Name: SN:

Biology 413 (Zoogeography) Mid-term Exam
Winter Term 2 – 2020

Directions:

1. **Write your name and student number on each page of the exam.**
2. **Use the space provided for your answers. You can use the back of the final page for extra space, but label your answers clearly. If you need additional sheets of paper, let me know.**
3. **You will have 50 minutes to complete the exam. Please plan accordingly.**
4. **The exam questions are organized into two parts and consist of 7 pages.**
5. **PART I consists of 7 short-answer and multiple part questions.**
6. **PART II consists of 3 long-answer (essay-form) questions (choose between Q's 8 & 9).**

Marks

PART I: 25 points
PART II: 28 points
TOTAL: 53 points

PART I

Answer Questions 1 – 7, using 2-3 sentences or less (point-form is OK in this section). Use the space provided. These questions should take no more than 3-4 minutes each.

Question 1 [2 points]:
In contrast to Earth, which is tilted on its axis at ~ 23.5 degrees (Figure 1), both Jupiter and Venus do not experience seasons. What can you infer about the axial tilt of these two planets?

The axial tilt of these planets must be close to zero, minimal or very small.

(Both Jupiter and Venus have a tilt of about 3 degrees)

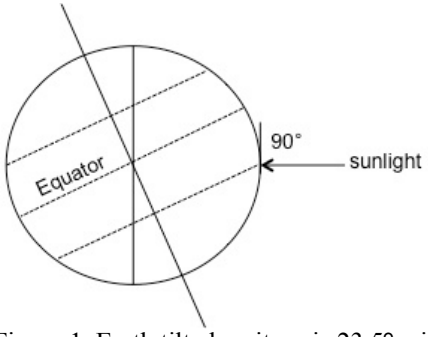

Figure 1. Earth tilted on its axis 23.5° with the angle of incoming sunlight shown. Latitudes indicated with dotted lines.

Question 2 [4 points for parts a and b]:
a) Explain why we tend to see deserts at 30 degrees N and S latitude.

Earth is heated most intensively at the equator, this air rises and cools, losing its moisture over the equator, and then descends at 30 N&S latitude. As this dry air warms it absorbs moisture from the landscape at these latitudes. This has the effect of drying out the land and generating desert climates at 30 degrees N and S latitude.

b) Explain why deserts at these latitudes tend to be found on the western side of continents.

When land is warmer than ocean water (typically during summer), cool westerly winds over oceans absorb water as the air warms while passing over warmer land. The world's driest deserts occur where very cold currents/winds encounter warm land, on the western side of continents at the Horse latitudes (e.g., Atacama desert in South America, western Australia, Namib Desert in Africa).

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PART I

Answer Questions 1 – 7 using 2-3 sentences or less (point-form is OK) in the space provided.

Question 3 [4 points]:

Species distributions are dynamic in space and time, but in all cases, ranges can be described by five basic parameters: *r*, *b*, *d*, *i*, *e*.

a) Use an equation to show how these five parameters are related to one another, and define each parameter using a few words. [2 points]

r = b + i – d – e where r is the per capita rate of population growth, b is per capita birth rate, d is per capita death rate, i is per capita immigration rate and e is per capita emigration rate

b) Figure 3 shows "source" and "sink" habitat patches that are linked by dispersal. If populations persist in the sink habitat (r > 0), what can we infer about parameters *b*, *d* and *i* in the sink habitat? [2 points]

In a sink habitat by definition b < d, yet because the population persists over time (r ≥ 0) and because the sink is linked to a source by dispersal, we know that i must be high in the sink to maintain r ≥ 0 (and e is probably minimal). We could also say that combined, i + b > d in the sink habitat.

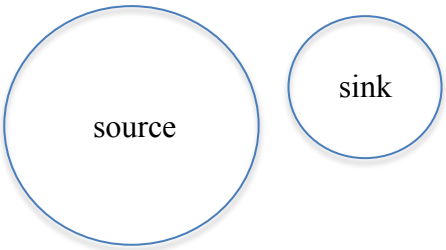

Figure 3. Source and sink habitats.

Question 4 [4 points]: Janzen's hypothesis poses that mountain passes are 'higher' in the tropics, meaning that tropical mountains pose more significant barriers to species dispersal compared to temperate mountains. Use Figure 4 to explain the basic argument underlying this hypothesis.

