LAST LECTURE – basic genetics

You should be able to:

Calculate N_e and F

Understand how:

N_e affects drift and inbreeding

Drift and inbreeding influence genetic diversity

Genetics (basics) – alleles, heterozygosity, genetic drift, inbreeding, quantitative traits

Evolutionary Analysis

Ch 11. Principles of Conservation Biology 3e

Estimating effective population size. 1

If a harem has 1 male and 100 females, the effective size is

$N_e = (4 \times N_m \times N_f) / (N_m + N_f)$

$= (4 \times 1 \times 100)/(1 + 100)$

$= 400/101$

$= 4$

Unequal sex ratios reduce effective size

Estimating effective population size. 2

Variance in LRS = 12.1
Mean family size, k=1.7

If captive population N=10

$N_e = k(Nk-1)/(V_k+k(k-1))$

$N_e = 1.7(17-1)/(12.1+(1.7(0.7))$

$= 1.7(16) / 12.1+1.2)$

$= 27.2/13.3 \approx 2$

When $V_k/k > 1$ Ne is less than census size

Estimating effective population size. 2

Variance in LRS = 12.1
Mean family size, k=1.7

If captive population N=10

$$N_e=(Nk-1)/(k-1+(V_k/k))$$

$$N_e = (10x1.7-1)/(1.7-1+(12.2/1.7))$$

$$=(17-1) / (0.7+7.2)$$

$$= 16/7.9 \approx 2$$

When $V_k/k > 1$ Ne is less than census size

Estimating effective population size. 3

Hunting reduced Northern elephant seal pop'n to 20-30 individuals before they recovered to over 100,000.

Assume N_{e1}= 100,000

N_{e2}= 20

N_{e3}=100,000

Calc Ne

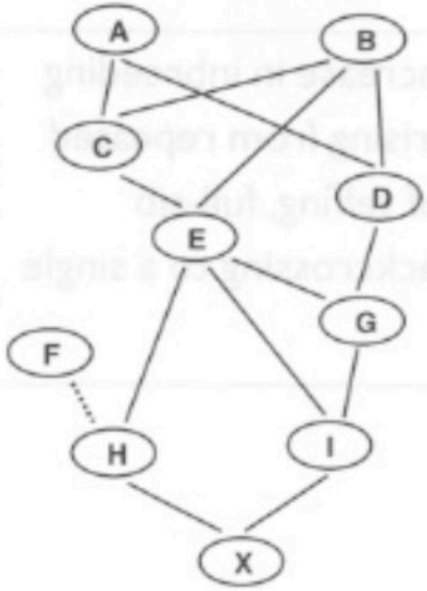
$Ne = t/(1/N_{e1} + 1/N_{e2} + 1/N_{e3})$

Ne= 3/ (0.00001+0.05+0.00001)

= 60

Effective size is much closer to minimum than mean

Calculating F



$$F=\sum(1/2)^n\ (1+F_{ca})$$

Paths	F_{ca}	Contribution to Fx
HEI	1/4	$(1/2)^3$x5/4
HEGI	1/4	$(1/2)^4$x5/4
HEBDGI	0	$(1/2)^6$
HECBDGI	0	$(1/2)^7$
HECADGI	0	$(1/2)^7$

$\sum$ means SUM

F_x= 0.2656

Calculating F - the coefficient of inbreeding

Isle Royale gray wolves
Established by 1 pair in 1949
heterozygosity = 3.9%
Mainland pop'n
heterozygosity = 8.7%

$F_e = 1-(H_t/H_0)$ $F_e = 1-(0.039/0.087) = 1 - 0.45$
$= 0.55$

How does:

N_e affects drift and inbreeding

Drift and inbreeding influence genetic diversity

Frankham 1996 summarized available data

TABLE 11.5 ***General Correlates of Genetic Variation among Population***

1. Genetic variation within species will be positively correlated with population size.
2. Genetic variation will be positively correlated with habitat area.
3. Genetic variation will be greater in species with wider ranges.
4. Genetic variation in animals will be negatively correlated with body size.
5. Genetic variation will be negatively correlated with rate of chromosomal evolution.
6. Genetic variation will be positively correlated with population size across species.
7. Genetic variation will be lower in vertebrates than in invertebrates or plants.
8. Genetic variation should be lower in island populations than mainland populations.
9. Genetic variation will be lower in endangered species than nonendangered species.

Source: After Frankham 1996.

Species with more diversity have larger pop'ns and occupy more area

Does this mean greater diversity is beneficial?

Evaluating the importance of inbreeding and loss of genetic variation in captive and/or wild populations?

Q.What information would you want?

Why might genetic processes become important in small populations?

