



Chimpanzee Kinshasa with her brother Kuba and son Kiriku (from left to right) in the Taï National Park in the République de Côte d'Ivoire. These animals are extremely sociable and live in large groups, which means that pathogens can spread within a community with great ease.

VIRUSES FROM THE WILDERNESS

TEXT: CATARINA PIETSCHMANN

Roman Wittig, who heads up the Taï Chimpanzee Project at the Max Planck Institute for Evolutionary Anthropology in Leipzig, knows what happens when a virus changes its host, and has experienced it several times in the Taï National Park in the République de Côte d'Ivoire, the last time having been four years ago, when a coronavirus that is harmless to humans jumped from humans to chimpanzees. In collaboration with Fabian Leendertz of the Robert Koch Institute in Berlin, he is looking into pathogens that cause disease in chimpanzees and which of them could also pose a threat to humans.

Everything had to happen very quickly when SARS-CoV-2 reached the Côte d'Ivoire: which team members would remain and who would be flying back to Germany? “We weren't so worried about the staff,” Wittig explains, “as they are isolated and very well protected out there in the rainforest.” Instead he wanted to not only protect the park's chimpanzees from getting infected but also, as he explains: “If we had all flown home, the chimps would have been left to the mercy of poachers.” Zoonoses,

such as SARS-CoV-2, are diseases that can be transmitted from animals to humans, or vice versa. The pathogens involved could be viruses, but also bacteria, fungi, worms or infectious proteins – the so-called prions. Pigs, rodents, birds, and bats, including flying foxes, have been a recurring source and target of such host exchanges in the past. The same is true of our closest animal relatives, the great apes. For example, we share 99 percent of our genetic material with chimpanzees, which are particularly susceptible to respiratory diseases. Many of the chimps in the National Park were repeatedly falling victim to mysterious infections as early as the 1990s. “They started coughing and sniffing, became lethargic and lost their appetites,” says Wittig: “They slept on the ground rather than in the trees – something they never usually do for fear of leopards.” There was a major wave of infections in 1999, which caused severe symptoms in 50 to 70 percent of the animals, almost one in five of which died. Behavioral scientist Christophe Boesch was also at a

loss at the time. Together with his wife Hedwige, Boesch founded the chimpanzee project in the Taï National Park in 1979 and, as Director of the Department of Primatology, later transferred it to the Max Planck Institute for Evolutionary Anthropology in Leipzig in 1997. Fabian Leendertz flew out to the national park, which is the last remaining extensive rainforest area in West Africa, and spent 13 months investigating the deaths. This was the start of a close collaboration between the two Institutes that continues to this day.

“There have been several major and minor outbreaks of disease during the past 20 years.” Leendertz explains: “We examined all the sick and deceased animals and collected fecal samples from the sick ones. We performed autopsies on the dead ones under strict safety precautions, as we were aware that there had also been cases of Ebola in chimps.” The analyses revealed that many of the outbreaks were caused by respiratory diseases.

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Leendertz was able to identify various common cold viruses as well as a coronavirus known as OC43. The viruses came from humans and cause only mild symptoms in adults. The apes' immune systems, by contrast, were unable to fight the pathogen, which was new to them. Leendertz also identified *Streptococcus pneumoniae* bacteria – so-called pneumococci – in the chimpanzees, which can also be transmitted by humans. “We now know that such secondary bacterial infections can contribute to the severity of a viral disease.”

The researchers developed strict handling and hygiene guidelines to protect wild animals from human diseases in the future, which are still in force today. Anyone arriving at any of the four camps in the Tai National Park to carry out research is quarantined for five days. “Handwashing and wearing a mask are also compulsory,” says Wittig. Since that time, researchers have been monitoring the health of the chimpanzees in Tai National Park: the team collects fecal and urine samples and examines them for pathogens in the laboratory.

But humans are not the only ones capable of transmitting pathogens to animals: there is a plethora of unknown viruses, bacteria and parasites slumbering in primeval forests around the world, which could become dangerous to humans. For many years, therefore, scientists have been hunting down mosquitoes, mice and bats and studying the pathogens they carry. Unfortunately, however, this does not enable us to identify which of the pathogens can actually cause diseases in humans. Apes, on the other hand, are susceptible to a spectrum of pathogens very similar to that of humans and often fall ill from the same infections. “So any pathogens we find could be heading our way,” Leendertz explains: “That’s why we now use chimps as indicators of new, potentially dangerous germs.” The rainforest serves as a huge open-air laboratory for the veterinarian.

“The animals live here in their natural environment and when they fall ill, they help us to identify the causes.”

