

BIOL 112

Lecture 4: Evolution and Speciation

Reminders

- Answers to the HMNH are due at the beginning of lab this week. You must type them and turn in your pin.
- Prelab: Skulls and Evolution also due this week. Read the manual before lab.



iclicker #3. A high proportion of the cats on Key West have extra toes (polydactyly). What is the most likely explanation?

- a) high rate of mutation
- b) founder effect
- c) bottleneck effect
- d) directional selection for extra toes

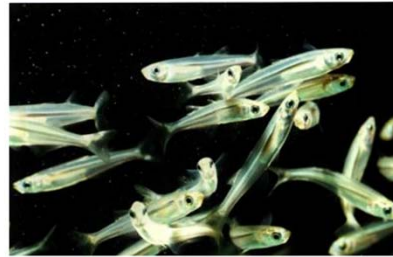
Answer: b

This question asks students to apply an understanding of the different mechanisms of evolution to formulate a hypothesis that explains an actual situation. In this case, history tells us that the so-called Hemingway cats descended from a six-toed cat brought to the island by a ship captain in the 1800s.

Frequency dependent selection (balancing selection) and sex ratio

Most species are observed to have balanced sex ratio 1 male:1 female. Easily explained by meiotic segregation of sex chromosomes but what about species w/out sex chromosomes?

Sex in Atlantic silversides is determined by genes and temperature, but the influence of temperature varies with latitude.



In South low temps early in season more females develop, high temps later in season more males develop

In North (i.e.) Nova Scotia temp does not affect sex

Kept populations at constant temp for years. Initially had a large proportion of one sex but over time frequency dependent selection yielded a balanced sex ratio

Speciation

- The origin of a new species. Important focus of evolutionary studies.
- **Microevolution:** consists of changes in allele frequency in a population over time
- **Macroevolution:** broad pattern of evolutionary change above a species level

The Biological Species concept

- The **biological species concept** states that a **species** is a group of populations whose members have the potential to interbreed in nature and produce viable, fertile offspring; they do not breed successfully with other populations
- Gene flow between populations holds the phenotype of a population together

Other Definitions of Species

- Other species concepts emphasize the unity within a species rather than the separateness of different species
- The **morphological species concept** defines a species by structural features
 - It applies to sexual and asexual species but relies on subjective criteria

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- The **ecological species concept** views a species in terms of its ecological niche
 - It applies to sexual and asexual species and emphasizes the role of disruptive selection
- The **phylogenetic species concept** defines a species as the smallest group of individuals on a phylogenetic tree
 - It applies to sexual and asexual species, but it can be difficult to determine the degree of difference required for separate species

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Reproductive Isolation

- **Reproductive isolation** is the existence of barriers that impede two species from producing viable, fertile offspring
- **Hybrids** are the offspring of crosses between different species (maybe be viable, not viable or not fertile)
- Reproductive isolation can be classified by whether factors act before or after fertilization

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Prezygotic barriers block fertilization from occurring by:

- Impeding different species from attempting to mate
- Preventing the successful completion of mating
- Hindering fertilization if mating is successful

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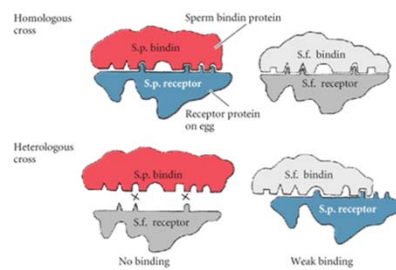
- **Habitat isolation:** Two species encounter each other rarely, or not at all, because they occupy different habitats, even though not isolated by physical barriers
- **Temporal isolation:** Species that breed at different times of the day, different seasons, or different years cannot mix their gametes
- **Behavioral isolation:** Courtship rituals and other behaviors unique to a species are effective barriers
- **Mechanical isolation:** Morphological differences in sexual organs of closely related species can prevent successful mating

