CAN COMPETITION DRIVE DIVERGENCE?

Stuart et al. 2014—Accompanying Student Worksheet

Evolutionary change can occur rapidly when natural selection is strong. Yoel Stuart and colleagues designed a field experiment with anole lizards to test the classic evolutionary hypothesis that negative interactions, such as competition, can drive changes in body form (aka phenotypic divergence).

Recently, the Cuban brown anole (*Anolis sagrei*) has invaded areas in the southeastern United States where the slightly less aggressive green anole (*Anolis carolinensis*) is the only native anole species. These two species are very similar in their habits: both are active during the day, eat insects, and live on the ground or low down on bushes and tree trunks. The green and brown anole, therefore, have the potential to be strong competitors.

In May 1995 Stuart and colleagues introduced the brown lizard (*A. sagrei*) to three small islands off the coast of Florida where only native green anoles and no brown anoles live (experimental islands). They used three additional islands as controls, with no competitor. Based on interactions between the two species in other locations, the researchers **predicted that the native green anole would move higher into the canopy** to avoid competition from the introduced brown anole. From 1995 to 1998 the team measured perch heights for both species, i.e. how high the lizards were off the ground.

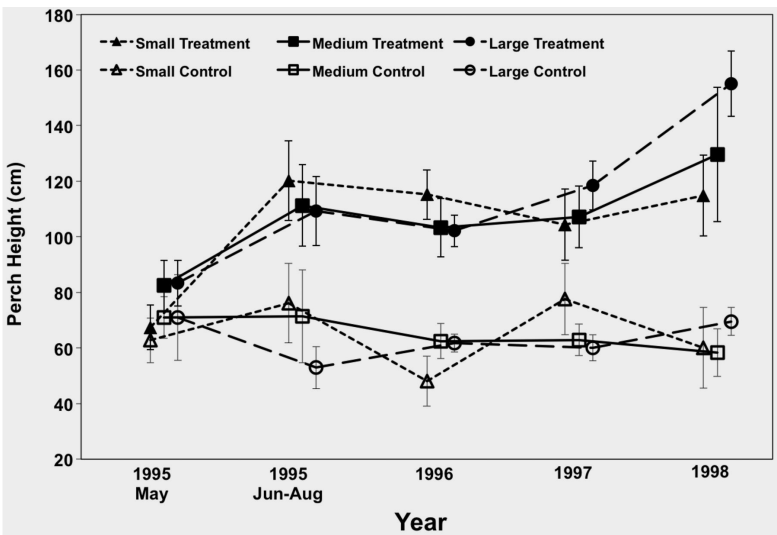


Figure 1:
The figure shows perch height of the native green anole after the introduction of the invasive brown anole.

A. sagrei was introduced to one small (black triangle), one medium (black square), and one large (black circle) island. Control islands (white triangle, square, and circle) had no brown anoles. Error bars represent the standard error of the mean (SEM).

1. What do the x- and the y-axes show? *The y-axis shows the height at which native anole lizards are found (perch height), measured in centimeters off the ground. The x-axis shows different time periods from the introduction of the competitors in May 1995 to the end of the experiment in 1998.*

2. At the beginning of the experiment, right after introducing the brown anole, did native green anoles perch at different heights on control and experimental islands? Recall that the experiment started in May 1995. *No, there was no difference in perch height at the beginning of the experiment. Note the overlapping error bars for treatment and experimental islands.*

3. How quickly did differences in perch height between experimental and control islands appear? Did island size matter? *Regardless of island size, by June-August 1995, native anoles perched higher off the ground on experimental islands. The overlapping error bars for small, medium, and large islands indicate that there is no difference between islands of different sizes.*

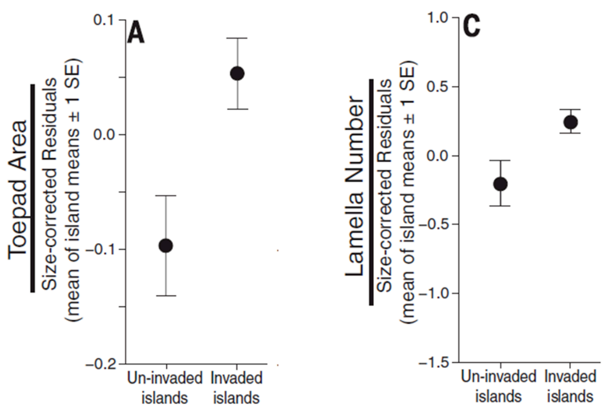
4. Why do you think the researchers chose islands of different sizes? *They chose different sizes to see if the size of the island (and thus the space available to anoles) had any impact on the outcome of the experiment.*

5. Does the data support the researchers' hypothesis that native anole lizard will move higher into the canopy when faced with competition from the Cuban brown lizard? Explain your answer. *Yes, as the authors predicted, the native anole lizards moved to higher perches when they faced competition.*

Anole lizards gain their tree-clinging abilities, in part, from the size of their toepads. The toepads are made of expanded scales called lamellae that are covered with billions of small hairs, called setae. The setae interact with the molecules of the surface the lizards are walking on, creating a clinging force. Anoles with larger toepads relative to their body size also have more lamellae, enabling them to cling to surfaces more easily. So anole species living in trees typically have larger toepads and more lamellae than anoles living on the ground.

To test whether changes in perch height were also driving changes in body form, such as toepads, the authors looked at the toepads and lamellae of native green anoles 20 generations after their islands had been naturally invaded by brown anoles and compared them to the toepads and lamellae of anoles living on un-invaded islands.

6. What, if any, differences do you predict between the toepads of green anoles living on islands with and without competition from the brown anole? Make a prediction about toepad size and number of lamellae. *The authors predicted that the native anoles would have larger toepads with more lamellae on islands with the competing brown anole.*



<u>Figure 2:</u>
The graphs show relative toepad area (A) and lamellae counts (C) for native green anoles (*A. carolinensis)* on islands with and without the invasive brown anole (*A. sagrei*). Error bars are standard errors of the mean (SEM).

The y-axes in both graphs represent the size of a lizard's toepads (or how many lamellae its toepads have) *relative* to the lizard's overall body size.

7. What is on the x- and y-axis of each graph? *The y-axis shows toepad area relative to body size in A and lamellae number in C. The x-axis in both figures shows the type of island. Note: you can ask your students which of the axes in both figures shows categories versus a continuous scale.*

8. Is there a difference in toepad size and lamellae number between anoles on invaded islands versus un-invaded islands? If so, how do they differ? *The figure shows toepad size in Anolis carolinensis after the experimental introduction of A. sagrei compared to when no competitor was introduced.*

CONCLUDING QUESTION

9. Together, does the data from figure 1 and figure 2 support the evolutionary hypothesis that negative interactions, such as comptetion, can drive morphological changes*? Together, the data show that competition between closely related species can drive evolutionary change on observable time scales.*

REFERENCE
Y. E. Stuart, T. S. Campbell, P. A. Hohenlohe, R. G. Reynolds, L. J. Revell, J. B. Losos 2014. Rapid evolution of a native species following invasion by a congener. *Science*, **346**, 463-466. *DOI: 10.1126/science.1257008*