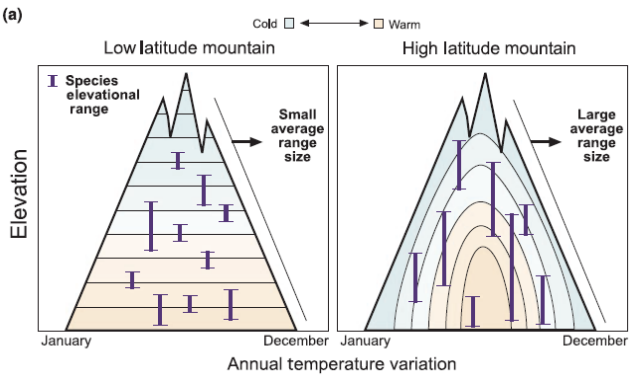

Figure 4. Annual temperature variation (coloured zones) and average range size of species (vertical bars) for tropical (left) and temperate (right) mountains.

The figure shows that species occurring in the tropics experience a narrower range of thermal conditions annually compared to temperate species. This is reflected in the smaller average elevational range sizes of tropical species, and broader ranges in temperate species. This physiological and elevational specialization means a mountain of a given height in the tropics would pose a greater barrier to dispersal for a species compared to a temperate mountain, because tropical species would need to disperse through regions outside of its physiological tolerance to colonize new areas beyond mountain passes. Temperate species would be less likely to encounter thermal regimes outside its physiological range of tolerance.

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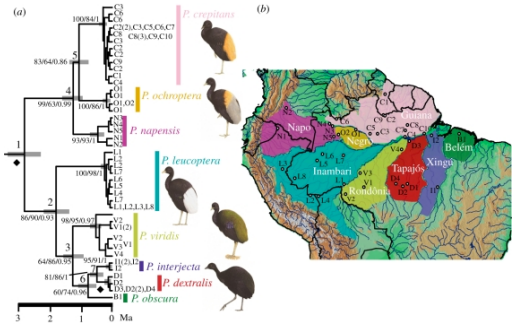
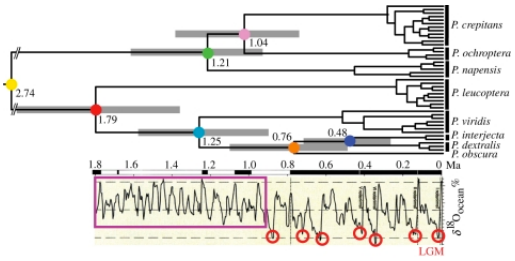
PART I

Answer Questions 1 – 7 using 2-3 sentences or less (point-form is OK) in the space provided.

Question 5 [4 points]: Haffer's (1969) hypothesis represents the "old view" that "islands" of Amazonian lowland forest persisted during the last glacial maximum and can explain current patterns of disjunct taxa and speciation. Does this example of diversification in trumpeters support this view? Explain.





The figures show that the ranges of trumpeter species are separated by large river systems in the Amazon. The phylogeny indicates that trumpeter species divergence dates occurred before the period of glaciation. This example does not readily support the old refugia hypothesis and instead suggests that the establishment of river barriers prior to the Pleistocene glaciation were responsible for diversification. [Students may add that there is within species divergence that occurs within the last two million years, so refugia may have influenced this]

Question 6 [3 points]: The advance and retreat of glaciers resulted in latitudinal and elevational shifts of major habitats and biomes. How does the current distribution of spruce tree species reflect these shifts? (Hint: what regions are spruces restricted to in the *southern* extent of their geographic range?)

Figure 5. Geographic distribution of spruce (*Picea spp*.) in North America.

Spruce trees have a broad east-west distribution at higher latitudes, but are restricted to higher elevations in the southern part of their range (e.g., in the Rockies and Appalachian mountains). With glaciation, the spruce geographic range probably shifted broadly southward, and then back north with glacial retreat as climates warmed. During northward shifts in range, spruce populations also shifted to higher elevations in the southern part of the range, inhabiting climates similar to those in the northern part of its current range. This explains the southern range extension of the spruce range at higher altitudes.

Question 7 [4 points]: In discussing the evolution of dispersal and philopatry, we considered different factors that may favor dispersal in animal populations. Briefly explain *two* of those factors.

Three possibilities:

Hedging your bets: finding the best situation in a variable environment – if site environmental conditions are unpredictable, moving to a different location may be favored (more dispersal in spatially variable environments).