Small populations - low Ne so EXPECT

Genetic drift → loss of heterozygosity
loss of rare alleles

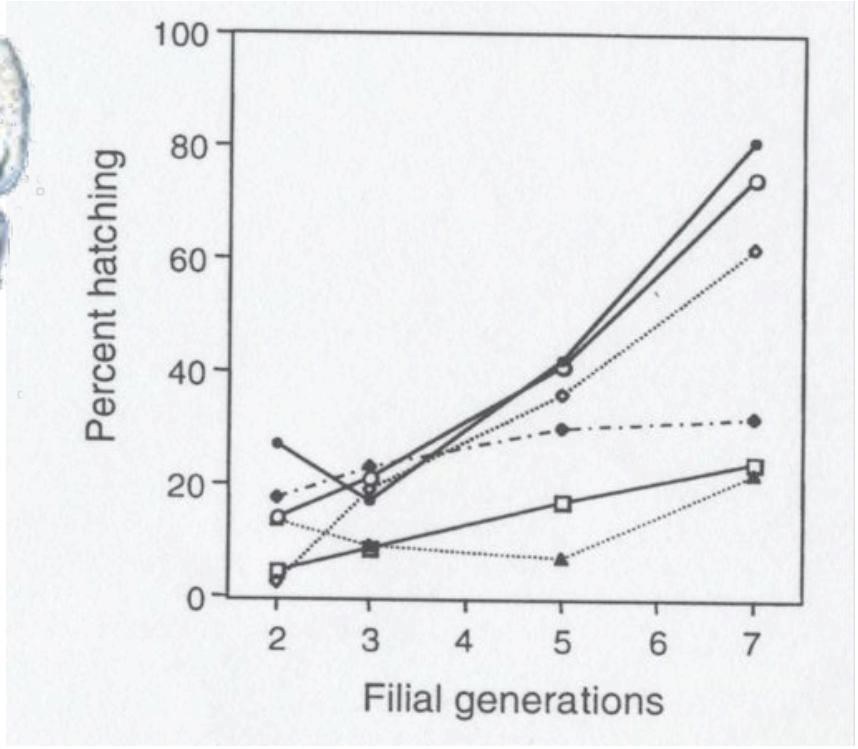
↘

Reduced Fitness
Lower Survival/Reproduction

↗

Inbreeding → loss of heterozygosity
exposure of deleterious recessives

What can reduce the impact of genetic processes?

