Speaker 1:

Welcome to the Michigan Minds Podcast, a quick and informative analysis of today's top issues from University of Michigan faculty.

Erica Colaianne:

Thank you both so much for joining Michigan Minds. I'm really excited to talk with you today and learn about this exciting research study that you're going to share. So I want to jump right in, could you each please introduce yourself and tell us about your role at the University of Michigan?

Lauren Petrullo:

Hi everyone, my name is Lauren, I'm an integrative biologist and National Science Foundation Postdoctoral fellow in biology. I am in the department of Psychology in the bio psychology concentration and I've been a member of the Dantzer Lab since 2020. Before that, I was at Stony Brook University where I got my PhD in anthropological sciences.

Ben Dantzer:

And I'm Ben Dantzer, I'm an associate professor in the Department of Psychology in the bio psychology area, and I'm also in the Department of Ecology and Evolutionary Biology. And I study how wild animals cope with environmental changes and those wild animals include squirrels.

Erica Colaianne:

Fantastic, thank you. And Ben, can you tell us a little bit more about the areas in which your research focuses?

Ben Dantzer:

I consider myself to be a behavioral biologist, and we mostly think about how wild animals cope and even adapt to environmental changes. And to do this work, we use evolutionary theory, we also use techniques from animal physiology or behavior, and we try to measure the behavior and physiology of animals to those environmental changes.

And when we say environmental changes, that could be natural environmental fluctuations like food or weather patterns, or it could be global climate change or the effects of humans. And like I said, we study squirrels, but we also study other animals like bovls, mice, and other mammals.

Erica Colaianne:

Thank you. And Lauren, could you tell us about your research areas and your experience being a National Science Foundation? Postdoctoral research fellow at U of M?

Lauren Petrullo:

Sure. Very broadly, I'm interested in understanding why animals do the things that they do from an evolutionary perspective. So I work with red squirrels in the wilds and I also work with non-human primates in captivity to answer questions about the role of things like maternal effects and hormones and the microbiome on impacting individuals' developmental trajectories and those trajectories that animals take as they grow and get older.

I became an NSF post-doctoral fellow in late 2020, and that's been a really great experience because it's allowed me the intellectual freedoms to explore lots of different types of research questions while also integrating and engaging within the Dantzer Lab at the University of Michigan and also the broader University of Michigan post-doc community.

Erica Colaianne:

Fantastic, thank you both. And just yesterday, a study that you authored was released in which you researched the reproduction of squirrels during food booms and busts. Can you tell us about this study, how you conducted it and outlined the findings?

Lauren Petrullo:

This study was born out of a desire to really try to understand why we sometimes see animals make what we might consider to be mistakes. Things like breeding too early or too late in a particular year or season or having too many or too few offspring in a particular year or season. And so we expect that natural selection will be constantly working toward promoting the most appropriate or favorable response an animal might make. So it's a little bit confusing when we do see animals sometimes do the wrong thing and we wanted to try to figure out why this might happen.

There's a body of theory out there that tries to explain why we might see these mistakes. And in this study, we combined a few of those different perspectives to draw up some work where we could test the idea that maybe animals are actually making mistakes because there are different types of mistakes that they could make and some of those are worse than others.

Other researchers have explained this phenomena using a smoke alarm analogy, where you have a smoke or fire alarm in your house and that alarm can make two different types of mistakes. So it can either go off when there's no fire, if you're cooking, if you take a shower and lots of steam comes out into the room if the battery's low, things like that. Or it could not go off when there really is a fire, and obviously the latter is a much worse mistake than the first, and so we make our fire alarms to be really gullible or really sensitive, even if that means that sometimes they might go off at the wrong time just so we can be sure that they do go off actually at the right time because the cost of those two different mistakes is different. When there actually is a fire, not alerting you to it is really devastating. And the minor inconvenience of your alarm going off when there is actually no danger is a pretty small and negligible cost in comparison.

All of that being said, this idea of unequal costs of different types of mistakes is really at the heart of our study. And we wanted to ask a similar question, but looking at wild animals instead of smoke alarms. Are there really ever times when animals make one type of mistake in order to avoid making an even worse different type of mistake?

Erica Colaianne:

And what led you to conduct this study and to focus on squirrels? And I'm particularly interested because we're releasing this on National Squirrel Appreciation Day and we do all know how infamous the University of Michigan's Ann Arbor Campus squirrels are?

Ben Dantzer:

That's a great question. My take on this is that, scientists are often looking for models to understand natural phenomenon. So that could be biomedical researchers that are on the Michigan medicine campus, for example, studying mice and rats to understand how the brain works or develop and test new drugs or generally focused on applying their research findings in mice and rats to trying to improve the human condition or health. And I don't think any of those researchers necessarily grew up thinking that they love mice and rats and they wanted to work with them. And I think people like Jane Goodall was fascinated by chimpanzees early in life and they ended up going on to study them.