Reducing inbreeding depression: Dispersal can make breeding with relatives less likely by moving away from natal territories (higher dispersal when chance of inbreeding is higher)

Reducing intraspecific competition: Dispersal can be favored when local densities, and the strength of competition for resources, is very high.

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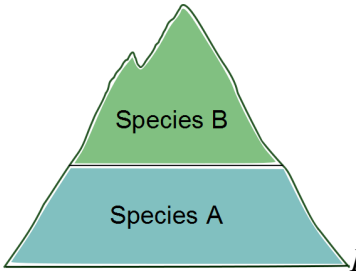
<u>PART II</u> CHOOSE ONE of the following Questions 8 and 9, and answer using complete sentences.

<u>Question 8 [6 points]:</u> Species A and B show a pattern of replacement along the mountainside in the figure below. How could you test which geographic mode of speciation has led to this distribution? What evidence would you need to support this mode of speciation?

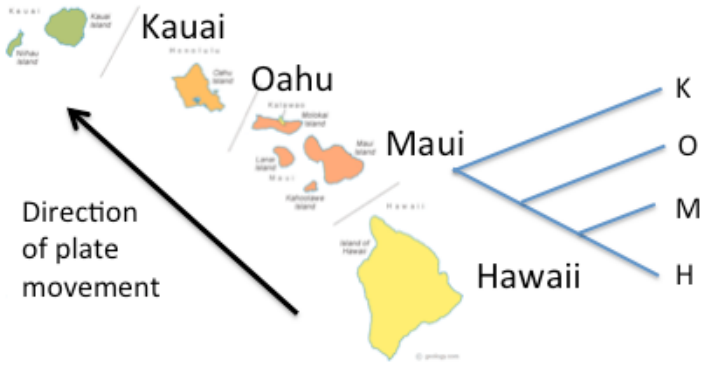


Parapatric speciation can be described as speciation along an environmental gradient, in which populations remain connected through gene flow in part of the range, most likely towards the centre of the gradient, but populations at either extreme of the gradient maintain isolation and do not have genetic exchange (as such, selection at opposing ends of the gradient should favour strong differentiation in the face of gene flow, where populations are in contact). In contrast to allopatric speciation, there is no physical barrier to gene flow in parapatric speciation.

To demonstrate parapatric speciation, 1) we would have to eliminate the possibility that diverging populations were ever isolated. 2) The two species with parapatric distributions should also be sister species (i.e., the other species' closest relative). 3) Additional evidence for parapatric speciation would show divergent selection pressures at opposing ends of the environmental gradient.

For full credit, students need all three of the points in the second paragraph (2 points for each). Full credit is also awarded if a student leaves out the last point (3) but has a clear definition of parapatric speciation, like in the first paragraph above.

<u>Question 9 [6 points]:</u> The figure below of the Hawaiian archipelago shows the direction of plate movement over an existing hotspot, and the islands Kauai (K), Oahu (O), Maui (M) and Hawaii (H).



Label the tips of the phylogeny (right) with island letters, corresponding to the relative age of the islands (and likely relationships of species found on each island) [2 points]. Briefly describe the relationships among island faunas in your phylogeny [2 points] and how this is explained by the different ages of islands in the ocean archipelago. [2 points]

As the plate moves across a hotspot, new islands are generated through volcanic activity (optional: so younger islands also tend to be the largest and have experienced the least erosion). In the Hawaiian archipelago, Kauai is the oldest island and Hawaii is the youngest. This is reflected in the relative age of faunas existing on each island, and their phylogenetic relationships, since faunas occurring on Kauai are the most basal lineages in the phylogeny (older) and those occurring on Maui and Hawaii are the most recently diverged (or represent groups that have recently speciated). These faunas are found on islands that have only been available for colonization in more recent geological time.

