Workshop on population and speciation genomics

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evolution

“The process by which different kinds of living organism are believed to have developed from earlier forms during the history of the earth.”

The Oxford Advanced Learner’s Dictionary
evolution

heritable variation + selection

ADAPTATION INNOVATION SPECIATION

species

- ...are fundamental (real) natural units

Bombina bombina

Bombina variegata
\textbf{species}

\begin{itemize}
  \item \ldots are varied
\end{itemize}

\textbf{Ring Species:}
Two species appear to be present at one place, but those two “species” are connected by a series of forms that are geographically arranged in a ring. No phenetic character could be used, except arbitrarily, to divide the ring into two species. A division would be meaningless, as there really is a continuum, not a number of clear-cut, separate species.

\textbf{species}

\begin{itemize}
  \item \ldots are not (always) easy to define
\end{itemize}
Paraphyletic Species:
The evolution of part of the original species into a new one renders the remaining populations paraphyletic. For example, the Blue Tit (*Parus caeruleus*) is a paraphyletic species. The North African subspecies *P. c. degener* and *P. c. ultramarinus* are the sister group to the European Blue Tit (*P. c. caeruleus*) plus the Eurasian Azul Tit (*P. cyanus*) with four subspecies (*P. c. cyanus*, *flavipectus*, *tianshanicus*, and *yaniseensis*).

“Species are groups of interbreeding natural populations that are reproductively isolated from other such groups” (Mayr 1963)
speciation continuum

ancestral species

no

partial

complete

reproductive isolation

species A

species B

time

speciation continuum

locus under selection

chromosome [position]
disruptive selection
divergence hitchhiking

diversity

genome hitchhiking

post-speciation divergence

reproductive isolation

time

JL Feder, SP Egan & P Nosil (2012) TREE
speciation continuum

V Soria-Carrasco et al. (2014) Science

selection

Charles R. Darwin (1809-1882)
natural selection

... “is the process by which the forms of organisms in a population that are best adapted to the environment increase in frequency relative to less well-adapted forms over a number of generations” (Ridley 1996)

sexual selection

... “is the selection on mating behavior, either through competition among members of one sex (usually males) for access to members of the other sex or through choice by members of one sex (usually females) for certain members of the other sex” (Ridley 1996)
<table>
<thead>
<tr>
<th>sexual selection</th>
<th>fitness</th>
<th>competitors</th>
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<td>individual fitness</td>
<td>other members of the same sex</td>
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| natural selection | fitness of the genotype | other individuals in the same population |

...operates if the following conditions are met:

- **reproduction**: organisms must reproduce to form new generations
- **heredity**: offspring resemble parents ("like must produce like")
- **trait variation**: individuals in natural populations vary in (adaptive) traits
- **variation in fitness**: individuals in natural populations vary in the number of their offspring that survive to reproduce (‘lifetime reproductive success’)

(Ridley 2004; Stearns & Hoekstra 2005)
Natural populations show variation at all levels, from gross morphology to DNA sequences. Selection can only operate, if heritable variation exists.

Natural variation is generated by two processes:

- **Recombination**
  - "reshuffling" of genetic material by introducing or breaking up physical linkage

- **Mutation**
  - Generation of new genetic variation by "mistakes" during the copying of a DNA strand
New mutations are only transmitted to the next generation, if they occur in *germinal tissue*!
natural variation

The Heliconius Genome Consortium (2012) Nature

D Brawand et al. (2014) Nature