# Migratory locusts in a wind tunnel

*02 May 2012*

Insects are capable of masterful feats of flying; whenever they witness locusts flying long distances or moths hovering over flowers, aerodynamicists can only marvel. This is why researchers at the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR) are working on a new collaborative venture with the University of Oxford and optical metrology company LaVision GmbH, a project that involves examining the flight characteristics of locusts and moths in a wind tunnel. The very latest measurement technology enables scientists to view the slipstream turbulence behind these creatures in three dimensions and at an unprecedented resolution. This knowledge is bringing engineers closer to the point where they can build miniature aircraft that fly like insects.

This research is being conducted in the one-metre wind tunnel at DLR Göttingen. "DLR and LaVision have a leading position in optical metrology, and we are bringing some extraordinary investigation subjects with us," explains Richard Bomphrey from the Zoology Department at the University of Oxford as he describes the Anglo-German collaboration. Oxford is one of the leading research centres for the study of insects.


Video: Migratory locusts in a wind tunnel

**Mimicking nature**

The problem with designing and building very small flying machines is that one cannot simply continue reducing the size of existing aircraft designs. These use separate devices for propulsion and lift – the engines and the wings – and this takes up space. "Nature has solved the problem of how to build miniature flying machines," states Bomphrey – with beating wings that combine propulsion and lift. To emulate this example from nature, a more detailed understanding of the different functional aspects of insect wings needs to be gained. Locusts are able, for example, to cover long distances while consuming very little energy. Bumblebees

are excellent load carriers and can transport their own weight in pollen. Moths, on the other hand, possess astonishing manoeuvrability and can hover above flowers to collect nectar.

The key to understanding the flight characteristics of insects lies in precise calculation of the velocities of airflow behind their wings. To establish this, these creatures are placed in a wind tunnel to enable them to exhibit the most natural flying characteristics possible. To do this, researchers exploit a reflex action; as soon as locusts cease to feel ground under their feet and find themselves facing a headwind, they begin to fly. The locusts and moths are fixed to small rods with a drop of glue and are then blown at 11 and seven kilometres per hour respectively. This glue is removed from the insects after completion of the tests, without harming them.

**Three-dimensional representation**

Then, we introduced extremely small particles into the air, and these followed the airflow precisely. The movement of these small particles can be visualised using pulsed laser light," explains Andreas Schröder from the DLR Institute of Aerodynamics and Flow Technology. This form of metrology is known as particle image velocimetry and was developed at Göttingen. An area five centimetres in height and 22 centimetres long behind the locust is illuminated using the latest metrology techniques. Eight high-performance cameras take 230 images from different viewing angles over a 23-second interval. "The resolution is 100 microns – that is, 0.1 millimetres," says Dirk Michaelis from LaVision. Computer processing of these images generates a 3D representation of the airflow velocities behind the insect. The entire flight sequence, from the raising and lowering of the wings through to their return to the starting position is reconstructed. "This is the first time that this has been accomplished, and it has provided us with important knowledge, not previously obtainable, about the flight characteristics of insects," states Bomphrey.

**Mini-aircraft for disaster operations**

If this research work eventually culminates in the production of small, insect-like flying machines, these would have many applications. For example, they could be used in industry for monitoring pipelines and for automatic detection of leaks, and could also provide assistance during disasters. Bomphrey suggests: "Devices of this kind would have been able to enter the reactor buildings at Fukushima after the incident, without risk to human health." Other potential applications could include unusual camera shots of football games, or the collection of comprehensive weather data.

The researchers believe it could take around 20 years for artificial insects to enter widespread use.

