2024 VOL 18 ISSUE 1

current conservation

Current Conservation carries the latest in research news from natural and social science facets of conservation, such as conservation biology, environmental history, anthropology, sociology, ecological economics and landscape ecology.

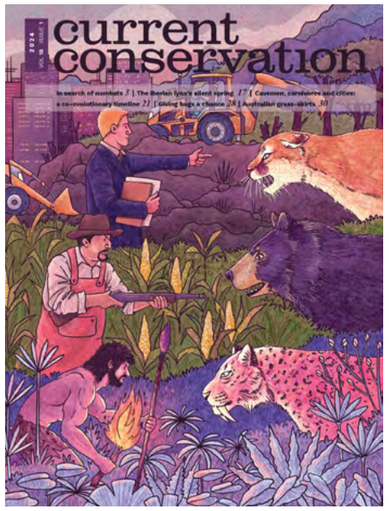
For more details, visit our website at
www.currentconservation.org

This magazine is produced with support from:

ISSN **0974-0953**

Contents

editor's note



Cover art **Rohan Dahotre**

The Anthropocene has come to be known as a geological period in Earth's history dominated by human activities. Large-scale agricultural expansion, industrialisation and urbanisation, combined with unsustainable resource extraction have profoundly impacted the planet's geology and ecosystems, resulting in climate change, biodiversity loss, pollution, deforestation, and alterations to land use patterns.

In this issue, we learn about these human-made impacts: on endangered numbats and grass-trees in Australia; on the Iberian lynx population in Spain, which failed to breed in 2023; on Masai giraffes in Kenya and Tanzania, undergoing a 'silent extinction'; on gaur in India, whose coexistence with humans rests on a delicate balance; and on large carnivores living in proximity to urban areas.

Yet, we are also reminded of the wonders of nature—of fireflies and bugs. For, as Rachel Carson wrote in *Silent Spring*, "the more clearly we can focus our attention on the wonders and realities of the universe about us, the less taste we shall have for destruction".

We hope you enjoy this issue.

– Devathi Parashuram

In search of numbats

Author **Lorraine Miller** | *Illustrator* **Zofia Chamienia**

It's 8 AM on a chilly September morning in Boyagin Nature Reserve in Western Australia. I glimpse at my handheld GPS and correct my course as I make my way through the bush, stepping over fallen logs and weaving in and out of the wandoo and marri trees. My device starts beeping, and then I catch sight of what I am looking for—a camera trap, poking up out of the ground like an orchid reaching for the sun. I bend down to open the waterproof casing to change the batteries and record the data on the screen, before arming the camera once again and setting off to find the next one.

I am a zoologist and the vice-president of a conservation organisation called Project Numbat, a charity dedicated to helping save the numbat from extinction. I will forgive

you for not knowing what a numbat is. Despite being the mammal emblem for Western Australia, this little critter is not very well known, even in its home state.

Numbats are small carnivorous marsupials, also called dasyurids, with stripes on their backs, a big bushy tail, a long snout, and an even longer tongue. This prominent and unusual body part is around 10–11 cm long, close to a third of the length of an entire numbat. They use this sticky appendage to eat nothing but termites as they scurry from one hollow log to another. While previously widespread across vast ranges of Southern Australia, numbats nowadays are only found in a few small pockets of bushland throughout Western Australia.

As a consequence, they are classified as an endangered species on the IUCN Red List. The main threats to their survival include deforestation, the increasing severity of bushfires due to climate change, and introduced predators. Foxes and cats frequent these areas of bushland, hunting threatened species. Even though our team is concentrating on surveying the current numbat population, we also inadvertently collect data on other endangered species, and the presence of introduced predators.

The early morning mist already began to clear as the low-lying sun started to break through the trees. It looked like it was going to be a nice day—hardly any wind and not a cloud in the sky, perfect weather for spotting wildlife. I made it back to the truck with my two other team members. As we drove to the next GPS point, I scrambled around in the bags checking batteries and memory cards. There is nothing more disheartening than trekking through the bush, all the way to your camera, only to find you didn't bring enough batteries, or had grabbed the wrong memory card.

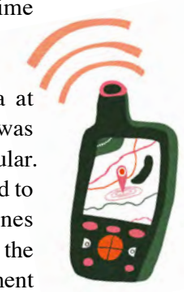
We were wading through a patch of thick leaf litter listening to the leaves crunch beneath our feet and trying not to make too much noise in the hope of spotting a local inhabitant when all of a sudden, one of our team yelled "Snake!" When someone yells 'snake' in Australia, you try to run as fast as possible in the opposite direction until someone else has determined the species, especially when you are ankle-deep in leaf litter. But as zoologists, our curiosity often overrides our sense of survival. It is quite comical to see a group of people both running away and also trying to look for the thing they are running away from. But the snake was long gone.

Armed with my clipboard, I recorded the data being read out to me, and while I waited for the rest of the team to finish servicing the camera, I scanned the surrounding bushland hoping to spot that characteristic fluffy tail. I managed to see a kookaburra, a black cockatoo, some echidna digs, a boobook owl, and some cat scat. The domestic predators had been here, and not surprisingly, there were no signs of numbats.

At the next site, we were hopeful we would see a numbat as there were far more fallen logs than elsewhere. These hollow logs are not only the perfect place for numbats to hunt for termites and seek shelter from predators, but also provide a life-saving retreat from raging bushfires, which are a natural part of life in the Australian bush. To limit the likelihood of runaway "hot" fires in important habitats, prescribed or "cold" fires are utilised to burn leaf litter under semi-controlled conditions. Numbats are well adapted to these fires and use hollow logs to shelter from them. Without fallen logs, there would not be numbats here. I bent down to inspect a log only to find small tufts of thick brownish fur stuck in the bark—perhaps further evidence of the presence of invasive predators.

The team continued on when we heard rustling coming from a nearby bush. I edged closer to see what was making the noise but clearly got a little too close as a small brown creature with legs like springs jumped out of the bush, straight towards me! A woylie was not an uncommon sight in this habitat, but it certainly startled us before disappearing over the ridge. We had checked over a dozen cameras by this point and my legs had started to become tired and sluggish. I lifted my foot to step over another branch but the tip of my shoe caught on the fallen tree and sent my body flying over the top. I shot my hands out in front of me but it was too late to stop the fall. My face planted firmly on the ground as I lay in a heap on the floor.

I jumped up quickly, not wanting to become a feast for the bull ants and as I dusted myself off, I noticed a small white skull on the ground. I picked up the skull to examine it. Elongated snout, canine teeth—this was definitely a fox skull. Foxes were introduced to Australia by British colonies in the 1870s for recreational hunting. They were soon well established and are now classed as pests across the mainland. Like cats, foxes hunt small mammals, birds and reptiles, often resulting in the reduction of already threatened species. Only a few offshore islands provide native species with respite from them. This skull was further evidence of the extent of the predator problem in this prime numbat habitat.



I always enjoyed checking the camera at Boyagin Rock, as even though the climb was tough, the view from the top was spectacular. We approached the granite outcrop and tried to find the best route to the top. Loose stones shifted under our feet as we clambered up the steep hill, trying to hold on to our equipment whilst having to grab hold of branches in order to heave ourselves over the rocky mound. We reached a level area and tried to dodge the lichen as we watched ornate crevice dragons bask in the sun. From here you can see across the majo-

rity of the nature reserve which includes areas of woodland, shrubland, herbaceous communities, and large areas of farmland. Vast eucalyptus forests were once prevalent in the whole region, but now this key habitat is depleted due to the expansion of agricultural land. The numbats are forced to move through this open and more dangerous landscape.

As I began to record the data from the camera, I noticed that the small patches of mud and lichen in between the rocks were soft and damp. I started to glance over it, looking out for any numbat tracks to photograph. After

a minute or so I came across some tracks, but they weren't from a numbat, they were from a cat. Once we were back to civilisation, we downloaded the photos and compiled the data. The traps revealed an array of wildlife, from possums and kangaroos to woylies and numbats. But they also showed us how many foxes and cats there were in the same habitat. The data was sent to the Department of Biodiversity, Conservation and Attractions, which runs Australia's most ambitious program to eradicate invasive predators from key habitats—Western Shield.

We had parked at a picnic area for the last camera survey, and by then we had resigned ourselves to the fact that we were not going to be seeing any numbats that day.

We jumped in the truck and made our way back past the benches and onto the larger dirt track road that led straight out of the reserve. "Oh look at that, a squirrel… no wait! It's a blooming numbat!" one of our team yelled as the small furry creature darted across the road in front of our truck and into a hole underneath a tree root. We stopped the car and quietly wound down our windows. As we stared at the hole beneath the tree, we realised it was not just one numbat, but a female with two youngsters peeking out from a small hole. It was living evidence that threatened species can bounce back from the brink, given the chance. And this is what gets us out of bed even on those chilly Sunday mornings.

