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BULLETIN

OF THE ENTOMOLOGICAL SOCIETY OF CANADA

IN THIS ISSUE:

- Deadline to apply for ESC Student Awards
- Gold Medal Address: Kevin Floate
- Special Features: Entomology & Human Health

Photo contest winners, clockwise from top: 1st Place: *Colletes wilmattae* (K. Peters), 2nd Place: Snow Scorpionflies (R. LaLonde), 3rd Place: Speckled Dun (R. LaLonde)

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UP FRONT

Spring is approaching, and many of us are only a stone's throw from the field season. Before you begin organizing your gear, I'd like to share a brief update on what your ESC Executive has been working on since the Calgary JAM.

Bulletin refurbishment

Long-time readers of the *Bulletin* may have already noticed its new look. In support of long-time Editor Bernie Roitberg and Assistant Editor Sydney Worthy, Dr Amanda Roe and I are helping to refresh the layout and improve usability over the coming year, particularly for online and mobile readers. Key updates include separate English and French editions, a cleaner visual design, and some subtle visual gilding by Amanda and myself. Rest assured, these changes are largely cosmetic and functional—the content you've come to expect and enjoy remains very much the same.

ESC Seminar Series

This year's inaugural ESC Seminar Series was organized by Dr Rose Labbé, who assembled an impressive slate of 4 excellent speakers representing a broad range of perspectives and expertise. Topics span from best practices for mentoring students and staff to trait evolution in parasitic wasps. Two talks have already taken place, so be sure not to miss the final two upcoming seminars on 26 March and 16 April, 12–1 pm EST.

ESC JAM in Winnipeg

Preparations are well underway for the upcoming ESC JAM in Winnipeg, "Insect Apocalypse". Important deadlines are approaching, so I encourage members to check the meeting website regularly for updates and announcements.

Strategic Framework progress

We are continuing the work initiated by my predecessor, Dr Christine Noronha, under the ESC Strategic Framework. Efforts remain focused on streamlining committees to improve efficiency while reducing the workload placed on our volunteer members.

I will leave it there for now. I wish you every success in your upcoming research and teaching activities, and I look forward to seeing many of you in Winnipeg when the meeting begins on 4 October 2026.

Rob Johns, ESC President

JOINT ANNUAL MEETING 2026

The Entomological Societies of Canada and Manitoba cordially invite you to attend the 2026 Joint Annual Meeting!

The annual meeting will be held from Sunday, 4 October to Wednesday 7 October 2026, at the Canad Inns Destination Centre Polo Park in Winnipeg, Manitoba. The theme of the meeting will be Insect Apocalypse: Causes, Effects, Realities. https://entsocmb.ca/2026_JAM/JAM.html

Keynote speakers will include Dr. May Berenbaum, University of Illinois School of Integrative Biology, and Dr David L. Wagner, University of Connecticut, professor of Ecology and Evolutionary Behavior.

MEET YOUR NEW SEPAC COMMITTEE MEMBERS

We are very excited to **welcome** Sarah Eisenbarth, Jeremy Irvine, and Emma Stainforth to the **SEPAC committee**. We invited them to tell us a bit about themselves, and here's what they had to say:

Sarah Eisenbarth (She/Her)

I am finishing my last year of my undergraduate degree, majoring in Ecology, Evolutionary Biology, and Environmental Sciences (University of Alberta) with a hard focus on invertebrate biology. Before university, I got my diploma in Laboratory Research and Biotechnology at the Northern Alberta Institute of Technology (NAIT) and have been working there as an Educational Laboratory Technologist for the past 5 years. One of my (many) passions is helping students in science get connected with the scientific community, and teaching about the whacky weird critters that are in our own backyard. This summer, I am thrilled to start my first entomology-focused job, and to spend more time fishing and posting to iNaturalist.

- Affiliation: NAIT/University of Alberta
- SEPAC Position: Member-at-Large
- Favourite Arthropod: *Lethocerus americanus* (giant water bug) and *Gammarus lacustrus* (lacustrine scud)

Jeremy Irvine (He/Him)

I am a PhD student in entomology at the University of Saskatchewan, where my research focuses on the chemical ecology and management of insect pests in agricultural systems. I was drawn to this work through my background in farming and an interest in applied entomology that directly supports growers and sustainable pest management. This summer, I'm looking forward to field work and learning from growers, students, and collaborators.

- Affiliation: University of Saskatchewan
- SEPAC Position: Member-at-Large
- Favourite Arthropod: Weevils

MEET YOUR NEW SEPAC COMMITTEE MEMBERS

Emma Stainforth (She/Her)

I am an MSc Agriculture student researching leafhoppers in Dalhousie University's Insect Biodiversity in Agroecosystems Lab, working with the LeafHope Project at Laval University. I also serve as President of the Dalhousie Bug Club and look forward to leading student field trips this summer.

- Affiliation: Dalhousie University
- SEPAC Position: Social Media Manager
- Favourite Arthropod: African Migratory Locust, though leafhoppers are slowly stealing my heart

Getting Involved with ESC

ESC's Student and **Early Professional Affairs Committee** (SEPAC) is always keen to take on **new members**! Volunteering for SEPAC is a great way to get involved with the Society and promote entomology across Canada. If you are interested in joining or just have suggestions for new initiatives in the coming year, email us at students@escsec.ca, or contact us personally at georgiana.antochi-crihan@saskatoon.ca and berenice.romero@usask.ca. We look forward to hearing from you!

Reminder: ESC Award Deadline 1 March 2026

The ESC offers **eight scholarships** and **multiple travel awards** to full-time students each year. Awards are granted for a wide range of entomology disciplines, including taxonomy, systematics, community ecology, IPM, biodiversity, and more. Applications are due 1 March 2026.

Students may apply for a maximum of three scholarships each year. For complete details on preparing applications, please visit the ESC Student

ESC STUDENT AWARDS ANNOUNCEMENTS

Hello **ESC students**!

I invite you to consider applying for up to three **student awards** this year! Awards **deadlines** are **1 March 2026**. Links to the application page with instructions. https://esc-sec.ca/student/student-awards/

Applications for all Scholarships are to be submitted by email to the ESC Association Coordinator at info@esc-sec.ca by 1 March each year. Application procedures for all scholarships except the Entomological Society of Canada Research Travel Scholarships are similar, and found in the section "**Application Procedures for Scholarships other than Research Travel Scholarships**". Please pay attention to the details and all the best on your submission!

To the **ESC general membership:**

There is an exciting **opportunity** for regular members to serve the Society. The **ESC student awards committee** is looking for new members to serve on the current cycle of student applications. We'll be adjudicating applications for all of the ESC Student awards coming in from 2026 as well as the Becker conference travel awards before our Joint Annual Meeting.

Please respond to Tyler.Wist@agr.gc.ca to join this essential ESC committee, help and get to know our students and serve this dynamic community of Ento-enthusiasts.

Thank you,

Tyler Wist

Chair of the ESC Student Awards Committee

LOCAL SOCIETY ROUNDUP

British Columbia

The 2025 meeting of the Entomological Society of BC was held on 21 and 22 November at the University of the Fraser Valley Abbotsford campus. The theme was "Better together: Celebrating partnerships from micro to macro”. With 42 presentations and 71 attendees, it featured a full day of student speakers on day 1, followed by an evening social of pizza, networking and a highly competitive game of trivia. Dr Sandra Gillespie and Dr Dezene Huber provided keynote presentations on day one. Day two featured presentations from professionals after which the meeting concluded with the AGM and presentation of student awards. We disbursed $2,750 in scholarships and student awards and the ESBC Legacy Award was conferred to Tammy McMullan in recognition of her achievements and contributions to the field

of entomology.

Michelle Franklin passed the role of President to Vice President Michelle Tsent. Other changes to the executive include Asim Reynard stepping in as 1st VP and Jeanne Robert as 2nd VP. Freya Innes joined the board as the graduate student director, and Eva Burghardt has stepped in to edit the Boreus newsletter.

Saskatchewan

The Entomological Society of Saskatchewan held our fall meeting in person (and virtually) in Saskatoon at the AAFC building on 5 December 2025. There were five student presentations as part of the annual student presentation competition. Congratulations to Rebbeca Nixon who won the student presentation competition with her talk “Characterization of the complete Mitochondrial Genome of the Western Dog Tick Dermacentor similis (Acari, Ixodida)”. Dr Meghan Vankosky gave a presentation on referencing for publications and presentations and Prieto Tellarini presented on the IPPM Now app for insect identification. An Entomological Activities Award was presented to the Species-at-Risk Committee for the Dakota Skipper Survey. The Society welcomes Georgiana Antochi-Crihan as our next Vice President, and Jeremy Irvine as our incoming President to the ESS Executive. Iain Phillips (Secretary) and Tyler Wist (Treasurer) remain in their respective Executive positions. The date for the spring meeting was tentatively set for 24 April 2026.

The ESS Executive met on 19 January 2026 for onboarding and to discuss upcoming administrative activities.

The Species-at-Risk Committee met on 30 January 2026 to begin to plan spring and summer 2026 activities.

Manitoba

The 2026 Joint Annual Meetings of the Entomological Societies of Canada and Manitoba will be held at the Canad Inns Destination Centre Polo Park in Winnipeg, Manitoba from Sunday 4 October to Wednesday 7 October 2026. The theme of the meeting is “Insect Apocalypse: Causes, Effects, Realities”. Keynote speakers include Dr May Berenbaum, University of Illinois School of Integrative Biology and Dr David L. Wagner, Professor of Ecology and Evolutionary Behavior. Meeting information, including accommodation reservations, can be found at the meeting website: https://entsocmb.ca/2026_JAM/JAM.html

GOLD MEDAL ADDRESS

“Jack of all trades, master of dung” – from farms to forests, feedlots and faeces

Kevin Floate (retired)

Kevin (kevin.floate@agr.gc.ca) is an Honourary Research Affiliate with Agriculture and Agri-Food Canada at the Lethbridge Research & Development Centre. His passions continue to be insects, gardening and curling.

I’m honoured to be the 2025 recipient of the Gold Medal Award (Figure 1). Many people are deserving, but few get nominated. For nominating me and providing letters of support, I thank Vincent Hervet, Paul Fields and Héctor Cárcamo. I also thank the Achievement Awards Committee for their work.

How did I end up receiving this award? I don’t feel special or particularly smart. I can only attribute it to a combination of luck, hard work and a strong network of mentors and collaborators. My career has taken a few twists and turns that I’ll relate here in hopes that some of the lessons I’ve learned will help some of you.

Figure 1. Kevin searching for insects in a cow pat (Photo credit: Cam Goater).

My father was a store manager for a chain of retail stores, a job that resulted in our family moving many times. The youngest of five children, I was born in Prince George, British Columbia. Six months later, the family relocated to Saskatoon, Saskatchewan where we remained for the next 12 years. During this time, my dad built the family cottage at Wakaw Lake where I spent many happy days on the water or in the bush looking for insects. Large flood lights shining out over the lake at night brought troves of insects to the cabin windows to further fuel my passion for insects. My parents supported my interests and tolerated the various frogs, turtles, lizards, snakes and insects that co-habited my bedroom back in the city. It was also in Saskatoon where I met Jim Butler, a next-door neighbour who had a collection of tropical insects that he took pleasure in showing to a little boy.

The family later moved to Calgary where I completed Grades 7 to 10, and then we moved again to Kindersley, Saskatchewan where I completed high school before returning to Saskatoon in 1979 to begin a BSc in Agriculture at the University of Saskatchewan. I took every insect course available, collectively taught in the Biology Department by Dr Cedric Gillott, Dr Dennis Lehmkuhl and Dr Bob Randell. After my third year, I worked for the summer with Dr John Doane and his technician Bob Vibert. John was a crop entomologist at Agriculture and Agri-Food Canada's (AAFC) Saskatoon Research Centre. I recall many long hours with Bob in the field pulling weeds, sifting soil to recover wireworms or working in the lab to identify grasshoppers for Dr Owen Olfert—another AAFC entomologist. And then, later that summer, I got a phone call that set me on the path to a MSc program.

That phone call was intended for John, but as the only person in the lab at the time, I was asked to pass along the following message… "Tell John the little flies he sent us are orange wheat blossom midge" (OWBM). In the early 1980s, farmers in northeast Saskatchewan suffered reduced crop yields in apparently healthy stands of wheat. The cause became apparent in 1983 when a massive outbreak identified OWBM as the culprit. It was from this outbreak that John had sent the flies, and which made the midge a priority target for research. When John asked me if I'd be interested in doing a MSc project on this pest, I jumped at the chance. And for the next three years under the co-supervision of John and Cedric, I studied carabid beetles as predators of the midge and their susceptibility to the insecticides being tested for midge control. Using pitfall traps, soil cores, lab bioassays and a serological method I developed to detect midge protein in beetle guts, I concluded that carabids killed up to 86 larvae/m^2/day—sufficient to perhaps attenuate, but not prevent, midge outbreaks (Floate et al. 1990). With use of field arenas, I was somewhat disturbed to learn that beetles suffered 82% mortality when placed on soil sprayed one week prior with chlorpyrifos (Floate et al. 1989). The toxicity of chemical residues in the environment would become a major focus of research later in my career.

But my MSc thesis was also a huge amount of work. My main study site was a 3-hour drive northeast of Saskatoon. I'd head out by myself and return the same day after emptying pitfall traps or staying in Nipawin when necessary. A few times during those pre-cell phone days, I got stuck in the mud or the truck broke down and I had to walk to the nearest farmhouse for help. The insecticide bioassays required collecting many beetles by hand the day before they were placed in field arenas. This occasionally meant collecting beetles by car headlight, returning to my motel room well after sunset and missing out on supper. After one such trip I told John that I just couldn't do it anymore. Thereafter, John made sure I had a second pair of hands to help me when needed. His response taught me an important lesson… "It's okay to ask for help."

It was during my MSc that I met my wife, Dr Rosemarie De Clerck-Floate (Figure 2), who was doing her MSc in the Biology Department under the supervision of Dr Taylor Steeves. Rose and I married in 1988 and sent out many letters via 'snail mail' to universities in Canada and the United States hoping to find PhD supervisors. Rose was ecstatic to receive a positive reply from Dr Peter Price at Northern Arizona University (NAU), in Flagstaff, Arizona. His world-renown expertise on gall-forming insects was a perfect fit for her own interests on insect-plant interactions. I also received a positive response from NAU, but from Dr. Tom Whitham.

Figure 2. Rose and Kevin at the ESC/ESS JAM in Saskatoon in 2007.

Tom had been studying a leaf-galling aphid in Weber Canyon in northern Utah. He found that the aphid was concentrated in a narrow overlap/hybrid (O/H) zone between pure zones of Fremont and narrowleaf cottonwood due to the greater susceptibility of hybrid trees to the aphid (Figure 3) (Whitham 1989). Tom thought the same pattern occurred for wood-boring beetles and wanted me to pursue this for my PhD thesis. But after several weeks of surveys in Weber Canyon during my first field season, I found nothing to support Tom's belief. I instead decided to study a chrysomelid beetle that also was concentrated in the O/H zone—but not because of hybrid susceptibility. In a series of studies, I showed that beetles in the O/H zone could shift between their two cottonwood host species to increase fecundity by up to 600% relative to non-shifting beetles in either pure zone (Floate et al. 1993). This experience taught me a second lesson… "Recognize when things aren't working & change gears."

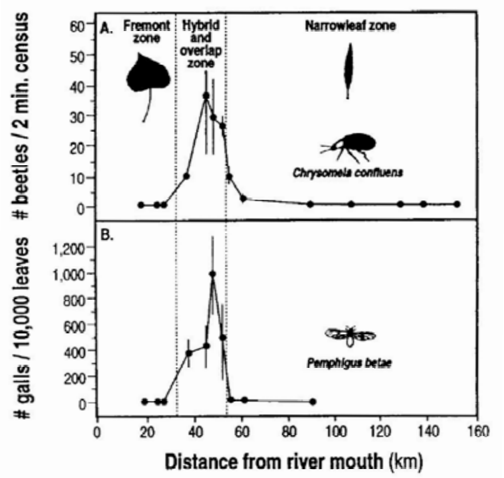

Figure 3. Concentrations of a free-feeding beetle and a leaf-galling aphid in an overlap and hybrid zone between pure zones of two cottonwood species (Whitham et al. 1996).

One of my PhD courses was Insect Ecology taught by Peter Price. As a course project, he challenged each student to develop a novel hypothesis related to their thesis research. I'm a visual thinker and saw hybrid trees as stepping stones bridging the genetic gap between the parental host species. I extrapolated this image to hypothesize that hybrids act as bridges to facilitate shifts between the hybridizing plant species by herbivorous insects over evolutionary and ecological time. Peter liked the hypothesis but cautioned me that many ideas fail when tested in the field. The following year I collected data on the distributions of gall-forming insects, which validated the hypothesis. After some 17 iterations between Tom and myself, we finally got the paper published (Floate and Whitham 1993). The hard work paid off. When I was later interviewed for a job with Agriculture and Agri-Food Canada, I was told that this paper was a main reason why I was offered the position. To paraphrase a quote attributed to Thomas Edison, “Success is one percent inspiration and ninety-nine percent perspiration”.

Figure 4. House in Weber Canyon, Utah where we lived for 5 years (April–September).

The main cottonwood system used by Tom and his students to study insect distributions was in Weber Canyon near Ogden, Utah. It was also where Rose (supervised by Peter) established her study sites. From April into September, Rose and I lived in Utah for our field work and then spent the rest of the year in Flagstaff doing coursework. In Flagstaff, we lived in a double-wide trailer just outside of town on the edge of the forest. It was old and drafty and shook whenever the wind blew, but we didn’t mind. It was a beautiful setting, and the Grand Canyon was only 1½ hours down the road.

Our accommodations in Utah were… less beautiful. With Tom’s other students, we lived in an old caretaker house with peeling wallpaper and a mouse infestation on a piece of property with a small powerplant beside the Weber River. On either side of the property were lanes of an interstate highway with a double set of train tracks on the canyon wall above the house Figure 4). A military base, a few kilometres away, ensured regular air traffic overhead. In return for his students chasing off trespassers and keeping up the grounds, Tom rented the house from the power company for the princely sum of $1 per year. We loved the location despite the plane, train and traffic noise, the lack of a phone and television, and occasional semi-trucks careening off the highway through the locked gate onto the property. My time was further enriched by experiencing a fire scouring the walls of the canyon to threaten the house, working in isolated study sites with human-silhouette targets pock-mocked with bullet holes, sampling for insects on trees in hobo jungles, and accidentally driving onto a restricted military base. And thus, another lesson… “Hope for the best, plan for the worst, it is what it is.”

Rose and I had early on decided that the other would follow whoever got the first job offer. That person was Rose who was hired in 1992 as a Research Scientist with Agriculture and Agri-Food Canada at the Lethbridge Research and Development Centre (LRDC) in Lethbridge, Alberta. I remained in Flagstaff for another year as a post-doctoral fellow before also landing a position as a Research Scientist at LRDC. Upon arriving in Lethbridge, I learned that the drainage of the Oldman River, which runs through the middle of the city, has three cottonwood species that overlap and hybridize. Thus, after devoting five years in the United States to study insects on hybrid cottonwoods, I found myself in perhaps the best place in North America to continue this work. But I had been hired by AAFC as a livestock entomologist with a mandate for the biological control of pest flies affecting cattle. In the end, I was able to complete additional studies on hybrid cottonwoods and meet my AAFC mandate, giving credence to the saying "Where there's a will, there's a way".

On weekends and holidays, I made trips to nearby sites to characterize tree leaf morphology that I used to map the extent of pure and overlap/hybrid (O/H) zones of cottonwoods on river drainages in southern Alberta (Floate 2004). I also collected data on gall-formers, which showed that the aphid Tom had studied in Utah was also concentrated in O/H zones in other rivers drainages including that of the Oldman River (Floate et al. 1997). I thought that was the end of my cottonwood research, until I became aware of work done by Dr Nathalie Isabel at the Laurentian Forestry Centre in Sainte-Foy, Quebec. Nathalie had developed genetic markers to distinguish between different categories of hybrid cottonwoods for which I saw applications in southern Alberta. I didn’t know Nathalie, but reached out to her with the end result being a funded project for Nathalie and me to study hybridization in southern Alberta using her molecular methods. From individual trees, we collected data on leaf morphology, genetic markers and assemblages of gall-formers. We then combined these datasets to show that geographic elevation structured the extent and type of pure and O/H zones of cottonwoods throughout the Oldman River drainage, with different categories of hybrids acting to concentrate different types of gall-formers (Figure 5) (Floate et al.