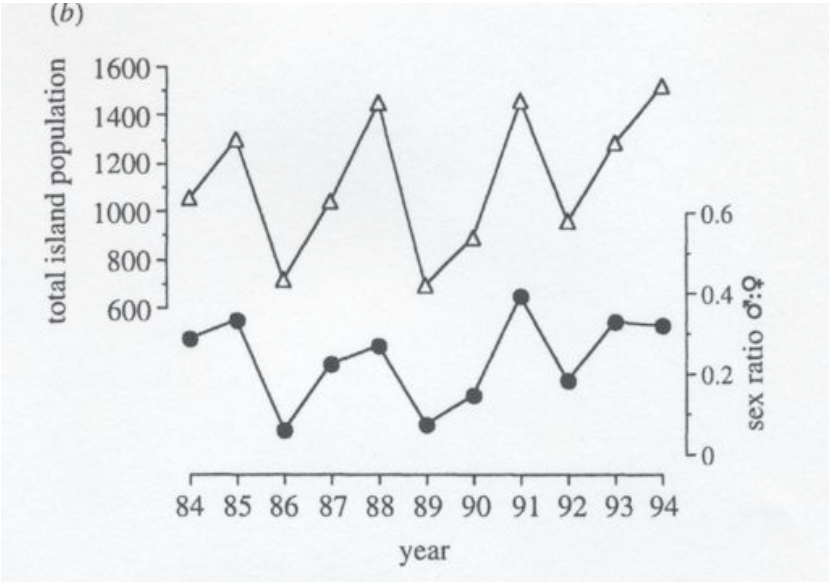


Purging may allow rapid recovery

Mate preferences may provide additional resilience against inbreeding depression

Selection during population crashes can increase mean H

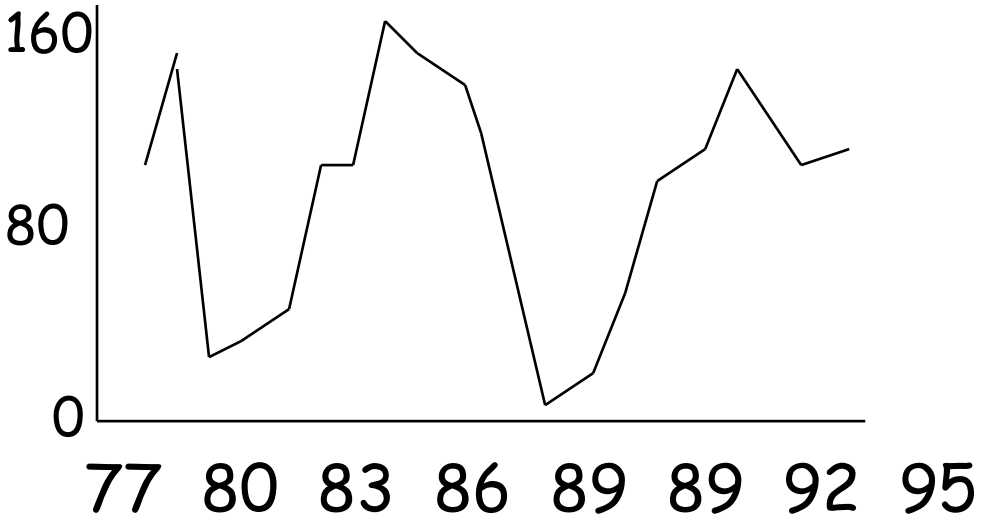
Soay Sheep

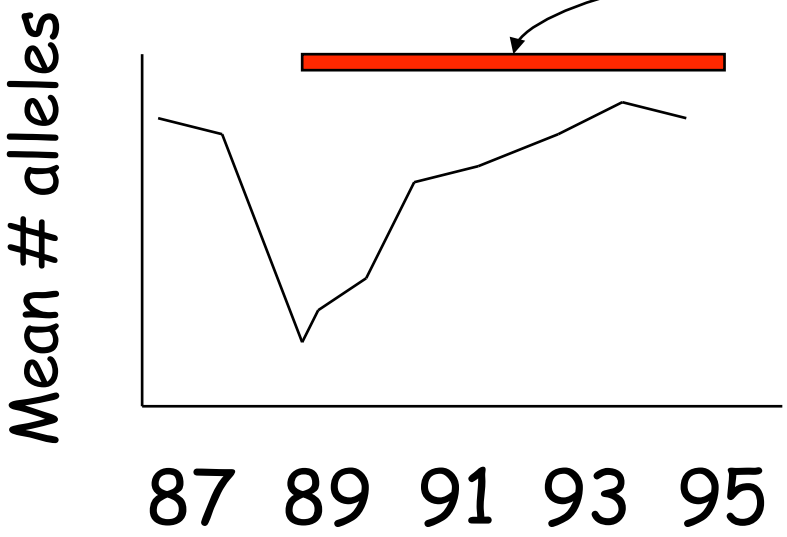


Adenosine deaminase
Survival fs, ss > ff

Bancroft et al 1995, Pemberton et al. 1996

Migration can replace losses





≈ 1 immigrant year

Keller et al 2001

Evaluating the importance of inbreeding and loss of genetic variation in captive and/or wild populations?

Do small populations have lower genetic diversity?

Does lower heterozygosity correlate with reduced survival or reproduction

Does inbreeding reduce survival or reproduction?

Does reduced genetic diversity or inbreeding increase extinction risk?

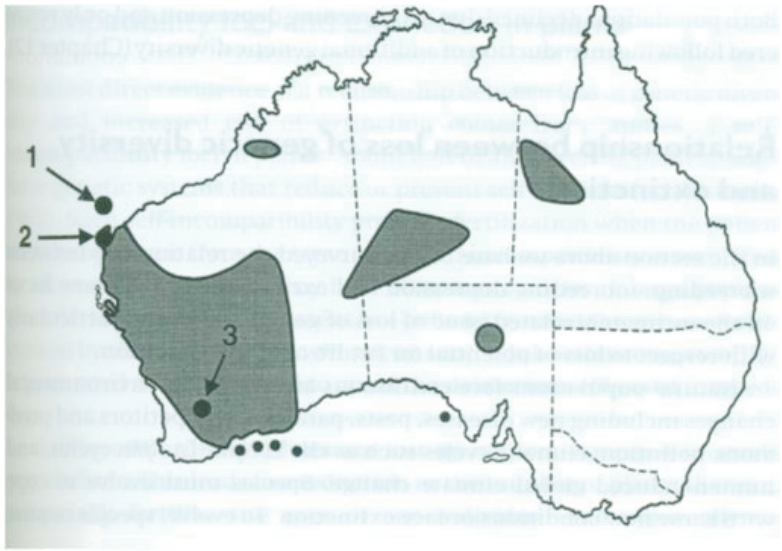
Do small pop'ns have lower genetic diversity?

Greater prairie chicken

Illinois
1860's - millions
1972 2000
1993 <50
Kansas, Minnesota, Nebraska
1990's 4000-100,000

	Allelic diversity
Illinois	
Now	3.67
Pre-1960	5.12
Kansas	5.83
Minnesota	5.33
Nebraska	5.83

Do small pop'ns have lower genetic diversity?



Black footed rock wallabies (Eldredge et al. 1999)

Location	Prop polymorphic loci	Mean alleles/loci	Average heterozygosity
Barrow Island	0.1	1.2	0.05
Mainland			
Exmouth (2)	1.0	3.4	0.62
Wheatbelt (3)	1.0	4.4	0.56

Do small pop'ns have lower genetic diversity?

	A	H
Non-endangered		
European kestrel	5.5	0.68
Greater kestrel	4.5	0.68
Lesser kestrel	5.4	0.7
threatened		
Mauritius kestrel	1.4	0.1
Seychelles kestrel	1.3	0.12

YES: Genetic variation is

+vely correlated with population size

lower is island than mainland populations

lower in endangered than non-endangered spp

Does lower Heterozygosity correlate with reduced survival or reproduction?

