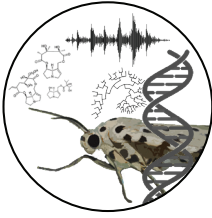


# ARCTIINAE RESEARCH COMMUNITY MEETING 2021





**ARCTIINAE RESEARCH COMMUNITY MEETING 2021**  
MAY 28<sup>th</sup>, 2021 | VIRTUAL MEETING

✉ [arctiinae.research@gmail.com](mailto:arctiinae.research@gmail.com)

🐦 @ARC\_SCI

📺 [youtube.com/channel/UC1SwSy3vqpXkyCh2ByscqbA](https://www.youtube.com/channel/UC1SwSy3vqpXkyCh2ByscqbA)

**2021 Organizing Committee:**

Dr. Nicolas J. Dowdy, Milwaukee Public Museum  
Dr. Richard Gawne, Tufts University  
Dr. Ossi Nokalainen, University of Jyväskylä

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ARC2021 v1.2

Welcome to the inaugural meeting of the Arctiinae Research Community (ARC2021)! This is the first of what we hope will be an annual meeting bringing researchers from all over the world together for collegial discussions about the biology of tiger moths. Due to the ongoing COVID-19 pandemic, this year's event will be held virtually, via Zoom. A total of 35 speakers from many different career stages, backgrounds, and countries will present at this year's event. In addition, 21 auditors will be actively participating in the audience. As indicated in the schedule, the presentations at this year's meeting will cover many facets of tiger moth research, and we hope that this leads to ongoing communication and collaboration among our participants. Contact information for all participants can be found in this booklet, and details will be forthcoming about group communication options that will enable us to keep in touch after the meeting has concluded.

The organizing committee would like to thank everyone who has agreed to take part in this meeting, and we appreciate your continued patience as we work to navigate the extra administrative difficulties that come with virtually hosting a meeting of this size.

If you have any questions before, during, or after the meeting, please do not hesitate to contact a member of the organizing committee.

Sincerely,



**Dr. Nicolas J. Dowdy**

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## Keynote Speaker



**Prof. William E. Conner**

Wake Forest University  
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William E. Conner obtained his Ph.D. in Neurobiology and Behavior at Cornell University under the guidance of Thomas Eisner. Conner has been a Professor of Biology at Duke University and Wake Forest

University for 40 years. He has mentored 18 PhD and MS students, 14 of whom have worked on the behavior of the Arctiinae. He has focused on the chemical ecology of tiger moths and the pyrrolizidine alkaloids that play important roles in their defense and sexual selection. More recently he has investigated the role of tymbal sounds in tiger moth behavior. Conner edited

*Tiger Moths and Woolly Bears: Behavior, Ecology, and Evolution of the Arctiidae* published in 2009 by Oxford University Press.

### Tiger Moths (Arctiinae): An Amazing Journey

I will introduce the hyper-diverse behavior of tiger moths with historical vignettes from the ConnerLab. It all began with the pyrrolizidine alkaloids (PAs) and *Utetheisa ornatrix*. The PAs defend *Utetheisa* from invertebrate and vertebrate predators. PAs are the precursors of courtship pheromones released from spectacular androconial organs – inflatable coremata and flocculent scales. Ultimately, females choose their mates based on titers of PA-derived courtship pheromones. A second modality – tymbal sound – adds to the tiger moths’ defensive armament. Using microphones and high-speed video cameras we discovered the “*pièce de résistance*” – moths can jam the sonar of echolocating bats. It has been a little over a decade since the “Tiger Moths and Woolly Bears: Behavior, Ecology, and Evolution of the Arctiidae” was published, and we have still barely scratched the surface.

# Keynote Speaker

Johanna Mappes's decades-long interest is to understand how species interactions (mutualistic and antagonistic) shape traits that help individuals to fight their enemies. She finds fascinating to experimentally solve evolutionary mysteries like “how rare, initially disadvantageous traits of prey can become advantageous via natural selection”. She studied Ecology and environmental science in Jyväskylä and Stockholm (Ph.D 1994), had the Academy of Finland postdoctoral fellowship followed by the Senior research fellowship and visiting affiliations in UC Santa Cruz, Santa Barbara and Australian National University. She was appointed Professor of Evolutionary ecology (2008) at Jyväskylä followed by the Academy Professorship (2009-2013, 2019-2023) and Helsinki University as the Professor of Ecology (2020).



**Prof. Johanna Mappes**  
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## How It All Started: The Wood Tiger Moth Story

Do you ever wonder why we chose the wood tiger moth for our study species? Well, you need wonder no longer. I will give you a little historical journey to our lab and tell how we started, what were the biggest highs and lows and what this odd little moth has taught us about natural selection over these years.

## Keynote Speaker



**Prof. H. Frederik Nijhout**

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Fred Nijhout obtained his PhD in insect development and physiology from Harvard university in 1974, working in the laboratory of Dr. Carroll Williams. He did two postdoctoral stints at the University of Washington and the National institutes of Health, before joining the Zoology Department at Duke University in 1977. He has been there ever since (although the department changed its name from Zoology to Biology in 2000). He has worked extensively on the development and evolution of color patterns in the Lepidoptera, and in the control of growth, size and shape in the Lepidoptera.

### What is the Primitive Color Pattern?

The Arctiinae have, arguably, the most riotously diverse color patterns among the Lepidoptera. Yet, there is reason to believe that this diversity has simple origins. I will show that analysis of the wing patterns of more basal Lepidoptera can provide useful insights into the origin of tiger moth color patterns, as well as the mechanisms and processes by which those color patterns diversified.

## What's Amata with this moth? Aposematic variation in an Australian lepidopteran

Georgina E. Binns, Hannah M. Rowland, Donald J. McLean, Nathan S. Hart, Kate D. L. Umbers, Johanna Mappes, & Maria E. Herberstein

12-minute, Traditional

Variation in warning signals is common in aposematic organisms but the factors responsible are largely unknown. We used an Australian Arctiinae to test whether climate or predation relate to variation in the warning signals of the wasp moth, *Amata nigriceps*. Images of ~300 museum specimens of *A. nigriceps* collected over 125 years were used to compare wing patterns over time. Using 260 recently collected specimens from a range of populations, we correlated population specific patterns with local predator diversity, rainfall, and temperature. We found that historically, *A. nigriceps* are getting less black over time. Local wing patterns correlated with increasing historical temperatures and increased relative humidity, which are likely proximate factors in melanin production. Local predation pressure also related to variation in warning signals; populations with increased local specialist diversity exhibited increased wing spot size and thus increasing conspicuousness, whereas an increase in local generalist predator diversity causes increased variation.



**Georgina Binns**

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Georgina Binns is in her 3rd and final year of a PhD candidature at Macquarie University, Sydney, under the supervision of Prof. Mariella Herberstein. Her thesis currently traverses several areas of interest which include understanding the biotic and abiotic effects on the variation in warning signals, chemical defence ecology, and confirming the taxonomy of *Amata* tiger moths in eastern Australia. She has a professional background in wildlife management (specifically in Macropods) and conservation biology (Chiroptera).

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## Variation in warning signals in *Amata nigriceps*: how do predators respond?

Liisa Hämäläinen, Georgina Binns, & Marie Herberstein

12-minute, Traditional

Aposematic species advertise their unprofitability with warning signals, but this requires predator avoidance learning. Because invariable signals are easier to learn, selection is expected to favour monomorphic warning signals, but surprisingly many aposematic species show variation in their colour patterns. This includes an aposematic tiger moth, *Amata nigriceps*, that has variable black and red wing colour patterns, with the proportion of red varying from 10% to 35% among individuals. Assumed selection from predators makes this variation puzzling, but so far no studies have tested whether the proportion of red influences predators' responses to the moths. We investigated this using two types of predators: great tits (*Parus major*) that are naïve to the moth colour patterns, and noisy miners (*Manorina melanocephala*) that are experienced local predators. In my talk, I will present preliminary results from these predation experiments and discuss future research plans.



**Dr. Liisa Hämäläinen**

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Liisa Hämäläinen completed her PhD at the University of Cambridge in 2019, supervised by Dr. Rose Thorogood. During her PhD, she investigated how predators use social information about chemically defended prey, and how this influences selection for prey defences. Currently Dr. Hämäläinen is a Visiting Fellow at Macquarie University where she works with Prof. Marie Herberstein on aposematic *Amata nigriceps* moths. The aim of the project is to quantify variation in warning signal expression and chemical defences within and among *A. nigriceps* populations, and to investigate how this variation influences predator learning.

## Red or dead: imperfect Müllerian mimicry between burnet and red, not yellow, wood tiger moths

Bibiana Rojas, Katja Rönkä, Ossi Nokelainen, Janne K. Valkonen, & Johanna Mappes  
12-minute, Traditional

Imperfect mimicry is a phenomenon whereby a species gets anti-predator protection through vague similarity with a noxious model; the more deterrent the model, the less accurate the mimic needs to be. In the Caucasus, the aposematic wood tiger moth (*Arctia plantaginis*) exhibits continuous variation from yellow to red, and field predation experiments with artificial moths have revealed that red moths have the lowest attack risk. Here, through avian vision modelling and learning experiments with wild-caught avian predators, we test the hypothesis that red moths are better protected because of their colour similarity with burnet moths (*Zygaenidae*), which are known to be extremely noxious. Our data show that birds with previous experience with burnet moths attack yellow moths significantly sooner than red moths, while inexperienced birds do not differ in their latency to attack red and yellow moths. These findings hint at a case of imperfect mimicry, and highlight the importance of accounting for predator behaviour and cognitive biases in addition to their physiological limitations in studies on the role of predator selection in the evolution of defensive colouration.



