Census at the Zoo

Although everyone is talking about species protection, the lack of information about the species that need to be conserved can be quite shocking. To ensure that threatened animal species can be protected more effectively, the research team working with **Dalia Amor Conde** in the Conservation Demography Research Area of the Evolutionary Biodemography department headed by James W. Vaupel at the **Max Planck Institute for Demographic Research** in Rostock is using special methods to gather important data about the lives of endangered animals.

TEXT **KLAUS WILHELM**

The jaguar has taken the bait. Now the dogs make their grand entrance – at dawn, in the service of science and for the protection of the big cats. Tony Rivera, an experienced former jaguar hunter, lets his pack of hounds off the leash. They have picked up the scent of the jaguar across the dense Mayan rainforest of the southern Mexican state of Yucatán. Fernando Colchero and his assistant hurry behind the panting dogs. For years, he and his colleague Dalia Conde, together with researchers from the National Autonomous University of Mexico (UNAM) and the conservation NGO Jaguar Conservancy, have been studying the habitat and movement behavior of the charismatic predators in the Yucatán peninsula, Guatemala and Belize.

Normally, when jaguars are pursued, they simply make themselves scarce. But not this time! Instead of fleeing up the next tree, the animal decides to attack. The jaguar leaps onto one of the dogs in a single bound. He fights for his life until his barking fades away. To everyone's surprise, the jaguar then releases its victim and disappears into the undergrowth.

"We thought the dog was dead," recalls Colchero today. The young man and his companion run after the big cat, which suddenly darts out from the green mass of vegetation again, confronting its pursuers. "It was about to go for us," says Colchero, "the adrenaline rush in my body was incredible."

His companion lashes out with a machete. Meanwhile, Colchero steps toward the jaguar, which then actually hesitates. At that moment, the rest of the research team arrive and sedate the indignant animal with a dart.

"The dog that was attacked wasn't dead at all, he just played dead," says Colchero, a native of Mexico. "It was a female jaguar. Females don't bite dogs to death, but male jaguars do." The jaguar is fitted with a collar equipped with a GPS device that will track it as it moves about in its habitat. Such data from the cooperative project conducted by the Max Planck Institute and the Mexican non-governmental organization Jaguar Conservancy is crucial for future research in Rostock and for protecting the animals.

"That was a stressful project," confirms Dalia Amor Conde, Colchero's partner in both his professional and private life. "One time, members of the team were kidnapped by drug dealers in the forest in Guatemala," says the young biologist. Luckily, no one was hurt, but we had to change our field site and we lost one year of data.

The two scientists look out from the meeting room in the Rostock-based Max Planck Institute directly across an arm of the Baltic Sea, onto a scene that is completely different from what they would experience in the jungle heat. Cool, calm, picturesque. With them are Owen Jones and Alexander Scheuerlein. Together they form a key part of the Evolutionary Biodemography department (EvoDemo). The biologists, mathematicians and statisticians have something completely new in mind: they want to transfer human demographic methods to animal populations.

As a discipline originally tailored to humans, demography uses statistical methods to figure out how populations evolve. It deals with age structures, births and mortality, as well as the environmental and social factors that change the population. These are all things that can also apply to animal populations. Dalia Conde, head of the Conservation Demography Area, thus views the extinction of a species as a demographic process.

The flexible fertility and mortality rates lead to a situation where the populations of a species become smaller and smaller. If many populations shrink,

eventually the entire species will disappear. "In order to be able to use management programs to protect species more effectively, we need to understand the demographic processes of these species," says Conde.

As an example, biologists have for a number of years now been using population viability analysis, as it is known, to calculate the probability of a population becoming extinct after a certain period of time. Demographic factors are incorporated into the assessment: What is the mortality rate of a species over the course of its life? How many young does it have, or in other words, how fertile is it?
Critics, however, constantly challenge the method, as it delivers reliable results only if it is based on realistic data. "But due to a lack of data, many of the analyses are based on vague expert opinions on a species," says Dalia Conde.

The biologist therefore initiated a project called DatLife – a digital platform that systematically collects all the globally available demographic infor-

After the tiger and the lion, the jaguar is the third-largest feline predator in the world and America's biggest cat. Its territory, which at one time extended from the southwest of the US to Argentina, has diminished by more than half in recent decades.