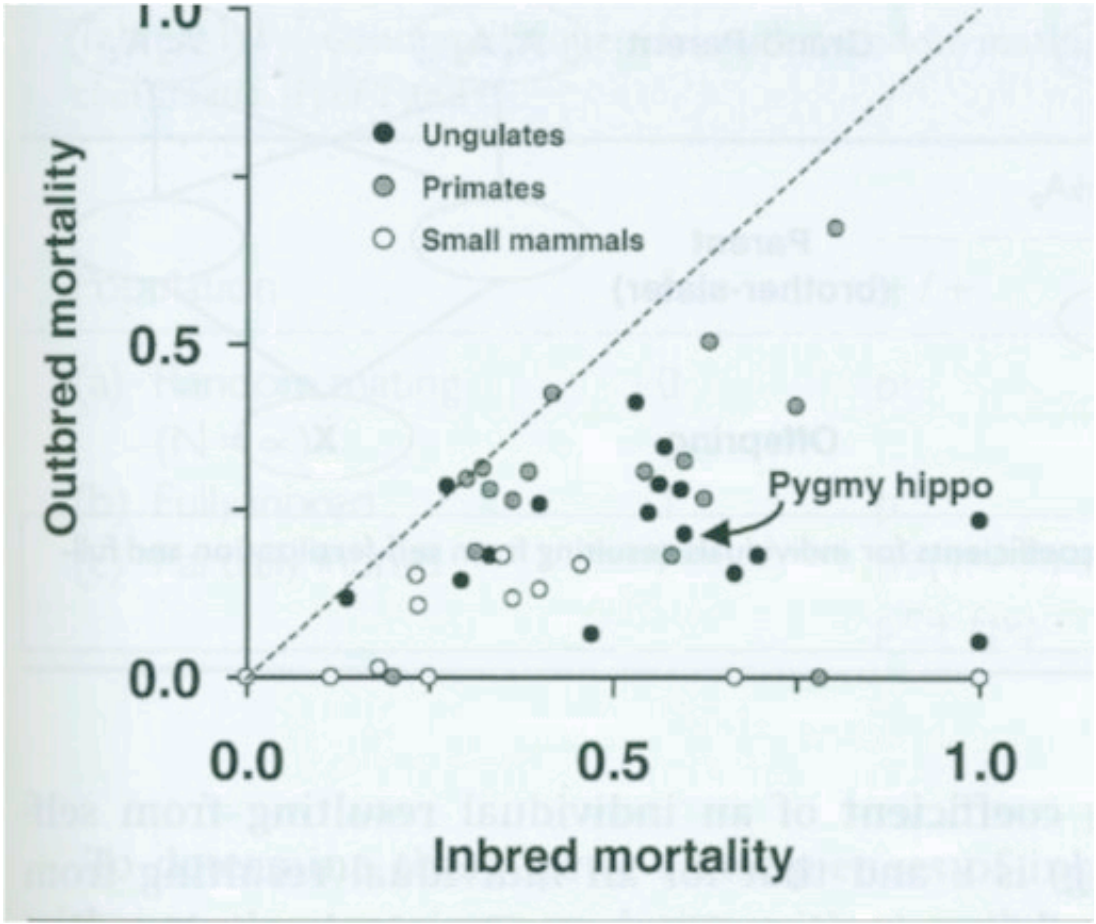
Black footed rock wallabies
H correlates with % females with young

Natterjack toad
H correlates with survival and larval size

Chiltern gentian
H corr with seed number, flower number, total fitness

YES: data is limited but
Meta-analysis
34 datasets
28 +ve corr
Reed and Frankham 2003

Does inbreeding reduce survival?

