Thermal imaging: A promising tool to measure stress in wild animals

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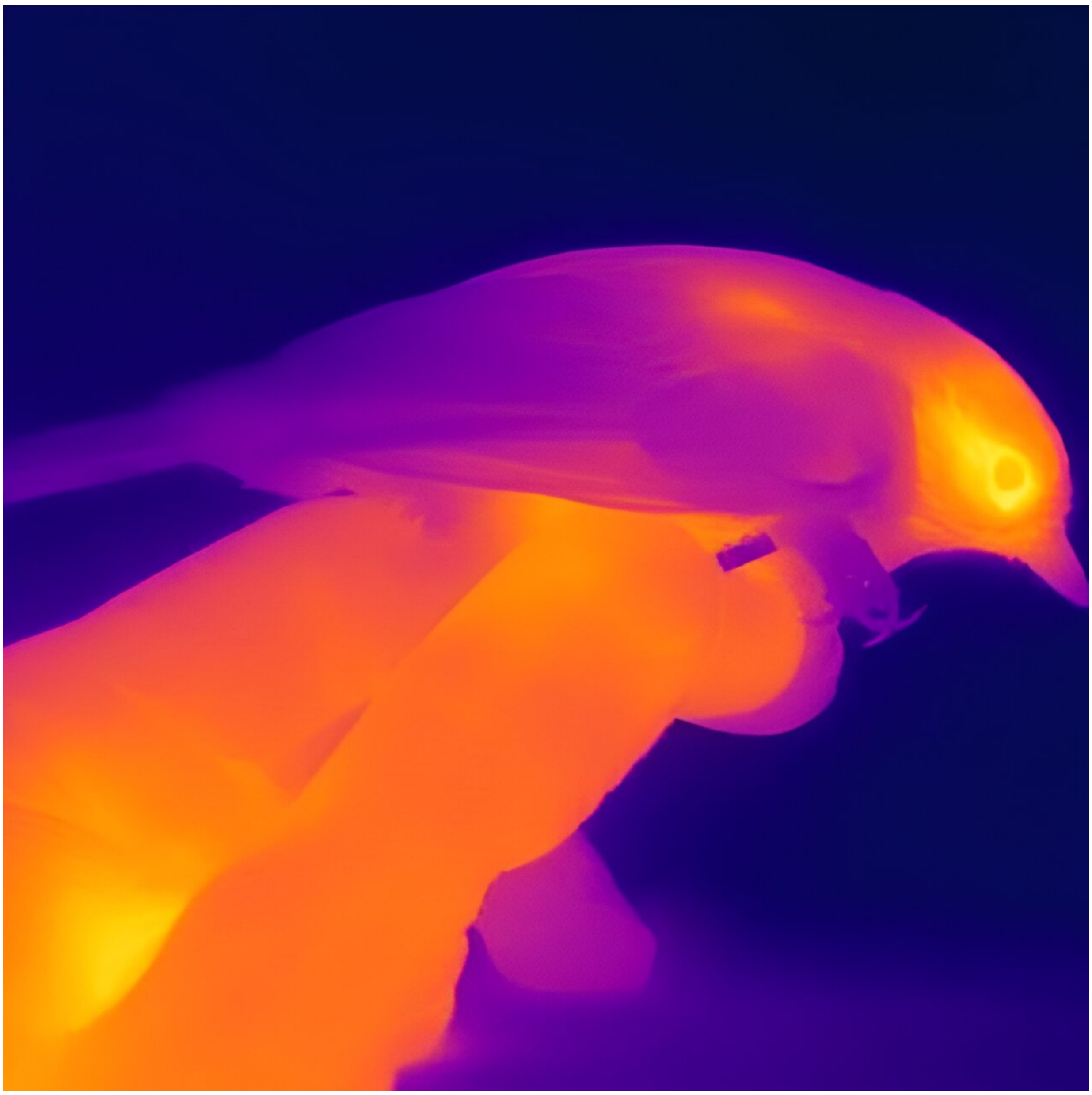

Thermal imaging, made possible by an infrared camera, can measure body surface temperature in birds and help researchers study stress. Tufts researchers found temperature changes of the beak and the skin around the eye in house sparrows correlated with stress-induced changes in the autonomic nervous system. Credit: Paul Jerem

Thermal imaging technology is poised to transform the study of the stress response in wild animals, according to Tufts researchers who have proven that the temperature shifts measured by the non-invasive technique correlate with other physiological changes in the animals.

Paul Jerem, a Marie Curie Global Fellow, and Professor of Biology Michael Romero combined thermal imaging, or thermography, with a heart rate monitoring device in an experiment that is the first to track an association between changes in body temperature and heart rate.

Their findings "confirm body surface temperatures can act as a proxy for sympathetic nervous system activation during acute stress," as their paper, published in the *Journal of Experimental Biology*, reports.

