PREDICT
CAMEROON

One Health in action (2009-2020)

Using a One Health approach to strengthen disease surveillance to prevent zoonotic threats.

CAMEROON

Locally known as "Africa in miniature," Cameroon contains great ecological and cultural diversity. As Cameroon experiences rapid population growth, extractive industries such as mining and hydroelectric power are cutting into rainforests that are home to some of the world's largest populations of gorillas, chimps, and other apes. As industry and agricultural expansion into the forest continue to bring humans and animals into closer proximity, the risk of zoonotic disease emergence intensifies.

Using a One Health approach, the PREDICT team safely conducted human and animal biological sampling and human behavioral research to identify and characterize risk factors associated with zoonotic disease spillover. The team concurrently sampled non-human primates, bats, rodents and humans in selected villages and towns primarily in Southern Cameroon to explore the transmission dynamics of zoonotic pathogens within village communities and rural hospitals, and bushmeat markets to develop a deeper understanding of the behaviors, beliefs, and practices among people engaged in the bushmeat trade alongside active surveillance for zoonotic pathogens.

Through analysis of project data and findings, the PREDICT team was able to identify risks and educate communities and health professionals on behavior change and intervention strategies designed to protect people and wildlife from disease threats.

During the course of the PREDICT project, Cameroon experienced several disease outbreaks, including Yellow Fever and Monkeypox, and when requested by the government of Cameroon, we assisted with field outbreak investigations. In addition, the team played a key role in activities under the Global Health Security Agenda, including assisting with evaluation of the country's strengths, gaps, and priority actions for enhancing national health security; prioritization of zoonoses of public health concern in Cameroon; and development of a national One Health policy.

IMPLEMENTING PARTNERS

- Ape Action Africa
- Centre Pasteur Cameroon
- Food and Agriculture Organization
- Metabiota Cameroon
- Ministry of Livestock, Fisheries and Animal Production
- Ministry of Forestry and Wildlife
- National Public Health Laboratory/Ministry of Public Health
- Ministry of Environmental Protection and Sustainable Development
- Ministry of Scientific Research and Innovation
- Ministry of Defense/Military Health Research Center
- Mosaic
- National Program for the Control and Fight Against

Emerging and Re-emerging Zoonoses
- National Veterinary Laboratory of Cameroon
- One Health Workforce
- Preparedness Response
- University of Douala and the University of Maroua researchers
- United States Centers for Disease Control and Prevention

>200

DEVELOPED the One Health Workforce by training more than 200 people in Cameroon.

>16.2K

OPERATIONALIZED One Health surveillance and sampled over 16.2K animals and people, to identify ways to help minimize the spillover of zoonotic disease threats from animals into human populations.

LABORATORY STRENGTHENING

· Military Health Research Center

56,601
TESTS

118 PREDICT   **25** KNOWN
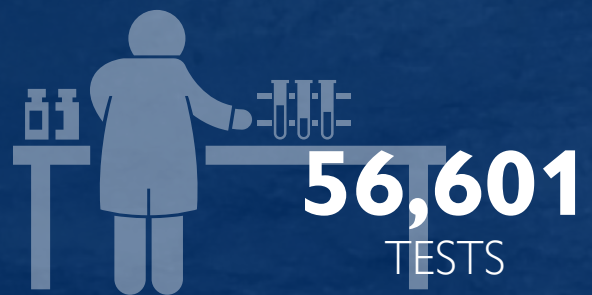
DETECTED 143 unique viruses in both animal and human populations.

Global Health Security Agenda

MOHAMED MOCTAR MOUCHIE MOULIOM

Country Coordinator
Mosaic

"PREDICT has effectively contributed to Cameroon's increased capacities for zoonotic disease surveillance and the detection of priority zoonotic diseases and unknown threats. The opportunity to work with specialists from various professional backgrounds and to share their experience has helped me to build my own capacity in the One Health approach and project management more efficiently than ever before."

VICTORINE MAPTUE TOGEUM

Human Clinical & Behavioral
Research Coordinator
Metabiota

"The position I held in the PREDICT project has truly boosted my professional career. Indeed, the research carried out within the framework of this project enjoys great visibility and will be cited most often. This has helped increase my notoriety within the national and international scientific community. The Cameroonian government can turn the results of this research into concrete measures that build capacity in the health field."

