

Molecular evolution in Uppsala

What's the Difference?

Lab Times talks to Hans Ellegren about how a humble bird from the forests of Sweden could help to answer one of biology's most problematic questions: Which genes are responsible for forming a species?

Imagine a birdwatcher and the chances are you'll think of a man packing his lunchbox, cleaning his binoculars, yawning (it is 4.30am) and pulling on a sensible anorak. He is probably in a hurry, having just received a text message telling him where some poor exhausted bird has been seen, blown thousands of miles off course. At least that's the stereotype.

Of course, this image of child-like enthusiasm, inspiring as it is, is not entirely representative of your average birder. Nevertheless, 'twitching' (tracking down rare birds to tick their names off a personal 'seen' list) remains surprisingly popular. Maybe it touches a deep-rooted urge to categorise and understand our environment.

It is certainly a step too far to say that bird-watching is directly useful to evolutionary biologists. However, the careful ob-

servation of animals in their native environment is the bedrock upon which the work of a modern evolutionary biologist is built. One such scientist, Hans Ellegren, heads a research group at the University of Uppsala, Sweden. His group's projects are diverse, but focus on birds and have an overarching interest in the genetic basis for adaptive evolution in natural populations.

modern discipline by Nico Tinbergen (himself a bird-watcher), when he described the different ways in which a 'why' question can be answered in biology. Why do birds sing in the morning? Why do animals hang around in groups? Why do males fight? All perennial questions. And from the sound home economics of a starling deciding when is best to stop collecting grubs and carry them back to the nest, to the evolutionary arms race between cuckoo chicks and their unwilling hosts, birds have taken centre stage. After all, it was birds that started the whole thing off when their beaks helped Charles Darwin to crystallise his theory of evolution by natural selection.

But to what extent can behaviour be explained by an animal's genes? How deep is the link between phenotype and genotype, and what is the relation to a species'

had an enormous effect, in various ways. For example, genetic resources have allowed analyses of relationships within and between populations in a way that was previously not possible. Moreover, genomic sequences have told us a lot about the role of natural selection and genetic drift as driving forces during evolution." However, the answer seems not to be the emphatic "yes" that you might expect. "What we are still to see is translating genome sequences into those specific phenotypic traits, characteristic to individual species and evolutionary lineages", Ellegren says.

A fast growing field

However, Ellegren warns against an overly pessimistic attitude and highlights the wider benefits of understanding the genetics of natural populations. "Getting to know what the genes look like in the species which live around us is very important basic knowledge. Knowledge we need to understand, for example, biodiversity."

The field of molecular evolutionary biology is undoubtedly growing fast. As an example, Prof Ellegren points to the journal *Molecular Ecology*, whose impact factor has increased steadily since the journal was first published in 1992 (it now stands at a very respectable 5.1) and is now a very successful ecology journal in its own right. "Indeed, if you browse through evolutionary journals in general, there is a lot of genetics and an increasing amount of genomics."

Learning from large scale studies

Ellegren's view of the relatively new discipline of molecular evolutionary biology also hints at what he sees as one of evolutionary biology's biggest challenges in coming years: speciation, or how two populations become different species. "There have been some attempts in this direction in models like *Drosophila*, but I think we will come to see many more examples using natural populations of birds and mammals."

The basis for speciation has vexed biologists since the publication of Darwin's *The Origin of Species* 150 years ago (a book which, funnily enough, doesn't say too much about the subject). But the applica-



Pied and collared flycatchers have only recently split into separate species. Now Hans Ellegren wants to pinpoint the genetic differences in their genomes.

Looking at animal behaviour through the lens of evolution was kick-started as a

ecology? This is where Hans Ellegren and his team step forward. It is clear to most of us that over the last ten years genome sequencing has changed the face of many areas of biology. But has this change also swept through evolutionary biology? Since Ellegren's interest focuses on explaining evolutionary phenomena in molecular terms, he is ideally placed to address the question. He is quick to emphasise all that genome sequences have done for us. "Clearly it has

tion of state-of-the-art molecular techniques could, potentially, start to provide some answers. Hans Ellegren certainly thinks so, "Being able to study genomes and gene expression on a large scale, I foresee that we will get to learn what it is about two populations that makes them become different species".

Polygynous birds

So we are brought, full circle, back to birds and one bird in particular. Mention *Ficedula hypoleuca*, or the pied flycatcher, to an evolutionary biologist and they may well go misty-eyed about Rauno Alatalo and Arne Lundberg's elegant experiments in the 1980s on polygyny (males mating outside their pair with other females).

