Population genetics lab

(Please remind me to record if I forget)

14 October 2022

Taking attendance

BA-AZ-DO

Population genetics lab assignment

- **Due: 28 OCT 2022 at 23:59 UK time**
- 25% of total grade
- Follow the online lab
- Turn in on Canvas Quizzes
- Emailed Tables 3 & 4

The study system for the assignment

- Species: *Daphnia pulex*
- Small freshwater crustaceans
- Sensitive to environmental change[1]
- Can reproduce asexually & sexually[2]
- Sampled in 8 lakes near Chernobyl[2]

Figure 1: Close up picture of Daphnia pulex.

[1] Flaherty, C M, & S I Dodson. 2005. *Chemosphere*. 61:200-207.
[2] Goodman, J, et al. 2019. *Ecol. Evol.* 9:2640-2650.
[3] Public Domain image by Eric A. Lazo-Wasem

Microsatellites: repeated non-coding DNA sequences

- Repeated DNA sequences (e.g., ‘AGTC‘)
- Do not code for proteins
- Not under selection (neutral)
- Mutations change repeat number

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Hypothetical microsatellite alleles:

1. AGTCAGTCAGTCAGTC (4 repeats)
2. AGTCAGTC (2 repeats)
3. AGTCAGTCAGTC (3 repeats)

Daphnia example with microsatellites

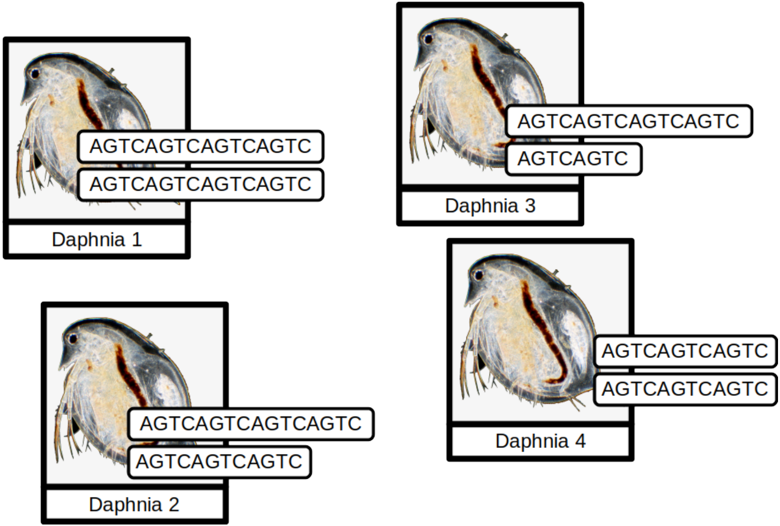

Figure 2: Example diploid population with microsatellite alleles.

[1]Public Domain image by Eric A. Lazo-Wasem

Can label microsatellites with a letter

1. AGTCAGTCAGTCAGTC (4 repeats) $\rightarrow$ p
2. AGTCAGTC (2 repeats) $\rightarrow$ q
3. AGTCAGTCAGTC (3 repeats) $\rightarrow$ r

Can label microsatellites with a letter

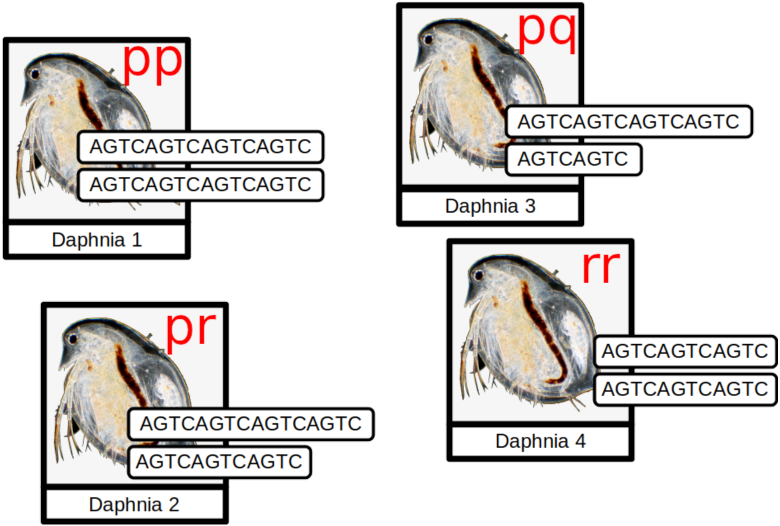

Figure 3: Example diploid population with microsatellite alleles labelled.