ACHIEVEMENTS

- Through the PREDICT project's influence, Cameroon now has a growing team of experts at various levels of government and has formed the National Program for the Control and Fight Against Emerging and Re-emerging Zoonoses, partnering with many local institutions trained to assist in investigations of zoonotic disease outbreaks.

- The PREDICT team contributed to building the national One Health viral disease detection network for new and known zoonotic viruses at the Military Health Research Center (CRESAR) in Yaoundé, providing training opportunities to laboratory scientists and enhancing country capacity for disease detection.

- The PREDICT project worked with the Directorate of Veterinary Services of the Ministry of Livestock (MINEPIA) to develop training materials for zoonotic disease surveillance in wildlife for Ministry of Wildlife staff (eco-guards). These trainings were held during three national training sessions which cover twenty protected areas in Cameroon. This newly-constituted network aims to implement a wildlife event-based surveillance system to collect weekly health information on disease cases and mortality in protected areas.

ONE HEALTH SURVEILLANCE

Through effective partnerships across animal and human health sectors and successful stakeholder engagement at national, regional, and local levels, the PREDICT project used the One Health approach for zoonotic disease surveillance. Increased bushmeat trade, combined with intensifying animal production and landscape changes due to activities such as hydroelectric dams and industrial rubber plantations, makes southern Cameroon a hotspot for high-risk interfaces between animals and humans. By integrating human biological surveillance and behavioral risk investigations with wildlife surveillance, focused in areas of increasing animal-human contact, the PREDICT team helped Cameroon to improve their capacity for disease detection, prevention, and response.

We conducted surveillance in two rural towns and at a bushmeat market, all located within the Dja et Lobo Division. These 3 areas in the South Region of Cameroon are located near the Dja Faunal Reserve, which is a UNESCO World Heritage Site with great biodiversity and is home to endangered species such as western lowland gorillas, chimpanzees, leopards, forest elephants, giant pangolins, bongo antelopes, and buffalos. Local populations hold traditional hunting rights around the Dja reserve, but over the past years, rubber projects implemented by foreign investors have converted 10,000 hectares of forest into rubber plantations (Corrie MacColl Cameroon Plantations), resulting in major social and environmental impacts. Rapid forest encroachment and land use change has been shown to lead to the emergence of infectious disease in wildlife (Daszak et al., 2001), and animals increasingly come into the villages to forage for food, exposing them to human populations.

We were particularly interested in enrolling people who exhibited symptoms that could be suggestive of exposure to viruses (such as influenza-like illness, severe acute respiratory infection, encephalitis, non-trauma related hemorrhage, or acute diarrhea), and especially those cases for which no other diagnosis could be made. Surveillance occurred at hospitals, communities, and wildlife markets. Biological sampling and syndromic surveillance of febrile patients occurred at two hospitals (one in each of the rural towns). In these rural areas the primary source of hunted wildlife comes from the surrounding forests, thus wildlife hunters, transporters, sellers, and butchers were targeted for and enrolled in community-based surveillance. Individuals from crossroad markets, like the bushmeat market in a rural Dja et Lobo Division town where animals and meat (cooked or raw) are sold to the local public, were also enrolled in community-based surveillance. The people working in the animal value chain were interviewed about their wildlife interactions, and biological samples were also safely collected from animals they handle and work with, in order to determine the level of risk these practices might present.
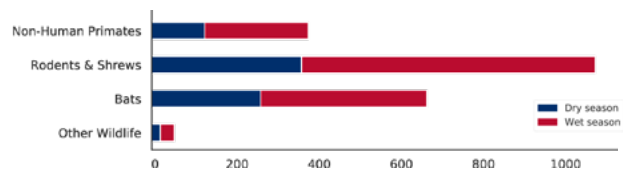
Numbers of individuals sampled by taxa group in the town of Sangmelima and a bushmeat market in Dja et Lobo Division
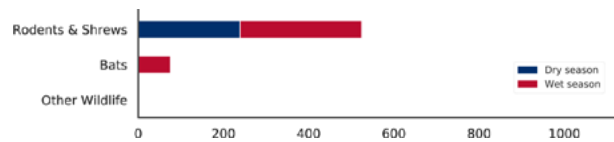
Numbers of individuals sampled by taxa group at a rural town in Dja et Lobo Division

