Si el Norte Fuera el Sur:

A Case of Squirrel Monkey Identities[1]

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Scenario

You are a biologist working to protect a recently discovered population of Central American squirrel monkeys (*Saimiri oerstedii*) on the Pacific Coast of Costa Rica. Just a few years ago, this small troop of approximately 30 individuals was found in an isolated patch of secondary forest close to Finca La Cusinga, on the border of Ballena Marine National Park. The attached map of southwest Costa Rica shows the locations of Ballena Marine National Park, Corcovado National Park, and Manuel Antonio National Park, as well as important potential geographic barriers such as mountains and rivers. Because almost none of the terrestrial ecosystems along this coast are protected, you have convinced a conservation foundation to purchase approximately 200 hectares (ha) of forested land in the area inhabited by the newly found squirrel monkeys. Your objectives are to manage this reserve for secondary forest, which is *S. oerstedii*'s preferred habitat, and to establish a viable population of squirrel monkeys.[2]

The situation of this tiny population is critical for at least two reasons. First, previous studies of *S. oerstedii* have shown that groups with less than 15 members face almost certain extinction, indicating your 30-member troop is probably at high risk. Second, this group is one of only three remaining populations of squirrel monkeys in Costa Rica. Historically, *S. oerstedii* once occupied a much wider range, inhabiting contiguous tropical wet forest along the Pacific lowlands of Costa Rica and Panama at altitudes lower than 300 meters (m). A 1983 census put the Costa Rican population at approximately 200,000 individuals, with a relatively continuous distribution. By the end of the 1990s, only 4,000 *S. oerstedii* remained. These were confined to two National Parks, one in Manuel Antonio on the Central Pacific Coast and one in Corcovado on the South Pacific Coast. Elsewhere, the species was believed to be extinct.

In designing your recovery plan, you decide your first priority is to bolster population numbers and increase genetic variability. This will require introducing animals from another area to mate and reproduce with the La Cusinga monkeys. After much discussion with officials from the Osa Peninsula and Central Pacific Conservation Areas[3], you decide that the Osa Peninsula is your best option for a source population. Since the Osa's forests are relatively less fragmented and therefore support a larger monkey population compared to Manuel Antonio, you reason that extracting monkeys from the Osa will have relatively less impact on the overall status of *S. oesterdii* in Costa Rica.

After a long and painful permit process, you begin culling young females from the Osa population and introducing them to the La Cusinga preserve. (You introduce only young females because in this species it is the females that disperse.) As a good scientist, you hire skilled undergraduate assistants to observe the social and reproductive behaviors of this animal in the field to ensure the success of your program. Within a very short time, you begin to fear that your plan is failing. Of 30 reproductively mature females introduced to La Cusinga, not one has reproduced successfully.

Although the animals from the Osa look almost identical to those from La Cusinga, you suspect they are reproductively isolated, and perhaps even separate species. Your focus turns to identifying differences between the two populations, and determining the reasons for reproductive isolation. The data collected by your field assistants on morphological and behavioral differences reveals few factors, other than those listed in Table 1, that distinguish the two populations. (A list of general *S. oerstedii* characteristics is given in Table 2.) However, you do notice that the La Cusinga population more closely resembles Manuel Antonio monkeys than it does Osa monkeys.

Table 1: Comparison of *Saimiri oerstedii* Populations

Characteristic	La Cusinga/Manuel Antonio	Osa Peninsula
Body weight (grams)	F 600; M 750	F 650; M 800
Head coloration	females - black males - gray	females - black males - black
Body coloration	females & males orange	variable, but generally less brilliant than in Manuel Antonio; more of a copper-yellow
Grooming of infants by mothers	common	never observed
Spatial associations between resident males	remarkably close	close, but not as tight as in Manuel Antonio

Table 2: General Characteristics of *S. oerstedii*

Trait	*S. oerstedii*
Group Size	35-65
Typical fruit patch harvested	Small, low density
Aggressive within-group fruit competition (events/hour)	Extremely low (0.004)
Superciliary patch above eyes	Forms a peak, shaped like a Gothic arch
Female-female social aggression	Rare
Female-female affiliative coalitions	Not detected
Male-male social aggression	Rare
Male-male affiliative coalitions	Present
Male-female social relations	Egalitarian and males integrated into troop
Female troop residence	Emigrate before first mating season
Male troop residence	Usually natal
Male defense of immature troop members from predators	Vigorous
Interbirth interval	1 year
Intratroop birth synchrony duration	2 weeks
Infant age at weaning	Less than 6 months
Existence of a distinct 'travel' call to coordinate troop travel	Ubiquitous
Dental anatomy: molar structure	Narrow and long

Your Assignment
Working in your assigned group, use the information from the case study to develop and present a model of evolutionary divergence between these two populations. You may include as many details as you like in your story, but you must follow some guidelines:

- Your story should account for at least some of the data supplied in the case study.
- It is acceptable to add more data to your story as long as it fits the patterns you see in the data provided. Attached to this document is additional information on the squirrel monkey, as well as references that may prove helpful in developing your story.
- As part of your story, you may report fictitious experiments that support or disprove your hypotheses for evolutionary divergence. Any fictitious experiments must be potentially feasible, given the logistical and ethical constraints of field biology. Moreover, any fictitious results presented must be biologically compatible with what we already know about squirrel monkeys.