Lorraine Miller *is a zoologist and author, specializing in great apes and devotes her spare time to the animal health, welfare, and conservation charities she works with.*

Zofia Chamienia *is a Polish illustrator based in the UK, who specializes in bold, playful designs, full of incidental shapes and wobbly lines*

The great gourmands of Kotagiri

Author and Photographer **Pavithran M. M.**

A mighty gaur walking in the middle of the road amidst the traffic in Kotagiri—one of the six taluks in the Nilgiris district of Tamil Nadu, India—reminded me of chariot processions I had seen at the village festivals of my childhood. The chariot carries the deity, and the temple is its destination. But where is the gaur headed? What is its destination? Was it walking in search of the forest it had seen in the same place, many years ago?

It seemed to be very old and looked as though it had walked more than a thousand miles. Who knows, maybe it crossed seven hills and seven seas. Wait, seas? Indeed, gaurs are capable of swimming. I began observing the gaur, curious to see where it was going. It moved to the edge of the road and entered a tea garden, like a person going home after a long day at the office, and started grazing. I understood then that when a gaur visits tea gardens in the Nilgiris district, it is probably in search of food.

Gaurs are large-bodied animals. Males weigh between 1000–1500 kg while females weigh between 700–1000 kg. They spend most of their day feeding, their diet consisting of grasses, herbs, scrubs, and leaves of trees. They prefer tea gardens over grasslands because the weeds and grass there are tasty, enriched with salt from the fertilisers used for the tea plants.

Gaurs move into tea gardens and other human-inhabited regions due to the easy availability of food, as an increase in invasive plant species and fragmentation of grasslands have reduced the availability of fodder inside forests. Another reason gaurs might prefer human-inhabited areas is protection—local people believe that prey animals approach human settlements to protect themselves from predators. Furthermore, regulations on poaching have significantly increased the gaur population over the years, while reducing their fear of humans.

Currently, they have become so habituated to human presence, that in fact, a person can see gaurs more frequently in parts of Kotagiri town than in a forest village. In contrast, earlier only the indigenous communities in Kotagiri used to see them when they went deep inside the forest to work—mostly to collect non-timber forest products (NTFP). As people in the Kotagiri landscape have been interacting with gaurs for more than two decades, they have their own perspectives about the animal, with some people referring to them as neighbours, and some even as relatives.

Different communities, one common perspective

Kotagiri is home to diverse communities, namely indigenous communities such as the Kotas, Todas, Irulas, Kurumbas, and Badagas, Tamils from the Nilgiri plateau and other parts of the state, Tamils repatriated from Sri Lanka, and Malayalis (people from Kerala). Each community has its own name for the gaur: they are called *Kaadu Eema* by the Kotas, *Kod-ir* by the Todas, *Doddu* by the Irulas and Kurumbas, *Kaadu Emme* by the Badagas, while Malayalis know gaurs as *Kaati*, and Sri Lankan repatriates and people from other parts of Tamil Nadu refer to them as *Kaatu Maadu* (wild cattle) and *Kaatu Erumai* (wild buffalo).

Every community has interacted with these herbivores, albeit in different ways. For instance, gaurs graze in tea estates where female workers collect tea leaves, sometimes at a distance of less than 10 feet from them. As most of the Sri Lankan repatriates and people from other parts of Tamil Nadu work in estate-related occupations and other daily wage jobs, they come into contact with gaurs while going to or returning from work. They also encounter gaurs close to their homes and in the villages. The animals frequently enter the Badaga *hattis* (villages) either to forage or as a thoroughfare. At times, when gaurs can't find food in the forest, they enter the *Seemai* (villages of Irulas and Kurumbas) and feed on plants and leaves of particular trees grown near the houses.

One common view that people have about the origin of gaurs is that they are feral domestic cattle. Many years ago, when there was famine on the mainland, people used to bring a great number of cattle, camp in the foothills, and let the cattle graze inside the forest. When some cattle wandered off into the forest, they mated with wild buffaloes and gave birth to the first gaurs. I have heard this perspective from tribal communities who have lived in this landscape

for centuries, as well as from people who moved there only 40–50 years ago.

Mutual respect and fear

In Kotagiri, a relationship based on fear and respect between gaurs and humans allows for the sharing of space. However, this wasn't the case when gaurs first began to enter human-inhabited areas 25–30 years ago. Earlier, people were afraid of gaurs. They questioned their course of action if gaurs began occupying these regions. Where could they relocate if they were forced to leave this place? The fear that people had of gaurs in the initial days gradually changed to respect combined with fear.

Over the years, people have become aware of the animal's day-to-day activities. Now, when questioned, all of them—even children—will state that gaurs come into the village only for food and water. They feel that they are gentle beings and don't harm anyone unless they are threatened. People believe that if they put both hands together and bow respectfully while requesting a gaur to move out of their way, it will surely go away—*"Kai eduthu kumbutu po saami na poirum!"*

In this shared landscape, gaurs and humans maintain a safe distance from one another. There is concern among people that gaurs could attack them if they went nearby or threw something at them. People say that just as they are scared when a gaur comes near, gaurs too experience fear when people come too close to them. According to the locals, the animals may worry that the humans would take away their calves or attack them. Fear acts as the key to mutual avoidance and respect between gaurs and people.

Inverse interactions

In recent years, there have been negative consequences, even casualties, because of human-gaur interactions. However, the figures are insignificant. At times, gaurs enter agricultural lands and raid crops when the field is left unprotected. Labour productivity is also affected by gaurs grazing in the tea estates. Additionally, the presence of these large herbivores in human-inhabited areas prevents people from growing any vegetation close to their houses.

Furthermore, people feel afraid to go out at night, even to nearby places. Gaurs may occasionally cause damage to human properties, including houses, roofs, compound walls, and vehicles. Human deaths and injuries have occurred as a result of gaurs resting inside tea gardens—gaurs typically hide their entire body while resting among the tea plants, only exposing their horns and a small portion of their faces. When someone unknowingly strays close to the animal, the gaur gets startled and attacks them.

Kotagiri, which is 28 km away from Ooty—a popular hill station—is also becoming increasingly attractive to tourists since the place is less congested than Ooty. Tourists' perspectives on gaurs differ from those of locals. They initially mistake them for domestic buffaloes. Once they identify the animals as gaurs, they get excited and approach to take pictures. Sometimes, they even try to take selfies with the gaur close behind them. This behaviour often startles the animal, leading them to attack the tourists. Locals believe that if a gaur cannot retaliate immediately, it will carry forward the memory of the incident and end up harming someone else instead. This is more likely to affect local people rather than tourists who stay there for a short period.

The way ahead

One of the key elements influencing continued coexistence in the Kotagiri landscape is the locals' perceptions of gaurs. I have heard, observed, and understood that gaurs enter human-inhabited regions primarily in pursuit of food. Locals in Kotagiri indicate that, in recent times, gaurs have slowly started to include cooked vegetable waste in their diet. This behaviour may trigger gaurs to visit human-settled areas more often, potentially making people more vulnerable. Consequently, people's attitudes towards the animal may change for the worse.

Meanwhile, the gaur population in Kotagiri is on the rise. In 2020, a survey conducted by the Tamil Nadu Forest Department estimated that 2000 gaurs were

inhabiting the Nilgiri division. Furthermore, changes in land-use patterns, such as the conversion of tea estates into resorts and buildings, are resulting in the erection of more fences, reducing connectivity for gaurs to move between habitats. Considering factors such as the shift in the dietary preference of gaurs, the increase in gaur population, and the urbanisation of the landscape, will the fear and respect between gaurs and humans remain delicately balanced in the future as well?

Further Readings

International Union for Conservation of Nature. 2016. Bos gaurus. The IUCN Red List of Threatened Species. https://www.iucnredlist.org/species/2891/46363646. Accessed on August 9, 2023.

Mongabay-India. 2020. Oh My Gaur! Living alongside the Indian bison that's moving out of forests. https://india.mongabay.com/2020/12/oh-my-gaur-living-alongside-the-indian-bison-thats-moving-out-of-forests/. Accessed on August 9, 2023.

Acknowledgements

The article was prepared with support from Dr. Madhuri Ramesh, Azim Premji University. It is based on findings from the Human-Gaur Relationship Project, which is a part of the Aralikatte: Nature-Culture Fellowship by the Wildlife Conservation Society-India. The project was funded by Rohini Nilekani Philanthropies and the fieldwork was supported by Keystone Foundation.

