Western Science

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EPISODE TITLE

Start Your Engines: The F1 of Bird Migration

PODCAST SUMMARY

Chris Guglielmo studies the process of migration in birds. However, while most researchers heavily focus on the flight, Chris focuses on the pit stops. Those pivotal breaks between long flights where birds are against the clock, in desperate need of a refuel. His research reveals birds as a dexterous athlete, capable of overcoming environmental and biological adversity. Chris joined the show to detail how migration is more like a prime-time sport than you think.

INTERVIEW

Henry Standage 0:30
Hey, welcome to the podcast. Most of us probably know a marathon runner. Somebody who likely possesses dedication, heart, and a sturdy, consistent athleticism. But marathon runners in nature take a different approach. Dr. Chris Guglielmo looks at bird migration. But instead of just focusing on the flight, he looks closely at the pitstop as well. It turns out the birds morph their body to fluctuate weight at a rate that simply is impossible for humans. This is all in order to refuel on route to their destination. Later, we discussed the global appeal of westerns world class avian research facility, and Chris recounts some behind the scenes stories from his time helping documentarians use the facility for footage. Here's the interview.

If migration is a 24-hour Formula One race you don't look as much at the race itself, but rather the pitstop. So why don't we begin by talking about the pitstop. Specifically, how do birds refuel on these long flights?

Chris Guglielmo 1:43
Now that's actually a really interesting analogy that you chose, because I was thinking about it. And it's really actually almost flipped over for migratory birds. Because in a man's race, most of the time, the, you know, the car is on the track driving, and what their goal is when they come into the pit, is to refuel as quickly as they can and get back on the track. And when you look at bird migration, they actually spend about 70% or 80% of the migration time at these pitstops, refueling and, and about 70 to 80% of the energy as well, not in flight, but actually during the refueling. So, the refueling is really important to the overall journey. And so how they do it is they fuel their flights with a lot of fat, which is something we're not very good at, but they get really, really fat. Basically, during the migration season or during these pitstops. They change the setpoint of their normal body weight, so they might be skinny. But before they take off on a big flight that could last overnight, or I mean, there's species that can fly up to nine days over the Pacific Ocean without stopping for food or water. So they have to put everything on before they go and the setpoint for their appetite and their body weight in the brain changes so that they basically double their food intake and they go into this state we call hyperphagia - to really they just eat like crazy. And they put on a lot of weight. And sometimes they change their diets. So for example, in Fall migration, where songbirds that are normally insect eaters will switch to eating fruit, because it's really available, all the trees are fruiting in the late summer in the fall, in anticipation of all these birds coming. And so that's a way that they can find lots of food, and it's high in sugar, which they very quickly turn into fat.

Henry Standage 3:54
So, you've answered my follow up though, which is how did they know if their body's in the right shape to continue?

Chris Guglielmo 4:01
So, it comes from a chemical in the brain, which is really interesting. Yeah, there's lots of different candidate hormones and we know more about the mammals than we do in birds unfortunately. Some of the ones, like there's a hormone leptin that is secreted by your fat cells that tells you how fat you are and that seems to work in most in mammals. But when they looked for that hormone system in birds, it just wasn't really there and didn't function the same way. And to continue that car analogy just a little bit longer when a driver on these 24 hour races knows when they need to go to the pitstop it's because the cars indicating something or just from the expertise they've gained from driving that car so much, they can feel something that needs to be fixed.

Henry Standage 4:51
How does a bird know that they need to stop soon does it come back to that chemical you were just talking about? They inherently know they're low on it or is it something else?

Chris Guglielmo 5:02
Yeah, that's another really mysterious thing. Again, we're doing a study with that same hormone ghrelin and to see if it changes during flight in our wind tunnel. We have a wind tunnel here Western, where we're able to artificially migrate birds sometimes overnight, our record flight has been a 28-hour nonstop flight by a little 12 or 15 gram warbler. And we're trying to get at that question like what signals are changing during those long flights that tell them it's time to stop. And these really long flights, they not only use and exhaust their fat stores, but they also burn up their lean tissues. So, things like digestive organs, the liver, even the heart, and the flight muscles shrink in size by anywhere from about a quarter to two halves. And so, there's things like stress hormones that might also be involved that start to kick in, when they get down to that low fuel level, that let them know that it's time to stop.

Henry Standage 6:09
What does it look like when a bird isn't ready for that migration, but they still go for it?

