

Extinction mystery deepens

SCIENTISTS have created the most detailed three-dimensional undersea map of the Chicxulub crater in the Gulf of Mexico, the site of an asteroid crash 65 million years ago – around the time of one of the greatest mass extinctions the world has ever known. The researchers found that the shape of the crater can have more to do with the geological conditions surrounding the crash than the impact itself.

Penny Barton from the University of Cambridge and Joanna Morgan from Imperial College London led a team on board the US research ship *Ewing* to examine the shape of the 180km-wide crater.

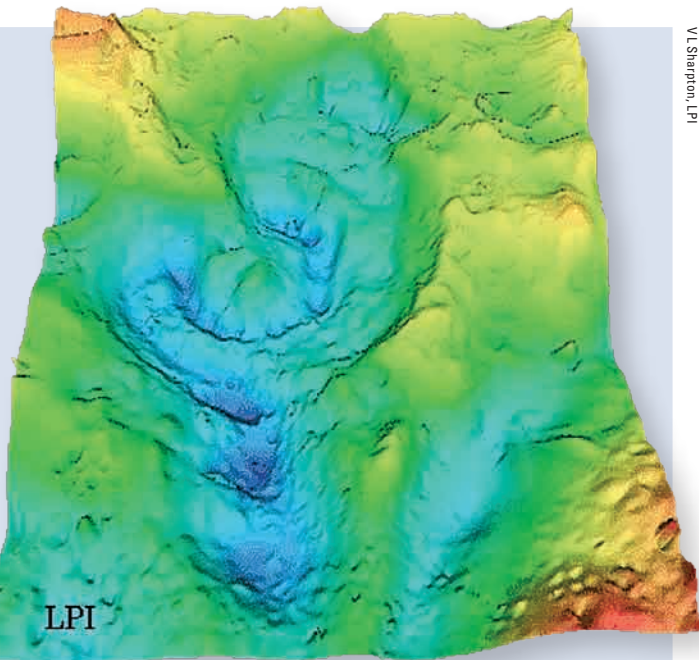
'We were trying to create some images of the crater from the near surface down to about 30km,' said Penny.

The crater is perfectly preserved beneath a kilometre of sediment – the only complete 'peak ring' crater on Earth.

Previously, scientists believed the shape of a crater, particularly whether it is symmetric or not, can reveal the trajectory of the object that caused it. This helps determine the extent of the damage. An object coming in at a low angle causes more damage than a steep approach because more ocean and land vaporise on contact.

Joanna said, 'Everyone uses crater asymmetry to work out the angle of impact. But our work shows this is not a reliable indicator at all.'

The research also overturns another long-held belief. Scientists have assumed the 14-18km wide asteroid hit a mixture of dry land and shallow



VL Sharpton, LPI

water, 200m deep at most. The seismic survey shows that at least part of the asteroid hit ocean 2km deep.

If correct, much more water would have vaporised on contact than once thought.

Importance of pre-impact crustal structure for the asymmetry of the Chicxulub impact crater. *Nature Geoscience*. Published online.

'Dynamic modeling suggests asymmetries in the Chicxulub crater are caused by target heterogeneity'. *Earth and Planetary Science Letters* (in press).

Inheriting the Earth



SOME may eat dung and some may eat each other, but beetles could teach humans a thing or two about survival. A comprehensive study of 1880 species of beetle has revealed that their explosion in diversity happened during the dinosaurs' reign, at least 270 million years ago. This is much earlier than previous estimates which were based on the assumption that beetles' extraordinary diversity – there are 350,000 known species, and probably over one million yet to be discovered – was linked to the emergence of flowering plants 140 million years ago.

'With beetles forming such a large proportion of all known species, learning about their relationships and evolution gives us new insights into the origin of biodiversity,' says Alfried Vogler from the Department of

Life Sciences, Imperial College London and the Natural History Museum.

The beetle's success and 'extreme diversity' is down to its ability to find new niches, says Alfried and colleagues in the journal *Science*. Beetles, for example, have adapted to use all parts of plants. The team used DNA techniques and fossilised pollen records to show that switches to new niches occurred repeatedly and often.

'Beetles have switched from terrestrial to aquatic habitats at least ten times,' added Alfried.

Beetles – defined by hard wing covers – account for one quarter of all life forms on the planet.

'A comprehensive phylogeny of beetles reveals the evolutionary origins of a superradiation'. *Science* Vol. 318.