2016). It was with great satisfaction when I told Tom I had finally published the last dataset from my PhD thesis some 20 years later. This experience and my subsequent work taught me another lesson… "Reach out and make connections. Science is a team sport."

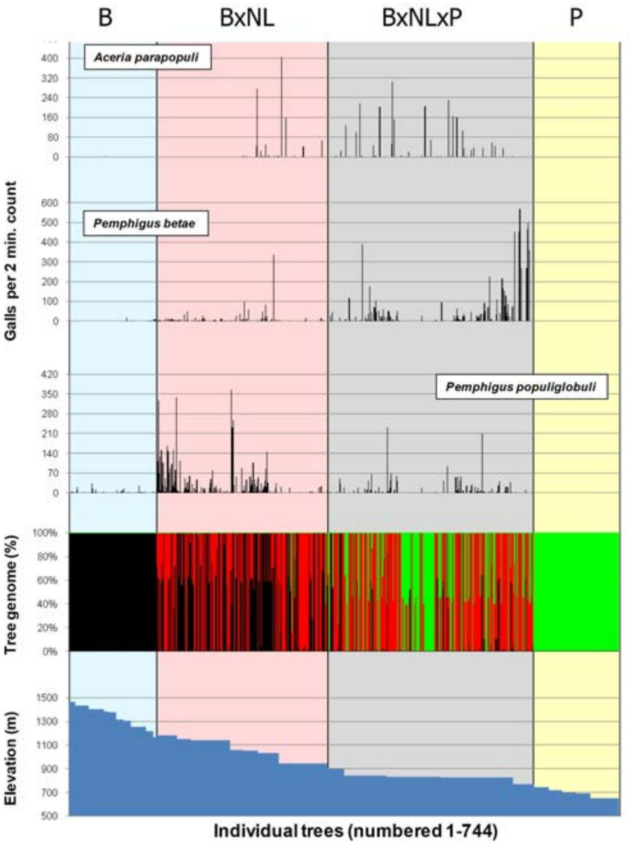

Figure 5. Distribution of pure and overlap/hybrid zones of balsam poplar (B), narrowleaf cottonwood (N) and plains cottonwood (P) along an elevation gradient in the drainage of the Oldman River. Molecular markers show the genetic composition of individual trees (B = black, N = red, P = green) with corresponding densities of three gall-forming arthropods.

But now let me talk about my transition into a livestock entomologist. I was aided in this process by Roy Spooner, who was assigned to me as my technician to help set up my new lab and learn the ropes of becoming a federal employee. Equally important was the work of Dr Tim Lysyk at LRDC, who was studying the biology of stable fly and house fly in feedlots and dairies, and of horn fly on pastures. His work also included life history studies on pteromalid wasps that were pupal parasitoids of these flies and for which he had done a survey on dairies in southern Alberta. I was hired to build upon Tim's findings and began by examining these wasps as biocontrol agents using colonies of flies and parasitoids that he had established in the lab. This research was aided by the fact that the flies and their parasitoids are multivoltine and easily reared in large numbers. Thus, for two field studies, I reared and released an estimated 5.1 million parasitoids (Floate et al. 2000; Floate 2003). Over the next few years, I worked mainly with Dr Gary Gibson (AAFC Ottawa), but also with Dr Ali Khan (Alberta Agriculture) and Dr Christine Noronha (AAFC Charlottetown) to publish surveys of parasitoids for feedlots and dairies in Alberta, Ontario, Quebec, New Brunswick and Prince Edward Island. I also published papers on the ability of different parasitoid species to overwinter, to locate host pupae in different substrates at different depths, and to develop in live versus freeze-killed hosts.

Ultimately, however, I realized that there was nothing more I could do to advance use of these wasps as biocontrol agents and decided that my program needed to evolve.

Thus, I expanded my focus to study *Wolbachia* bacteria. These bacteria infect an estimated 20-70% of all insect species and I had recently become aware that such infections were present in some of the parasitoid species I had in culture. Plus, *Wolbachia* were attracting a great deal of attention at the time (and still are) for their ability to fundamentally alter the biology and reproduction of their insect hosts. Work on *Wolbachia* meant adding molecular expertise to the lab, for which I was fortunate to hire Dr George Kyei-Poku as a post-doctoral fellow. To better understand the *Wolbachia* system, I also spent a year in Brisbane, Australia on a transfer-of-work in the lab of Dr Scott O'Neill (University of Queensland), a world expert on these bacteria. George passed his molecular skills onto my then technician Paul Coghlin, who then trained Diana Wilches, who entered my lab first as a graduate student and then as my full-time technician when Paul retired. Between George, Paul, Diana and with the work of MSc students Graham Taylor and Yanyan Li, we documented the presence of *Wolbachia* in different pest and beneficial insects, examined methods of curing infections with antibiotics and elevated heat, and showed the effect of *Wolbachia* infections on different host species. I'm particular proud of the work we did with the parasitoid wasp *Trichomalopsis sarcophagae*, which showed how the reproductive advantage conferred to infected females allowed the spread of *Wolbachia* in lab colonies of the wasp monitored for 20+ generations (Floate et al. 2025).

The tools available at the time largely limited our focus to *Wolbachia*. But when advances in technology reduced the cost, I was later able to include

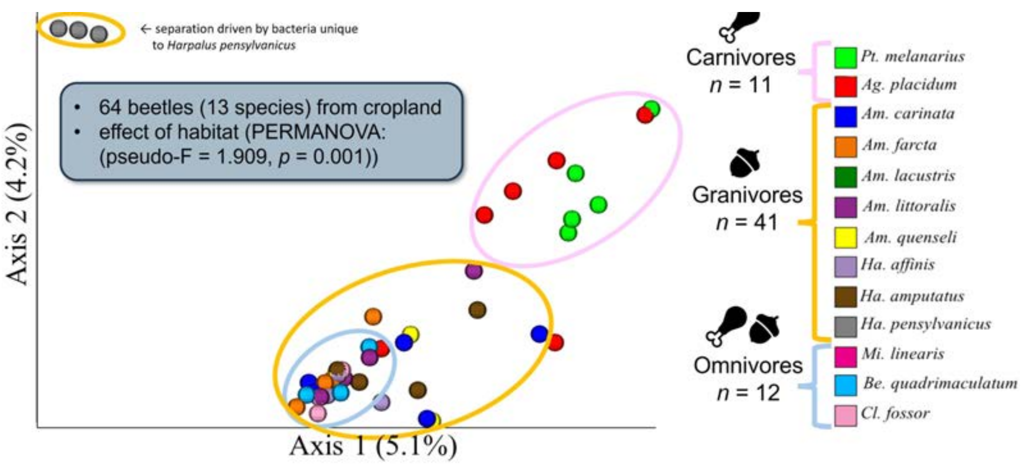

Figure 6. Separation of carabid beetles by feeding guild based on differences in their gut bacteria (Fisher 2024).

next-generation sequencing (NGS) methods in my research. Use of NGS allowed us to characterize the presence and relative abundance of, not just *Wolbachia*, but all of the bacterial taxa present in an insect. Thus, Brian Fisher, the last graduate student to pass through my lab was able to use NGS to show how the bacterial microbiomes of carabid beetles were shaped by diet, habitat and genetic-relatedness (Figure 6) (Fisher 2024).

During this time, I also found myself working on crop pests and stored product pest insects. Cutworm outbreaks in Alberta and Saskatchewan brought Vincent Hervet into my lab as a PhD student. Vince studied the life history of a parasitoid wasp and assessed its ability to develop on 47 potential host species of Lepidoptera, including many pest cutworm species (Hervet et al. 2023). A cutworm guide I wrote also came about from this work (Floate 2017). Largely supervised by Jennifer Otani (AAFC Beaverlodge), Shelby Dufton joined my lab for MSc research on orange wheat blossom midge and its natural enemies, a project with similar aspects to my own MSc thesis. And it was Paul Fields (AAFC Mordan) who worked to turn me into a stored product entomologist. Initially Paul and I supervised Yanyan Li, who did her PhD in my lab on *Wolbachia* bacteria in different stored product pests and documented the effect of *Wolbachia* on the confused flour beetle. Paul and I then co-supervised Diana Wilches for her MSc work on khapra beetle. This insect is among the world's most destructive pests of stored grains and grain products and is not known to be present in Canada with the exception of the laboratory colony that Diana established in LRDC's specialized quarantine facility. Diana studied the microbiome of different life stages of khapra beetle and the ability of larvae to survive extreme temperatures. Under certain conditions, she showed that a portion of larvae could survive exposure for 8 days at -20 °C (see Table 1). Sunil Shivanajappa subsequently entered my lab as a MSc student to continue work on khapra beetle, examining cross-tolerance between temperature extremes and humidity, the effect of diet quality on diapause termination, and the ability of khapra beetle to survive prolonged starvation by molting to reduce its size and food requirements.

Thus, having done my MSc on farms in northeast Saskatchewan, my PhD in cottonwood forests in Utah, and being hired by AAFC in Lethbridge to work on the biocontrol of feedlot flies, my research evolved to include insect microbiomes, agricultural pests, and stored product pest insects. Learning the new techniques, study systems and literature to allow for this expansion was challenging, but ultimately rewarding and illustrative of the adage… "If you always do what you've always done, you'll always be where you've always been." Hence, the title of my Gold Medal presentation; i.e., "Jack of all trades, master of dung—from farms to forests, feedlots and faeces". But where does the "dung" fit in?

In parallel with my work on various pest and beneficial insects and their associated bacteria, I also studied the effects of chemical residues in dung—the result of a chance comment made by a chemist at the time I was hired. He jokingly suggested I study “toxic waste dumps”—and so I did for the next 30+ years. Cattle treated with veterinary parasiticides can faecally excrete insecticidal residues. My first project with AAFC examined the effect of these residues on dung-breeding insects. I showed that topical application of the parasiticide ivermectin suppressed insect activity in dung of cattle treated up to 12 weeks prior (Figure 7) (Floate 1998). That paper was the first study I’d published as a sole-author and helped built my self-confidence. But the paper has also been heavily scrutinized with 150+ citations thus far. To me, the study showed insecticides killed insects. But to industry, it was a

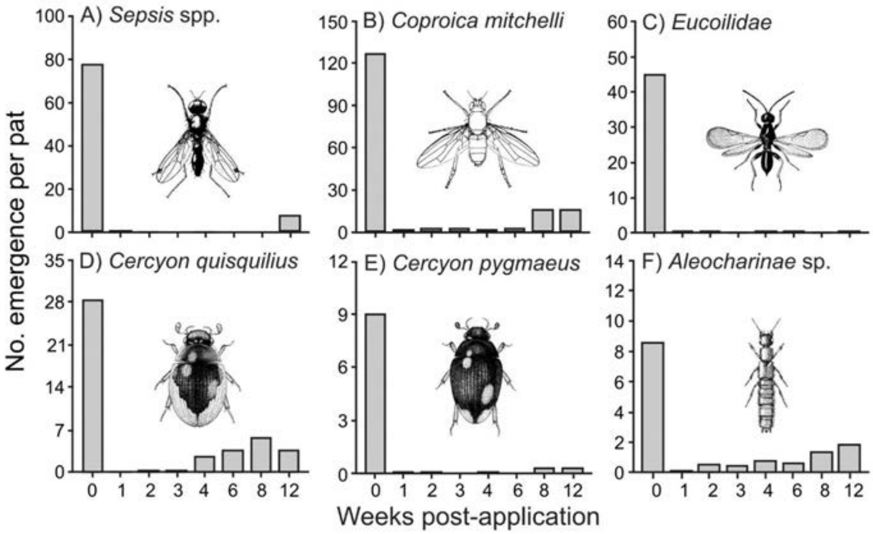

Figure 7. Insects emerging from dung of cattle treated 0–12 weeks previously with ivermectin in a pour-on formulation (n = 12 pats) (Floate 1998).

potential threat to sales of a product used worldwide. Reduced insect activity can slow dung pat degradation and potentially reduce pasture quality. If presented out of context, this finding could be interpreted by ranchers as a message not to use ivermectin as a control option for cattle parasites. Subsequent meetings with industry groups and many public presentations to producer groups alleviated this concern.

The findings of that early study have now been validated by other labs and by further work in my own lab. We have now published 40+ papers on dung insects and faecal residues including work by MSc students Giselle Bezanson and Sydney Backmeyer. And for all the work associated with these papers, I had wished for a guide written for the layperson to help my students identify the many species of insects in cow dung and understand the factors affecting insect colonization and dung pat degradation. Being mandated to work from home during the covid pandemic gave me the time I needed to write Cow Patty Critters (Figure 8), a guide free to download in either English or French (Floate 2023). This was a huge amount of work made easier by my passion for the topic and is by far my most widely read publication. These collective publications document diverse lethal and sublethal effects of residues on insects in dung of cattle treated with different products, including one product that can reduce insect activity in dung of cattle treated 24+ weeks prior (Nieman et al. 2018; Backmeyer et al. 2023). Most recently, we have shown that residues can leach from the pat into the soil to affect soil microorganisms and microfauna. Some 15 years ago, my local manager suggested this line of research had nothing more to offer, but new products and formulations continue to enter the market.

Delving in dung paid unexpected dividends. In 2001, I was invited to Australia to talk to ranchers, researchers and industry about the non-target effects of veterinary parasiticides on dung insects. In 2002, I was invited to England and became an inaugural member of Dung Organisms Toxicity Test Standards, a group formed to coordinate the international research needs of academics, industry and government regulators. In 2006, I was invited to a 4-day workshop at Pensacola, Florida during which attendees wrote a complete draft of the book Veterinary Medicines in the Environment (Crane et al. 2009). From 2009–2016, I travelled several times to Europe to help coordinate research among four countries that led to formal guidelines accepted by the Organisation for Economic Co-operation and Development on how to assess the environmental risk of faecal residues (OECD 2008). In 2018, I was invited to England by the European Medicines Agency as an expert panelist for discussions on a parasiticide product being considered for registration in Europe. These and other experiences bring to mind this quote by Ralph Waldo Emerson: “Do not go where the path may lead, go instead where there is no path and leave a trail.”

Whatever success I’ve had in my career reflects the support and mentorship of many people. These include my MSc and PhD supervisors, with whom I am still in contact 30 to 40 years later. And I value the many hours spent in the lab, field or over coffee exchanging ideas and advice with colleagues on all manner of topics. My career has also been enriched by continuous interactions with the undergraduate and graduate students (see appended list) that have passed through the lab, several of whom are now employed by AAFC as research scientists or technicians... much as I started my own career with AAFC as a MSc student.

And I’m thankful for the insights I’ve gained and friends I’ve made volunteering for various organizations. This includes roles with the Entomological Society of Canada, the Entomological Society of Alberta, the

Scientific Committee of the Biological Survey of Canada (Terrestrial Arthropods), COSEWIC (Arthropods Specialist Subcommittee), the now now-defunct Canadian Forum for Biocontrol and the Western Committee for Livestock Pests. Serving as Editor of The Canadian Entomologist and of the Bulletin of the Entomological Society of Canada gave me an insider's perspective of the publication process that has served me well. For those of you with the requisite time and energy, consider volunteering for similar roles when opportunities arise. The connections you make will pay dividends and sustain the strength of our national community of amateur and professional entomologists.

Graduate Students:

- Graem Taylor (MSc, 2008–2010). University of Victoria, Victoria, BC (co-supervised by Dr Steve Perlman).
- Yanyan Li (PhD, 2012–2014). Inner Mongolia Agriculture University, China (co-supervised by Dr Bao-ping Pang (IMAU) and Dr Paul Fields (AAFC Mordan, MB)).
- Vincent Hervet (PhD, 2013–2016). University of Lethbridge (co-supervised by Dr Rob Laird).
- Diana Wilches (MSc, 2013–2016). University of Lethbridge (co-supervised by Dr Rob Laird).
- Shelby Dufton (MSc, 2016–2019). University of Lethbridge (co-supervised by Dr Rob Laird and Jennifer Otani (AAFC Beaverlodge, AB)).
- Giselle Bezanson (MSc, 2017–2019). University of Lethbridge (co-supervised by Dr Cam Goater).
- Sunil Shivananjappa (MSc, 2017–2019). University of Lethbridge (co-supervised by Dr Rob Laird and Dr Paul Fields (AAFC Mordan, MB)).
- Sydney Backmeyer (MSc, 2019–2021). University of Lethbridge (co-supervised by Dr Cam Goater).
- Bryan Fisher (MSc, 2022–2024). University of Lethbridge (co-supervised by Dr Theresa Burg).

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HERITAGE LECTURE

Heritage, verbiage, and reflections on a half-century of entomology

John Acorn

John Acorn (jacorn@ualberta.ca) is on the faculty in the Department of Renewable Resources at the University of Alberta. He is broadly interested in insect ecology, taxonomy, and paleontology, and he has also promoted entomology to a general audience through talks, books, and television.

At the 2025 JAM conference in Calgary, I was pleased, honoured, and humbled with the opportunity to deliver a heritage lecture. Mind you, I approached the task with caution. For Canadian entomologists, heritage is primarily a matter of history, and our history is quite obviously dominated by tales of white men. I too am a white man. Learning about heritage is intended to enhance one's sense of identity, and membership in a group. So why would listening to an 'old white guy' tell stories about more old white guys, make other people feel more like they belong in our society? This is an excellent question, and the obvious answer is that often, it will not. Thus, I was (and still am) cautious.

At the university where I work, I teach two courses in which heritage is an important theme. One is about "parks, ecology, and society" and the other is about "environmental interpretation and science communication." I teach about heritage interpretation, world heritage sites, and the like. Agencies such as Parks Canada have specific notions about "commemorative integrity" that are just about as vague as their guiding principle of "ecological integrity". From this experience, I have realized that heritage is not something that you need to earn. All that is required is that you know that it exists. We attach ourselves to heritage, or adopt heritage, and it changes our self-image, our national identity, and so on. Or, we choose not to.

As I write this text, the JAM is a distant memory. It is late January, and next Saturday, my wife and I will attend a Burns Night celebration at the home of a colleague and friend. My role is to deliver the *Address to a Haggis*. Burns Night is a celebration of Scottish heritage, but I have never been to Scotland, and my Scottish accent is entirely bogus. I do own a kilt, mind you, made from the MacNeill tartan, since my grandmother was a MacNeill. Her ancestors came to Prince Edward Island more than a century ago, where they mingled with the Acorns. Legend has it that the first Acorn was from Germany: Johann Eichhorn. In PEI, he found himself surrounded by Scots, including many MacEacherns, so he changed his name to Eachern, to sound Scottish, and it soon became Acorn, because it isn't Scottish. So, my family has been adopting/faking its Scottish heritage for a very long time.

As an undergraduate, I also enjoyed adopting a certain amount of Japanese heritage. I was a founding member of the Aikido Club at the University of Alberta, and for a while, back in the late 1970s, a majority of the members of that club were entomology students. One, Gerald Hilchie, went on to become an Aikido instructor. The rest of us were too bruised and sore to continue, but we did enjoy participating in the rituals that come with the study of a traditional Japanese martial art.

These stories highlight an important aspect of heritage: it is not just a matter of stories; it also involves language, regalia, rituals, objects, and places. With this in mind, the JAM conference itself is a part of our heritage. The banquet is a ritual, and the Heritage Lecture is a ritual in its own right. It isn't just about heritage; it is itself heritage. It used to be longer, by the way, and I was quite surprised by my 30-minute time limit. I suspect that this reflects the discomfort that now characterizes our approach to heritage in general.

This is also the reason for the word “verbiage” in my talk title (*Heritage, verbiage, and reflections on a half-century of entomology*). The society is understandably nervous about heritage, and about the verbiage that often attends it. Now that I am committing my thoughts to a text file, however, I see that the word verbiage is appropriate for me after all. I thought this thing would be shorter.

The conference itself is a shared ritual that dates back to the origin of the society. Most things have not changed: we present short talks to each other, accompanied by images on a screen. Often, the audiovisual equipment malfunctions, much like it did in the days of 35mm film "slides” and their failure-prone carousel projectors. A century of technological improvement has not made audio-visual equipment any more reliable.

