Forecasting future infectious disease outbreaks

May 18 2015

Flying squirrels are a known reservoir for anaplasmosis and one the 50+ hyper-reservoir species predicted to carry additional pathogens infectious to humans. Credit: Holly B. Vuong, Cary Institute of Ecosystem Studies/Rutgers University

Machine learning can pinpoint rodent species that harbor diseases andgeographic hotspots vulnerable to new parasites and pathogens. So reportsa new study in the *Proceedings of the National Academy of Sciences* led by Barbara A. Han, a disease ecologist at the Cary Institute of EcosystemStudies..

Most emerging infectious diseases are transmitted from animals to humans, with more than a billion people suffering annually. Safeguarding public health requires effective surveillance tools.

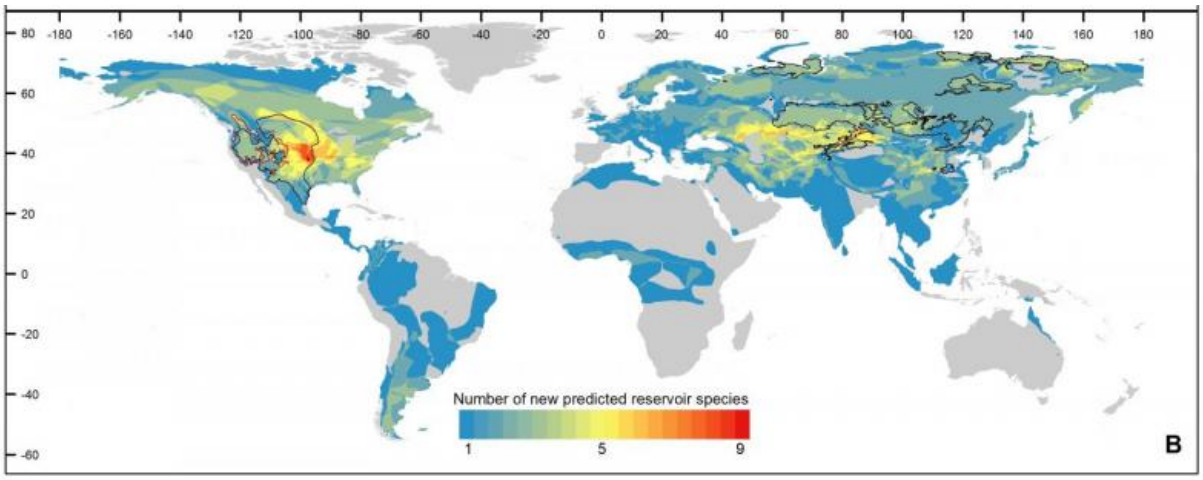
Han comments: "Historically, emerging infectious diseases have been dealtwith reactively, with efforts focused on containing outbreaks afterthey've spread. We were interested in how machine learning could informearly warning surveillance by revealing the distribution of rodent speciesthat are effective disease reservoirs."

With University of Georgia Odum School of Ecology colleagues John Paul Schmidt, Sarah E. Bowden, and John M. Drake, Han employed machine learning, a form of artificial intelligence, to reveal patterns in an extensive set of data on more than 2,000 rodent species, with variables describing species' life history, ecology, behavior, physiology, and geographic distribution.

The team developed a model that was able to predict known rodent reservoir species with 90% accuracy, and identified particular traits that

distinguish reservoirs from non-reservoirs. They revealed over 150 new potential rodent reservoir species and more than 50 new hyper-reservoirs - animals that may carry multiple pathogens infectious to humans.

"This study shows the value of bringing new analysis techniques together with big data," commented study co-author John Drake. "By combining ecological and biomedical data into a common database, Barbara was able to use machine learning to find patterns that can inform an early warning system for rodent-borne disease outbreaks."



A majority of new reservoir and hyper-reservoir rodent species are predicted to occur in the upper latitudes. Credit: Han et al.