Sleeping giants – ranking climate ‘tipping points’



J.Limages / Alamy

‘SOCIETY may be lulled into a false sense of security by smooth projections of global change,’ warn scientists who have compiled a shortlist of critical thresholds or ‘tipping points’ in the Earth system.

The nearest thresholds are those triggering summer sea ice loss in the Arctic and melting of the Greenland ice sheet, according to Tim Lenton and colleagues in a paper published in *Proceedings of the National Academy of Sciences*. The paper evaluates tipping points relevant to global policy and then estimates their likelihood.

The team introduce the term ‘tipping element’ to describe those major parts of Earth’s climate system, such as large ocean or atmospheric circulations, ice sheets, monsoons or forests, that could exhibit a tipping point.

‘Human activities have the potential to push these past critical states into different modes of operation, implying large-scale impacts on human and ecological systems,’ said Tim from the University of East Anglia and NERC’s Tyndall Centre for Climate Change Research, working with colleagues at the Postdam Institute of Climate Impact Research, Carnegie Mellon University, Newcastle University and Oxford University.

The researchers focus on

those tipping elements that could pass a tipping point this century. Nine policy-relevant tipping elements emerge: **disappearance of Arctic summer sea ice** (threshold passed under 0.5-2°C global warming, consequence once transition has occurred: amplified warming, ecosystem change); **Greenland ice-sheet meltdown** (1-2°C, 2-7 metre rise in sea level); **West Antarctic ice-sheet collapse** (3-5°C, 5m sea-level rise); **reorganisation of the Atlantic thermohaline circulation** (3-5°C, regional cooling); **increased amplitude of the El Niño Southern Oscillation** (3-6°C, drought in South-east Asia); **shift in Indian summer monsoon variability** (temperature not applicable, drought); **collapse of the West African monsoon** (3-5°C, potential greening of the Sahel); **Amazon rainforest dieback** (3-4°C, biodiversity loss, less rainfall); and **boreal forest dieback** (3-5°C, changes in biodiversity).

They also pinpoint the critical parameters controlling these tipping elements. If a slight rise above a certain value of a critical parameter, say, a change in temperature, salinity or rainfall, continues for some time, it induces change. The nature of many tipping points is that they are difficult to reverse: returning to past parameter values will not

necessarily mean a return to the original state of the system.

Forewarning is possible. But researchers need ice and ocean records going further back in time to detect shifts. In the example of the thermohaline circulation, which is largely responsible for Western Europe’s temperate climate, NERC scientists have built a monitoring system across the Atlantic Ocean. To accurately predict an approaching critical threshold, this system needs to be complemented by Atlantic sea-surface-temperature records stretching back beyond the current 150-year dataset.

The team accept large

uncertainties still remain about tipping points. ‘It seems wise to assume that we have not yet identified all potential policy-relevant tipping elements,’ concludes the paper, which calls for a systematic hunt for others drawing on past data and next-generation climate models.

The work is part of two NERC research programmes: the eScience programme and QUEST (Quantifying and Understanding the Earth System).

‘Tipping elements in the Earth’s climate system’. *Proceedings of the National Academy of Sciences*. Vol. 105(6).

Anthropocene: a new epoch

HUMANS have changed planet Earth so dramatically that there is now justification to split the Earth into two distinct epochs: pre-industrialisation and post-industrialisation, or the Holocene and the Anthropocene, say the Stratigraphy Commission of the Geological Society of London.

The commission, which includes three scientists from the British Geological Survey, analysed a proposal made by Nobel Prize-winning chemist Paul Crutzen in 2002. He suggested the Earth had left

the Holocene and started the Anthropocene era because of the global environmental effects of increased human population and economic development.

The group state in *GSA Today*, a journal of the Geological Society of America, that, ‘Sufficient evidence has emerged of stratigraphically significant change for recognition of the Anthropocene as a new geological epoch to be considered for formalisation by international discussion.’

Summer floods – full report published

THE MOST comprehensive and authoritative report yet on the record-breaking summer 2007 floods has been published by the National Hydrological Monitoring Programme (NHMP), operated jointly by the Centre for Ecology & Hydrology and the British Geological Survey.

The report systematically breaks down the series of events which led to flooding that it says has 'no close modern parallel for the June-August period'.

It states, 'In the worst affected areas flooding was more extreme than the benchmark event of March 1947.' In marked contrast to 2007, the 1947 flood

was caused by a rapid thaw following severe blizzards.

But the report plays down the link to climate change. '[The floods have] fuelled speculation that flood risk is increasing due to global warming. By their nature, however, any cluster of extreme hydrological events cannot readily be linked directly to climate change.'