[1] Public Domain image by Eric A. Lazo-Wasem

Table 1 in the population genetics lab practical

Sample	Allele1	Allele2	Genotype
Ved1	152	152	pp
Ved2	152	152	pp
Ved3	152	152	pp
Ved4	152	152	pp
Ved5	152	152	pp
Ved6	152	152	pp
Ved7	152	152	pp
Ved8	152	152	pp
Ved9	144	152	pq
Ved10	148	152	pr
Ved11	152	152	pp
Ved12	152	152	pp
Ved13	152	152	pp
Ved14	152	152	pp
Ved15	152	152	pp
Ved16	144	152	pq
Ved17	152	152	pp
Ved18	152	152	pp
Ved19	152	152	pp
Ved20	152	152	pp
Ved21	152	152	pp
Ved22	144	152	pq
Ved23	152	152	pp
Ved24	152	152	pp
Ved25	152	152	pp
Ved26	148	152	pr
Ved27	152	152	pp

[1] Auld, S. Radiation, genotypes and evolution in Chernobyl Daphnia – BIOU3GE. Evolution & Genetics. University of Stirling. 12 OCT 2022.

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Ved2	152	152	pp
...	...	...	...
Ved26	148	152	pr
Ved27	152	152	pp

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Ved1	152	152	pp
Ved2	152	152	pp
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Ved26	148	152	pr
Ved27	152	152	pp

***Daphnia* samples from lake Vedilitsy**

- 22 pp genotypes
- 3 pq genotypes
- 2 pr genotypes

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Ved27	152	152	pp

***Daphnia* samples from lake Vedilitsy**

- 22 pp genotypes
- 3 pq genotypes
- 2 pr genotypes

- 49 p alleles
- 3 q alleles
- 2 r alleles

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Sample	Allele1	Allele2	Genotype
Ved1	152	152	pp
Ved2	152	152	pp
...	...	...	...
Ved26	148	152	pr
Ved27	152	152	pp

Daphnia **samples from lake Vedilitsy**

- 22 pp ($22/27 = 0.814$)
- 3 pq ($3/27 = 0.111$)
- 2 pr ($2/27 = 0.074$)

- 49 p ($49/54 = 0.90$)
- 3 q ($3/54 = 0.06$)
- 2 r ($2/54 = 0.04$)

Table 1 in the population genetics lab practical

Sample	Allele1	Allele2	Genotype
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***Daphnia* samples from lake Vedilitsy**

- 22 pp ($22/27 = 0.814$)
- 3 pq ($3/27 = 0.111$)
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- 49 p ($49/54 = 0.90$)
- 3 q ($3/54 = 0.06$)
- 2 r ($2/54 = 0.04$)

(Note, there are zero observed qq, rr, or qr genotypes)

Table 2 in the population genetics lab practical

Allele	Number	Freq
p (152)	59	0.90
q (144)	3	0.06
r (150)	2	0.04

Genotype		Exp. Freq.	Obs. Freq.
pp	p^2	?	0.81481481
qq	q^2	?	0
rr	r^2	?	0
pq	$2pq$	?	0.11111111
pr	$2pr$	?	0.07407407
qr	$2qr$	?	0

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Allele	Number	Freq
p (152)	59	0.90
q (144)	3	0.06
r (150)	2	0.04

Exp. Freq.

- **pp**: Probability of sampling p for the first allele, then p again for the second allele is $p \times p = p^2$ ($0.90^2 = 0.81$).

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r (150)	2	0.04

Exp. Freq.

- **pp**: Probability of sampling p for the first allele, then p again for the second allele is $p \times p = p^2$ ($0.90^2 = 0.81$).
- **pq**: Probability of sampling p for the first allele, then q for the second allele, **or** sampling q for the first allele, then p for the second allele is $(p \times q) + (q \times p) = 2pq$ ($2 \times 0.90 \times 0.06 = 0.108$).

Table 2 in the population genetics lab practical

Allele	Number	Freq
p (152)	59	0.90
q (144)	3	0.06
r (150)	2	0.04

Genotype		Exp. Freq.	Obs. Freq.
pp	p^2	0.81	0.81481481
qq	q^2	0.0036	0
rr	r^2	0.0016	0
pq	$2pq$	0.108	0.11111111
pr	$2pr$	0.072	0.07407407
qr	$2qr$	0.0048	0

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Table 2 in the population genetics lab practical

$$H_O = Obsf_{pq} + Obsf_{pr} + Obsf_{qr}$$

$$H_O = 0.111 + 0.074 + 0 = 0.185$$

$$H_E = Expf_{pq} + Expf_{pr} + Expf_{qr}$$

$$H_E = 0.108 + 0.072 + 0.005 = 0.185$$

Genotype		Exp. Freq.	Obs. Freq.
pp	p^2	0.81	0.81481481
qq	q^2	0.0036	0
rr	r^2	0.0016	0
pq	$2pq$	0.108	0.11111111
pr	$2pr$	0.072	0.07407407
qr	$2qr$	0.0048	0

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Question 1 of the practical

- Use Table 3 to complete Question 1 A-F
- Procedure similar to what we just did
- New data set is from a different lake
- Note that there will be one more allele

F statistics: What is identity-by-descent?