**Dr. Bibiana Rojas**

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Bibiana Rojas is a behavioural and evolutionary ecologist whose research interests have largely focused on predator-prey interactions. She is particularly interested in the evolution of warning signals, which she has been studying since she was a PhD student (2007-2012) at Deakin University (Australia) under the supervision of Prof. John Endler. She then joined Prof. Johanna Mappes' group at the University of Jyväskylä (Finland), where she studied mostly the multimodal warning signals of wood tiger moths, with a particular focus on their chemical defences and how these deter avian predators. She is currently an Academy of Finland Research Fellow, and her research group also studies parental care, larval aggression, and other aspects of amphibian behavioural and evolutionary ecology.

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## Arctiine moths and plants containing pyrrolizidine alkaloids (PAs)

Michael Boppré

12-minute, Synthesis

Relationships of Arctiini to plants containing 1,2-dehydro pyrrolizidine alkaloids (PAs) are of two kinds: i) for larvae of some species PA-plants represent primary hostplants for gaining nutrients for development, ii) for adults of other species PA-plants serve as secondary hostplants, exclusively for obtaining PAs via a peculiar behavior that is independent of nutritional requirements (PA-pharmacophagy). In both cases PAs are sequestered for defence against antagonists, and males of diverse species synthesize male courtship pheromones from PAs; thus, PAs link intra- with interspecific chemical communication. We know of exciting biology about a few species and of some peculiarities of PA-pharmacophagy, however, we appear to be far away from sound generalizing statements and from understanding the evolution of arctiine-PA relationships. The paper comparatively discusses what is known but focuses on what can be expected from further natural history studies, exemplified by a plea to employ PA-baiting. Studying arctiine-PA relationships is integrative and has high potential to contribute to general biological issues, including aspects of human health.



**Prof. Michael Boppré**

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Retired full professor at the Albert-Ludwigs-Universität, Freiburg, Germany. Research interests: biology, physiology, ecology and evolution of chemical communication in insects with focus on Danainae butterflies and Arctiinae moths, particularly in the context of male pheromones: androconial organs, chemistry and biosynthesis of pheromones, ethology, relation of intra- and interspecific communication (sexual communication and chemical defense; mimicry). Insect-plant relationships, particularly the roles of plant secondary metabolites (mainly pyrrolizidine alkaloids) for insects; pharmacophagy under functional, ethological, ecophysiological, chemoeological, developmental and phylogenetic aspects. Continuing interest in taxonomy, PA-pharmacophagy, evolution, mimicry, systematics, chemical and acoustic communication of Neotropical Arctiinae; fieldwork in Costa Rica, Peru.

## Variation in chemical defence across wood tiger moth populations and its relevance in defence against birds

Cristina Ottocento, Anne Winters, Bibiana Rojas, Johanna Mappes, & Emily Burdfield-Steel  
12-minute, Traditional

Defensive chemicals are an important and widely used anti-predatory strategy in prey animals. Chemical defences often vary both in quantity and quality, which is puzzling if prey survival is dependent on the strength of the defence. The wood tiger moth, *Arctia plantaginis*, is a chemically defended, warningly-coloured species. A major component of the moth's defences, methoxy-pyrazines, are synthesized de novo and secreted from the thoracic glands in response to attacks by avian predators. We first experimentally manipulated the strength and ratios of pure (i.e., synthetic) methoxy-pyrazines (SBMP and IBMP) and tested the birds' reactions. Then, we investigated the natural variation of pyrazines across wild populations and compared that to the laboratory-raised moths. Birds showed the strongest adverse reaction when the two methoxy-pyrazines were combined in a 50:50 ratio. Wild raised moths produced higher overall concentrations of pyrazines than lab-raised moths, but less IBMP. Interestingly, the defences of wild moths elicited weaker aversive responses in birds than those of lab-reared moths, which confirms that the composition, not just the amount of pyrazines, is important. Our results suggest that despite being produced de novo, both internal and external factors influence the production and efficacy of chemical defence of tiger moths.



**Cristina Ottocento**  
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Cristina Ottocento is a PhD student at the University of Jyväskylä, Finland, under the supervision of Johanna Mappes, Bibiana Rojas (University of Helsinki and University of Jyväskylä) and Astrid Groot (University of Amsterdam). She did her BSc and MSc in Evolutionary Biology at the University of Padova, in Italy. In 2018, she moved to the cold and snowy Central Finland, where together with Bibiana Rojas, Johanna Mappes and Emily Burdfield-Steel she studied how the early life resource availability affects the anti-predatory defence in Wood tiger moth. For her PhD studies, she is interested in trying to understand what mechanisms drive speciation, in particular, if there is an ongoing divergence process between the Caucasus and European wood tiger moth populations.

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## Predator-induced plasticity on wood tiger moth larvae

Diana Abondano Almeida, Johanna Mappes, & Swanne Gordon  
5-minute, Traditional

Predator-induced plasticity in life-history and antipredator traits during the larval period has been extensively studied in organisms with complex life-histories. However, it is unclear whether different levels of predation could induce warning signals in aposematic organisms. Here, we investigated predator-induced plasticity in warning coloration and life-history traits in the larva of *Arctia plantaginis*. As juveniles, a larger orange patch on an otherwise black body signifies a more efficient warning signal against predators but this comes at the costs of conspicuousness and thermoregulation. Given this, one would expect that an increase in predation risk would induce a plastic increment in the expression of the orange patch. Using a full-sib rearing design, in which individuals were reared in the presence and absence of a non-lethal simulated bird attack, we evaluated the plastic responses of warning signal size, growth, molting events, and development time in wood tiger moths. All measured traits except development time showed a significant plastic response to predation. However, against our expectations, larvae from the predation treatment developed a more melanized warning signal (smaller orange patch), reached a smaller body size, and molted more often. Our results suggest plasticity is indeed important in aposematic organisms, but in this case may be complicated by the trade-off between costly pigmentation and other life-history traits.



**Diana Abondano**  
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Diana Abondano Almeida, originally from Colombia, received her BSc in Biology at the Pontificia Universidad Javeriana in 2009, and her Master's in Ecology and Evolutionary Biology at the University of Jyväskylä, in Finland in 2017. In her Master's thesis, she studied the phenotypic plasticity in the aposematic wood tiger moth larva. Since 2014 she has been working with different aposematic organisms (Lepidoptera) and assisting projects investigating the causes for colour polymorphism, predator-prey interaction, and the genetic basis of reproductive and ecological isolation between sympatric species. In August 2018 she joined the WZS-Lab to do her PhD on Chemical communication in neotropical frogs.

# The genetic basis of male colour polymorphism in the wood tiger moth

Melanie Brien, Anna Orteu, Charley Yen, Juan Galarza, Chris Jiggins, & Johanna Mappes  
5-minute, Traditional

Colour is often used as an aposematic warning signal. Predator learning is expected to lead to a single colour pattern within a population, but there are many puzzling cases where aposematic signals are also polymorphic. The wood tiger moth, *Arctia plantaginis*, uses its bright hindwing colours as a signal of their unpalatability. Males have discrete colour patterns, and in Finland, both white and yellow morphs can be found. These colour morphs also differ in behavioural and life history traits, such as immunity, chemical defences and flight patterns. Complex polymorphisms such as these are often explained by supergenes, groups of tightly linked alleles. Conversely, we found a simple genetic basis for the male colour polymorphism. Using a QTL analysis of lab crosses, GWAS of wild populations, and RNAseq analysis, we found a single gene in the 'yellow' family genes controlling the switch between white and yellow colour. These 'yellow' genes have been linked to melanin synthesis and behavioural traits in other insect species. Our results add to only a few examples of seemingly paradoxical and complex polymorphisms which are controlled with a simple genetic basis.



**Dr. Melanie Brien**  
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Melanie Brien obtained her PhD at the University of Sheffield, UK studying the genetics and evolution of structural colour in *Heliconius* butterflies. Now she is researching the genetic basis of polymorphic colouration in the wood tiger moth, as part of a collaborative project with Johanna Mappes and Juan Galarza at the University of Jyväskylä, Finland and Chris Jiggins at the University of Cambridge, UK.

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## TBD

Melanie Brien, Anna Orteu, Charley Yen, Juan Galarza, Chris Jiggins, & Johanna Mappes  
5-minute, Traditional

The wood tiger moth, *Arctia plantaginis*, presents polymorphic aposematic colouration to deter predators. While female hindwing coloration varies continuously, males present discrete morphs. The yellow and white male morphs have been associated with distinct predator avoidance strategies that include differences in chemical defences, mating success and flight activity, and are determined by a single Mendelian locus with two alleles. To explore the genetic basis of this trait, we have produced a high-quality genome assembly and identified a candidate locus using QTL and GWAS. Furthermore, using transcriptomic data of developing hindwings, we have identified yellow-e as the candidate gene controlling the development of the yellow and white morphs. Interestingly, the yellow family of genes has been implicated in colour polymorphism in many other Lepidoptera species. Using multiple genomics techniques, we identify the gene controlling male colour polymorphism in *A. plantaginis* and shed light on the evolution of complex phenotypes.