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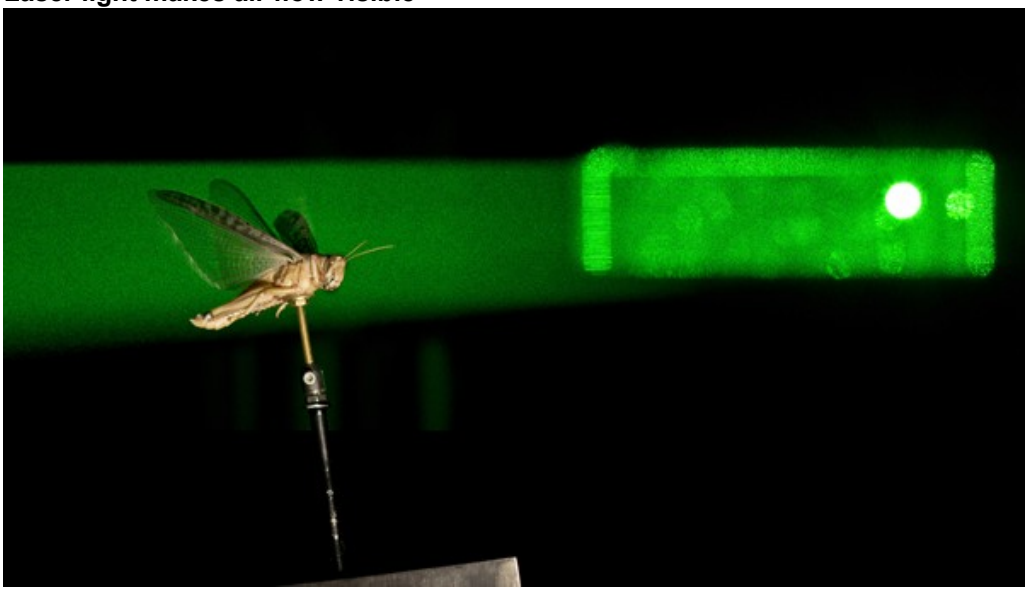
**A locust in the wind tunnel**

Paradigm for mini-aircraft – locusts are excellent fliers so, researchers at the German Aerospace Center (DLR), together with the University of Oxford and the optical metrology company LaVision GmbH, are studying them in a wind tunnel at DLR Göttingen. The insects are fixed to small rods with a drop of glue, which can be removed upon completion of the tests without harming them.

Credit: DLR (CC-BY 3.0).

**Laser light makes air flow visible**



These investigations are being conducted in the one-metre wind tunnel at DLR Göttingen. "DLR and LaVision have a leading position in optical metrology, and we are bringing some extraordinary investigation subjects with us," explains Richard Bomphrey from the Zoology Department at the University of Oxford as he describes this Anglo-German collaboration. Oxford is one of the leading research centres for the study of insects. The insects are fixed to small rods with a drop of glue, which can be removed upon completion of the tests without harming them.

Credit: DLR (CC-BY 3.0).

**Natural flight characteristics**

The key to understanding the flying characteristics of insects lies in precise calculation of the airflow velocities behind their wings. To establish this, these creatures are placed in a wind tunnel to enable them to exhibit the most natural flying characteristics possible. To do this, researchers exploit a reflex action; as soon as locusts cease to feel ground under their feet and find themselves facing a headwind, they begin to fly. The locusts and the moths are fixed to small rods with a drop of glue and are then blown at 11 and seven kilometres per hour respectively. This glue is removed from the insects after completion of the tests, without harming them.

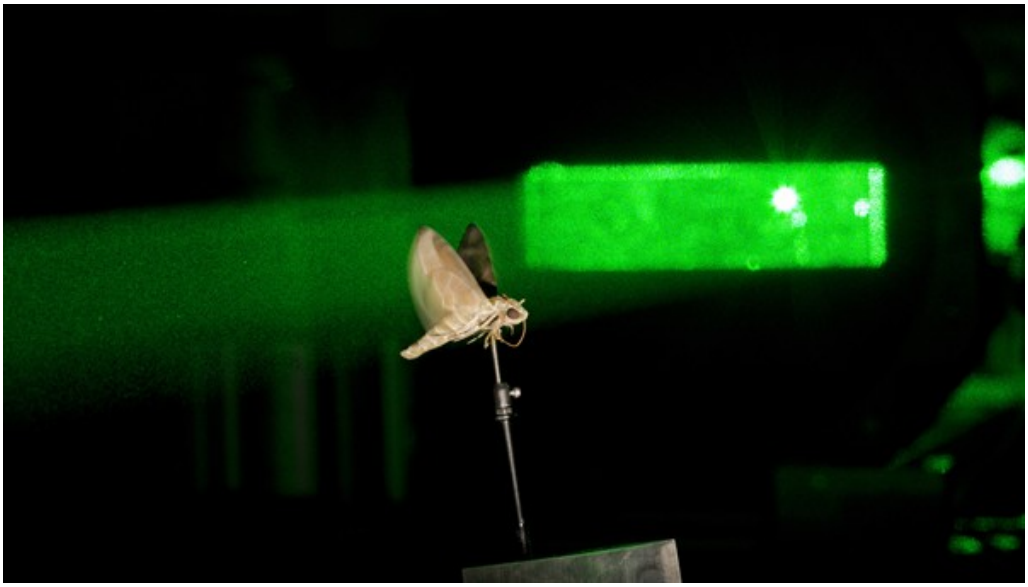
Credit: DLR (CC-BY 3.0).

