". This foundation is built on evidence, knowledge and inspiration.

The Canadian Museum of Nature provides inspiration through its public exhibitions, galleries and programs based at its heritage Victoria Memorial Museum building in Ottawa, as well as its national travelling exhibitions, web site and strategic partnerships.

The Museum also houses and curates over 14.6 million natural history specimens at its Natural Heritage Campus in Gatineau. These specimens are the evidence on which Museum scientists, associates, colleagues and other researchers base their studies resulting in the generation of new knowledge about the natural world.

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Beaty Centre for Species Discovery

Jeffery M. Saarela, Director
Centre for Arctic Knowledge and Exploration

November 2019

ACKNOWLEDGEMENTS

This report was made possible with the assistance and innovation of David Shorthouse as well as contributions from Susan Goods, Lory Beaudoin, Jennifer Doubt, Dominique Fauteux, Andre Martel, Troy McMullin, and the Section Heads in Research and Collections: Jean-Marc Gagnon (Zoology), Lynn Gillespie (Botany), Jordan Mallon (Palaeobiology), Paula Piilonen (Mineralogy) and Sean Tudor (Collection Services and Information Management).

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Cover and inside front cover photos: Martin Lipman

FOREWORD

This Research Review expands on information in the Museum's Annual Report. As this is the first such report, it will serve as the basis for recognition of future trends in the Museum's impact on the generation and accumulation of scientific knowledge. It provides an annual overview of the research publications by museum staff and associates, and/or enabled by the Natural Heritage Campus of the Canadian Museum of Nature, particularly the Museum's collection of 14.6 million specimens. These specimens are organized into 3.4 million catalogueable units or lots, of which 2.9 million are accessioned into the permanent collection and the remainder exist as prepared or unprepared backlog material. The Museum collection grows by an average of 20,000 specimens per year.

There are 54 scientists, curators, technicians and associated staff in the Museum's Research & Collections Division. The Museum also has over 40 honorary research associates and an active visiting scientist program that brings scientists and their expertise to the Natural Heritage Campus to study specimens in our collections and to collaborate with staff.

This Research Review documents 255 scientific articles published in 2018 by staff, students and research associates formally affiliated with the Museum, in-person visitors to the collections, national and international researchers who have requested information or loans of specimens, and researchers who have accessed and used museum specimen data via the Global Biodiversity Information Facility (GBIF), the museum's Collection Online website and related specimen-data aggregators. Nowhere have the products of all of these collective science activities been brought together in one report until now.

The publications comprise not only peer-reviewed primary articles in scientific journals but also books, including "Marine Fishes of Arctic Canada", winner of the 2019 Dartmouth Medal for outstanding reference work, an annual award presented by the American Library Association.

The Research Review also profiles a subset of the scientific publications, including a concise description of the content of each study and explanation of its broader significance. These profiles demonstrate the diverse science that Museum researchers are engaged in, and the many ways that Canadian Museum of Nature collections are used by others to build and enhance knowledge.

The results of this report show that the global science impact of the Canadian Museum of Nature is substantial.

METHODS

This Research Review highlights a scientific publication-tracking tool developed by Assistant Collections Information Manager David Shorthouse using Google Scholar. The tool searches for certain strings of characters or text indicative of an association with the Museum and compiles these publications for subsequent examination to determine the nature of the association with the Museum. To identify GBIF-mediated use of Canadian Museum of Nature data we relied on the GBIF literature tracking tool, which identifies research uses and citations of biodiversity information accessed through GBIF's global infrastructure and links those to a publisher page (Canadian Museum of Nature: https://www.gbif.org/publisher/a41250f0-7c3e-11d8-a19c-b8a03c50a862). We also conducted manual online searches of the literature, including searches of codes that are used globally to identify Canadian Museum of Nature collections, such as CANL (lichens), CANM (mosses), NMC (National Museum of Canada, as the Canadian Museum of Nature was formerly known) and CMN. Using all of these approaches, a list of 2018 publications (probably still not all-inclusive) has been assembled to which the Museum has in some way contributed.

Publications included in the list are those authored or co-authored by museum staff or research associates and publications by authors not associated with the museum that provide evidence that Canadian Museum of Nature specimens contributed to the published research. Evidence includes citation of, or reference to, one or more CMN specimens in a paper, inclusion of one or more CMN specimens in a GBIF dataset cited in the paper, indication that a CMN collection was searched for relevant specimens during a study (regardless of whether or not suitable material was found), and indication of significant use of CMN collections for consultation and identification of studied species.

To broadly characterize the kinds of research questions to which CMN personnel and collections contribute, each paper in the list was assigned to one of the following four research themes: Earth History and Evolution, Environmental Health, Species Discovery, and Endangered Species and Conservation. Although many papers could be placed under more than one category, we subjectively chose the single category that best encapsulated each work. We determined the country of origin of the primary author of the scientific publications, as a way to assess the museum's contributions to global science. All papers are relevant to the Museum's Beaty Centre for Species Discovery, and we also determined if papers are related to Arctic science, which is one of the museum's research and collections strengths. We additionally determined the proportion of papers published in open access format.

In addition to providing the complete list of the 2018 scientific publications arranged alphabetically by first author under each research theme, the report profiles a subset of studies, each with a concise summary of the content and explanation of its potential broader impact and contribution to advancing knowledge.

RESEARCH REVIEW 2018

We identified 255 papers published in 2018 by museum staff and associates and/or enabled by the museum's collection of 14.6 million natural history specimens.