Photo: AtPIX

Field research in the rainforest: GPS data tells Dalia Amor Conde the type of habitat she is in at the moment (1). At night, only all-around protection helps guard against jungle pests: hammock and mosquito net (2). If the researchers want to be able to locate a jaguar with tracking devices, they need to sedate the animal with an anesthetic dart. They then measure the animal and fit a tracking collar around its neck (3).
(4) From left: Fernando Colchero, Dalia Amor Conde, Jessica Dyson, Heliot Zarza.

mation that has ever been published about all known animals. It illustrates just how flimsy the scientific basis is that underlies much of the data. Many of the assessments made about how long a species can live are based on just one individual.

Researchers at the MPIDR know the maximum lifespan of only 1 percent of amphibians, 7 percent of reptiles, 14 percent of birds and 23 percent of mammals. "Not nearly enough," remarks Alexander Scheuerlein, "and the maximum lifespan doesn't yet say much in terms of a viability analysis."

The situation is even worse when it comes to other demographic data. Even in the case of mammals, basic information is known for just 2 percent of species. The reason for this dire state of affairs is simple: the Max Planck researchers' experience in capturing jaguars clearly shows how difficult it is to collect demographic data in the wild. They have thus been working on an alternative for the last two years: zoological gardens.

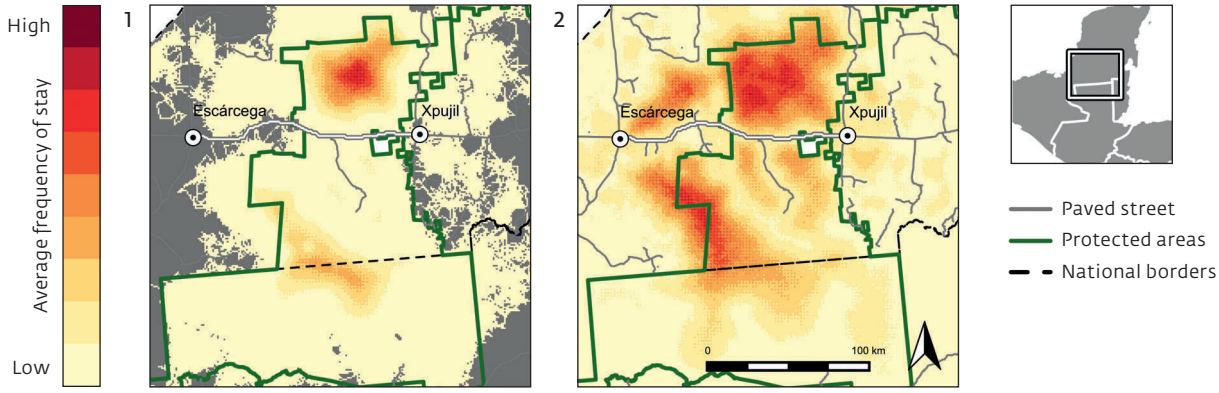
INCOMPLETE SPECIES INVENTORY IN ZOOS

A total of 850 zoos around the world are linked via the International Species Information System (ISIS) and supply this treasure trove with new demographic data about their inhabitants on an ongoing basis. Reliable data on more than 2.5 million individuals has been collected to date, some of it covering accurate descriptions recorded over more than 40 years: time of birth and death, onset of sexual maturity, number of offspring and rate of reproduction – everything is there.

For the first time ever, the Rostock scientists, together with their ISIS colleague Nate Flesness, determined the composition of the cohort of inhabitants in the world's zoos. This means that 25 percent of all bird species and 20 percent of all mammals are represented in zoos, but only 12 percent of reptiles and 4 percent of amphibians. Some 66 percent of all mammal species classified as vulnerable, endangered or critically endangered are kept in zoos.

The figures for endangered birds, reptiles and amphibians, on the other hand, are significantly lower. "Overall, one in seven endangered animal species is in captivity," says Dalia Conde. "There is room for improvement, but it's better than nothing."