PARTICIPANT CHARACTERISTICS ACROSS HOSPITAL & SURVEILLANCE SITES

	COMMUNITY-BASED SURVEILLANCE	CLINIC-BASED SURVEILLANCE	
SITES	Sangmelima (n=215)	Sangmelima (n=218)	Town in Dja et Lobo Division (n=218)
GENDER (FEMALE)	67 (31%)	109 (50%)	108 (49%)
GENDER (MALE)	148 (69%)	109 (50%)	110 (51%)
CHILD (<18)*	7#	10 (2-17)	5 (2-17)
ADULT (≥18)*	44 (20-86)	38 (18-78)	37 (18-90)

*Average (range)
#Sample size of 1

HIGHLIGHTS & FINDINGS FROM THE PREDICT PROJECT IN CAMEROON

- Confirmation of a Monkeypox virus infection in primates as part of an outbreak response in a primate sanctuary, which was an important demonstration of ministerial, military, and CDC collaboration in Cameroon

- Detection of different bat coronaviruses, as well as several bat strains of coronavirus 229E, a virus previously detected in bats and related to the human strains

- Identification of rodent and bat adenoviruses thus shedding light into the diversity, evolution and transmission of members of this virus family

- Detection of herpesviruses in primates and rodents, expanding our knowledge about herpesvirus hosts and distribution.

One particularly important feature of the PREDICT project in Cameroon is that we worked closely with ministerial partners at every phase of surveillance, from sample collection to laboratory analysis. The in-country PREDICT lab partner was the Cameroonian Military Health Research Center (CRESAR), the military health research lab that hosted the PREDICT team and supported the detection and identification of viruses.

VIRUS DETECTION

The PREDICT project was designed to not only detect those viruses which are known to cause human disease, but also related viruses that have yet to be discovered. By using specially designed primers during consensus PCR assays, the team was able to detect both known and new viruses. During PREDICT-1 (2009-2014), 20 viral families were included in testing. In PREDICT-2 (2015-2019), we prioritized viral families to focus on coronaviruses, filoviruses, paramyxoviruses, flaviviruses, and influenza viruses, results of which are reported in the virus table below.

There has been a tremendous amount of work done through the PREDICT project in Cameroon, including 4,220 animals sampled, 651 humans sampled and interviewed, and over 56,000 tests performed in the last 5 years. Through PREDICT-1 and PREDICT-2, 143 viruses were detected, and an enormous amount of associated metadata was collected. By carefully combing through and analysing this data, the team made a number of highly impactful discoveries, to be shared with the public.

VIRUS FINDINGS IN PEOPLE

While Dengue fever is a well-documented and highly studied disease in places like South East Asia, it is relatively overlooked in many parts of Africa, including Cameroon, where little is known about the prevalence of the disease. Our work led to the detection of the virus in two individuals from the South Region of the country who were infected with Dengue virus (serotype 1), and who were also co-infected with malaria. Because Dengue fever was not identified by the local hospital from which these people were enrolled, this finding indicates that Dengue fever may be an underdiagnosed condition in Cameroon and supports the need to increase surveillance and treatment options for this flavivirus-caused condition in the area.

Additionally, hospital syndromic surveillance detected eight individuals with influenza A, two with paramyxoviruses, and one with a coronavirus. The paramyxoviruses were previously known viruses belonging to the Parainfluenza virus 2 and Parainfluenza virus 3 lineages, which are both relatively common causes of lower respiratory tract infections in humans. Interestingly, the Parainfluenza virus 3 is genetically very similar to a virus that other studies have also found in non-human primates. This positive individual was an infant enrolled from a hospital, whose parents reported that the child had no contact with non-human primates.

VIRUS FINDINGS IN WILDLIFE

During PREDICT-1, the project's work in Cameroon significantly increased the knowledge on the diversity of adenoviruses in bats in the region and has suggested new ways of understanding how these viruses evolve through factors in both the host and the viruses themselves, which may also be relevant to other viruses outside the Adenoviridae family. We also detected an adenovirus discovered in a Moustached Monkey (*Cercopithecus cephus*) that was more related to human adenoviruses than to other non-human primate varieties, perhaps suggesting the potential for increased risk of human infection by viruses from this primate lineage. Surveillance in rodents that were captured from nearby human settlements also found 14 new species of adenoviruses that were previously unknown to science.