**Manoeuvrable moths**

Moths are also being tested in the wind tunnel. They have amazing manoeuvrability and can hover over flowers to collect nectar.

Credit: DLR (CC-BY 3.0).

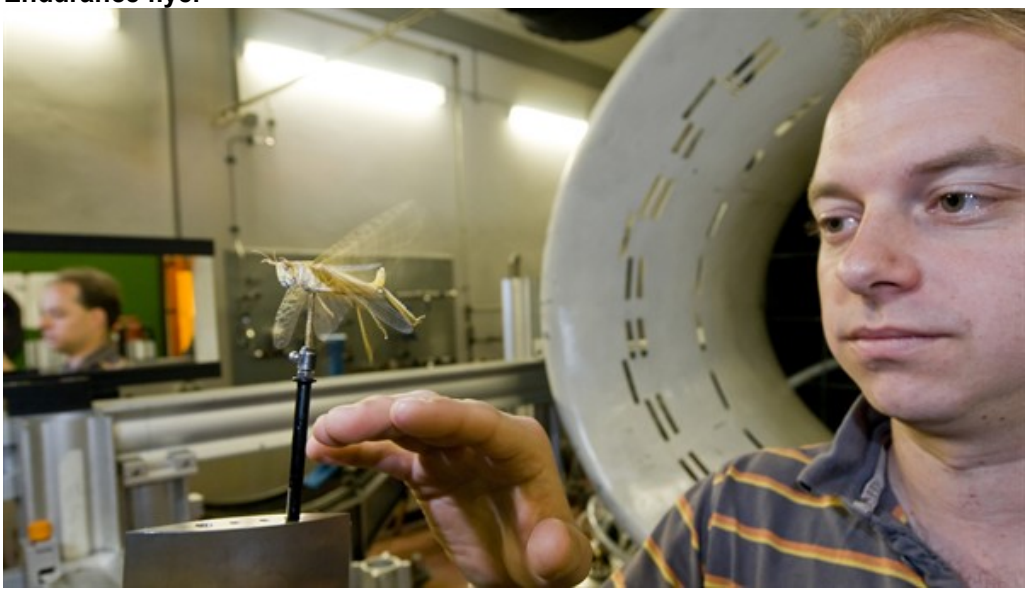
**A moth in the wind tunnel**



A moth 'flying' in the wind tunnel at DLR Göttingen. The insects are fixed to small rods with a drop of glue, which can be removed upon completion of the tests without harming them.

Credit: DLR (CC-BY 3.0).

