<u>A STEP IN SPECIATION</u>

The Analysis of Field Observations

Adapted from Investigation 9.4 in *Biological Science - An Ecological Approach* (BSCS Green Version), 1987, Kendall/Hunt Publishing Co.

<u>BACKGROUND:</u> Ever since Charles Darwin formulated his hypothesis on how the finches of the Galapagos Islands evolved into 13 species, the processes of how new species are formed have intrigued scientists around the world. The formation of new species is called **<u>speciation</u>**. Speciation is thought to occur when isolated populations of the same species diverge from one another. The processes that cause such populations to diverge from one another are the same processes that leads to evolutionary change within each population. What are these forces? If you cannot recall what different mechanisms lead to evolution, you need to review the assumptions of Hardy-Weinberg Equilibrium again.

Before starting this activity you should define and be familiar with the following terms:

Allopatric speciation:

Gene flow:

Cladogenesis vs. anagenesis:

Geographic isolation:

Reproductive isolation:

Sympatric speciation:

In this exercise, you will investigate real data collected on several species of salamanders in California including their geographic distributions, their likely evolutionary relationships, and the probable sequence of formation from the original form. The small salamanders of the genus *Ensatina* are strictly terrestrial. They even lay their eggs on land. Nevertheless, these salamanders need a moist environment and do not thrive in arid regions. In California, the species *Ensatina eschscholtzii* has been studied by R.C. Stebbins at the University of California (Berkeley). This investigation is based on his work.

Some of the concepts you should learn in this activity include:

1. While natural selection explains evolutionary modifications within lineages, speciation explains evolutionary branching and diversification.
2. Speciation involves genetic differentiation, ecological differentiation (niche separation) and reproductive isolation.
3. Isolation of members of a species in different environments may result in the formation of a number of subspecies.

PROCEDURE, PART A COLLECTION AREAS:

1. Imagine that you are working with Stebbins' salamander specimens:
    a. In the list below, the salamanders are identified by subspecies (a subspecies is a geographically restricted population that differs consistently from other populations of the same species). For example, the first one is *Ensatina eschscholtzii croceator*, shortened to *E.e. croceator*. "*croceator*" indicates a particular subspecies population of *Ensatina eschscholtzii*.
    b. The parentheses after each subspecies name contain a number and a color. The number is the total of individuals Stebbins had available for his study. The color is the one you should use for that subspecies when you plot its collection area on the California map.
    c. Following the parentheses is a list of grid codes indicating where on the map the subspecies was collected. For example, 32/R means that one or more specimens were collected near the intersection of horizontal Line 32 and vertical Line R.
    d. The letter before the subspecies name indicates the corresponding salamander picture on the color sheet. For example, *E.e. eschscholtzii* is picture b on the color sheet.

a. *E.e. croceator* (15; brown): 32/R, 32/S, 30/T, 31/T
b. *E.e. eschscholtzii* (203; red): 30/M, 32/O, 34/S, 35/V, 36/W, 35/Z, 38/Y, 40/Z
c. *E.e. klauberi* (48; blue): 36/Z, 38/a, 39/a, 40/a
d. *E.e. oregonensis* (373; purple): 9/B, 7/E, 6/E, 13/C, 10/C, 7/D, 15/D
e. *E.e. picta* (230; yellow): 2/B, 2/C, 3/C, 4/C
f . *E.e. platensis* (120; green): 8/J, 10/J, 11/M, 13/M, 15/M, 15/O, 17/M, 15/P, 20/Q, 24/S, 21/R, 25/T, 26/U
g. *E.e. xanthoptica* (271; orange): 17/G, 17/F, 19/H, 19/O, 20/I, 20/J, 21/I

2. Plot each collection area by filling in the corresponding square on the California map. Color in the square above and to the left of the point where the specified grid coordinates cross. For example, the square in the upper left-hand corner is 1/A. Use the colors indicated for each subspecies population (listed above) to make a distribution map of *Ensatina eschscholtzii* in California.
3. Answer the Discussion Questions for Part A, based on your work discussions with partners.

