LS1201 Assignment #1

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The name “Red Queen” was established by Leigh Van Valen (1973) in reference to parasite-mediated frequency-dependent selection. The Red Queen, in Lewis Carroll’s Through the Looking Glass, says to Alice, “Now, here, you see, it takes all the running you can do, to keep in the same place.” The RQH reflects the apparent need for host populations to evolve continuously to avoid being overwhelmed by pathogens. According to this theory, obligate pathogens are under selection at all times to infect more hosts. If virulence is genetically determined and specific for particular host genotypes, then pathogen genotypes capable of infecting the most common host genotypes should be at a selective advantage. Conversely, rare host genotypes have a selective advantage because they have a lower probability of becoming infected by pathogens specific to common host genotypes. As rare host genotypes become more common, pathogens capable of infecting them will be favoured and should increase in frequency (Figure 1). Such a coevolutionary “arms race” can lead to a frequency-dependent selection regime that renders sexual reproduction advantageous to the host. Sexual reproduction, unlike asexual reproduction, offers the ability to re-cover genotypes that are presently selected against but will be selected for in the future. In other words, the advantage of sexual reproduction comes from its ability to respond to cyclical changes in selection pressure caused by pathogens over time, and not just the generation of genetic diversity.

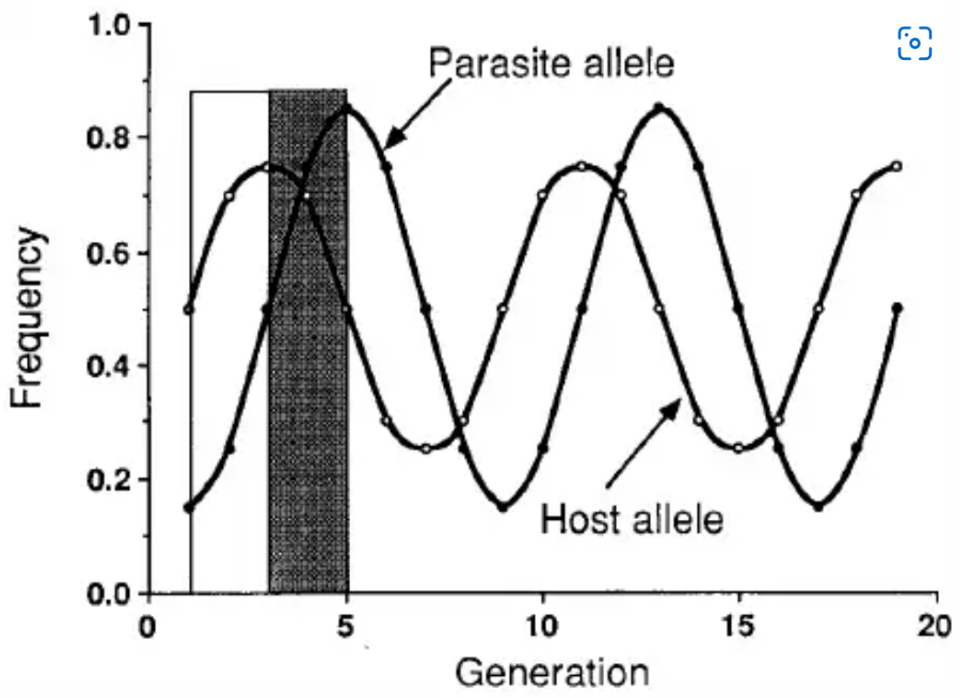

Figure 1: Cycling of parasite and host allele frequencies according to the Red Queen Hypothesis(courtesy of Curt Lively). The dark box indicates the portion of the cycle where the common host genotype is over-infected since the frequency of the specialized pathogen genotype is above 50%. The lightbox indicates the portion of the cycle where the most common host genotype is under infected since pathogen frequency is still rising due to time-lagged frequency-dependent selection.

Since the population of the snail Potamopyrgus antipodarum consists of asexual clones and sexual individuals in New Zealand freshwaters, it can be used to study evolution as well as the advantages of sexual reproduction. The selective advantage is that the progeny experiences increased fitness, and genetic variation is promoted in the population. The overall rate of adaptation increases, by permitting genetic exchange between diverse lineages. On the other hand, self-fertilisation can lead to the confining of beneficial alleles to a single lineage.

The capability of antagonistic interactions to drive evolutionary changes has been studied, like that of P.antipodarum and different trematode parasites. This revealed that there is a high correlation between the presence of parasites and the frequency of sexual individuals in the population. Sexual reproduction is more common where parasites are common. To conclude, the presence of a co-evolving pathogen selected for maintaining high levels of outcrossing in mixed-mating populations, gave rise to elevated levels of outcrossing. This was consistent with the microevolutionary predictions of the Red Queen.

Asexual reproduction gives rise to genetically identical clones, whereas in sexual reproduction there is a high chance of the development of variation. In the case of the snails as well, variation arising from sexual reproduction can produce variants of the snail which are more resistant to the parasites.

Again, based on the Red Queen hypothesis, we can say that the parasites will also need to co-evolve along with the evolving snail population in order to not get eradicated by the more resistant snail population.

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