**Anna Orteu**  
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Anna is a PhD student at the University of Cambridge working on the evolutionary genetics of mimicry in butterflies and moths with Prof. Chris Jiggins. She did her master's in Evolution, Ecology and Systematics at the University of Munich LMU in Germany, and before starting the PhD, worked in evolutionary genomics of social insects at the University of Melbourne, Australia. Her main interests are centered around evolutionary and population genomics of adaptive traits.

## Phylogenetic relationships of the Ctenuchina: more questions than answers?

Rebecca B. Simmons, Melissa Sisson, Katie Bierstedt,  
& Sydney Winterton  
12-minute, Traditional

The phylogeny of mimetic tiger moths in the Ctenuchina and Euchromiina is difficult to discern because of rapid species evolution and the convergence of coloration and patterns in adults. We are using seven genes to construct phylogenetic relationships of ctenuchine genera, which allows us to examine the evolution of coloration and pattern in these mimics. Our study is the first to examine relationships of genera within the Ctenuchina with these data, and will aid in designing further revisionary studies for these moths. Our results indicate that while Euchromiina appears to be monophyletic with strong support, Ctenuchina is paraphyletic with respect to the euchromiines. We will also discuss our preliminary results regarding the evolution of wing patterns within the Ctenuchina.



### Dr. Rebecca Simmons

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Dr. Rebecca (Becky) Simmons is a Professor of Biology at the University of North Dakota where she and her students examine evolutionary questions involving moths, bats, pigs, gulls, and wild horses. Dr. William Conner introduced her to tiger moths and served as her advisor for her MS in Biology at Wake Forest University, where she described the mating behavior in *Euchaetes egle*. Becky earned her Ph.D. in Entomology at the University of Minnesota under the direction of Dr. Susan Weller, studying the phylogeny and evolution of mimicry in tiger moths. She is a research associate of the National Museum of Natural History, Smithsonian Institution and the McGuire Center for Lepidoptera and Biodiversity, Florida Museum of Natural History.

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## Honest signalling – testing the resource allocation hypothesis

Emily Burdfield-Steel, Miriam Furlanetto, Cristina Ottocento,  
Bibiana Rojas, Ossi Nokelainen, & Johanna Mappes  
12-minute, Traditional

Variation in aposematic signals is puzzling as predator learning is expected to result in strong stabilising selection on warning signals. It has been suggested that signal variation correlates positively with levels of secondary defence, and hence provides an “honest” signal. One potential mechanism underlying signal honesty is the resource allocation hypothesis. This predicts that both defence and signal production utilize the same pool of resources, leading to a trade-off between the two. This can then lead to quantitative honesty, as individuals with access to plentiful resources may invest more heavily in both signal and defence, while low-resource individuals cannot. We tested this hypothesis using the wood tiger moth (*Arctia plantaginis*). We found that both the strength of their warning colour and strength of chemical defence are influenced by nitrogen availability during development. Our results show that resource allocation can influence naturally-occurring warning signal variation in this species, and that this may provide information to predators about the defence status of their potential prey.



### Dr. Emily Burdfield-Steel

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Emily Burdfield-Steel is an Assistant Professor of Chemical Ecology in the Institute for Biodiversity and Ecosystem Dynamics (IBED) at the University of Amsterdam (UvA). Dr. Burdfield-Steel is interested in how intra- and inter-specific communication shapes evolutionary processes. Areas of study include the evolution of mating communication systems in response to reproductive interference and the role of chemical and visual signals in aposematic insect populations.

# Are Newly Emerged Females of the Polka-Dot Wasp Moth Mute?

Frank Coro

12-minute, Perspective

*Syntomeida epilais* (Arctiinae) require acoustic communication for successful mating behavior. Starting normally on their third night after emergence, perched, virgin females phonorespond to conspecific male emissions. My aim is to determine if newly emerged females (one and two nights after emergence) are able to phonorespond to playback of conspecific male emissions and that of a sympatric bat attack sequence. 18 one-night old and 22 two-night old females were acoustically stimulated while perched during their normal courtship behavior hours. All 40 females phonoresponded to the bat attack sequence, while only five of them responded to their male signals showing high threshold, around 90 dB SPL. As control, 18 three-night old virgin females were stimulated with the same acoustic signals and under the same conditions. All 18 females responded to their male signals and to the bat echolocation calls, showing a significant decrease in their threshold, between 54 and 60 dB SPL.



**Prof. Francisco Coro**  
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B.Sc. in Biology at Havana University, Cuba; Ph.D. at Moscow State University, Russia. At Havana University taught Animal Physiology from 1970 until 2005. Since 2007 teaches Human Physiology at Miami Dade College, USA, where he is currently Professor. He has done research for 50 years in Bioacoustics of Moths, including Arctiinae. He has mentored Ph.D., M.Sc., and undergraduate students. His research has included: structure and physiology of tympanic organs; physical features of sound emissions; phonoresponses to acoustic stimuli present in their environment. He has published 49 articles. His continuing interest has been the neuroethology of intraspecific acoustic communication in Arctiinae.

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# Recent advances in the phylogenomics of the Arctiinae (Lepidoptera: Erebidae)

Nicolas J. Dowdy, Makani L. Fisher, Alan R. Lemmon, Emily M. Lemmon, William E. Conner, & Jennifer M. Zaspel

12-minute, Traditional

I will discuss recent advances in the phylogenomics of the Arctiinae. These include a recently developed anchored hybrid enrichment probe set (>700 loci) developed by Dowdy et al., 2020 and a new, nearly complete genus-level phylogeny of the subtribes Phaegopterina and Pericopina. In addition, I will discuss some new techniques which combine this phylogenomic toolkit with traditional sources of molecular data such as the COI 'barcoding' locus to greatly increase taxonomic representation in our phylogenies. Highlights of the phylogenetic positions of some clades of interest to the Arctiinae Research Community will be given. Finally, I will give some details about future directions for the phylogenetics of the group.



**Dr. Nicolas J. Dowdy**  
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Dr. Dowdy obtained his Ph.D. from WFU under the mentorship of Dr. William E. Conner in 2017. His dissertation work focused on the behavioral and chemical ecology of arctiine anti-predator defenses. In 2018, after a collections-based postdoctoral fellowship at Purdue University with Dr. Jen Zaspel, he was awarded a National Science Foundation Postdoctoral Research Fellowship in Biology which supports his current work on tiger moth phylogenomics. Recently, he accepted a permanent position as a Research Curator and Head of Zoology at the MPM. His on-going research includes the taxonomy, systematics, and evolution of anti-predator and mating strategies within Arctiinae.

## Sexual and natural selection mold the acoustic signals of tiger moths in parallel

Yohami Fernandez, Nicolas J. Dowdy, & William E. Conner  
12-minute, Traditional

Sound production in tiger moths (Erebidae: Arctiinae) plays a role in natural selection. Some species use tymbal sounds as jamming signals avoiding bat predation. High duty-cycle signals have the greatest efficacy in this regard. Tiger moth sounds can also be used for intraspecific communication. Little is known about the role of sound in the mating behavior of jamming species or the signal preferences underlying mate choice. We recorded sound production during the courtship of two high duty cycle arctiines, *Bertholdia trigona* and *Carales arizonensis*. We characterized variation in their acoustic signals, measured female preference for male signals that vary in duty cycle, and performed female choice experiments to determine the effect of male duty cycle on the acceptance of male mates. Although both species produced sound during courtship, the role of acoustic communication appears different between the species. *Bertholdia trigona* was acoustically active in all intraspecific interactions. Females preferred and ultimately mated with males that produced higher duty cycles. Muted males were never chosen. In *C. arizonensis* however, sound emissions were limited during courtship and in some successful matings no sound was detected. Muted and clicking males were equally successful in female mate-choice experiments, indicating that acoustic communication is not essential for mating in *C. arizonensis*. Our results suggest that in *B. trigona* natural and sexual selection may work in parallel, to favor higher duty cycle clicking.



**Yohami Fernández Delgado**  
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Yohami Fernández is a Ph.D. Candidate in Dr. Conner's lab in Wake Forest University. She received her Bachelor and Master's degrees at the University of Havana under the guidance of Dr. Emanuel Mora. Yohami has worked on acoustic communication in tiger moths and its dual role in prey-predator interactions and courtship behavior. Her current work is focused in understanding the efficacy of the jamming behavior in tiger moths as an anti-bat defense and how sexual and natural selection working in concert influence this behavior.

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## The Other Moth of the Modern Synthesis: Revisiting Fisher and Ford's Studies of the Scarlet Tiger Moth (*Callimorpha dominula*)

Richard Gawne

5-minute, Perspective

Early studies of the peppered moth (*Biston betularia*) are widely regarded as being fundamental to the establishment of the modern evolutionary synthesis during the first half of the twentieth century. Around the same time, researchers such as R.A. Fisher, E.B. Ford, and others associated with the Oxford school of ecological genetics conducted pioneering long-term studies of the scarlet tiger moth (*Callimorpha dominula*). This work helped to establish some of the core tenets of the modern synthesis, but has largely been forgotten by biologists who are not directly working on Lepidoptera. This talk revisits and builds upon the work of Fisher and Ford by applying modern insights from evolutionary developmental biology to the color patterns of *C. dominula*.