- Your story must incorporate the three concepts from the "Concept List" assigned to your group. If you wish, you may include additional concepts. For each concept you include, whether assigned or not, you must demonstrate its relevance to your story.

- The concepts you use may or may not be compatible in a single evolutionary story. For example, you may present a story that includes three or more concepts working together in the process of speciation. Alternatively, you may treat two or more concepts as competing hypotheses and present evidence for or against each hypothesis.

- Keep in mind that in an evolutionary story you will describe events in your monkey population(s) that may have occurred over very long time periods. Current evidence indicates the ancestors of *S. oerstedii* arrived in Central America from South America some 500,000 years ago, so you may decide that geological and climatic events since that time are relevant to your story. In addition, remember the historical range of *S. oerstedii* was continuous along the Pacific Coast of Costa Rica and western Panama until only 20 years ago. In other words, *S. oerstedii* was only very recently confined to the small populations of Manuel Antonio and Corcovado.

- The presentation of your story should last no more than 10 minutes. Prior to your presentation, your group must submit a one-page written summary of your story.

- You are not limited in terms of how you tell your story. Be creative!

- You are free to include graphics and illustrations with your story.

Remember: Your oral presentation must demonstrate to your classmates how certain evolutionary processes can function in the real world. Therefore, you must elaborate on how each concept you incorporate would work in the context of squirrel monkey evolution. For example, stating that "the animals became two species because of sexual selection" is not sufficient. You must also explain the process and implications of sexual selection, how sexual selection can give rise to speciation, and what evidence might indicate that sexual selection is at work.

Concept List

	Assigned Concepts			
Group Number	**Mechanisms of Evolution**	**Modes of Action of Selection**	**Speciation**	**Reproductive Isolation**
One	Founder effect		Allopatric speciation	Temporal isolation
Two		Disruptive Selection	Sympatric speciation	Behavioral isolation
Three	Bottleneck effect	Stabilizing selection		Mechanical isolation
Four		Sexual selection	Parapatric speciation	Reduced hybrid viability
Five	Genetic drift	Directional selection		Genetic isolation

Additional Background on the Central American Squirrel Monkey

This case study is based on the biology of the Central American squirrel monkey, *Saimiri oerstedii*, whose historical range is found along the Pacific wet lowlands of Costa Rica and Panama at altitudes lower than 300 meters (m), an area of less than 8,000 square kilometers (km^2). According to the Holdridge classification system, the bulk of this area is characterized by tropical wet forest, with small patches of tropical dry forest and wet forest transition near the mouth of the Sierpe and Terraba Rivers.

Molecular, morphological, and behavioral data indicate that *S. oerstedii* is distinct from the South American squirrel monkeys. In this case study, a fictitious scenario is presented in which *S. oerstedii* is divided into two reproductively isolated populations--presumably two different species. Currently, the Central American squirrel monkey is thought to be two subspecies, *S. oerstedii oerstedii* found on the Osa Peninsula and *S. oerstedii citrinellus* found in Manuel Antonio. The geographic boundary between the distribution of the two subspecies is the Terraba River. This river is the largest water drainage in the southern zone of Costa Rica, and together with the Sierpe River forms the delta of the Sierpe-Terraba Mangrove Forest Reserve, comprising approximately 227 km^2 of protected wetlands.

The major components of the squirrel monkey diet include caterpillars, grasshoppers, and small berry-like fruits. These undergo large fluctuations in availability across the annual cycle of the Pacific wet lowlands of Costa Rica. These items are sparsely distributed, and even during seasons of peak food abundance a troop's range exceeds 80 hectares (ha), with about 60% of its time allocated to foraging activities. *S. oerstedii* are considered unusually peaceful primates, with very little intra- or inter-group aggression. In addition, male-male social ties are extremely close in comparison with other species of monkeys.