Treasure in the cold storage room

Over 50,000 fecal and 40,000 urine samples, as well as tissue from autopsies and genetic samples are currently in storage in the cold rooms at the Max Planck and Robert Koch Institutes. In most cases, the researchers even know which chimpanzee a given sample was taken from. “Such long-term data represents a treasure of immense importance,” as Roman Wittig explains: “It becomes increasingly valuable over time because very few studies go back that far.”

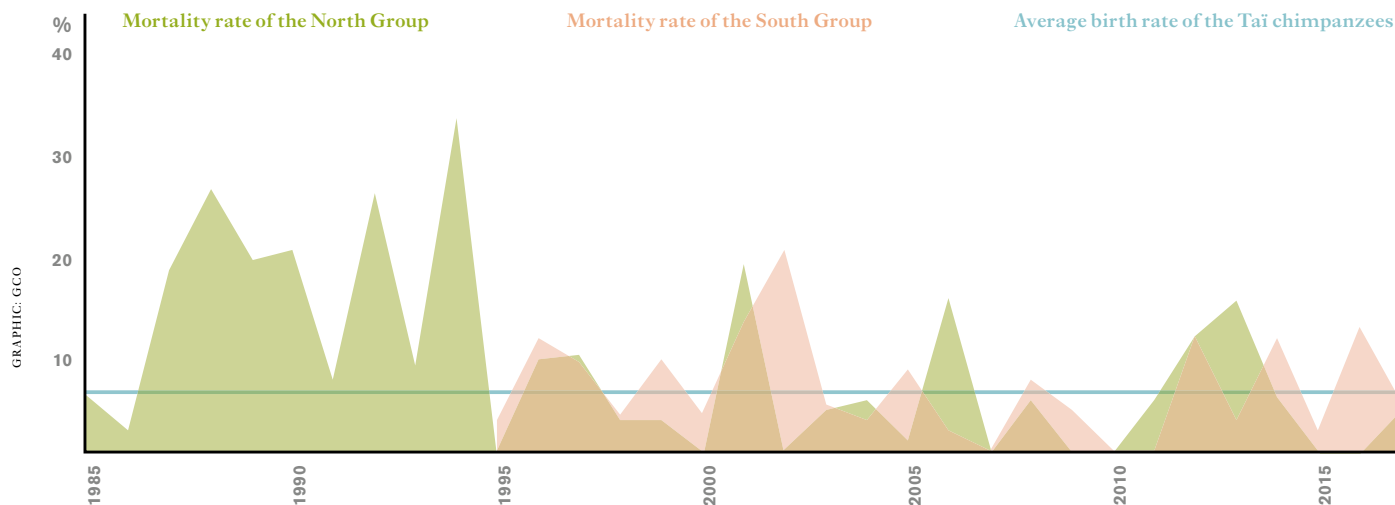
Thanks to the continuous emergence of new technologies, researchers are even able to reexamine samples that have already been analyzed to shed light on things such as nutritional status or changes to the immune system and intestinal flora. When, for example, they discovered a new, atypical anthrax pathogen known as *Bacillus cereus* biovar anthracis, in dead chimpanzees, they also analyzed older bone and tissue samples and discovered that of 55 dead animals, 31 had been infected with the bacterium. Subsequent analyses revealed that the pathogen had also been responsible for the deaths of numerous wild chimpanzees, gorillas and elephants in Cameroon and the Central African Republic. “Now there are signs that suggest that humans in the region have also become infected with the pathogen,” said Leendertz.

Once a month, Roman Wittig’s team collects feces and urine from each of the habituated chimpanzees. Fabian Leendertz and Wittig examine the feces for traces of pathogens.

This photo shows a student of the Tai Chimpanzee Project collecting urine in a plastic bag from a chimpanzee perched in a tree above her. The mask she is wearing protects against a possible infection of both humans and animals.



PHOTO: SONJA METZGER/TAI CHIMPANZEE PROJECT



Chimpanzee mortality rates between 1985 and 2017 in the North and South Group of the Tai Chimpanzee Project. The comparison with the average birth rate shows that significantly more chimpanzees died than were born in many years. In the last 20 years, the chimpanzee population in the park as a whole has decreased by 90 percent. Only in the past few years has the population stabilized to a certain extent.

“A disrupted ecological equilibrium favors zoonoses.”