If we are honest with ourselves, we should also admit that much of what is presented is not exactly obvious to the audience, nor was it back in the day. We suffer from what cognitive scientists call “the curse of knowledge”, which simply means that it is extremely difficult for any of us to imagine that our peers don’t know all of the things that we do. So, we confuse each other frequently, but we accept it as normal because we are, after all, human. If I can offer a bit of advice here; in your own talks, try very hard to be clear, and realize that however confusing you find other people’s talks and posters, that’s how confusing you are to them.

Some things about the conference have changed, however. Visual communication is now much more competent than it used to be, and those of us who study and teach visual communication often point to scientists as exemplary visual communicators. As well, posters are relatively new. Looking back through the Proceedings of the Entomological Society of

Alberta, the earliest image I can find of a poster was from 1998, and it looked much like a poster would today. The science back then was just as rigorous as it is now, but more difficult to do without computers (or with early, awkward computers). Don't make the mistake of thinking that our predecessors were less sophisticated than we are.

What else has changed? Well, the questions periods are now much gentler. In the past, no one ever began with, "thanks for a really good talk," and the more aggressive questioners would stand to deliver their criticisms with a frightful amount of bluster. And generally, yes, they were old white guys. It was a male-dominated time, and the most dominant males were very dominant indeed. Not all, but some.

Once we recognize that conferences are rituals, various other things come into focus. After all, it would be cheaper, faster, and more efficient for any of us to simply read published papers back home and email the authors if we feel the need to follow up. That way, we could keep up with our fields. During the pandemic, many conferences (not to mention classes) went online, often with accompanying recordings. In communication terms, these were all improvements on the traditional conference. But we still prefer to meet in person, just as students prefer to come to the classroom. Why? Because we are human, and humans prefer it that way.

So far, I have been reflecting on past conferences, but I should also say something about entomology in Alberta. I will try to do that without unnecessarily glorifying the old white guys of the past. One approach might be to take pleasure in the fact that we are all fallible, acknowledging that stories of failures, screw-ups, and scandals are also a part of our heritage. I love those types of stories, to the extent that I am sometimes accused of loving them too much.

For example, any account of entomology in Alberta needs to include mention of Colonel Strickland. "Strick" was an entomologist in both the federal civil service, and the early years of the University of Alberta, so both applied and basic-science entomologists adopt his story as part of their heritage. He was, by all accounts, a remarkable person; highly intelligent, productive, and a great leader. But he wasn't perfect. Every morning, I walk past a hallway display that highlights the following heroic story: "1922: E. H. Strickland, the first Professor of Entomology, leads an effort with thousands of volunteers to control grasshoppers, which are threatening to destroy all crops in southern Alberta. The cost is a staggering $248,000. The following year, Strickland is summoned to the legislature to explain what the opposition considers a misappropriation of funds. Documents are gathered, showing that although Alberta spent much more than Saskatchewan and Montana to fight the infestation, their crops were wiped out while Alberta's weren't."

Excellent! What a guy. Except for one thing. The insecticide of choice back then was arsenic. In fact, the entire arable land surface of Alberta was sprinkled with arsenical bait. Luckily, there are no long-term effects, that we know of, as a result of this extremely bad decision, but I think we can agree that there is just as much to be learned from Strickland's mistakes as there is from his triumphs.

Another Alberta story is the discovery of the order Notoptera in 1914, in Banff. People of my age learned that Edward M. Walker, a prominent Toronto entomologist, discovered the grylloblatids. Only recently has it become standard practice to also acknowledge the contributions of Takatsuna Kurata, Walker's colleague, who was an accomplished entomologist and arachnologist in his own right. Retelling these stories in ways that correct the systemic biases of the past has value to be sure.

Many of my long-time colleagues and friends began as amateurs. When University of Alberta taxonomist George Ball retired, he surveyed his former graduate students and found that about half of them began as amateur entomologists, in their childhood, while the other half were inspired by their experiences as undergraduates. Both groups did equally well in their subsequent careers. For the amateur cohort, of which I was a proud member, our hub was an organization called TIEG, the Teen International Entomology Group, coordinated by Cornell University, with the help of the ESC. We communicated by snail mail (which was then called "mail") and occasionally the Alberta TIEG members got together to go collecting. That is how I met Felix Sperling, among others, back in 1973. Art Borkent, the prominent dipterologist, was also a proud TIEG member. I have written about the history of TIEG elsewhere, and I like to make the point that most attempts to promote entomological interests among young people have been rather '*r*-selected', reaching large numbers of kids, but in a somewhat limited fashion. TIEG was different, and it was '*K*-selected'. There were few of us involved, but our involvement was intense, and the result was a remarkable proportion of the original membership who went on to careers as entomologists. Notably, all of those stories were stories of starting as an entomological outsider and becoming an insider later on.

Heritage is not the same, then, as history, and history is continually being rewritten to suit the needs of the present day. Heritage typically converges on a few stories of particular people or events in the distant past and attempts to perpetuate the importance of these narratives into the present day. But heritage can also diverge into the past, to acknowledge the diversity from which we collectively arise. In Alberta, we have a provincial holiday called Heritage Day, on which we attend heritage festivals that feature such things as the food, regalia, and dances of the various countries of origin for the current population of the province. I like this notion of heritage, and we should celebrate this in our science as well.

Of course, the flip side of heritage is legacy. When we celebrate the legacy of someone from the past, this is considered heritage. Beside my armchair at home, there sits a book that I intend to read soon, entitled *The Mattering Instinct*, by Rebecca Newberger Goldstein. It promises to explore the deep human desire to leave a legacy, and thereby "matter." The jacket of the book hints that this tendency also comes with potential problems.

Most scientists seem to enjoy planning their own legacies. It is easy to believe that our research papers and conference presentations will be at the core. Those who teach will also point to students as part of their legacy. They may or may not notice that students almost always diverge from the influences of their mentors, and most have little or no interest in perpetuating the legacies of their former professors or supervisors. I am probably a good example, since although such mentors as John Spence and George Ball had a very positive influence on me, I have developed in very different directions during my own career. George, reflecting on this, paid me what I think was a very nice compliment during his own Heritage Lecture, when he said, "you can't tell by the look of a frog how far it might jump." It took me a while to see those words in a positive light, but that is how he intended them.

You can't really plan your legacy—it happens in other ways. My television shows have inspired biological careers, I am told, and many people have enjoyed my books as well. Fewer have mentioned my music. My students often find things of interest in my courses. Growing up with an entomologist as a father, my son Benjamin has chosen an entomological career for himself. As well, like other scientists, I take gratification from each time a paper of mine is cited, even if the citation results in a difference of opinion, and a kerfuffle in the literature.

Well into the future, though, I'm really not sure what my own legacy will be. Perhaps it will just be specimens. I have collected quite a few over the years, and specimens last a long time, during which new uses for specimens might well be invented, as they have already. So, I try to label mine carefully and protect them from decay.

I notice when other people's specimens fail in this regard. Not long ago, in the E. H. Strickland Entomological Museum, I was asked if I had any idea what a label meant, below a one-legged, no-abdomen crane fly: "GC DAB June 15, 1972." I puzzled for a moment, and then realized I knew the answer. The specimen was collected at Gorge Creek, Alberta, where the University of Alberta had a field station (which is now operated by the University of

Calgary). The collector was David A. Boag, an ornithologist (and therefore not someone who should be expected to properly curate their insects). Victor Shegelski, the collections manager, was skeptical of my interpretation, but when Felix Sperling appeared moments later, he completely agreed with me. As grey-haired old guys, we possess what is known as "institutional memory," and as long as we are alive and mentally competent, such puzzles can be solved. It's another type of heritage, I suppose.

Perhaps the best advice I can offer is to see legacy as something that is important while it is happening, but relatively short-lived. We influence others by facilitating moments that matter to their lives. Not only that, we also really can't predict which of these moments will have an impact, and which will not. That, I think, is why we continue to enjoy and pay for in-person conferences. A conference facilitates countless meaningful moments, most of which are completely unplanned.

All of this supports the notion that the meeting in Calgary was itself heritage, as was my Heritage Lecture. Heritage is not just "the history", it is an ongoing, self-inventing process. As Marshall McLuhan famously said, "the medium is the message," just as the conference itself is the heritage. With this in mind, the best way to celebrate our heritage is to participate in the events that make us an entomological community, looking forward with optimism, and reflecting on the past with whatever insights the present moment might happen to provide.

SPECIAL FEATURE COMPENDIUM: ENTOMOLOGY AND HUMAN HEALTH

Arthropods impact human health in so many ways, from food security to infectious disease and beyond. In this collection of papers, we authors explore a range of disease topics, all within an entomological context. Of course, we generate as many questions as answers; that's the stuff that science is made of. We hope you will enjoy reading this offering.

Bernie Roitberg

The Relevance of Insect Hormesis to Human Health

G. Christopher Cutler

Chris Cutler (chris.cutler@dal.ca) is a Professor in the Faculty of Agriculture at Dalhousie University, where he teaches and does research on insect hormesis, insect pest management, insect agroecology, and ecotoxicology. Most days he would rather be snowboarding, mountain biking, or backcountry camping.

Abstract
Hormesis describes a biphasic dose-response relationship in which low levels of environmental stress stimulate adaptive biological responses, while higher levels are inhibitory or harmful. Evidence now indicates that hormesis is a fundamental and widespread biological phenomenon operating across taxa, stressors, and endpoints. This paper synthesizes evidence demonstrating how hormesis in insects intersects with human health through agriculture, disease transmission, and biomedical research. Sublethal stress can exacerbate pest outbreaks and accelerate resistance evolution, intensifying crop damage and pesticide use and exposure risks, while controlled stress may enhance biological control efficacy and sterile insect release programs to reduce chemical inputs. Hormetic responses in insect disease vectors may influence pathogen transmission dynamics. Insects—particularly *Drosophila melanogaster*—also serve as indispensable models for elucidating conserved hormetic mechanisms relevant to aging, metabolism, and resilience. Finally, recognizing hormesis has important implications for environmental risk assessment and public-health policy, study of insect hormesis through an ecological lens helps us better ensure the health and sustainability of the environmental we live in.

Introduction
Coping with stress is an unavoidable reality of all organisms in nature. Insects and humans are commonly exposed to many forms of environmental stressors, including chemicals (e.g., metals, phytochemicals, agrochemicals, etc.), pathogens, temperature extremes or fluctuations, and nutrient deficiency (reduced energy availability). The amount/dose of stressor an organism is exposed to exists along a continuum and can be modeled in a relatively simple dose-response manner (Figure 1). Traditionally, it was mostly assumed organisms responded to stress in a threshold or linear fashion. A threshold response presumes there is a stressor dose threshold above which we see inhibitory or deleterious effects, but below the threshold we see no effects. A linear non-threshold (LNT) response assumes there is a linear relationship between stressor dose and risk, terminating at zero (Figure 1).

Although threshold and LNT dose-response models have long informed assessments of human and environmental health, their prominence is being challenged. Historically marginalized or ignored, there is now overwhelming

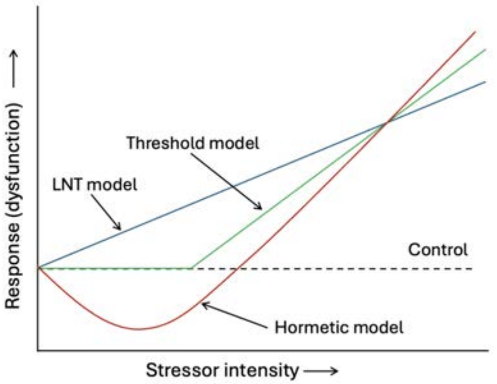

Figure 1. Depiction of linear non-threshold (LNT), threshold, and hormetic stresser does-response models.

evidence for the hormesis dose-response model, which is argued to be the most fundamental and common stress-response curve (Calabrese 2010). The hormetic response follows a biphasic curve characterized by high-dose inhibition and low-dose stimulation (Figure 1). That is, hormesis is a biological process in which exposure to a low dose of a chemical agent or environmental stress factor that is inhibitory or dysfunctional at higher doses elicits an adaptive, stimulatory, or beneficial response (Calabrese et al. 2007; Mattson 2008).

Hormesis has been extensively documented across many forms of life, including insects and humans, and is now recognized as a unifying biological principle with broad ecological and biomedical relevance (Calabrese and Baldwin 2001; Calabrese 2014; Cutler et al. 2022; Mattson and Calabrese 2009; Wan et al. 2024). Because both insects and humans exhibit hormetic responses and given the fundamental role insects play in human health and well-being, the study of hormesis in insects has relevance for human health.

In this paper, I discuss the interplay among hormesis, insects, and human health, emphasizing the potential impacts of hormetic responses in insects on human well-being, and the critical role of insects as models for studying hormetic mechanisms relevant to human health.

Conceptual Foundations and Mechanisms of Hormesis

Evolutionary theory views exposure to moderate environmental stress as a driver of evolutionary change. To survive and reproduce in harsh competitive environments, natural selection would favour evolution of mechanisms that enable adaptive responses to various hazards and stressors. Hormesis can be thought of as a manifestation of the plasticity of biological systems based on stressor intensity, where low-stress exposure activates preventive adaptation mechanisms, preparing the organism to cope with potential future, more intense stressors (Mattson and Calabrese 2009). This has implications for biological fitness and "health" of the organism. In some cases, a hormetic response—such as increased reproduction or longevity following mild stress exposure—may not necessarily enhance overall fitness, as short-term gains in one life-history trait can be offset by trade-offs in another (Forbes 2000).

However, there are also circumstances in which hormetic mechanisms increase fitness or prime organisms for future stress, thereby conferring a selective advantage (Costantini 2019). Experiments with various insect-stressor models have demonstrated that either of these fitness outcome scenarios may occur (Ayyanath et al. 2013; De La Torre and López-Martínez 2023; Gong et al. 2023; Ray et al. 2022; Rix and Cutler 2018).

What mechanisms underlie the hormetic response? Broadly, hormesis may arise from either (1) over-compensatory biological processes that follow a temporary disruption of homeostasis or (2) direct stimulation that occurs without disturbing homeostasis (Calabrese and Baldwin 2002). In the first case, the modest "overshoot" or overcompensation response reflects a highly regulated form of biological insurance that persists after tissue repair is complete and homeostasis has been restored, effectively preparing organisms for future, more severe stressors (Calabrese 2001; Perrone and D'Angelo 2025). In contrast, direct-stimulation hormesis follows a different activation pathway: it is not triggered by disrupted homeostasis but represents an adaptive enhancement of normal maintenance functions (Calabrese and Baldwin 2002; Mattson 2008). Although these two forms of hormesis differ in their initiating mechanisms, their quantitative similarities—and their reliance on many of the same physiological systems and endpoints—suggest that hormesis represents a fundamental biological strategy that integrates diverse signaling pathways into a unified functional response (Perrone and D'Angelo 2025).

At the molecular and biochemical level, the broad generality of hormesis across taxa, endpoints, and stressors indicates the involvement of multiple receptor-mediated and cell signaling pathways (Calabrese 2005; 2013). Pathways regulating cell proliferation, inflammation, apoptosis, and responses to oxidative, thermal, and radiation stress—particularly ERK1/2, p38, and JNK—are frequently implicated (Calabrese 2013; Cargnello and Roux 2011). Activation of the conserved redox-sensitive transcription factor Nrf2, which coordinates cytoprotective and metabolic stress responses, is also considered central to hormetic mechanisms (Calabrese and Kozumbo 2021). In insects, diverse stressors induce heat shock proteins and antioxidant enzymes that mitigate cellular damage, while hormetic insecticide doses can upregulate detoxification enzymes such as cytochrome P450s, glutathione-S-transferases, and esterases, increasing tolerance or resistance (Rix and Cutler 2022).

Interesection of Insects, Hormesis, and Human Health

Hormesis intersects with insects and human health in several important ways. For example, hormetic responses in insects to environmental stressors can directly influence human wellbeing through their effects on agriculture or vectoring of diseases. In addition, insects serve as indispensable model organisms for studying the mechanisms and outcomes of hormesis (see Thomas, this issue). The following sections summarize the major ways hormesis in insects may shape or impact human health (Table 1).

Agricultural Entomology and Hormesis

The adverse effects of insect pests on our food supply are well recognized. It is estimated that even today—with the benefit of decades of discovery and technological developments—insect pests are responsible for global pre-harvest crop losses in the range of 10-15%, with additional losses accumulating post-harvest (Oerke 2006), and increasing crop losses to insect pests predicted in a warming climate (Deutsch et al. 2018). The implications of food insecurity from insect pests on human health are obvious. Less appreciated, at least until recently, is how hormetic responses could exacerbate the challenges of insect pests to food security.

How might this occur? One mechanism is through hormetically induced pest outbreaks and resurgences. Ecological backlashes following insecticide applications have traditionally been attributed to indirect effects on natural enemies, such as predator and parasitoid mortality (Hardin et al. 1995; Ripper 1956). It is now clear, however, that insecticide-induced hormesis can also directly contribute to pest resurgence (Cutler and Guedes 2017; Guedes and Cutler 2014). In agricultural systems, pesticide residues decay over time, coverage is often heterogeneous, and pests frequently encounter doses well below labeled field rates. Exposure to these low, sublethal concentrations—within the so-called "hormetic zone"—can stimulate fecundity, survival, stress tolerance, or other fitness-related traits, thereby accelerating population growth and increasing the likelihood of pest resurgence or secondary outbreaks.

Dozens of experimental studies across diverse pest taxa document such stimulatory responses, including increased reproduction, longevity, and oviposition (Cutler 2013; Cutler et al. 2022), with evidence linking insecticide applications to outbreaks of mites (Cordeiro et al. 2013; Dittrich et al. 1974), planthoppers (Chelliah and Heinrichs 1980; Reissig et al. 1982), aphids (Lowery and Sears 1986; Rix et al. 2016), and thrips (Morse and Zareh 1991). Moreover, hormetic increases in pest population growth may be accompanied by stimulated feeding behaviour on crops (Wang et al. 2023; Wolz et al. 2021; Zeng et al. 2016). Such community scaling-effects are not expected to be strictly liner (Cutler et al. 2022), and there could be density-dependent dampening of hormesis effects as pest populations increase in size—these are questions requiring further study. Nevertheless, from a human-health perspective, hormesis-induced resurgence dynamics could intensify the pesticide treadmill, leading to more frequent applications, higher cumulative active ingredient use, and greater potential for environmental and occupational exposure, along with increased crop losses.

Hormesis also intersects with resistance development, another major lever on pesticide use and thus human and environmental health. If resistant individuals increasingly experience sublethal field doses, hormetic stimulation can raise population growth and accelerate the spread of resistance alleles or induction of resistant factors. Experimental evidence supports this. In a pyrethroid-resistant strain of *Sitophilus zeamais*, low insecticide doses increased population performance (Guedes et al. 2010), while field-collected *Myzus persicae* showed hormetic responses accompanied by altered expression of detoxification genes linked to metabolic resistance (Sial et al. 2018). Sublethal imidacloprid similarly increased aphid reproduction and primed detoxification pathways, with multigenerational exposure enhancing tolerance to subsequent chemical stress (Rix et al. 2016; Rix and Cutler 2018). Parallel effects have been reported in other systems, including transgenerational hormesis and increased insecticide tolerance in brown planthopper and Colorado potato beetle following chronic low-dose exposure (Gong et al. 2023; Margus et al. 2024).

Hormesis has potential benefits for human health through improving biocontrol, resulting in reduced pesticide dependence. If mild, controlled stress can enhance performance longevity, fecundity, or stress tolerance in reared insects, it could improve mass rearing, release success, and greenhouse biocontrol reliability, lowering chemical inputs (Cutler et al. 2022; Cutler and Guedes 2017). Experimental studies provide proof-of-concept across predators and parasitoids. For example, in the predatory stink bug *Podisus distinctus*, sublethal permethrin exposures can produce stimulatory responses with increased demographic performance in a classic hormesis-type pattern (Guedes et al. 2009), and neonicotinoid exposures that stimulated *Podisus maculiventris* reproduction did not eliminate key behaviors needed for pest suppression (Rix and Cutler 2020; 2021). In parasitoids, an LD20 of chlorpyrifos increased host-searching and infestation efficacy, directly enhancing biocontrol-relevant performance (Rafalimanana et al. 2002). Comparable effects have been reported in the egg parasitoid *Trichogramma chilonis*, where multigenerational exposure to low insecticide concentrations enhanced multiple fitness traits important for mass rearing and field persistence (Ray et al. 2022), and where low-dose exposure improved parasitoid functional response—an endpoint tightly linked to control efficacy (Ray et al. 2023).