Of these, 67 were authored or co-authored by CMN staff members (including five papers with a CMN research associate co-author), and an additional 34 by CMN research associates.

Canadian Museum of Nature specimens contributed in some way to the published research in the remaining 150 papers. Eighteen papers were relevant to Arctic science, including nine with staff co-authors and two with research associate co-authors.

Forty-one percent of the papers were published in an open access format, accessible to all readers without charge.

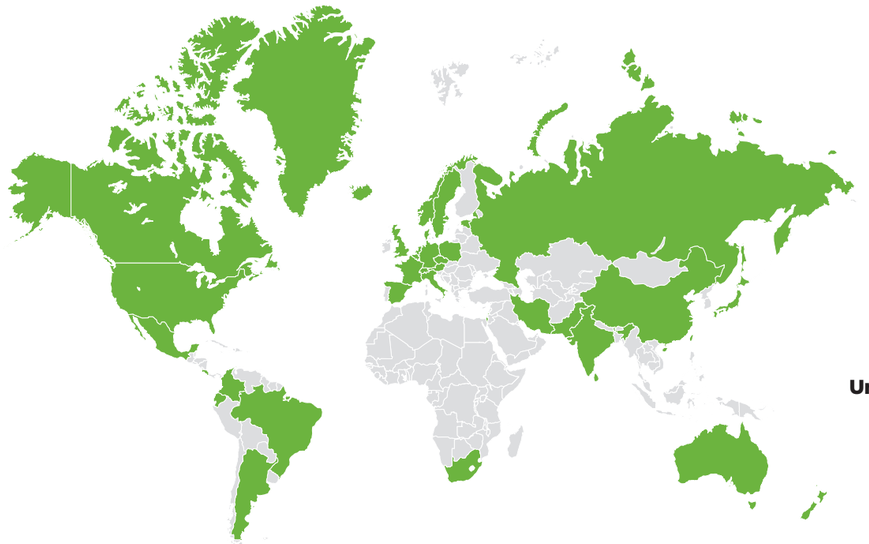
First authors of the papers come from 36 countries. Following Canada, with 89 papers, the best-represented country in the dataset is United States, with 66 papers (Figure 1). China is represented by 11 papers, 18 countries are represented by 2–9 papers, and the remaining 15 are represented by one paper.

In 2018, 204 (81%) publications provided evidence that CMN specimens somehow contributed to the research. A total of 135 publications (including those of staff and associates) explicitly cite one or more CMN specimens, 53 cite a GBIF dataset that includes CMN specimens, seven indicate that CMN collections were searched for material relevant to a study, and nine indicated that CMN collections were consulted to aid in identification of specimens or for some other purpose related to the work. Although we have aimed to be comprehensive, it is certain that some papers that should be included in the list have been missed, given the manual effort required to find and confirm that relevant publications meet our criteria for inclusion and the highly variable way that natural history collection data is referred to in scientific papers. Omissions should be brought to the attention of the authors.

The list demonstrates the breadth of natural sciences research conducted by CMN staff and research associates, and the diversity of research to which CMN collections contributed in some way. We assigned 55 publications to the Earth History and Evolution research theme. The bulk of these publications are from the palaeobiology literature, and a small subset from the field of mineralogy. Forty-seven of these papers, of which all but two are palaeobiological in nature and ten include a CMN staff member or research associate as a co-author, cite one or more CMN specimens, reflecting the importance of the CMN fossil collection to global science. We assigned 23 papers to the Environmental Health research theme and 15 to the Endangered Species and Conservation theme. Over half (61%) of the former and nearly half (47%) of the latter cite one or more GBIF datasets that include CMN specimens, demonstrating how making natural history collections information available online can contribute to diverse research.

The research theme to which CMN contributed most substantially — with 162 papers — in 2018 is Species Discovery, which includes papers focused on the taxonomy, systematics and ecology of extant biodiversity. Of these, 122 papers used CMN specimens or data in some way, including 78 papers that explicitly cite CMN specimens, including the deposition of 32 holotypes in the CMN collection. This result is not unexpected, given the critical role of museum specimens in taxonomy and systematics research aimed at documenting and understanding global biodiversity.

GEOGRAPHIC ORIGINS OF PAPERS BY FIRST AUTHOR



FIRST AUTHOR COUNTRY	NUMBER OF PAPERS
Canada	89
United States	66
China	11
Brazil	9
Germany	8
United Kingdom	8
Spain	7
France	5
Australia	4
Norway	4
Switzerland	4
Colombia	3
Costa Rica	3
Iran	3
Mexico	3
Russia	3
South Africa	3
Denmark	2
Italy	2
Japan	2
Netherlands	2
Argentina	1
Austria	1
Belgium	1
Czech Republic	1
Ecuador	1
Estonia	1
India	1
Israel	1
New Zealand	1
Pakistan	1
Poland	1
Sri Lanka	1
Sweden	1
Taiwan	1

Figure 1.
Summary of the geographical origins of papers, determined as the country of the first author, and the number of papers from each country.

The Canadian Museum of Nature currently shares data online for 988,482 (33.9%) of its 2.9 million accessioned specimen units or lots (Table 1).

Of these, 817,888 are mobilized via GBIF (accessed 6 June 2019) and the remainder (data for phycology and mineral collections) via other databases (Table 1). The completeness of these digital records varies, ranging from records comprising only a species name and high-level geographical provenance (i.e., country and province/state) ("skeletal" records") to records for which complete information has been captured, including geographical coordinates, which often must be determined secondarily, and one or more images of the physical specimens. Currently, 77.6% of GBIF-mobilized CMN data includes geographical data, excluding Fossil Vertebrate, Fossil Invertebrate, Palaeobotany and Palynology collections, for which we deliberately do not publish detailed locality information. Images are available for 11.8% of all CMN specimen records mobilized via GBIF; more than 99% of these images are of botanical specimens, primarily vascular plants, which are flat and relatively straightforward to image such that they are useful for research, and which have been a Museum priority for imaging.