ROMAN WITTIG

In samples taken from several outbreaks, the researchers also recently succeeded in detecting the pathogen responsible for monkeypox, a viral disease that is transmissible to humans and can cause a mild illness similar to smallpox, but can also be fatal. The list of currently known zoonoses includes over 200 diseases, ranging from A for Anthrax to Z for Zika. At up to 300,000 new infections per year the Lassa virus, which first appeared in 1969, is among the most prominent examples. This was followed in 1983 by HIV which has so far killed 41 million people around the world. Then it was one thing after another: the H5N1 bird flu has been around since the 1990s, SARS emerged in 2003, the H1N1 swine flu in 2009, Mers in 2011, Ebola in 2014, and Zika in 2015. And now SARS-CoV-2. This does not surprise Fabian Leendertz, who considers it to be only a matter of time until the

next pathogen makes the leap to humans, as we are doing everything possible to promote zoonoses: we are encroaching ever further into hitherto pristine regions and coming into closer contact with wild animals. We hunt, trade and eat wild animals on a massive scale. And thanks to today’s mobility, we are able to spread pathogens across the entire globe within a very short time.

The, for the most part illegal, hunting of wild animals is increasing the worldwide risk of pathogens being transmitted from animals to humans. The consumption of “bushmeat” also has a long tradition in Africa. “The people attribute special powers to wild animals and there is a widespread belief that these powers will be transferred to them when they eat the animals.” There is also the fact that many animals have become so rare that prices have soared and, as a



result, wild animal products have become status symbols for the rich. Rhinoceros horn is so sought after in China and Vietnam that it is now worth its weight in gold. Although hunting wild animals is prohibited in many African countries, monitoring is lax and the profits tempting. Leendertz himself witnessed how custom officials at Abidjan airport asked a fellow passenger to open her suitcase: it was full of desiccated monkeys!

To counteract the ever-increasing destruction, Wittig and Leendertz have proposed the so-called “One Health” concept, which is intended to reduce the risk of new pandemics. “It is simply becoming increasingly apparent that disrupted ecological equilibrium favors zoonoses. We need healthy ecosystems for the sake of our own health. Therefore,” Wittig

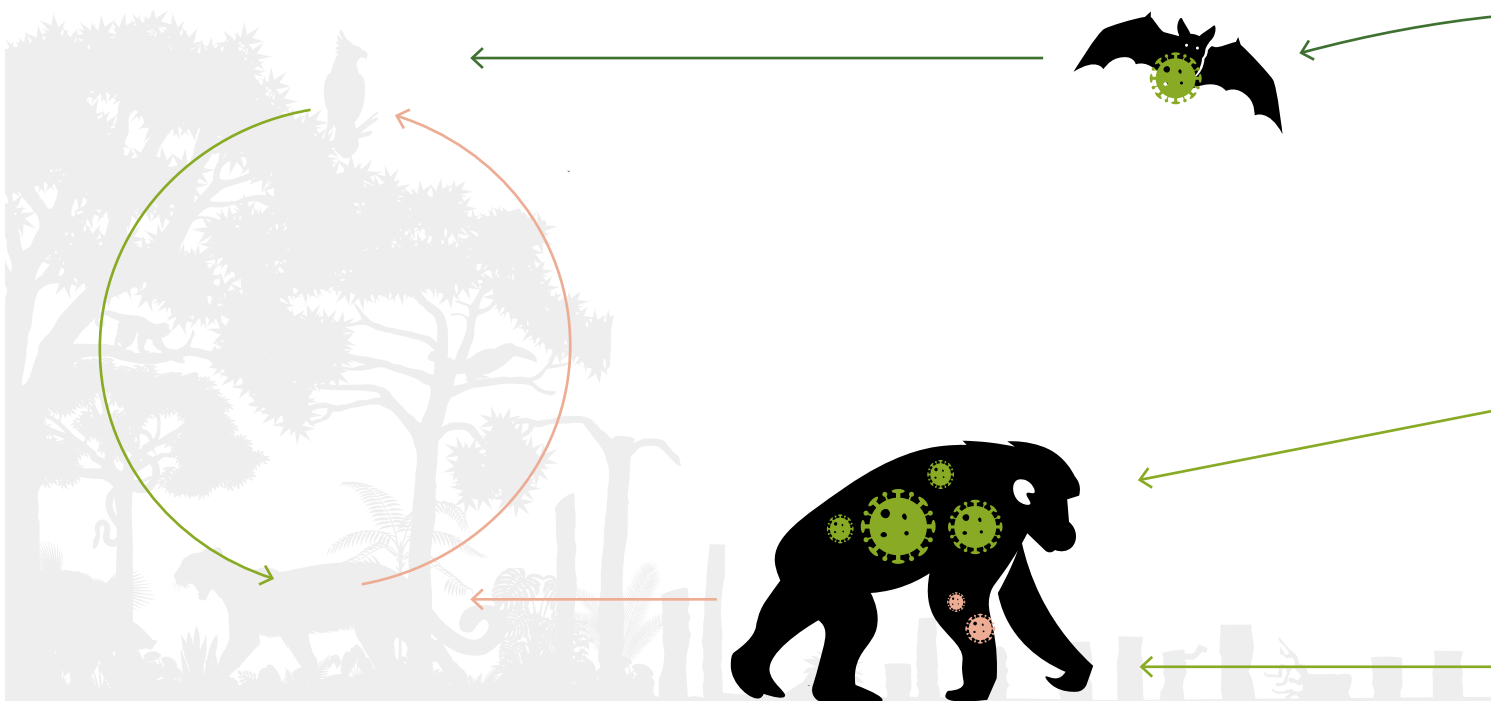
insists, “we ought to do everything possible to put a stop to the deforestation of the rainforests, the illegal hunting of wild animals and climate change.”