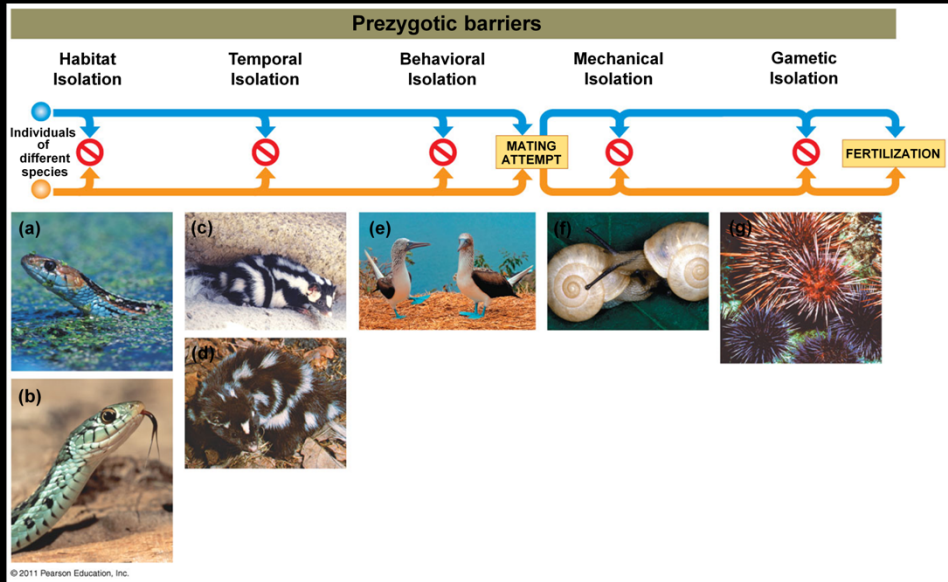
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Gamete isolation

- Sea urchins release eggs and sperm into open ocean.
- How do the sperm and egg of the same species recognize each other?

QuickTime™ and a decompressor are needed to see this picture.





Postzygotic barriers prevent the hybrid zygote from developing into a viable, fertile adult:

- Reduced hybrid viability: Genes of the different parent species may interact and impair the hybrid's development
- Reduced hybrid fertility: Even if hybrids are vigorous, they may be sterile
- Hybrid breakdown: Some first-generation hybrids are fertile, but when they mate with another species or with either parent species, offspring of the next generation are feeble or sterile

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Postzygotic barriers

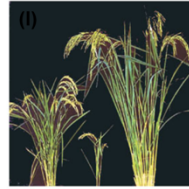
Reduced Hybrid Viability

Reduced Hybrid Fertility

Hybrid Breakdown

FERTILIZATION

VIABLE, FERTILE OFFSPRING



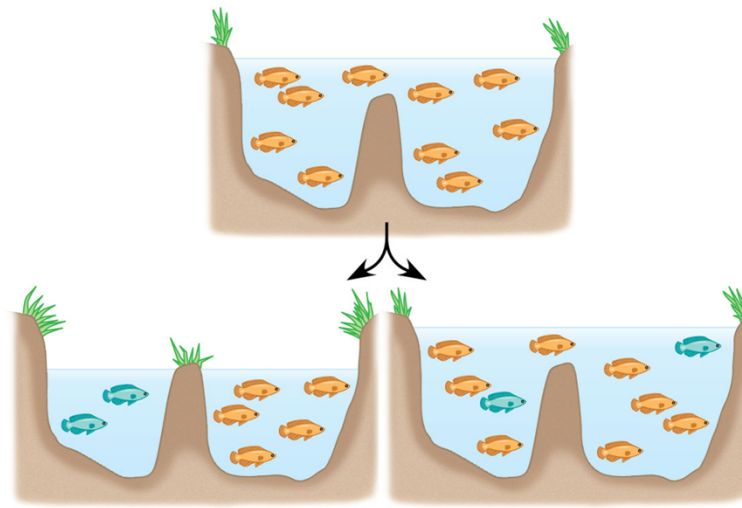
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Speciation can take place with or without geographic separation

- Speciation can occur in two ways:
 - Allopatric speciation
 - Sympatric speciation

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Figure 24.5



(a) Allopatric speciation.
A population forms a new species while geographically isolated from its parent population.