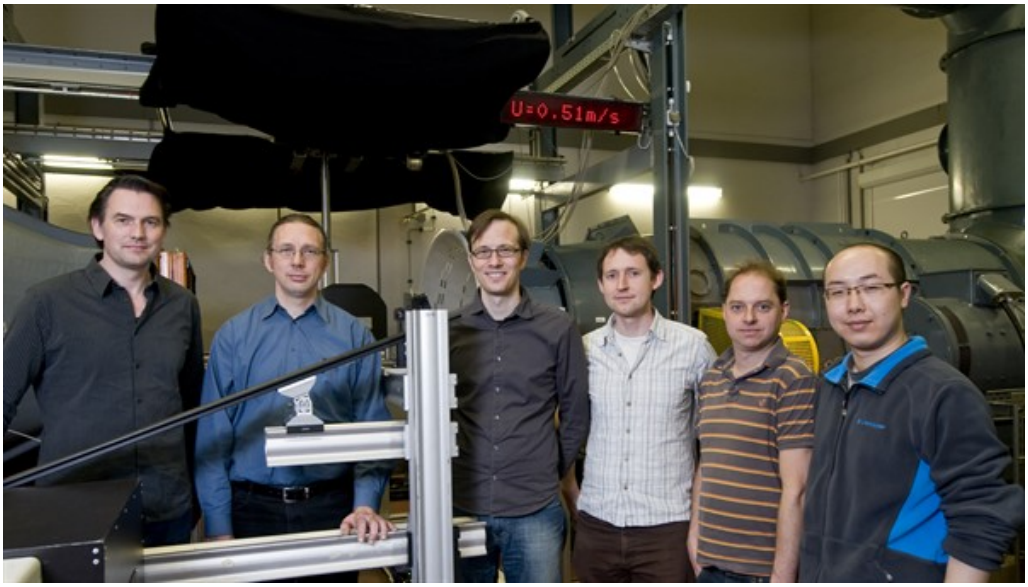
**Endurance flyer**



A locust in the wind tunnel at DLR Göttingen, with Per Henningsson from the University of Oxford. The insects are fixed to small rods with a drop of glue, which can be removed upon completion of the tests without harming them.

Credit: DLR (CC-BY 3.0).

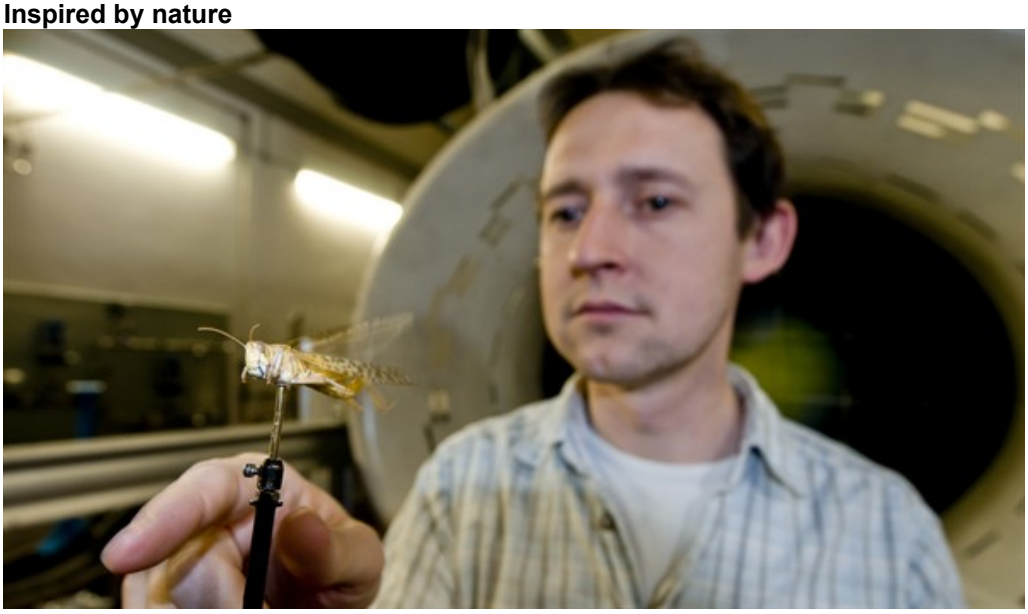
**The research team**




The research team (left to right): Andreas Schröder (DLR), Dirk Michaelis (LaVision GmbH), Daniel Schanz (DLR), Richard Bomphrey and Per Henningsson (University of Oxford) and Ma Xingyu (DLR visiting scientist from China).

Credit: DLR (CC-BY 3.0).

**Inspired by nature**



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