Pavithran M. M. *has a master's degree in social work from Pondicherry University. He is passionate about environmental studies, particularly human-wildlife interactions, indigenous cultures and practices, and traditional ecological knowledge of communities.*

THAT WAY, THIS WAY, THAT WAY, THIS

Author **Madhuri Ramesh** | *Illustrator* **Leeza John**

Fireflies are common insects in both temperate and tropical ecosystems. They feed on garden pests such as snails and slugs. Contrary to what their name suggests, fireflies are not flies—they are beetles. To be precise, they are bioluminescent beetles, i.e., insects that can produce light through biochemical reactions in their bodies. The human fascination with fireflies is embedded in many cultures and places around the world, and maybe it stems partly from some ancient envy, that insects should have learned to light a fire before we did. In this column, I showcase the importance of fireflies in two different archipelagic cultures: the first is from the Andaman Islands (India) and the second is from Japan.

The *waye-dama*

The Ang people (earlier known as the Jarawa) of the Andaman Islands consider fireflies to be the earthly equivalents of stars—both are called *waye-dama*. They believe that while the twinkling of the stars maintains cosmic rhythms such as the durations of day and night, the twinkling of the fireflies synchronises the rhythms of the forest with the sky, especially the play of heat and light. A retelling of an Ang tale describes the significance of fireflies in their culture:

One night, deep inside the forest, an Ang ancestor could not sleep and felt disturbed by the glow of *way dama* all around him. In a fit of temper, he broke off the branches on which the *waye-dama* were resting and threw it into the cold water in which the mangroves stood. As he fell asleep, the *waye-dama* began dying in the cold mangrove water and their body heat leached out. It turned the shells of mangrove crabs red with heat, leaving them too ti to climb out of their tidal pools. (That is why to this day, mangrove crabs have to wait until the full moon has cooled down the forest before they can emerge from the water and lay their eggs.)

Eventually, the ancestor woke up and began to stumble around because it was too dark to see without any *waye-dama* in the forest. As he tried to find his way, he fell over two strange things on his path—an empty Ang stomach and a tuberous root. As soon as they recognised him, the stomach and the root began complaining loudly. They ordered him to take them along with him, in the comfort of his beautifully woven basket. But once inside the basket, their complaints did not cease. Now, the stomach wanted to be kept inside his body and the root wanted to be cocooned inside the stomach. But both the stomach and the root were rigid with cold and the Ang did not know how to fit them inside his body. Seeking guidance, consulted the woodpeckers, who how to work with hard objects.

The woodpeckers took pity on the confused Ang and taught him how to extract resin and make a smouldering fire that would warm up his body. They told him that once his body was warm, he would be able to the stomach inside. He followed woodpeckers' instructions but was with the problem of what to do with root. Next the resin came to his ue—it told the Ang to dip his fingers toes in the mangrove water and seek orgiveness of the *waye-dama*. When g did so, the body heat of the crabs, which was essentially the fire of the *waye-dama*, flowed into his body and he was able to kindle a cooking fire to warm up the root and put it into his stomach. Ever since that day, the Ang people have respected the *waye-dama* for teaching them how to maintain the glow of life.

The *hotaru*

In Japanese culture too, fireflies or *hotaru* occupy a prominent position—many works of art depict people capturing, playing with, or simply admiring fireflies. In literature, *hotaru* represent the transience of life as well as intense love. The famous poet Kobayashi Issa is said to have written 230 haikus in the 18th century, all on fireflies, including:

A giant firefly:
that way, this way, that way, this -
and it passes by.

A tragic Japanese short story titled *Hotaru no haka* by Akuyuki Nosaka uses the symbolism of fireflies to describe real-life events around the bombing of Kobe, which was an important Japanese port, during World War II. The animé version of this story is well-known to English speakers as the poignant "Grave of the fireflies". Until World War II, there were even bands of professional firefly catchers, who used mosquito netting to capture masses of fireflies and sold them in gauze-covered boxes to customers in large cities such as Osaka. There were shops and pushcarts as well, called *mushiya*, that specialised in the sale of different kinds of insects, such as singing crickets, jewel beetles, and of course, fireflies. Several Japanese traditional songs that are still sung today refer to fireflies:

Ho ho hotaru koi
Atchi no mizu wa nigai zo
Kotchi no mizu wa amai zo
Ho ho hotaru koi

Ho ho firefly, come
The water there is bitter
The water here is sweet
Ho ho firefly, come

Firefly tourism

In current times, nature tourism often replaces the deeper connection that nature worship fostered in earlier periods. In the case of fireflies, there is an entire network of locations that tourists visit for the sole purpose of viewing and admiring firefly aggregations. Firefly tourism, as it is called, attracts over one million tourists each year to over 12 countries—such as Mexico, United Kingdom, Croatia, Thailand and Japan—scattered across three continents (North America, Europe and Asia). Imagine a biochemical reaction in an insect driving such large-scale movement of people! But what exactly is this intriguing phenomenon?

In fireflies, bioluminescence is caused when a compound called luciferin gets oxidised in the presence of an enzyme called luciferase. This reaction releases energy in the form of green or yellow light that makes the firefly's abdomen glow. This glow is called "cold light" because it has neither ultraviolet nor infrared components. Amongst the 2000-odd species of fireflies, bioluminescence serves one or both of the following purposes: It helps the males and females of a species find each other during the breeding season, because the colour and pattern

of the light pulses are often species-specific. It may also serve to warn predators that certain species of fireflies are toxic and keep the latter safe from predation.

However, fireflies are increasingly threatened by pesticide use and artificial illumination, because they are sensitive to chemicals and light. Therefore, well-run tourism packages will often insist on firefly-watching etiquette such as avoiding the use of perfumes or flash photography in their vicinity. The next time you see pulses of light in your garden or on a bush by the roadside, I hope you will take a minute to admire these luminous insects.

Further Readings

Pandya, V. 2016. In pursuit of fireflies: the poetics and politics of 'lightscapes' in Jarawa forests. In: *New histories of the Andaman Islands – Landscape, place and identity in the Bay of Bengal, 1790-2012*. (eds. Anderson, C., M. Mazumdar and V. Pandya). Pp 201–228. Cambridge: Cambridge University Press.

Lewis, S. M., A. Thancharoen, C. H. Wong, T. López-Palafox, P. V. Santos, C. Wu, L. Faust et al. 2020. Firefly tourism: Advancing a global phenomenon toward a brighter future. *Conservation science and practice* 3(5): e391: https://doi.org/10.1111/csp2.391.

Madhuri Ramesh ***teaches in the School of Development, Azim Premji University. Her research focuses on the politics of biodiversity conservation and she is interested in inclusive forms of resource management.***

Leeza John ***is an illustrator who loves textures and patterns. She often leaves her digital tools to create art with everyday objects, hence her work is varied and constantly evolving.***

The Iberian lynx's silent spring

Author and photographer **João Pompeu**

One afternoon, while I was out walking in a field before sunset, a birdwatcher halted his car beside me. He leaned out and asked, "Have you seen anything?" referring to lynxes. On hearing my negative response, he complained: "Look how dry the Sierra is! I've never witnessed anything like this. There are no lynxes, no birds, no blossoms, and, thus, no fruits for the animals… There is no life. The landscape has fallen into a profound silence."

In the heart of Sierra de Andújar in southern Spain lie the *dehesas*—agrosilvopastoral systems with a predominant grassy layer and sparse *Quercus* and *Fraxinus* trees—that attract numerous wildlife enthusiasts throughout the year. Due to its socio-environmental conditions, 39 percent of the mammal species and 48 percent of the birds in Spain can be seen in Andújar.

Amongst the rich fauna of the region, the Spanish imperial eagle (*Aquila adalberti*), Eurasian otter (*Lutra lutra*), and the cat with golden eyes—the Iberian lynx (*Lynx pardinus*), stand out as the most eagerly anticipated animals for wildlife observers.

Despite extensive conservation efforts over the last two decades, the Iberian lynx remains endangered. The 2022 Iberian Lynx Census, promoted by the Spanish and Portuguese environmental authorities in partnership with NGOs, revealed 326 females of reproductive age. To ensure the long-term survival of lynx populations, scientists estimate that at least 750 reproductive-age females need to persist in the landscape.

If the Iberian lynx is now found in many parts of the peninsula after assisted reintroduction, this is partially thanks to Sierra de Andújar, which, along with Doñana in southern Spain, is home to the only two surviving populations of the feline. Nevertheless, it is probably in Sierra de Andújar where most of the genetic diversity of the Iberian lynx is preserved. This has a practical implication for lynx conservation because losing this diversity might jeopardise the long-term viability of the other populations.