The question remains as to what the demographic data relating to zoo inhabitants really means and whether it reveals anything about their wild relatives. "Let's take the mortality of species," says Alexander Scheuerlein, drawing a few curves on a sheet of paper.



Photos: Jaguar Conservancy; graphics: Animal Conservation

They illustrate the likelihood of animals dying at certain stages of life. This is linked to the principles of evolution.

An animal's fitness, in evolutionary terms, is measured solely by the number of its progeny, which in turn is determined by fertility and mortality. "So we can understand evolution only against the background of demography," says Owen Jones, describing the EvoDemo group's philosophy. "Evolutionary processes affect species demography – and vice versa."

The popularly held theory purports that mortality increases as life progresses, while fertility decreases. However, Alexander Scheuerlein cannot detect this rule universally in the demographic data sets that he has collected. Some species show a constant mortality rate, such as the freshwater polyp, Hydra. For many others, it is very high shortly after birth, but then decreases progressively – even into old age in the case of tortoises. "Probably because they are getting bigger all the time and can stand up to natural predators more effectively."

The mortality curves of baboons and chimpanzees are fundamentally similar to those of humans. The Max Planck researchers have now constructed mortality curves for around 100 animal species, all of them based on data collected in field and laboratory studies.

LIFE'S MORE COMFORTABLE IN THE ZOO

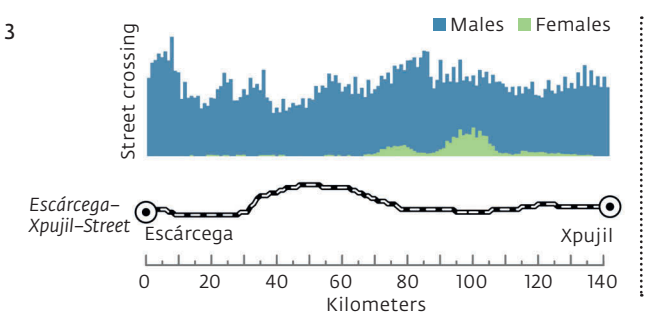
The Rostock-based researchers are currently analyzing the demographic data submitted by the zoos. They are using it to construct mortality curves and compare them with reliable curves of populations living in the wild. They want to find out the extent to which the curves differ. It is clear that life is very different and much tougher in the wild than it is in zoological gardens. After all, wild animals aren't routinely cared for by a vet in the way that zoo inhabitants are.

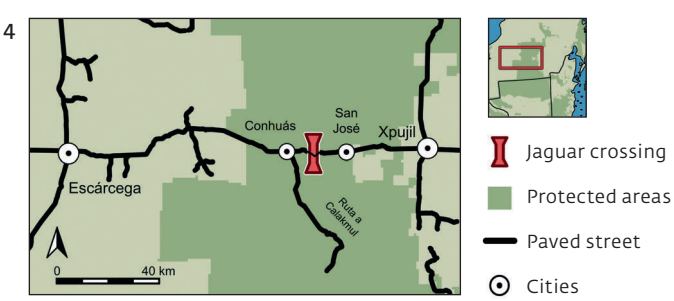
While no findings are yet available on the differences in important demographic data, the MPIDR team certainly has some initial presumptions. Paired birds whose social systems aren't complex probably have similar mortality rates in the zoo and in the wild. The mortality curves run in parallel even though the zoo inhabitants naturally live longer.

The situation is somewhat different for social animals like baboons. For animals like these, natural social systems are often different in the zoo, where there are no longer any alpha or beta males. This has a sustained influence on mortality rates.

Through such comparisons, the scientists want to obtain enough information to enable them to draw conclusions about the demography of wild animal species for which they have no data. This data could then be fed into new population viability analyses – with ultimately much more meaningful information for the management of endangered species. "I trust this data much more than vague expert opinions," emphasizes Dalia Conde.

The data from the zoos could also be used as control populations for future field studies on endangered spe-





Using positioning data in the tracking collars, a computer model simulates the movement profiles of female (1) and male (2) jaguars in Yucatán. The dark red markings indicate the locations most often frequented by the animals. The scientists can use these calculations to predict the points at which the feline predators frequently cross the 140-kilometer-long road from Escárcega to Xpujil (3). This is where crossings can be created (4).

