HOW A BIG CITY REDUCED THE GENETIC DIVERSITY OF COYOTES

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YOUNG REVIEWERS:

MATÍAS
AGE: 15

SEBASTIAN
AGE: 11

The world's cities are expanding at a very fast rate, taking over natural land inhabited by many different animals. It is very important that we monitor the impact this expansion is having on animals in and around our cities. Coyotes are the perfect species to study the effects of urbanization on wildlife, because they are found in both urban and natural environments. We examined how urbanization affects coyotes throughout the Los Angeles area in the United States. We discovered that urbanization influences where different groups of coyotes choose to live and that it also reduces the genetic diversity of coyotes. We should be concerned for the well-being of coyotes because low genetic diversity decreases the ability of any species to fight diseases and deal with other threats. We conclude that the coyote, a species formerly thought to be resistant to human disturbance, is in fact impacted by urbanization.

CITIES AFFECT SPECIES

Human activities can affect two important aspects of all species on the planet: their ecology and their evolution. **Ecology** describes how an organism interacts with its environment. This includes how a species uses various resources, such as food, water, or shelter, and even how it behaves in different situations. **Evolution** describes how a species changes over time. The actual processes that cause evolution are the small changes in the genetic information of a species, which is stored in its DNA. If any genetic change allows an organism to survive better, that organism is more likely to have a higher number of offspring and pass the genetic change on to them. Over time, lots of these small changes can add up and can even result in a completely different species.

One human activity that greatly affects the ecology and evolution of animals is urbanization [1–3]. **Urbanization** transforms natural landscapes into cities. Cities change the movement patterns of animals and the foods and resources available to them. Urbanization can also influence the evolution of animals by breaking up a larger population into many smaller ones. Over time, these smaller populations can accumulate changes in their DNA and can develop new behaviors, such as preferring a certain food source or habitat type.

It is easy to imagine how urbanization would affect species that do not do well in cities, such as lions, tigers, or bears. But do you think urbanization affects other species that we often see in cities, such as pigeons, rats, or coyotes? That is precisely the question that we tried to answer.

COYOTES!

Coyotes, known by scientists as *Canis latrans*, are wild animals in the dog family and are often the top predators in many cities throughout North America (Figure 1A) [4]. Coyotes are also found in many natural habitats, such as forests, grasslands, and even mountainous areas. That makes coyotes one of the few species that we can study to understand the effects of urbanization on wildlife, because they live in both urban and natural environments.

A previous study in California (United States) found that, when coyotes move from place to place, they prefer habitats like the ones in which they were born. This phenomenon is called **natal habitat-biased dispersal** [5], and it happens because parents teach their pups the skills to survive in a certain habitat, so the pups grow up preferring that habitat [6]. For example, a coyote born in a grassland will prefer to move to another grassland and avoid spending a lot of time in forests, while a coyote born in a forest will prefer to move to another forest and avoid spending a lot of time in grasslands. We wanted to see if the

ECOLOGY

The scientific study of how organisms interact with their environments, including how they use resources, such as food or shelter and how they behave.

EVOLUTION

The process by which a species or population changes over time due to changes in the genetic information stored in the DNA, which are passed down from generation to generation.

URBANIZATION

The process by which humans change natural landscapes into urban ones, by clearing the land to build roads, buildings, and cities.

NATAL HABITAT-BIASED DISPERSAL

The tendency of an animal to prefer habitats similar to the one it was born in when it moves from place to place.

Figure 1

(A) A coyote living in an urban area in Los Angeles, California. **(B)** The locations of the 125 coyotes in this study. Coyotes in Populations 1 (blue), 2 (green), and 4 (yellow) were found primarily in urban habitats, while coyotes in Population 3 (brown) were primarily found in mountainous regions. Hybrid coyotes were mixed with the other populations. Coyotes in the mountainous areas that live far away from each other are more related to one another than they are to nearby coyotes in the city, probably due to natal habitat-biased dispersal.

Figure 1

GENETIC MARKER

A specific segment of DNA which can be targeted by scientists to compare genetic variations among individuals of the same species.

ALLELE

A specific version of a gene or genetic marker in an organism's DNA. Individuals typically inherit two alleles per gene or genetic marker, one from mother and one from father.

same pattern holds true with artificial urban habitats and the natural habitats that surround a city.

HOW MANY POPULATIONS OF COYOTES EXIST IN THE LOS ANGELES AREA?