The Iberian lynx mates from December to February, when winter temperatures are low. After 65 to 72 days of gestation, late spring and early summer usually yield cute observations of newborn cats playing around while the mother hunts. Or at least this is what is expected to happen in Andújar.

Most known females in Andújar did not breed in 2023, and this situation has been observed in the landscape for several years. In 2013, for example, only 15 cats were born from 64 reproductive females. This trend is often attributed to a prevailing scarcity of prey, particularly rabbits (*Oryctolagus cuniculus*), which constitute more than 90 percent of the lynx's diet.

Some critical factors affect rabbit populations in the Iberian Peninsula, such as habitat fragmentation, hunting, and disease outbreaks—mainly myxomatosis and rabbit hemorrhagic disease. However, little is known about climate change, another factor that potentially affects both predators and prey.

Whether hotter winter temperatures—which are more and more common in southern Spain—followed by drier springs will preclude the breeding of Iberian lynxes is still an open question that deserves close attention. According to climate change projections, minimum winter temperatures in Andújar in 2030 are expected to be on average 1.37ºC higher (and ranging between 0.01ºC to 2.94ºC) than the historical period from 1970 to 2000 in a stabilising climate change scenario. On the other hand, spring precipitation (30 mm/month, on average) is expected to reduce by 0.20 mm/day. Thus, the region suffering from successive and longer dry periods and more frequent heat waves could already be experiencing the effects of climate change.

The high temperatures and the lack of rainy days during the 2023 spring transformed the colour palettes of the landscape from dark green to dry yellow in just two-and-a-half months. This change, expected to happen gradually and by mid-summer, affected the observations of the Iberian lynx as well as other mammal and bird species in Sierra de Andújar. To avoid the heat and to save water, animals naturally restrict their activities and movement across the landscape.

Page 17- The *dehesa* landscape in the Sierra de Andújar, Spain, in early spring

Page 18-19- Top left: Iberian lynx (*Lynx pardinus*) is one of the most sought after species for wildlife enthusiasts in the Sierra de Andújar landscape. **Bottom left:** Common rabbits *(Oryctolagus cuniculus)* comprise a significant proportion of the Iberian lynx's diet. **Top right:** Instead of dark green, the dry Sierra landscape turned prematurely yellow in the middle of spring 2023.

Page 20- Top: Fewer and fewer females of reproductive age, like the one photographed here, are giving birth. **Bottom:** An adult male hunting in the dry grasslands of the Sierra in late spring.

Cavemen, carnivores and cities:

A co-evolutionary timeline

Author **Sierra Lippert** | *Illustrator* **Rohan Dahotre**

In an increasingly urbanised world, tensions between humans and large carnivores are mounting. Urbanisation exacerbates the issue of conflict between humans and large carnivores as our spaces begin to overlap and human-carnivore interactions become more frequent. These interactions can have negative outcomes on one or more of the interactants. Both parties are affected by urbanisation, with carnivores losing their habitat and potentially posing a threat to human lives, property and livelihood.

As apex predators, large carnivores play a crucial role in keeping ecosystems balanced. A decrease in carnivore populations can lead to trophic cascades—predator removal alters the abundance among other trophic levels, such as prey and plants—impacting ecological services like regulation of disease, wildfire, and invasive species, carbon sequestration, and biogeochemical cycles.

The spring of 2023 was not the first silent spring for the lynxes in Andújar. It probably won't be the last. My real desire, shared by all those who engage in observing wildlife in the Sierra, was to follow a pregnancy, witness the birth of kittens, and hear them playing throughout the changing seasons. While I spotted females of reproductive age and adult males, the environmental conditions did not favour mating.

While I am happy for the reproductive success of other Iberian lynx populations, where rabbits are not a limiting factor for their survival, I wish only the best for the Andújar´s population and its unique—and essential—genetic diversity. I hope that next spring, there will be plenty of energy and noise from a new generation of golden-eyed cats that will contribute to saving the species from extinction. And that the *dehesas* ecosystems of Sierra de Andújar flourish with a splendid array of colours and a healthy abundance of life.

João Pompeu ***is a conservation biologist and independent documentary photographer. He portrays environmental processes related to his scientific research focused on climate change.***

Due to these serious implications, it is imperative to understand how these changes impact the evolution of both humans and large carnivores. Historically, the overlap in localities between humans and large carnivores has driven co-evolution between humans and certain species, and has even led to extinctions. With interactions increasing over time, humans have adapted through technological strategies, such as weapons, poisons, repellents, fences, and traps. Large carnivores, in turn, have been adversely impacted due to reduced species richness, diversity, population size, and gene flow. With overlap in shared space continuing to increase, it is critical to examine its effects on species' evolutionary trajectories and mitigate the negative impacts that could lead to the extinction of biodiversity.

Historical impacts

Humans and large carnivores have coexisted for over four million years. The competitive interactions between humans and large carnivores placed pressure on both parties, creating an opportunity for co-evolution. This created an ecological circumstance for humans to scavenge, while at the risk of predation. In fact, the pressure large carnivores put on humans likely influenced the shift towards cooperative defence, cooperative breeding, and changes in reproductive investment.

Early human co-evolution occurred specifically with hyenas, bears, and wolves that overlapped in localities, leading them to adapt to each other. Due to overlapping spaces, these carnivores likely interacted with early humans in various situations. Hyenas were able to exploit human-related feeding opportunities while providing a protective presence and ecosystem services by clearing carcasses, bones, and food scraps. Neanderthals are speculated to have explored hyena dens and exploited their bone and meat storage.

Similarly, bear dens were occasionally explored for materials and also used for shelter. At the same time, bears were noted to have utilised hominid remains as Neanderthal burial practices were typically held within their habitat. Thus, Neanderthals promoted a broader feeding niche for these scavenging species through their burial practices and provisioning of specific types of carcass scraps. Moreover, one of the most evident examples of co-evolution between early humans and carnivores is with wolves. Wolves and humans cooperatively hunted, and wolves provided services such as resource transportation and guarding. Over time, this commensal relationship led to the emergence of the domestic dog and hybrid pack-families composed of humans and dogs.

While early humans co-evolved with some carnivore species, fossil records indicate that they also negatively impacted the diversity of large carnivores such as early lions, sabre-toothed cats, and giant bear-dogs. Scavenging and kleptoparasitism initially drove their extinction, however, increased brain size, locomotor adaptations, and advanced tool use by humans further escalated the exploitation and reduction of the carnivore guild. Some of these factors contributed to co-evolution between humans and certain large carnivore species, such as hyenas, bears, and wolves. However, those that did not benefit from humans faced a greater risk of extinction. Simple tools and weapons created by humans put them on an even playing field with carnivores, but as technology improved, the balance fundamentally altered and shifted in favour of humans.

Modern impacts

In modern times, urbanisation is a key contributor to the imbalance between humans and large carnivores. Urban proximity can have effects on species richness and distribution. Previously, native species richness was negatively associated with urban intensity but not proximity.

However, urbanisation may not have the same effect on all species. Solitary species such as mountain lions were found to be less abundant with increasing proximity, while scavenging animals such as coyotes were found to be more abundant with proximity. Furthermore, a recent study found that while spatial avoidance did not occur in brown bears, their temporal behaviour did change.

In human-dominated landscapes, brown bears have adapted by becoming more nocturnal.

Besides the emergence of behavioural adaptations, urbanisation can also generate genetic changes within large carnivore populations. Habitat fragmentation caused by urbanisation disrupts habitat connectivity due to the emergence of human avoidance behaviours. In a study focused on bobcats, it was found that gene flow had decreased as a result of habitat fragmentation. In fact, the reduced gene flow was so significant that it resulted in two genetically different sub-populations of bobcats. As urbanisation becomes more prevalent, gene flow may continue to decrease leading to more sub-populations, inbreeding and overall less genetic diversity, culminating in higher risk of extinction.

Human-large carnivore co-evolution also affects species relations. In some cases, humans do not affect the occupancy of species, but the interactions amongst themselves. Changes in large carnivore populations have resulted in trophic cascading effects that extend to mesocarnivores, herbivores, and plants. This phenomenon, known as the human shield effect, argues that humans employ a top-down effect on apex predators, which in turn affects mesopredators and increases their spatial overlap. Mesopredators indirectly benefit from the decreased occupancy of the apex predators they compete with. This effect is displayed through the increasing co-occurrence of species such as coyotes, grey foxes, bobcats, and skunks with human activity. These results reflect the evolutionary impact humans can have on entire communities.

Mitigation efforts

Given that its effect on carnivores is evident and escalating, mitigation efforts are vital to consider as a response to urbanisation. Informed urban planning is one strategy for combating the evolutionary impacts of urbanisation. The most effective urban planning focuses on the areas and species most heavily impacted and at risk of extinction. Species that have limited ranges and available habitat are particularly vulnerable to the risk of extinction. As a result, the focus should be on urban areas that are biodiversity hotspots and hold endemic species.