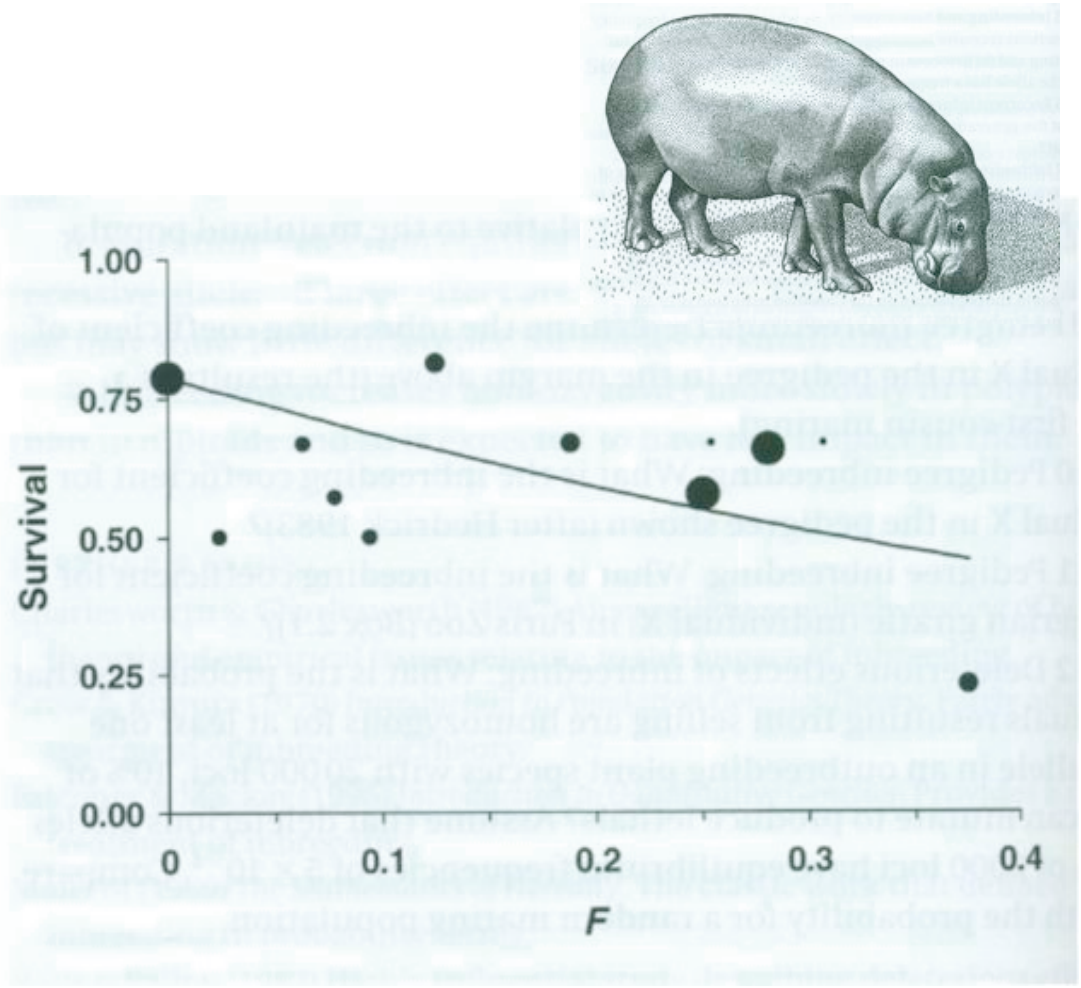


(Ralls and Ballou 1983)

YES: inbreeding depression is common in captive populations

Does inbreeding reduce survival?