The large number of papers identified that cite a GBIF dataset including CMN specimens is encouraging, demonstrating how our collections are contributing to development of new knowledge and addressing the global biodiversity crisis. We predict the number of papers that access and use GBIF-mobilized Canadian Museum of Nature data will increase in the coming years, for a number of reasons.

As the global GBIF dataset grows in size, more and more researchers are likely to use the available information in their work. As a result, a greater number of CMN specimens are likely to be included in broader datasets. As the number of digitized CMN specimens increases (i.e., the creation of a digital footprint, at minimum skeletal records), a greater number of GBIF-mediated CMN data points will be available to the global community. Georeferenced data points are required for most research studies that use GBIF-mediated data. Therefore, as the proportion of georeferenced CMN specimens increases, a greater number of CMN data points will be discoverable using map-based queries in the GBIF portal. As the proportion of images associated with CMN specimen record increases and those images are mobilized, we expect usage of those resources to increase, particularly in systematic and related biodiversity studies where an image may be useful or, in some cases required, for a specimen to be considered in a study (even if it is impossible to identify a specimen from an image, as is the case for many groups of organisms).

DATA MOBILIZATION

TABLE 1. SUMMARY OF CANADIAN MUSEUM OF NATURE COLLECTIONS
including number of physical specimens, number of records digitized and mobilized, number of mobilized records that are georeferenced, and number of mobilized records with an associated image for each. Digital records are mobilized via the Global Biodiversity Information Facility (GBIF), unless otherwise indicated.

Canadian Museum of Nature Collection	Number of physical specimens[1]	Number (%) of records[2] digitized and mobilized	Number (%) of mobilized digital records georeferenced[3]	Number (%) of mobilized digital records with an associated image
Herbarium[4]	1,015,502	294,562 (29)	208,682 (70.8)	95,847 (32.5)
Algae	101,155	47,305 (46.8)[5]	40,638 (80.1)[6]	13,244 (13.1)[5]
Bird	119,003	100,970 (84.8)	90,520 (89.7)	207 (0.2)
Crustacea	69,015	68,962 (99.9)	65,265 (94.6)	52 (0.08)
Fish	62,862	61,880 (98.4)	58,539 (94.6)	15 (0.02)
Mammal	59,502	59,469 (99.9)	44,468 (74.8)	10 (0.02)
Mollusc	129,190	50,737 (39.2)	37,984 (74.9)	257 (0.5)
Fossil Vertebrate	51,662	50,125 (97)	–[7]	47 (0.09)
Amphibian and Reptile	37,858	37,666 (99.5)	31,577 (83.8)	41 (0.1)
Faunal Assemblage	86,976	0	0	0
Insect	1,051,052	19,051 (1.8)	7,764 (40.8)	16 (0.08)
General Invertebrate and Annelid	42,109	30,538 (72.5)	27,480 (89.9)	46 (<0.01)
Parasite	18,701	15,475 (82.7)	13,606 (87.9)	5 (0.03)
Palynology	14,569	14,566 (99.9)	–[7]	2 (0.01)
Palaeobotany	4,593	4,441 (96.7)	–[7]	1 (0.02)
Fossil Invertebrate	4,539	3,204 (70.6)	–[7]	0 (0)
Mineral	47,698	42,555 (89.2)	35,743 (74.9)	0 (0)
TOTAL	**2,915,986**	**988,482 (33.9)**		

1. These numbers are estimates and include only accessioned material; backlog material is excluded.
2. "Records" means catalogueable units, not total number of specimens (i.e., one jar of fishes, a catalogueable unit, may contain 12 individual specimens).
3. "Georeferenced" means the digital record includes geographical coordinates that allow the record to be mapped and retrieved in map-based queries.
4. Including bryophytes, lichens and vascular plants. Algae are treated separately because their data are published in a separate database.
5. Mobilized via http://www.nature-cana.ca/databases/index.php
6. Mobilized via http://collections.nature.ca/en/Search/Index
7. Precise locality information for palaeontological collections is shared only upon request.

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Photo: Martin Lipman

BOOKS

COAD, B. W. & REIST, J. D., EDS. (2018)

Marine Fishes of Arctic Canada

Canadian Museum of Nature & University of Toronto Press. xiv + 618 pp. (Recipient of the 2019 Dartmouth Medal)