We conducted our study in and around Los Angeles, California because it has many highly urban areas and many highly natural areas, both of which coyotes call home. We studied whether the DNA of coyotes in urban areas differed from the DNA of coyotes in more natural areas. To do this, we first collected tissue samples from 125 coyotes throughout Los Angeles. Unfortunately, most samples came from coyotes that died in roadkills. We analyzed the coyotes' DNA by measuring the length of 10 specific regions of the DNA, called **genetic markers**, which told us how the 125 coyotes were related to one another. Coyotes with similar changes in those 10 DNA markers are more related to one another. The various versions of the genetic markers (or of any other gene) that exist throughout a species are called **alleles**. Studying differences in alleles is similar to the way a crime scene investigator uses DNA to find the killer, or to how a

court uses DNA to identify a baby's parents. We analyzed the DNA data using a computer program to determine how many genetically distinct populations of coyotes exist throughout Los Angeles. We classified coyotes into one of four populations based on their genetics, or to a hybrid population if a coyote's parents came from two different populations.

Next, we mapped the locations where each coyote was found. Since coyotes move around a lot, we drew a circle around each location, to show the average living area of a coyote. We calculated the amount of urban and natural land within those circular areas using satellite maps, like those on Google Earth. This allowed us to compare the average amounts of urban and natural habitat in the home ranges of coyotes from different populations. We did this to determine if the populations that differed genetically also differed in habitat.

Finally, we measured the amount of genetic diversity within each population. **Genetic diversity** is the overall level of differing genetic characteristics within a population. A population that is more genetically diverse is healthier and can overcome sudden changes in the environment. It is important to note that the health of individual coyotes and the health of coyote populations are related but different ideas: individual health describes the likelihood of survival of an individual coyote, while population health describes the long-term likelihood of survival of the entire group. For example, imagine a population of coyotes that all share the exact same allele that protects them from a virus. If the virus tried to infect this population, the coyotes would be just fine because they are all protected. However, if a new virus tried to infect this population, the whole population might die out, because they lack the allele to protect them against the new threat. But, if the population were genetically diverse, with some coyotes possessing the allele that protects them from the first virus and other coyotes possessing the allele that protects them from the new virus, then the population as a whole would be better prepared to survive, no matter which virus attacks it. We measured genetic diversity as the number of alleles to determine if the health of coyote populations in urban and natural areas differed. Our hypothesis was that coyotes in urban areas would have less genetic diversity than coyotes in natural areas.

WE FOUND FOUR DISTINCT POPULATIONS OF COYOTES

We discovered that coyotes living throughout Los Angeles can be grouped into four genetically different populations (Figure 1B). Three of those populations were primarily found in urban habitats with lots of roads and buildings. However, one population was found primarily in mountainous regions on the outskirts of the city. Hybrid coyotes were found interspersed throughout the other populations. The most

