**Biodiversity at the Genetic Level: Consequences of Human Land Use on the Genomes of Amphibians**

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**T**chx tchx tchx. Off to the left. Maybe 5 meters. Beyond two rows of coffee plants. I stand still hoping for another sound to break the serenity of the coffee plantation at dusk. *Tchx tchx tchx*. There it was again. I carefully duck below coffee bushes, never-the-less bumping the branches, spraying remnant droplets of water from the afternoon rain storm over myself. Was the sound coming from this plant? I quickly scan the upper surfaces of the leaves, probing for the source. Nothing. Need another sound to hone in. I try to imitate the call, hoping to elicit a response.

“Tchx tchx tchx”, I say.

Nothing. It was a poor imitation... but the sound was definitely coming from this plant. Has to be. I start scanning up the branches and over the stems. I swear it’s somewhere here.

*Tchx tchx tchx.*

There! My quarry sits on a branch of the coffee plant partially concealed by leaves, a full two plants over from the one I was futilely searching. The small brown frog freezes, head elevated, prepared to emit another call in the Costa Rican night. Before he can escape I strike— with a combination of speed and gentleness my hand envelops the frog, creating a small enclosure within my fist. Success! First captured frog of the evening.

In June and July of this year I spent my evenings at Las Cruces, searching for, and when lucky, capturing frogs in the forest fragments, coffee fields and pastures of Coto Brus. My purpose, however, was not simply to capture frogs for its own sake, but to document the patterns of genetic diversity within these animals, to understand how land use change will affect this cryptic aspect of biodiversity.

There are three aspects of biodiversity: species diversity, or the number and types of different species in an ecosystem, ecosystem diversity, the different types of habitats and combinations of species, and finally genetic diversity, the variation within species that results in the myriad differences across the genome of individual organisms. Human actions are damaging species diversity by contributing to extinctions, and ecosystem diversity through habitat destruction or by altering species composition. But human actions can also have more subtle effects, that erode the very genetic structure of species.

To assess this process, and to elucidate which types of species are more susceptible to loss of genetic diversity, I am focusing my studies on two closely related species of frogs: the spot shouldered frog (*Craugastor crassidigitus*), and Fitzinger’s robber frog (*Craugastor fitzingeri*).

Both Fitzinger’s robber frog and the spot shouldered frog are small, usually between 2 and 4 centimeters long (that’s about 0.75 to 1.5 inches for all you constrained to using imperial units). Unlike the majority of frogs that people are familiar with, they have eliminated the aquatic stage from their life histories—they are never tadpoles. Instead they lay their eggs in humid leaf litter, and develop directly into miniature versions of the adults. Both species are found hiding amongst the leaf litter during the day, while at nights the males climb low vegetation and make clicking noises (which sound a
Fitzinger’s robber frog (Craugastor fitzingeri) perches atop a fallen branch in a pasture, preparing to flee from an overly-enthusiastic researcher. Fitzinger’s robber frog dwells in human modified habitats in Coto Brus, such as pastures and coffee plantations. Living in these well connected, non-fragmented habitat types allows them to easily share genetic diversity between populations. Photo Luke Frishkoff.

bit like a small person banging two stones together) to define territory and attract mates. Despite these broad ecological similarities, around Las Cruces they are different in one important respect: The spot-shouldered frog is found in forest fragments, while Fitzinger’s robber frog makes its home in open human-modified areas—coffee plantations, pastures, and the bromeliad section in front of the Wilson house. These broad similarities, contrasted by the marked difference in habitat preference makes this species pair a good model for understanding the implications of habitat selection on the genetics of organisms in a changing human landscape.

According to population genetic theory, two major factors will determine how much genetic variation exists in a population. First, the size of the population (large populations can hold onto more variation), and second, how well connected that population is to other populations (as an isolated population will only obtain variation from mutations that occur within the population, while well connected populations get variation from these mutations and a bonus from migrating individuals from different populations with unique variants).

The processes of human mediated land use change will influence populations in both respects—habitat destruction makes populations smaller, and fragmentation makes them more isolated. If the spot shouldered frog cannot travel between forest fragments, then, based on theory, I expect this species to show the genetic imprint of isolation—few genetic variants, and those variants that exist to be unique in each population. In contrast, because Fitzinger’s robber frog dwells in agricultural habitat which is well connected throughout the landscape, this species should have high levels of genetic variation, and this variation should be shared between populations at the landscape level. In effect an agricultural species should act as if it is one large population in Coto Brus, instead of many small ones. Conversely, if both species share genetic diversity between populations then it suggests that even though the spot-shouldered frog uses forest as habitat, it can still easily traverse the intervening countryside, and thereby maintain variation between populations.

Having done my field work capturing, obtaining genetic samples from, and releasing, a small army of frogs across Coto Brus, I have now built up a supply of lab-karma which must be paid off. I will therefore be spending the rest of the summer and autumn sequencing a small portion of these frogs genomes. While much work is still to be done, preliminary results seem to support the primary hypothesis illustrated above. The agricultural species has more variation and this variation is shared between populations, while lower levels of variation are held within the forest species, and these variants are unique to each population.

While genetic variation may seem esoteric, and divorced from real world conservation goals, such a viewpoint would be a mistake. Genetic variation represents the future potential of a species to adapt to novel conditions—as without variation natural selection has no alternatives to select among. With the earth undergoing a suite of rapid changes, spanning climate disruption, pollution, invasive species, and land-use change, conservationists need an understanding of what types of species will be more or less likely to be able to adapt to these new regimes.

While it’s easy to get caught up in the dire condition of biodiversity, be it at the species, ecosystem, or genetic level, it’s also essential to enjoy the biodiversity that is extant among us. So on that note, the next time you’re at Las Cruces, take a stroll outside the Wilson House, right after sundown, and you’ll also hear the sporadic clicking of Fitzinger’s robber frog from among the bromeliads. That tchx tchx is a love song. The male attempting to entice a mate. Take a moment to contemplate how he’s striving to share his genes with future generations and distant populations, forging the path of evolution’s future.