These experiments used a population of birds in woodland to the south of Uppsala and the subject of the study is also the subject of Ellegren's next genomics project. He is planning to sequence the genomes of the pied flycatcher and its cousin, the collared flycatcher, *F. albicollis*. "These species have been studied for



Hans Ellegren

a very long time, in terms of their life history and their evolutionary history." This work has generated a breadth of knowledge which makes them a very attractive target for a genomics expert. "We hope to pinpoint the probably very few differences which underly their separation." Hans Ellegren hopes that by understanding these genetic differences, he will be able to identify which genes define species and to understand their role.

Genetic markers for behavioural traits?

So how much can genomic data reveal? Can it, for example, start to explain an animal's behaviour? Can the link between genotype and phenotype be stretched to include the genes which are responsible for finding out what a bird prefers for breakfast? To address such fundamental issues in molecular evolution (and not necessarily those phrased so glibly), Ellegren has teamed up with Wolfgang Forstmeier at the Max-Planck Institute for Ornithology in Seewiesen near Munich. Together, they will analyse a captive population of zebra finches in which a number of behavioural traits have already been measured. Ellegren's task is to produce a genetic map

of the molecular markers that he finds to complement these data. The next step is to analyse the co-segregation of behavioural traits with specific markers.

"The zebra finch is a very useful model for studying neurobiological processes which lie behind certain behaviour." By using such a well characterised model species, they hope to link specific behavioural traits to specific loci.

It appears, then, that it is the depth of knowledge about birds' behaviour gained over decades of careful observation and documentation which now promises to be so useful in unlocking the secrets of their evolution. It may also help to find more general trends and principles relevant to all life. A salutary lesson to those who recommend that research be driven by pre-defined and predictably deliverable goals.

Hans Ellegren's research group is based in the Evolutionary Biology Center of Uppsala University, an institute which brings together groups with a wide range of expertise under one roof and is one of the largest of its kind in Europe. He is funded almost exclusively by competitive grants from the Swedish Research Council. Over the last ten years or so, the Swedish government has decided to fund not only small and medium sized grants, but larger ones too. Two of these, one for a Strong Research Environment, the other for a Centre of Excellence, are organised by Ellegren and help keep his group ticking over, giving it also some much-coveted long term stability.

From small to large grants

So what is it like working in Sweden, a country which prides itself on its highly developed social insurance systems? "Many PhD students will have children during their studies and may stay at home for a year during this time...it is also common for both men and women to try and combine more equally a scientific and a family life". Ellegren is quick to point out, though, that there is no short-cut to scientific success, since "dividing time between home and work often becomes a very difficult equation to balance". *Allocation of time budgets in a population of Swedish evolutionary geneticists*: must be a project in there somewhere...

WILLIAM TEALE

Lab Times

Founded 2006. Issue 1, 2009

Lab Times is published bimonthly

ISSN: 1864-2381

Publisher: LJ-Verlag Herfort und Sailer
Kai Herfort, Ralf Neumann, Hubert Rehm

Office: Alte Straße 1, 79249 Merzhausen, Germany
Tel.: +49 (0)761-286869; Fax: +49 (0)761-35738

Management: Kai Herfort, Tel: +49 (0)761-286869

Editors:

Ralf Neumann (Editor-in-chief), Kai Herfort, Winfried Koeppelle, Hubert Rehm, Harald Zähringer
Tel.: +49 (0)761-2925884, editors@lab-times.org

Reporters:

Thorsten Braun, Susanne Dorn, Rafael Florés, Jeremy Garwood, Andrea Herb, Karin Hollricher, Matthias Nawrat, Livia Puljak, Ralf Schreck

Graphics, Design and Production:

Ulrich Sillmann (Art Director), Kai Herfort, Winfried Koeppelle, Ralf Neumann, Harald Zähringer

Cover Artwork: Kai Herfort

Sales:

Advertising Manager: Bernd Beutel
Top-Ad Bernd Beutel, Hammelbacherstraße 30,
69469 Weinheim, Germany
Tel: +49 (0)6201-29092-0
Fax: +49 (0)6201-29092-20
info@top-ad-online.de

Recruitment:

Ulrich Sillmann,
Tel: +49 (0)761-2925881, jobs@lab-times.org

Printed at:

Stürtz GmbH,
Alfred-Nobel-Straße 33, 97080 Würzburg, Germany

Web:

www.lab-times.org
Webmaster: Carsten Rees
Tel.: +49 (0)761-1563461,
webmaster@lab-times.org

Prices & Subscription rates:

- price per issue: €3,50
- research institutes/units: free of charge
- annual subscriptions for companies and personal subscribers: €20

Subscribe at <http://www.labtimes.org/kontakt/sub.html>, or mail to: subscriptions@lab-times.org

Bank Accounts:

- Volksbank Freiburg
KTO: 319 0 315,
BLZ :680 900 00,
BIC: GENODE61FR1
IBAN: DE24 6809 0000 0003 1903 15

- Basler Kantonalbank
KTO: 16 428.471.36
BIC: BKBBCHBB
IBAN: CH06 0077 0016 0428 4713 6