What can you do with 300,000 dead bees?

A lot, as it turns out. With biodiversity under threat worldwide, scientists say old-school specimen collections — including an impressive hoard of bees at York University — have a crucial role to play in research.

Laurence Packer's lab at York University is a library of the world's bees, containing more than 300,000 specimens from hundreds of different genera.

By: Kate Allen  Science and Technology reporter, Published on Mon Jan 25 2016

Bees pile up inside Laurence Packer's lab like books in a busy library. Cases and cases of them, each specimen stuck with a labelled pin, sit stacked on chairs, on tables, in row upon row of shelving. The shelves are organized by continent: Asian bees. African bees. Australian bees. Freezers of bees sit waiting to be catalogued.

The 20,000-plus species of bees known to science are grouped into approximately 520 genera, and Packer's York University lab boasts representatives from all but a couple dozen of them. His collection houses more than 300,000 specimens: fuzzy bees that look like tiny pandas, aquamarine bees with bodies as hard and iridescent as glass, bees smaller than a pinhead, bees with absurdly long tongues.

The Packer lab actually is a kind of library. It is a bee reference collection, the largest in Canada and one of the world’s most diverse.

Obesity isn’t caused by overeating but by excess insulin, says Scarborough doctor
Specimen collection is often a low-tech science: the tools in Laurence Packer's bee-catching kit include a net, trap, cups and a solution of propylene glycol to preserve the specimens.

Yet as global biodiversity plummets, scientists say such old-fashioned collections have never been more vital. They are “the only concrete evidence of what species were present at what place and what time,” says Chris Darling, curator of insects at the Royal Ontario Museum.

Funding agencies, however, seem to have adopted the popular attitude that specimen collections are passé. In Canada there are no federal grants dedicated to maintaining collections. And though the cost of an average expedition wouldn't cover the cost of a new car, researchers struggle to fund their collecting trips.

"People are going out there and finding new galaxies,” Packer says. “But we don’t even know what’s under our own feet."

This weekend Packer is flying to Chile, where he will spend 36 days travelling more than 14,000 kilometres, sleeping in a tent in remote desert environments where bee diversity is highest. He expects to collect several thousand specimens, a handful of them never before seen. The trip will cost perhaps $6,500. (Canada's premier particle astrophysics lab, by comparison, costs $8 million annually to operate.)

One of Packer’s goals is to bring his collection from 90 per cent of bee genera closer to 100 per cent. But specimen collectors don’t view success the same way as, say, record collectors do. A record collector would never buy 12 copies of the Beatles’ White Album from the same record store every year for a decade, but that’s exactly what biologists are looking for: a baseline, and variations from that baseline.

“The main value of a collected specimen is that it represents that a particular organism was present in a particular place at a particular time, with a particular genome and a particular morphology,” says Luke Mahler, an evolutionary biologist at the University of Toronto who contributes to and relies heavily on collections. “Having that reference is absolutely essential for studies that rely on some sort of knowledge of biodiversity as it is distributed across space or through time.”
Some specimens collected in a solution of propylene glycol in Laurence Packer's lab at York University.

Collections are “not static. They need to grow,” says the ROM’s Darling.

Data gleaned from collections has powered a raft of important findings in recent years. Last July, Packer and a group of Canadian, American and European colleagues co-authored a report in the prestigious journal Science on the effects of climate change on 67 bumblebee species. By assembling a database of 423,000 observations from specimens collected as long ago as 1901, the team discovered that bees were being “squeezed”: they were disappearing from the southern edge of their ranges and failing to shift northward. The finding has major importance for humans, since wild bees are crucial crop pollinators.

Collections have been used to show that bees’ tongues and salamanders’ bodies have rapidly shrunk as a result of climate change. Birds and rodents have been used to track the emergence of infectious diseases such as the Spanish influenza and modern hantavirus outbreaks. In the 1960s, scientists weighed eggshells from museum collections and found that eagles’ and falcons’ shells began thinning when DDT was first introduced, leading to restrictions on the insecticide and recovery of the birds. In 2002, researchers reported that sexual abnormalities were less common in frog specimens collected before the widespread adoption of atrazine, an herbicide.