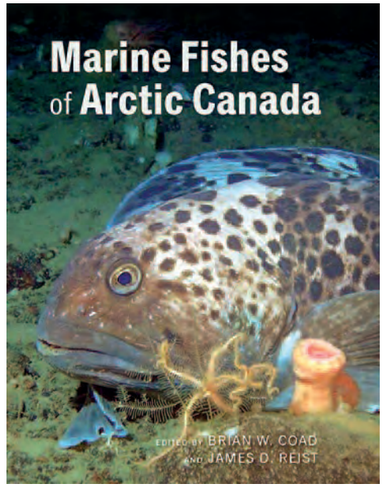
Canadian Museum of Nature ichthyologist Dr. Brian Coad collaborated with Dr. Jim Reist, head of the Arctic Assessment Unit at Fisheries and Oceans Canada, to co-edit this copiously illustrated and comprehensive book on the marine fishes of Arctic Canada. They each also contributed chapters, with contributions from ten other authors (including Canadian Museum of Nature research assistant Noel Alfonso and research associate Dr. Claude Renaud). The book provides up-to-date information on 222 species. Each of the 58 families is described in a general account followed by species accounts comprising common name, taxonomy, physical description and identification, habitat data, biology, distribution, commercial importance, and traditional knowledge. Much of the information presented in the book is based on study of the extensive fish collections housed at the Canadian Museum of Nature, which includes the world's most comprehensive collection of marine arctic fishes of Canada. Many of the species are known only to scientists and come from the deeper waters of the Davis Strait while others have been important food sources for Indigenous peoples. The book is an indispensable reference work for Northern residents, biologists and ecologists, environmental groups, and resource extraction companies operating in the North, as well as commercial and amateur fishers in Canada and in other circumpolar countries. As the pace of climate change increases, study of the Arctic is crucially important, making this an important as well as timely work.

RICHARDS, J. M. & GASTON, A. G., EDS. (2018)

Birds of Nunavut

UBC Press, Vancouver. (mixed media product includes two-volume set and PDF)

Nunavut is a land of islands, encompassing some of the most remote places on Earth. It is also home to some of the world's most fascinating bird species. *Birds of Nunavut* is the first complete survey of every species known to occur in the territory. Co-written by a team of 18 experts, it documents 295 species of birds (of which 145 are known to breed there), presenting a wealth of information on identification, distribution, ecology, behaviour, and conservation. Lavishly illustrated with over 800 colour photographs and 155 maps (citing numerous Canadian Museum of Nature specimens), this is a visually stunning reference work on the birds that live in and visit Nunavut.



EARTH HISTORY AND EVOLUTION

The Earth has a long history of change over time. Understanding the past can be key to managing the present and predicting the future. Museum scientists work with rocks to understand how the Earth was formed and with fossils preserved in them to understand how its species have evolved and what aspects of their morphology may be important in explaining their biology, where they live and how many of them there are. By looking at why some groups of organisms are successful with lots of species, and others not, we can better understand extinctions and how these might be explained and possibly even prevented. Understanding Earth history is a complex blend of geology and palaeobiology.

BUCKLEY, M., LAWLESS, C., & RYBCZYNSKI, N. (2018)

Collagen sequence analysis of fossil camels, *Camelops* and *c.f. Paracamelus*, from the Arctic and sub-Arctic of Plio-Pleistocene North America

Journal of Proteomics. https://doi.org/10.1016/j.jprot.2018.11.014 Centre for Arctic Knowledge and Exploration, research associate.

Canadian Museum of Nature Research Associate Dr. Natalia Rybczynski and her colleagues provide sequence results on collagen from a ~3.5 million-year-old giant camel specimen from Nunavut along with the younger Pleistocene remains of the Yukon giant camel and the western camel (*Camelops hesternus*) for comparison with living camels. Although the study supports a role for the sequencing of ancient collagen in the understanding of vertebrate evolution, it highlights the limitations in reconstructions of relationships based on partial sequence data, particularly the impact of omitting even only a single peptide. The palaeontological camel specimens studied are held in the palaeobiology collections of the Canadian Museum of Nature.

DOWNS, J. P., DAESCHLER, E. B., LONG, A. M., & SHUBIN, N. H. (2018)

Eusthenopteron jenkinsi sp. nov. (Sarcopterygii, Tristichopteridae) from the Upper Devonian of Nunavut, Canada, and a review of *Eusthenopteron* taxonomy

Breviora, 562(1), 1–24. https://doi.org/10.3099/MCZ44.1 Centre for Arctic Knowledge and Exploration, cites one or more CMN specimens.

Eusthenopteron is an important transitional fossil fish that shares bones in its fore-fin with those in the arms of terrestrial vertebrates. This paper documents a new species of this impressive fish based on the Nunavut fossil collections housed at the Canadian Museum of Nature.

FLETCHER, T. L., CSANK, A. Z., & BALLANTYNE, A. P. (2019)

Identifying bias in cold season temperature reconstructions by beetle mutual climatic range methods in the Pliocene Canadian High Arctic.

Palaeogeography, Palaeoclimatology, Palaeoecology, 514, 672–676.
https://doi.org/10.1016/j.palaeo.2018.11.025
(Available online 24 November 2018)
Centre for Arctic Knowledge and Exploration, **data access via GBIF.**

Scientists are often looking for ways to determine past environmental conditions and this study proposes that palaeoclimatogologists can use well-preserved beetle wing covers from the fossil and subfossil record to estimate past Arctic temperatures. The results, while complex, show that beetle-derived estimates of temperature across the Arctic during the Pliocene period are consistently lower than those derived from other sources. It's not always a simple relationship and some environmental reconstructions have to be interpreted with caution.

FRASER, D., HAUPT, R. J., & BARR, W. A. (2018)

Phylogenetic signal in tooth wear dietary niche proxies

Ecology and Evolution, 8, 5355–5368.
https://doi.org/10.1002/ece3.4052
Beaty Centre for Species Discovery, staff, open access.

Tooth wear (microscopic pits and scratches on teeth) commonly reflects the diets of living animals, and is often used to infer the diets of extinct species. In this paper, Canadian Museum of Nature palaeobiologist Dr. Danielle Fraser and colleagues offer a cautionary note: tooth wear can have an evolutionary basis in addition to an ecological one. When considering tooth wear, evolutionary history can sometimes mask the ecological signal of interest.