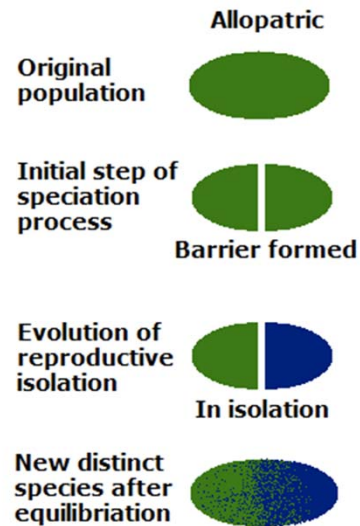
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(b) Sympatric speciation.
A subset of a population forms a new species without geographic separation.

Figure 24.5 Two main modes of speciation.

Allopatric (“Other Country”) Speciation

- In **allopatric speciation**, gene flow is interrupted or reduced when a population is divided into geographically isolated subpopulations



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Figure 24.6



- The definition of barrier depends on the ability of a population to disperse
 - For example, a canyon may create a barrier for small rodents, but not birds, or pollen

Figure 24.6 Allopatric speciation of antelope squirrels on opposite rims of the Grand Canyon.

More examples of Allopatric Speciation

- 15 pairs of sibling species of snapping shrimp (*Alpheus*) are separated by the Isthmus of Panama
- These species originated 9 to 13 million years ago, when the Isthmus of Panama formed and separated the Atlantic and Pacific waters

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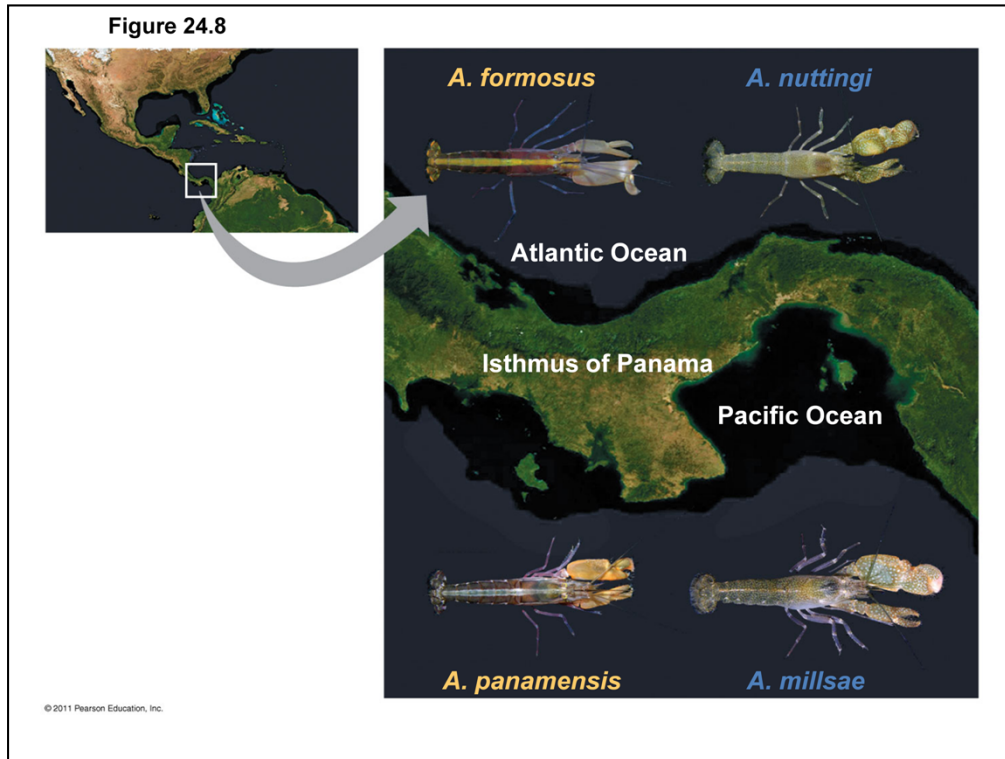
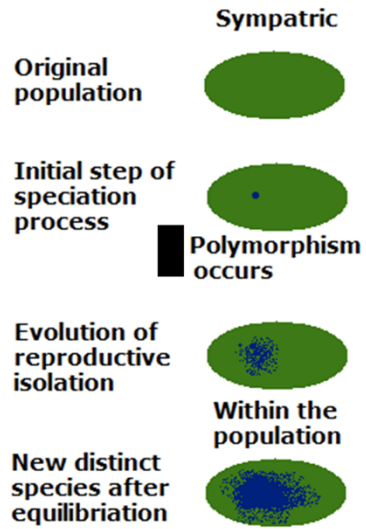