**Dr. Richard Gawne**  
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Richard Gawne is a postdoctoral researcher in the Center for Regenerative and Developmental Biology at Tufts University (USA). Previously, he was a fellow at the Konrad Lorenz Institute for Evolution and Cognition Research in Vienna, Austria. He completed his PhD in 2017 with Fred Nijhout. His primary interests are in color pattern evolution and development.

# Aposematic moths are phenotypically more variable than camouflaged

Ossi Nokelainen, Sanni A. Silvasti, Sharon Y. Strauss, Niklas Wahlberg, & Johanna Mappes  
5-minute, Perspective

Many species such as tiger moths have conspicuous coloration, which is known to advertise their chemical defenses to avian predators. A long-standing paradigm of protective coloration predicts that predator learning exerts a purifying selection towards a locally most effective warning signal. Nonetheless, there are several examples of tiger moths as well as other lepidoptera showing a puzzling degree of colour variation and polymorphisms. Here, we suggest that aposematic moths should in fact be phenotypically more variable than camouflaged moths. In order to be conspicuous and detectable species must stand out, which can be achieved through increasing brightness or colour contrast against their visual background. Thus, we should reconsider our rationale whether predator selection is deemed to decrease variation in warning coloration among aposematic species.



**Dr. Ossi Nokelainen**

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Ossi Nokelainen obtained his Ph.D. at University of Jyväskylä (2013), Finland under the supervision of Prof. Johanna Mappes and Dr. Carita Lindstedt. His thesis was on the maintenance of colour polymorphism in the aposematic wood tiger moth (*Arctia plantaginis*). Currently, Ossi is a postdoctoral researcher in his 'home' university. Dr. Nokelainen has worked over 10 years focused on predator-prey interactions, polymorphism and animal coloration. During this time, he has published 28 articles, supervised 15 students and peer-reviewed submissions for 25 journals. He uses multispectral imaging, vision modelling and experimental approaches at the interface of sensory, behavioural and evolutionary ecology.

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# Syntomini (Erebidae: Arctiinae) – a short overview

Łukasz Przybyłowicz

5-minute, Synthesis

Syntomini is, without doubt, the most systematically neglected monophyletic lineage within Arctiinae. For a long time, they (or its subgroups) were not even recognized as tiger moths, instead placed within Notodontidae, Zygaenidae, Sesiidae, or even as a separate family Thyretidae. Subsequent revisionary and phylogenetic studies have shed light on this issue providing evidence that the division of Syntomini into Syntomina and Thyretina is also artificial. However, in virtually all modern molecular-based studies of arctiine phylogeny, this tribe is tremendously underrepresented. Unpublished estimates put the number of described species at about 900 with almost half distributed in continental Africa. Syntomini, a group confined exclusively to the Old World, harbors one of the most profound and spectacular radiations of all arctiines, with as many as one hundred species endemic to Madagascar. Even more fascinating, this insular lineage birthed a transcontinental journey which sent ancestors of the genus *Dysauxes* as far north as southern Scandinavia.



**Dr. Łukasz Przybyłowicz**

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Łukasz Przybyłowicz obtained his Ph.D. at Jagiellonian University under the guidance of Prof. Józef Razowski. Currently, he is an Associate Professor and Head of the Department of Invertebrate Zoology at Institute of Systematics and Evolution of Animals Polish Academy of Sciences. Dr. Przybyłowicz has worked for more than 20 years on systematics and biogeography of Arctiinae and currently supervises 2 Ph.D. students. He has worked on various aspects of inventorying, α-taxonomy of different groups of arctiines, and higher-level phylogenies, leading to the publication of more than 60 articles. His current interests are focused on revising Madagascar Syntomini and understanding its evolutionary history.

# TBD

Jenna Lommi, Jimi Kirvesoja, Ossi Nokelainen,  
Johanna Mappes, & Anne Winters  
12-minute, Traditional

Arctiines have diverse anti-predator defences that can stimulate different sensory modalities or act at different stages of predation. Thus, they offer an intriguing system for investigating selection for multiple defences. We tested the efficacy of three lines of defence (colour, smell, taste) during predation of aposematic wood tiger moths by birds. Moths with two hindwing phenotypes (genotypes: WW/Wy=white, yy=yellow) were manipulated to have aversive smell (methoxy-pyrazines), taste (pyrrolizidine alkaloids) or both. Birds hesitated to approach homozygous white moths compared to yellow independent of smell, but only hesitated to attack white heterozygotes if they smelled bad. Colour and smell contributed additively to birds dropping moths. After capture, birds only discriminated toxic from non-toxic moths, if they had methoxy-pyrazine smell. White moths with both smell and taste defences had greatest survival. We suggest methoxy-pyrazines are context-setting signals for colour and attention-alerting, “go-slow” signals for taste, mediating the relationship between these anti-predator defences.



## Dr. Anne Winters

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Anne Winters completed her PhD at The University of Queensland, under the supervision of Dr. Karen Cheney, and worked as a postdoc for Prof. Johanna Mappes at the University of Jyväskylä. Currently, she is a Marie Skłodowska-Curie Postdoctoral Research Fellow at The University of Exeter with Prof. Martin Stevens. Dr. Winters' research has focused on anti-predator defences of invertebrates including marine molluscs and terrestrial insects, with a particular interest in aposematism. Her ongoing work on *Arctia plantaginis* investigates the implications of variation in sequestered chemical defences, how multiple compounds interact to dissuade predators, and the efficacy of multiple sensory modalities in disrupting different stages of predation.

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## On the phenotypic plasticity of the Ornate Bella Moth, *Utetheisa ornatrix*

Andrei Sourakov, Clara J. Brandon, Isaac Long, Logan M. Locascio, Alyssa M. Quinn, Eric Anderson, Jodie V. Johnson, Eve N. Rowland, Lisa A. Taylor, & Hans T. Alborn  
12-minute, Traditional

Over the last 10 years, we conducted several experiments to better understand the extent of phenotypic plasticity within the Ornate Bella Moth. We have tested several variables, from temperature to hostplants, to determine how the moth interacts with the environment. We focused on the biology of moths feeding on hostplants found in Florida, many of which are invasive exotics and represent novel host associations. Our efforts therefore may have both evolutionary and applied aspects. Understanding co-evolution between a herbivore and its hosts can shed light on the influence of hostplants on herbivore microevolution. These native moths may be viewed as biocontrol agents of invasive plants by some, even though they may also be viewed as pests by others. Finally, this moth has been an excellent model for understanding, predator-prey interactions, wing pattern plasticity, and for introducing the next generation of scientists to field and laboratory work with Lepidoptera.



## Dr. Andrei Sourakov

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Andrei Sourakov obtained his Ph.D. at the University of Florida in 1997. Currently, he serves as a Collections Coordinator of Lepidoptera at the Florida Museum of Natural History and teaches “Insects and Plants” as a graduate faculty of Entomology. Dr. Sourakov has worked with Lepidoptera all his life, conducted field work in more than 20 countries, and his interests range from biogeography and speciation to community and chemical ecology. He views Lepidoptera as a perfect group for answering broader biological questions, and, like many before him, he has been using the Ornate Bella Moth, *Utetheisa ornatrix* (along with several other arctiines), as his model species.

# The microbiome of the wood tiger moth (*Arctia plantaginis*)

Juan A. Galarza, Liam Murphy, & Johanna Mappes

12-minute, Traditional

Here we investigate if the bacterial community present in the thoracic fluids of wood tiger moths (*Arctia plantaginis*) plays a role in protection against the moth's avian predators. We hypothesise a defensive-symbiosis interaction between the bacteria and its moth host, which in turn impacts predator-prey interactions between the moth and its avian predators.



**Dr. Juan Galarza**  
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Juan obtained his PhD at the university of Hull, UK, majoring in population genetics. He then was a research fellow at the university of Windsor, Canada before returning to Europe at the Doñana Biological Station in Seville, Spain, where he worked on ecological genetics and speciation of social insects. Currently, Juan is a senior researcher working with Prof. Johanna Mappes at the university of Helsinki, Finland. His projects include population genomics of wood tiger moth, the molecular bases of its warning colouration, and multi level species interactions between microbiome-moth-predators.

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# Perspectives From Studying a Self-Medicating Woolly Bear Caterpillar

Michael S. Singer

12-minute, Perspective

I will use a narrative of my past research on the evolutionary ecology, behavior, and physiology of *Apantesis incorrupta* to highlight exciting questions and future research directions. *Apantesis incorrupta* may be best known for its self-medication behavior. That finding was the culmination of basic ecological, behavioral, and physiological research emphasizing the importance of tri-trophic interactions, the intricacies of foraging behavior, and the distinction between different biological levels of specialization. *Apantesis incorrupta* is a physiologically specialized dietary generalist. Its physiological specialization to ingest and sequester PAs from host plants stands in contrast to its phylogenetically immense host range. The evolutionary process leading to this paradox, probably ubiquitous in the Arctiina, is an exciting question that has already been framed by the phylogenetic analysis of PA pharmacophagy in Arctiines. Arctiina undoubtedly have many more secrets to tell in this arena. To learn them, researchers will not only need to harness the most powerful technologies, but also remember to leverage observations of these wonderful organisms in their natural environments.