<u>Discussion Questions for Part A Collection Areas :</u> Answer all of the following questions:

1. Is the species uniformly distributed? Use your knowledge of the species' ecological requirements (see "Background") to offer an explanation of its distribution. Are there any other factors that might affect distribution?

2. Consider the physiography of California. In other words, does the species seem more characteristic of mountain areas or of valley areas?

3. Do you expect any patterns in the distribution of subspecies? Why or why not?

4. Examine the salamanders on the cutouts in the envelope provided. Note that some subspecies have yellow or orange spots and bands on black bodies. Some have fairly plain, brown-orange bodies. One has small orange spots on a black background. There are other differences as well: for example, some of them have white feet. Now refer to your distribution map. Does there appear to be any order to the way these color patterns occur in California? For example, do the spotted forms occur only along the coast? Do spotted forms occur in the north and unspotted ones in the south? What DO you find? Arrange the cutouts in their appropriate areas on your map. This should make comparisons, trends, and patterns easier to see.

5. Subspecies *E.e. eschscholtzii* (specimen b) and *E.e. klauberi* (specimen c) are different from each other. What relationship is there between their distributions?

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PROCEDURE, PART B COLLECTION AREAS:

1. You may wonder if there are salamanders in some areas for which you have no records. You also may wonder if there might be additional subspecies for which you have no specimens. A biologist faced with these questions would leave the laboratory and go into the field to collect more specimens. Imagine that you have done this and returned with the following data:

b. *E.e. eschscholtzii* (16; red): 36/Z, 41/Z, 33/M, 34/W, 34/U
c. *E.e. klauberi* (23; blue): 40/b, 40/Z, 36/a
h. Unidentified population 8 (44; pink): 4/I, 5/H, 7/H, 7/F, 6/J, 9/F
i . Unidentified population 9 (13; burgundy): 28/T, 27/T, 26/T, 28/S, 29/T
k. Unidentified population 11 (131; turquoise): 23/J, 24/K, 24/I, 29/M, 25/J, 25/I
l . Unidentified population 12 (31; black): 6/C, 7/C, 6/B

2. Mark with the color gold the following places that were searched for *Ensatina* without success:

   11/I, 14/I, 17/K, 22/N, 26/Q, 5/M, 32/U, 32/a, 35/f

   Specimens of populations 8 (specimen **h**) and 9 (specimen **i**) are shown in the color pictures. (There are no illustrations for populations 11 and 12).

3. Answer the Discussion Questions for Part B, based on your work and interpretations, and your discussions with partners.

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Discussion Questions for Part B Collection Areas : Answer all the following questions.

1. According to Stebbins, the unidentified populations are not additional subspecies. What, then, is the probable genetic relationship of populations 8, 9, and 11 to the subspecies plotted on the map?

2. On this basis, describe (or make a colored drawing of) the appearance you would expect specimens of population 11 to have.

3. Why is it unlikely that you would ever find individuals combining characteristics of *E.e. picta* and *E.e. xanthoptica*?

4. Look at the distribution of the original collections of *E.e. eschscholtzii* and *E.e. klauberi*. What reasons were there for trying to collect additional specimens from extreme southwestern California?

5. How do the results of the additional collections differ from the results in other places where two different populations approach each other?

6. Bear in mind the biological definition of a species and also the appearance and distribution of the named populations of *Ensatina*. Which one of these populations could be considered a species separate from *E.e. eschscholtzii* ? (The population was indeed once considered by biologists to be a separate species).

7. Now imagine that, while examining salamanders in another collection, you find specimen j from population 10, shown in the colored photo. Compare its characteristics, especially the spotting pattern, with those of the named populations. Also, consider the distribution of these populations. Between which two populations is this specimen most likely a hybrid? On your map, draw a line where you might expect to collect other specimens like this one.

8. In a brief paragraph, explain why you think Stebbins concluded that there is only one species of *Ensatina* in California.

9. Suppose that volcanic activity in northern California should become violent and completely destroy all the salamanders in that region. How would this event affect the species *Ensatina*?