Chris Guglielmo 6:15
So, if they're migrating, for example, overland, then they'll settle down somewhere and find a good place to refuel. But there's lots of stories about, for example, trans Gulf migrants that migrate across the Gulf of Mexico, say, from Yucatan, to the Florida coast, and where they just aren't going to make it and now they land on ships, they land on oil platforms. And sometimes they're found washing up on the beaches. And I used to teach about this in a course on migration here at Western. And then once one April, I went down to Florida with a fan on a family vacation. And I was on the Gulf of Mexico side of Florida. And I was swimming, and I looked over to me and there is this little black throated blue warbler, perfectly dry above, but he had his wings out and he was just floating in the water. And it was only about maybe 50 feet from the shore. And he was completely exhausted. And he was alive. And I just fished them him of the water and they had a wildlife rehab center, right in the town there. And they said they get birds like that all the time that are just there. They just don't make it to shore. So yeah, about 80%, we think of the annual mortality occurs during migration in some of these species. And that's how it can happen either by predators or because they make a bad judgment. And they die. But say I'm a bird flying across the coast, and I see a couple of different spots I could land in to migrate for the night or to, you know, to start for the night. Why would I choose one habitat or the other? What makes a good habitat for a bird to refill that? That's also a big question we're interested in with our field studies. And you know, what is a high quality stopover habitat, and I think at the coarsest level, it depends on the kind of bird so if it's a forest bird, then it's going to be looking for mature trees and nice forest habitat. If it's a wetland bird, it's going to be looking for that if it's a shore bird, it's going to be looking on the coast for mud flats or sand. So that's kind of the first level but then when they land in one of these habitats, they can vary in how good they are. And there's really two components. One is the amount of food and their ability to get food. And the second is safety. So, they have to balance both of those things, because they could find a really wonderful place that's got tons of food. But it's very risky, it's open. And there might be a lot of predators there. And on the flip side, you know, they could go to a really safe place, but there's no food to eat. So those are kind of the general things they're looking for. We have some ways of studying how fast they refuel in different habitats, either by trying to re-catch them a few days after we caught them the first time and look at their changes in weight. Or we have techniques where we can take a blood sample from every bird we

catch, and we can measure the profile lipids in their blood. And those can be correlated with the sort of instantaneous rate of fueling, like it's a little snapshot of how well they're doing in that habitat where we caught them. We've done studies where we've compared native forests to a forest that's been heavily invaded by invasive species of plants. We've done things comparing different geographic locations. And right now we have a study going in New Brunswick where we're comparing birds that migrate along the coast of the Bay of Fundy to inland because in that scenario, sometimes the geographic features of the landscape will funnel birds in high densities into certain areas, like along the coast. And the question is, are they using the coast because it's good habitat, like maybe the ocean moderates the temperature and there's more insects and so there's more food, or are they, just because of bad luck. And actually, the places where they refuel more quickly are inland. And so, we're doing lots of studies like that. And it's a big question for conservation, like how do we provide the places they need to start? Yes, somebody may well have done a study like this, but I would love to see the results where birds are forced to go out of their comfort zone. So, a habitat that's maybe not natural to them, and then a couple of different options and see which one they pick. We've been thinking about experiments where you know, you might translocate birds from the habitat, you cast them into one you're interested in. And then study them. Do they stay and refuel in that just as long? Or like you're saying, if you put them in the wrong habitat, do they say, okay, I'm out of here and leave that night. Probably the biggest trap in terms of bad refueling, we think is, is urban areas is getting into cities where birds are attracted by parks in cities, and maybe the food's not so good there. We actually did a study in New York, and we compared urban parks to more pristine areas north of New York City, we went into it thinking, yeah, these birds are going to land in the city parks. And they're not going to do too well. It turned out that that wasn't the case. Even though the densities of birds were higher in the city parks, they refueled at the same rate as birds outside the city. So, it actually showed if you provide green space and cities, the birds will be able more or less to find food and refuel. Well, the downside of being in a city are things like hitting window glass on buildings, or cats and other dangers. So that's where this balance between food and safety come into play.

Henry Standage 12:40
Something you've already touched on a little bit is how birds are able to change their physique fluidly during migration, gained tons of weight, lose it, gain it again, what is it about their physique that allows for this without serious health ramifications?