It goes on to add, 'The 2007 flooding was remarkable in its extent and severity, and truly outstanding for a summer event. It underlined the UK's continuing vulnerability to climatic extremes but long-term rainfall and river flow records confirm the exceptional rarity of the hydrological conditions experienced.'

The Summer 2007 Floods in England and Wales – A hydrological appraisal brings together both flood data and meteorological data. It calls summer 2007 a 'very singular episode, which does not form part of any clearly emerging pattern or long-term trend consistent with currently favoured climate change scenarios'.

Further floods later in the year were averted when England and Wales experienced their second driest August to October since 1978, says the report.

The team led by Terry Marsh and Jamie Hannaford found that the total river outflows for England and Wales during June and July was 'well over three times the long-term average and nearly twice the previous maximum (1968)'.

The May to July rainfall was the highest for England and Wales since 1766 but, 'It was the concentration of the most exceptional run-off into several major basins that caused the extensive flooding in the summer of 2007.'

Insurance claims for the 2007 floods are approaching £3 billion.



Antarctic snowfall doubles

SNOWFALL in the western Antarctic Peninsula has doubled since the 1850s, say researchers in the journal *Geophysical Research Letters*.

Ice cores drilled in 2007 by a team from the British Antarctic Survey and the Desert Research Institute in the US show snowfall has increased from half a metre a year in the 1850s to over one metre a year from 1997 to 2006.

While the findings are consistent with predictions, the scientists were surprised by the magnitude and speed of change, particularly in recent decades.

Researchers believe the rise is linked to changes in a large-scale weather pattern known as the Southern Hemisphere Annular Mode. These changes are caused predominantly by the ozone hole and increasing greenhouse gases. Over the past decade, westerly winds around Antarctica have become stronger, bringing warmer, wetter air down to the Antarctic Peninsula.

Lead author Liz Thomas said, 'The rapidity is significant because it shows that large-scale changes in weather patterns can happen very quickly – even within our lifetime – and if these shifts in snowfall can happen in the Antarctic Peninsula, they could happen elsewhere.'

'A doubling in snow accumulation in the Western Antarctic Peninsula'. *Geophysical Research Letters*, Vol. 35.



in a photograph/Alamy

Avalanche prediction

SKIERS' worst nightmare – the avalanche – is the focus of a new three-year project by scientists at University College London (UCL) and colleagues at Leeds and Cambridge universities.

The team want to develop radar imaging instruments to look below the surface of these natural hazards.

'If you use an optical camera

you can only see what's on top – a very light powder cloud,' explained Paul Brennan from UCL. 'With the radar we should be able to see movement underneath, in particular the velocity distribution of all components.'

The system could be applied to similar large-scale natural movements, such as landslides and lava.

Environmental scientists trusted most

THE UK public trust researchers working for environmental organisations and universities more than any other scientists, says a report for Research Councils UK on public attitudes to science published in March. Scientists working for the government or industry came off worst.

Defying gravity – new satellite ready for launch



ON 31 MAY, the second European Space Agency satellite in its Earth Explorer series of missions is scheduled to launch from northern Russia.

After lift-off from the Plesetsk Cosmodrome, the satellite will enter a low Earth orbit where it will measure the planet's gravity field with extremely high accuracy and resolution. The gravitational signal is strongest close to the Earth, but the environment is hostile. The mission is slated to last just 20 months.

The GOCE mission (Gravity Field and Steady-State Ocean Circulation Explorer) will help UK researchers to locate gravity anomalies around the globe and link these to dynamic deep Earth processes that cause volcanoes and earthquakes.

Keith Haines from NERC's National Centre for Earth Observation said, 'NERC scientists will be able to combine GOCE data with sea level measured from satellite radar altimeters and determine ocean currents with unprecedented accuracy, which will then be used in

ocean and climate prediction studies.'

GOCE will measure the Earth's geoid – a surface of equal gravitational potential. The geoid follows a hypothetical ocean surface at rest, in the absence of tides and currents. It is this precise model of the Earth's geoid that will allow oceanographers to derive accurate measurements of ocean circulation, sea-level and ice-mass change.

The data will also allow an international unification of nationally based height systems on land, for example the Ordnance Survey heights in the UK.

Many NERC-funded scientists, particularly at the Proudman Oceanographic Laboratory and the National Centre for Earth Observation, are keenly anticipating data from the mission.