Similar applications are possible in sterile insect release (SIR). In Caribbean fruit fly (*Anastrepha suspensa*) and cactus moth (*Cactoblastis cactorum*), early-life anoxia conditioning prior to irradiation induces hormetic responses that increase oxidative stress resistance, male sexual performance, and field activity compared with unconditioned insects (López-Martínez et al. 2021; López-Martínez and Hahn 2012). Deliberate application of mild anoxia stress and hormetic principles to enhance performance of insects used in SIR remains largely unexplored, despite clear potential for improving release success.

Medical Entomology and Hormesis

Insects have a profound impact on human health as vectors of pathogens—viruses, bacteria, parasites—that cause disease. Vector-borne diseases are a risk for 80% of the world's population, being responsible for around 17% of global infectious diseases and over 700 000 death annually (WHO 2017). The efficiency of insects as vectors arises from ecological plasticity, close association with humans, and physiological compatibility with pathogen development, and can vary with fluctuations in environmental stressors (Brass et al. 2024). As we continue ongoing efforts to combat insects that vector diseases, it is apparent that mild stress—exposure to chemical insecticides or other stressors—may stimulate biological processes in arthropods that vector disease pathogens. The implications of such responses for human health may be significant.

Mosquitoes are notorious for their role in transmission of pathogens that cause disease. There is evidence of hormesis occurring in mosquitoes. For example, in laboratory experiments with the yellow fever mosquito, *Aedes aegypti*, increased fecundity, the intrinsic rate of increase, finite rate of increase, net reproductive rate, and survival were observed in progeny of mosquitoes exposed to LC10 and/or LC20 thiamethoxam treatments (Mehmood et al. 2025). These phenotypic responses with mild thiamethoxam treatments were accompanied by significant increases in P450 gene expression in *A. aegypt*i parents and progeny. Similarly, *A. aegypti* larvae reared in low concentrations of copper (Cu^{2+}) resulted in adults with increased adult longevity (Perez and Noriega 2014), and *A. aegypti* larvae exposed to 600 mg copper L^{-1} infected with dog heartworm (*Dirofilaria immitis*) gave rise to adult mosquitos with significantly increased (~10%) fecundity compared to controls (Neff and Dharmarajan 2021).

Pathogen-vectoring insects less prolific than mosquitoes are also prone to hormetic responses. Muscidae (e.g., the house fly, *Musca domestica*), Calliphoridae (blow flies), and other flies pose risks to both human and animal health because they frequently associate with feces, carcasses, garbage, and other decaying organic matter (Tomberlin et al. 2016). Decades ago, experiments with organochlorine and organophosphorus insecticides reported increased fecundity, fertility and/or weight in house flies exposed to low amounts of DDT, dieldrin, aldrin, diazinon, and malathion (Afifi and Knutson 1956; Hunter et al. 1958; Ouye and Knutson 1957). More recently, houseflies exposed to low doses of permethrin and imidacloprid had increased fecundity (45-55% above controls) and fertility (50-64% above controls) (Yusmalinar et al. 2017). Similarly, low and environmentally relevant levels of dietary cadmium significantly enhanced the pupation rate of blowfly (*Phormia regina*) larvae, while higher doses inhibited pupation success (Nascarella et al. 2003).

As a general biological phenomenon, the occurrence of hormesis should not be restricted by insect taxon, guild, life history, or behaviour (Cutler 2013). Widely documented incidence of hormesis in a diversity of agricultural insect pests should therefore be expected to also occur widely in insects that vector pathogens of human importance. However, few studies have explicitly tested hypotheses examining biological stimulation following exposure to mild stress. This represents a research area ripe for fundamental discovery, with important implications for human health.

Insects as Models for Hormesis in Biology, Medicine, and Toxicology

Hormesis is central to human health because it describes the limits to which integrative biological processes (e.g. tissue repair, aging processes, complex behaviors such as anxiety, learning, and memory) can be enhanced or diminished by pharmaceutical, chemical and physical means (Calabrese 2014). Indeed, many biological systems respond optimally to low levels of stress. For example, essential nutrients, plant-derived compounds, and neurotransmitters act as mild stressors at low doses, activating protective pathways that enhance cellular resilience, metabolism, and brain function. These hormetic responses support processes such as learning, memory, and resistance to metabolic and neurodegenerative disease, whereas overstimulation leads to tissue damage and pathology. Exercise and dietary energy restriction further demonstrate how controlled stress promotes health and healthy aging by engaging these adaptive mechanisms (Mattson and Calabrese 2009; Perrone and D'Angelo 2025).

Animal models are crucial to predict effects of various biotic and abiotic factors and interventions on human health (see Thomas, this issue). Due to its prolific reproduction, short generation time, and genetic homologies to humans, few animal models have been more important than *Drosophila melanogaster* (Michán et al. 2010). Because *D. melanogaster* and humans share so many stress-response pathways, this is certainly true in hormesis research. For example, repeated mild heat stress extends lifespan and is associated with durable heat-shock/proteostasis signatures (Hercus et al. 2003; Le Bourg et al. 2001; Sarup et al. 2014); "mitohormesis" occurs with systemic lifespan extension driven by mitochondrial stress in muscle and longevity benefits from specific mitochondrial ROS signaling (Owusu-Ansah et al. 2013; Scialò et al. 2016); early-life low-dose oxidant exposure can increase adult *D. melanogaster* longevity via microbiome remodeling (Obata et al. 2018); rutin hormetically prolongs *D. melanogaster* life, as does lithium through conserved GSK3/NRF2 stress defenses (Castillo-Quan et al. 2016; Chattopadhyay et al. 2017); and, hormesis-like adaptive stress can improve outcomes in a Parkinson's-relevant parkin knockdown model (Bonilla-Ramirez et al. 2013). Thus, due to their many evolutionary and physiological parallels, *D. melanogaster* has been an indispensable model to study hormetic aspects of aging, disease, and stress resilience in humans.

Beyond the biomedical laboratory, hormesis has important implications for human health in the context of environmental risk assessment and policy because it challenges the assumption that all exposure to environmental chemicals is inherently harmful—an assumption with far-reaching consequences for public-health standards, risk communication, environmental priorities, and remediation costs. Ignoring hormesis has made decision-making less scientific and more intuitive, increasing vulnerability to political influence and fostering zero-risk expectations that can drive calls to eliminate products or activities regardless of their costs or benefits (Calabrese 2004). Policies that focus solely on eliminating exposure may inadvertently remove low-level stimuli that contribute to resilience and health, including naturally occurring metals (e.g. selenium, cadmium, iron, zinc), phytochemicals (e.g. quercetin, curcumin), and gases (e.g. carbon monoxide, ozone) (Mattson and Calabrese 2010).

As in the biomedical sciences, insects and other animals serve as valuable tools in studying potential hormetic effects of contaminants in the environment (Rix et al. 2022). As described above, exposure to low doses of metals or pesticides can increase reproduction or survival in mosquitoes and blow flies, and multigenerational cadmium exposure led to *Chironomus riparius* populations that appeared stimulated at low Cd levels (Postma and Davids 1995). Cotton leafworm, *Spodoptera litura*, reared on diets with low $ZnCl_2$ concentrations gave adults with fecundity almost double that of controls, with no compromise in other life history parameters (Qi et al. 2024), and similar positive growth and food-utilization effects were observed in this species when fed low Cd–Pb mixtures across generations (Zhang et al. 2023). We even see that many substances poisonous to pollinators can induce hormetic effects on bee reproduction and behavior at low doses (Cutler et al. 2022; Cutler and Rix 2015). Thus, studies with insects can show how exposure to environmental contaminants can elicit adaptive or stimulatory responses at low doses, emphasizing the importance of considering non-monotonic dose-response relationships in ecological risk assessment.

Conclusions

Insects occupy a unique dual role in human health and well-being. On one hand, they are a persistent affliction, acting as pests of agricultural and medical importance. On the other, they are indispensable models in biomedical and environmental health research, offering powerful insights into the biological processes that compromise or promote health. Threaded through both roles is hormesis—a unifying biological principle that shapes how organisms respond to stress and, in turn, how those responses influence ecosystems and human health (Table 1).

Though perhaps a relatively minor player in the grand scheme, it is argued in this essay that hormesis in insects has significant implications for human health. The insects that compete with us for food and spread pathogens can be directly stimulated by the very chemicals we deploy to suppress them, potentially exacerbating the challenges of crop protection and medical entomology. But as an evolutionarily conserved and mechanistically robust response influencing reproduction, longevity, immunity, and tolerance to chemical and environmental stressors, hormesis in insects also provides a unifying framework for understanding adaptive stress biology across taxa. Insights from insect hormesis inform biomedical research, toxicology, and public health by improving our understanding of low-dose stress effects, adaptive homeostasis, and resilience. Future research should prioritize cross-taxa modeling of hormetic dose-responses, integration of hormetic endpoints into regulatory frameworks, and One Health approaches that link insect, human, and ecosystem health.

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Table 1. Representative examples of insect hormesis with human-health relevance

Domain	Insect	Stressor	Hormetic response	Relevance	Key references
Agriculture pests	Aphids	Imidacloprid	Increased reproduction; detox gene expression	Pest resurgence; pesticide treadmill	Rix et al. 2016; Rix & Cutler 2018
Agriculture pests	Planthoppers	Neonicotinoids	Enhanced fitness; transgenerational tolerance	Accelerated resistance evolution	Gong et al. 2023
Agriculture pests	Mites	Pyrethroids	Increased population growth	Escalated crop losses	Cordeiro et al. 2013
Biocontrol	Predatory stink bugs	Neonicotinoids	Increased reproduction; intact predatory behavior	Reduced pesticide dependence	Rix & Cutler 2020, 2021
Biocontrol	Parasitoid wasps	Imidacloprid	Enhanced fitness and functional response	Improved biological control efficacy	Ray et al. 2022, 2023
Sterile insect technique	Fruit flies	Anoxia + irradiation	Improved mating success and field activity	Enhanced pest suppression	López-Martínez et al. 2012; 2021
Disease vectors	Mosquitos	Thiamethoxam	Increased fecundity and longevity; P450 upregulation	Vector population amplification	Mehmood et al. 2025
Disease vectors	Mosquitos	Copper	Increased adult longevity	Altered disease transmission dynamics	Perez & Noriega 2014
Disease vectors	Blow fly	Cadmium	Increased pupation at low doses	Sanitation and disease risk	Nascarella et al. 2003
Biomedical research	*Drosophila*	Heat, ROS, phytochemicals	Extended lifespan; stress resilience	Insights into aging and disease	Hercus et al. 2003; Obata et al. 2018

What insects can teach us about cancer: A forgotten connection

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Abstract
Cancer is not just a medical problem, it is also an evolutionary and ecological one. Yet, most studies of cancer focus almost exclusively on vertebrates, overlooking the richest source of biological diversity on the planet: insects. In this paper, we explore how insects can deepen our understanding of tumour biology, from the molecular level to the ecological and evolutionary scales. Experimental models such as *Drosophila* reveal how fundamental oncogenic mechanisms are shared across life, while field observations show how tumorous processes can influence insect behaviour and fitness. Insects are also proving useful in unexpected ways: ants can detect cancer through smell, insect peptides show anticancer activity, and even plant galls induced by insects mirror aspects of tumour growth. Together, these examples suggest that looking at cancer through the lens of insect biology can reveal universal principles about how multicellular life maintains, and sometimes loses, its internal balance.

Introduction

Tumourigenesis is an almost inevitable consequence of multicellularity, arising from conflicts among the cooperative cellular units that form an organism (Domazet-Lošo et al. 2007; Aktipis et al. 2015; Boutry et al. 2022b). Within a multicellular framework, natural selection operates across hierarchical levels: while selection at the organismal level promotes cooperation for collective functionality, selection at the cellular level may initially favour uncontrolled proliferation, which can subsequently give rise to parallel cooperative systems (i.e., tumours) that undermine the organism's integrity (Gatenby et al. 2020; Capp et al. 2023). Cancer thus emerges as a predictable by-product of complex life rather than a pathological anomaly, i.e., a manifestation of the inherent evolutionary tension between cooperation and competition within multicellular systems (Capp et al. 2023; Nedelcu 2020; Maley et al. 2025).

Despite this universal background, cancer biology has been dominated by studies in a few vertebrate models, primarily humans and rodents, chosen for their biomedical relevance and experimental tractability, respectively. Only a limited number of comparative analyses have extended this perspective to zoo animals such as mammals, birds, and reptiles (e.g., (Vincze et al. 2022; Kapsetaki et al. 2024; Kapsetaki et al. 2023; Madsen et al. 2017a)), and to vertebrates living in more or less polluted areas (e.g., Martineau et al. 2002; Baines et al. 2021; Giraudeau et al. 2018). While these systems have sometimes yielded profound insights into the molecular and genetic mechanisms of tumourigenesis, and/or anticancer defences (e.g., Nagy et al. 2007; Sun et al. 2022; Abegglen et al. 2015; Vazquez et al. 2017), their overrepresentation constrains our ability to identify the general principles governing tumour initiation, evolution, and suppression. By focusing narrowly on vertebrates, we risk mistaking lineage-specific adaptations for universal rules of oncogenesis, and neglecting the broader ecological consequences of tumourigenesis for population dynamics and ecosystem functioning (Dujon et al. 2022b).

Evolutionary oncology offers a way forward. By comparing cancer-related phenomena across species, life histories, and ecological contexts, it seeks to uncover how selection pressures and biological architectures shape somatic stability and breakdown (e.g., (Vincze et al. 2025)). Within this comparative framework, insects stand out as a striking yet largely neglected model. They constitute the most diverse and evolutionarily successful group of multicellular organisms on Earth, encompassing over half of all known animal species (Mora et al. 2011). This sheer diversity, spanning solitary and eusocial lifestyles, terrestrial and aquatic habitats, and a wide range of trophic strategies, makes insects uniquely suited for testing how ecology, physiology, and sociality influence somatic maintenance and tumour dynamics.

Recent work (Thomas et al. submitted;) has further expanded the comparative and eco-evolutionary perspective on cancer by emphasizing how non-model organisms and overlooked taxa can illuminate fundamental oncogenic processes. This article highlights that cancer-related phenomena are deeply embedded in ecological contexts, shaped by life-history traits, environmental exposures, and evolutionary trade-offs rather than being solely driven by intrinsic genetic instability. By integrating cancer biology with ecology and evolution, we reinforce the idea that tumourigenesis is not an anomaly restricted to humans and laboratory models, but a predictable outcome of multicellular life exposed to diverse selective pressures. Such a perspective strongly supports the relevance of insects as models for identifying general principles of somatic maintenance, tumour suppression, and breakdown across the tree of life.

Insects also offer practical and conceptual advantages. Their short life cycles, large populations, and amenability to genetic manipulation allow rapid, high-replicate experiments that can probe the evolutionary dynamics of somatic conflict. Their relatively simple tissues and well-characterized developmental processes provide an accessible system for dissecting the fundamental links between environment, metabolism, and oncogenic processes. Importantly, eusocial insects, where selection operates not only on individuals but also on colonies, provide an unparalleled natural laboratory for exploring how multilevel selection shapes the evolution of somatic cooperation and the suppression of selfish cellular behaviours. In this context, the notion of "social cancers" (Tsuji and Dobata 2011; Oldroyd 2002) offers a compelling parallel: just as tumours emerge from the breakdown of cooperation among cells within an organism, social groups can experience analogous pathologies when individual interests override collective function. Studying these parallels in eusocial insects may thus illuminate the deep evolutionary connections between cooperation, conflict, and the maintenance of integrity, whether at the cellular, organismal, or societal levels (Grunewald et al. 2011).

Although cancer incidence appears low in insects (Scharrer and Lochhead 1950) compared to vertebrates (Madsen et al. 2017), this observation is itself informative. Their apparent resistance may reflect short lifespans, efficient somatic maintenance mechanisms, or developmental architectures that minimize opportunities for malignant progression. Understanding why tumourigenesis is rare in insects could thus provide key insights into the evolution of cancer suppression and the design of robust multicellular systems.

Beyond their value as comparative models, insects also offer powerful experimental systems for exploring both the proximate and ultimate dimensions of cancer. On the mechanistic side, genetically tractable insect models, such as *Drosophila melanogater* and other engineered species, allow direct manipulation of oncogenic pathways to investigate the cellular and molecular processes underlying tumour initiation and progression. On the ecological and evolutionary side, insects provide an exceptional framework to test how tumourigenesis can influence life-history traits, such as reproductive investment, predation risk, and longevity, and to assess how these feedbacks shape population and ecosystem dynamics.

By integrating insects into the broader comparative landscape of cancer biology, we can thus move beyond vertebrate-centric perspectives to build a unified eco-evolutionary understanding of cancer, one that links molecular mechanisms, organismal trade-offs, and the ecological consequences of somatic conflict across the tree of life.

Drosophila as a conceptual and experimental model of tumour biology

Among insects, *Drosophila melanogaster* has become an indispensable model organism in genetics, development, and behaviour. Over the past two decades, it has also been increasingly used to study tumour biology, including metastasis (Mirzoyan et al. 2019; Bilder et al. 2021; Gong et al. 2021; Miles et al. 2011). Because of its unparalleled genetic tractability, short generation time, and the conservation of key signalling pathways with mammals, *D. melanogaster* and related species offer a unique bridge between reductionist molecular oncology and systems-level evolutionary perspectives. Through sophisticated genetic manipulations, researchers have engineered flies with tumours that faithfully reproduce several hallmarks of human oncogenesis, including uncontrolled proliferation, tissue invasion, and disrupted intercellular communication. These experimentally induced neoplasms often involve activation of oncogenic *Ras*, hyperactivation of the JAK/STAT signalling cascade, or loss of epithelial cell polarity, alterations that parallel those observed in many human cancers (Wu et al. 2010; Amoyel et al. 2014; Igaki et al. 2006; Dillard et al. 2021; Enomoto et al. 2021). Moreover, research on *Drosophila* spermatogenesis has revealed that mutations affecting the regulation of germline stem cells can lead to tumour-like over-proliferation within the testes, mirroring key features of vertebrate testicular cancers (Hime et al. 2007). These parallels further emphasize the relevance of insect models for elucidating conserved oncogenic mechanisms across organ systems (see also Rossi et al. 2017; Suo et al. 2016; Robles-Fort et al. 2021).

Beyond reproducing specific molecular lesions, *Drosophila* tumour models have been instrumental in revealing how oncogenic pathways interact to drive malignancy. For instance, co-activation of RasV12 with loss of polarity genes such as *scribble* or *dlg* leads to cooperative tumour growth, invasive behaviour, and activation of stress-responsive signalling through the JNK and Hippo pathways (Wu et al. 2010; Igaki et al. 2006; Pagliarini and Xu 2003; Stefanatos and Vidal 2011). These studies have shown that tumourigenesis is not solely a cell-autonomous process but also depends on intercellular communication, microenvironmental feedback, and competitive interactions within tissues (Bilder et al. 2021; Gong et al. 2021). The experimental tractability of *Drosophila* allows real-time visualization of clonal expansion, metastasis-like dissemination, and tumour–host interactions under precisely controlled genetic backgrounds (Mishra-Gorur et al. 2019; Sharpe et al. 2023). Such approaches establish *Drosophila* as a model for integrating developmental biology and oncology, providing an evolutionarily conserved framework to investigate how multicellular cooperation can break down under oncogenic stress (Choutka et al. 2022; Badmos and Cagan 2025)

Drosophila as a conceptual and experimental model for exploring the evolutionary ecology of host-tumor interactions

Beyond their molecular relevance, *Drosophila* models provide an elegant platform for testing ecological and evolutionary hypotheses about cancer. These systems allow researchers to experimentally connect the internal dynamics of tumour growth with organismal behaviour, life-history strategies, and ecological interactions, dimensions that are seldom accessible in vertebrate models.