But what we are similar in the sense of these biomedical researchers, realizing that mice and rats serve as a way to generate scientific knowledge to improve the human condition. And we realize the strength of the scientific knowledge that we can gain from having a model system in squirrels. And squirrels are a model system in ecology and evolution primarily because what we need to do in these types of studies is accurately measure Darwinian fitness, so the survival and reproduction of animals. And this is often really tricky to do. For example, if you were to study a migratory bird like the many warbler species that come to Michigan in the late spring and early summer, those birds often leave for most of the year, so how do you track survival in that species that's migratory?

And what we can do with squirrels, is that we can accurately measure survival and reproduction because we can track individual squirrels over their entire lifetime. And we can also do that where we can measure fluctuations in their natural environment. And so over time, I think that all of us grow to appreciate squirrels and have this strong fondness for our study animals squirrels are not. But the work we try to do here is focusing on some general questions in evolutionary biology or psychology or whatever field it might be, and squirrels just happen to be a great system to do this work.

Lauren Petrullo:

I'll just say that for this study specifically, squirrels are really a perfect model system because in the region where we work, in the Yukon in Canada, the red squirrels living there inhabit a highly fluctuating environment. And so they have to cope with really extreme and dramatic changes in their preferred food source, which is seeds from these cones of white spruce trees. And in some years, there are a ton of cones we call those years mast years, but most of the time there's little to no food produced by those trees at all for the squirrels.

And more importantly, this food when it is produced is actually only available in the fall, but squirrels have their offspring or their litters in the preceding spring and summer months, which means that they need to be able to predict the future when reproducing and take their best guess at how much food will be available in the months ahead. And that type of guesstimating leaves a lot of room for squirrels to make mistakes, and so it makes them a really good study system for our questions.

And then more specifically, since 1989, a really special project called the Kluane Red Squirrel Project or KRSP, as we call it, has been working in this region of the Yukon collecting really dense and high quality long-term data on the fitness and lives of the squirrels that live there as Ben mentioned. And KRSP was originally founded by Stan Putin from the University of Alberta and has now amassed an exceptionally valuable and really rare data set on the lives of thousands of squirrels, which gives us also a really nice sample size for these questions.

Erica Colaianne:

What is the potential best outcome for a female squirrel to have many large litters? And what could go wrong if there isn't enough food?

Lauren Petrullo:

The best outcome for squirrel mom having a large litter is that she guessed correctly and it is in fact one of those mast years or those years where the trees produce lots of cones containing those seeds that squirrels like to eat. And what that means is that all of that food will be available in the fall to support that large litter of offspring that she just had in the months earlier. And the more of her babies that survived that harsh winter with full bellies of all that food, the better her reproductive success and her fitness will be in both the short term like that year, but also over her entire lifetime.

On the flip side, if it's not a mast year but she has a large litter and there isn't enough food in the fall, then it's more likely that her pups will actually grow very slowly, which is bad because bread squirrels here are highly competitive and they need to secure territories before winter. So the faster they grow, the sooner they're able to find their own place. It's also more likely that those pups won't survive their first winter as a result of not obtaining that territory.

This means that moms who had those large litters in years when there won't be a lot of future food would've spent a lot of biological cash on producing that litter, but won't get to really reap the benefits of increasing their fitness because the pups won't survive and then won't pass on their genetic material. So her fitness in this case would be worse in both the short term and potentially over her lifetime, especially if she fails to produce that large litter when it is in fact going to be a mast year.

The main take home point here that I want to emphasize is that, it appears in our work that it is better for a squirrel mom to actually take a chance and gamble by having that large litter in those spring or early summer months, even if she's not sure if it will be a mast year or not come fall because squirrels only live on average about three and a half years and they probably will only get one shot at a mast year if they get a shot at all. And those mast years really act as a catapult for squirrel fitness if they get the chance to experience one, so they better get it right because the cost of getting it wrong is pretty big.

Erica Colaianne:

This is so fascinating. So does this indicate that squirrels have an inclination as to when food will be in abundance? And is that something that will be, or is being impacted by climate change?

Ben Dantzer:

Yeah. We've known for quite some time now that these squirrels in the Yukon, they seem to be able to predict these times of a food surplus or these mast cone crops. And we still don't know exactly how they do it, but we think that they're queuing into it by eating specific parts of these spruce trees. So in a sense, what they're doing is eavesdropping on the trees, and we think they're able to do this by eating specific parts of the spruce tree called spruce buds. And these might contain these phytochemicals or phytohormones that alter squirrel physiology and in a specific way that might cause this elevation in their litter sizes. And we're pretty excited about trying to understand this because the squirrels and the spruce trees have co-evolved, and the squirrels seem to be able to predict when there's going to be a mast year.