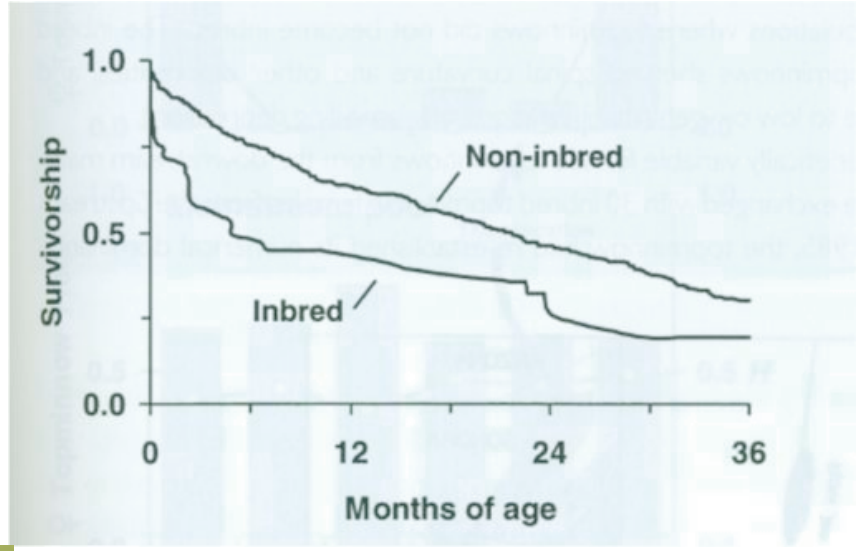
Pygmy hippo

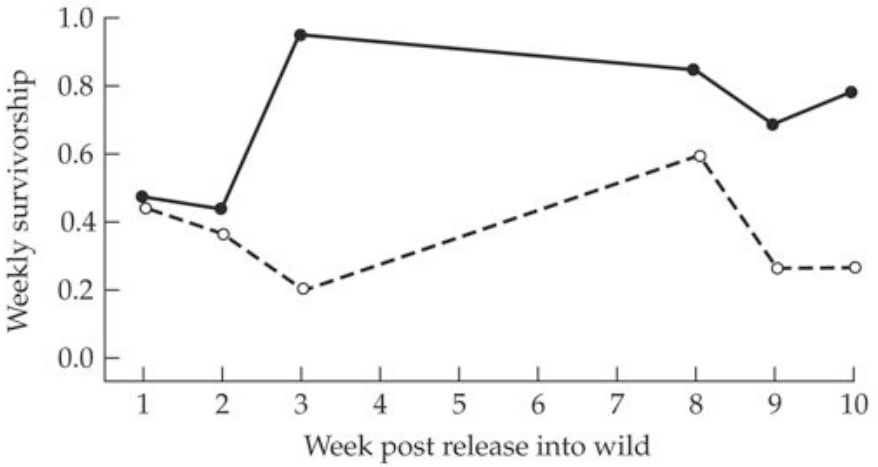


Juvenile survival (birth-1yr) declines with inbreeding

Inbreeding depression in the wild

golden lion tamarins in natural habitat in Brazil





Inbred and outbred lines of white footed mice

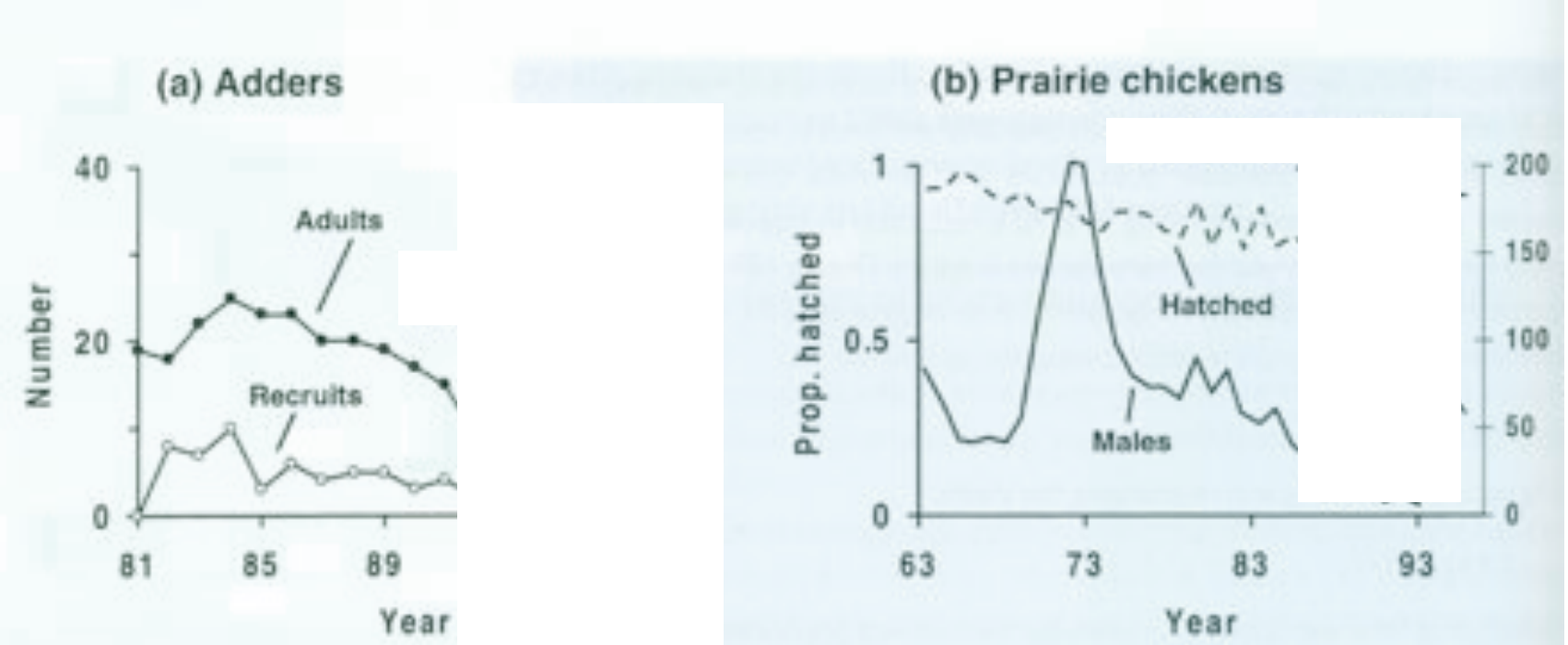
Inbreeding depression in the wild

Adders	Small population	Large pop'n
Mean H	0.07	0.31
Litter size	6	10
% abnormal	32	9

Q. This data is not experimental. How would you strengthen your conclusions?

Madsen et al 1996

Recovery from inbreeding depression



Q. Options?

Does inbreeding reduce survival or reproduction?

Inbreeding frequently results in a decline in reproductive fitness or survival = inbreeding depression

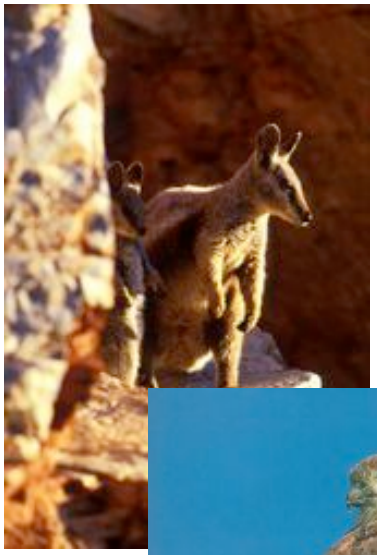
Evidence for inbreeding depression is extensive

Captive	41/44 mammal species
Wild	141/154 cases

Inbreeding depression is typically greater in the wild Why?