In a pioneering study, Arnal and colleagues investigated how tumour development influences reproductive timing in *D. melanogaster* (Arnal et al. 2017). Using a genetically engineered strain that develops colorectal-like tumours, the authors tested the hypothesis that cancer may induce a terminal investment strategy, whereby individuals shift reproductive effort earlier in life to compensate for reduced survival prospects. They found that cancer-bearing females advanced their oviposition peak by approximately two days (which is significant for an insect that only lives on average 28-30 days) compared to healthy controls, without altering the total number of eggs produced. This pattern reveals a plastic life-history adjustment, an adaptive response that maximizes reproductive output before death and exemplifies how somatic pathologies can reshape the trade-off between longevity and fecundity. Such results echo theoretical expectations from life-history evolution, suggesting that the presence of tumours can act as an internal stressor or signal of reduced expectation of life driving the reallocation of energetic resources toward immediate reproduction. Interestingly, this form of adaptive reproductive shift, long recognized in hosts facing castrating or lethal parasitic infections (Agnew et al. 2000; Michalakis 2009), was, until recently, unknown in the context of cancer. The discovery of such a pattern in *Drosophila* opened new perspectives on how internal somatic threats can trigger evolutionary responses akin to those induced by parasitic stress. Similar phenomena have since been documented in other systems, including invertebrates such as hydras (Boutry et al. 2022a) and vertebrates such as Tasmanian devils (Jones et al. 2008), suggesting that cancer, like parasitism, can act as a selective force shaping reproductive strategies across taxa (Boutry et al. 2020; Dujon et al. 2022a; Ujvari et al. 2016).

Building on this framework, subsequent studies have broadened the ecological scope of *Drosophila* cancer models. In particular, Dawson and colleagues showed that the social environment significantly influences tumour progression in flies (Dawson et al. 2018). In their experiments, flies carrying genetically induced gut tumours were housed under different social conditions (e.g., isolated, in groups of healthy flies, or in groups with other tumour-bearing flies), and the authors found that social context modulates the pace of tumour growth. Moreover, flies were capable of discriminating between individuals at different tumour stages and selectively choosing their social partners accordingly, preferring to associate with healthier individuals over those bearing more advanced tumours. This behavioural modulation has several possible ecological and mechanistic interpretations. On one hand, avoidance of highly diseased conspecifics may reduce exposure to pathogen- or tumour-promoting stressors or limit competitive costs and resource depletion associated with illness. On the other hand, preferential association might buffer less severely affected flies from negative influences of severely ill conspecifics, including those bearing advanced tumours (e.g. altered metabolite profiles, immune or inflammatory signals). In this sense, cancerous individuals may not represent a unique category but rather fall within a broader class of diseased individuals. Nevertheless, this work highlights that tumour-bearing flies, like other sick individuals, are not merely passive victims of pathology but can actively restructure their social environment, with potential consequences for individual- and group-level disease dynamics.

More recently, Duneau and Buchon provided compelling evidence that tumourigenesis can influence ecological interactions beyond intraspecific ones (Duneau and Buchon 2022). In their laboratory experiments, they used *D. melanogaster* flies with genetically induced intestinal cancers alongside healthy controls, exposing them to hunting spiders (jumping spiders and wolf spiders) as predators. They found that flies with advanced-stage cancers faced a significantly higher predation risk compared to healthy flies, whereas early-stage hyperplasia did not cause a marked difference in predation. Furthermore, the preference index of spiders (a measure of selective predation) increased with tumour severity, indicating that more heavily afflicted individuals were preferentially targeted.

Collectively, these studies transform *Drosophila* from a molecular model into a conceptual laboratory for evolutionary oncology. By linking tumour progression to behavioural, reproductive, and ecological outcomes, they reveal that cancer is not only a cellular pathology but also an evolutionary agent influencing life-history strategies, social organization, and survival via interspecific interactions.

Beyond *Drosophila*: mosquitoes and the ecology of cancer

Insects have also been discussed in more speculative but thought-provoking contexts linking cancer, vectors, and ecology. Arnal and colleagues explored four provocative questions: (1) Can mosquitoes themselves develop cancer? (2) Could they transmit cancer cells between hosts, as they transmit pathogens? (3) Can they act as vectors for oncogenic pathogens? (4) Do mosquitoes prefer to feed on cancerous individuals? These questions, though primarily conceptual, aimed to spark discussion about how vector biology and oncology might intersect (Arnal et al. 2020). The authors argued that while the short lifespans of mosquitoes, together with their largely post-mitotic adult tissues and limited somatic cell turnover, likely reduce the temporal window for tumour initiation and progression, their ecological interactions could still influence oncogenic processes indirectly, for example through the transmission of viruses, chronic immune modulation, or exposure to environmental carcinogens. This conceptual framework laid the groundwork for a more integrative eco-oncological perspective, suggesting that hematophagous insects, by linking vertebrate hosts, pathogens, and contaminated environments, may play a subtle but significant role in shaping disease dynamics.

Building on this theoretical foundation, Arnal et al. (2025) conducted the first experimental test inspired by these ideas. They examined whether mosquitoes exposed to sublethal doses of malathion (see Cutler, this issue), a widely used pesticide with known mutagenic potential, would alter their feeding preference toward cancerous or healthy hosts. The results did not support the predicted behavioural shift, yet transcriptomic analyses revealed strong molecular responses to pesticide exposure, including upregulation of oxidative stress, detoxification, and immune signalling pathways. These findings indicate that environmental contaminants can profoundly reshape mosquito physiology without triggering tumour formation, underscoring that indirect eco-toxicological effects may be more biologically relevant than direct oncogenesis in these systems. Together, the two studies delineate the conceptual and experimental boundaries of mosquito–cancer interactions and highlight the importance of viewing vectors not as direct agents of cancer transmission, but as sentinels and modulators within a broader eco-evolutionary network linking pollution, immunity, and oncogenic risk across species.

What insects can tell us about the evolution of somatic maintenance
From an evolutionary perspective, insects offer a unique window into how ecological pressures and life-history strategies shape the trade-offs governing somatic maintenance. Many species combine short life spans, rapid reproduction, and high extrinsic mortality, conditions under which selection for long-term tumour suppression may be weak. Yet, these same features make insects excellent models for studying how somatic integrity is maintained under fluctuating environmental and physiological constraints. In eusocial taxa such as ants, bees, and termites, where reproductive and somatic roles are partitioned among castes, the regulation of colony health mirrors the organization of multicellular bodies: queens act as the germ line, while workers collectively perform functions akin to somatic maintenance. Investigating cancer-like processes or cellular conflicts in these systems can

thus illuminate how selection operates across biological hierarchies to preserve cooperation and suppress selfishness.

Beyond intrinsic factors, insects are constantly exposed to extrinsic stressors (e.g., temperature fluctuations, parasites, pathogens, and anthropogenic pollutants such as pesticides) that can influence somatic stability. Chronic or sublethal exposure to such compounds, as shown in recent transcriptomic work on mosquitoes (Arnal et al. 2025), can profoundly alter detoxification, oxidative stress, and immune pathways, potentially affecting mutation rates, tissue repair, and overall fitness (Arnal et al. 2020; Lu et al. 2021). These findings highlight that environmental stress may modulate the balance between somatic maintenance and deterioration even in organisms with short life cycles. Integrating these ecological, toxicological, and evolutionary dimensions transforms insects into powerful models for exploring how selection, environment, and physiology jointly shape the evolution of somatic resilience across the tree of life.

A recent comprehensive review (Thomas et al. submitted) synthesizes growing evidence that cancer should be understood as a multiscale evolutionary process, emerging from interactions between cells, tissues, organisms, and their environments. The authors emphasize that tumour progression is shaped not only by genetic alterations but also by ecological interactions and systemic constraints, calling for integrative frameworks that bridge molecular oncology with evolutionary and ecological theory. This synthesis aligns closely with the perspective developed here, in which insects serve as powerful systems for exploring how somatic conflicts, environmental stressors, and life-history strategies jointly influence cancer dynamics. By situating cancer within a broader evolutionary landscape, this work further validates the use of diverse biological systems to uncover universal principles of tumor evolution and control.

Other directions

In an entirely different but equally thought-provoking line of research, ants have recently been shown to detect human cancer cells through olfactory cues. Piqueret et al. (2022, 2023) demonstrated that *Formica fusca* workers can learn to discriminate between the odours of healthy and cancerous human cell lines after only a few conditioning trials, responding to volatile organic compounds specifically emitted by tumour cells. In parallel, electrophysiological studies on locusts have revealed that insect olfactory neural circuits can also discriminate cancer-related volatile signatures with high accuracy, suggesting that these neural architectures could be harnessed for bio-sensing applications (Farnum et al. 2023). This remarkable convergence highlights the potential of insect sensory systems to perceive biochemical signatures of oncogenesis and underscores once again the diverse ways insects can contribute to cancer research, from genetic and ecological models to neurobiologically inspired diagnostic tools (see also Parnas et al. 2024 for an example involving bees).

Beyond their relevance as biological and ecological models of tumour evolution, insects also provide unexpected bridges to cancer therapeutics. Many compounds originally developed as antiparasitic or insecticidal agents have later shown strong anti-tumour potential in vertebrates, highlighting the conservation of key cellular mechanisms across distant taxa. One striking example is, though not insect-specific, is flubendazole, a benzimidazole anthelmintic widely used against parasitic worms, which has been shown to exert potent anti-tumor effects in various cancer types through disruption of microtubule dynamics, induction of apoptosis, and autophagy-mediated cell death (Chen et al. 2022). Likewise, insect-derived peptides themselves emerge as promising anticancer agents. For instance, Lee et al. (2021) demonstrated that poecilocorisin-1, a peptide isolated from the true bug *Poecilocoris lewisi*, exhibits strong antitumour activity against human skin cancer cells by modulating the transcription factor Sp1 and promoting apoptotic pathways (see also Małek et al. 2023; Adamski et al. 2019).

Very similarly, mineral molecules such as iron oxide nanoparticles secreted by mealworms (*Tenebrio molitor*) fed an iron rich diet, have also been explored as a way to produce safe and biocompatible vectors for the delivery of molecules and gene therapies targeting cancer cells (Majd-Marani et al. 2025). These findings expand the scope of insect-based oncology beyond modelling and sensing, suggesting that insect biomolecules could inspire a new generation of bioactive compounds with therapeutic potential (see also (Lee et al. 2021; Ratcliffe et al. 2011)). Such repurposing and bioinspired translation underscore how evolutionary conserved cytoskeletal, regulatory, and proliferative pathways can be exploited across species boundaries. This translational continuum, from ecological insights into host–parasite interactions to pharmacological applications in oncology, exemplifies how studying cancer through an evolutionary and comparative lens, including insects, can inspire novel therapeutic perspectives and drug development strategies. Interestingly, insects also manipulate development in other kingdoms: Raman (2011) reviews how gall-inducing insects reprogram plant tissues to form elaborate structures, highlighting the capacity of insect effectors to hijack host morphogenetic pathways. This cross-kingdom example underscores the deep parallels in how small signals from insects or tumours can rewire host development.

Limitations of insect models for cancer research

Despite their considerable potential, insect models present important limitations for cancer research. Their lack of an adaptive immune system restricts direct comparisons with vertebrate tumour–immune dynamics, which play central roles in both cancer progression and therapeutic response. Likewise, their relatively simple body plans and the absence of certain organ systems limit investigations into tissue-specific oncogenesis or metastasis-like dissemination. In addition, the short lifespans of most insect species constrain the temporal window for tumour initiation, clonal evolution, and long-term somatic deterioration.

Yet, these very limitations can be turned into strengths. Insects represent early-evolved multicellular systems that have diversified under strong ecological and environmental pressures. Studying them can thus help identify which hallmarks of cancer are fundamental outcomes of multicellularity and which depend on more derived features such as complex organ structure or adaptive immunity. Moreover, their ecological exposure to chronic stressors, including parasites, temperature extremes, and anthropogenic pollutants like pesticides, adds a valuable dimension rarely accessible in vertebrate models. As shown by Arnal et al. (2025), sublethal exposure to environmental contaminants can reshape physiological and transcriptomic landscapes even in the absence of tumour formation, revealing how exogenous factors interact with somatic maintenance. In this sense, insects provide essential conditions for defining the minimal ecological, physiological, and evolutionary requirements for tumour emergence, persistence, and suppression across life forms.

Future directions: toward an eco-evolutionary oncology of insects

Insects could play a central role in establishing a truly integrative understanding of cancer, one that unites molecular mechanisms, ecological interactions, and evolutionary theory within a single framework. Their extraordinary diversity, ecological ubiquity, and responsiveness to environmental stressors make them ideal systems for investigating how selection shapes somatic maintenance across levels of biological organization.

Several promising research avenues emerge from this perspective:

- Behavioural ecology of cancer: Assessing how tumour-bearing individuals alter their social interactions, mating behaviour, or competitive strategies under natural or semi-natural conditions, and how such behaviours feedback on tumour progression.
- Experimental evolution: Using short-lived genera such as *Drosophila* or *Aedes* to explore how populations evolve resistance or tolerance to oncogenic mutations and environmental carcinogens across generations.
- Environmental stress and tumour dynamics: Expanding research on pollutants, temperature variation, and nutritional stress to evaluate their influence on somatic stability, mutation accumulation, and tumour initiation (e.g., Dujon et al. 2024). The recent findings of *Arnal et al.* (2025), illustrate how sublethal pesticide exposure can profoundly modify

transcriptomic pathways linked to detoxification and oxidative stress, even in the absence of tumour formation.

- Eusocial insects as analogues of multicellular cooperation: Investigating whether colony-level regulation of health in ants, bees, or termites can illuminate the evolution of cancer suppression mechanisms at higher levels of biological hierarchy.
- Cross-kingdom and vector-mediated interactions: Testing speculative but increasingly tractable hypotheses about vector-borne or environmentally-mediated modulation of oncogenic processes, including the indirect effects of mosquitoes and other hematophagous insects on host immunity, microbiota, or viral ecology.
- By combining these approaches, researchers can transform insect models into versatile, eco-evolutionary laboratories for probing the general laws that govern cancer emergence, adaptation, and containment. Integrating insect ecology, environmental toxicology, and evolutionary oncology will help bridge the conceptual gap between the cellular origins of cancer and its ecological consequences at population and ecosystem levels.

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Resistance is Futile?

Bernie Roitberg

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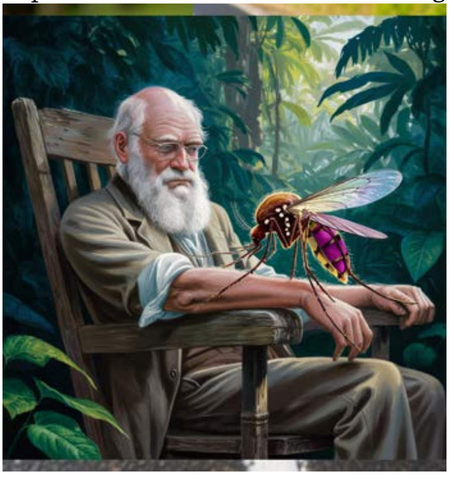
Time after time, whether in agriculture or human health, we have applied tactics meant to either reduce the number of pest organisms or at least their impact. These tactics have ranged from chemical pesticides (e.g., indoor



residual sprays against malarial mosquitoes, CDC 2024) to physical barriers (e.g., row covers to protect plants from insect herbivores, Athey et al. 2022) to behavioural exploitation (e.g., via sex pheromones against frugivores, Thiery et al. 2023) and others. And, time after time, we have witnessed those target pests evolving resistance to such tactics. In some cases, resistance appears *de novo* however, in others, it appears that the mechanisms underlying such resistance have been around for thousands of generations but now prove beneficial for them against new challenges; simply put, this is old wine in new bottles (Pennisi 2023).

Populations evolve resistance when trait variants that confer improved survival and/or reproduction in the face of a control tactic become more common e.g., individuals with highest sequestration rates produce relatively more offspring in the face of some chemical biocide. At first blush, this seems like an impossible task for the pest manager who will be caught in some kind of arms race; an increase in dosage leads to higher sequestration rates which leads to an even higher dosage with concomitant response.

There are some workarounds that can be effective in defusing a resistance response. The first one is very simple: employ tactics at such high values that they are well beyond the normal range of resistance such that no variants in the pest population survive and proliferate. When this holds, the target population will not evolve resistance. For example, it is highly unlikely that, when applied properly, that a population of flies will ever evolve the ability to negate the lethal damage caused by a flyswatter or, more appropriately for this article, that mosquitoes will ever evolve the ability to pass through mosquito netting to feed on their human hosts.

Of course, resistance can take many paths. The aforementioned flies might evolve resistance to flyswatters by avoiding them altogether either via stimulus dependent responses (e.g., enhanced reaction to movement), or stimulus-independent behaviour (e.g., lower activity rates that leads to fewer encounters with flyswatters) regardless of their physical susceptibility to the swatter. In that same manner, mosquitoes can overcome the physical barrier of the bednet by evolving toward altered activity cycles to initiate feeding earlier in the day, which leads to encounters with human hosts before such persons take shelter (Thomsen et al. 2017). Even when the tactic is significantly more sophisticated than a flyswatter, for example gene drive (Champer et al. 2016), there is still potential for resistance evolution (Target Malaria 2022). The arms race continues.

There is a second approach that deserves more consideration: elucidation and exploitation of low or non-evolvable resistance traits. Typically, traits do not readily respond to selection if they have low heritability and/or they are tied to some other key life history traits e.g., antagonistic pleiotropy (Williams 1957). As an example of the latter, resistance traits might be non-evolvable when expressing resistance generates fitness costs in some other part of the organism's life history. It follows that if the physiological cost of sequestration is high, it may not be possible for an insect herbivore to evolve resistance to highly toxic plants (Pokharel 2023). How might we exploit such tradeoffs in insect disease vectors?

Take the malaria vector *Anopheles gambiae*. Despite being a highly effective vector, there are critical aspects to its life history that may be exploited as control tactics with low or no resistance evolvability (Hoi and Roitberg 2014). Adult females must acquire both sugar (as nectar) and blood to survive and reproduce, respectively (Foster 1995). However, due to physical constraints of anopheline anatomy, it is not possible for an individual female to sequentially feed to repletion in quick succession on both resources The payoffs for doing so are size and energy-state dependent i.e., this is a complicated tradeoff (Roitberg and Friend 1991). Furthermore, these two non-substitutable resources are found in different habitats, meaning that individual mosquitoes must move from one site (the domicile) to the other (the field) to acquire each of those nutrients. However, there is significant mortality risk in doing so, again in a state-dependent manner (Roitberg et al. 2003).

Now, suppose we develop tactics that exploit these tradeoffs. For example, suppose we keep nectar-bearing plants at considerable distance from human domiciles and thus reduce mosquito ability to sustain search for blood meals as well as their survivorship (Roitberg and Mangel 2010). One possible evolutionary response would be for mosquitoes to evolve toward extracting energy from bloodmeals for somatic function at the expense of gametic performance. This will be a difficult evolvable response. As noted above, this change in feeding strategy would be both physiologically very costly (e.g., Benoit et al. 2011) but also dangerous—it is a lot safer to feed on a flower than on a human. Similarly, it is not possible for anophelines to forego feeding on blood sources in order to reproduce; to my knowledge, autogeny is not an option in any *Anopheles* mosquitoes based upon larval ecology and adult physiology and anatomy.

In addition to managing location of nectar sources, it is also possible to make such sources dangerous as a kind of ecological trap (Schlaepfer et al. 2002). Work in Mali with poison sugar baits shows great promise (Muller et al. 2010; Traore et al. 2020) however, as noted above, this might take us back to the problem of physiological or behavioural resistance.

There is another feature of mosquito biology and biting behaviour that is critical to the spread of malaria: for malaria to increase in incidence, an individual mosquito must first bite an infected human and then some days later, when infectious, feed on a healthy individual. When such mosquitoes move widely between blood-feeds 1 and 2, the more likely that they will feed on different hosts and that the conditions above are more likely to hold and malaria prevalence will increase. Again, working from the blood-feeding-sugar-feeding dichotomy described above it should be possible to optimize the distance between domiciles and nectar sources to minimize biting heterogeneity without any obvious resistance evolution. This is not quite as easy as it sounds since the optimal distance for reducing biting heterogeneity may differ from the optimal distance to reduce mosquito evolutionary fitness as above, but I do not see great difficulties in solving this tactics tradeoff problem, computationally (e.g., Mangel 2006). The greater difficulty may come in convincing stakeholders to alter their land use priorities.