Photos: Jaguar Conservancy; graphics: Animal Conservation

cies. In the zoo, animals aren't subject to the same environmental influences as they are in the wild. Comparison with the zoo controls should also provide the researchers with valuable information about which environmental factors, such as climate change, affect the demography of wild species.

LACK OF DATA MAKES SPECIES PROTECTION MORE DIFFICULT

All of this requires sophisticated methods, processes and programs. The Max Planck researchers, Colchero, Jones and Maren Rebke, also a member of EvoDemo, have just developed a software program to analyze field study data. It is called BaSTA (for Bayesian Survival Trajectory Analysis) and its purpose is to close the gaps and resolve the shortcomings that constantly arise in field studies. Ordinarily, scientists acquire their demographic data by capturing animals, putting tracking collars with an ID number on them or ringing them. In this way, they can follow the animal's fate. Ideally, the animal's age is known. It should also be noted in any later measurements, and the time of death should be recorded.

In reality, however, the researchers often don't know the animals' ages. Or they can reconstruct only part of the lifespan. Nevertheless, in order to get results, they simply estimate the mortality and use only individuals whose age is known. "Both of these things reduce the information value of a study," says Colchero. This can result in incorrect mortality data even in the last stage of life. And the biologists rarely find all of the animals previously included in their study. Are they already dead, or is there some other reason for their disappearance?

In short, much of the demographic data remains vague, and consequently, so do the recommendations for species protection. Out of necessity, biologists and statisticians recently developed statistical processes that complete the sketchy data collections by adding sound assumptions. Many of these methods are good, but complicated for the average user. "BaSTA, on the other hand, is child's play to use," says Owen Jones enthusiastically.

The program can even be used to extrapolate times of birth and death. "We take as much data as possible from a study and use it to model parameters to close the gaps," says Jones, the British biologist. No information is lost.

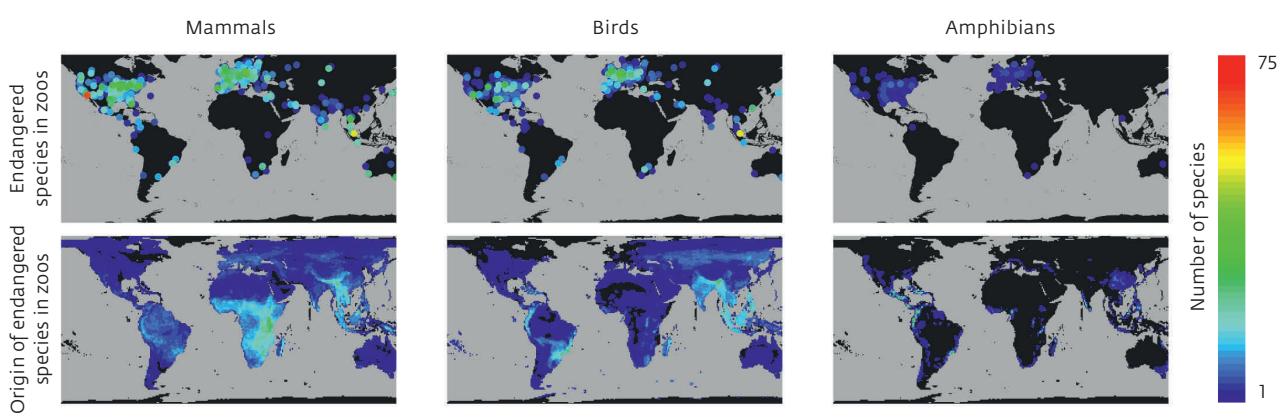
This means that BaSTA will also be valuable for future jaguar studies. "In order to use our demographic models for protecting these and other animals, we need to understand their habitats," says Dalia Conde. By this she means how big their habitat is and how they use it. The populations of big cats still seem to be reasonably robust, even though they have already lost 40 percent of their former habitat in Central and South America – especially in the Amazon region but also in the Mayan rainforest.

