Animal home-building habits may provide clues to climate change adaptation

Birds build nests to keep eggs and chicks safe and warm, but they may also adjust nest insulation in very hot conditions to reduce the risk of overheating. Some mammals, such as rabbits and ground squirrels, construct burrow systems in which the temperature stays relatively constant, so they can avoid the more extreme temperatures that prevail above-ground. And termites – the master builders of the insect world – make mounds with their own solar-powered air-exchange system to control the temperature, humidity and concentration of oxygen and carbon dioxide inside the colony's nest.

Paying closer attention to how animals modify their 'home structures' to alter the microclimates within them may help us understand how they will respond to climate change. This was the crux of a recent paper published by a group of four researchers in the journal *Trends in Ecology and Evolution*.

"It's crucial that we continuously improve our ability to predict and mitigate the effects of climate change," says Professor John Terblanche from Stellenbosch University's Department of Conservation Ecology and Entomology,

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The African paradise flycatcher builds a cup-shaped nest made from both coarse and fine plant material, held together with spider web and camouflaged with lichen. Many bird species are known to reduce nest insulation in very hot conditions to prevent overheating of eggs or chicks.

who was part of the group. "One of the ways we can do this is by gaining a better understanding of how animals influence their own small-scale experience of climate at the level of individual members in a population."

Lead author of the paper, Professor Art Woods, is from the University of Montana in the United States, while the other authors are Dr Sylvain Pincebourde from the University of Tours in France and Associate Professor Michael Dillon from the University of Wyoming in the United States. Asked how these far-flung scientists came to team up for the paper, Prof. Terblanche explains that each member of the group had already collaborated with two of the others before they all got together for a week in Tours when he was on sabbatical there in 2019. They met up specifically to discuss mutual interests and propose some topics that they felt needed further consideration in the climate change literature.

"We all got along extremely well and this paper spun off naturally from our discussions. For the past two years we've had monthly group Zoom meetings to discuss books, papers and ideas – and have even nicknamed our little group 'Thermal Warriors' in honour of a classic book of the same name by one of the forefathers of insect thermal biology, Bernd Heinrich!"

The paper's title, 'Extended phenotypes: buffers or amplifiers of climate change?', refers to a concept that was introduced by the British evolutionary biologist Richard Dawkins in his 1982 book, *The Extended Phenotype: The Long Reach of the Gene*. Over the last decade, the concept has spawned a major research field, partly due to developments in next-generation sequencing technology that allow the entire genetic code of an organism to be read in a matter of days, but also because of its relevance to medicine, agriculture and conservation.

But what exactly is an 'extended phenotype'? A phenotype is an organism's observable characteristics or traits, determined by its collection of genes – its genotype – and environmental influences. Dawkins argued that genes have an effect that extends beyond just the organism's own body, because by influencing behavioural traits they may cause the organism to have an effect on the surrounding environment or other organisms. For example, beavers build dams on rivers to create sheltered ponds for their own benefit, but this 'ecosystem engineering' has a considerable impact on hydrology, nutrient dynamics and local biodiversity. And many parasites can manipulate their hosts, changing their behaviour to increase their own chance of survival and reproduction. Internal parasites in the form of fungi or flukes, for instance, may turn their invertebrate

At the end of July, Stellenbosch University launched its School for Climate Studies, the first school of its kind in South Africa that has the status of a faculty. The vision is for the School to be a world-class institution for interdisciplinary and transdisciplinary climate-related studies in and for Africa, and to support and encourage research partnerships with other entities, both nationally and internationally. The School will conduct research, coordinate curricula development and facilitate postgraduate training, advice and consultancy as well as technology transfer in the multiple fields of climate studies.

intermediate hosts into 'zombies', causing them to move into positions where they are more likely to be eaten by the definitive host, such as a bird or fish. The cuckoo takes this manipulation a step further, with 'action at a distance'. It fools other bird species into raising its chick by laying its egg in the nest of the host, and has evolved to ensure that both the egg and sometimes even the hatchling resemble those of the host.

These three examples represent the three categories of extended phenotype defined by Dawkins. Like beaver dams, bird nests, burrow systems and termite mounds are extended phenotypes because they are modifications that animals deliberately make to their local environment

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Solar radiation on African termite mounds drives a natural ventilation system that ensures an optimal microclimate within the underground nest.

Hans Hillewaert, CC BY-SA 3.0

Cape ground squirrels live in the hot, dry parts of southern Africa, but can retreat to their cool burrows for short intervals during the day to reduce body temperature.

to maximise the survival of their own genes. What is not known is whether animals will be able to make further modifications that will allow them to withstand the possibly harsher environmental conditions they could be exposed to with climate change. In other words, how much plasticity do extended phenotypes exhibit, and how rapidly can they evolve to 'keep up' with climate change?

The researchers call for a renewed effort to understand the role of extended phenotypes in animals' experience of climate variability. This information could enhance the predictive ability of climate change models that aim to forecast the effects of climate change, including how species' ranges may shift, what the relative risks of extinction are for different animal groups, and which species will thrive, all of which have important implications for human food security and disease risk.

Written by Quest Editor, Sue Matthews, using press releases from three of the universities as well as other sources.

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