Determining chronic stress levels can provide critical information for conservationists and policymakers concerned about protecting wildlife populations. But traditionally, researchers have had to capture animals to sample their blood for stress hormones to know the levels of stress animals are under.

That technique is not only difficult but also interrupts the animals' usual behaviors and increases the very stress that the researchers hope to understand and reduce.

Since they have validated thermal imaging as an effective stress monitor, Tufts researchers are optimistic that it will provide a more easily applied alternative that can do many things that would be impossible using traditional methods, said Jerem.

Freed from the downsides of taking repeated blood samples, thermal imaging "provides clear opportunities to track response development through time, establish detailed individual response phenotypes, and link acute stress physiology with fitness," according to their findings.

The work merged two different approaches to measure stress in house sparrows.

Jerem measured surface temperatures using an infrared thermal imaging camera pointed at a dowel perch. With birds in profile, the cameras took readings of surface temperature changes around the birds' heads.

The infrared cameras recorded the surface temperature of the eye region and the bill of house sparrows, which was about 99° Fahrenheit when the birds were at rest. The cameras showed that the birds had a lower temperature after they were handled by people.

That change reflects an activated sympathetic nervous system, the suite of metabolic events triggered when an animal senses danger. During activation, blood is diverted to vital organs like the heart and brain, effectively cooling the rest of the body.

Romero brought to the inquiry a novel miniature "backpack" he developed with a former graduate student that has allowed him to monitor heart rate in birds. The device was created by sewing a dime-sized echocardiogram transmitter into a tiny bag; the "backpack" is fitted to the bird by polyester shoulder straps and lower straps that slip under the wings.

Jerem's goal in working with Tufts was to develop a new way of assessing physiology using non-invasive thermal imaging, specifically to study both acute stress and metabolic rate. Romero's device, he says, filled a gap in technique.

"The beauty of Michael's heart rate transmitters," Jerem says, "is that they cover both aspects of what I'm trying to do: I can look not only at sympathetic nervous system activation and heart rate variability, or variability between consecutive beats of the heart, but, based on that data, I can also model metabolic rate from heart rate."

Metabolic rate matters because it shows how quickly, or slowly, nutrients are converted into energy, Jerem says. Energy production is a link between food resources and fitness, or how well wild animals maintain survival/reproductive tactics, including running, flying, and territory defense.

Any disruptive environmental changes, such as drought and wildfires that lead to food scarcity or the destruction of habitats, he says, "can have a corresponding impact on metabolic processes and, consequently, on the animal's capacity to survive that change."

Romero speaks with gratitude about the opportunity to work with Jerem.

"What Paul brought to the lab was absolutely phenomenal in that he had the expertise and the ability to use these kinds of cameras to take body surface readings," he says. "Our findings reflect an excellent collaboration between his expertise and the expertise we already had in our lab."

Thermal imaging—known as thermography—is not in itself new; it has proved useful in wildlife studies, for instance, that explore thermal regulation in species as varied as the Arctic fox, the Egyptian fruit bat, and the Mongolian gerbil.

During his graduate studies, Jerem used the technique to study the stress response in the blue tit. He also brought his passion for the field to the wider public by helping create a science showcase at Glasgow's Hunterian Museum; the exhibition highlighted how thermography can show how birds adapt to cold and help monitor the welfare of both captive and wild birds.

Romero's work has focused on the physiological process activated over long stretches of time; acute stress is hypothesized to divert resources away from reproduction and towards survival but "it's worth noting that effects are likely to relate to more than just the number of stressful events an animal experiences," he says. "Variation in the individual stress response, or how easily an animal is triggered into a stress response, and how quickly that animal can recover, is also likely to be an important factor influencing outcomes."

Romero's research, for instance, on marine iguanas in the Galapagos, found reduced survival with higher stress reactivity. Similar effects have been found in European white stork nestlings.

The Tufts researchers believe thermal imaging could have a "transformative potential for improving our understanding of how wild animals use stress to adapt to changing environments," they report.

"Data about the variability of stress responses in wild animals is relatively scarce," Romero says. "It is particularly difficult to get at using blood sampling. Being non-invasive, thermal imaging is especially well suited to capturing the repeated measurements necessary to determine response variability within—and between—individuals."

Its application could include gathering information about stress in individual animals to help scientists understand changes at the community level and identify at-risk and endangered populations.

"You might imagine a species of conservation concern, whose survival depends on funding from ecotourism," Jerem says. "It should be possible to use thermal imaging to assess the effects of ecotourism—such as human contact—on a species with minimal effect. Then, population dynamics could be predicted from these individual responses, allowing us to judge whether the effects of conservation funded by the ecotourism outweigh the effects of human contact."

More information: Paul Jerem et al, It's cool to be stressed: body surface temperatures track sympathetic nervous system activation during acute stress, *Journal of Experimental Biology* (2023). DOI: 10.1242/jeb.246552

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