GENETIC DIVERSITY

The overall level of differing genetic characteristics within a population, which is an indicator of the genetic health of a population, and often measured by the number of alleles.
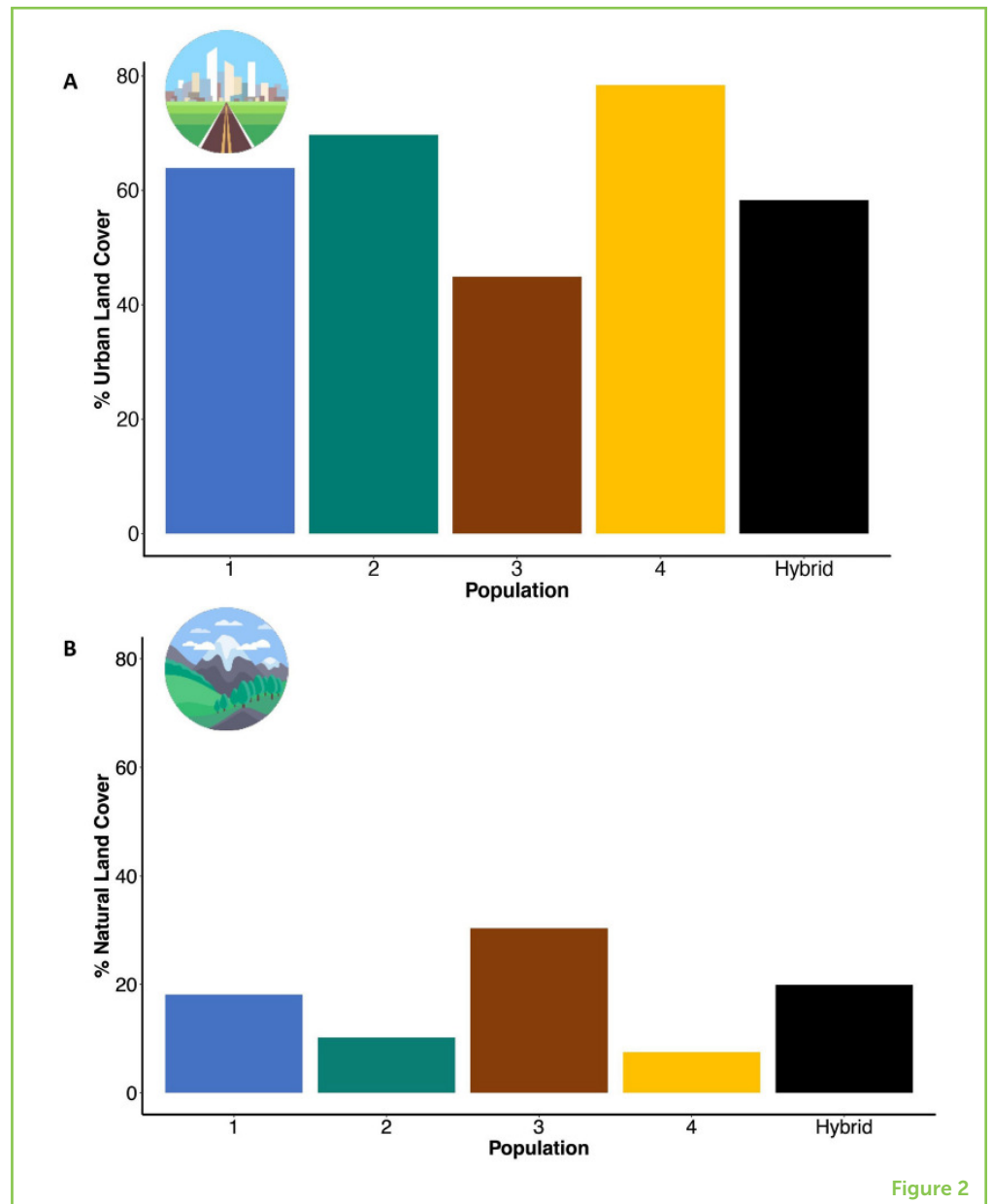
Figure 2

striking result was that the coyotes that live in mountainous, less urbanized regions that are very far away from each other are more related to one another than they are to coyotes from other, nearby populations with more urban territory. Habitat preferences and natal habitat-biased dispersal are likely causing this genetic pattern, because when groups of coyotes move to new locations, they choose familiar habitats that are similar to those in which they grew up.

We then compared the average amount of urban and natural land within the circular living areas of coyotes in the four populations and the hybrid coyotes (Figure 2). We found that one population, called Population 3, had significantly more natural land and significantly less urban land than all other populations. Coyotes in Population 3 lived in territories where, on average, 30% was natural habitat, while for

We measured genetic diversity of the coyote populations by counting the number of alleles for each of our chosen genetic markers. You can see that the genetic diversity of coyotes (y-axis) decreased as the percent of urbanized territory in the coyotes' home range (x-axis) increased. Genetic diversity is an indicator of the health of the population: the higher the genetic diversity, the healthier the population. This means that urbanization might be making coyote populations less healthy.