And in general, this is the fun part of science because it's an adventure and we don't really understand how they're doing it and we're trying to unravel this puzzle. So you mentioned climate change and whether this situation is going to be impacted by global climate change, so we're quite interested in the frequency of these mast years, these booms in food. We expect them to increase in frequency due to more precipitation, especially rainfall in the summertime and warmer temperatures in the summertime.

In the Yukon, we had a mast year in 2019, and then we had another one just this last year in 2022, only three years later. And this is something that we've actually never seen before and it's coincided with these much higher levels of rainfall in our study area in the Yukon. For example, when I first started going to the Yukon a long time ago, we didn't really bring rain gear, and we're outside during whatever the conditions are. And nowadays, bringing appropriate rain gear is extremely important because we're getting so much rainfall in this area. So we expect climate change to be influencing these high latitude locations in the Yukon, and we're documenting those changes in real time.

If we think about whether the frequency of mast years does go up, it could also affect what makes a good squirrel. So in their evolutionary history, we think that squirrels should only really experience one or zero of these mast in their entire lifetime. Under these circumstances, squirrels seem to go all in and produce all of these offspring, these large litters in those mast years. But if there's an increase in the frequency of mast years, we think what makes a good squirrel might change. So reproduction is costly for wild animals, they don't have unlimited resources.

Squirrels might be more conservative if we start to see a higher frequency of these mast years. They may not produce these very large litters in mast years because they're going to experience more than one. And this could have important implications in terms of the population abundance of squirrels. So we obviously don't know what will happen yet, we test hypotheses and we gather data to test those hypotheses, but our work emphasizes the value of these types of long-term studies because we have more than 30 years of this baseline data, and now we're moving into this era of rapid climate change in the Yukon, and we can actually see how the squirrels and the trees will respond.

Erica Colaianne:

There's so many different elements to this work. I'm curious, what excites you or intrigues you most about these outcomes?

Lauren Petrullo:

I think that these findings are really exciting because they offer us a new perspective on animal mistakes and animal behavior and animal decision-making, or what some other people in other subfields call mismatches or errors. I think that we've historically assumed that when animals are able to be really flexible or plastic in a particular trait, in this case, the size of the litters they produce for the squirrels, that they will sometimes get it right and sometimes get it wrong. And when they get it wrong, it's just an unfortunate consequence of this flexibility or plasticity.

But I think what's really cool, is that our work seems to show that it's actually sometimes beneficial to make these mistakes, in that it makes animals more likely to get it right in the future if the future environment becomes favorable. So the squirrels that, in our case, seemed to gamble with their reproduction and take this pie in the sky approach appear to be successful. And it's really cool to see that type of strategy actually be successful in nature.

Erica Colaianne:

You've shared so much information with us today about this work, what is a key takeaway from everything that you've shared and from your research that you hope everyone listening takes with them?

Ben Dantzer:

Given that it's Squirrel Appreciation Day, I think it's important for people to recognize the value of studying an animal like a squirrel. For most people in Michigan or most of North America, the only wildlife that they interact with or see on a daily basis or avoid running over in their cars are squirrels. And we study squirrels because it really helps us to address these outstanding scientific theories in our discipline. We can track individuals over their lifetime, we could see why some squirrels live long and others die early, or why some squirrels, like in this case, produce many babies and others produce very few of them.

Squirrels are a great scientific study system in addition to being interesting wildlife that most people interact with on a daily basis. And I think overall, some people question why are these results relevant or are they only applicable to squirrels? But what we're trying to emphasize is how important squirrels are to ecosystems, especially in the Boreal Forest in the Yukon where we work. And understanding the causes of variability in squirrel populations, why are there lots of squirrels, why are there few squirrels? Is going to be important to understand what the potential consequences of changes in squirrel abundance are for general ecosystem health.

Erica Colaianne:

Thank you so much, and unfortunately we're reaching the end of our time. But before we wrap up, is there anything else that you would like to share?

Lauren Petrullo:

I would especially just like to thank our other three co-authors on this study, Andrew McAdam at the University of Colorado Boulder, Stan Boutin at the University of Alberta, and Jeff Lane at the University of Saskatchewan, and all of the technicians and field assistants and people that work on the Kluane Red Squirrel project that made data collection possible for this and other studies. It's really a collaborative project that has trained 100s of field researchers and is often people's first exposure to real science, especially out in the field. And our research has benefited tremendously from all of their hard work over the years. And we also would like to thank the Champaign Aishihik First Nations for allowing us to conduct our work and our research on their traditional territory in the Yukon.

Erica Colaianne:

Thank you, Ben and Lauren so much for this immensely insightful interview, I greatly appreciate your time.

Lauren Petrullo:

Thank you so much.

Ben Dantzer:

Thank you.

Speaker 1:

Thank you for listening to the Michigan Minds Podcast, a production of the University of Michigan. Join the conversation on social media with hashtag UMICH Impact.