**Dr. Michael S. Singer**  
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Michael (Mike) Singer received his Ph.D. at the University of Arizona under the guidance of Dr. Elizabeth Bernays. Currently, he is Professor and Chair of Biology at Wesleyan University in Middletown, Connecticut, U.S.A. His Ph.D. work and early postdoctoral research focused on tri-trophic interactions surrounding the larval stage of *Apantesis incorrupta*, a tiger moth of the southwestern USA. This collaborative research program produced publications on various evolutionary ecological, behavioral, physiological, and biochemical topics. The most transcendent finding of this work was the discovery of self-medication behavior by these woolly bear caterpillars, which increase their ingestion of pyrrolizidine alkaloids in response to parasitism by tachinid flies. While Mike remains interested in arctiine biology, his current research widens the ecological scope of tri-trophic interactions, using forest caterpillars in Connecticut as a study system.

# Perspectives of Arctiinae diversity research in the Neotropics

Gunnar Brehm

12-minute, Synthesis

Neotropical Arctiinae species richness is highest in the Amazon-Andes foothills, at intermediate disturbance levels and in the forest canopy, and their body size increases with elevation. Arctiinae will be a model group in two new research projects in NW Ecuador and SE Peru. The study in Ecuador will focus on pollination (metabarcoding) within a larger research unit that investigates the reassembly of networks after disturbance in the Chocó rainforest. Arctiinae will be compared with Sphingidae and we will measure traits such as body size, proboscis length and colour patterns. The study in Peru is one of four projects that investigate insect diversity along an elevational gradient between 250m and 3500m. It will reveal changes of richness, body size and wing coloration / aposematism in comparison with Geometridae. Species will be DNA barcoded and illustrated catalogues will be produced.



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Gunnar Brehm is interested in the macroecology and biogeography of geometrid and arctiinae moths, and he has mainly worked in Ecuador, Costa Rica and Peru. One focus of his work are elevational gradients, but he is also interested in many other aspects of the ecology and systematics of the two moth groups. He obtained his Ph.D. at Bayreuth University (Germany) under the supervision of Konrad Fiedler and is employed at the Phytisches Museum (Jena, Germany) since 2006.

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## A Leopard Does Not Change its Spots, but Tiger Moths Come in Various Forms Most Beautiful

Katja H. Rönkä, Robert B. Davis, & Toomas Tammaru

5-minute, Future

How can we investigate the ultimate reasons behind tiger moth diversity and conspicuousness? An improved molecular phylogeny enables using the comparative method within the previously difficult-to-classify tribe Arctiini. I will present an ongoing collaborative project looking at phylogenetic comparisons between size and coloration as the first step in utilising this method in tiger moths.



**Dr. Katja Rönkä**

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Katja Rönkä defended her thesis on predator-prey interactions and the maintenance of warning colour polymorphism in the Wood Tiger Moth, *Arctia plantaginis* (formerly *Parasemia*, Rönkä et al. 2016) supervised by Prof. Johanna Mappes, Dr. Bibiana Rojas & Prof. Niklas Wahlberg at the University of Jyväskylä. She has experience from various field surveys and a master's study on the movement ecology of the False Heath Fritillary to organizing macrolepidoptera collections at the Finnish Museum of Natural History. Currently Dr. Rönkä studies coevolutionary interactions in an avian system, but is also involved in developing field survey methods in ecological research.

# Microbiome Variation in the Wood Tiger Moth

Liam Murphy, Johanna Mappes, & Juan Galarza

5-minute, Traditional

Insects are hosts to multitudes of symbiotic bacterial communities. However, insight of how the bacterial assemblage varies across the host's range is limited to just a few groups of insects. *Arctia plantaginis* is a chemically defended diurnal moth whose specialised cervical glands harbour their own microbiome. We sampled fluids from these cervical glands from four distant locations in Estonia, and Southern, Central, and Northern Finland, and characterised bacteria present in them through full-length 16S ribosomal RNA sequencing. In total, 451 amplicons sequence variants (ASVs) were found. Four bacterial genera (*Sphingomonas*, *Methylobacterium*, *Achromobacter*, and *Stenotrophomonas*) were observed in all locations. *Sphingomonas* was present in at least half of the samples in Estonia, Northern and Southern Finland, while *Achromobacter* was found in half of Central Finnish samples. Bacterial species richness was significantly higher in Northern Finland than in Estonia. Only the Northern and Southern Finland locations differed significantly in their bacterial phylogenetic diversity. Latitude and environmental sources of bacteria appear to be the largest drivers shaping microbiome composition, though community composition did not differ significantly across the sampled range.



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I am a PhD student working on the microbiome of the wood tiger moth in the Mappes lab in Jyväskylä, Finland. Juan Galarza & Johanna Mappes are my supervisors. Aside from the moth's interactions with its bacterial communities, I am interested in their immune functions and use of behavioural immunity.

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# Contribution to the knowledge of tiger moths (Erebidae: Arctiinae) in Argentina

Hernán M. Beccacece

5-minute, Traditional

Knowledge of Argentinian tiger moths has largely remained static for the last 50 years with few recent studies and there is no checklist of the species present in the country. Previous studies estimated more than 250 species; however, this number is far from accurate. Here, I present a preliminary checklist occurring in Argentina. This preliminary checklist was made mainly with literature data, specimens deposited in Argentinian collections (IFML, MACN, MLP, MZUC), and personal sampling. Specimens were identified using type specimens, genitalia dissections and consultations with specialists or collections. A total of 325 species were registered and 40 species are new records for Argentina. Several specimens, mostly *Lithosiini*, *Euchromiina*, and *Ctenuchina* could not be identified. Genitalia dissection and molecular analyses are needed to establish their identity. Continued inventory efforts will increase the number of known species and support strategies for conservation. Another powerful tool to explore are citizen science websites where several photographic records from Argentina were uploaded, but specimens were not found in collections.



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Hernán M. Beccacece obtained his Ph.D. at Universidad Nacional de Córdoba (UNC), Argentina under the guidance of Dr. Fernando Navarro and Dr. Francisco Ludueña-Almeida. Currently, he is a Assistant Research of IMBIV-CONICET and Assistant professor of the Facultad de Ciencias Exactas, Físicas y Naturales, UNC. He has worked for more than 10 years on taxonomy, phylogeny, and biodiversity of Arctiinae and has published 12 articles related to Arctiinae and 9 related to Lepidoptera. He is working on describing new species, pest of crops, biodiversity, and conservation studies of tiger moths present in Argentina.

## The other half of the story: female role in the maintenance of color polymorphism

Chiara De Pasqual, Astrid T. Groot, Emily Burdfield-Steel, Ossi Nokelainen, Swanne Gordon, & Johanna Mappes  
5-minute, Traditional

Color polymorphism is widespread in nature, and the wood tiger moth is no exception. It is puzzling, however, how multiple color morphs can persist within populations. The wood tiger moth is an ideal species to study how genetic color morphs can be maintained within populations. In the Finnish population, the hindwing coloration is a heritable, one locus two allele (White and Yellow) trait. We know from previous studies that more heterozygous white males have higher mating and reproductive success. But what about females? Do they play a role in the maintenance of color polymorphism? We tested mating success, reproductive output and the attractiveness of genotyped females to understand if and how they could contribute to the maintenance of color polymorphism.



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Chiara De Pasqual is currently a PhD student at the University of Jyväskylä (Finland). The interest in tiger moths already started in 2016 when she joined Johanna Mappes' group to study predator generalization on the polymorphic wood tiger moth (*Arctia plantaginis*) for her Master project. After an internship at Lund University (Sweden) working with the polymorphic damselfly *Ischnura elegans*, she re-joined Johanna's group in 2018. She is currently studying how sexual selection and sex pheromones can contribute to the maintenance of the polymorphic hindwing coloration in the wood tiger moth.

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## Diversity in wood tiger moths, and academia

Swanne Gordon

5-minute, Future

The existence of multiple morphs in aposematic warning signals is puzzling. Individuals that bear the most common signal should have a survival advantage due to efficient predator learning. This positive frequency dependence should select for fixation of the most common morph. Yet many aposematic organisms are polymorphic, suggesting that other processes must come into play. Here we explore the effect of frequency dependent selection on polymorphism in the aposematic wood tiger moth. Overall, we show that multiple factors including spatio-temporal variation in predation, sexual selection, and gene flow interact to help maintain the dimorphism, but that much remains uncovered. We end with a focus on what research we will undertake next.



**Dr. Swanne Gordon**  
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Swanne Gordon obtained her MSc at McGill University with Dr. Andrew Hendry, and her Ph.D. at University of California, Riverside under the guidance of Dr. David Reznick. Currently, she is an Assistant Professor of Biology at Washington University in St Louis. Dr. Gordon studies how evolution generates, limits, and sustains biological diversity. Her research specifically tackles two main points: the mechanisms behind the rapid evolution of life histories and sexually selected traits, and the maintenance of diversity in warning signals and anti-predator behaviour.