Figure 3
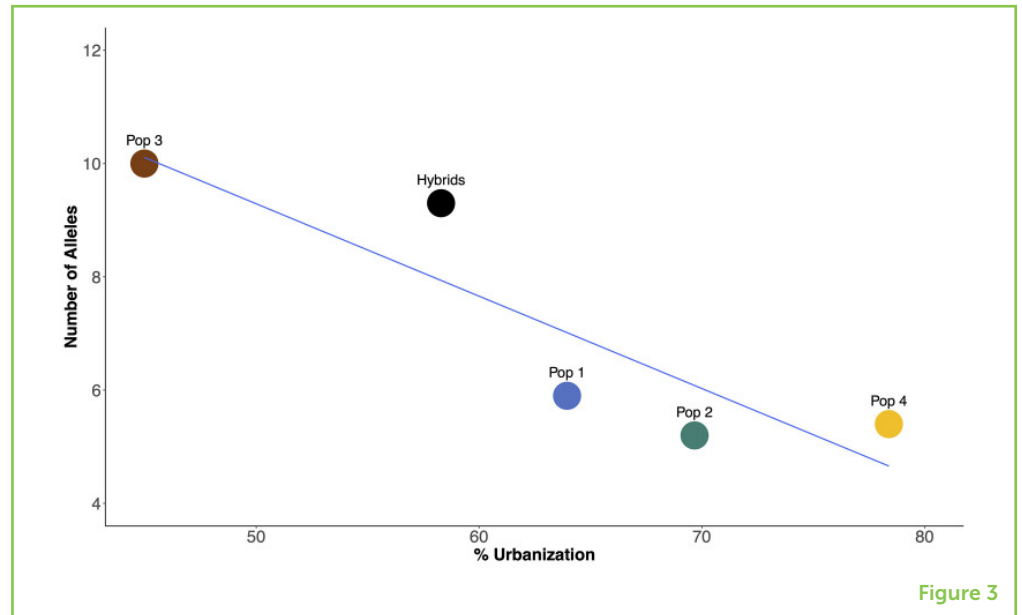
the other populations the amount of natural habitat varied between 8 and 18%. This led us to conclude that there are three "urban" coyote populations in Los Angeles and one "natural" population in the mountains surrounding Los Angeles.

Finally, we looked at the genetic diversity of our coyote populations by analyzing the number of different alleles for each of the genetic markers (Figure 3). Population 3, the more natural population, had a greater variety of alleles, meaning that this population was more genetically diverse than the urban populations. This told us that, as urbanization increases, genetic diversity decreases. This is important because, if you remember, genetic diversity is an indicator of population health.

BIG CITIES ARE NOT GOOD FOR COYOTES

We discovered that the coyote, a species normally thought to be resistant to human disturbance, is in fact negatively impacted by urbanization. Genetically distinct coyote populations in Los Angeles differ in the amount of urban land within their home ranges. This supports the idea that natal habitat-biased dispersal is causing genetic differences, based on habitat preferences. Moreover, coyote populations in natural areas are more diverse—and thus healthier—than those in urban areas. Big genetic changes in species usually occur slowly, over many hundreds or thousands of years. However, coyotes in and around Los Angeles show significant genetic changes since the city started to expand, only about 100 years ago. This tells us that cities can rapidly alter the genetic composition of wildlife.

While our study focused only on coyotes, we can use the information we obtained about the effects of urbanization to understand the impacts that humans have on all the species around us. Our research could be used to help create conservation plans to protect wild species. For example, we should protect natural areas surrounding cities, to preserve healthy wildlife populations with high levels of genetic diversity. Additionally, we could construct wildlife overpasses and underpasses to help animals move between natural areas separated by roads, thus helping to connect animal populations. It is important to monitor the impact of cities on the wildlife around us and to find creative solutions to preserve the world's biodiversity for future generations.

AUTHOR CONTRIBUTIONS

JM conceived and designed the research. AA and JM collected the samples, performed the laboratory work, analyzed the data, and wrote the manuscript.

ORIGINAL SOURCE ARTICLE

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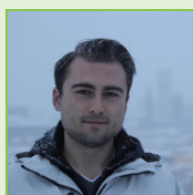
YOUNG REVIEWERS

MATÍAS, AGE: 15

I love playing music and doing magic tricks. I like science and my favorite subject is physics.

SEBASTIAN, AGE: 11

I like sports, reading, math, animals, and the great outdoors!

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Anthony is a 2019 graduate of Pepperdine University, where he majored in Biology and worked in the research lab of Dr. Javier Monzón, focusing on coyote genetics. In the past year he has been working on the genetics of brown bears in Slovenia, a country in southern Europe, during his prestigious Fulbright Research Fellowship. Anthony has always loved animals and has been interested in science since he was a child. Besides research, he enjoys spending time with family and friends, hiking, and being outdoors. *anthony.adducci@fulbrightmail.org
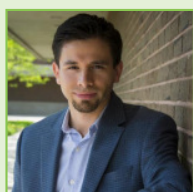
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Javier is a wildlife biologist and professor at Pepperdine University, where he teaches Zoology, Ecology, Animal Behavior, and Conservation Genetics. He has been passionate about animals for as long as he remembers. As a child, he kept a growing list of all the animals he knew! He has conducted research on canaries, capuchin monkeys, coyotes, eagles, and ticks. His current research focuses on the ecology, behavior, and evolution of animals that are "*living on the edge*." He investigates the genetic differences that arise in animal populations that expand geographically or expand into urban areas.