Inbreeding depression is reversed by outcrossing

Does reduced genetic diversity or inbreeding increase extinction risk?

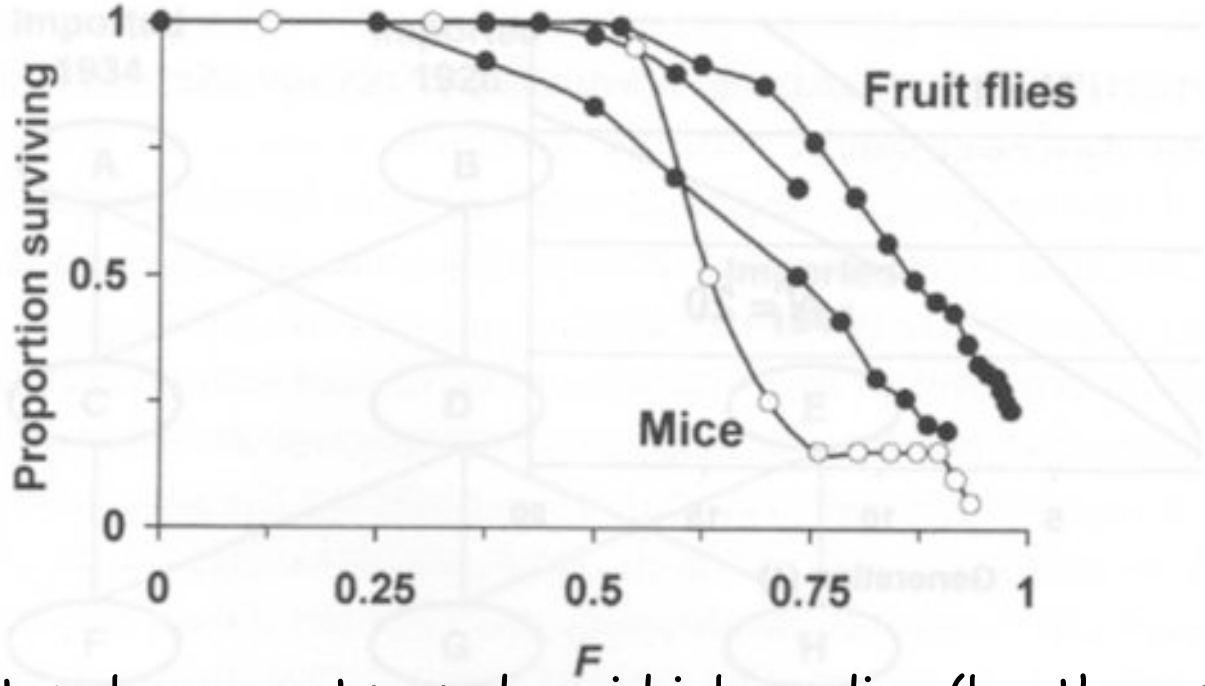


Barrow island rock wallaby pop'n
Small, highly inbred, low genetic diversity
persisted > 1600 yrs

Mauritius kestrel
6 generations with N< 50
Very low genetic diversity
Population still recovered

Inbreeding does NOT always cause declines in pop'n size

Does inbreeding increase extinction risk?



Note: above expts used rapid inbreeding (brother-sister matings) to generate F in each experimental line

Inbred pop'ns of lab animals show elevated extinction rates

Does inbreeding increase extinction risk?