Mitigation efforts should consist of protecting the habitat of endemic and range-restricted species and coordinating urban development to prevent contiguous urban clusters that hinder habitat connectivity. For example, the United Nations' Sustainable Development Goals (SDGs) incorporated urban conservation strategies into their global urban agenda. The 15th SDG aims to protect and restore biodiversity within ecosystems. This specific goal has several targets with indicators that set measurable outcomes of action by 2030.

While habitat protection is an important strategy to mitigate the evolutionary impacts of urbanisation, so is decreasing species' attraction to urban areas. Species that have not successfully adapted to urban environments due to inflexibility in diet, movement patterns, and social behaviours can be negatively impacted by urbanisation. However, scavenger species such as red fox, coyote, Eurasian badger, and raccoon can achieve high densities within urban areas due to the ecological opportunity provided through food and shelter.

Additionally, large carnivore species such as bears, hyenas, and wolves living adjacent to urbanised areas can benefit from scavenging opportunities. With this in mind, utilisation of urban areas may seem beneficial for scavengers. However, these outcomes can often lead to human-related killings, either due to conflict or encounters with man-made objects such as vehicles. Deterrents and reduction of feeding opportunities are two effective ways to minimise carnivore attraction to urban areas and anthropogenic mortalities.

Conclusion

Co-evolution between humans and large carnivores is a profound evolutionary dynamic due to the ecological roles of both interactants. In the early ages, both drove each other to adapt through an evolutionary arms race. In modern times, humans have the upper hand due to vast technological advancements. Urbanisation is an outcome that can have some significant impacts on large carnivores, such as decreased species richness, behavioural change, reduced gene flow, and increased species interactions within carnivore guilds.

With urban populations projected to become the majority, it is crucial to further investigate and mitigate the negative evolutionary effects and pressures exerted on large carnivores by humans. Given the critical role apex predators play in the ecosystem, the evolutionary effects on large carnivores may trickle down to the rest of the community in unforeseeable ways. Protection of natural habitat and behavioural aversion towards humans can serve to minimise interactions and evolutionary impacts. Simultaneously, further research is needed to investigate the effectiveness of these and other strategies as the issue of urbanisation continues to grow.

Further Reading

Carter, N. H. and J.D. C. Linnell. 2016. Co-adaptation is key to coexisting with large carnivores. *Trends in ecology & evolution* 31(8): 575–578.

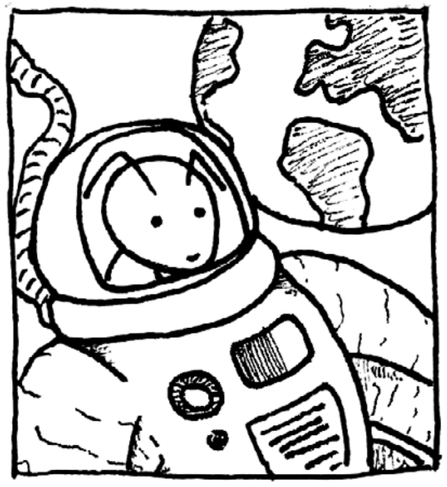
Gámez, S. and N.C. Harris. 2021. Living in the concrete jungle: carnivore spatial ecology in urban parks. *Ecological applications* 31(6): e02393.

Hussain, S., M. Weiss and T. Nielsen. 2022. Being-with other predators: Cultural negotiations of Neanderthal-carnivore relationships in Late Pleistocene Europe. *Journal of Anthropological Archaeology* 66: 101409.

Simkin, R. D., K. C. Seto, R. I. McDonald and W. Jetz. 2022. Biodiversity impacts and conservation implications of urban land expansion projected to 2050. *Proceedings of the National Academy of Sciences of the United States of America* 119(12): e2117297119.

Sierra Lippert *is a graduate student with Project Dragonfly at Miami University and San Diego Zoo Wildlife Alliance. During her coursework, she studied cheetah conservation in Namibia.*

Rohan Dahotre *is a wildlife illustrator based out in Pune. He loves illustrating animals, birds, and all things wild, contributing to the cause of wildlife awareness, conservation, and welfare.*



GIVING BUGS A CHANCE

Author and Illustrator **Karyn Light-Gibson**

As a child, I was lucky enough to grow up in a metropolitan city while also having a forest in my backyard. Since I can remember, insects and all "bugs" have been my favourite creatures on the planet. I would watch ant colonies for hours trying to determine how their system functioned, collect praying mantises or crickets to observe their behaviour, and watch spiders spin their victims in webs.

I was surprised to learn that others did not feel the same, even those with access to nature at their doorstep. One time at school, I was quietly observing a bee that was either exhausted or dying. Out of nowhere, someone ran up and smashed it with their foot. I was shocked and angry but struggled to explain why I was so upset. The person laughed and said that it didn't matter anyway. Another time, my mom was sunbathing in the backyard and I was so excited to give her two presents: one hand full of rolly pollies and the other full of worms. I was confused by my mom's disgust with the gifts.

After other similar incidents, I decided that if others did not want to be around bugs, I would make being around bugs my entire life. I knew that I wanted to help educate people about the importance of bugs. At that point, I wasn't quite sure how I would do it, but I talked to anyone who would listen. No matter where I went, people would tell me about their dislike or fear of bugs, but I was also able to find those who loved them as much as I did.

Insects and other invertebrates are the most populous animals on earth, yet are rarely the focus of conservation efforts, with the exception of a few well-researched species like honeybees. There are many reasons for this, including a poor understanding of these species, difficulty in specifying a single species for conservation, and a lack of interest in insects by the general public. Bugs are a vulnerable group who are often overlooked and underappreciated.

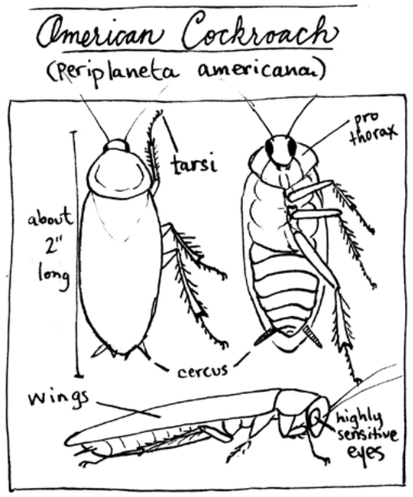
The field notes that I have collected over the past year weren't from some distant land, but instead from the city where I live—Denver, Colorado. While exploring rainforests and faraway lands is extremely important, discussing wildlife and conservation in urban spaces is equally important but less often done. More and more land is used for infrastructure, not for urban parks and open spaces. It is estimated that by 2050, 69 percent of the world and 89 percent of people in the US will live in cities. Dunn and colleagues (see Further Reading section) presented what they call the pigeon paradox: as human populations shift to cities, humans will primarily experience nature through contact with urban nature. Without the understanding and help of people who live in urban environments, we doom ourselves and all other species.

Why the hate?

Two Japanese researchers came up with the urbanisation-disgust hypothesis: urban living creates situations in which people encounter insects indoors more often than outdoors, and they also lose the ability to identify them. This leads to a more intense and generalised disgust of insects (and other "bugs"). They also state that urbanisation reduces insect knowledge which contributes to disgust. Their survey of 13,000 people supports this hypothesis. So how can we increase insect knowledge and reduce the amount of disgust? Education about invertebrates is an important first step, but overstepping bounds and making people feel insecure is not the way to go.

My use of the word bug is very deliberate. While all insects are not bugs, 'bugs' is often the term used to describe any small invertebrate we see in our homes and lawns. True bugs only include specific insects from the order Hemiptera (cicadas, aphids, and planthoppers to name a few). It also doesn't include any other invertebrates like spiders or centipedes. I think it is important to use the term "bug" for insects and other invertebrates in conversation with people since that is the term they generally use for these animals. No one responds well to being told that they are wrong, and this is especially true when trying to talk about a subject most people prefer to avoid. Whether or not they use the right terminology is not the focus of this work; broad appreciation is. I wondered how to incorporate my years of experience and schooling in education, culture, and language with my love of bugs and art.

The last two years have led me on a journey of discovering how to positively engage those who live in urban environments with bugs. As luck would have it, I found two different ways that seem to start great discussions and may help shift our psyche: zines (small, self-published "books") and popular culture. Art, insects, and popular culture have always been important to me, but I had never thought of combining them. These mediums allow us to talk about conservation in a manner that engages all audiences. I am not the first to implement these strategies, but I feel that they should be used more widely. By addressing disgust through creative methods like zines, and connecting bugs to already existing characters or cultural artefacts we can combat the disgust of insects.



