Humans' new best friend

The domestic cat may be our means to understand the complexity of genetics

The mother, the surrogate mother and the kitten, born of cloning, in 2001

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While the dog has traditionally been given first place, the horse and elephant have also been considered important. And in science and medical research, the mouse and Guinea pig have held sway.

Leslie A Lyons, from the University of Missouri, however, presents the case of the domestic cat. In an article in the journal, *Trends in Genetics*, Lyons explains that the cat, apart from having been part of human households since ancient times, is genetically close to us and a convenient proxy to help discover remedies for human ailments.

The role of the cat in control of vermin is legendary. It forms part of the folk tales of all communities, and in Egypt, the cat enjoyed nearly divine status. That is perhaps because the cat has all the traits of its more fearsome relatives — tigers, lions, cheetahs, leopards and panthers — but has integrated with humans ever since we stopped being hunter-gatherers and became farmers. And in the United States, the article says, a third of households have a pet cat.

The result is that the physiology of the cat is well understood and certainly more deeply studied than that of other domestic animals, "...whether the cat is one of the 10 per cent representing a fancy breed or the 90 per cent representing a randomly bred alley cat," the article says. It refers to the database of the "99 Lives Cat Genome Sequencing Consortium" — a collaborative effort coordinated by the Lyons Feline Genetics Laboratory at the University of Missouri — and how complete genetic information is now available for tracking down a host of genetic diseases that affect cats.

And how should this be of interest to humans? For starters, the article says, it was feline leukaemia that showed us the way to understand how cancer develops, and more recently, the Covid-19 drug, remdesivir, was first used to cure peritonitis, a coronavirus-induced fatal disease of cats.

Cat genetics has been of interest since the time of Charles Darwin and it has helped decode several genetic puzzles, the article says. One learning being the complexity of genetic pathways and the understanding that all the over 20,000 genes that we have are interrelated. Over 98 per cent of the animal genome, the article says, fall in the "dark matter" zone, of genes that do not code for proteins. And of that, some 10 per cent are "conserved" or remain essentially unchanged, over all species and course of evolution. The suggestion is that this conserved portion has a role in regulating how the protein-coding part of the genome acts, leading to the variations of function, biology and physiology, and behaviour and temperament; and interspecies evolution and the characteristics of species and their diseases.

In the case of cats, the article says, chromosomes, or the strands of genetic material, are easily told apart, for analysis using tools of genetic engineering. And the genome of the cat is found to have more collections of genes that are usually inherited together, in common with the human genome, than is the case of other mammals like mice, rats, dogs or pigs, the article says.

The genetic information for the domestic cat, and some other greater cats, is now fully available. And there have been studies of the results of extensive cross breeding, which is feasible between lines of felines. The data thus covers the chromosomes from end to end, and the animal from "nose to tail", the article says.

"Thus, genome-edited cats are feasible, allowing the production of a large animal biomedical model for disease studies, understanding basic biology and physiology, and providing an alternative for long-term model therapeutic trials. New genomic technologies are allowing cats to develop new avenues for understanding evolution, domestication, and adaptation. Feline genomics holds great potential and promise for advancing human medicine and mammalian biology," the article says.

The article refers to "Copy Cat", or "Cc", the first cloned cat that was created in 2001. The cell donor had black, orange and white fur, but the kitten did not have any orange fur. This ran against Mendel's laws and basic genetics; and was an indicator that there was more to heredity and genetics than we were aware of.

Speaking of the colouration of cat coats, there is a paper this week in the journal, *Nature Communications*, where Christopher B Kaelin, Kelly A McGowan and Gregory S Barsh, from Hudson Alpha Institute for Biotechnology, Alabama, Stanford University, go into the mechanics of how the fur patterns of cats come to be. The question studied, in fact, is wider, of how the cheetah gets its spots and the tiger its stripes (or how the cow's coat has black and white patches, or even the patterns on the squirrel).

The work, however, was carried out on the cat, thanks to ample experimental data and material available through "trap-neuter-return", a programme to control the population of free-roaming cats. And also, data from the "99 Lives Cat Genome Sequencing Consortium".

The question of patterns, or form, in biological organisms was first studied by computer scientist and mathematician Alan Turing, who developed a theory of "reaction and diffusion", where waves of chemical agents could generate patterns of form. Further work led to identifying genetic factors that suppress or promote the production of pigments by cells. The current work, reported in *Nature Communications*, deals with the details of how specific hair cells acquire the message of what colour of hair they would produce.

