OPTIONAL ECOLOGY WORKSHEET – ECOLOGY & EVOLUTION - Key

The abundance of amphibians (frogs and salamanders) is declining worldwide with at least 41% of amphibian species at risk of extinction. One factor contributing to this decline is the chytrid fungus, *Batrachochytrium dendrobatidis* (also called the Bd fungus). This parasitic fungus grows in the skin of amphibians impairing the amphibian's ability to absorb water and air, which can lead to death. Non-lethal effects can include lethargy and poor swimming ability, which can affect the amphibian's ability to forage.

1. Evaluate whether the following statement is true and explain your reasoning: "If a frog becomes infected by the Bd fungus but does not die, we can be certain its fitness is unchanged."

The statement is not true, because survival is only one aspect of fitness. If an infected frog survived but the infection caused it to lose its reproductive ability (i.e., it became sterile), the frog's fitness would be 0. Therefore, we cannot be certain that the fitness of a frog who survives Bd infection will be unchanged.

B. dendrobatidis inhabit moist soil and fresh water. Environmental factors, including temperature and moisture availability, can affect the abundance of the chytrid fungus.

2. Based on the following data (see table and figures below and on next page), in which one of the following three B.C. locations (A, B or C) will the chytrid fungus likely be the **most abundant**? Explain your answer. Be specific.

Table 1. Temperatures and Precipitation Conditions at 3 B.C. Lakes

Location:	Summer Temperature Range (°C)	Monthly Precipitation (mm)
A	4°C - 16°C	8 mm
B	24°C - 30°C	208 mm
C	17°C-24°C	580 mm

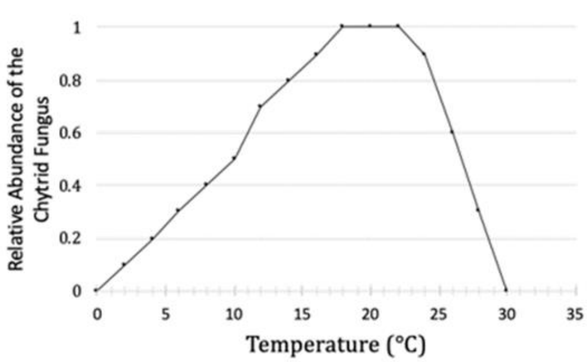

Figure 1. Relative abundance of the chytrid fungus at a range of temperatures. Optimal temperature range for growth and survival is from 17°C to 25°C.

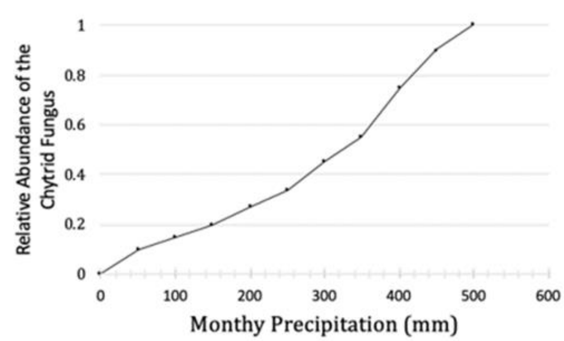

Figure 2. Relative abundance of the chytrid fungus at different monthly precipitation levels. The chytrid fungus needs water for reproduction and movement of spores.

We would expect chytrid fungus to be most abundant in Location C, since Location C provides optimal conditions for the fungus. Chytrid fungus is most abundant between the temperatures of 17 and 25 °C (Fig. 1) and achieves maximum abundance at precipitation rates of 500 mm/month (Fig. 2). Location C is characterized by temperatures of 17-24 °C and monthly precipitation rates of 580 mm. In contrast, the temperatures at Location A are below optimal (4°C - 16°C) and at Location B can rise above optimal conditions (24°C - 30C°). Locations A and B also receive much less precipitation than Location C (8 mm and 208 mm, respectively). Therefore, all else being equal, I would expect the chytrid fungus to be more abundant at Location C.

3. Research findings suggest that an aquatic invertebrate, *Daphnia major*, eats the spores of the Bd fungus, which is the infective stage of this fungus. The optimal temperature for *D. major* for foraging is around 20°C; temperatures above 29°C are lethal. Given this new information, would you change your answer to question 2? Explain your answer.

Assuming *Daphnia major* is present in Location C, I would change my answer. The optimal foraging temperature of *D. major* is 20 °C and it does not experience lethal temperatures until 29 °C. As Location C temperatures never reach lethal limits for *D. major* (mean temperatures 17-24 °C), *D. major* will likely be able to consume Bd spores throughout the summer, limiting Bd abundance at Location C.

However, at Location B, temperatures (24-30 °C) are never within the optimal range and can exceed the upper range of tolerance for *D. major*, suggesting *D. major* should not be as abundant at Location B compared to Location C, and may even be absent for periods of time. As such, the chytrid fungus would likely be at reduced risk of predation by *D. major* at Location B. Bd has a relative abundance of ~ 0.3 in areas with a monthly precipitation of 200 mm/month (Fig. 2) and we can remain present in temperatures up to 30 °C (Fig. 1). This leaves a small window of conditions within which Bd can remain present, though the conditions will be suboptimal.

Taken together, we expect that the chytrid fungus will be more abundant at Location B than at Location C.

4. There is evidence of emerging resistance to the Bd fungus in amphibian populations. Experiments suggest that amphibians that carry an allele, called the Q allele, have greater survivorship than individuals that carry the B allele for the same gene. Both alleles are involved in immune responses.

In Location B (see Table 1 above), the frog (*Rana pipiens*) population (N=150) includes 25 individuals that are homozygous for the Q gene, 120 individuals that are heterozygotes, and 5 individuals that are homozygous for the B allele.

Based on these data, is the frog population at Location B in HWE with respect to the immune system gene? Explain why or why not. Show your calculations.

<u>Total number of individuals</u>:

150

<u>Observed genotype frequencies</u>:

QQ = 25/150 = **0.167** **QB** = 120/150 = **0.800** **BB** = 5/150 = **0.033**

<u>Allele frequencies</u>:

Q = (25*2 + 120)/(150*2) = **0.567** **B =** (5*2 + 120)/(150*2) = **0.433**

Expected genotype frequencies:

QQ = 0.567^2 = **0.321** **QB** = 2*0.567*0.433 = **0.491** **BB** = 0.433^2 = **0.188**

No, the frog population at Location B is not in HWE. We observed fewer homozygous individuals (for both QQ and BB) and more heterozygous individuals than expected under HWE.

Based on your understanding of HWE assumptions explain why this frog population may or may not be evolving with respect to this immune system gene.

The frog population may be evolving. We observed far more heterozygous individuals than would be expected under HWE. This suggests a possible fitness benefit to being heterozygous. From prior experiments, we know that having at least one Q allele confers resistance to Bd fungus. However, we also observed far fewer homozygous QQ individuals than would be expected under HWE. This suggests a possible fitness consequence to being homozygous for QQ. Taken together, it is possible that selection against homozygotes of either type (against BB due to lack of Bd resistance, against QQ for undiscovered reasons) is driving the patterns we see.

Could also invoke genetic drift to explain reduced abundance of QQ.

4. Could resistance to the Bd fungus be classified as an adaptation for this frog population? Explain why or why not.

Yes, we could classify resistance to Bd as an adaptation for the frog population. It meets all three criteria:

1. The trait is heritable (we know from background information that resistance is conferred by the Q allele)

2. The trait has a function (confers resistance to Bd)

3. The trait affects fitness (frogs carrying the Q allele have greater survivorship)