# Proposed molecular and morphological review of *Sphecosoma*

Melissa S. Sisson, Rebecca B. Simmons, & Susan J. Weller  
5-minute, Future

*Sphecosoma* is a moderately large genus, with 89 described species, in the Arctiinae subtribe Euchromiina. The genus is distributed across the Neotropics and are polybiine wasp mimics. The largest treatment of *Sphecosoma* was completed by Hampson (1898) and was reviewed in Simmons and Weller (2006). Simmons and Weller (2006) used 52 morphological characters in their analysis and found *Sphecosoma* to be polyphyletic, being comprised of multiple species groups. Simmons and Weller (2006) divided the genus into two groups: 1) *S. aliena* group and 2) *S. cogata* group. Recent molecular work with euchromiine genera found similar results in regard to *Sphecosoma*. Here the authors present the proposal of an expanded morphological and molecular review of the genus *Sphecosoma*. We will incorporate the morphological characters from Simmons and Weller (2006) and the following five molecular markers: DI region of 28s, DII region of 28s, EF-1 $\alpha$ , GAPDH, and RpS5. We hope to provide combined evidence for *Sphecosoma* to be split into multiple genera.



**Melissa Sisson**  
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Melissa Sisson is currently finishing her Ph.D. at the University of North Dakota under the advisement of Dr. Rebecca Simmons. Melissa's research focuses on the phylogenetic relationships of the mimetic tiger moths, specifically examining the relationships of the subtribe Euchromiina. Her continuing interests are to better understand the relationships of the euchromiine genera and the evolution of wing pattern elements across the mimetic tiger moth lineage.

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# Population dynamics of *Arctia virginalis* over the past 38 years: What drives big years and crashes?

Richard Karban, Adam Pepi, Patrick Grof-Tisza, & Vincent Pan  
12-minute, Traditional

We have surveyed a population of *Arctia virginalis* caterpillars annually since 1985 at the Bodega Marine Reserve in central California. Caterpillar densities varied by several orders of magnitude and were higher following wet years and in wetter sites. Dry sites often experienced local extinctions and acted as population sinks. Ants are important predators of early instar caterpillars although ants were less active than caterpillars and less effective predators under cool, wet conditions. Caterpillars are also attacked by a locally specific tachinid parasitoid. Both caterpillars and flies survived parasitism and parasitized caterpillars increased their chances of surviving by switching host plants and behaviors. We found no evidence that parasitoids drove caterpillar populations but rather they lagged one year behind. Recently, we have found a baculovirus that may regulate caterpillar populations.



**Dr. Richard Karban**  
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Rick Karban completed his PhD at the University of Pennsylvania. He is currently a professor in the Department of Entomology and Nematology at the University of California in Davis. He became interested in arctiines soon after his arrival in California in 1982 and has been surveying their populations ever since. He has also worked on plant defenses against herbivory, particularly induced defenses and the cues that plants perceive to adjust those defenses.

# Leaf Retention Increases Infection Risk of an Arctia Caterpillar

Vincent S. Pan, Adam Pepi, & Richard Karban

5-minute, Traditional

The long-standing hypothesis that plant traits can be selected to exploit animal pathogens as bodyguards against herbivores has yet to be empirically demonstrated. We examined whether winter leaf retention of bush lupines (*Lupinus arboreus*) promotes the persistence of a granulovirus thereby increasing the infection risk of caterpillars (*Arctia virginalis*) feeding on the canopy during spring. We also manipulated the amount of lupine litter available to younger caterpillars that live under the canopy in a feeding experiment, since leaf retention reduces litterfall. Greater winter leaf retention increased caterpillar infection rates in early spring. This reduced herbivory and increased plant inflorescence density by summer. Young caterpillars exposed to less litterfall were more likely to starve to death but less likely to die from a severe infection. Herbivory pressure may thus select for higher winter leaf retention to impose a stronger top-down control via facilitating viral outbreaks.



**Vincent Pan**

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Vincent Pan is currently a lab technician at Oklahoma State University under the guidance of Dr. Eric LoPresti. He earned his undergraduate degree while working in Dr. Rick Karban's lab at University of California, Davis, primarily studying winter leaf abscission as a herbivory resistance trait. In a few months, he will begin studying the variability of herbivory and plant quality at Michigan State University under the guidance of Dr. Will Wetzel.

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# Thermal melanism or ultraviolet protection? Wing melanism, predation, temperature, and solar radiation in Ranchman's tiger moth (*Arctia virginalis*)

Adam Pepi, William Hemstrom, Claire Beck, & Fiona Beyerle

12-minute, Traditional

Melanistic pigmentation in insects has a variety of potential functions, and within Lepidoptera wing melanism has been proposed to increase solar thermal gain as an explanation for darker phenotypes occurring in colder areas. Tradeoffs with aposematic signalling and protection from ultraviolet radiation have also been proposed as explanations for variation in melanism. To investigate the roles of the temperature, solar radiation, and predation in driving variation in melanism of the Ranchman's tiger moth (*Arctia virginalis*), we characterized wing melanism in moths from 23 populations across the range. We conducted predation experiments using artificial moths in populations with both morphs, and only light morphs. We found that melanism was strongly associated with higher temperatures, weakly associated with total insolation, and negatively associated with colder temperatures. Our results contrast with previous findings that wing melanism in Lepidoptera is associated with colder conditions and higher predation risk, and suggest that diel temperature variation or protection against ultraviolet radiation may be potential drivers of variation in wing melanism that have been overlooked.



**Adam Pepi**

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Adam Pepi is a PhD Candidate in Ecology at UC, Davis, in the Karban and Holyoak labs. He did his M.S. in the Elkinton lab at University of Massachusetts Amherst, and a Fulbright fellowship with Birchmoth at University of Tromsø and the Norwegian Institute for Nature Research. In Fall 2021 he will be starting a postdoc with Lawrence Uricchio at Tufts University. Adam is interested broadly in plant-insect population & community ecology, especially in the context of climate change. He also has an interest in the ecology and biological control of invasive insects.

## Host preference and selective sequestration in the lichen-feeding tiger moths (Erebidae: Arctiinae: Lithosiini)

Makani L. Fisher, Stephen L. Cameron, C. Riley Nelson, Steve L. Leavitt, & Jennifer M. Zaspel

12-minute, Traditional

Lichens are intrinsically resistant to herbivory, however, Lithosiini specialize on them and their secondary chemistry. Lichen metabolites have been detected in as many as 40 lithosiine species and can influence larval host selection. Past studies have focused on lichen secondary chemicals that deter caterpillars, so we investigated which metabolites can attract caterpillars. We carried out host preference assays with *Cisthene angelus* caterpillars to lichens with secondary chemicals from differing metabolic pathways. Additionally, we characterized sequestration patterns and measured caterpillar growth. We found that caterpillars had early preferences, but lost them overtime, likely in favor of fulfilling nutritional needs. We also found caterpillars to have utilized more unique compounds from the early preferred lichen. These compounds are believed to be for antipredator defenses and further study into the chemistry of these tri-trophic interactions will help to better understand the evolution and ecological role lithosiines and their lichen feeding behavior.



**Makani L. Fisher**  
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Makani Fisher obtained his bachelor's and master's at Brigham Young University where he investigated the caterpillar host preferences of *Cisthene*. He is now a Ph.D. student at Purdue University under the guidance of Dr. Jennifer Zaspel where he works on the evolutionary ecology of the subtribe Cisthenina. In particular, he is investigating the combination of different molecular data types for phylogenetic analyses, addressing the *Hypoprepia fucosa*-miniata complex, and investigating the role of lichen secondary chemistry in antipredator defenses. His continuing interests are in how lichen chemistry is sequestered and reutilized by caterpillars and putting it into evolutionary and ecological contexts.

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## Two highly sexually dimorphic *Lophocampa* species

Michel Laguerre & Benoît Vincent

5-minute, Traditional

During a visit to the MUSM collections (Lima, Peru), we found a mosaic gynandromorph specimen exhibiting a female habitus similar to *Lophocampa teffeana* and an unknown male habitus. A few years after, a male genitalia of an unknown species, first assigned to the genus *Euagra*, was studied and immediately associated to the genus *Lophocampa*, based on the presence of the spinose processes at the valvae basis. Moreover, the habitus of this specimen corresponded to the male part of the gynandromorph and allowed to target the specimens to be barcoded to attempt the pairing of a strongly dimorphic species. *L. teffeana*'s sister species, *L. albotestaceus*, has also been sequenced, along with male specimens from French Guiana and Peru. It was thus possible to match the males with the two species of *Lophocampa* known so far only from female individuals. This study made it possible to highlight a spectacular sexual dimorphism as well as the hitherto unknown existence of two diurnal *Lophocampa* species.



**Benoît Vincent**  
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Benoît Vincent holds a Master 2 in Systematic and Evolution, obtained in the Museum National d'Histoire Naturelle (MNHN) in Paris. Between 1998 and 2014, he was an entomologist assigned to the Institute of Criminal Research of the French Gendarmerie (IRCGN) and was also at the origin of the Fauna-Flora ID unit, which uses the technique of DNA Barcoding to identify animal traces found on a crime scene. Since 2015 he is a "water and nature" inspector at the Regional Environment Department in Toulouse (France). Since 1997, he's specialized in neotropical Arctiini (Phaegopterina, Arctiina, Pericopina). He regularly conducts entomological expeditions in Latin America to study this group. He has described as author (or co-author with Michel Laguerre) 54 new species.