The team examined non-viable cat embryos, which became available through the "trap-neuter-return" programme. They found that expression of particular genes comes before formation of the skin and it appears as strip-like variations of skin thickness. A particular protein that regulates the process has been discovered, and it is found to have a slightly different form in different lines of cats. And the mechanism may be the same one in the case of other mammals.

The domestic cat, so far regarded only as a catcher of mice and one who purrs and preens, may be our means to understand the complexity of genetics, which lies behind how organisms function in health and sickness.

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CATASTROPHIC FEEDING

The invasive emerald ash borer has destroyed millions of trees, but scientists are aiming to control it with tiny parasitic wasps

KRISTINE GRAYSON

The emerald ash borer (*Agrilus planipennis*) is a deceptively attractive metallic-green adult beetle with a red abdomen. But few people ever actually see the insect itself — just the trail of destruction it leaves behind under the bark of ash trees.

These insects, which are native to Asia and Russia, were first discovered in Michigan in 2002. Since then they have spread to 35 states and become the most destructive and costly invasive wood-boring insect in United States history. They have also been detected in the Canadian provinces of Ontario, Quebec, Manitoba, New Brunswick and Nova Scotia.

In 2021, the U S Department of Agriculture stopped regulating the movement of ash trees and wood products in infested areas because the beetles spread rapidly despite quarantine efforts. Now federal regulators and researchers are pursuing a different strategy: biological control. Scientists think that tiny parasitic wasps, which prey on emerald ash borers in their native range, hold the key to curbing this invasive species and returning ash trees to North American forests.

I study invasive forest insects and work with the USDA to develop easier ways of raising emerald ash borers and other invasive insects in research laboratories. This work is critical for discovering and testing ways to better manage forest recovery and prevent future outbreaks. But while the emerald ash borer has spread uncontrollably in nature, producing a consistent laboratory supply of these insects is surprisingly challenging — and developing an effective biological control programme requires a lot of target insects.

The value of ash trees

Researchers believe the emerald ash borer likely arrived in the U S on imported wood packaging material from Asia sometime in the 1990s. The insects lay eggs in the bark crevices of ash trees; when larvae hatch, they tunnel through the bark and feed on the inner layer of the tree. Their impact becomes apparent when the bark is peeled back, revealing dramatic feeding tracks. These channels damage the trees' vascular tissue — internal networks that transport water and nutrients — and ultimately kill the tree.

Before this invasive pest appeared on the scene, ash trees were particularly popular for residential developments, representing 20-40 per cent of planted trees in some Midwestern communities. Emerald ash borers have killed tens of millions of U S trees with an estimated replacement cost of $ (U S) 10-25 billion.

Ash wood is also popular for lumber used in furniture, sports equipment and paper, among many other products. The ash timber industry produces over 100 million board feet annually, valued at over $ 25 billion.

Why quarantines have failed

State and federal agencies have used quarantines to combat the spread of several invasive forest insects, including Asian longhorned beetles and *Lymantria dispar*, previously known as gypsy moth. This approach seeks to reduce the movement of eggs and young insects hidden in lumber, nursery plants and other wood products. In counties where an invasive species is detected, regulations typically require wood products to be heat-treated, stripped of bark, fumigated or chipped before they can be moved.

The federal emerald ash borer quarantine started with 13 counties in Michigan in 2003 and increased exponentially over time to cover than a quarter of the continental U S. Quarantines can be effective when forest insect pests mainly spread through movement of their eggs, hitchhiking long distances when humans transport wood.

Female emerald ash borers, however, can fly up to 12 miles per day for as long as six weeks after mating. The beetles also are difficult to trap, and typically are not detected until they have been present for three to five years — too late for quarantines to work.

Next option: Wasps

Any biocontrol plan poses concerns about unintended consequences. One notorious example is the introduction of cane toads in Australia in the 1930s to reduce beetles on sugarcane farms. The toads didn't eat the beetles, but they spread rapidly and ate lots of other species. And their toxins killed predators.

Introducing species for biocontrol is strictly regulated in the U S. It can take two to 10 years to demonstrate the effectiveness of potential biocontrol agents and obtaining a permit for field testing can take two more years. Scientists must demonstrate that the released species specialises on the target pest and has minimal impacts on other species. Four wasp species from China and Russia that are natural enemies of the emerald ash borer have gone through the approval process for field release. These wasps are parasitoids — they deposit their eggs or larvae into or on another insect, which becomes an unsuspecting food source for the growing parasite. Parasitoids are great candidates for biocontrol because they typically exploit a single host species.