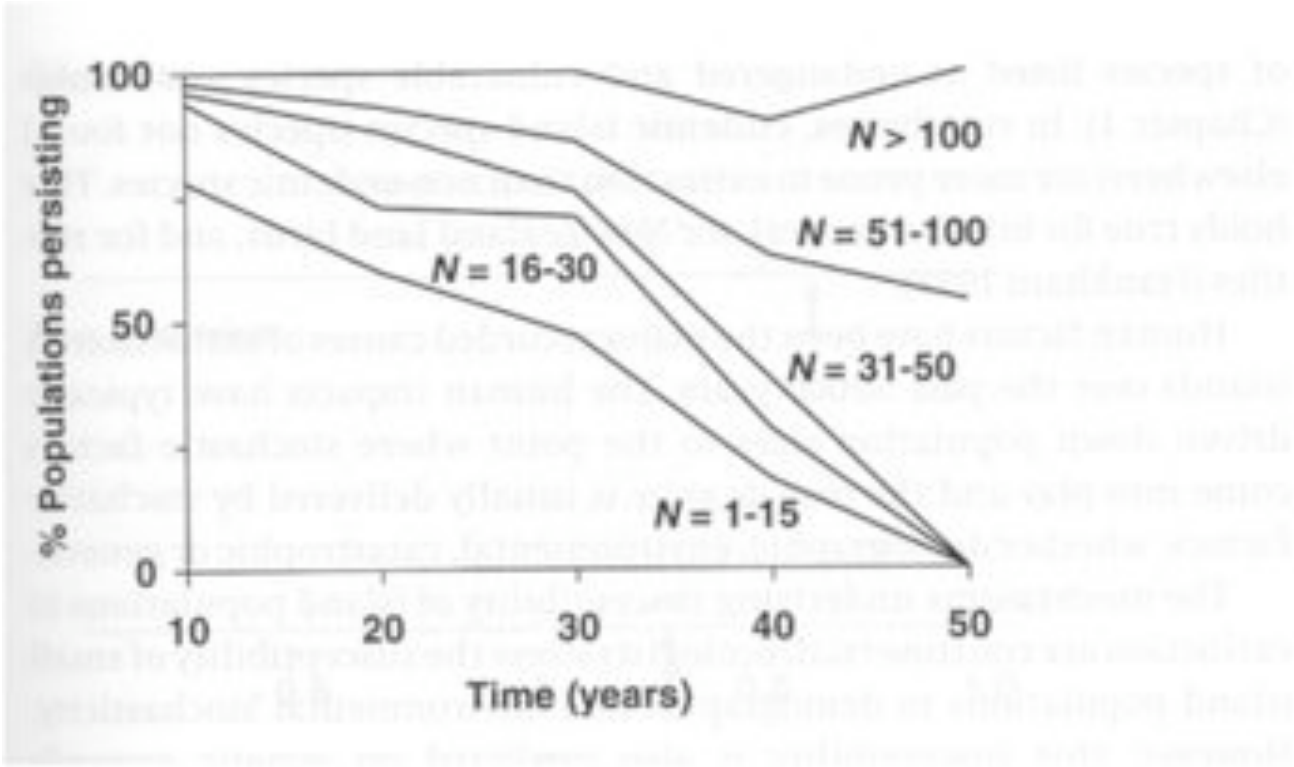


Fig. 2.4 Extinction rates are higher in smaller than larger populations. Relationship between persistence and population size in North American bighorn sheep (after Berger 1990).

Circumstantial evidence

Does inbreeding increase extinction risk?

Extinction proneness of island populations

NOTE: Island populations are usually more inbred and less genetically diverse than mainland pop'ns

	Number spp. extinct since 1600	% on islands
Mammals	85	60
Birds	113	81
Molluscs	191	79
Flowering plants	384	36

Q. Why isn't this conclusive?

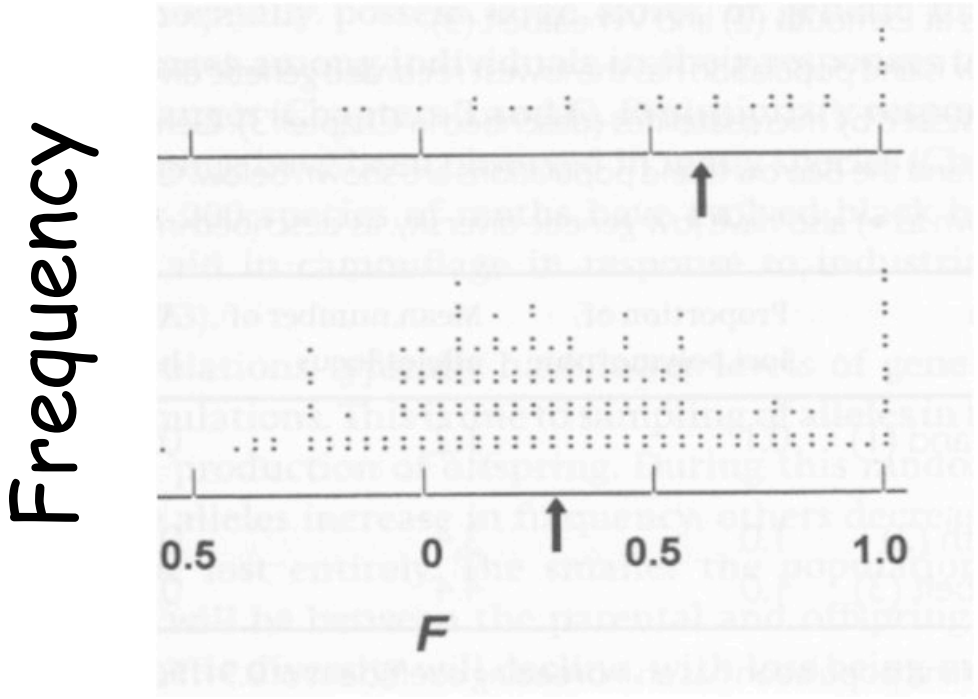
What else is different about island populations?

Does inbreeding increase extinction risk?

Extinction proneness of island population

Endemics

Non-endemics



Greater extinction proneness of endemic than non-endemic island species is predicted by genetic, but not demographic or ecological considerations

SUMMARY

Small population size results in loss of genetic diversity and inbreeding

Inbreeding results in a decline in reproductive fitness in all outbreeding pop'ns of animals and plants

Inbreeding depression can be reversed by outcrossing

Inbreeding depression may increase extinction risk

Tutorial
Genetic variation and population growth
Inbreeding effects in a wild population

Next lecture

Does loss of genetic variation reduce potential for future adaptive evolution?
How much variation do we need for genetically viable populations?