VIRUS TABLE (2015-2019)

VIRAL FAMILY	VIRUS	SPECIES	SAMPLING LOCATION	# OF POSITIVE INDIVIDUALS		
				TOTAL	WET SEASON	DRY SEASON
Coronavirus	Betacoronavirus 1 (OC43)	Human	Hospital (Dja et Lobo Division)	1	0	1
	PREDICT_CoV-30	Woermann's Fruit Bat	Ebolowa, Sangmelima	2	2	0
	PREDICT_CoV-35	Franquet's Epauletted Fruit Bat, Nut-Colored Yellow Bat	Nybissan, Sangmelima	2	2	0
	PREDICT_CoV-44	Noack's Roundleaf Bat	Sangmelima	11	5	6
	PREDICT_CoV-54	Giant Roundleaf Bat, Commerson's Roundleaf Bat	Sangmelima	15	5	10
	PREDICT_CoV-66	Little Collared Fruit Bat	Ebolowa	1	1	0
	PREDICT_CoV-70	Halcyon Horseshoe Bat	Sangmelima	1	1	0
	PREDICT_CoV-81	Noack's Roundleaf Bat, Sooty Roundleaf Bat	Sangmelima	19	15	4
	PREDICT_CoV-97	Egyptian Fruit Bat	Sangmelima	1	1	0
	PREDICT_CoV-109	Halcyon Horseshoe Bat	Sangmelima	1	1	0
	Bat coronavirus Hipposideros	Noack's Roundleaf Bat	Sangmelima	2	1	1
	Bat coronavirus HKU9	Egyptian Fruit Bat	Sangmelima	4	4	0
	Coronavirus 229E (Bat strain)	Noack's Roundleaf Bat, Short-Tailed Roundleaf Bat, Unidentified Hipposideros Bat	Ebolowa, Sangmelima	39	33	6
	Eidolon bat coronavirus	Straw-Coloured Fruit Bat	Maroua	1	1	0
	Kenya bat coronavirus/ BtKY83/59/58	Halcyon Horseshoe Bat	Sangmelima	1	1	0
	Zaria bat coronavirus	Giant Roundleaf Bat	Sangmelima	7	5	2
	PREDICT_CoV-98	Goliath Shrew	Sangmelima	1	1	0
	PREDICT_CoV-75	African Palm Civet	Ebolowa	1	1	0
Paramyxovirus	Human parainfluenzavirus 2	Human	Hospital (Dja et Lobo Division)	1	0	1
	Human parainfluenzavirus 3	Human	Hospital (Dja et Lobo Division)	1	0	1
	PREDICT_PMV-79	Noack's Roundleaf Bat, Unidentified Hipposideros Bat	Ebolowa	2	2	0
	PREDICT_PMV-80	Giant Roundleaf Bat	Town in Dja et Lobo Division, Sangmelima	2	1	1
	PREDICT_PMV-82	Giant Roundleaf Bat	Town in Dja et Lobo Division	1	1	0
	PREDICT_PMV-97	Noack's Roundleaf Bat	Ebolowa	1	1	0
	PREDICT_PMV-127	Noack's Roundleaf Bat	Sangmelima	1	0	1
	PREDICT_PMV-133	Noack's Roundleaf Bat	Sangmelima	1	1	0
	PREDICT_PMV-138	Noack's Roundleaf Bat	Sangmelima	2	2	0
	PREDICT_PMV-139	Short-Tailed Roundleaf Bat	Sangmelima	2	2	0
	PREDICT_PMV-147	Noack's Roundleaf Bat	Sangmelima	1	1	0
	PREDICT_PMV-152	Noack's Roundleaf Bat	Sangmelima	1	1	0
	PREDICT_PMV-161	Noack's Roundleaf Bat	Sangmelima	1	1	0
	PREDICT_PMV-163	Noack's Roundleaf Bat	Sangmelima	1	1	0
	PREDICT_PMV-91	Unidentified Crocidura Shrew	Sangmelima	1	1	0
	PREDICT_PMV-101	Unidentified Crocidura Shrew	Town in Dja et Lobo Division, Sangmelima	3	1	2
	PREDICT_PMV-131	Jackson's Soft-Furred Mouse	Town in Dja et Lobo Division	1	1	0
	PREDICT_PMV-148	Fire-Bellied Brush-Furred Rat, Goliath Shrew, Misonne's Soft-Furred Mouse	Town in Dja et Lobo Division, Sangmelima	3	3	0
	PREDICT_PMV-156	Goliath Shrew	Sangmelima	1	1	0
	PREDICT_PMV-160	Fire-Bellied Brush-Furred Rat	Town in Dja et Lobo Division	1	1	0
Influenza virus	Influenza A	Human	Hospital (Dja et Lobo Division), Sangmelima Hospital	5	2	3
	Influenza B	Human	Hospital (Dja et Lobo Division)	3	3	0
Flavivirus	Dengue virus serotype 1	Human	Hospital (Dja et Lobo Division), Sangmelima Hospital	2	2	0
Poxvirus	Monkey pox	Chimpanzee, Environmental Sample	Mefou	4	4	0
Total				**152**	**113**	**39**

