Conservation genetics

A fundamental level of biodiversity

A hypothetical example

• You’re the manager of a conservation reserve housing the endangered “spectacled hummus marmoset”
• There are only two or three small populations left, each with < 50 individuals
• What are you concerned about from a genetic standpoint?
• What should you try to do about it?

Conservation vs. “Normal” Ecology

• Just a reminder that we’re focusing on situations of low population abundances (usually) caused by human actions
• Are there examples of low population numbers without humans involved?
  – Bottleneck effect
  – Founder’s effect

Low numbers of individuals means…

• Difficult to maintain genetic diversity
• Effects of genetic drift become apparent
• A greater chance of inbreeding will occur

A real example

• 1982: 22 individuals
• 2014: 425 individuals
  – (219 in the wild)
• In 1987 all were in captivity
• Reintroduced in 1992
• Cost $35-40 million over last 20+ yr
• Do you think 22 birds have enough genetic diversity to keep a species going?

What are we not going to talk about?

• Identifying species for CITES
• Monitoring species’ abundance and distribution
• Paternity analysis

http://alaska.fws.gov/gem/mainPage_1.htm
Why is low genetic diversity thought to be bad?

• Richard Frankham’s (1995) review argued species with low variation would have “reduced ability to cope with environmental change during evolution, and so have shorter evolutionary lifespans.” His evidence:
  – Selfing & asexual species are more prone to extinction than are outbreeders
  – Low variation is associated with increased susceptibility to diseases, pests, and parasites in domestic animals & plants, and weeds
  – Loss of variation led to increases in parasite load in fish in the wild
• Your critique of the evidence?

Low numbers of individuals means…

• Difficult to maintain genetic diversity
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Genetic drift

• Is…

• Occurs in ALL populations, but effects are most prominent in _____ populations
• A type of ‘sampling error’ that can lead to ____ of genetic diversity

Fig. 11.3

Inbreeding effects first seen where?

• A few decades ago, inbreeding was ignored as a potential problem in conservation
• Ralls’ data changed our views

Inbreeding depression

• Is…

• Alleles in question are usually selected against in large populations, but maintained in low proportions

Inbreeding and Juvenile Mortality in Small Populations of Ungulates

Abstract: Juvenile mortality of inbred young was higher than that of noninbred young in 15 of 16 species of captive ungulates. In 19 of 25 individual females, belonging to ten species, a larger percentage of young died when the female was mated to a related male than when she was mated to an unrelated male.

Rails et al. 1979, Science

Rails et al. 1988
Any possible problems of reducing inbreeding?

• No, I’m not advocating inbreeding
• Rather, are there concerns with some of the solutions?

OD can occur because...

• ??
• And groups of co-adapted genes can be disrupted

Translocation Causes Extinction of a Local Population of the Freshwater Shrimp Paratya australiensis

Species Survival Plans

• Successful captive breeding of imperiled species in zoos are subject to guidance from the Association of Zoos and Aquariums
• An important type of ex situ conservation
• One cautionary note:
  – Captive breeding may reduce fitness in the wild

So, should we care?

• Maintaining genetic diversity is important, but it’s often more complicated than simply ensuring inbreeding does not occur
  – Remember, natural selection often decreases genetic variation present by selecting for best adaptations (e.g., directional and stabilizing selection)
• Nevertheless, resource managers must act to protect species, especially if the species is listed as Threatened or Endangered
• What can managers do to ensure genetic diversity is maintained even when they do not have the resources to conduct genetic testing?

Effective population size

• (Genetically) effective population size, $N_e$, equals the …

• Richard Frankham’s review of several studies found $N_e$ to be ___% of $N$, or the typical census size

Minimum viable population size

• So, from a genetic diversity perspective, what is the minimum number of breeding individuals needed to maintain genetic diversity for some time in the future?
• MVP estimates the population size that should be sufficient for some time interval, often set at 100 years
Rules of thumb for population sizes to maintain genetic diversity (1)

- 50/500 rule (Franklin 1980)
  - 50 individuals ($N_e$) to offset inbreeding depression
  - 500 individuals ($N_e$) to offset genetic drift
- How is loss of genetic diversity offset?
  - _______ in these different sized populations
- Where did the estimates of _______ rates come from?
  - Lab populations of *Drosophila melanogaster*, variation in numbers of abdominal bristles
- Where did the 50 come from?

Rules of thumb for population sizes to maintain genetic diversity (2)

- 500/5000 rule (Lande 1995)
  - 500 individuals ($N_e$) to offset inbreeding depression
  - 5000 individuals ($N_e$) to offset genetic drift
- Why the increases?
  - Offsets are usually deleterious (90%), while only 10% are ‘quasi-neutral’ and provide potentially useful genetic variation
  - So, Franklin’s estimates need to be increased 10X
- Theory vs. data…

Traill et al. (2010)’s suggestions

- Most population estimates based on the best science and those for the long-term are around 5,000 individuals
- If we go lower than this (i.e., 50/500), we’re probably only ensuring a 100-yr window of safety against extinction
- Scientists are not policy makers, rather they provide scientifically-defensible options with explicit assumptions that can be examined by all stakeholders
  - Analogous to climate scientists providing predictions of future conditions given various assumptions
- Policy-makers can then decide whether or how much to act based on science, economics, politics, etc.

A dose of reality

- Genetic diversity of small populations can be important, but…
  - It typically takes several generations of reduced numbers before inbreeding depression really takes effect
  - Natural processes can offset loss of genetic diversity (although it takes many generations)
  - Heterozygosity by itself is not as important as being adapted to your environment
  - It’s irrelevant if your entire habitat is lost
- Genetic diversity must be combined with demographics and habitat considerations to safely conserve a species
  - Lande (1988)

One more dose of reality

- How do you reconcile the problem of little genetic diversity when species persist…
  - For 10,000 years, cheetahs have had 90-99% less variation than other cats (O’Brien et al. 1983)
  - Endangered Iberian lynx have had extremely low genetic variability for 50,000 years based on genetic data of old remains (Rodriguez et al. 2011)
  - The 200,000 northern elephant seals alive today descended from about 20 following over hunting in the mid-1800s
  - Mauritius kestrel; 4 individuals in 1974; today > 800

Offsetting loss of genetic diversity (1)

- 0.01 = 1% mutation rate per gene per generation
- But...100 to 10,000 X higher than usual
Offsetting loss of genetic diversity (2)

"Genetic rescue"

A segue to next chapter

See Frankham (2015; Molecular Ecology)