Bugs in our lives

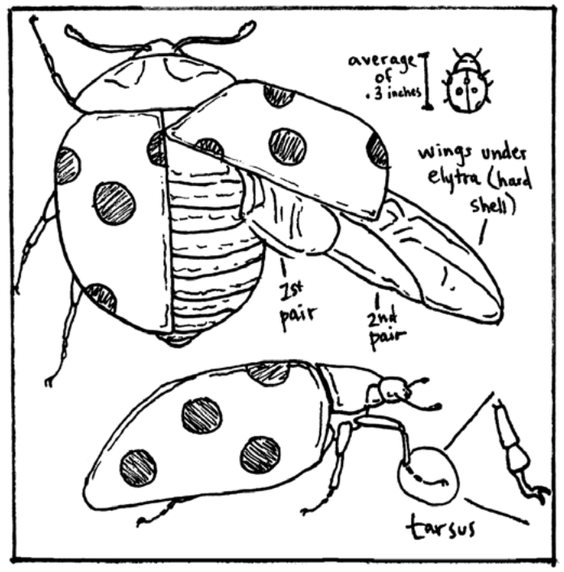
The first project I undertook was to create a zine to help people understand the importance and amazing traits of some common urban bugs—American cockroaches, house flies, wolf spiders, and so on—most of whom could show up in houses or apartments in the US. A small publisher took a chance on me because they could see my passion. The editor told me that they hated bugs but couldn't stop reading my zine. People have said things like, "I loved learning about black widows! I'm not so scared of them anymore!"

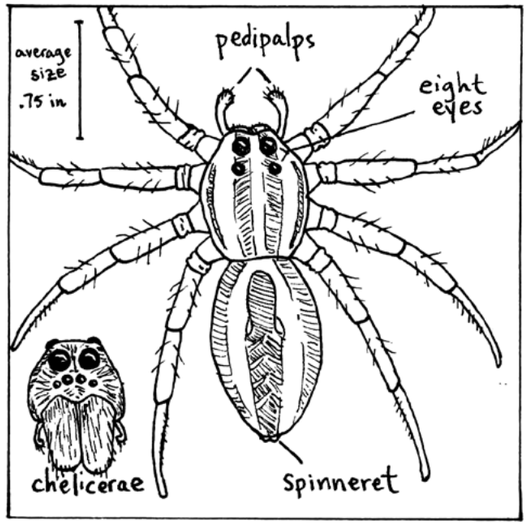
Again, this is not new. Search for bug zines online and you will see that they are everywhere. Many conservation organisations have pamphlets available about insects, but they are often full of scientific jargon, look mass-produced, or contain overwhelming amounts of information. Pamphlets have their audience but there is also a sizable market for small, accessible, handmade materials from conservation organisations. Zines are easy to make, cheap to produce, and allow people to talk about a subject in their own fashion. They are great for organisations, individuals, and classrooms alike. Zines give students ownership over the content and have been shown to create more engagement around their chosen topics.

My second approach was connecting insects with popular culture. Superheroes are more popular today than ever before and some of the most famous are named after invertebrates: Ant-Man, Spider-Man, The Wasp, etc. Taking this into consideration, I submitted a proposal to deliver a presentation at the Denver Fan Expo. There were over 100,000 people who attended the convention. One of the most common characters that both young and old attendees dressed up as was Spider-Man. In my presentation, I talked about superheroes and their real-life counterparts. While on stage in front of a massive crowd of people, I asked about the similarities and differences between Spider-Man and spiders. I had people in line for other booths yelling answers at me across the floor, parents and kids talking and drawing more "accurate" versions of some characters or creating an entirely new character. The interest and excitement was palpable, particularly among kids. It was an amazing experience that informed my next steps in using popular culture to engage a wider audience in the appreciation, or perhaps even conservation, of bugs, even if it meant shifting the needle of our perception of insects only slightly towards the positive end.

Research has shown us that people are not inclined to assist in conservation efforts just because we tell them there is a dire need for action. It is too overwhelming or too abstract or too distant to create a sense of urgency or make people feel like they can help in any way. Throughout my experiences over the last year, I have discovered ways to overcome those obstacles. While these projects don't turn everyone into bug lovers, I am determined to try and in as many creative ways as I can. I know that I want to create and do more non-traditional insect conservation projects by tapping into what people already enjoy and showing them how it connects to the natural world. I hope to talk about how insects are woven into our culture and history, and allow for the ownership of ideas and accessibility of materials. I aim to develop unusual ways to communicate about insects that speak to people who may not typically care about these creatures.

I hope you will join me in the call to create love and appreciation around bugs in our lives.





Further Reading

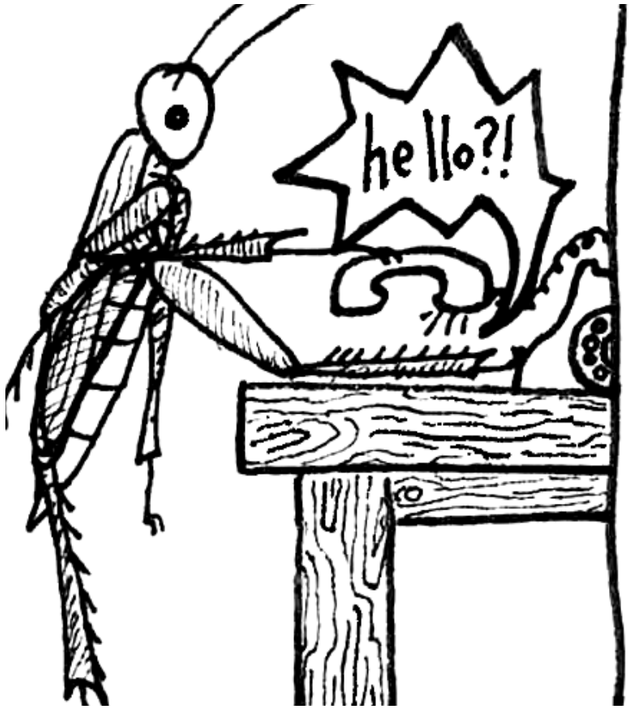
Dunn, R. R., M. C. Gavin, M. C. Sanchez and J. N. Solomon. 2006. The pigeon paradox: dependence of global conservation on urban nature. *Conservation biology* 20(6): 1814–16.

Fukano, Y. and M. Soga. 2021. Why do so many modern people hate insects? The urbanization–disgust hypothesis. *Science of the total environment* 777: 146229.

Schmidt-Jeffris, R. A. and J. C. Nelson. 2018. Gotta catch'em all! Communicating entomology with Pokémon. *American entomologist* 64(3): 159–164.

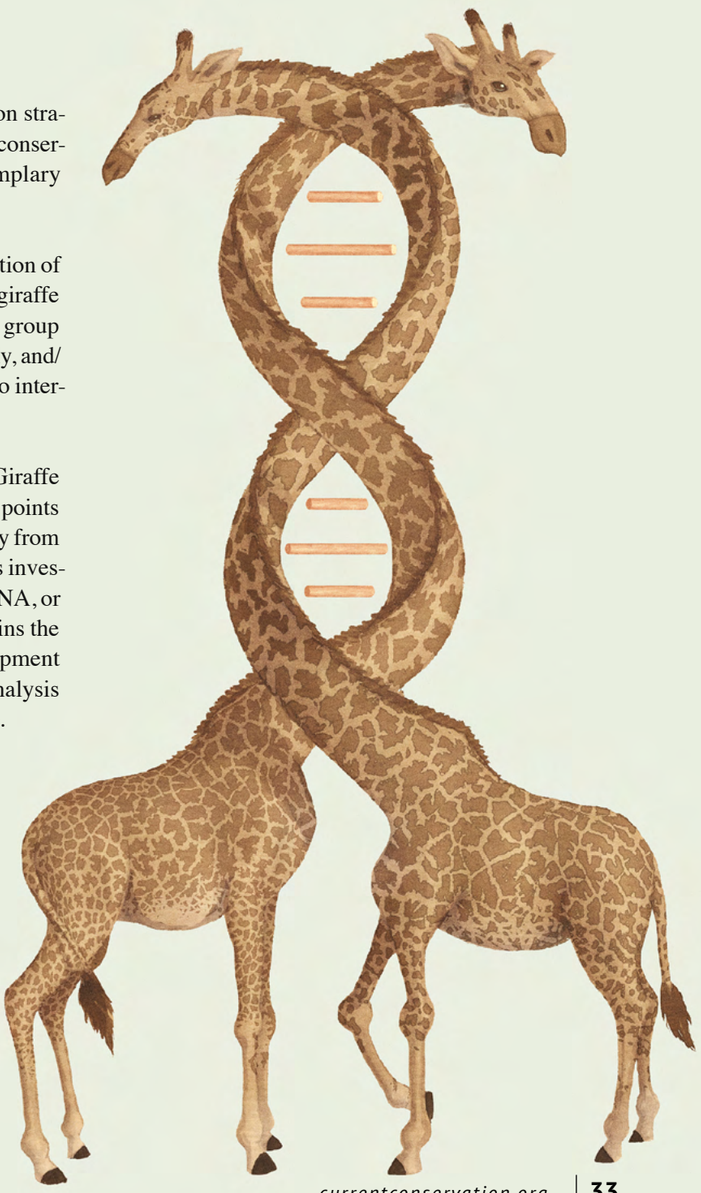
Yang, A. 2010. Engaging participatory literacy through science zines. *The American biology teacher* 72(9): 573–577.