Chris Guglielmo 13:01
I've seen myself and other scientists say, you know, we should be studying these birds as potential models of what's called the metabolic syndrome or type two diabetes, because they really do look like a type two diabetic, they, like I said, get morbidly obese in this migration season, they have blood sugar levels of blood glucose levels that are many times higher than a mammal, but they don't show the health side effects. As far as we know, they don't get coronary disease or atherosclerosis. And they don't get the circulatory effects and blindness that can be associated with diabetes. And then the interesting thing is when they're done migrating, they basically cure themselves. And they go back down to a very low weight with, you know, modest fat stores, or none, because it's costly to fly with all that extra weight. But I wouldn't say we have any comprehensive understanding of how they managed to avoid these health effects that we see in humans. And we can mimic this in, small mammals, like mice and rats that are used in medical research on those same topics.

Henry Standage 14:14
You know, who would love to know why birds are able to do this, is Christian Bale the actor, he's gone from 140 pounds to play Batman to playing Dick Cheney to going back down to 160. And I think a report came out a year or two years ago that his doctor was like, you're going to die if you keep doing this.

Chris Guglielmo 14:41
Yeah. I don't know how he can do that. I if I stray too much out of my narrow body weight, I feel terrible.

Henry Standage 14:49
I'm sure he would be fascinated by the physique of a bird he might even want to play one. Another thing that makes this so impressive about birds is they're changing climates. And altitude in such a rapid, volatile manner.

Even small changes pertaining to global warming surely affect them. So, I was wondering if you could just say what some of those effects are?

Chris Guglielmo 15:13
Earlier springs, longer summers, hotter summers can affect migratory birds because timing their arrival at the breeding ground, for example is really important. And so, if they get there at the wrong time, they get there late, after there's been a burst of insects that would be good for breeding, then that mistiming can reduce their success in inbreeding. So if we think about, you know, the advancement of springs happening earlier, what we're finding is that short distance migrant birds, that only that winter down in the United States and come through Canada and then breed up in our boreal forests, they seem to be a bit more flexible in responding to the earlier conditions, and initiating their migration earlier. But there's other species that are really long-distance migrants that go down to even you know, Colombia, Brazil, the other side of the equator, or along the equator. And they seem to be more rigid in their timing that's based on photo period. So, their internal clock is telling them, okay, now it's time to go back. That's evolved over, 10s of thousands of years, and now, they get there, and they're there a bit too late. And their numbers seem to be declining the most. So that's kind of one scale that you can think about how warming will affect them. The other interesting thing is that, when they're flying, they generate a lot of heat. And if they get overheated, they don't have a canteen with them. So, if they get too hot, what they have to do is evaporate water, and birds don't sweat, they do this mostly through the respiratory system. So respiratory evaporation. Now to bring their body temperature back down, we did an experiment on this in our wind tunnel here at what we call the AFAR, the advanced facility for avian research at Western and in that tunnel, we can manipulate the altitude and the humidity and the temperature the birds fly in. And in this experiment, we just dropped the humidity down quite low, so that they would have to use more water to stay cool. What we found that they did to balance themselves out was they burned up more of their organs and their muscle tissue about the same amount of fat. But by burning up organs, it releases about five times more water than they get from oxidizing fat. And so, it turns out that their guts in their muscles are like their canteen on these journeys. Now, if they do that too quickly, obviously, they might have to land before they even run out of fat because their muscles start to get weak and they can't support it anymore. The end. The other downside is that they burn all that stuff up, then when they land, if their guts half the size that it should have been, then, you know, they've got to rebuild that gut capacity. And before they can fatten quickly and that's actually been shown in some other experiments. So, what you'd expect happening if the atmosphere is warmer than it should be that they'll either face those consequences and and fly shorter distances at a time. Or they'll have to change their altitudes more than then normal. And, just in the last few years, there was just a really interesting paper that came out on shorebirds where they had GPS, very high-resolution GPS trackers on them. And these birds do a three-day flight from Europe down to Africa. And they actually show that they don't fly like an airplane, they don't take off and go up to a high altitude and then stay up there and then slowly come down. That would be the most efficient thing to do. They change their altitudes a lot. And wind was really important in determining the altitude they chose. The most important thing was the temperature. When they hit warm air, they went up too much higher altitudes to get the colder air. And we think that's because they're trying to avoid overheating and too much water loss so that they can keep making these flights. There could come a time when the atmosphere is just too warm, and they'll have no choice but to fly in that warm air.