Figure 24.8 Allopatric speciation in snapping shrimp (*Alpheus*).

Sympatric (“Same Country”) Speciation

- In **sympatric speciation**, speciation takes place in geographically overlapping populations



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Examples of Mechanisms of Sympatric speciation

- Chromosome change
- Disruptive selection
- Hybrids
- Co-evolution eg. between insect and host plant species. If a portion of the population switches plant species

- An **allopolyploid** is a species with multiple sets of chromosomes derived from different species e.g. *Tragopogon* spp.

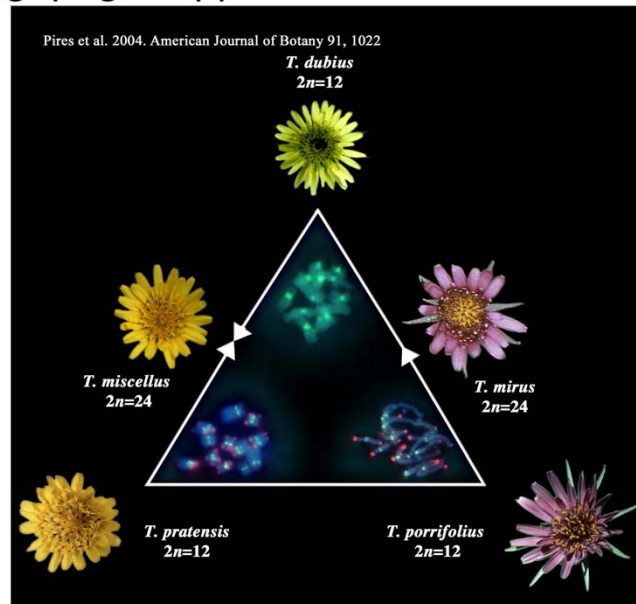
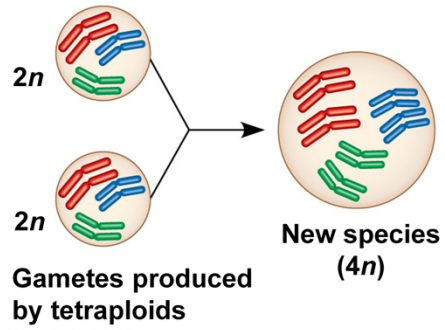
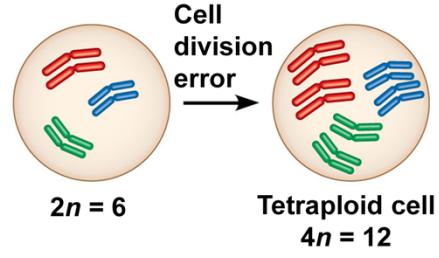


Figure 24.UN01



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Figure 24.UN01 In-text figure, p. 495