NERC manages the UK's £40 million annual subscription to the European Space Agency's Earth observation missions.

Eruptions linked to sea-level rise

VOLCANIC eruptions cause sea levels to rise by around 9mm in the first year after eruption, say researchers in *Proceedings of the National Academy of Sciences*.

The team suggest the eruptions disturb the global water cycle upsetting the balance between ocean evaporation and worldwide rainfall, snowfall and run-off.

'Most experts didn't expect this result,' said Miguel Maqueda, a climate modeller from the Proudman Oceanographic Laboratory (POL). 'Previous research had suggested that global sea levels should fall.'

The researchers from POL and the University of Lapland scanned 830 tide gauge records following five major volcanic eruptions. They found that after the initial rise, sea levels fell to 7mm below their original position. Eventually, levels returned to normal.

'The volcanoes cause the atmosphere and ocean surface to cool. This means less evaporation so sea levels rise initially. Eventually, the cooler atmosphere holds less water so river run-off falls, reducing sea level. Cooler water also contracts, but this takes time, hence the lag,' explained Miguel who works closely with the paper's authors.

The paper shows that after an eruption, rain and snowfall on land can change by five percent. This is comparable to a large El Niño-La Niña cycle.

'Observational evidence for volcanic impact on sea level and the global water cycle'. *Proceedings of the National Academy of Sciences*. Vol. 104.

Meet Britain's most invasive species



M. Majerus

IT TOOK the grey squirrel a century to achieve what the harlequin ladybird has in just four years. From the first sighting in the south-east of England in 2004, the harlequin ladybird can now be found in every county in England and parts of Scotland and Wales, according to a new report from the Centre for Ecology & Hydrology (CEH). This makes the harlequin the most invasive ladybird on Earth, and one of the most invasive species.

The harlequin was first introduced to Europe and North America from eastern Asia to control aphids in greenhouses and gardens. High numbers of the harlequin in Battersea, Chelsea and Clapham have led researchers to believe it possibly arrived in the UK on the Eurostar, or from flowers imported from Europe.

An online survey has helped track the harlequin's movements. Over 20,000 sightings have been logged since March 2005.

The results of the survey are published in a special edition of the journal *BioControl*, co-edited by Helen Roy from CEH.

'From biological control to invasion: the ladybird *Harmonia axyridis* as a model species'. *BioControl* 2007.

Wind patterns correlate to ocean warming

THE LINK between rising ocean temperatures and climate change caused by human activities is not as clear cut as previously thought, at least in the North Atlantic Ocean, say researchers in the American journal *Science*.

Over the entire North Atlantic Ocean, the surface heat flux of the ocean, or how much heat moves between the ocean and the atmosphere, has risen by 0.4 Watts per square metre (W/m^2) based on measurements over the last 50 years. A clear signal for ocean warming. But wait. The North Atlantic is one of the most comprehensively

monitored oceans in the world. This average temperature rise hides large variations around the ocean basin. The tropics and subtropics have warmed substantially, while the pole and environs have cooled. Regionally the heat content of the ocean has fluctuated between $4W/m^2$ and $-4W/m^2$. The regional changes are a factor of ten larger than the basin average.

When researchers from Liverpool University and Duke University in the US ran climate models to look at these regional variations, they found that they correlated well with variations in wind patterns in the region. These wind patterns are well understood and are related to

the North Atlantic Oscillation (NAO). This is a large slowly shifting atmospheric phenomenon over the North Atlantic that affects weather in the UK.

So, while scientists can detect a warming trend, the mechanism is not straightforward.

Ric Williams, from Liverpool University but on sabbatical to Duke University, said, 'Probably the regional changes reflect natural variability induced by the winds, rather than as a result of global warming.'

'The spatial pattern and mechanisms of heat-content change in the North Atlantic'. *Science*, Vol. 319.

News in brief

£1.2 million for spin-out

A newly formed spin-out company from the Centre for Ecology & Hydrology, Microbial Solutions Ltd, has raised £1.2 million to commercialise its wastewater treatment technology, which uses bacteria to clean toxic fluids used in the metal working and manufacturing industries.

International cooperation

NERC Council member Professor Robert Watson has been awarded the 2007 American Association for the Advancement of Science (AAAS) International Scientific Cooperation Award for his outstanding contributions to promoting international scientific cooperation and his work on environmental and sustainable development.