# Auditors



**Prof. James K. Adams**

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James Adams obtained his Ph.D. from the University of Kansas in Spring of 1990, defending his dissertation on the defenses of adult Tiger Moths. Since Fall of 1990, he has been teaching in the biological sciences at Dalton State College in Dalton, GA. He has published on and is involved in several moth faunal surveys around the state of Georgia, and has described or co-described a few species of noctuid/geometrid moths. He has published on zygaenoids as well. He is also the editor for the 50+ page quarterly News of the Lepidopterists' Society, and has been since Fall 2011.



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Bernardo Espinoza has worked on Arctiinae since 1992, first for the old INBio collections as a Lepidoptera technician and Lepidoptera curator respectively and after that for Dan Janzen & Winnie Hallwachs and the GDFCF in Guanacaste, Costa Rica focused on the Arctiinae alpha taxonomy. At present his main interest continues to be the taxonomy of this group, but now including the DNA barcoding processes as a fundamental element on the diagnostic for the different species present in the country and in particular those members of complex species of which we still know nothing.



**Dr. Viviane G. Ferro**

Universidade Federal do Rio Grande do Sul  
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Viviane Ferro obtained her Ph.D. at Universidade de Brasília under the guidance of Dr. Ivone Diniz. Currently, she is a Professor at Universidade Federal do Rio Grande do Sul, Brazil. Dr. Ferro has worked for more than 20 years on Arctiinae diversity and has mentored 19 students. She has worked on *Utetheisa ornatrix-Crotalaria*-predators interactions, diversity and conservation of Brazilian tiger moths, leading to the publication of 29 articles.



**Dr. Robert Hegna**

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Currently an associate professor of biology at Palm Beach Atlantic University. Focused on questions relating to how polymorphic warning signals evolved and maintained within wild populations of poison frogs and the wood tiger moth. Currently looking into the warning signal of the polka-dot wasp moth and microplastics.

# Auditors



**Katherine Hernandez**  
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Katherine Hernandez is a Ph.D. Candidate at the University of Colorado at Boulder. Currently, she is being advised by Deane Bowers studying the role diet, insect immunity, and temperature has on the chemical ecology and flight performance on species in Nymphalidae. Katherine has mentored students from underrepresented backgrounds in ecology and evolutionary biology. Her Master's work was on the chemical ecology of *Apantesis* larvae.



**Dr. Fernando Hernández Baz**  
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Dr. Hernández Baz is a faculty member of the biology department at the Universidad Veracruzana in Xalapa, Mexico.



**Dr. Rahul Joshi**  
Zoological Survey of India  
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Rahul Joshi obtained his Ph.D. at Punjabi University, Patiala, (India) University under the guidance of Dr. Jagbir Singh. Presently, he is working as Scientist in Zoological Survey of India working mainly on taxonomy of macro-moths. Dr. Joshi has worked for more than 10 years on taxonomic studies of Indian Lithosiini. He is mainly dealing with genitalic studies to sort out complexes and described more than 25 new taxa in about 35 research articles. His further interest is to work on DNA barcoding of Indian Lithosiini taxa.



**Dr. Michel Laguerre**  
Muséum National d'Histoire Naturelle, Paris  
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Michel Laguerre is a chemical engineer from ENSC Toulouse and holds a PhD and a Science DSC obtained at the University of Bordeaux. He is retired now from CNRS and European Institute for Chemistry and Biology (IECB). As a biochemist, he has published around 140 scientific publications in peer-reviewed journals. In parallel and after some interests in Ethiopian Rhopalocera he specialized into neotropical Arctiini since 1992. He regularly conducted entomological expeditions in Latin America to study this group. In entomology he has published around 60 papers including the updated Arctiini Neotropical catalog (excluding Ctenuchina and Euchromiina) in collaboration with Benoit Vincent. His continuing interests are the general classification and the biogeography of the Neotropical Arctiinae.

## Auditors



**Dr. Ray B. Nagle**  
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rnagle@email.arizona.edu

I am a retired surgical pathologist with a PhD in experimental pathology. I have a lifelong interest in arctiine moths and their life histories. Currently working on a book describing the Arctiinae of Arizona.



**Alma Oksanen**  
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Alma Oksanen (MSc) started working as a Laboratory Coordinator in the Predator-Prey Interactions Group in December 2020 at University of Helsinki. She is passionate about larval rearing and keeping good care of the moth stock is her priority. Before entering the world of *Arctia plantaginis* moths she worked more than ten years assisting in *Melitae cinxia* butterfly studies in Research Centre for Ecological Change.



**Dr. John Palting**  
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madreandiscovery.org

John Palting completed a PhD at the University of Arizona in the laboratory of Wendy Moore, studying the molecular phylogeny and chemical ecology of Southwestern Lithosiini. He is employed outside academia by Roche Pharmaceuticals, but maintains an active working relationship with Lepidoptera researchers and is involved in fieldwork in the Sonoran Sky Island region of Arizona and the adjacent Mexican state of Sonora. John is a contributor to an ongoing, free database project called Madrean Discovery where he documents the biodistribution of arctiines and other moths in the Sky Island ranges.



**Margarida Pereira de Freitas**  
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margaridapf@hotmail.com

# Auditors



**Dr. Danúbia Marcela Pereira Valente**  
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**Anna Przystałkowska**  
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Anna Przystałkowska is a PhD student and technical worker employed in the Department of Invertebrate Zoology at the Institute of Systematics and Evolution of Animals, Polish Academy of Sciences, Krakow. Her research interests are: taxonomy, phylogeny and biogeography of Lepidoptera of the Ethiopian Region. The main research project is a morphogenetic study of the genus *Apisa*.



**Dr. B. Christian Schmidt**  
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[canacoll.org/Lep/Staff/Schmidt/Schmidt.html](http://canacoll.org/Lep/Staff/Schmidt/Schmidt.html)

Christian Schmidt is a research scientist with Agriculture and Agri-food Canada, and is based at the Canadian National Collection of Insects, Arachnids and Nematodes (CNC). His PhD research (University of Alberta; Felix Sperling advisor) revised the systematics of *Apantesis* tiger moths and their relatives. His current research focus is on the taxonomy, systematics, and diagnostics of North American owllet moths and their relatives (Noctuoidea), with particular interest in Arctic-Alpine species, cryptic species complexes, species boundaries, biogeography, faunal inventories, evolutionary systematics, and Lepidoptera conservation.



**Dr. Navneet Singh**  
Zoological Survey of India  
nsgill007@gmail.com

Navneet Singh obtained his Ph.D. at Punjabi University, Patiala under the guidance of Professor Jagbir Singh Kirti. Currently, he is a scientist in Zoological Survey of India, Kolkata, India. Dr. Singh has worked for more than 15 years on the morpho-taxonomy of India Arctiinae and about 100 research papers with almost equal number of new species discoveries and more than 10 new genera. Recently, he started to look after the role of Arctiinae, if any, in pollination.

# Auditors



**Dr. José Augusto Teston**  
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Ana Carla Walfredo da Conceição  
Universidade Federal do Oeste do Pará  
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Currently a PhD student in Biodiversity and Biotechnology under the guidance Dr. José Augusto Teston. Interests include: Lepidoptera; moths, Arctiinae and Sphingidae; conservation and the Amazon.



**Dr. Susan J. Weller**  
University of Nebraska State Museum &  
University of Nebraska-Lincoln  
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Dr. Weller is Director of the University of Nebraska State Museum and Professor of Entomology at University of Nebraska-Lincoln. She pursued her Ph.D. (1989) at the University of Texas-Austin with Drs. Larry Gilbert and John Rawlins (Carnegie Museum). Weller received curatorial training at The Natural History Museum (London) as a Fulbright-Hayes Fellow and at the National Museum of Natural History through two Smithsonian Fellowships. Weller's research incorporates a variety of data and explores the landscape of systematic and comparative analyses. She maintains an active interest in collaboration on arctiine research although current job duties preclude leading research projects.



**Marcin Wiorek**  
Polish Academy of Sciences  
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Marcin Wiorek is a Ph.D. student under the guidance of Dr. Łukasz Przybyłowicz, at the Institute of Systematics and Evolution of Animals Polish Academy of Sciences in Kraków, Poland. He is interested in different aspects of evolution, taxonomy, phylogeny, biogeography and ecology of tropical tiger moths. His current research concerns Madagascan lineage of the tribe Syntomini, especially taxonomic revision of the genus *Thyrosticta*, and also Old World Arctiini genus *Euchromia*. He took part in a field expedition to Madagascar in 2020. He collaborates with Dr. Niklas Wahlberg's lab in Lund (Sweden) starting from training obtained during the visit in 2019.

## Auditors



**Dr. Jennifer M. Zaspel**  
Milwaukee Public Museum  
zaspelj@mpm.edu

Jennifer Zaspel obtained her Ph.D. at the University of Florida under the guidance of Dr. Marc Branham. Currently, she is VP and Academic Dean at the Milwaukee Public Museum. Dr. Zaspel has worked for more than 20 years on the systematics, evolution, and biogeography of Arctiinae. Her continuing interests are in understanding the role of lichen secondary compounds and antipredator defenses in Lithosiini.