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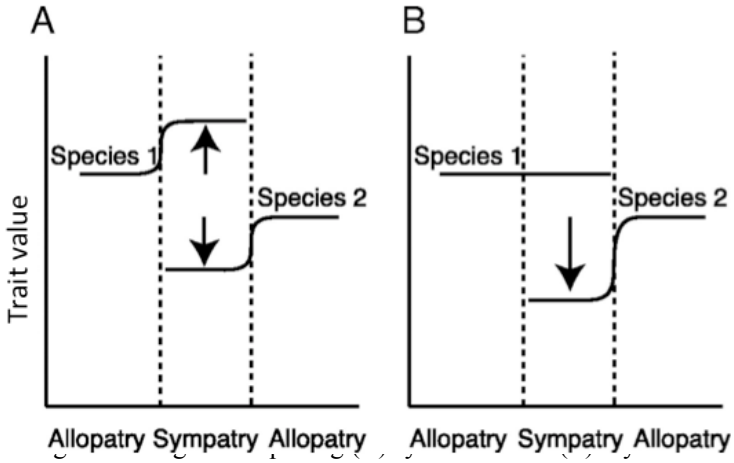
PART II
Answer BOTH Questions 10 and 11 using complete sentences.

Question 10 [10 points]
In class we discussed the collared and pied flycatchers (genus *Ficedula*), which experience reinforcement due to selection against maladapted hybrids in zones of contact. In these species, we also see evidence of character displacement, such that phenotypic traits (e.g., plumage) are more highly differentiated where the two species co-occur, compared to trait values in allopatric populations.

In another study with African Tinkerbirds, Kirschel et al. 2009 contrast "symmetric character displacement" shown below in (6A) with another scenario, shown in (6B), called "asymmetric character displacement." The arrows in 6A and 6B show the direction of predicted divergence in traits where populations of Species 1 and Species 2 are sympatric.



character displacement with shifts in trait values occurring in sympatry.

a) Based on Figures 6A and 6B, provide a definition for asymmetric character displacement [2 points]

In the case of asymmetric character displacement (Figure 6b), one species shows a large shift in trait variation or a given phenotype where it occurs in sympatry with another species, whereas the other species does not show a shift in sympatry compared to allopatric populations. In allopatry, both species have similar phenotypes or trait variation. (Character displacement can occur as a result of interspecific competitive interactions or reinforcement, or both.)

For full credit, students need to say that one species experiences ***a shift in trait value*** *where it co-occurs with the other species, compared to the trait value in allopatric populations. Only 1.5 points are awarded if it the answer isn't completely clear.*

PART II
Answer BOTH Questions 10 and 11, using complete sentences.

Question 10 continued
b) In symmetric character displacement (Figure 6A), Species 1 and Species 2 occur at equal density in zones of sympatry. In the case of asymmetric character displacement (Figure 6B), one species is much more common than the other.

In Figure 6B, which species has a greater effect on the trait value of the other species? Which species is therefore more common and which species is rare? Explain how differences in density between the two species in areas where they co-occur could result in the pattern of asymmetric character displacement shown in 6B [8 points].

In Figure 6B, when one species is common and the other species is rare, the common species (Species 1) will have a greater effect on the rare species (Species 2). (2 points)

Individuals in the rare species with divergent phenotypes will be favored by selection, resulting in an overall shift in the average phenotype in sympatric populations of the rare species. By contrast the rare species (Species 2), due to its low numbers, will have a marginal impact on populations of the common species. (6 points) Other well-articulated answers are acceptable for this explanation.

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PART II

Answer BOTH Questions 10 and 11, using complete sentences.

Question 11 [12 points]:

We discussed numerous potential determinants of species distributions in the context of Hutchinson's fundamental and realized niche. Define the fundamental and realized niche [4 points] and provide four possible determinants of species distributions as they relate to the fundamental/realized niche concept, using an example (e.g., from lectures, elsewhere, or hypothetical) to support your answers [8 points].

The fundamental niche is the total range of abiotic environmental conditions in which a taxon can survive and reproduce. From Hutchinson, the n-dimensional hypervolume (or multidimensional space) describes the range of abiotic environmental conditions in which a taxon can survive and reproduce (each abiotic factor is a single dimension). The realized niche is a subset of the fundamental niche comprising the actual environmental conditions in which a taxon survives and reproduces in nature, including biotic factors (e.g., competition, predation, mutualism, parasitism). (4 points).

There are many possible determinants of distributions, including ***abiotic*** *interactions (e.g., climate/soil related factors),* ***biotic*** *interactions (i.e., direct/diffuse competition, predation, parasitism, mutualism),* ***metapopulation dynamics****,* ***disturbance*** *and* ***historical factors****/dispersal barriers. Full credit given for an answer that describes four different factors supported by a logical example (hypothetical or actual example is fine, as long as it effectively explains the determinant and how that determinant relates to the fundamental/realized niche (2 points per example for 8 points total).*