EPIDEMIOLOGICAL & BEHAVIORAL RISK

The PREDICT team conducted behavioral risk characterization in three sites across southern Cameroon, Dja et Lobo Division. Through this work, the team identified risk behaviors that may be associated with zoonotic disease transmission and communicated findings to participating communities to improve awareness of potential disease threats and opportunities for prevention and control.

The team regularly conducted community-based risk communication sessions with groups in frequent contact with wild animals – specifically bushmeat hunters, transporters, and sellers – and therefore were at higher risk for zoonotic disease. These sessions included discussions on zoonotic disease infection risks and potential risk mitigation strategies. The PREDICT team advised the bushmeat trade community to avoid handling or butchering fresh meat if their hands are cut or scratched, to always have soap and water nearby to wash immediately in case they are cut during butchering, to avoid contact with wildlife bodily fluids (using impermeable plastic to wrap meat during transport), to avoid contact with dead animals found in the forest, and to keep wildlife carcasses or bushmeat out of reach of children.

BEHAVIORAL TRENDS AND LONGITUDINAL ANALYSIS OF BUSHMEAT MARKET SPECIES & PRICES

Bushmeat markets are an area of concern when considering the possibility of zoonotic viruses making the leap from wild animals into humans. Understanding which animals are associated with zoonotic disease spillover and spread, which species are present at local markets, and the economic factors that perpetuate their sales, is critical to alleviating this risk. At 2 bushmeat

IN-DEPTH ETHNOGRAPHIC INTERVIEWS & FOCUS GROUPS REVEALED:

- Some market workers and hunters interviewed said that bushmeat doesn't transmit illness to people, and that transmission of disease cannot occur between animals and humans.

- Some market workers and butchers say that working with wild animals is not risky. Many believe that the only risk is of cutting oneself, not due to blood-blood contact between animals and humans, but because the wound may get infected if not treated properly.

- Most vendors perform wound care when they cut themselves. Some report stopping bleeding by putting salt or lemon on the wound and others use alcohol and bandages.

- Most market workers and hunters do not consider PPE important. Several mention that gloves are not a feasible protective measure, as "hospital-style gloves are too thin to protect against anything, and larger gloves used for heavier tasks are too cumbersome for the work we do."

- According to a restaurant worker, people in Sangmelima do not hunt or consume bats, as their physical appearance is off-putting to many, with a few individuals explaining that they are too ugly to eat.

- Participants noted they received health advice from the Ministry of Health via telecom companies sending SMS text messages, via the Ministry of Health. Those interviewed see SMS texts as a positive intervention, with helpful messages and good health advice. This medium for behavioral change communication would be an effective strategy to continue and expand in Cameroon.

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market sites, the team recorded sales of nearly 40 different species of wild animals, many of which are protected species that are illegal to hunt or to sell, and several of which are endangered due to their low remaining population sizes in the wild and frequent involvement in illegal trafficking. Prices ranged widely for different species, and the demand for the wild meat was high.

Through interviews and questionnaires, we learned that peoples' involvement in the bushmeat value chain was much more intense in some areas of Cameroon than others, and that the hunting and butchering of certain species of animals – like non-human primates and rodents – is much more common than others, such as bats. We also found that men and older individuals are up to 7 times more likely to hunt for these animals than young women, and also that older individuals considered these activities to be riskier than young hunters did. This information helps to target risk communication discussions to those groups where impacts will be highest. By engaging vendors and community members in group discussions about the risk of contracting diseases from wild animals, and ways to keep themselves healthy, the team is encouraging safe behaviors and alternatives to bushmeat to lower the overall risk of disease emergence.

These sessions also included behavioral change intervention sessions whereby the team conducted a guided activity designed to help people understand the risk of interaction with bats, reviewing images in the *Living Safely with Bats* book, a resource developed by the PREDICT project. The community asked questions and the team made recommendations for living more safely with bats and other animals that they interact with regularly.