My points in discussing the scenarios above goes beyond management of human health and the knock-on effects from traditional approaches (Knols 2024). First, we need not see resistance as some inevitable outcome from applying management tactics however our ability to avoid such obstacles will rely on our knowledge of arthropod ecology and evolution. Thus, I echo the great entomologist, Bill Wellington's call to put the insect back in insect ecology (Wellington 1977).

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Emerging Arthropod-Borne Diseases and The One Health Concept

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Introduction

Regardless of the arthropods we study, whether we seek to conserve, promote, collect, or eliminate them, we tend to recognize the crucial role of diversity for the health and integrity of ecosystems. As proponents of integrated pest management, we understand the interconnectedness of the environment and the beings within it. The modern One Health concept originated in 2004 from a symposium organized by the Wildlife Conservation Society, where 12 recommendations, the Manhattan Principles, were drafted in response to growing concern over the spread of severe acute respiratory syndrome (SARS) and highly pathogenic avian influenza H5N1 (Gibbs 2014; Mackenzie and Jeggo 2019). "One Health" essentially acknowledges that the health of humans, domestic animals, and wildlife is 'one'. The concept of shared, inclusive health principles across animal, human, and ecosystem health is not inherently new. This holistic approach is ingrained in Indigenous approaches to health (e.g., the Medicine Wheel) and in early writings by Hippocrates and Aristotle, which framed the dogma of Western medicine by defining public health as the intersection of animal, human and environmental well-being (Hillier et al. 2021; Pitt and Gunn 2024). Twenty-two years later, the concept has been adopted by international agencies, policy and government bodies, and academia, and has woven its way into the public sphere through mainstream media coverage. At its core, the One Health concept emphasizes a multi-faceted approach – including the triad of human, animal, and environmental health – to understand the emergence, persistence, and drivers of zoonotic infectious diseases.

A large proportion of these emerging zoonotic pathogens are vector-borne (Kreuder Johnson et al. 2015), which is where entomologists enter the conversation. Three elements are required for a vector-borne infection to occur: a host – the organism that will develop the infection; a pathogen – the infectious agent that will cause disease in the host; and a vector – the organism that will transmit the pathogen from one host to another. This three-way interaction occurs within an environment that may facilitate or impede transmission. Therefore, arthropod-borne diseases readily lend themselves to this One Health lens. Many arthropods can transmit infectious agents that cause disease in humans and other animals. Transmission is typically described as "mechanical" when the vector transfers the pathogen by moving it from one host to another, and as "biological" when the pathogen multiplies and/or develops within the vector (or non-circulative versus circulative, respectively, in the lingo of plant pathologists). Arthropods are also mobile, moving from host to host, facilitating zoonotic transmission as they move between animals and humans in the environment. Lastly, arthropods are highly susceptible to climatic changes which continue to affect their phenology and ecology (Dantas-Torres et al. 2012; Day 2011; Forrest 2016).

Here, we present two arthropod-borne diseases emerging in Canada through a One Health lens. We first focus on anaplasmosis, a largely tick-borne disease, followed by bartonellosis, which is primarily louse-borne. While other vector-borne diseases are endemic, emerging, or re-emerging in Canada (e.g., West Nile virus, Lyme disease, Eastern Equine Encephalitis, Rocky Mountain Spotted Fever), we chose to focus on disease systems that have not received much mainstream attention and lend themselves to interesting contrasts and comparisons.

Anaplasmosis

Bacteria from the genus *Anaplasma* (formerly tribe *Ehrlichieae*) are obligate Gram-negative, blood- and vector-borne intracellular parasites. Numerous *Anaplasma* species can cause disease, known as anaplasmosis, which is defined largely by the affected host (e.g., bovine, canine, equine, or human) and the infected blood cell type (i.e., monocytes, erythrocytes, granulocytes, or platelets) (Rymaszewska and Grenda 2018). General symptomology involves fever, headache, and muscle pain, as well as more severe splenic and hepatic involvement (Dumler 2005). *Anaplasma phagocytophilum* and *A. marginale* have the greatest impact globally, affecting animal, human, and economic health. They are both present in Canada and are the focus of this first section.

Infection with *A. phagocytophilum* is cosmopolitan in both host and geography and is often termed human granulocytic anaplasmosis (HGA) in humans, tick-borne fever in domestic animals, and equine anaplasmosis in horses. While symptoms are mostly non-specific and relatively mild in humans, infections in mammals can cause low fertility, decreased milk yield, abortion, depression, and edema (Atif 2015). Transmission is predominantly tick-borne via bite, although blood-borne transmission has been documented (Atif 2015). In Canada, blacklegged ticks (*Ixodes scapularis* Say) and western blacklegged ticks (*Ixodes pacificus* Cooley & Kohls) are the main vectors. Human cases of anaplasmosis were rare in Canada and the United States, but the number of infections has increased over the last decade (Baker et al. 2020; Dai et al. 2025; Manitoba Health, Seniors and Active Living 2020). The disease became reportable in Manitoba in 2015, when active surveillance detected an increase in infected ticks and the emergence of human infections (Manitoba Health, Seniors and Active Living 2016). Then, there was an 'unusual' cluster of 25 cases in Québec in 2021 (Campeau et al. 2022). Human anaplasmosis became a nationally notifiable disease in 2024; that year alone, 673 cases were reported (Public Health Agency of Canada 2026), representing a significant shift in disease burden. Spatial modelling in the Northeastern United States demonstrates that the expansion of human anaplasmosis mirrors the early spread of Lyme disease; however, there were clear geographic 'hot spots' for anaplasmosis, showing a radial pattern, as opposed to the general diffusion historically observed with Lyme (Russell et al. 2021). While this granularity has not been applied in a Canadian context, maps of publicly available case counts (Ontario Agency for Health Protection and Promotion 2026) appear to show a similar pattern.

This rise in human anaplasmosis incidence is closely associated with the northward range expansion of blacklegged ticks, driven by changes in climate, particularly increasing temperatures, that favour tick survival (Bouchard et al. 2019; Sonenshine 2018). Ticks spend most of their natural lives at ground level, so changes in local microclimates influence their survival and activity. Blacklegged ticks are more active during warm winter conditions (Ferguson et al. 2024), and warmer winters mean shorter periods of snow cover, which in turn extend the activity period for ticks and increase the likelihood of encounters (Bouchard et al. 2019). The animal-host component is also changing as small mammal communities shift in favour of white-footed mice and eastern chipmunks (Millien et al. 2023; Myers et al. 2009). Incidentally, these two small mammal species are important reservoirs for *A. phagocytophilum*, and are especially competent at infecting larval ticks, thereby contributing to the maintenance of the pathogen in the environment (Audet-Legault et al. 2025). While there is increasingly strong scientific evidence that spending time in nature is beneficial for human health (Nejade et al. 2022), there are risks: the majority of tick-borne infections in humans are acquired during yard work or outdoor recreational activities (Campeau et al. 2022; Dumas et al. 2024) thus reinforcing the importance of the One Health lens.

In contrast, *A. marginale* acts as the causative agent of bovine anaplasmosis, affecting cattle and bison. The bacterium can be spread biologically by ticks and mechanically by large biting flies, and is endemic in tropical and subtropical regions (Kocan et al. 2010). Infections range from asymptomatic to severe, including anemia, reduced weight gain and lactation, abortion and increased mortality, all resulting in significant losses for producers; recent estimates place the average cost at US$ 660 per clinical case (Railey and Marsh 2021). Surviving animals remain infected for life and serve as reservoirs for the pathogen (Ierardi 2025). Canada was considered anaplasmosis-free, having identified – and eradicated – only five bovine anaplasmosis occurrences between 1968 and 2000, mostly associated with imported cattle (Howden et al. 2010). Surveillance for bovine anaplasmosis in Canada was conducted as part of the national bovine serological survey (BSS), which occurs every 3-5 years. Until 2014, the disease was a nationally reportable animal disease and was managed by a test-and-cull program with producer compensation. From 2008 to 2013, several outbreaks of *A. marginale* were detected in Manitoba, Saskatchewan, Ontario, and Quebec (Paré et al. 2012; Yunik et al. 2016). This increase in the number of cases and the associated costs of continued eradication efforts led to legislative changes in 2014, which included ending surveillance, removing testing requirements for imported animals, and ending compensation to producers for infected animals (Smylie 2014). There have been multiple cases of bovine anaplasmosis in Canada in the last decade, suggesting the disease may become established in some regions. This comes at a cost to producers, who now bear the burden of the disease: the responsibilities and expenses of testing animals they purchase and culling infected animals fall on them. So, while bovine anaplasmosis is not a disease of humans, this arthropod-borne disease can affect the mental health of producers and the economic health of our livestock industry, again emphasizing the need for a One Health approach. The main drivers of the emergence of bovine anaplasmosis include the movement of infected animals and the use of blood-contaminated tools, but the range expansion of two tick species, *Dermacentor andersoni* Stiles and *Dermacentor variabilis* (Say), should not be overlooked (Dergousoff et al. 2013; Dergousoff et al. 2025).

Bartonellosis

Bacteria of the genus *Bartonella* are Gram-negative, intracellular, blood- and vector-borne, and cause persistent infections in their hosts. Infection is often associated with the heart (i.e., endocarditis), though other manifestations of infection include peliosis (a vascular condition within organs resulting in blood-filled cysts), relapsing fever, and lymph node inflammation (Chomel et al. 2009; Jacomo et al. 2002). Before, 1990, *Bartonella* spp. infections were essentially associated with two human diseases: Carrion's disease (*B. bacilliformis)*, and trench fever (*B. quintana*). Currently, at least 13 other *Bartonella* species have been identified as pathogenic, all affecting the heart and causing valvular-related, often fatal lesions in humans and other animals, including dogs, cats and cattle (Chomel et al. 2009; Regier et al. 2016). Multiple wildlife reservoirs have been identified, including rodents, lagomorphs, and cervids, as well as additional *Bartonella* spp.-positive taxa such as bats, reptiles, and marine mammals, whose role in transmission remains unknown (Breitschwerdt and Kordick 2000; Regier et al. 2016). Unlike most other vector-borne pathogens that tend to have species-specific transmission routes, *Bartonella* spp. are known to be transmitted both mechanically and biologically by numerous arthropods, including sand flies, lice, fleas, mites, and ticks, with infection noted in keds and other biting flies from the family Hippoboscidae (Regier et al. 2016). Bacterial prevalence throughout the animal kingdom is not well known, but estimates in vertebrates are high, ranging from 50-95% (Breitschwerdt and Kordick 2000).

In Canada, bartonellosis in humans is caused by two species, *Bartonella henselae* and *Bartonella quintana.* Fleas (*Ctenocephalides* spp.) can transmit *B. henselae* to domestic animals. This infection is known as 'cat scratch disease' because it is spread through scratches from claws contaminated with infected flea frass containing *B. henselae.* Although transmission primarily occurs in cats (Karem et al. 2000), serological evidence also shows infection in dogs (Gary et al. 2006). *Bartonella quintana* is spread through the bite of lice, primarily the body louse *Pediculus humanus corporis/humanus* L. (Karem et al. 2000), although head lice (*Pediculus humanus capitis* De Geer) have also been implicated (Petel et al. 2025). Unlike head lice, which live on the scalp, body lice reside and reproduce on clothing rather than hair. As such, the increased incidence of *Bartonella* infections in North America appears to be driven by socioeconomic factors, including housing availability, access to veterinary care, and hygiene practices (Boodman et al. 2024b; Lashnits et al. 2019).

In the case of *B. quintana,* the term 'urban trench fever' has emerged to characterize the increasing prevalence of the disease among unhoused individuals (Brouqui and Raoult 2006). Cases of 'urban trench fever' in Canada are increasing (Boodman et al. 2024b), and organ donor-derived *B. quintana* infection from deceased individuals who experienced houselessness has become a secondary emerging public health issue (Boodman et al. 2024a). This increase in *B. quintana* cases likely reflects a 'perfect storm' of socio-economic and eco-parasitic factors (Raoult 2001). Indeed, limited access to water, reduced hygiene practices, shared bedding and clothing, and overcrowding of hosts all contribute to rapid vector multiplication and favour the propagation of a highly contagious pathogen. These shifts demonstrate a markedly different relationship between humans and the environment: that of the 'built' rather than 'natural' space, a known factor exacerbating the emergence of infectious diseases (Patz et al. 2004).

Concluding remarks

How humans relate to the environment has evolved dramatically throughout our history, shifting from shared hunter-gatherer lands to privately traded property that we exploit or seek to preserve (Adam 2023). Whether we spend time in nature, managed yards, rural or urban environments, we are in contact with arthropods that can affect our health. Herein, we presented examples of vectors (ticks and body lice) that feed on hosts, whether human, livestock, or wildlife, and in doing so readily transmit pathogens that affect human health. Exposure to these arthropods is tied to the environments we spend time in, and in both cases, the modifications we have made to our "habitat" promote arthropod development and increase the risk of encounter. However, affected populations differ socio-economically: human anaplasmosis, transmitted by blacklegged ticks, is linked to yard work and outdoor recreational activities, implying property ownership, access to nature, and time for leisure; in contrast, urban trench fever, transmitted by body lice, is associated with overcrowding and limited access to water, implying extreme precarity and vulnerability. Integrated pest management and One Health closely align in their principles for promoting and preserving human and environmental health, and the management of vector-borne zoonotic diseases must embrace both concepts.

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Entomology in the Third Reich: Studying Flea Beetles under Fascism

Alec McClay

Alec McClay (alecmcclay001@gmail.com) worked for many years in biological control of invasive plants, with the Commonwealth Institute of Biological Control, the Alberta Environmental Centre and Alberta Research Council, and later as an independent consultant. In retirement he has become a keen user of iNaturalist, is learning Irish, and spends a little too much time worrying about the state of the world.

In 1944, as the chaos and destruction of the Second World War were building to a climax, the Viennese entomologist Franz Heikertinger completed and published a monumental study of a genus of flea beetles (Coleoptera: Chrysomelidae: Alticinae) (Heikertinger 1944). By this time, Austria had been under brutal Nazi occupation for six years, since its absorption into the German Reich in the Anschluss of 1938. Allied armies had landed in Italy in the previous September and in Normandy in June. Vienna was already under increasingly heavy aerial bombardment from Allied forces, and within a few months German forces would be driven out of the city, amid fierce street fighting, by the advancing Soviet armies. Much of the city would be left in ruins (Wikipedia 2025a).

This was the setting in which Heikertinger reviewed the 85 known Palaearctic species of the genus *Aphthona*, developed identification keys for them, described their morphology, distribution and host plants, illustrated the male genitalia of 40 species, and described five new species and several new forms and varieties. For good measure he added three supplements on the *Aphthona* of Japan, China, and British India. In July of 1944, he published these findings in 89 pages of volume 30 of the *Koleopterische Rundschau, KR* (*Coleopterological Review*), the journal that he himself had edited since 1918, and would edit for the rest of his life. In the paper, the war is mentioned only twice, in passing, to lament the difficulties that it had occasioned in exchanging information and specimens with colleagues in other countries.

Figure 1. Franz Heikertinger. Portrait from Klausnitzer (2003).

The existence of this paper has fascinated and puzzled me since I first became aware of it. What are we to make of it? How was it possible that in the midst of such unspeakable hardship and horror, someone could dedicate such effort and commitment to the study of a group of tiny, inconspicuous, plant-feeding beetles, and leave us a permanent record of his findings? Who was Franz Heikertinger and what part did he play in the scientific community and in Austrian society at large? Recently have I tried to answer some of these questions: partly perhaps because I am retired and have more time on my hands, but also because I find myself thinking more these days about the position of scientists in turbulent political times. I am not by any stretch an historian or a German scholar, but with the help of Wikipedia and Google Translate, I have managed to learn a bit about Heikertinger, his work, and its context.

Heikertinger was born in Vienna in 1876 and spent his youth in the Austria of "La Belle Époque", the long period of relative stability and prosperity in Europe between the end of the Franco-Prussian War in 1871 and the outbreak of the First World War in 1914 (Stein undated). Vienna was then the capital of the Austro-Hungarian Empire, under the autocratic rule of the Habsburg Emperor Franz Joseph, and was enjoying a flowering of the arts, culture and economy. During this period many imposing new public buildings were built, such as government ministries, the Opera, and the Hoftheater. Sanitation, water supplies, and transportation were improved, and the population of the city surpassed one million. The Postal Savings Bank, in which, as we will see, Heikertinger spent his entire non-entomological career, built an imposing new headquarters building, opened in 1910. It was designed by the famous architect Otto Wagner and considered one of the finest examples of the Viennese Secession school. Composers such as Johann Strauss the Younger, Gustav Mahler, Anton Bruckner, and Arnold Schoenberg, and artists such as Gustav Klimt, Egon Schiele, and Oskar Kokotschka were developing new musical and graphic styles. Tellingly, though, both Mahler and Schoenberg had to convert from Judaism to Catholicism to be accepted in Viennese musical society. Another aspiring young Austrian artist spent a few years before the First World War trying to make a living in Vienna: his name was Adolf Hitler.

Heikertinger's life seems to have been outwardly placid and, in his youth, almost idyllic. The fullest account that I have found is in the obituary by his friend and fellow coleopterist Hans Strouhal (Strouhal 1955). (Tantalizingly, Strouhal quotes from an incomplete autobiographical sketch found among Heikertinger's papers after his death, which I have not seen.) Heikertinger was the only son of a postal worker, Anton Heikertinger. From his childhood on, Franz would accompany his father on long walks in the meadows, hills and forests around Vienna, which first awakened his interests in flowers, beetles and butterflies. He graduated from secondary school in 1895 but decided not to continue on to the Vienna Technische Hochschule because of his lack of interest in mathematics. Instead, perhaps following in his father's footsteps, he took a job at the Postal Savings Bank in Vienna, where he worked for the next 41 years. In 1902 he married Christine Eisner, and the marriage lasted until her death in 1947.

Once he started his career at the Savings Bank, his duties do not seem to have been too onerous. His workday ended early enough to allow him to pursue his interest in insects, often going out collecting in the surroundings of Vienna. Within a few years his collecting activities and his visits to the Natural History Museum had brought him into contact with other entomologists such as Karl Skalitzky and Ludwig Ganglbauer, and in 1904 he started to attend the evening meetings of a circle of coleopterists affiliated with the Zoological-Botanical Society of Vienna. At Ganglbauer's advice, he began to collect and specialize in the Alticinae, a group of flea beetles that became the main focus of his research and publications. He published his first papers in 1911, one of which was a description of one new species and three new varieties of *Aphthona* from Asia (Heikertinger 1911).

Figure 2. The Austrian Postal Savings Bank headquarters in Vienna. CC BY-SA 4.0, Thomas Ledl, Wikimedia Commons.

The First World War dealt a severe blow to Vienna's comfortable and prosperous existence. Although the city did not see combat, there were shortages of food and clothing, and severe inflation wiped out the savings of many middle-class Viennese (Wikipedia 2025db). The economic problems of the First World War period somewhat hampered entomological activities in Vienna, but not enough to prevent the twice-monthly evening meetings of the coleopterists' group in the "Leber" restaurant.

The Emperor Franz Joseph died in 1916, and was briefly succeeded by his great-nephew Karl, but with the end of the war in 1918 the Habsburg monarchy collapsed, the Austro-Hungarian Empire was dissolved, and Austria became a republic (Wikipedia 2025c). After the war, political instability and polarization continued, and inflation became hyperinflation. A coalition government collapsed in 1920, and throughout the 1920s there were intense political struggles among various left- and right-wing parties and their paramilitary wings, with outbreaks of street fighting. The city of Vienna itself for most of this time was governed by the left-wing Social Democratic Workers' Party of Austria, and became known as Red Vienna, while more conservative parties such as the Christian Social Party were stronger in rural areas.

In 1918, Heikertinger took over the editorship of the *KR*, a position he held for the rest of his life. In 1920, he also took over as editor of the *Wiener Entomologische Zeitung, WEZ (Viennese Entomological News)*, and continued in that role until the journal was merged into the *KR* in 1933. In 1936, at the age of 60, he retired from the Postal Savings Bank, where he had risen to the rank of Central Inspector. From then on Heikertinger was able to devote himself full time to his entomological pursuits. On his retirement he was awarded the Knight's Cross, First Class of the Austrian Order of Merit, by the Federal President of Austria.