With the dawn of high-powered genomic technology, collections have also become a major resource for DNA analysis of organisms and the diseases or environmental residues they carry, an application unfathomable to early naturalists such as Darwin whose specimens still sit in museums. Like many scientists, Mahler says that “the greatest value of collections is the unforeseen questions people will come up with in the future.”
Agapostemon: Despite their brilliant colours, these bees are often overlooked despite being abundant even in downtown Toronto. They can be most easily seen flying around Rose of Sharon and other large flowers in late summer, often sleeping in the flowers.

The University of Guelph’s insect collection, the oldest in Canada and the country’s second largest, with three million specimens, has been “absolutely critical to the documentation of invasive species,” says Steve Marshall, professor and collection director. His research group has discovered more than 600 new species — some invasive, some native to Canada but previously unrecognized — often through routine maintenance of the collection. In the 1990s, Marshall was the first to report the appearance in Ontario of the invasive multi-coloured Asian lady beetle, a major pest.

He has tracked the decline of native species, too. “If you were to visit here, I could pull drawer after drawer and point at beautiful insects, and say, look at the labels — you won’t see any after 1950. This is gone.”

Yet the Guelph insect collection has never had sustained, direct funding. Marshall keeps it alive using volunteers and small chunks of grants for his studies that rely on the collection.

“There have been brief periods of soft money over the last 30 years, but on the whole, the collection has fallen between the cracks,” he says. “It’s an interesting phenomenon, because it’s widely acknowledged as an extraordinarily important resource.

“Collections kind of fall into that grey zone,” Marshall adds. “They’re not quite research; they’re a resource used by researchers. I think the collections themselves should be perceived as a research, but they’re really not. So finding money for a collection is really difficult.”

Fine specimens

A few of the world’s premier collections:

- The Smithsonian:

The Smithsonian Institution National Museum of Natural History has an astounding 126 million items in its collection. Martha, the last living passenger pigeon, who died in 1914, is one of them. For the centenary of her death, the Smithsonian made a 360-degree digital view of the bird available online. Pufferfish samples at the Smithsonian are being used as part of a federal U.S. program to try to prevent human poisoning from these toxic fish.

- The Natural History Museum:
The London museum calls itself “the world’s most important natural history collection,” housing more than 80 million specimens. Over the next five years, staff plan to digitize a quarter of the specimens, starting with more than 500,000 butterflies and moths. They hope the freely available resource will help scientists worldwide answer vital questions, but anyone can access the museum’s data portal.

- The Field Museum:

This Chicago institution is home to Sue, the largest known *Tyrannosaurus rex* specimen. The museum struggled with highly publicized budget problems in recent years, and according to a report in Nature News, the number of curators dropped from 39 in 2001 to 21 last year. (They were not alone: Nature said the Smithsonian dropped from 122 curators in 1993 to 81 more recently.) But in 2015 the museum also announced the three largest philanthropic gifts in its history, including $10 million (U.S.) for a centre to manage the 27 million specimens in its collection.

- The Butantan Institute:
Lab technician Eladio de Almeida extracts venom from a rattlesnake, at the Butantan Institute, in Sao Paulo, Brazil, Aug. 3, 2004.

A 2010 fire at this collection in Sao Paulo, Brazil, destroyed 85,000 snake specimens and 450,000 scorpion and spider specimens. The Butantan had been one of the world’s top collections of venomous animals, which had been used to produce antidotes and vaccines, as well as for zoological research.

- Collections at risk:

Museums such as the ROM often include specimen collection as a core part of their mission statement. But orphan collections — specimens maintained by one or a handful of academics at universities and colleges — are constantly at risk of fading into oblivion, researchers say. And smaller museums that have fallen on hard times have put their collections into caretaking mode, maintaining the specimens but making them unavailable to scientists.

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