Bats stay in the lead

S ANANTHANARAYANAN

Echolocation by animals, like bats and dolphins, proves consistently better than artificial methods but their prey have developed unique defence mechanisms too

Locating objects by sending out sound waves, radio waves or even light waves, and watching for the reflection, is part of many technologies. The first reference of using sound for detection seems to be by Leonardo da Vinci, of a tube sent down in water, while one listened at the open end for sounds of enemy ships. There was also the use of an underwater bell, in addition to the lighthouse, to alert ships of dangers.

The use of sound waves for detection of underwater objects is now advanced, and so is the use of radio waves, in Radar. Sonar, whose development dates from the Titanic tragedy, is an essential part of navigation, and Radar is a vital part of aircraft operations, commercial and military. The quality of performance, however, is nothing to compare with what is found in the natural world, particularly in the case of bats and dolphins.

Laura Kloepper, assistant professor at St Mary's College in Notre Dame, Indiana described her study of the methods that the bat uses, in a presentation last week, at the annual meeting, in Victoria, Canada, of the Acoustical Society of America with the Canadian Acoustical Association. At the same event, Thomas Neil of the University of Bristol, UK, described how species of moth, the main food of bats, have adapted to evade their predators' ability to make things out in pitch darkness.

Bats navigate with the help of high pitched clicks that they generate with their larynx or tongues. With the help of echoes, which are received slightly apart by the two ears, the bat is able to create a three dimensional map of the surrounding space, just like we can with our eyes. As high pitched sound has short wavelength, fine detailing is possible. The bat, in fact, uses signals of different frequencies -- lower frequencies where the signal needs to travel a longer distance and high frequencies, as high as 200,000 cycles a second, when there is need for details. The flying bat, at high speed, is able to navigate through a labyrinth of obstacles and locate and capture fleeing, mite-sized prey.

Another animal well known for echolocation is the dolphin. The dolphin uses an almost identical method, emitting clicks and squeaks, with an organ to pick up the echoes. While the dolphin uses sound not just for navigation but also for communication, the detection and navigating ability is still adapted well enough to make out pebble-sized objects and tell the different texture of rock, metal or animal tissue.

Impressive as the capability is, a further mystery is how the bat and dolphin are able to do all this even when flying or swimming in groups. In thick swarms of bats, or a school of dolphins, each of hundreds, even thousands, of other animals is navigating and foraging with its own staccato of clicks. How each one is able to tell apart the echoes of its own sounds from sounds of others, or other echoes, has been puzzling. If we understood the methods that animals use, it would help us develop strategies for other fields, like air traffic control or robotics, or even electronic jamming in military operations.

Moths covered with sound absorbing fur

Kloepper, who believes that bats are more proficient, used an arrangement of speakers and microphones to generate dolphin clicks to interfere with the echolocation of lone dolphins. She did find that dolphins modified their own signals, so that they could be told apart. "But they did not have the same level of control of their call as bats do", she says.

Kloepper puts the difference in control down to the complexity in the sounds the animals use to echolocate. Dolphins produce short-lived and well separated clicks. The chances are hence low that clicks and echoes would overlap. "Bats, on other hand, have calls that are much longer in duration, so have a higher probability of overlapping with other bats when they are flying in the same airspace", Kloepper says.

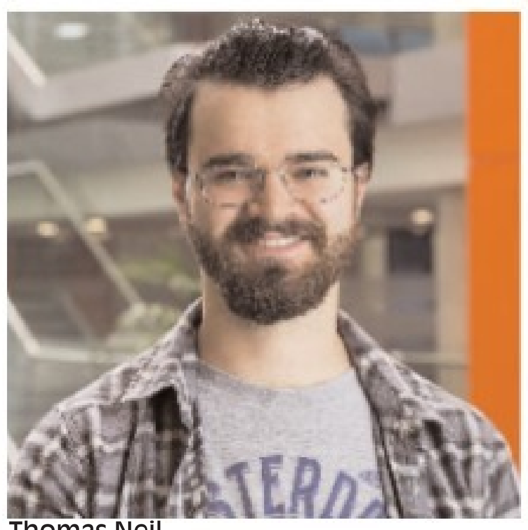
When flying in a swarm, particularly, the bat is likely to be swamped by signals and echoes. How the bat copes is by marking its own clicks with a signature that it can recognise. The typical strategy is to use a particular frequency of sound, and to rapidly switch this frequency. Bats are known to make frequency switches as often as once every fifth of a second, and each one of the bats in the swarm can keep track of its own clicks.