A major problem is the fragmentation of their habitat. For this reason, Dalia Conde and Fernando Colchero, supported by the Mexican government and several non-government organizations, have studied the role played by the construction of roads in the fragmentation of the jaguar's habitat.

The scientists and their colleagues trekked through the Mayan rainforest for months, experiencing the misery of how difficult it is to apprehend the timid animals. They eventually caught seven females and four males. Since then, five of them have been wearing collars with radio telemetry sensors, and the others have been fitted with GPS collars. This enabled the two researchers to determine the animals' positions four times a day for a number of years, and consequently to analyze the movement pattern of the big cats.

DIFFERENCES BETWEEN THE SEXES

At the end, the biologists loaded their data into a computer model. Their results showed that, while males are happy to live in densely populated areas and cross roads more frequently, the females purposely avoid these regions and only rarely cross the road. "They see the road and they turn around," says Conde. "As if they were allergic to it." The males,



Distribution of endangered mammal, bird and amphibian species in ISIS zoos (top) and their presence in the wild (bottom). The number of species increases from blue to red. The most-endangered species live in zoos in different climate zones than those they inhabit in the wild.

Graphics: Conde et al., 2011 Science 331: 1390-1391

daredevils that they often are, are also much more at risk of getting run over.

The researchers were able to use their model to identify locations at which the animals crossed the road most frequently. They advised the authorities to build bridges or tunnels for the jaguars precisely at those locations. Several jaguars (and other animals) have actually died already at one of the crossing hotspots predicted by the researchers. "Protective measures for the jaguars can also help other species," confirms Colchero.

In a second study, Conde and Colchero have shown how the big cats use their habitat. The biologists have also verified that males and females have a different mentality. Male jaguars much more frequently live in areas of the forest where there are very tall trees and scarcely any undergrowth, as they know from experience that this is where they will find the best prey.

The females also wander through such regions, but they prefer areas with smaller trees and dense vegetation cover, which makes each movement difficult. "It is extremely hot and sticky here because it is much easier for the sun to penetrate through to the ground," says Conde, who knows this from her own experience. Furthermore, the females, unlike the males, avoid large agricultural spaces, where they are largely unprotected.

The selection of locations appears to be carefully thought out. That's because poachers also prefer forested areas with tall trees, where it is easy for them to get around. And they advance a maximum of four kilometers into the forest, meaning that they stay close to paths and roads wherever possible. "In this way, the females avoid male jaguars and poachers who could harm them and their young," says Dalia Conde. Based on these findings, the biologists can give the conservationists specific information about the areas of the forest where conflicts between jaguars and humans are most likely to occur. And then they could work more with the local population in precisely these spots.

From the Mexican jungle to the Baltic Sea: Fernando Colchero (second from left) and Dalia Amor Conde (second from right). Beside them, Alexander Scheuerlein (right) and Owen Jones (left).

In a subsequent step, the Rostock biologists want to link the demographic data with their findings about the animals' habitats in order to provide specific recommendations for species conservation programs. Some species, such as the black rhino, the European wolf, the West African goliath frog and the East African Agapornis parrots, live in a stable habitat, but their populations consist of only a few animals.

With the new knowledge about fertility and mortality rates, researchers could predict how many males and females would have to be released into the wild to ensure the evolution of a stable group. Conservation programs could also be optimized for declining habitats and semi-stable populations, as in the case of the jaguar.

In the worst case scenario – a shrinking habitat and declining population density, as is the case for many Australian amphibians – just one option remains: live in the zoo. And wait for better times. ◀

TO THE POINT

- **Reliable demographic data exists for only a fraction of all animal species. The DatLife database, which is expected to be online at the end of this year, therefore collects globally available information on all known animal species.**
- **Observations of zoo animals could help close any gaps in knowledge. But consideration must be given to the fact that life in captivity can have an effect on the demography, with the result that species with complex social systems may possibly have a different mortality than their counterparts in the wild.**
- **Male jaguars in the Central American rainforest frequently live in densely populated areas and cross roads. Females, in contrast, live a more reserved existence and prefer forest areas with dense understory. The researchers can use this knowledge to refine their demographic models for the conservation of these predators and the improvement of protective measures.**

Photo: Thomas Hagedorn