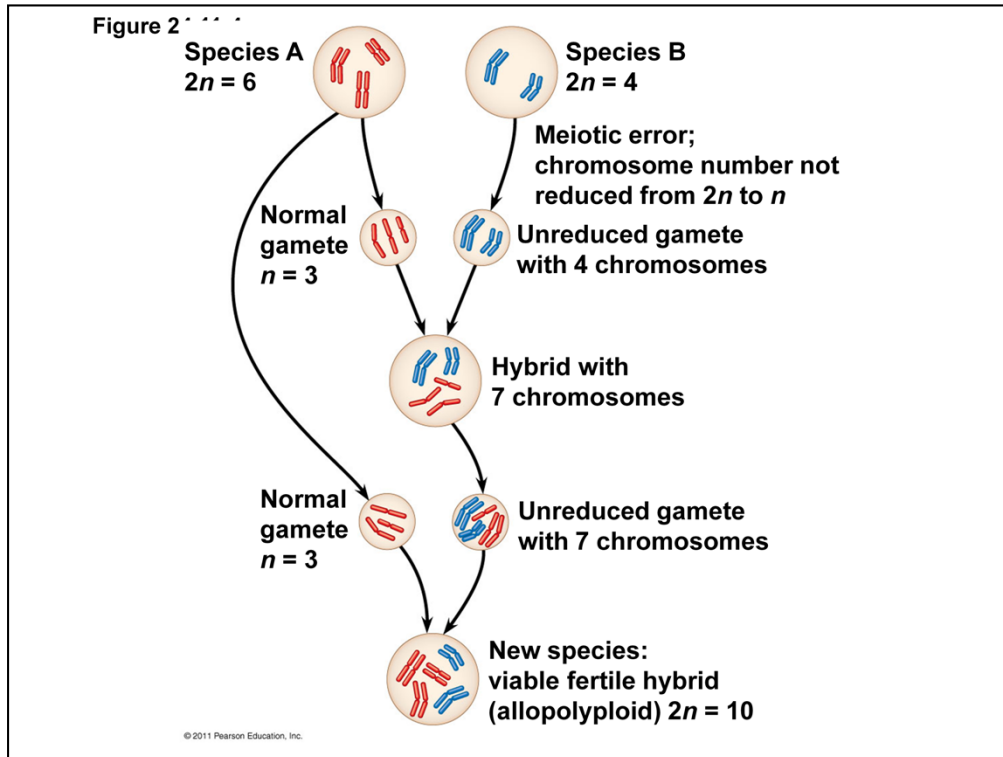


Figure 24.11 One mechanism for allopolyploid speciation in plants.

Lake Victoria Cichlids

- Rapid speciation: Evidence lakes were dry 14000 years ago. From an estimated 5 ancestral species, 400 species evolved



Mechanisms proposed to explain rapid speciation: Sexual selection for color variation, Disruptive selection, ecological niche partitioning

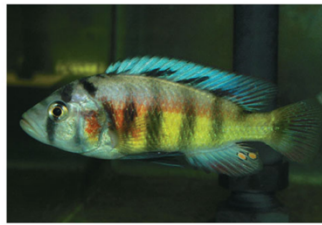
Figure 24.16



Pundamilia nyererei



Pundamilia pundamilia



Pundamilia "turbid water,"
hybrid offspring from a location
with turbid water

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Figure 24.16 Fusion: The breakdown of reproductive barriers.

Figure 24.12

EXPERIMENT

Normal light

**Monochromatic
orange light**

P. pundamilia



P. nyererei



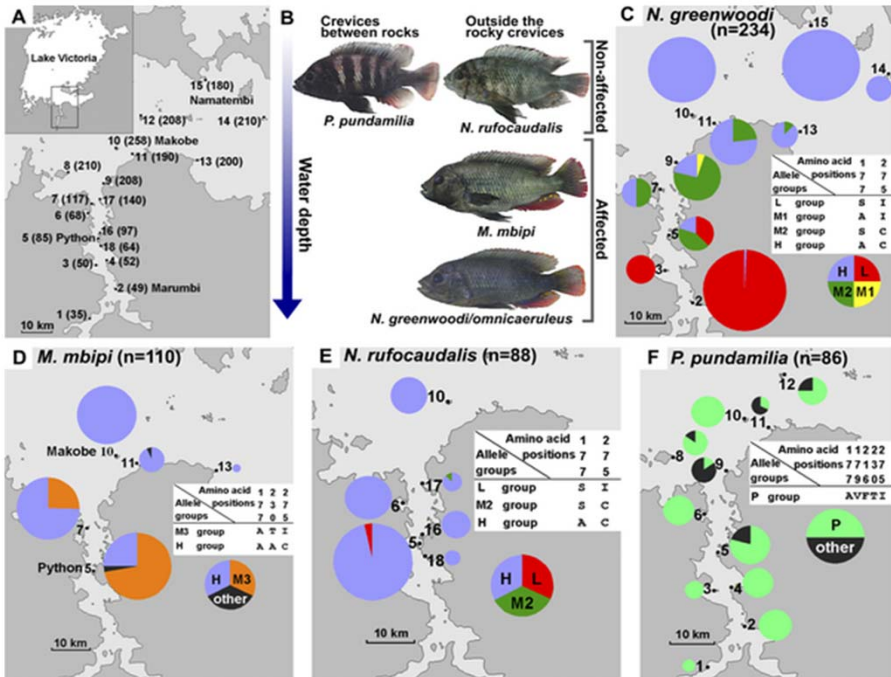
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Figure 24.12 Inquiry: Does sexual selection in cichlids result in reproductive isolation?