Darwin today

To prepare for the bicentenary of the birth of Charles Darwin in 2009, and the 150th anniversary of *On the Origin of Species*, NERC, along with other research councils, launched the Darwin Today website on 11 March. www.darwin.rcuk.ac.uk

Geology online

The British Geological Survey launches an all-new website on 7 April. www.bgs.ac.uk

PM opens Environment Centre Wales



From left to right, Prime Minister Gordon Brown, Bangor MP Betty Williams, NERC Chief Executive Alan Thorpe.

PRIME MINISTER Gordon Brown officially opened the £7 million Environment Centre Wales, a collaboration between the Centre for Ecology & Hydrology and Bangor University, on 15 February.

'You are drawing on the talents of people across this country and Europe. I believe this is a fine example of how cooperation in a major area of research should work in the future,' said the Prime Minister.

The new building complies with the highest environmental assessment rating for its design and construction. It sports solar panels, ground-source heat pumps, rainwater-recovery systems and a combined heat and power plant. The builders used locally sourced materials where possible and they landscaped the grounds planting native flora.

Left: The new Environment Centre Wales.



Eat up all your sprouts



EAT UP all your greens and you will become fit and strong, but choose them carefully, say researchers in the journal *Science*. A team from NERC's Centre for Population Biology and the Wageningen University in the Netherlands has found unexpectedly far-reaching impacts on ecosystems of cultivated crops such as brussel sprouts compared to their untamed relative, the wild cabbage. The findings show that growing crops could potentially impede important functions, such as natural predation and control of agricultural pests.

The group found that food webs (who eats who) based on sprout-eating aphids are less complex than webs founded on aphids feeding on higher-quality plants like wild cabbage. On the sprouts, they noted fewer and smaller aphids, concluding that the sprouts were of a lower nutritional value for the insects than the cabbages. They then looked at the consequences for the food web around the aphid.

The implications of poor nutritional quality spread throughout the web. The sprouts affected not only the herbivorous aphids, but also the aphid's primary predator, a parasitoid wasp, which mummifies and eats aphids. This in turn affected a secondary parasitoid wasp that eats the primary wasp.

One of the paper's authors, Frank Van Veen, explains, 'Our study has shown that changing just one element, in this case plant quality, leads to a cascade

of effects that impact on predators across the food web.

'The important message in my view is that when we want to predict the ecological effects of environmental change we need to take interactions among species into account. For example, climate change may affect a particular species directly, say temperature affects growth rate, but it can also affect them indirectly, through effects on other species in the ecological community that are passed on through a network of interactions.'

Beacons for public engagement

THE UK'S major research funders have committed £9.2 million to a new initiative to encourage, recognise and reward academics who invest time and energy in public engagement.

The Beacons for Public Engagement project, launched in February, will comprise six beacons: Manchester, Newcastle, Norwich, London, Cardiff and Edinburgh, and a coordinating centre in Bristol.

Active volcano found beneath Antarctic ice

A LAYER of ash across an area larger than Wales is the first evidence of a volcanic eruption from beneath Antarctica's most rapidly changing ice sheet, say scientists in the journal *Nature Geoscience*.

The volcano on the West Antarctic ice sheet erupted over 2000 years ago (325BC) but

remains active.

Scientists from the British Antarctic Survey used airborne ice-sounding radar to find the ash.

Lead author Hugh Corr says, 'The discovery of a subglacial volcanic eruption from beneath the Antarctic ice sheet is unique in itself. But our techniques also allow us to put a date on the eruption, determine how powerful it was and map out the area where ash fell.

'We believe this was the biggest eruption in Antarctica during the last 10,000 years. It blew a substantial hole in the ice sheet, and generated a plume of ash and gas that rose around 12km into the air,' he added.

'A recent volcanic eruption beneath the West Antarctic ice sheet'. *Nature Geoscience*, online.

Rapid Watch green light

Funding of £16.1 million has been agreed for the Rapid Watch programme, a follow-on from NERC's successful and influential Rapid Climate Change programme. The announcement guarantees daily measurements of the Atlantic Meridional Overturning Circulation, the ocean circulation largely responsible for western Europe's temperate climate, up until 2014. The centre-piece of the Rapid Climate Change programme is a pilot array of scientific instruments across the Atlantic Ocean along the latitude 26.5° North. The funding will ensure this array provides at least a decade of data. Climate models predict greenhouse gas emissions could cause an abrupt slowdown of the circulation.

In quotes

'Looking around today I can see how the House of Commons could benefit from some of the design innovations here.'

Prime Minister Gordon Brown at the launch of the Environment Centre Wales.