Kloepper has experimented with a novel application of the "unmanned aerial vehicle" or the drone, to verify and investigate this behaviour of the bat, right in the middle of the swarm, in full flight. Normally, the motor that propels the unmanned vehicle would be too noisy for fineries of the bat vocalisations to be captured. But Kloepper and her group designed unmanned vehicles where the noise of the propellers was blocked from the microphones and the bat sounds could be recorded. In addition to unmanned vehicles, they used a living hawk, mounted with a device to record bat sounds, which could mingle with flying bats.

Working with a swarm of Brazilian free tailed bats, numbering millions, they were able to record and extract individual clicks as the bats swooped down from high altitude, to roost, reaching speeds as high as 128 kmph. At these speeds, there is also the Doppler shift of frequencies,

Kloepper and her student, Morgan Kinniry said that in a paper earlier this year in the journal, *Scientific Reports*. The paper reports that bats employed both changes in frequency and changes in pulse duration, as wells as combinations of the two.

The method is not far removed from the technique in networking computer devices with Bluetooth. As many intelligent devices like computers, cell phones, headphones, even refrigerators and vacuum cleaners now communicate without wires, there is a need to keep signals apart. Bluetooth is a communication standard where pairs of devices settle on a pattern of unpredictable frequency changes, so that their exchanges stay unique.



Thomas Neil

Laura Kloepper

Detection evasion

Side-by-side with the technology of bats to spot prey in the darkness of the night, some species of prey have evolved evasive strategies. A method that one species of moth uses is to generate its own series of clicks, which "jam" the bats' signal and put predators off track. Other species of moths, whose defence is their distasteful flavour, thanks to the specific plants that they feed on, advertise the fact with clicks in response to bat clicks. Neil from Bristol describes yet another strategy, of moths evolving body covering that does not create an echo. The moth then becomes essentially invisible.

The method not to reflect sound is to absorb it. A typical place where we need to absorb sound is in recording studios or auditoria to eliminate reverberation. Materials like mats of glass fibre, with micrometer-sized pockets where air cannot transmit sound, are formed, and they are the most common acoustic insulators. Neil found that a category of moths which are deaf to the sounds that bats produce, have body covering that renders the predators essentially as deaf as the prey. He used a method called acoustic tomography, or measuring the intensity of reflected sound in slices of frequency. "Thoracic fur provides substantial acoustic stealth at all ecologically relevant ultrasonic frequencies," Neil says, "Moth fur is thin and lightweight, and acts as a broadband and multidirectional ultrasound absorber that is on par with the performance of current porous sound-absorbing foams."

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Cast of characters

Ribosomes play a central role in protein synthesis and catalyses formation of the peptide bonds that link amino acids into a polypeptide

TAPAN KUMAR MAITRA

For genes encoding ribosomal ribonucleic acid and transfer RNA (and certain other small RNA molecules), RNA is the ultimate expression of a gene. But for the thousands of other genes in an organism's genome, the ultimate gene product is protein.

Translation, the first and most important phase of protein synthesis, involves a change in language from the nucleotide sequence of an mRNA molecule to the amino acid sequence of a polypeptide chain. In essence, the sequential order of mRNA nucleotides, read as triplet codons, specifies the order in which incoming amino acids are added to a growing polypeptide chain.