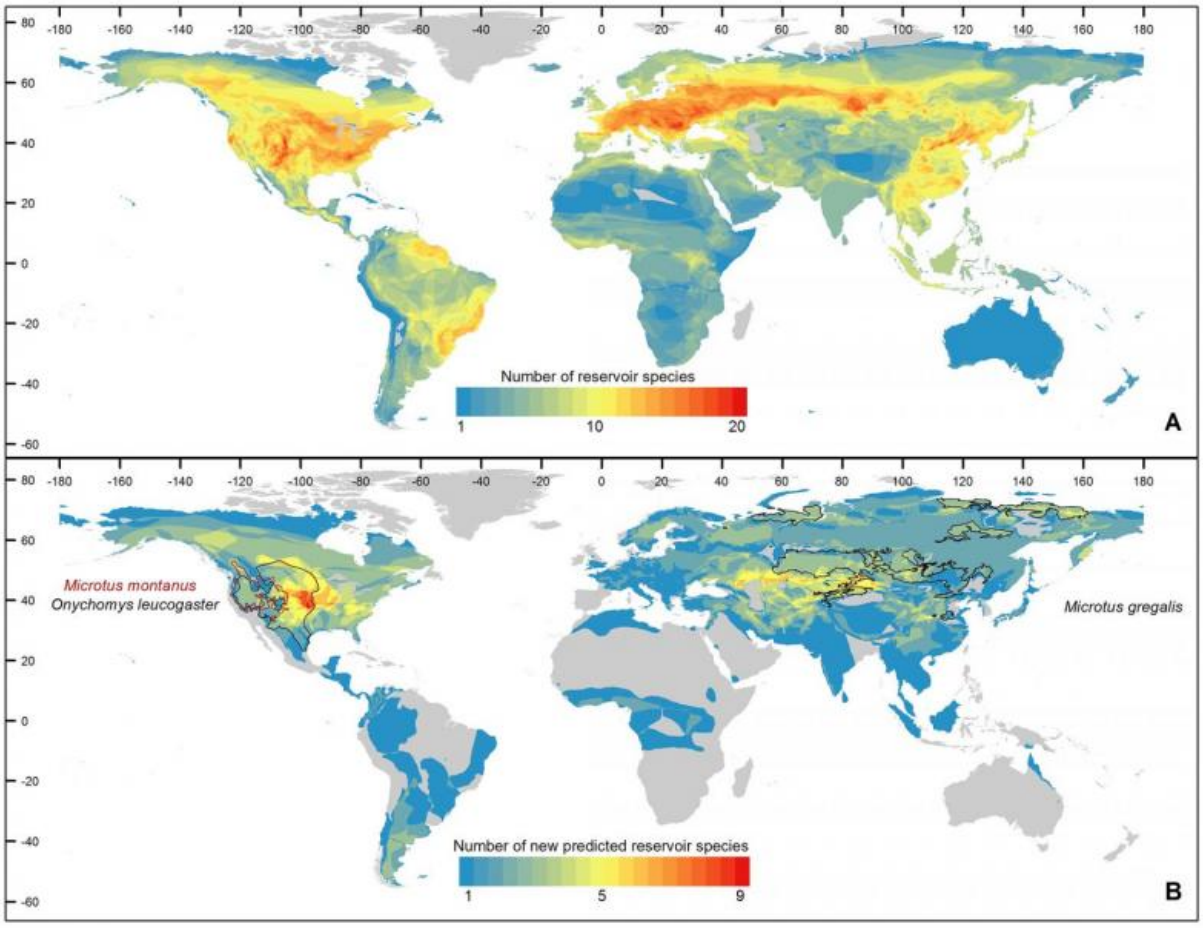
With Han explaining, "Results equip us with a watch list of high-risk rodent species whose intrinsic traits make them effective at carrying infections transmissible to people. Such a list is increasingly important given accelerating rates of environmental change."

Among the take home messages: rodents are not created equal in their

ability to transmit disease. The riskiest reservoir species are those that mature quickly, reproduce early and often, and live northern temperate areas with low levels of biodiversity. The paper adds to the growing body of knowledge that 'pace of life' affects infection tolerance in animals.

"Biologically-speaking, species that bear as many offspring as possible in a shorter period of time may tend to invest fewer resources in immune response compared to slower-living animals. This could make certain rodent species more effective disease reservoirs," notes Han.

Geographic areas found to have a high diversity of rodent reservoirs included North America, the Atlantic coast of South America, Europe, Russia, and parts of Central and East Asia. Predicted future hotspots of rodent reservoir diversity spanned arctic, temperate, tropical, and desert biomes, including China, Kazakhstan, and the Midwestern United States. A majority of new reservoir and hyper-reservoir species are predicted to occur in the upper latitudes.



A map shows the global hot spots of rodent reservoir diversity (A) and 150 novel reservoir species predicted by the models to be in the 90th percentile probability of harboring one or more undiscovered zoonoses (B). In both panels A and B, warmer colors are the overlapping geographical ranges of multiple species. Panel B also outlines (black and maroon) the geographic ranges of three species with the highest probability (about 70 percent) of being undiscovered zoonotic reservoirs. Credit: University of Georgia

"It was surprising to find more emerging rodent-borne diseases predicted for temperate zones than the tropics—given assumptions that the tropics are where new diseases originate," Drake commented. "This result shows how data-driven discovery can correct such stereotypes."

Findings provide a basis for targeted surveillance efforts, which are vital given the cost of monitoring for emerging infectious diseases. Han notes, "Turning our predictions into preventative measures will require collaboration with experts on the ground. It's where the real work begins. A start would be to look at the newly predicted rodent reservoirs and assess which have increasing contact with people through activities like urbanization, agricultural and hunting practices, and displacement from political or climate instability."

More information: Rodent reservoirs of future zoonotic diseases, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1501598112

Provided by Cary Institute of Ecosystem Studies