'This is a remarkable time to be working at the highest level in scientific research. The challenges have never been so great, the responsibilities never so acute, the costs never so high. We have a responsibility to work with policy-makers and the public to ensure we deliver the research in a form they can use.'

NERC Chief Executive Alan Thorpe speaking to ministers and vice-chancellors at the launch of the science budget.

'It is an extremely worrying development.'

Sarah Wanless, Centre for Ecology & Hydrology, in *The Observer* on the spread of pipefish in UK waters.

'Sufficient evidence has emerged... for recognition of the Anthropocene.'

The Stratigraphy Commission of the Geological Society of London in the journal *GSA Today*.

'It appears you had a life changing impact on our pupils. Parents say some children have changed their GCSE options on the strength of last year's volcano exercise!'

Clive Beckwith, Carlton le Willows school, Gedling, Nottingham to scientists from the British Geological Survey.

Bye, bye black sheep

ON THE REMOTE Scottish island of Hirta, an apparent contradiction to Darwin's idea of survival of the fittest has been unravelled.

Within the island's population of Soay sheep, dark brown sheep are larger than their tawny coloured relatives. However, although large animals are more likely to survive and reproduce, the frequency of dark brown sheep has declined over the past 20 years.

A team of researchers from Sheffield, Edinburgh and Brisbane report in the American journal *Science*, 'Explaining such discrepancies is a major challenge in evolutionary biology.'

With no natural predators on the island, the researchers could discount camouflage as an evolutionary driver.

'It comes down to where on the genome the coat colour gene is located,' says lead author Jake Gratten from the University of Sheffield. 'It just happens to be closely linked genetically to other genes controlling body size, as well as juvenile survival and reproductive success.'

The team used statistical genetic techniques to show that the dark-colour gene tends to be co-inherited with genes for large body size but reduced juvenile survival and reproductive success. Conversely, the light-colour gene is co-inherited with genes for smaller size but greater survival and reproductive success. This means that sheep with two copies of the dark gene are large, but have poor survival and reproductive success

compared to both light-coloured sheep and dark sheep with one copy of the dark gene and one copy of the light gene. Overall, sheep carrying the light-colour gene are favoured, which explains the decline in frequency of dark sheep.

Sheep with two copies of the dark gene look identical to sheep with one dark and one light gene, making it impossible to explain the decline without first using a genetic test to distinguish between the two types of dark sheep.

The St Kilda sheep have long drawn evolutionary biologists off the mainland. Jake explains, 'The population is ideal to study because of its simplicity; there are no natural predators and there is no immigration or emigration. The population increases naturally while resources permit, then as much as 70 percent of the population can die over winter. Only the largest, healthiest individuals survive these population crashes.'

The research, based on two decades of data, shows that selection acting on simple traits such as coat colour, which are controlled by a single gene, can have a complex genetic basis. It also highlights the importance of understanding the genetic basis of fitness variation when making predictions about the evolutionary consequences of selection.

'A localized negative genetic correlation constrains microevolution of coat color in wild sheep'. *Science*, Vol. 319

Bird arrival time switch



David Klauer/Nature Picture Library

RESEARCHERS have recorded what may be a curious evolutionary consequence of climate change: the arrival order of two birds to UK shores, the sand martin and the barn swallow, has reversed.

Historically, barn swallows winter in southern Africa, arriving in Britain in late February or early March. The sand martin winters in western Africa, departing for the UK later in March. Warmer weather in Europe is driving changes in migration timing.

When scientists from the Centre for Ecology & Hydrology (CEH) and Adam Mickiewicz

University, Poland, examined 56 years of migratory data, they found that sand martins now arrive on average before barn swallows.

Tim Sparks from CEH says the findings clearly show the birds are changing at different rates and proposes this may be evidence of an evolutionary response or adaptation to a warming climate. The arrival date, at least in barn swallows, is heritable.

Patterns of spring arrival dates differ in two hirundines. *Climate research*, Vol. 35.

Location, location, location

FOR CENTURIES environmental scientists have been granted access to rivers to do their research, but until now, they have never owned their own. The Centre for Ecology & Hydrology has recently purchased 600m of the River Lambourn, near Boxford in Berkshire to permit unlimited access to the river and allow researchers to set up more permanent facilities.

The river, which is located in the chalk uplands of the Berkshire Downs, comes with 24 acres of water meadows and has been designated a Site of Special Scientific Interest (SSSI).

A team of researchers are already working at the site, but the centre aims to launch a comprehensive research programme in spring.