SCIENTIFIC ARTICLES
EARTH HISTORY AND EVOLUTION

LI, C., FRASER, N. C., RIEPPEL, O., & WU, X.-C. (2018)

A Triassic stem turtle with an edentulous beak

Nature, 560(7719), 476–479.
https://doi.org/10.1038/s41586-018-0419-1
Beaty Centre for Species Discovery, staff.

The evolutionary origins of turtles have long been debated as there have been no transitional fossils available, but recent fossil finds are helping to clarify turtle ancestry. This important paper, featuring work by Canadian Museum of Nature palaeobiologist Dr. Xiao Chun Wu and his collaborators, describes a Triassic turtle from China that lacked a shell but possessed the distinctive sharp beak and rigid pelvis. This fossil represents an intermediate form between other reptiles and shelled turtles; it supports the view that turtles have a diapsid ancestry and are closely related to modern-day reptiles.

Fossil of Eorhynchochelys sinensis, a 228-million-year-old turtle that lacked a shell but had the first toothless turtle beak. Li, C © Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China

MALLON, J. C., & BRINKMAN, D. B. (2018)

Basilemys morrinensis, a new species of nanhsiungchelyid turtle from the Horseshoe Canyon Formation (Upper Cretaceous) of Alberta, Canada

Journal of Vertebrate Paleontology, 38(2), e1431922.
https://doi.org/10.1080/02724634.2018.1431922
Beaty Centre for Species Discovery, staff, open access.

The Canadian Museum of Nature has many unopened field jackets in its collections containing unknown fossil wonders. One such jacket, collected in 1924 from Alberta, was recently opened and found to contain the shell of a new species of large turtle, described here by Canadian Museum of Nature palaeobiologist Dr. Jordan Mallon. Other field jackets may harbour similarly exciting discoveries.

PIILONEN, P., SUTHERLAND, F., DANIŠÍK, M., POIRIER, G., VALLEY, J., & ROWE, R. (2018)

Zircon xenocrysts from Cenozoic alkaline basalts of the Ratanakiri volcanic province (Cambodia), Southeast Asia — trace element geochemistry, O-Hf isotopic composition, U-Pb and (U-Th)/ He geochronology — revelations into the underlying lithospheric mantle

Minerals, 8(12), 556. https://doi.org/10.3390/min8120556
Beaty Centre for Species Discovery, staff, open access.

Zircon ($ZrSiO_4$) is a common mineral in a wide range of rock types. It has many chemical and physical properties that make it an extremely valuable mineral in helping geologists to understand the Earth. In particular, it is extremely resilient in most geological environments. Zircon is most commonly used to date rocks, including some of the oldest on the planet here in Canada. It also helps us trace the geological evolution of certain rocks and better understand how they formed.

This paper by Canadian Museum of Nature mineralogist Dr. Paula Piilonen and her team focuses on very young (<1 million year old) zircons from alkaline basalts in Ratanakiri province, Cambodia, where they are mined to be used as gemstones. The zircons are hitchhikers, having been picked up in the mantle by basalt magma as it ascended to the Earth's surface. Gem zircons from four different deposits were analysed to determine their chemistry, age and isotopic compositions. Using this information helps better understand where these hitchhikers formed and the nature of the mantle more than 100 km beneath Cambodia and Southeast Asia.

Zircon xenocryst in alkaline basalt, Ratanakiri province, Cambodia. Paula Piilonen © Canadian Museum of Nature.

STEWART, K. M., & RUFOLO, S. J. (2018)

Kanapoi revisited: Paleoecological and biogeographical inferences from the fossil fish.

Journal of Human Evolution. https://doi.org/10.1016/j.jhevol.2018.01.008
Beaty Centre for Species Discovery, staff

The Turkana Basin in East Africa is one of the most important fossil locales in the world for studying human evolution. Included among the many fossils are those of fishes, which provide an important source of information concerning the aquatic habitats around which the early hominids lived. This paper, by Canadian Museum of Nature palaeobiologists Dr. Kathlyn Stewart and Dr. Scott Rufolo, details some of those fossils, and demonstrates their rich diversity.

ENVIRONMENTAL HEALTH

With increasing human population, our natural world is changing. Understanding human-induced impacts, such as those related to climate change, introduction of invasive species, and loss of habitats, is key to ensuring a sustainable future. In many instances, knowledge about plants and animals can be used to measure and assess the general health of today's ecosystems. These indicator species may be indicative of good and bad changes and are often a simple and fast way to detect change. Border security and the prevention of introduced species is also a concern as invasive species can often have profound impacts on the ecosystems to which they are newly adapting.

JARNEVICH, C. S., YOUNG, N. E., TALBERT, M., & TALBERT, C. (2018)

Forecasting an invasive species' distribution with global distribution data, local data, and physiological information

Ecosphere, 9(5), e02279. https://doi.org/10.1002/ecs2.2279
Beaty Centre for Species Discovery, data access via GBIF, open access.

Understanding invasive species distributions and potential invasions often requires broad-scale information on the environmental tolerances of the species. Resource managers are often faced with understanding these broad-scale relationships as well as the environmental factors that might influence where an invasive species occurs or potentially could occur. Using buffelgrass (*Cenchrus ciliaris*), the authors developed models to investigate whether environmental relationships of a species at a global scale are also important at local scales. Combining global and local data can provide a stronger approach to forecasting invasive species distributions.