Species decline in Lake Victoria

- Introduced perch species has decimated many species of cichlids
- Pollution has increased turbidity of Lake preventing species from selecting mates by color

Divergent Selection



Co-evolution insects and plant host



Pea aphid species *Acyrthosiphon pisum* populations on clover or alfalfa. Genetically divergent. Reproductively isolated because they mate on the host plant. Individuals born populations on clover choose clover, and individuals born on alfalfa choose alfalfa. Considered to be in process of sympatric speciation.

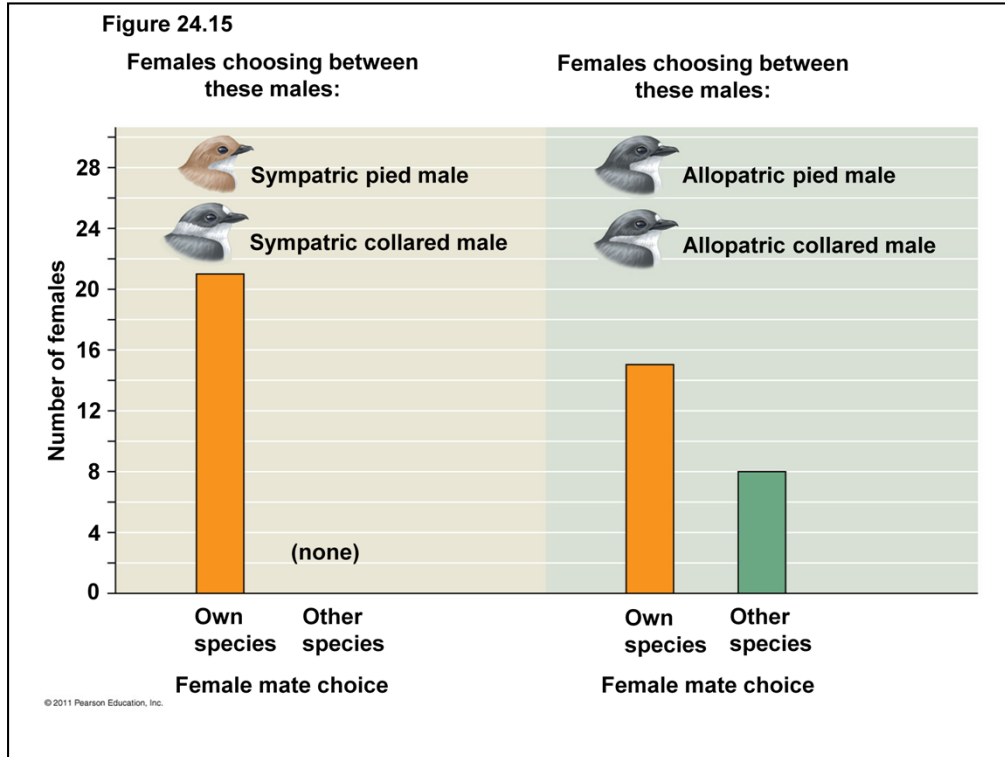


Figure 24.15 Reinforcement of barriers to reproduction in closely related species of European flycatchers.