Henry Standage 19:45
A big part of this is we know how oil affects animals that reside in the ocean but when oil reaches the shore, it can have the severe effects on birds where I think over 500,000 birds die a year as a result of an oil spill reaching their feathers. Why is it that oil has such a detrimental effect on a bird's ability to fly and survive?

Chris Guglielmo 20:11
On one hand, it's a question of the amount of oil that gets on to them. Often after oil spills, like the Gulf oil spill, the Deepwater Horizon, some birds are just hopelessly coated in oil. And so at that level, it's a toxic thing it gets through their skin, they ingest it while they're trying to print it off their feathers, it has terrible effects on their organs, it weakens the heart, they can get hypertrophy of the heart. One of the things it does is it oxidizes hemoglobin, or there's reactive products that are formed when it's being detoxified. And so their, their blood cell counts plummet, they become really anemic and they die. So, you know, that's kind of at that level. But in a lot of

oil spills, birds get just small amounts of oil on their feathers. And it's not enough to kill them outright. And often those birds get overlooked or, say there's a court case and they want to assign damages. And when they trace oil, birds are often overlooked. They're the current highest numbers than the ones that gets severely oiled. But, you know, you might think that they're going to clean themselves off, and they'll be okay. But it turns out that even that small amount of oil, when it gets on their flight feathers, or on their breasts, the breast feathers, it really increases the drag on their bodies, and it affects the abilities of the wings to make lift. And so, we actually found that it increases their flight cost by anywhere from about 25% it's just a little bit on the edges of their wings by up to 40% if they also have some oil on their bellies and breast feathers. So, we think it changes the aerodynamics, and has a big effect. It's like walking with a ball and chain and it never goes away until they clean themselves off. And you know, birds get like that if they have 40%, higher energy costs of flying, and they're trying to fly up to, to breed in the boreal forest or something like that. They're more likely to either give it up or die trying.

Henry Standage 22:36
Let's talk about avian malaria. Now, how does it impede a songbird's ability to migrate? Because I know it's quite common for them to get avian malaria. So why haven't they adapted to a point where they're still able to migrate without complications?

Chris Guglielmo 22:53
Avian malaria, it's similar to what we get to human malaria in terms of the parasite involved. Birds have several other parasites that they get besides what we call typical malaria. But nevertheless, they have these blood parasites that are transmitted to them by mosquito bites and other biting flies. And a lot of those feed on the red blood cells, so they feed on the hemoglobin, and when you look across birds, it's surprising how many have it. Like if we catch birds here in Ontario, just songbirds. And we take a blood sample, about 50% of them will be able to easily see that they have malaria, some of them have multiple infections. But what we actually found last year was if, even birds that you think are negative, if you keep them in captivity for several months, and they are sampled periodically, they often show up as having malaria later on, even though there's no mosquitoes in the system anymore. So, we think it's more like 70, or 80, or 90% of the birds out there have avian malaria. Now, it's no health risk to humans, it's just something they have. And they've evolved with it a lot longer than we have. So, you have these parasites they feed on the blood cells. And what they can do is make the burden mnemic. And if you think about what they need to do to migrate, they need to have high red blood cell counts because they could be flying at high altitude, they're exercising really intensely. And so, you know, in that way, the malaria could really impede their migration ability. Surprisingly, we don't find much correlation between having malaria and migrating in these birds. They seem to be able to deal with it unless they're in a really acute situation where they have a very large load of the parasites. So, it's a really interesting question like you ask it, you know, how do they still do it? Or do they not do it when they have malaria? They just seem to be able to tolerate it and still do their migration because you know, if 80 or 90% of them have it, then we would see a signal if they weren't able to migrate and survive while having malaria.

Henry Standage 25:33
Yeah, it seems to be right in the sweet spot between being tolerable and intolerable. So, let's finish up by talking about the movie. You were.... a consultant is the right word?

Chris Guglielmo 25:46
Yeah. It's kind of a long story with the messenger was a documentary film that came out in 2015, that we helped with the filming of sequences that are sprinkled through the movie. Sort of slow mo flight action.

Henry Standage 26:01
You have a prominent role in the behind the scenes footage.