LONG, S.-X., HAMILTON, P. B., YANG, Y., WANG, S., HUANG, W., CHEN, C., & TAO, R. (2018)

Differential bioaccumulation of mercury by zooplankton taxa in a mercury-contaminated reservoir Guizhou China

Environmental Pollution, 239, 147–160. https://doi.org/10.1016/j.envpol.2018.04.008
Beaty Centre for Species Discovery, staff, open access.

The mechanism and transport of contaminants in natural aquatic environments is a global problem. This study co-authored by Canadian Museum of Nature research assistant Paul Hamilton examined the amount of mercury (a human toxin) being transported and acquired in the lower trophic levels from algae to zooplankton, which is ultimately available to fish. Although the algae are not notably affected, the accumulation in zooplankton was excessive and will be acquired by fish and humans. This is a national Canadian concern.

MARTEL, A. L., & MADILL, J. B. (2018)

Twenty-six years (1990–2015) of monitoring annual recruitment of the invasive zebra mussel (*Dreissena polymorpha*) in the Rideau River, a small river system in Eastern Ontario, Canada

Canadian Journal of Zoology, 96(10), 1071–1079.
https://doi.org/10.1139/cjz-2017-0360
Beaty Centre for Species Discovery, staff, open access.

This study by Canadian Museum of Nature malacologist Dr. Andre Martel and Canadian Museum of Nature research assistant Jacqueline Madill culminates a comprehensive 26-year monitoring program for the invasive zebra mussel in eastern Ontario. This study represents the longest monitoring program on this highly invasive mollusc in a small-river system. Such long-term monitoring studies are often lacking for invasive organisms. The research brings further evidence of the high risk of non-intentional human transportation of non-native aquatic species into other ecosystems.

Underwater view of a freshwater native mussel in the process of falling due to the heavy weight of the attached Zebra Mussels (Dreissena polymorpha).

SCHINDLER, M., LUSSIER, A. J., PRINCIPE, E., & MYKYTCZUK, N. (2018)

Dissolution mechanisms of chromitite: Understanding the release and fate of chromium in the environment

American Mineralogist, 103(2), 271–283.
https://doi.org/10.2138/am-2018-6234
Beaty Centre for Species Discovery, staff, open access.

Chromium (Cr) is a toxic element to humans and other animals, particularly when it occurs in its oxidized form. The Black Thor chromite deposit in Northern Ontario is now being investigated as a major source of minable chromium. Here, the element occurs in an igneous rock called chromitite, which consists of two minerals, chromite and clinochlore. As recent research has determined that chromite nanoparticles are very abundant in the clinochlore we need to know if (and how) Cr could be undesirably introduced into the local environment. In particular: (1) Does chromitite dissolve at surface conditions? (2) Can chromite nanoparticles be released and be hazardous?

This study involving Canadian Museum of Nature mineralogist Dr. Aaron Lussier investigates these issues by experimentally dissolving bulk chromitite rock in solutions similar to those that may be encountered at various steps of extraction, processing, and storage. Results reveal that the nanoparticles are released into the dissolving liquid where they either dissolve further, stick onto the surfaces of other minerals, or potentially move with the water current. Understanding how fast and how completely this reaction occurs is critical to predicting the potential threat that chromium mining could pose to the local biosphere.

SPECIES DISCOVERY

Knowledge about life on our planet and its geological underpinnings continues to grow with numerous new species of plants, animals and minerals being discovered, named and classified by scientists throughout the globe. Identifying species and their inter-relationships is also an important part of understanding the process and impact of environmental change. Museums play a central but underappreciated role in developing this knowledge by acquiring and studying scientific specimens in their collections. Through programs of off-site loans and visiting scientists, museum collections are mined for previously unstudied or 'lost' specimens, which often represent new additions to the tree of life. Museum scientists also use evidence from DNA from extant species to reconstruct the evolutionary history of life on Earth.

ANDERSON, R. S. (2018)

The genus *Sicoderus* Vanin 1986 in the West Indies (Coleoptera: Curculionidae; Curculioninae; Erodiscini)

Zootaxa, 4497(3), 301-345.
https://doi.org/10.11646/zootaxa.4497.3.1
Beaty Centre for Species Discovery, staff, open access.

This paper reports a taxonomic study of *Sicoderus* weevils from the West Indies. Of the 32 species studied by Canadian Museum of Nature entomologist Dr. Robert Anderson, 18 are newly described to science and 12 of the holotypes are housed in the Canadian Museum of Nature collection. Species are generally restricted to one island, an unexpected result with implications for diversity and biogeographic studies in the West Indies on other groups of animals and plants. The area is considered one of the world's biodiversity hotspots. It is rich in opportunities for species discovery and should be afforded serious consideration in global conservation planning.

Sicoderus truncatipennis Vanin, lateral view.

GIVNISH, T. J., ZULUAGA, A., SPALINK, D., SOTO GOMEZ, M., LAM, V. K. Y., SAARELA, J. M., ... ANÉ, C. (2018)

Monocot plastid phylogenomics, timeline, net rates of species diversification, the power of multi-gene analyses, and a functional model for the origin of monocots

American Journal of Botany, 105(11), 1888–1910. https://doi.org/10.1002/ajb2.1178
Beaty Centre for Species Discovery, staff.

This study presents a new understanding of evolutionary relationships of monocots, a major lineage of flowering plants that includes staple crop species like corn, wheat and rice, palm trees, pineapples, lilies, orchids and bananas. The study is based on large amounts of DNA sequenced from chloroplasts of over 500 species. The study places the divergence of monocots from their closest-ancestor at 136.1 million years ago, and the results indicate the first monocots were aquatic. The study provides a new evolutionary framework for understanding the origins of monocot form and function, including those of many species that are economically and ecologically important.