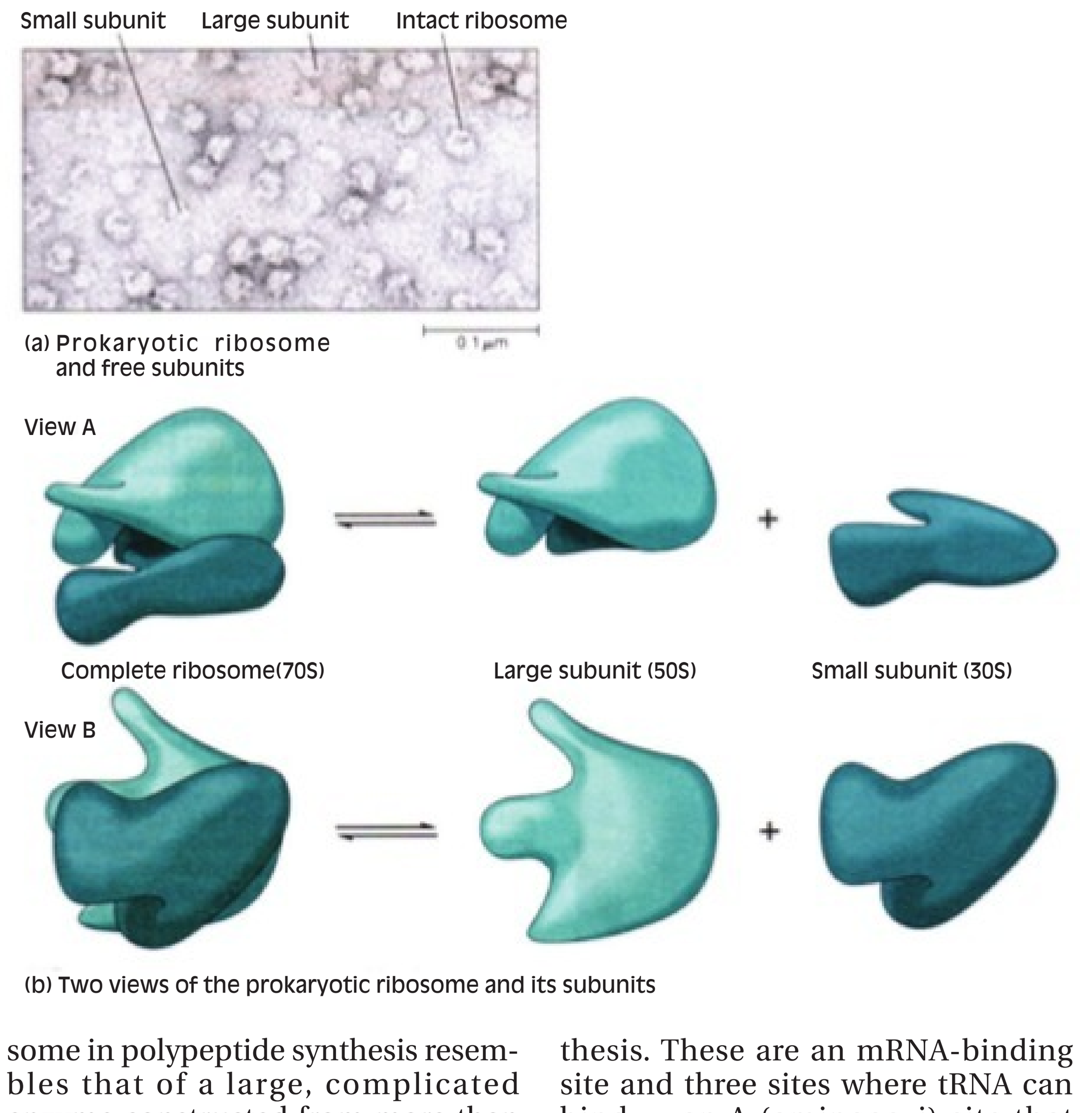
Ribosomes serve as the intracellular sites of the translation process, while RNA molecules are the agents that ensure insertion of the correct amino acids at each position in the polypeptide. We will start by surveying the cell's cast of characters for performing translation, before examining in detail the steps of the process.

The cellular machinery for translating mRNAs into polypeptides involves five major components — ribosomes that carry out the process of polypeptide synthesis, tRNA molecules that align amino acids in the correct order along the mRNA template, aminoacyl-tRNA synthetases that attach amino acids to their appropriate tRNA molecules, mRNA molecules that encode the amino acid sequence information for the polypeptides being synthesised, and protein factors that facilitate several steps in the translation process.

Ribosomes play a central role in protein synthesis, orienting the mRNA and amino acid-carrying tRNAs in the proper relation to each other so the genetic code is read accurately, and catalysing formation of the peptide bonds that link the amino acids into a polypeptide. Ribosomes are particles made of RNA and protein that reside in the cytoplasm of both prokaryotic and eukaryotic cells, as well as in the matrix of mitochondria and the stroma of chloroplasts.

In the eukaryotic cytoplasm, they exist both free in the cytosol and bound to membranes of the endoplasmic reticulum and the outer membrane of the nuclear envelope. Prokaryotic and eukaryotic ribosomes resemble each other structurally, but they are not identical. Prokaryotic ribosomes are smaller in size, contain fewer proteins, have smaller RNA molecules (and one fewer RNA), and are sensitive to different inhibitors of protein synthesis.

Like all ribosomes, prokaryotic ribosome consists of two dissociable subunits called the large and small subunits. A complete prokaryotic ribosome, with a sedimentation coefficient of about 70S, consists of a 30S small subunit and a 50S large subunit; its eukaryotic equivalent is an 80S ribosome consisting of a 40S subunit and a 60S subunit.



(a) Prokaryotic ribosome and free subunits

(b) Two views of the prokaryotic ribosome and its subunits

Ribosomal RNAs and protein molecules self-assemble into small and large subunits but the two types of subunits come together only when bound to mRNA. X-ray crystallography has recently allowed for the arrangement of all the individual proteins and RNA molecules of small and large subunits of bacterial ribosomes to be pinpointed down to the atomic level.

Functionally, ribosomes have sometimes been called the "workbenches" of protein synthesis, but their active role in polypeptide synthesis makes "machine" a more apt label. In essence, the role of the ribosome in polypeptide synthesis resembles that of a large, complicated enzyme constructed from more than 50 different proteins and several kinds of rRNA. For many years, it was thought that the rRNA simply provided a structural scaffold for the ribosomal proteins, with the latter actually carrying out the steps in polypeptide synthesis. But today we know that the reverse is closer to the truth — that rRNA performs many of the ribosome's key functions.