Chris Guglielmo 26:05
Yeah. So, the filmmakers came, they contacted us because they had heard about our wind tunnel, and they're making this movie about the decline of songbirds across the world. But they were focusing it on, you know, North America, really, and what's happening here in Canada. And they had heard about our wind tunnel, and they really

wanted to be able to show these birds in flight that no one had ever shown before. Because they fly at night. Nobody really has these kinds of birds in captivity. I mean, we're talking warblers, and thrushes and things that you see as a birdwatcher, but it's not like a canary or something or a parrot that people keep as pets, right. So we're, we're doing research on these kinds of birds, we know how to catch them, we know how to keep them happy in captivity, we know how to train them to do these migration flights in the winter. So anyway, they came, and they shot some test footage, to try to get money to produce the movie from places like CBC and other funders. So that's kind of when it kicked off. And we had a great time doing that. We got some beautiful footage. And that got the whole movie going. And then, you know, they filmed various film sequences out in the field, which was the main theme of the movie. So, they went to Costa Rica, they went to Alberta and looked at what was happening in with, you know, resource development in the boreal forest. They went to Turkey, you know, so they did all of that. But throughout the movie, they use these sort of really high resolution, HD color videos, and music to connect with the birds, with the people, with the audience. And so, we were involved in that. So, they came back a year or two later. And they said, you know, when we started talking, he said, okay, we need really beautiful birds. Like what bird, we want a yellow bird, we want a blue bird we want you know, can we get something red, or you know, and so we kind of went through the bird guide, and picked out candidate birds that I know are common. They're not endangered, they're really beautiful and then we brought those species in, we train them. And then we got some amazing, amazing film. It was a lot of fun. And we've done other ones like last year we did a we did a piece with CBC that's still in production now. I think it's called Canada's Wild Weather. And so, we were involved in one about wind. So, we'll see how that looks when that comes out.

Henry Standage 29:04
Yeah, at one point in the behind the footage scenes you say about a bird who's flying in the wind tunnel, and they're taking footage, "he's trying to figure out why the suns on the ground." And it's kind of a throwaway comment. But I found it really interesting because how perceptive are birds to changes like this? I mean, we've talked about them choosing habitats earlier in this podcast. So, when a bird sees that the sun is below them. What happens? Does their brain explode? Do they shrug it off? Do they try to fly upside down?

Chris Guglielmo 29:44
I think the primary cue they use must be gravity first of all, but yeah, we were trying to simulate them at night. But it's a real challenge because you're shooting at, I think they were shooting at like 1000 frames a second in high def color. And so, you need a lot of light to do that, we usually fly our birds in near darkness with just a little light bulb above them. So, they fly right under it. And they think that they're flying at night. And they make these beautiful, what we call flight calls that they use to keep in touch with each other while they're flying along. But here, we bring them in, and we were filming during the daytime. And we'd start them out with the light low to get them going. And then we have to bring up the lights. And in that case, we really want to illuminate the underside of the bird to get the color. We bring the bird in and they go, okay, is everything ready. And then it's like, okay, action, we let the bird go. Try to get as much film as we could try to get them in focus, trying to keep the camera on them is really difficult because they move around so much. And so quickly. So, they're constantly dipping in and out of focus. It's really, really challenging. And we see things that we never see otherwise. Because I don't have that kind of equipment. So, we see some pretty amazing things.

Henry Standage 31:10
How do we get people to appreciate birds more moving forward?

Chris Guglielmo 31:14
Well, I was writing a piece the other day, kind of a review paper and trying to figure out how to get people to, to appreciate what some of these birds can do. And the thing I was writing about was these birds I alluded to that leave Alaska, and they fly all the way down to New Zealand without stopping. And it takes eight days, on average, some of them over nine days to get there. And so, there's all these questions about how they navigate that, you know, my interest was, how do they budget all the fuel and water to survive this journey? And I was thinking about it. And I said, you know, often people, my kids often say, you can have one superpower, what do you what would it be? Most people say, I'd like to be able to fly. And so, I thought, yeah, that would be a great superpower. But I've never heard anybody think, how long could a superhero fly without stopping? I guess they never hardly ever show

them eat dinner or anything. But, you know, could Superman fly for over a week and not need to refuel. And so, I think that's their superpower is that they not only fly but they can do it for seemingly forever. I mean, it takes a shorter distance for a shorter time for humans to sit in a capsule and go to the moon than it takes these birds to get to New Zealand.

Henry Standage 32:55
Yeah, that's cool. They're warriors. They're long distance Iron Men. Once again, thanks for coming on the podcast.

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