LINZMEIER, A. M., & KONSTANTINOV, A. S. (2018)

Andersonoplatus, a new, remarkable leaf litter inhabiting genus of *Monoplatina* (Coleoptera, Chrysomelidae, Galerucinae, Alticini)

ZooKeys, 744, 79–138. https://doi.org/10.3897/zookeys.744.22766
Beaty Centre for Species Discovery, collaborator, open access.

Based solely on specimens collected by Canadian Museum of Nature entomologist Dr. Robert Anderson and Canadian Museum of Nature research associate Dr. Stewart Peck, this paper describes a new genus (named after Anderson) and 16 new species of Venezuelan ground-dwelling flightless leaf beetles. The study demonstrates that there are still many new and exciting finds to be made through fieldwork. The task of inventorying the biodiversity of Earth is nowhere close to being complete and new twigs and leaves on the tree of life are still being found.

MUSCHICK, M., RUSSELL, J. M., JEMMI, E., WALKER, J., STEWART, K. M., MURRAY, A. M., ... SEEHAUSEN, O. (2018)

Arrival order and release from competition does not explain why haplochromine cichlids radiated in Lake Victoria

Proceedings of the Royal Society B: Biological Sciences, 285(1878), 20180462. https://doi.org/10.1098/rspb.2018.0462
Beaty Centre for Species Discovery, associate, open access.

Small African cichlids known as haplochromines are typically colourful fish which are globally popular as aquarium fish. They are also well-known to science for their propensity to evolve extremely rapidly into new species — in Lake Victoria, Kenya, they have evolved into over 700 species in only 15,000 years! For this paper, Canadian Museum of Nature palaeobiologist Dr. Kathlyn Stewart was part of a team that tested whether rapid speciation occurs when early colonisers enter a new, unexploited environment. The team excavated and examined bones from the earliest fish to populate modern Lake Victoria. Their findings show that haplochromines were among the earliest entrants to the lake, but then evolved much more quickly than the other colonising fish species. In short, early colonisers do not have an evolutionary advantage in new environments.

SCIENTIFIC ARTICLES
SPECIES DISCOVERY

MCMULLIN, R. T., MALOLES, J. R., SELVA, S. B., & NEWMASTER, S. G. (2018)

A synopsis of *Chaenotheca* in North America, including a new species from southern Ontario, *C. selvae*, supported by morphometric analyses

Botany, 96(9), 547–553. https://doi.org/10.1139/cjb-2018-0042
Beaty Centre for Species Discovery, staff.

Canadian Museum of Nature lichenologist Dr. Troy McMullin and his colleagues have provided an updated synopsis of the lichen genus *Chaenotheca*. The first comprehensive treatment of this genus in North America was produced in 1975 and included 14 species. Since then, the number of species known from the continent has increased to 25. Most of the new species were added individually in numerous publications. This updated synopsis provides morphometric analyses that supported the distinction of these 25 species along with an identification key. They also describe a new species, *Chaenotheca selvae*, from southern Ontario. The holotype (i.e., the specimen to which the newly proposed name is formally linked) of the new name is housed in the National Herbarium of Canada at the Canadian Museum of Nature.

Chaenotheca selvae, a new species of lichen discovered in Guelph, Canada. Troy McMullin © Canadian Museum of Nature.

SAARELA, J. M., BURKE, S. V., WYSOCKI, W. P., BARRETT, M. D., CLARK, L. G., CRAINE, J. M., ... DUVALL, M. R. (2018)

A 250 plastome phylogeny of the grass family (Poaceae): topological support under different data partitions

PeerJ, 6, e4299. https://doi.org/10.7717/peerj.4299
Beaty Centre for Species Discovery, staff, open access.

Grasses (Poaceae) are the fifth largest family of flowering plants in the world, with some 11,500 species, including wheat, rice and corn, as well as numerous economically important forage and biofuel species. This study led by Canadian Museum of Nature botanist Dr. Jeff Saarela provides new insights into the evolutionary history of grass. The results will contribute to studies addressing grass genetics, ecology and evolution, including how the grass family evolved in response to past climate changes.

SORENG, R. J., & GILLESPIE, L. J. (2018)

Poa secunda J. Presl (Poaceae): a modern summary of infraspecific taxonomy, chromosome numbers, related species and infrageneric placement based on DNA

PhytoKeys, 110, 101–121. https://doi.org/10.3897/phytokeys.110.27750
Beaty Centre for Species Discovery, staff, open access.

Poa secunda is a valuable forage grass across western North America. The taxonomy of this morphologically highly variable bunchgrass is challenging and there has been much controversy as to how many taxa to recognize. This paper by Canadian Museum of Nature botanist Dr. Lynn Gillespie and her colleague proposes a new classification for *Poa secunda* of six varieties in two subspecies. Molecular evidence shows that the species and the section to which it belongs are of ancient hybrid origin.

SMITH, A. B. T., & EVANS, A. V. (2018)

Taxonomic review of Athliini (Coleoptera: Scarabaeidae: Melolonthinae), a new tribe of scarab beetles endemic to South America

Zootaxa, 4471(2), 279. https://doi.org/10.11646/zootaxa.4471.2.3
Beaty Centre for Species Discovery, associate, open access.

The Canadian Museum of Nature has one of the world's best collections of beetles. Based on the Museum's excellent collection of Scarabaeidae, Canadian Museum of Nature research associate Dr. Andrew Smith and 2018 visiting scientist Dr. Arthur Evans describe a new tribe of South American scarab beetles. This paper highlights the value of comprehensive and well-curated specimen collections in taxonomic studies documenting Earth's biodiversity.