The Federal President at this time was Wilhelm Miklas, coincidentally also the son of a postal worker, and only a few years older than Heikertinger (Wikipedia 2025d). A few years before this, Miklas's inaction during a parliamentary crisis had allowed the Chancellor, Engelbert Dollfuss, to seize dictatorial powers and rule by decree until his assassination in 1934 by Nazi sympathizers. Dollfuss's successor as Chancellor attempted to maintain Austrian independence while appeasing Hitler, but eventually was unable to resist the Anschluss. On March 12 1938, Hitler's troops crossed the border into Austria, meeting no resistance from the Austrian Army. Within two days Hitler had officially proclaimed the absorption of Austria into the German Reich, a move welcomed by many Austrians, although probably not as many as the 99.7% who supposedly voted for it in a rigged plebiscite the following month (Wikipedia 2025e).

The Nazi administration immediately moved to carry out its policies. In the first few weeks after the Anschluss 72,000 people were arrested, including political opponents, intellectuals, and especially Jews and Romany people. Jews were rounded up and many of their homes, businesses and places of worship were destroyed in the *Kristallnacht* of November 1938. Jewish organizations and institutions were shut down and many Jews fled the country. Of those who stayed, most eventually died in the death camps. In August 1938 construction began on the Mauthausen prison camp near Linz, which became the centre of a network of slave labour camps throughout Austria. I have not been able to find out if there were any Jewish entomologists active in Austria at this time, but if there were, they would most likely have shared the same fate as the rest of the Jewish community.

Throughout these years, Heikertinger continued a steady stream of publications, until his death in 1953. His output, if anything, became more prolific in the years between the Anschluss and the end of the Second World War. In addition to his taxonomic works, he wrote on mimicry, nomenclature, and advice for amateur insect collectors. Looking at the volumes of *KR* published during this period, we see that Heikertinger was far from alone in keeping entomology active in Nazi Austria. From 1938 to 1944, the journal published 71 research papers by 30 different authors in addition to Heikertinger himself, as well as news items such as obituaries, book notices, and lists of newly described species.

Heikertinger's published writings give little clue as to his political opinions. In a preface to readers of the 1938 volume of *KR* (Heikertinger 1938) (not included in the online volume), he writes with apparent enthusiasm of Austria having "returned to the German motherland" and of having "become, of its own volition, forever a part of the Greater German Reich". He quotes the Führer approvingly as having the ambition to "to place Germany at the forefront in all areas of human cultural life and endeavour" and ends the preface with a "Heil Hitler!". Does this reflect sincere devotion to the Nazi cause, or simply a wish to keep out of trouble with the authorities? Most of the editorial, however, is devoted to an appeal to German entomologists to support the journal in its financial difficulties, by subscribing to it and advertising in it. Other writings by Heikertinger suggest that he certainly saw science as a force for international cooperation and unity: in his farewell editorial to the readers of the *WEZ* in 1933 (Heikertinger 1933), he speaks of German and Austrian entomology as "part of the great, international and unifying entomological science". And in an editorial in the *KR* when it was able to resume publishing in 1947 (Heikertinger 1947), he wrote of his hopes that the journal will live to see better days in peacetime, that Austrian entomologists will work in friendly cooperation with colleagues from all over the world, and that they will uphold the ideal that "all men of science are brothers". (The thought that all women of science might be sisters does not seem to have occurred to him, but he was hardly alone in that at the time!) He concludes "We want neither hatred nor jealousy, we want to support one another, we want to rejoice in the successes of others and in the cooperation of all. Then what the madness of this war has torn down will slowly be rebuilt". Strouhal's obituary notes that "Heikertinger had only friends" among those who knew him.

The 1920s and 30s, when Heikertinger was embarking on his most productive years, were increasingly turbulent in Austria, as elsewhere in Europe. Extreme political polarization boiled over in outbreaks of violence. Throughout the continent, extremist and often racist anti-democratic movements, led by charismatic leaders, held huge numbers of people in their sway, and eventually came to political power. Heavily-armed nations looked outside their borders to expand their territories. Intolerant ideologies sought to crush intellectual activity that they deemed inconvenient, disloyal, unorthodox, or in conflict with their narratives of national greatness. And scientists, artists, scholars, and academics looked anxiously over their shoulders, many of them fleeing their homelands in search of physical safety and at least a greater measure of intellectual freedom. Even countries that managed to maintain democratic forms of government, and gave some sanctuary to scientific and intellectual refugees, were not entirely immune to the calls of authoritarianism and ethnic nationalism. I cannot help hearing echoes of our own times in all this.

When I first became aware of Heikertinger's 1944 paper, I had a half-formed impression of him as a lonely, heroic figure. I imagined him aware of the horrors being wrought around him by hateful ideologies, feeling powerless to do anything to resist them directly, but resolving that all he can do is to keep one small piece of the flame of science alight and preserve it until more peaceful times. Then its true value would once more be appreciated and it could take its place as part of the global heritage.

And indeed, in a way, this is what happened. At the taxonomic level, Heikertinger's work has stood the test of time well. Over 50 years after his 1944 review, in a revision by Konstantinov (1998), all species described by Heikertinger himself were recognized as valid. And of the 85 Palaearctic and Oriental species recognized in his 1944 treatment, only three were synonymized with previously described species.

Heikertinger could never have foreseen that, decades after his death, some of the *Aphthona* species that he so carefully documented would become valued biological control agents, and contribute significantly to the control of invasive European spurge species in North America (Gassmann et al. 1996; Bourchier and van Hezewijk 2013). Between 1982 and 1995, six European species of *Aphthona* were released against the invasive leafy spurge (*Euphorbia virgata* Waldst. & Kit.) and cypress spurge (*Euphorbia cyparissias* L.) in the United States and Canada, of which five became established and at least three (*A. flava* Guillebeau, *A. lacertosa* Rosenhauer, and *A. nigriscutis* Foudras) have had significant impacts on populations of their target weeds (Winston et al. 2022), and have been the

Figure 3. Adults of *Aphthona flava* feeding on leafy spurge, *Euphorbia virgata*. Norman E. Rees, USDA Agricultural Research Service - Retired, Bugwood.org

subjects of extensive redistribution programmes in the USA and Canada (Hansen et al. 1997; Alberta Invasive Species Council 2025).

Still less could Heikertinger have imagined that, further decades later, his works and many others in his beloved *KR* would be converted to digital format and made freely available to scientists and scholars throughout the world (ZOBODAT undated). I have no doubt that he would have taken great satisfaction in all these developments.

However, as I have learned more about Heikertinger's career and about the Austrian entomological community in those days, I have come to think that the truth may be more prosaic than this "lonely hero" image would suggest. Rather than a conscious act of quiet defiance, his devotion to his beetles and the entomological community may simply have been a choice to avert his eyes from unpleasantness and focus on a reassuring and familiar domain. Even in the middle of the most earth-shaking events and conflicts, there are pockets of what might pass, if you don't look too hard, for relative normality. In these pockets we find people trying to survive, get on with their lives, and pursue agendas and issues separate from the global clashes of ideologies and nations. As long as they can keep their heads down, make some accommodation with the powers that be, and scrape together the resources they need to survive and work, they can pursue their interests and keep their minds off the horrors of the larger world.

I am not sure yet what lessons are to be learned from contemplating Heikertinger and his colleagues toiling away with their sweep nets and microscopes, documenting the world of beetles as the human world around them descended into unimaginable violence and cruelty. It would be absurd to judge them for failing to stand up against the Nazis, when any open act of resistance would certainly have resulted in their immediate arrest and probable death. And as entomologists we can hardly fault them for continuing their dedication to insect science even under the most adverse circumstances. One wonders, though, what kinds of accommodations or collaboration with the Nazi authorities did they have to accept to be able to continue their research and publishing? At the very least Heikertinger, as editor of the *KR*, must have needed to ensure supplies of paper and ink, and access to printing services, resources which I presume would have been tightly controlled by the authorities.

A common feature of many extremist ideologies is the rejection of facts, science, expertise, and scholarship when they conflict with the goals and wishes of the movement, or simply the personal whims and prejudices of its leaders. Under Stalin in the Soviet Union, Mendelian genetics was suppressed in favour of Lysenko's more "Marxist" theories that allowed for the inheritance of acquired characteristics (Wikipedia 2025f). And in Nazi

Germany the *Deutsche Physik* movement promoted an "Aryan" approach to physics over the "Jewish" school embodied in Einstein's theory of relativity (Wikipedia 2025g). In our own times, we see climate science and vaccine research, to name but two, being suppressed and distorted in the service of political ideology, personal obsession, or corporate enrichment.

But regardless of whatever manufactured controversies may play out on social media, there are things that we are sure of as scientists. The Earth is about 4.5 billion years old. All humans belong to a single biological species and are linked by a shared evolutionary history to all other life forms on the planet, including flea beetles. Carbon dioxide levels in the atmosphere are steadily increasing and leading to global warming. Vaccines save lives and do not cause autism. The continents move around the surface of the Earth, carried by tectonic plates. We know these things because generations of scientists have gathered evidence, proposed theories, tested alternative explanations, and published their conclusions for other scientists to evaluate and criticize. And if any of them are eventually falsified or superseded, it will be through that same process of gathering evidence, testing theories, publishing papers, and building up a more comprehensive understanding of the world, one step at a time.

What should, or can, scientists do in such times as Heikertinger's—or ours? Possibly not as much as we would like to hope. At the very least though, it seems to me that our scientific training should have equipped us to seek out evidence, evaluate it critically and honestly, separate fact from opinion, distinguish reliable sources of information from unreliable ones, and work collaboratively with others who may be from different backgrounds, cultures, or nations (see The Last Word, this issue). Is it too much to suggest that as scientists we have a responsibility to at least stand up for these principles, in the wider world as well as in our own particular fields of expertise?

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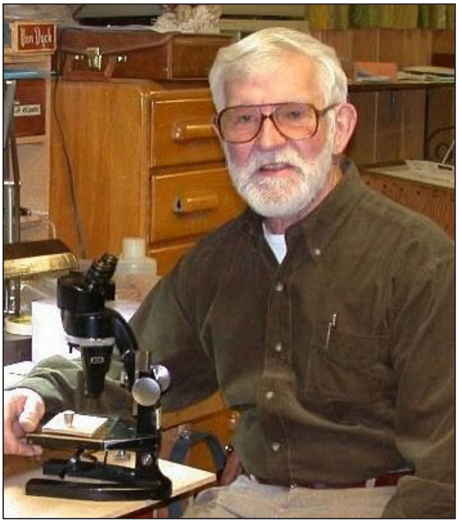
IN MEMORY

Remembering Malcolm MacFarlane Furniss (1926-2025)

Mal Furniss, a well-known forest entomologist, died in Moscow, Idaho, 11 November 2025. The youngest of six children, he was born 17 June 1926 at Branchville, New Jersey. His family moved to Waverly, New York, a rural town in the Appalachian Mountains where he developed a love for the outdoors. In 1946, he enrolled in forestry at the University of California, Berkeley and married Irene MacDonald Drummond. They had two children, Richard Allen and Carolyn Joyce. Two other children, Jeffrey James and Heidi died in infancy.



Mal began his career in forest entomology at Berkeley with the Division of Forest Insect Investigations, Bureau of Entomology and Plant Quarantine, U.S. Department of Agriculture (USDA). From 1954 to 1982, he studied bark beetles and other forest insects throughout western North America, as a research entomologist and project leader with the Intermountain Forest and Range Experiment Station, USDA. His assignments were to Boise, Idaho and then Ogden, Utah before transferring in 1963 to the Forestry Sciences Laboratory at Moscow and enrolling in a Master of Science program in entomology at University of Idaho (UI).

Mal retired from the USDA Forest Service in 1982 and was appointed Visiting Research Entomologist in the Department (later Division) of Entomology, UI. He conducted seminars and a workshop on insect photography, provided directed studies when requested by graduate students, served as advisor to the Aldrich Entomology Club, and increased the accessions of Scolytidae in the W.F. Barr Entomological Museum. Mal was well received by students at UI and when he substitute taught forest entomology at Washington State University in nearby Pullman.

In retirement, he also actively studied and published on numerous forest insects about which nothing significant had been previously published. Mal published over 100 manuscripts and presented over 70 papers on his research at meetings, related to Scolytidae and insects of forest-related shrubs that are important browse and habitat for ungulates. He was skilled with both black and white photography and digital imaging.

Mal received numerous honours and awards for his academic achievements, research accomplishments, photography, and international research cooperation. He belonged to the Entomological Society of America and Entomological Society of Canada. He belonged to the Western Forest Insect Work Conference, served as chair of its History Committee, and was especially proud to receive the conference's Founders Award in 1998.

Some of Mal's notable contributions to forest entomology are:

- Wrote field guide to 114 species of bark beetle and related ambrosia beetles (Scolytinae) of Idaho and vicinities (co-authored by James B. Johnson). The guide, published by UI, is based on cooperative surveys, museum records, and personal studies of Idaho's Scolytine fauna.
- Discovered in 1972 that the pheromone, 3-methyl-2-cyclohexen-l-one (MCH), repressed attraction of Douglas-fir beetles to susceptible host trees. Subsequently, he led a 10-year program of research and development of a slow-release formulation (patented) of the pheromone for aerial application to storm-damaged trees to prevent population build-up.
- Collected the first record of the Douglas-fir beetle in Mexico. Brought Mexican beetles to Idaho under USDA permit for controlled-breeding tests with Idaho beetles, resulting in his describing the Mexican population as *Dendroctonus pseudotsugae barragani* Furniss, the only subspecies so described in this destructive genus.
- Discovered multiple species of insects and mites associated with the Douglas-fir beetle. Included was a new species of Pteromalidae (Hymenoptera): *Karpinskiella paratomicobia* Hagen and Caltagirone, the only known insect parasitoid of an adult *Dendroctonus* species. He subsequently studied the parasite's impact on fecundity of parent beetles in infested trees.
- Determined the biology of *Dendroctonus punctatus* LeConte in white spruce and clarified its taxonomic relationship to the Eurasian *Dendroctonus micans* (Kugelann), with which it had been confused for 100 years. Petitioned successfully to give *D. punctatus* the common name, Boreal spruce beetle.
- Demonstrated the previously unknown mode of vectoring ascospores of tree-pathogenic blue-stain fungi (*Ophiostoma* spp) in pits on the integument of *Ips typographus* L in Norway and *I. pini* (Say) in Idaho.
- Studied numerous defoliator and phloeophagus insects infesting wild-land shrubs such as willow and curl leaf mountain mahogany of the Pacific Northwest and Alaska that are important to wildlife.
- Preserved and published the history of people and events in American forest entomology, from its inception by Andrew D. Hopkins in West

Virginia in 1890. Created a Deed of Gift by which his extensive history files were donated to the UI Special Collections and Archives library.

Early in his career, Mal and his family would tent camp or stay in a former CCC camp at his forest study locations. Later, he and Irene traveled by camper truck in Mexico's Sierra Madre Mountains where he studied Douglas-fir beetle. He also made many trips to Alaska where he obtained new records of bark beetles.

Mal was a dedicated vegetable gardener and passionate fisherman and hunter. He kept two horses for packing to mountain lakes and had a dog for hunting and companionship. Mal was a competent outdoorsman, a highly valued coworker, and a much cherished friend.

He was preceded in death by Irene and is survived by daughter Carolyn, son Richard, and grandchildren, all of whom he was immensely proud.

Sandra Kegley
Retired forest entomologist
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Bruce Baker
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Remembering Dr. Rory McIntosh (1955-2025)

In August 2025, we unexpectedly lost Dr Rory McIntosh, the Saskatchewan Ministry of Environment's Provincial Forest Health Expert, to a heart attack. Rory started with the Saskatchewan government in 2000 and was still actively working at the age of 69, with plans to retire in April of 2026.

Rory immigrated to Canada from England in 1981 to study forestry at the University of New Brunswick. In the summers, he worked on spruce budworm (*Choristoneura fumiferana*) and jack pine budworm (*C. pinus pinus*) in the pheromone research group at the New Brunswick Research and Productivity Council. In 1990 he moved west to the University of British Colombia to do his MSc on *Trypodendron lineatum* (striped ambrosia beetle) and remained at UBC for his doctorate studying the bionomics of *Pissodes strobi*, the white pine weevil. Rory conducted postdoctoral research in chemical ecology of wood boring insects at Simon Fraser University before moving to Prince Albert, Saskatchewan.

Rory started his professional career in Saskatchewan during the peak of a spruce budworm outbreak across the northern parts of the province and the focus at the time was aerial spraying to reduce populations and protect trees from defoliation. This work involved elucidating spray aircraft and application technologies, as well as the science behind BTK (*Bacillus thuringiensis* subspecies *kurstaki*), and conducting surveys such as spray timing based on insect and host development, efficacy monitoring, population forecast surveys, tree health assessments, etc. Rory took a professional approach in leadership overseeing a team that included the spray operations, working alongside other ministry staff, aerial applicators, pesticide suppliers, and program monitoring contractors. It was an amazing team of experts! Over the years, the spray bases were operated from various airports including Big River, La Ronge, Hudson Bay, and the Creighton area.

The spruce budworm outbreak eventually came to an end, the spray programs were wound down, and our forests began to recover. Rory had a vision for the program to evolve from “the budworm program” into a more comprehensive “forest health monitoring” program. Over the next several years, he put his plan into action. He worked to enhance the monitoring of forest disturbances. He guided participation in various forest health research projects, where no request for samples was turned down, whether it was someone needing branch samples for genetic work on pine trees, gall rust collections, or insect samples. He worked with pheromone suppliers on tests and trials of insect traps and lures. He was proud to collaborate with the Canadian Forest Service to monitor the Climate Impacts on the Health and Productivity of Aspen and Spruce plots located in Saskatchewan, a long running research project comparing tree health conditions to annual moisture levels across the boreal forest. Rory handled many media inquiries, always including a reminder telling people not to transport firewood, to prevent the spread of pests such as Dutch elm disease or the emerald ash borer. He worked on several insect and disease-related compliance files when regulatory violations were encountered, including a couple of larger files that increased the risk of spreading harmful pests and resulted in large fines being applied. Under Rory’s leadership, the program was certainly no longer just “the budworm program”.

Along the way, a new threat emerged, as the mountain pine beetle (*Dendroctonus ponderosae*) expanded its range in western Canada, spreading east and heading for Saskatchewan. Beetles were found attacking jack pine trees in Alberta; Rory and I focused our attention on the eastern spread. At one point the beetles were found within 40km of our border, in the Alberta side of the Cold Lake Air Weapons Range. Rory then worked closely with the Canadian Military to gain access into the Saskatchewan side of the range for several years in a row to monitor for the beetles. In addition to the monitoring work in Saskatchewan, Rory led a truly unique operation in Canada, where Saskatchewan helped control the spread of mountain pine beetle in Alberta, as a proactive measure. This partnership arrangement lasted from 2011–2022 and was an example of provincial collaboration that was one-of-a-kind in Canada. Around 2023 the mountain pine beetle populations in Alberta declined and we could count everyone’s efforts as a success.

Rory also invested considerable work into managing mountain pine beetle populations at Cypress Hills in southwest Saskatchewan for many years (work that is ongoing), and he always liked any chance to work there amongst the beautiful pines, which are the furthest east lodgepole pine stands in Canada. It was a special place for Rory, which you could tell anytime he talked about it.

Throughout Rory's career in Saskatchewan, his biggest passion was collaborating with others in the field of forest entomology and representing our province at the national level. His contributions were far and wide, ranging from forest research projects to participating on committees with organizations such as SERG International, the National Forest Pest Forum, the Forest Pest Working Group, National Forest Pest Strategy, TRIAnet, and others. He was well known across the country for advancing the science of forest pest management and for giving Saskatchewan a voice at those tables. A couple years ago, he prepared a presentation diving into the history of pest management that he shared with people across the country at various conferences and meetings he attended.

We will do our best to continue carrying out Rory's plan to implement an effective forest health monitoring program for Saskatchewan, but it won't be the same without him.