The poachers are now focusing on smaller game because the large animals in many regions have been exterminated. Bats, for example, are now being hunted by the hundreds of thousands. However, not only are they sought after as a source of meat, they also harbor a plethora of microorganisms. “Fruit bats and other bats are ideal hosts,” Leendertz explains, “because this genus includes a large number of species, and, for this reason alone, they host a wide variety of pathogens, which, because bats travel long distances in their nocturnal flights in search of prey, can be dispersed rapidly over long distances.” It is no coincidence,

therefore, that SARS, Marburg, Ebola and the new coronavirus originated in these flying mammals.

But how does a virus get from a bat to a chimpanzee?

As Leendertz explains, “A fruit bat will chew on a ripe fig one night and leave its saliva behind. The next morning, a chimpanzee will eat the remainder of the same piece of fruit, and the microbes it contains will find themselves in a new organism.” If they then succeed in evading the ape’s immune system, multiply within its body and then go on to infect other chimpanzees, they will have succeeded in changing hosts.



SUMMARY

Pathogens can easily cross the species boundary between chimpanzees and humans, because the two species are genetically closely related: in the past, HI-, Ebola- (from ape to man) and coronaviruses (from man to ape) have already succeeded in doing so.

The primary causes of zoonoses are considered to be habitat destruction, the illegal hunting of wild animals, intensive livestock farming and burgeoning mobility.

There are close links between human, animal and environmental health. In the battle against the transmission of the pathogens, researchers are therefore pursuing the “One Health” concept for a healthy environment, humans and animals.

As insectivores, the bats’ diet does not overlap with that of chimpanzees, but their habit of sleeping in hollow trees does result in contact opportunities. “Thirsty chimpanzees often find pools of water in such trees. They then chew up leaves, dip them as a makeshift ‘sponge’ into the pool and suck the water out of them – and a virus or bacterium can find its way into the new host.”

However, demonizing bats because of their “cohabitants”, driving them out of houses or even exterminating them would be a bad idea. Fruit bats, by contrast, are pure herbivores and feed on fruit, pollen, nectar and flowers and are, therefore, important pollinators. They then excrete the pips and seeds of their meals when they defecate far from the original location thus making an essential contribution to the reforestation of

the rainforests. “Bats” as Leendertz emphasizes, “also do a lot for us humans, even in major cities such as Berlin.” They can eat up to a third of their bodyweight in insects, including mosquitoes, every night. “Without bats, we would have malaria epidemics in regions in which the disease has thus far been virtually non-existent.” In addition, none of the coronaviruses that are dangerous to humans are found in Central European bat species.

Do chimpanzees actually take care of each another when one of them falls ill? “Yes,” says Wittig, “that happens all the time. For example, we recently saw a leopard attack an adult female and literally scalp her during the struggle. Her offspring and friends kept coming over to her and licking the wound. And she survived it. If a youngster is sick and cannot