The selected wasps are tiny and don't sting, but their egg-laying organs can penetrate ash tree bark. And they have specialised sensory abilities to find emerald ash borer larvae or eggs to serve as their hosts.

The USDA is working to rear massive numbers of parasitoid wasps in lab facilities by providing lab-grown emerald ash borers as hosts for their eggs. Despite Covid-19 disruptions, the agency produced over 550,000 parasitoids in 2020 and released them at over 240 sites.

The goal is to create self-sustaining field populations of parasitoids that reduce emerald ash borer populations in nature enough to allow replanted ash trees to grow and thrive. Several studies have shown encouraging early results but securing a future for ash trees will require more time and research.

One hurdle is that emerald ash borers grown in the lab need fresh ash logs and leaves to complete their life cycle. I'm part of a team working to develop an alternative to the time- and cost-intensive process of collecting logs -- an artificial diet that the beetle larvae can eat in the lab.

The food must provide the right texture and nutrition. Other leaf-feeding insects readily eat artificial diets made from wheat germ, but species whose larvae digest wood are pickier. In the wild, emerald ash borers only feed on species of ash tree. In today's global economy, with people and products moving rapidly around the world, it can be hard to find effective management options when invasive species become established over a large area. But lessons learned from the emerald ash borer will help researchers mobilise quickly when the next forest pest arrives.

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PLUS POINTS

Children's words

Listening to children about their needs and involving them more closely in decision-making could have improved global responses to the Covid-19 pandemic, according to an international survey.

People working with children — including teachers, care workers and community health workers — also cited lack of access, insufficient funding, school disruption and barriers to advocacy among the challenges they faced in supporting children, particularly those at high risk, during the pandemic.

More professionals, however, also reported positive outcomes prompted by the pandemic, including creative uses of technology, community liaison, raising awareness of children's risks and rights, and combining virus protection with psychosocial support.

The eight-week, real-time, daily survey received over 3,330 responses from 22 countries across five continents, including Canada, Kenya, India, the Philippines, Scotland, South Africa, Sweden, and the United States. The findings are captured in a series of planned reports from the United Kingdom-based University of Strathclyde's Institute for Inspiring Children's Futures, drawing on data from the Covid 4P Log (Protection, Provision, Participation, Prevention) for Children's Wellbeing, a smartphone app developed in close partnership with 17 organisations globally, for policymakers and practitioners in children's rights and wellbeing to anonymously share views and experiences of their work in the midst of the pandemic.

The Institute's executive director, professor Jennifer Davidson OBE, said, "This survey presents a mixed picture. It shows that people are still working flat out to help children during the pandemic and are being creative to achieve this but, despite everyone's efforts, underlying inequalities continue to exist that are seriously getting in the way.

"The survey suggests that the relationship and dynamic between governments and non-governmental organisations became quite different. It has often been NGOs and frontline workers who have been reaching families, while limited by the policies set by governments. In some places, the civic spaces people have, where they can say what they want, have shrunk, and people feel this could be undermining efforts on keeping people safe.

"These early findings indicate that children should be better listened to and involved in decision-making on the support they receive and that there's a need for increased support for — and good uses of technology in — services. There also needs to be sustained collaboration between governments and the third sector and a greater priority placed on children's rights, needs and protection in pandemic decision-making."

Simple solution

Researchers at the Indian Institute of Technology-Madras have developed an efficient technique for identification of pollution deposit levels in power transmission networks. The initial results have been published in the journal *IOP-Measurement Science and Technology* and the team is planning to approach the National Thermal Power Corporation Limited, Power Grid and other utilities to demonstrate the technology and its use in the real power system network.

The reliability of an electric power system largely depends on the performance of the electrical insulation. The outdoor insulation on transmission lines running over thousands of kilometres and the substation equipment, in addition to the electrical, thermal and mechanical stresses, are subjected to environmental pollution.

It would be simple and economical to measure the contents and thickness of pollution deposition remotely (non-invasively). An elegant solution based on laser induced breakdown spectroscopy, or Libs, has been developed by the research groups of professor R Sarathi, department of electrical engineering, IIT-Madras, and professor N J Vasa, department of engineering design, IIT-Madras.

The technology developed with Libs allows one to identify the composition and severity level of the pollution deposit just by shining the laser onto the insulator surface. In other words, no interruption of the power transmission is required nor the cumbersome process of climbing on to the tower. The technique is simple and reliable, which can provide accurate results within no time.