Brian Poniatowski
Government of Saskatchewan
Forest Insect and Disease Program Specialist
Ministry of Environment, Forest Service

Paragraph 2 adapted from Rory's own submission to: Vankosky, M., Erlandson M. and Gillott C. (Eds). 2019. Entomologists of Saskatchewan, Second Edition. Available at: https://esc-sec.ca/wp-content/uploads/2019/12/Entomologists-of-Saskatchewan-December-6-2019-FINAL.pdf

Remembering Les "Laszlo" Safranyik (1938-2025)

Les was born on 13 February 1938 in rural Hungary near the town of Szolnok. Even at a young age, Les had a love of nature and science and initially wanted to study astronomy. Fortunately (for us) he eventually studied forestry instead and joined the Faculty of Forestry at Sopron, Hungary. In 1957, 14 faculty members and 200 students fled Sopron after the Russian invasion and were 'adopted' by the Faculty of Forestry at the University of British Columbia in Vancouver. Les was among the evacuees, quite likely the youngest of the group.

Les adapted to life in Canada where he completed a PhD in forest entomology at the University of British Columbia, then accepted a job with Forestry Canada which led him to Victoria BC to work at the Pacific Forestry Centre. As his career progressed, Les met his beloved wife Elizabeth and they raised a son (Lazlo) and daughter (Elizabeth) on a small hobby farm on the Saanich Peninsula where he grew crops, raised various livestock and generally enjoyed working the land.

Professionally, Les made significant and seminal contributions to our understanding of bark beetle ecology, epidemiology and management, particularly with regards to mountain pine beetle and spruce beetle.

Les also devoted much time and expertise to professional entomological societies. He took on a number of roles including serving as President of the Entomological Society of Canada, President of the Entomological Society of British Columbia and other leadership roles in the Western Forest Insect Work Conference. Les also played a key role in organizing a number of society conferences, meetings and workshops.

Les collaborated widely, published prolifically, mentored numerous students and young research scientists. He edited books, authored book chapters, presented at numerous conferences and shared his knowledge and passion freely.

Les was honoured by numerous societies and organizations for his contributions. In 1986 the Entomological Society of Canada named him a Fellow of the Entomological Society of Canada for the impact of his research and mentorship within the Canadian entomological community. In 2001, Les received the Founder's Award from the Western Forest Insect Work Conference for his outstanding contributions to forest entomology in the west. In 2007, Les received a Merit Award from the Canadian Forest Service for Creativity and Innovation in Science. And in 2011, Les received the George Varley Award for Achievement in Forest Insect Ecology from the International Union of Forest Research Organizations (IUFRO) Entomology Research Group.

Even after his retirement, Les remained active in the entomological community and was generous with his time and expertise in assisting numerous students, young researchers and organizations grappling with complex forest insect related management decisions.

Les will be forever remembered as a pillar of the research community; his foundational discoveries continue to inform current research and forest management. But perhaps more than this professional legacy, those of us who had the honour and pleasure of knowing him primarily remember him for his kindness, generosity and gentleness. His professional brilliance and his human decency remain an inspiration to us all.

Bill Riel

BOOKS AVAILABLE FOR REVIEW

The ESC frequently receives unsolicited books for review. A list of these books is available online (http://esc-sec.ca/publications/bulletin/) and is updated as new books are received.

If you wish to review one of these books, please send an email to the Chair of the Publications Committee (Dezene Huber, huber@unbc.ca).

You should briefly indicate your qualifications to review the topic of the book, and be able to complete your review within 8 weeks.

Preference will be given to ESC members.

Guidelines

Book reviews should be approximately 800–1200 words in length. They should clearly identify the topic of the book and how well the book meets its stated objective. Weaknesses and strengths of the book should be described.

Formatting of the review should follow that of reviews in recent issues of the Bulletin. A scan of the book cover (jpeg or tiff format, about 500 kb) should be submitted with the review.

Available:

Ebertt Beeaff, D. 2025. Infinite Paradise: Witnessing the Wild, a Memoir. She Writes Press. ISBN: 978-1647429324 (request a review copy from the author: infiniteparadisebook@gmail.com)

Floate, K. 2024. Cow patty critters: An introduction to the ecology, biology and identification of insects in cattle dung on Canadian pastures. AAFC. ISBN: 978-0-660-44755-1 (free download: https://publications.gc.ca/collections/collection_2023/aac-aafc/A59-90-2022-eng.pdf)

Harbach, R.E. Composition and Nature of the Culicidae (Mosquitoes). CABI. ISBN: 978-1-80062-799-4 (will be provided to a qualified reviewer upon request)

Vankosky, M.A. and Martel, V. 2024. Biological Control Programmes in Canada 2013–2023. CABI. ISBN: 978- 1-80062-325-5 (free download: https://www.cabidigitallibrary.org/doi/book/10.1079/9781800623279.0000 or please contact veronique.martel@nrcan-rncan.gc.ca for a free hardcopy)

PHOTO CONTEST WINNERS

Thanks to everyone who participated in or voted on our 2025 ESC/SEC photo contest. By popular choice we have three winners selected, representing a range of taxa and styles.

In **first place** an image of a solitary bee on a flower by Kira Peters.

Caption: *Colletes wilmattae* on *Dalea villosa* by Kira Peters

Our **second-place** winner was Bob Lalonde, with a rarely seen behaviour of snow scorpionflies (Beloved of the Entomological Society of British Columbia*).*

Caption: Snow Scorpionflies (Boreus pilosus) come out onto the surface of newly fallen snow to mate.

Third Place: Our third-place winner was also Bob Lalonde, with a stunning image of a freshly emerged mayfly imago.

Caption: A Speckled Dun (*Callibaetus pictus*) has just emerged from its sub-imago stage and waits for the hour when mating commences.

22nd ANNUAL PHOTO CONTEST

The **22nd Annual Photo Contest** to select images for the 2027 cover of the Bulletin of the Entomological Society of Canada is now underway. **Contest rules**: Photos of insects and other arthropods in all stages, activities, and habitats are accepted. To represent the scope of entomological research, we also encourage photos of field plots, laboratory experiments, insect impacts, research activities, sampling equipment, etc. Photos should, however, have a clear entomological focus.

Digital images **must be submitted** in unbordered, high-quality JPG format, with the long side (width or height) a minimum of 1500 pixels. Entrants may submit up to five photographs. A caption must be provided with each photo submitted; photos without captions will not be accepted. Captions should include the locality, description of activity, if the main subject is other than an insect (if appropriate), and any interesting or relevant information. Captions should be a maximum of 40 words. The entrant must be a member in good standing of the Entomological Society of Canada. Photos must be taken by the entrant, and the entrant must own the copyright.

The **copyright** of the photo remains with the entrant, but royalty-free use must be granted to the ESC for inclusion on the cover of one volume (4 issues) of the Bulletin, and on the ESC website, and in various social media posts by the ESC (credited to the photographer, of course). Rather than a judging committee, the photo contest organizer will open voting to our members on a website.

Photographers of the top three photos chosen will be awarded the following **prizes**: 1st: $200 gift certificate for Henry's Camera. 2nd: $100 gift card for Henry's Camera. 3rd: $50 gift card for Henry's Camera. Submission deadline is 31 October 2026. Submit photos at this URL: https://pollunit.com/en/polls/escphotocontest2026

THE CANADIAN ENTOMOLOGIST UPDATE

The Canadian Entomologist Year in Review – Vol. 157 – 2025

In general, it was another good year for TCE! Submissions were down slightly from 2024 (Table 1) but ended with a greater number of published articles. Submissions originate from across the globe with Canada and India submitting the most followed by Brazil and China.

This year, we received several obvious examples of AI generated manuscripts. While these were relatively easy to detect and reject, as AI use becomes more sophisticated it will become more challenging to identify legitimate research.

Table 1: Manuscripts received (original and revised) between January 1 and December 31.

	2025	2024
Research Paper	88	85
Scientific Note	22	31
Review	4	2
Forum	2	1
Total submitted	116	119
Total published	56	47

**manuscripts rejected: 2025 – 36, 2024 – 36*
Average time to decision in 2025 – 38 days, 2024 – 42 days

EDITOR'S CORNER

Editor in Chief Opportunity

The Canadian Entomologist is seeking an active researcher in the field of entomology to join our team as co-Editors-in-Chief. The successful candidate would work closely with our other EiCs, Suzanne Blatt and Lisa Lumley. As co-EiC you will work collaboratively with the editorial team to make decisions on articles submitted to the journal and to grow the profile of the journal.

You will work along side the ESC board and Cambridge University Press to develop and implement a strategic vision for TCE that maintains the rigor and integrity of our society journal.

A successful co-EiC would have:

- an active publication record in the scope of the journal
- editorial or reviewing experience in scientific journals
- strong leadership and communication skills
- knowledge of the on-going technological shifts that could impact scientific publishing (e.g. AI, Open access, Open data)

This is a volunteer position with a 6-year term. Training of the new EiC will be provided. Informal inquiries about the role and responsibilities of this position are encouraged (amanda.roe@nrcan-rncan.gc.ca)

To apply, please provide a one-page letter of interest outlining your fit and interest in the co-EiC role to Amanda Roe by **30 June 2026**

CANADIAN JOURNAL OR ARTHROPOD IDENTIFICATION

Canadian Journal of
ARTHROPOD IDENTIFICATION

https://cjai.biologicalsurvey.ca/

A product of the Biological Survey of Canada & the Entomological Society of Canada

CJAI provides richly illustrated, peer-reviewed, open-access tools for identifying insects, arachnids and other arthropods in Canada. Check out this recent article on our website.

Key to the New World genera of Euphorinae (Hymenoptera: Ichneumonoidea: Braconidae)

Michael Sharkey,
Scott Shaw,
Cornelis van Achterberg,
Y. Miles Zhang,
Donald L. J. Quicke and
Julia Stigenberg

REGIONAL JOURNAL UPDATE

Proceedings of the Entomological Society of Manitoba

Volume 80 (2025)
https://entsocmb.ca/pdf/Proceedings/ESMproceedings_V80.pdf

Holliday, N.J. 2025. *Chlaenius cordicollis* (coleoptera: carabidae) not a frequent flyer in Manitoba, Canada. Proceedings of the Entomological Society of Manitoba, 80: 6-18.

M. Dupuis, M., M. Krul, T.D. Galloway, W. Knee and K. Rochon. 2025. Association between infestation parameters of nasal mites (acari: *Rhinonyssidae: tinaminyssus* spp.) and host body condition in rock pigeons (Aves: Columbidae: *Columba livia*) in Manitoba. Proceedings of the Entomological Society of Manitoba, 80: 19-29.

Capar, L., M. Alperyn, and J. Bannerman. 2025. Distribution of spongillaflies (Neuroptera: Sisyridae) in Manitoba. Proceedings of the Entomological Society of Manitoba, 80: 30-41.

Watson, J.B., and J. A. Bannerman. 2025. First records of family Embolemidae (Hymenoptera: Dryinoidea) in Manitoba. Proceedings of the Entomological Society of Manitoba, 80: 42-47.

ANNUAL MEETING OF MEMBERS

76th Annual Meeting of Members and Board of Directors Meetings

The 76th Annual Meeting of Members for the Entomological Society of Canada will be held in conjunction with the Joint Annual Meeting (JAM) of the Entomological Societies of Canada and Manitoba scheduled to occur 4–7 October at the Canad Inns (Polo Park) in Winnipeg, Manitoba. Meetings for both the outgoing and incoming Board of Directors will also take place during the JAM. Matters for consideration at any of the above meetings should be sent to the Secretary of the Entomological Society of Canada (see inside back cover for contact details).

Highlights from the December Board of Directors Meeting

The Board of Directors and Officers of the ESC met virtually on Wednesday, 17 December 2025, with President Rob Johns chairing. The meeting primarily focused on Board orientation, providing an introduction to the structure, roles, and responsibilities of the Board for new members, as well as a refresher for returning members. The orientation was presented by Executive Director Geoff Powell.

The following summarizes the main topics of discussion covered during the meeting.

Seminar speaker series

1st Vice President Rose Labbé had been working with an *ad-hoc* committee to develop a virtual seminar series for ESC members; she presented an overview of the plan the group had come up with. The Board was supportive of the idea and agreed that the plan seemed reasonable noting that since this was a trial run there would be time to reevaluate and adjust if necessary. The seminar series is tentatively set to start in the Winter of 2026.

Handling of CJAI charges and MOU

CJAI Editor Heather Proctor joined the meeting to seek Board guidance on how publication charges should be handled for the CJAI. She also reminded the group that a new MOU needs to be signed. The Board asked the Executive Director and Treasurer to meet with CJAI representatives to further discuss the handling processing fees and to propose a plan to the Board at the next meeting. In addition, a draft of a new MOU will be prepared for Board consideration.

Members are welcome to read the full BOD meeting minutes which can be found in the members area of the ESC website.

INVITATION TO JOIN BUGQUEST!

Join Canada's BugQuest

Learn Locally. Contribute Nationally.

Help us DNA barcode 'em all!

About the Quest:

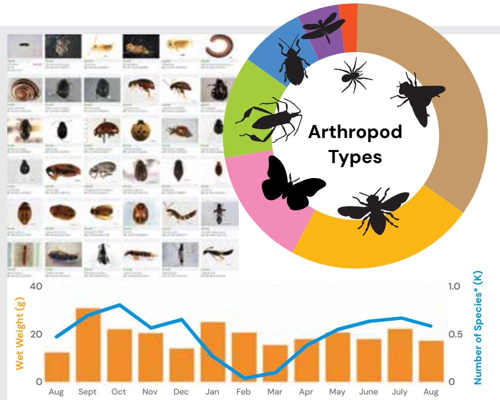
Starting in 2026, **BugQuest** will be deploying Malaise traps all across Canada to collect insects from key biodiversity areas, public science spaces, schools, and community sites.

We are inviting members of the **ESC** to deploy a trap and collect specimens that will help us document and better understand Canada's insect diversity. These identifications are made possible using DNA barcoding, a way to identify species by reading short segments of DNA.

The **BugQuest** project is coordinated by the Centre for Biodiversity Genomics at the University of Guelph, and builds on our previous nation-wide research programs. With advances in DNA technologies, we can now scale up biodiversity discovery in ways that were not previously possible – all we need are the bugs!

What you will get:

- A ready-to-use BugQuest Kit at no cost (valued at ~$1,000)
- DNA sequencing, data analysis, and shipping are also free of charge
- Photos and identification of the insect species you collected
- A view of your site's insect diversity and how it compares to other sites across Canada
- You'll be a part of an exciting quest inspiring discovery and renewed appreciation for our unknown biodiversity.



Examples of potential scientific results from Malaise trap data

What you will do:

We provide all the equipment, materials, shipping, and DNA analysis – you collect and send! Just set up the Malaise trap in few square metres of open space and add salt water, then simply change the Quest Bottle (a ~15 minute task) every week for 2 – 6 months.

UNIVERSITY OF GUELPH | Centre for Biodiversity Genomics

Are you ready to join BugQuest?

Visit https://bioscan.life/bugquest/ to learn more and accept the Quest!

MEETING ANNOUNCEMENTS

XVII International Symposium on Biological Control of Weeds
Rotorua, Aotearoa New Zealand, 8-13 March 2026
https://iobc-wprs.org/meeting/isbcw-2026/

Pherosphere 2026: IOBC-WPRS WG "Pheromones and Other Semiochemicals in Integrated Production
Dossenheim, Germany, 8-12 March 2026
https://iobc-wprs.org/meeting/pherosphere-2026/

27th Biennial International Plant Resistance to Insect Symposium
Canmore, Alberta 7-9 April 2026
https://app.groupize.com/e/27th-international-plant-resistance-to-insects-symposium

13th European Congress of Entomology
Tours, France 28 June -3 July 2026
https://www.ece2026.org/

Joint Conference SIP and IOBC: Microbial and Nematode Control of Invertebrate Pests
s'Hertogenbosch, The Netherlands, 2-6 August 2026
https://iobc-wprs.org/meeting/sip-iobc-wprs-2026/

IOBC-WPRS, Benefits and Risks of Exotic Biological Control Agents
Trento, Italy 14-17 September 2026
https://sites.google.com/fmach.it/brebca-2026

JAM Entomological Society of Canada and Entomological Society of Manitoba
Winnipeg, Manitoba 4-7 October 2026

Entomology 26 (Annual Meeting of the Entomological Society of America)
Columbus, Ohio 8-11 November 2026
https://www.entsoc.org/events/meeting/future

11th International Congress of Dipterology
Zagreb, Croatia, 10-16 July 2027
https://dipterists.org/icd.html

XXVIII International Congress of Entomology
Cape Town, South Africa, 17-21 July 2028
https://www.icecouncil.org/upcoming-congress

Is There A Fungus Among Us?

Recently, I read an article on symbiosis between a stinkbug and a fungus (Nishino et al. 2025). Two things struck me about this study. First, this is yet another demonstration of the importance of carefully observing one's focal organism. Here, Nishino and colleagues noticed that female but not male dinidorid stinkbugs possess enlarged structures on their hind tibia but more importantly, upon close inspection, these structures did not appear to be auditory as had been suggested. Further observations showed that this organ supported fungal growth and that subsequent to oviposition, females smeared their eggs with these fungi and that the fungi protected the stinkbug eggs from parasitic hymenoptera. Very cool!

Second, while antagonisms regularly feature in ecological studies, mutualisms such as the one above are much less commonly published. According to the Chrome bot on my iMac, antagonism publications probably outnumber mutualism publications by more than 5 to 1. There are many reasons for this discrepancy, including: (i) it is often difficult to observe mutualisms in nature (again, my call for close observation, without preconceived bias), (ii) charismatic antagonisms are exciting to study and report (be honest, if you had the choice between attending a talk on orcas versus one on bunnies, which would you choose?) and (iii) the costs and benefits for partaking in a mutualism versus an antagonism are often relatively small *viz* the lunch-life asymmetry principle (Dawkins and Krebs 1979) so maybe less exciting for biologists to investigate. On the other hand, mutualisms are very common and certainly can be eye-catching to the general public. It seems that everyone that I know is familiar with orchid-pollinator relationships, clownfish and their anemone hosts, oxpeckers and their mammal hosts on the African plains and, of course, the relationship that I seem to get asked about at every cocktail party, the social life of trees (Simard 2022).

At the societal level, there is no reason to treat other groups as adversaries. In fact, I would hazard to guess that the vast majority of ESC members have membership in several learned societies and, as such there is much to gain from promoting cross-fertilization with our societal cousins. In the past couple of decades, we have held joint AGMs with the ESA on a few occasions and with CSEE (Canadian Society for Ecology and Evolution) just once. I would argue that we should try as hard as we can to hold joint meetings with other societies such as the Canadian Botanical Association and the Canadian Society of Zoologists as well as a return to meeting with CSEE to name just a few. For those of you who are worried about being dwarfed by larger societies (does ESA scare you? It shouldn't!) we can return to ecological analogies such as cleaner fish and their often much larger hosts, the aforementioned oxpeckers and their hosts, ants and their acacia trees—they're doing just fine, aren't they? Mutualisms can and do work.

What binds us together as entomologists is not just our love of arthropods but also the biological concepts that they help us to understand (see Thomas et al., this issue). A few years ago, soon after our lab published a paper on mosquito flight dynamics (Roitberg et al. 2003), one of my colleagues who specializes on avian organisms told me that ours was the perfect paper on 'avian migration' using a model organism that he and his colleagues could only dream of employing. Similarly, we should comb the literature for publications on non-arthropods to help us understand our arthropod subjects. There is so much that we can learn from one another.

I'm not sure how many times I watched The Lion King (Allers and Minkoff 1994) with our daughter but one of the enduring mutualisms in that film was that of Timon the meerkat, Pumbaa the warthog and Simba the lion. None of them were entomologists but I am sure that they would have something to say about interactions within and without the ESC. Note, not all mutualisms have happy endings—see Paul Rudd's brilliant portrayal of a 'friend' in the movie, Friendship (DeYoung 2024).

Finally, thinking of the many contributions that ESC members make to our society, I take this opportunity to thank Assistant Editor Sydney Worthy for all her good work over the past couple of years. Sydney is stepping down and is being replaced by the team of Amanda Roe and Rob Johns; welcome aboard you two.

- Bernie

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Figure Caption: A high-fiving, aphid-ant mutualism. Image generated by Bernie Roitberg using Picsart / Image générée par Bernie Roitberg à l'aide de Picsart (https://picsart.com/create).

ENTOMOLOGICAL SOCIETY OF CANADA 2025-26

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