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# Frequently Asked Questions

## **Where is the schedule of presentations?**

The schedule for the meeting can be accessed here:

[https://docs.google.com/spreadsheets/d/1nYQfNYDqiWZCNYq-xoSrK8dJ7dUHe\\_vTUVgTFvvYgmE/edit?usp=sharing](https://docs.google.com/spreadsheets/d/1nYQfNYDqiWZCNYq-xoSrK8dJ7dUHe_vTUVgTFvvYgmE/edit?usp=sharing)

## **How will I give my talk?**

All talks will be given via Zoom screen share from the presenter's computer, unless other arrangements are made with the organizers in advance. At the appropriate time, a moderator will notify the presenter that they are free to begin sharing their screen with other participants.

## **How do I keep track of how long I have talked?**

There will be a timer bot added to each call. In addition, a moderator will notify you when you are nearing the end of your remaining time allotment.

## **What if I go over my allotted time?**

Please make a sincere effort to not exceed your allotted time. To be respectful of everyone's time, it is imperative that we strictly adhere to the schedule. In addition to providing an on-screen timer, the moderator will provide audio-visual cues to inform each presenter that their presentation is approaching the end of their allotted time. If a presentation exceeds its allotted time, the moderator will stop the presentation so that we can move on to the next presenter. This is regrettable, but necessary in order to ensure that each presenter receives their allotted speaking time and that everyone can present at their assigned starting time (we apologize in advance!).

## **Will there be time for questions after talks?**

We encourage everyone to leave ~1-2 minutes at the end of their allotted time for questions. In the interest of time management, we will must stop each presentation at the scheduled time. We encourage members to discuss unasked questions after the meeting or in the Google Doc dedicated to questions. The organizers plan to set up additional communication channels that will enable participants to remain in contact, and continue discussion after the conference.

# Frequently Asked Questions

## How do I ask a question?

Questions can be asked in real time, by writing directly into this Google Doc (please follow the formatting template shown there):

[https://docs.google.com/document/d/13-xjeZzXBart9dIV6EV5GEed\\_1d7K3ECUw6jEWgcKHfk/edit?usp=sharing](https://docs.google.com/document/d/13-xjeZzXBart9dIV6EV5GEed_1d7K3ECUw6jEWgcKHfk/edit?usp=sharing)

Questions will be posed to presenters in the order they are received. The procedure for questions will be as follows:

If there is time remaining at the end of a presentation, a moderator will look at the Google Doc and determine which participant asked the first question in the document. At this time, the moderator will cue this person by saying, e.g. “X has a question”. At this time, X should unmute and ask their question. The presenter will then respond. This procedure will then be repeated for the second question in the Google Doc, and so on. The Q&A period will conclude when the presenter’s allotted time has expired. We encourage presenters to continue answering unasked questions in the Google Doc after their presentation has concluded.

## What if my internet connection is unreliable, or I lose connection during my talk?

If you have an unstable internet connection, or are otherwise concerned about being disconnected from the call, we recommend that you pre-record your talk, and send it to the organizers before the start of the meeting. In the event of a lost connection, a moderator will then play the pre-recorded version of the talk that has been submitted. The procedure for resolving technical difficulties will be as follows:

If a presenter has connection issues, meaning they are experiencing significant audio/video lag, or have dropped from the call, we will wait 1 minute. If the presenter has not returned to the call at this time, or is still having connection issues, we will move on to the next talk in the schedule. If there is time at the end of the session before the next break, we will insert the presenter(s) who has lost connection there.

# Frequently Asked Questions

## **What if my internet connection is unreliable, or I lose connection during my talk? (continued)**

For example, if presenter 2 in Group A loses connection, we will move to presenter 3 after waiting 1 minute for presenter 2 to return. If there is time remaining before the break separating Group A and Group B, we will allow presenter 2 to give their presentation at that time. We will make an effort to ensure that everyone has the opportunity to give their talk if they experience technical difficulties. However, please note that given the meeting format, and number of participants, this might not be possible.

## **I recorded my talk and would like to share it. Where should I send it?**

Please email the file or a link to: [njdowdy@gmail.com](mailto:njdowdy@gmail.com)

## **Will the meeting be recorded?**

No, we would like the meeting to be casual, and recording can sometimes create tension for presenters that we would like to avoid.

## **Can I record the meeting?**

No, please do not record the meeting.

## **What happens in the unlikely event that the Zoom call drops?**

We have worked with university IT staff to ensure that this does not happen, and all 3 organizers will be co-hosts, which means it is highly improbable that the meeting will close prematurely. However, if this occurs, please give us 5-10 minutes, and we will be in communication via your provided email address to distribute a new Zoom link.

## **Should I turn on my camera?**

Yes, please! We are trying to create a friendly community of researchers who share a passion for tiger moths. If you are comfortable doing so, we encourage you to turn your cameras on during the meeting when possible. We hope to meet in person at some point, but for the time being we will have to make due with greeting each other digitally.

# Frequently Asked Questions

## **Can I share the conference Zoom link with colleagues who have not registered?**

Please do not share the Zoom link with people who are not registered and listed in the conference booklet. We would be happy to have more people join us in the future, but the digital format has certain capacity restrictions, and we also need to ensure that the digital security of the meeting is not compromised. This is extremely unlikely, but it has happened with many university events over the past year, so we must take some precautions against this.

## **What if I need to take a break, or otherwise leave the call during the conference?**

Given the length of the meeting, we expect that many people will need extra breaks, or extended time away from their computers. During such breaks, participants can exit the meeting completely if they choose to do so. The meeting link will remain active, and participants can re-enter whenever they choose. Please be advised that there will be a meeting waiting room, so it could take a few moments for a moderator to notice your presence after re-joining the call. We will work hard to ensure that this does not happen, but if you have been in the waiting room for several minutes without being let in, please contact one or more organizers at the following addresses:

[njdowdy@gmail.com](mailto:njdowdy@gmail.com)

[richard.gawne@tufts.edu](mailto:richard.gawne@tufts.edu)

[ossi.nokelainen@gmail.com](mailto:ossi.nokelainen@gmail.com)

[arctiinae.research@gmail.com](mailto:arctiinae.research@gmail.com)

## **What are we going to do during the scheduled breaks?**

During the breaks, we suspect that many people will leave the call for some period of time. However, we will provide multiple break out rooms during breaks to allow people to chat among themselves if they desire.

# Frequently Asked Questions

## **Can I tweet screenshots or otherwise discuss content from talks on social media?**

This depends on the presenters. We encourage presenters who do not want people to share or otherwise discuss their presentation content on social media to use the provided “no tweeting” and/or “no screenshots” icons. Placing these icons on the title slide should indicate that those restrictions apply for the entire presentation. Placing these icons on an individual slide should indicate those restrictions apply to that slide only.

## **What is the Arctiinae Research Community’s Twitter handle?**

Our Twitter handle is @ARC\_SCI. We encourage all participants to tag us when discussing the event. The hashtag for this event is #ARC2021. We recommend pairing this hashtag with #arctiinae as well.

## **What do I do if I have an administrative question during the meeting?**

Please contact one or all of the organizers (who will be denoted as “co-host”) via the Zoom chat. We will work to address your question or concern immediately.

## **How can I get in touch with people after the event?**

We have provided a list of email addresses in the conference program. In addition, we are working to organize other communication channels that will facilitate long-term connections between participants.

## **What if I cannot attend the meeting?**

If you are unable to attend the meeting as an auditor or presenter, please notify the organizers as soon as possible. We understand that things come up.

## **Will there be an ARC2022?**

We hope so! Our goal is to create a standing collaborative community, similar to what researchers working on other model organisms (e.g., *Heliconius*) have done. If there is interest, we will plan another meeting in 2022, and we hope you will join us again at that time.

# Frequently Asked Questions

## **What if my question is not in this FAQ document, or something comes up prior to the meeting?**

Please send an email to the organizers at the following addresses:

njdowdy@gmail.com

richard.gawne@tufts.edu

ossi.nokelainen@gmail.com

arctiinae.research@gmail.com

One of us will get back to you as soon as possible.

## **How do I cite content in this booklet?**

This booklet was prepared by Nick Dowdy (blame errors on him!) with additional editing by Rick Gawne and Ossi Nokalainen.

To cite content within, please reference the individual talks and their authors as you would from any other conference program. For example:

Dowdy, N.J., Fisher, M.L., Lemmon, A.R., Lemmon, E.M., Conner, W.E., & Zaspel, J.M. 2021. Recent advances in the phylogenomics of the Arctiinae (Lepidoptera: Erebiidae). Arctiinae Research Community Meeting 2021. <https://doi.org/10.6084/m9.figshare.14622423>

## **Where can I find the most up-to-date version of this booklet?**

We have posted this document via FigShare here:

[https://figshare.com/articles/book/ARC2021\\_Booklet\\_v0\\_9/14622423](https://figshare.com/articles/book/ARC2021_Booklet_v0_9/14622423)

The DOI of this document is:

<https://doi.org/10.6084/m9.figshare.14622423>

Please see the Table of Contents for the booklet version number (e.g., ARC2021 v1.0).

**If you have made it this far, thank you very much for joining us! We look forward to holding many more events like this.**