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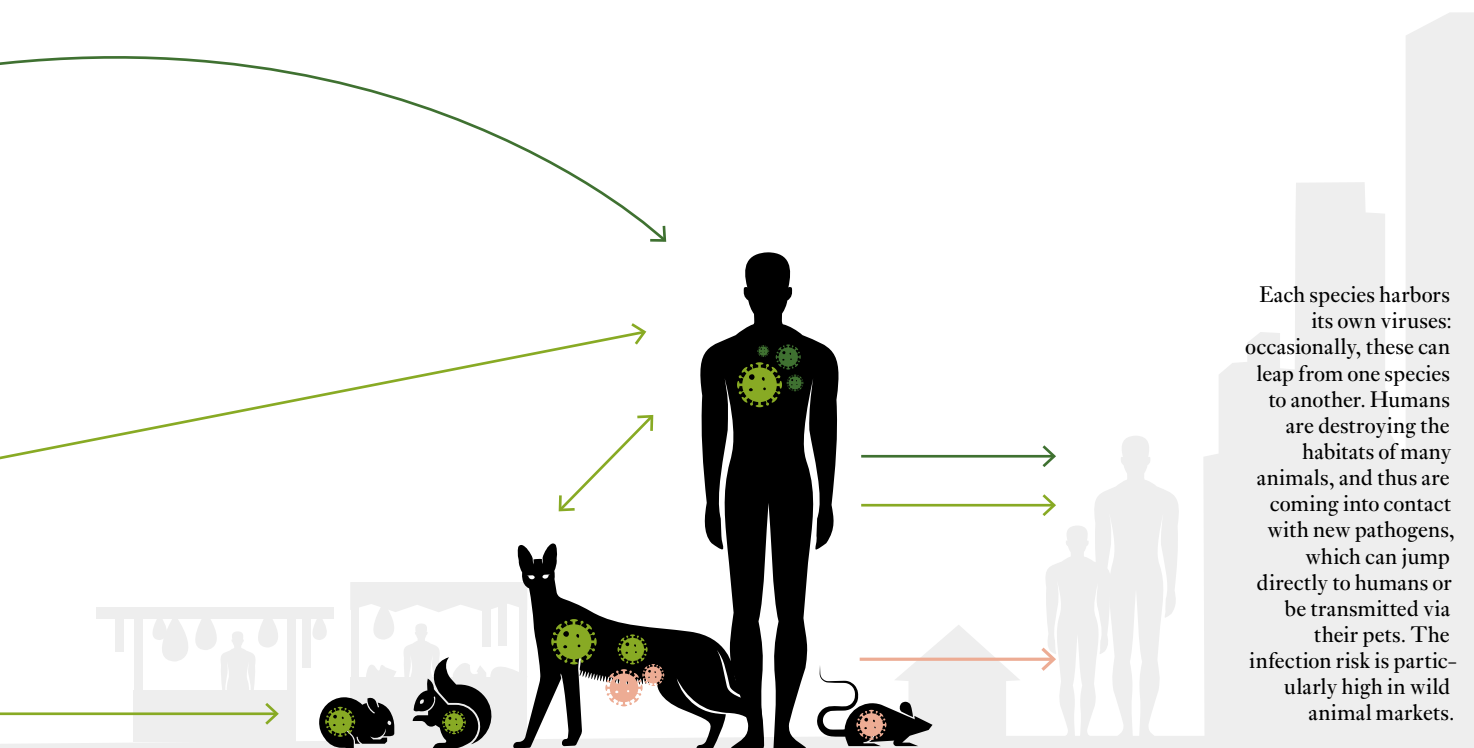


PHOTO: PICTURE ALLIANCE / REUTERS / AFOLABI SOTUNDE



A bushmeat vendor offers his goods for sale at the roadside. The transmission of pathogens is favored by poor hygienic conditions in wildlife markets.

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keep up with the group,” he continues, “the mother will leave it in a fruit-bearing tree. She then returns every other day to check on it until it recovers.”

If an alpha male or an old female dies, the group members gather round, touch the corpse and groom its fur. And some of them give in to their frustration. “When Ravel, a 15-year-old male, died,” Wittig recalls, “Oscar, his best friend with whom he had grown up, tried again and again to lift the corpse up and get it to stand up. But, when that didn’t work, he ran about screaming and flinging sticks around.” Dead chimps are also sometimes covered over with branches or leaves.

Do the researchers help sick chimpanzees? “No!” says Wittig. “We want to observe the animals’ natural lives, which include illness and injury – we don’t want to interfere in that.”

However, there was one exception: “It was when we realized we had infected the animals with our cold viruses and we didn’t yet know how to protect them.” To combat secondary pneumococcus infections, which is also transmitted by humans, Leendertz used a blowgun to inject some of the sick animals – including Sumatra, a female who was seriously ill at the time – with an antibiotic. That was over 20 years ago and, thanks to the therapy, Sumatra is now a very elderly chimpanzee matron.

So chimpanzees are extremely sensitive to respiratory tract infections. The consequences for them could be dramatic if SARS-CoV-2 were to reach the chimpanzees in the Tai National Park. If a vaccine was available, Wittig would probably inoculate at least those of them that have become accustomed to the researchers. “For the chimpanzees of Tai National Park, it’s purely a matter of survival: of the 3000 animals alive in 2000, just 300 are still alive today. We have a moral duty to protect the chimpanzees from an epidemic that we ourselves triggered.”

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