Karyn Light-Gibson *is an educator and artist in Denver, Colorado, with 14 years of teaching experience. She has an MA in Linguistics and an MA in Biology. She has published multiple zines and is writing a book about insects.*



Leveraging genetics to inform giraffe conservation

Author **Hannah Kania**
Illustrator **Vishnu M Nair**



Genetic data is increasingly used in conservation strategies. But how do scientists apply the data to conservation management? Giraffes present an exemplary case study to explore this question.

Currently, the International Union for Conservation of Nature (IUCN) recognizes only one species of giraffe with nine known subspecies. A subspecies is a group within a species that is geographically, genetically, and/or physically different from others, and is able to interbreed with other subspecies.

Intriguingly, a genetic study from 2018 by the Giraffe Conservation Foundation and Senckenberg BiK points to four distinct species of giraffe. A separate study from 2020 by researchers from the University of Paris investigated the totality of DNA data from giraffes. DNA, or deoxyribonucleic acid, is a molecule that contains the genetic instructions that determine the development and traits of all living organisms. The genetic analysis supports at least three distinct species of giraffe.

Despite these claims, the exact number of giraffe species has not yet been settled. Furthermore, the IUCN has not assessed the giraffe species recognition status since 2016. This imposes direct consequences for giraffe conservation. Conservation management relies on species data obtained from the IUCN. If the species data is wrong or not updated, it may impact the effectiveness of conservation measures.

While the species debate continues for giraffes, researchers are using genetics to address other conservation concerns. Monica L. Bond, a researcher with the Wild Nature Institute and University of Zurich—who has studied giraffes for over a decade—states that giraffes are undergoing what has been termed a 'silent extinction'. This means that people generally aren't aware that the world's tallest land mammals are endangered. They are threatened by the same pressures affecting wildlife across the globe, namely overhunting, loss of habitat, and climate change.

Conservation of populations

Such pressures apply widely across giraffes. However, the degree of concern varies among giraffe populations.

For example, Masai giraffes face different threats depending on their location. Masai giraffes, a species or subspecies of giraffe, are located in Kenya and Tanzania. They were declared endangered by the IUCN in 2019. Sadly, their populations have declined over 50 percent since 1985, accelerated by human development. Douglas Cavener—a professor at the Pennsylvania State University, who studies giraffe genetics— says that the habitat of Masai giraffes is highly fragmented, in part due to the rapid expansion of the human settlements in East Africa in the last 30 years, and the subsequent loss of wildlife habitats.

Further exacerbating these issues, Masai giraffes are separated by a large rift in part of their range. Cavaner informs that the Great Rift Valley cuts down through East Africa, and the steep slopes of its escarpments are formidable barriers to wildlife migration. Giraffes on either side of the rift face separate conservation concerns. On the eastern side, giraffes are experiencing heightened habitat fragmentation due to human development, whereas on the western side, they face intensified illegal hunting.

Diving into the genome

To better inform conservation of the Masai giraffe populations around the rift, a study published last month by Cavener, Bond and co-authors takes a closer look at giraffe genetics. The conclusions drawn from a copious amount of giraffe genetic data are striking.

The researchers looked at the genomes of 100 Masai giraffes to determine if populations on either side of the rift have crossed over to breed with each other in the recent past, which has important implications for conservation. For this purpose, they sequenced more than two billion base pairs that make up the entire nuclear genome as well as the more than 16,000 base pairs that make up the entire mitochondrial genome.

Sequencing is a process used to determine the precise order of the base pairs and provides crucial information for understanding the genome. Base pairs are the genetic code that collectively make up an organism's DNA. The entirety of DNA in an organism is known as a genome. For giraffes, this totals over two billion base pairs per individual.

Within an individual, there are two types of genomes—one genome in a cell's nucleus, the cell's brain so to speak, and one genome in a cell's mitochondria, the cell's energy producer. Together, the two genomes encode information about an organism. For a giraffe, they specify information about spot patterning, neck length and energy production, alongside other things.

Importantly, information from the nuclear genome is passed down from both parents, while information from the mitochondrial genome is only passed down through the maternal line. Comparing both genomes across individual giraffes can provide evidence for female versus male movements within the Masai giraffe range.

The researchers found that giraffes on the east of the rift share mitochondrial haplotypes—chunks of the mitochondrial genome that are inherited together. Strikingly, giraffes on the east side do not show overlap of haplotypes with giraffes on the west side. This clued researchers into how genetic material is being shared from mother giraffe to calf, as the mitochondrial genome is maternally inherited. Their results show that female Masai giraffes have not moved across the Great Rift Wall that separates the Serengeti-Ngorongoro (west) and Tarangire-Manyara (east) populations in the past 250,000 to 300,000 years, and it is possible they never did.

Moreover, the results from the nuclear genome demonstrate that male-mediated interbreeding has not occurred in at least 1,000 years—as nuclear genome information identifies patterns passed down from both parents. Cavener says that there are very few prospects of giraffes crossing over the rift on their own. Some male giraffes may have crossed the rift in the past, but certainly not in recent years.

Diversity concerns

Collectively, the data implies that giraffes on opposite sides of the rift do not interbreed, and hence do not share genetic material. Males have not crossed the rift in at least 1,000 years, and females have been mating only with giraffes on the same side of the rift for over 250,000 years. Thus, the researchers urge that the populations be considered as separate.

In considering the giraffe populations separately, each population now consists of less individuals than if they were one larger population. Cavaner reveals that the populations of giraffes on each side of the rift are genetically distinct, with each population having less genetic diversity than if they were one, larger interconnected population.

The Masai giraffes' inability to share genetic material across populations is not good for genetic diversity. Lan Wu-Cavener—an assistant research professor at the Pennsylvania State University and member of the research team—reveals that interbreeding among different populations results in the exchange of genetic information, and is generally considered to be beneficial as it can improve overall genetic diversity. Thus, the Masai giraffes on either side of the rift are more endangered than previously thought, as the amount of genetic diversity thought to be shared among them is less than once assumed. The new study highlights that conservation is of the utmost concern in order to preserve the variation that is left.

Conservation applications

The finding that Masai giraffes are not interbreeding or sharing genetic material across the rift has direct implications for conservation. Researchers have some ideas for how their genetic data can inform conservation efforts in Tanzania and Kenya. In consideration of the decreased genetic diversity within these populations, it is believed by Bond and Cavener that not interfering with the natural course of evolution is the best conservation strategy.

It may seem intuitive to translocate giraffes across the rift to increase their genetic diversity. On the contrary, researchers believe this would not be beneficial. Bond and fellow researchers caution against translocating giraffes across the rift wall for any reason, in order to preserve the genetic distinction between these two populations.

The decline of these populations due to human impact has been occurring since 1985. This time scale does not compare to the 250,000 years of non-interbreeding between these Masai giraffe populations—which ultimately led to genetic distinction between the populations. While translocation across the rift would increase genetic diversity, it would also change the course of evolution of the giraffe populations.

Bond states that the two giraffe populations are on their own evolutionary trajectory and shouldn't be tampered with. This means that we need to focus on conserving giraffe populations in their present range, through targeted habitat conservation and connectivity within the two geographic regions.

Cavener adds that conservation efforts for each population should be considered in an independent but coordinated fashion. The researchers hope that the Tanzanian and Kenyan governments will increase the protection of Masai giraffes and their habitats, especially given the recent increase in giraffe poaching in the area. Ultimately, the researchers believe that conservation of Masai giraffes needs to shift to mirror the genetic status of these two populations by considering them separately.

Excitingly, the application of Masai giraffe genetic data to conservation management does not end here. The research team plans to use the collected genetic data in future studies.

Knowing the genetics of individual giraffes provides information about relatedness, and can be used to study reproductive behaviours, influence of relatedness on behaviour, and heritability of traits. The researchers maintain that these questions are critically important for estimating the actual breeding population of the entire population, and will continue to guide their efforts to protect and conserve these majestic and charismatic animals.