STRENGTHENING CAPACITY

Following the 2017 WHO Joint External Evaluation, which found that Cameroon was lacking in wildlife disease surveillance capacity, the PREDICT team and the Food and Agriculture Organization (FAO) took action to bolster this capacity by jointly conducting three training sessions for 75 staff from the Ministries of Wildlife and Livestock. Further, the One Health Focal Point from the Ministry of Forests and Wildlife joined the PREDICT team to train 20 game rangers from protected areas around the country.

The PREDICT project helped to strengthen the workforce by training 85 veterinary students on zoonotic disease surveillance at two national veterinary schools. To preserve the initiatives created by USAID in Cameroon over the past 10 years, the PREDICT project participated in curriculum development for a Master of Science degree in Wildlife Health, with intake to begin in 2020 at the University of Buea. This program will be the product of a collaboration between OHCEA-Cameroon, Cameroon's Ministries of Higher Education (MINESUP), Forests & Wildlife (MINFOF), Livestock, Fisheries & Animal Industries (MINEPIA), University of Minnesota, Tufts University, FAO-ECTAD, USAID Preparedness & Response, and the PREDICT project in Cameroon.

OUTBREAK PREPAREDNESS & RESPONSE

The PREDICT project strengthened Cameroon's ability to investigate zoonotic disease outbreaks by providing on-the-job training to a vast number of people who engage in outbreak response activities. Government technical staff from the Ministry of Livestock, Fisheries and Animal Industries and the Ministry of Forestry and Wildlife who received training and hands-on experience with the PREDICT team in animal capture, safe handling, and sample collection techniques were on the front lines during a monkeypox outbreak in chimpanzees at Mfou Sanctuary in August 2016. The PREDICT team also provided support to the Military Health Research Center (CRESAR) and the National Veterinary Laboratory (LANAVET) to undertake diagnostic assays using PREDICT testing protocols to assist in the rapid identification of the monkeypox virus. We also assisted in the investigation of various wildlife die off events in bats and gorillas, including confirmation of an influenza outbreak where H5N1 influenza A was identified at a poultry farm in Yaounde in 2016, followed by donating 100 pairs of disposable coveralls and 1,000 N95 masks to the Ministry of Livestock, Fisheries & Animal Industries for the response.

PRACTICAL IMPLICATIONS

The PREDICT project's work in Cameroon has been pivotal in moving the One Health platform from theory to practice. The project brought into focus the importance of zoonotic disease spillover in the Congo Basin, one of the hotspot regions of infectious disease emergence. With its emphasis on increasing capacity expansion, the project has reinforced human and animal health preparedness and response capabilities in the country, and have led One Health trainings for professionals across Cameroon and the region.

The project provided technical trainings for dozens of government workers, health and medical staff, veterinary and wildlife workers, and to students who will become the next leaders in global health. In addition to the core PREDICT project activities of continued disease surveillance in both animals and humans, the Cameroon team has, for nearly a decade, also performed vital services such as assisting with disease outbreak investigations, created opportunities for learning and awareness about zoonoses in bushmeat markets and with wildlife hunters, and have also spread the knowledge gained by this program across the world through both peer reviewed publications and by presentations at international conferences.

Over the past 10 years, the project has had important impacts in Cameroon, in terms of viral discovery, establishing stronger partnerships across Ministries, and through in-depth research in markets and hunting communities on behavioral risks to which communities are exposed in the light of the animal interfaces with which they regularly interact. In its efforts to promote strong and integrated global health security, the PREDICT project has made a clear impact and has supported Cameroon in advancing its capabilities in zoonotic emerging infectious disease detection and surveillance. The seeds have been planted and Cameroon will continue to grow from the strong roots that USAID has helped nurture through the PREDICT project.

REFERENCE

•   Daszak, P., A.A. Cunningham, and A.D. Hyatt. 2001. Anthropogenic environmental change and the emergence of infectious diseases in wildlife. Acta Tropica 78: 103-116. DOI: 10.1016/s0001-706x(00)00179-0

For more information
view the interactive report at
p2.predict.global

SPECIAL FEATURE

Bats & People: What's the Risk in Cameroon?

To gain a more detailed understanding of the ways in which people in Cameroon interact with bats, which are known to carry many zoonotic pathogens, the PREDICT team travelled to distant locations to visit caves and forests where locals and tourists can be found mingling with bat populations.

Read more about this study at **bit.ly/2wdmLed**