Four sites on the ribosome are particularly important for protein synthesis. These are an mRNA-binding site and three sites where tRNA can bind — an A (aminoacyi) site that binds each newly arriving tRNA with its attached amino acid, a P (peptidyl) site where the tRNA carrying the growing polypeptide chain resides, and an E (exit) site, from which tRNAs leave the ribosome after they have discharged their amino acids.

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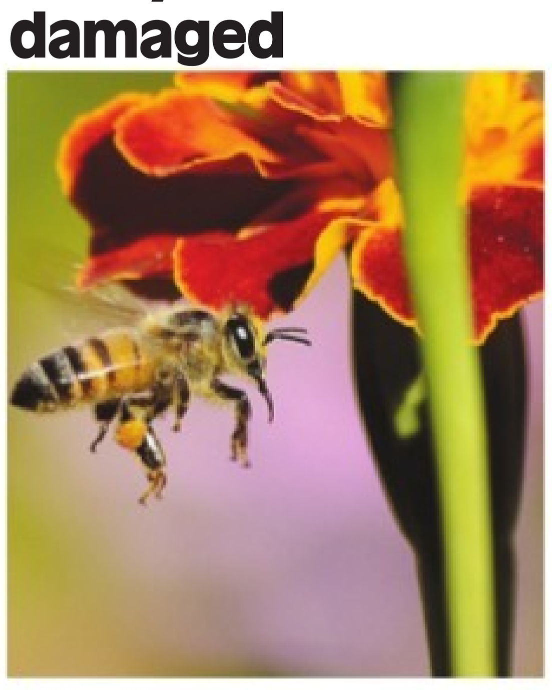
PLUS POINTS

Ecosystems damaged



High levels of pollution found in many of the world's major cities are having negative effects on plants and insects, according to new research from the University of Sheffield, UK.

The study, published in *Nature Communications*, reveals that plants exposed to high levels of nitrogen dioxide — similar to levels recorded in major urban centres — are able to better defend themselves against herbivorous insects. Led by Stuart Campbell from the University's department of animal and plant sciences, the research has discovered that plants exposed to increased levels of pollution produce more defensive chemicals in their leaves. Results from the study show that insects feeding on these leaves grew poorly, which suggests high levels of air pollution may be having cascading negative effects on communities of herbivorous creatures.

Campbell said, "Nitrogen dioxide is a pollutant that causes severe health problems in humans, but our research has found that it may also be having a significant impact on plants and insects.

"Many people may be aware that insect pollinators, such as the thousands of species of bees, along with flies, moths and butterflies, are crucial for food production — but they also ensure the long-term survival of wildflowers, shrubs and trees."

He said, "Insects that feed on plants help return plant nutrients to the soil, and are themselves food for wild birds, reptiles, mammals, and yet more insects. Insects are also immensely important for decomposing decaying organic matter and maintaining healthy soils. Scientists are warning about massive declines in insect numbers, which should be incredibly alarming to anyone who values the natural world and our sources of food.

"Nitrogen dioxide is a major component of smog and is an example of pollution caused from human activity, particularly our reliance on fossil fuels. Levels of this pollutant in the atmosphere remain particularly high in cities."

The international team of scientists also looked at whether insects have an effect on the ability of plants to absorb NO2 from the environment. Plants that had been fed on by insects absorbed much less NO2, according to the study.

The authors believe this indicates that insects could be influencing the amount of pollution removed from the air by urban green spaces. Urban trees can absorb gaseous pollutants like NO2 but the effects appear to vary between species and locations, and this may be due in part to the actions of leaf-feeding insects.

Flying past

Three huge asteroids flew past Earth last weekend. The trio of vast rocks swooped past just hours apart from each other, with one coming nearer to us than the moon. But reports that the asteroids "skimmed" past Earth or suggestions that they could have put us in any danger appears to be unfounded.

There were really three asteroids set to be flying by. And though came fairly close, it wasn't close enough to worry anyone.

The first was known as 2018 VA2 and flew past on Friday morning. That was as big as 75 feet wide, and passed by around 450,000 miles away. It was followed by another couple of objects that whipped by just 15 minutes apart on Saturday afternoon. At about 100 feet wide, each of them could cause significant damage if they came towards Earth, but thankfully even the closest was a full 865,418 miles away. The last was also the closest and smallest of the weekend. It passed by on Saturday evening at a relatively cosy 237,037 miles.

Various news organisations reported that Nasa had given out "warnings" about the rocks but they all flew by entirely safely, at distances of hundreds of thousands of miles away.

The independent