Looking beyond giraffes

Besides Masai giraffes, genetic data has been employed in several other conservation efforts. For example, researchers at the San Diego Zoo in California have used genetic data to guide breeding and reintroduction of California condors for over three decades. Australian researchers used genetic data to show that critically endangered vaquitas can bounce back if illegal fishing is stopped. Scientists with the Royal Zoological Society of Scotland are training researchers in Cambodia to set up a genetic laboratory. They are working on a genetic test to aid Siamese crocodile reintroduction. The applications of genetic data for conservation are evidently endless across myriad organisms.

Collectively, genetic data has the ability to inform conservation management at multiple levels—from breeding programs to policies that limit human development and activities. In the case of the Masai giraffes, genetic data collection and analysis is not stopping anytime soon. It is clear that genetic data is an asset to their conservation. As Dr. Bond says, "We hope that this research can inform science-based giraffe conservation so we can sustain these wondrous animals into the future."

Further Reading

San Diego Zoo Wildlife Alliance. 2020. Genotyping the California condor: What we've learned. Science Blog. https://science.sandiegozoo.org/science-blog/genotyping-california-condor-what-we%E2%80%99ve-learned. Accessed on July 2, 2023.

Giraffe. The IUCN Red List of Threatened Species. 2018. https://www.iucnredlist.org/species/9194/136266699#taxonomy. Accessed on July 2, 2023.

Lohay, G. G., D. E. Lee, L. Wu-Cavener, D. L. Pearce, X. Hou, M. L. Bond and D. R. Cavener. 2023. Genetic evidence of population subdivision among Masai giraffes separated by the Gregory Rift Valley in Tanzania. *Ecology and Evolution* 13:e10160. https://doi.org/10.1002/ece3.10160. Accessed on July 2, 2023.

Hannah Kania ***is a Biology PhD student at Duke University who loves biodiversity. Her passion lies in using genetics to inform conservation of Earth's flora and fauna.***

Vishnu M Nair ***is an illustrator and designer based out of Delhi. His work spans picture books, paintings and brand design***

Under the protective skirts of Australian grass-trees

Author and photographer **Sophie Petit**

Wrapped up in blankets and equipped with a cup of smoking hot chocolate, I sent Deb out into the pouring rain. It was the highest mean rainfall for June in the Adelaide Hills, South Australia, in 20 years.

Deb Frazer is a brave woman. She had already spent the hottest summer and coldest winter days and nights measuring the temperature under grass-trees—*Xanthorrhoea semiplana* subspecies (ssp.) *semiplana*. Much research has examined the microclimates of different natural shelters, but the effect of downpours has been generally overlooked.

Yet, wetting affects the insulation of bird and mammal coats and halves thermal resistance. Research on livestock has shown the terrible impacts of wetness in the cold, leading to death. The South Australian rainy season in the Mediterranean climate belt occurs in winter, and can get quite cold.

We generally assume that when it is cold and raining, animals will seek shelter. And without a second thought, we turn on the kettle as we settle in front of a bowl of soup.

But where do animals seek shelter? Shelter is an essential resource, and should be part of high-quality, well conserved habitats. Rock structures, tree hollows, and burrows protect animals from extreme weather. It turns out that grass-trees, Australian icons, can join the list of precious shelters at least in some of the ecosystems in which they occur.

Australia has 29 species of grass-trees in the genus *Xanthorrhoea* (family Asphodelaceae) distributed across most parts of the country. They have a long association with Aboriginal history, serving various purposes across different Indigenous groups. Also called yaccas, they are known to host a diversity of vertebrates and invertebrates. They feature long skirts of curving leaves, and their nectar-rich flowers are produced at the top of stupendous, long wooden scapes. While some species grow trunks over hundreds of years, others remain close to the ground.

Thermal, waterproof refuges

In *X. semiplana* ssp. *semiplana* found in the Adelaide Hills and Mount Lofty Ranges, the leaves die and dry up at the bottom of the canopies and stay in place, creating increasingly sturdy, thick, waterproof roofs curving to the ground. Our previous research showed that they host many native animals, including bandicoots and bush rats. Another student and I have observed echidnas resting under the thick canopies of grass-trees. But what is the thermal value of this plant as a shelter?

Deb and I found that on the hottest days of summer, the mean temperature under the thickest grass-tree canopies could be 20°C lower than in random spots around grass-trees or in ambient shade. The temperature at our four study sites remained extraordinarily stable under grass-trees, while external temperatures could exceed 40°C, which is believed to be lethal to several vertebrate species.

Although the differences in winter temperature between external and grass-tree canopy temperatures were much smaller, significantly warmer conditions were observed under grass-trees at night. In both summer and winter, the temperature variation was low under the grass-tree canopy. Temperature stability in winter could facilitate the maintenance of torpor—an energy-saving strategy used by many small vertebrates.

As Deb struggled through the downpour, she recorded soil wetness under grass-trees. She was amazed to find that under 80 percent of large and old grass-trees, the soil was perfectly dry, and partially dry under 20 percent of the other grass-trees. As expected, young grass-trees without full and thick skirts were nowhere near as good at providing shelter from the rain. Considering their exceptional habitat value, old grass-trees certainly play a role in determining the foraging times of animals, which are likely to use grass-trees when the weather is inclement.

The remarkable ability of at least some grass-tree species to protect a diversity of animals from deadly climatic extremes, combined with their anti-predator services (for example, large cats, foxes, and birds would have a difficult time penetrating the sturdy canopy of dead leaves), strengthens the mounting evidence that

these plants are keystone species in Australia. Animals—whole populations of some species—can use their services to survive drastic environmental conditions. Grass-trees just need to be present along with their generous old skirts of leaves. Will they be?

Grass-trees in peril

Historically, the two *X. semiplana* subspecies were extensively cleared for agriculture from many ecosystems, including in the Adelaide Hills and Mount Lofty Ranges, on the Yorke Peninsula, and on Kangaroo Island. They are now the victims of two other afflictions: a disease-causing oomycete (*Phytophthora cinnamomi*), recognised by the Australian government as a "Key Threat", and an increasing incidence of fires.

Highly susceptible to the soil pathogen *Phytophthora*, grass-trees die en masse in infected areas, along with other native plant species, dramatically reducing the habitat for local animal communities. Infections are facilitated by human, vehicle and animal passage, and fires. Fires can thus affect grass-trees negatively in an indirect way by increasing *Phytophthora* infestations, as well as directly with severe burns that end up killing the plants.

Although the resilience of grass-trees to bushfires is well known, it may be overestimated according to recent research. Moreover, even if grass-trees are not killed by fires, their old, thick skirts of dead leaves burn, leaving no shelter for animals in post-bushfire environments.

As South Australia becomes hotter and dryer with the changing climate, it burns more easily. People are understandably scared. The bushfires of 2019–20 ravaged widespread areas in Australia, including South Australia. With the support of part of the community, government organisations have been involved in conducting extensive prescribed burns in native ecosystems, sometimes inaccurately called "fuel reduction burns" and even more inaccurately "ecological burns". This feel-good terminology hides the negative impacts of frequent prescribed fires. Long-unburnt habitats, where most of our biodiversity thrives, are becoming a rare occurrence. Prescribed burning is often not backed by research, and ecological studies in other Australian ecosystems show that recently burnt habitats are drier, have more fuel, and burn more easily than long-unburnt ones.

Protecting grass-trees and their skirts goes a long way towards protecting Australian wildlife and biodiversity. It is not appropriate to "manage" the few areas of nature and wilderness we have left without research to support the radical strategies undertaken. This research should include long-term scientific monitoring, which is rarely carried out.

As we sip hot chocolate by the heater in the cold, rainy winter and sleep in the cool air conditioning on 45°C days, shouldn't we also protect the grass-trees from our actions, the very plants that provide many of our animals a cosy home with a solid roof?

Further Reading

Petit, S. and D. S. Frazer. 2023. The role of grass-tree *Xanthorrhoea semiplana* (Asphodelaceae) canopies in temperature regulation and waterproofing for ground-dwelling wildlife. *Pacific Conservation Biology* 29(5): 445–455. https://doi.org/10.1071/PC23014.

Sophie Petit ***is Associate Professor of Wildlife Ecology at the University of South Australia and Associate Researcher at Kangaroo Island Research Station.***

Photos

Page 38: Grass-tree *Xanthorrhoea semiplana* ssp. *semiplana* at Mount Crawford, Adelaide Hills (S. Petit)
Page 39: Some animals shelter directly under grass-trees; others place their burrows under grass-trees (S. Petit).