WIERSMA, Y. F., & MCMULLIN, R. T. (2018)

Is it common to be rare on the landscape? A test using a novel model system

Landscape Ecology, 133, 183–195. https://doi.org/10.1007/s10980-017-0599-3
Beaty Centre for Species Discovery, staff, open access

Geneticists have fruit flies. Biomedical researchers have lab rats. Landscape ecologists now have lichens. The lack of statistical replication of landscapes can makes it difficult to carry out testing, so Canadian Museum of Nature lichenologist Dr. Troy McMullin and his colleague hypothesised that smaller model systems could be used. They successfully tested this approach using lichens on tree trunks and found that patch patterns are statistically similar between trees. This is a novel way for landscape ecologists to use micro-landscapes as model systems to conduct observational and manipulative experiments to test questions about spatial pattern and processes using lichens to assess environmental changes.

ENDANGERED SPECIES AND CONSERVATION

Over the last few decades, natural habitats are being lost, species diversity on Earth is declining and we may be entering the next great period of extinction. Museum collections represent huge databases of relevant information about species presence in space and time. By studying collections, scientists can identify centres of diversity (hotspots), areas of endemism and ecosystems undergoing change. Through partnerships with organizations concerned with conservation, museums are irreplaceable sources of information in assessing species for their endangered status.

ENGLISH, P. A., GREEN, D. J., & NOCERA, J. J. (2018)

Stable isotopes from museum specimens may provide evidence of long-term change in the trophic ecology of a migratory aerial insectivore

Frontiers in Ecology and Evolution, 6, 14. https://doi.org/10.3389/fevo.2018.00014
Beaty Centre for Species Discovery, collaborator, open access.

Stable isotope ratios of museum specimen tissues may provide a record of diet and habitat change through time. Aerial insectivores are experiencing the steepest population declines of any group of birds in North America; one hypothesis for these population declines is a reduction in the availability of prey. These results, including data from Canadian Museum of Nature specimens, indicate that aerial insectivore populations may be declining due to changes in abundance of higher trophic-level prey. This study highlights the ability to use museum collections to enhance our understanding of ecological change and in making informed conservation decisions.

FAUTEUX, D., GAUTHIER, G., MAZEROLLE, M. J., COALLIER, N., BÊTY, J., & BERTEAUX, D. (2018)

Evaluation of invasive and non-invasive methods to monitor rodent abundance in the Arctic

Ecosphere, 9(2), e02124. https://doi.org/10.1002/ecs2.2124
Centre for Arctic Knowledge and Exploration, staff, open access.

Determining the density and distribution in small rodents in the Arctic to estimate their populations can be challenging due to complex logistical and ethical considerations. Canadian Museum of Nature mammologist Dr. Dominique Fauteux and his team have tested the reliability of five invasive and non-invasive methods of trapping small rodents in the Arctic. Live-trapping was the most robust method, but incidental observations also yielded highly precise estimates of abundance. These are preferable alternatives to other invasive methods of sampling small, potentially endangered mammals.

A brown lemming (Lemmus trimucronatus) on Bylot Island, Nunavut. Dominique Fauteux © Canadian Museum of Nature

HART, R. J. (2018)

Salmon, science, and conservation: Organizational power and the listing and recovery planning of an endangered species

Environmental Science & Policy, 88, 124–133. https://doi.org/10.1016/j.envsci.2018.06.020
Beaty Centre for Species Discovery, Canadian Museum of Nature data use.

This paper is an examination of the listing, approval and recovery planning process within COSEWIC (Committee on the Status of Endangered Wildlife in Canada) and SARA (Species at Risk Act) of a single conservation unit of Atlantic Salmon. Using co-citation and social network analyses, the author shows that DFO (Department of Fisheries & Oceans, more recently Fisheries & Oceans Canada) may have influenced collective decision-making in a way that prioritized DFO reports over peer-reviewed publications and, as a result, directed recovery funding to DFO. This is a reminder that science is objective and that the intersection of science, politics and parliamentary process may diminish that and lead to outcomes that are less than optimal for the species at risk.

PUBLICATIONS

Scoring of all papers, using the following scheme (see Methods), is summarized in square brackets following each listing.

Authorship:

1 – CMN staff author/co-author; 2 – CMN research associate author/co-author; 3 – no CMN-affiliated author/coauthor

Evidence of usage of CMN collections/collection data:

† – publication cites one or more CMN specimens; * – publication cites one or more GBIF datasets that includes CMN collections; ‡ – publication indicates CMN collections were searched for material relevant to a study; # - publication indicates CMN collections were used for consultation to identification of species.

Arctic – paper relevant to Arctic research

OA – open access publication

CMN staff and associates are in bold face.

Publications with a 2019 date were first available online in 2018.

Earth History and Evolution

Becerra, M. G., & Ramírez, M. A. (2018). Locomotor morphotypes, allometry, linear regressions and the smallest sizes in Ornithischia: estimating body length using hind limb variables. Ameghiniana, 55(5), 491-517. https://doi.org/10.5710/amgh.27.06.2018.3189 [3, †]

Bourke, J. M., Porter, W. R., & Witmer, L. M. (2018). Convoluted nasal passages function as efficient heat exchangers in ankylosaurs (Dinosauria: Ornithischia: Thyreophora). PLOS ONE, 13(12), e0207381. https://doi.org/10.1371/journal.pone.0207381 [3, †, OA]

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