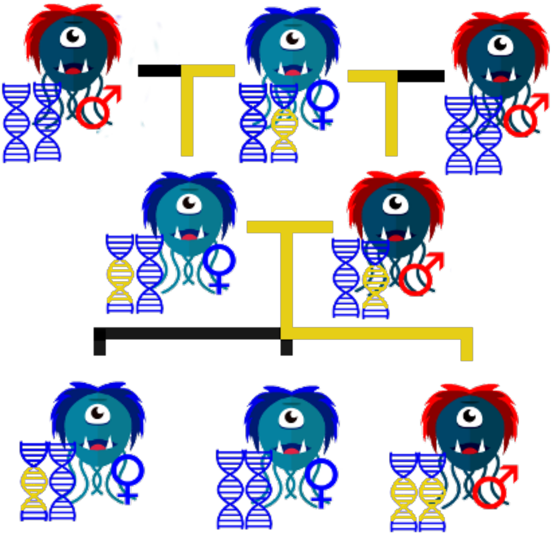

Figure 4: Cartoon figure illustrating identity-by-descent

Probability of identity-by-descent

The probability two alleles are identical-by-descent,

$$F_{IS} = \frac{H_E - H_O}{H_E}.$$

This is also called the *inbreeding coefficient*.

Proportion of total genetic variance contained in the subpopulation

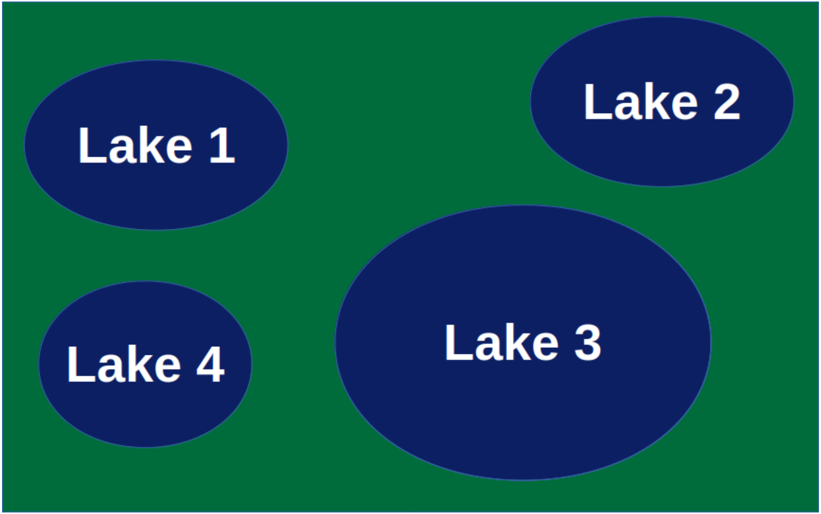

Figure 5: Four lakes (subpopulations) on a landscape.

Proportion of total genetic variance contained in the subpopulation

$$F_{ST} = \frac{H_T - H_S}{H_T}$$

The above F_{ST} measures genetic drift.

- H_T is total heterozogosity (if it were all one big lake)
- H_S is average heterozygosity of the subpopulations
- If $H_T = H_S$, then $F_{ST} = 0$.
- If $H_S = 0$, then $F_{ST} = 1$.

Population genetics lab practical Table 4

Population	Dose	Log10(Dose)	N	MLG	HE	HO	PA	TAR
Vediltsy	0.1	-1.00	27	27	0.447	0.564	1	29.202
Smolin	0.12	-0.92	28	28	0.517	0.452	2	34.687
Yampol	0.2	-0.70	28	28	0.416	0.408	2	29.424
Glinka	1.17	0.07	28	28	0.427	0.282	1	28.771
Buryakovka	1.77	0.25	28	28	0.448	0.325	0	31.427
Krasnyansky	55.79	1.75	38	38	0.611	0.491	3	40.704
Gluboke	181.15	2.26	28	27	0.599	0.650	4	40.429