The conservation status of *S. oerstedii* is dismal. A 1983 census put the Costa Rican population at approximately 200,000 individuals. Today, it is estimated that approximately 1,000 *S.o.citrinellus* and 3,000 *S.o.oerstedii* remain in the highly fragmented forest along the Pacific coast of Central America. Fragmentation has occurred due largely to the expansion of the agricultural frontier, timber extraction, and tourism development. Other threats include pesticide use on plantations surrounding forested areas, the pet trade, and disturbance by tourists, to which these primates appear particularly sensitive.

One interesting obstacle in the efforts to protect this remarkable and beautiful monkey has been doubts over its origin. For many years, it was assumed that *S. oerstedii* was introduced to Central America by pre-Columbian indigenous peoples and that it was a hybrid of its South American relatives. This suspected anthropogenic origin of an otherwise wild species of monkey made it a low priority for primate conservation efforts in Costa Rica. It was also the basis for a decision to exclude the species from Daniel Janzen's 1983 publication of *Costa Rican Natural History*, an otherwise encyclopedic volume of the flora and fauna of the nation. Recently, Cropp and Boinski (1999; 2000) have presented evidence disproving the anthropogenic origin of this species in Costa Rica. Genetic, behavioral, morphological, biochemical, and fossil evidence all indicate that *S. oerstedii* diverged from its South American relatives a minimum of 500,000 years ago, long before humans began to impact the Americas.

The neglected status of *S. oerstedii* during the past 20 years of Costa Rican conservation history (and its concurrent population crash) brings up an interesting question for reflection and discussion: Does the possible anthropogenic origin of a species like *S. oerstedii* make it less worthy of conservation efforts? Why or why not?

End Notes

[1] Adapted from Hewlett, James A. 2000. "Trouble in Paradise: A Case of Speciation." Available on the University at Buffalo National Center for Case Study Teaching in Science web site

[2] The scenario presented here is fictional in part. At the time of this writing, the only known populations of *S. oesterdii* in Costa Rica are confined to Manuel Antonio National Park and Corcovado National Park. No populations have been found near Ballena, although this area was once part of the monkey's natural range.

[3] Costa Rica is divided into 11 regional conservation areas, each of which is intended to locally integrate the management of lands assigned to different uses (e.g., forest reserves, national parks, wildlife refuges, etc.). Manuel Antonio National Park belongs to the Central Pacific Conservation Area, while Corcovado and Ballena Marine National Parks belong to the Osa Conservation Area.

References

1. Boinski, Sue. 1999. The social organization of squirrel monkeys: Implications for ecological models of social evolution. *Evolutionary Anthropology* 8(3):101-112.
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3. Boinski, Sue, Katharine Jack, Craig Lamarsh and Jessica A. Coltrane. 1998. Squirrel monkeys in Costa Rica: drifting to extinction. *Oryx* 32:45-58.
4. Boinski, Sue, and Laura Sirot. 1997. Uncertain conservation status of squirrel monkeys in Costa Rica, *Saimiri oerstedii oerstedii* and *Saimiri oerstedii citrinellus*. *Folia Primatol* 68:181-193.
5. Cropp, Susan, and Sue Boinski. 2000. The Central American Squirrel Monkey (*Saimiri oerstedii*): Introduced hybrid or endemic species? *Molecular Phylogenetics and Evolution*. 16(3):350-365.
6. Janzen, D.H. 1983. *Costa Rican Natural History*. Chicago, Illinois: University of Chicago Press. pp 12-65.
7. Stiles, F. Gary, and Alexander Skutch. 1989. *A Guide to the Birds of Costa Rica*. Ithaca, New York: Comstock Publishing. pp. 4-19.

If you would like to locate more Central American squirrel monkey references, consult the library database BINABITROP at the OTS web site http://www.ots.ac.cr.

Image Credit: Photograph of *Saimiri oerstedii* is provided courtesy of Lawrence Williams and the Squirrel Monkey Breeding and Research Resource, University of South Alabama. Used with permission and partially funded by NIH grant P40-RR01254.

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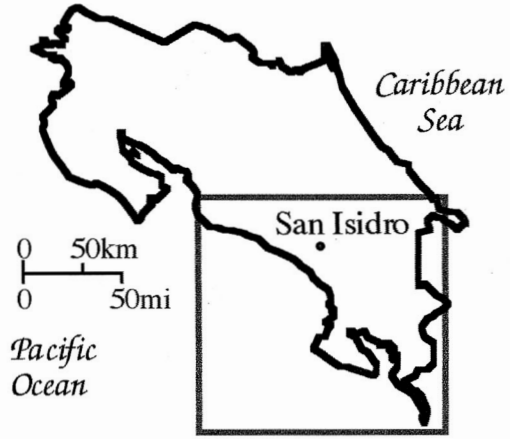
Map of Costa Rica with detail of Southern Pacific Coast



Note: Squirrel Monkey habitat is limited to the northeast by the Talamanca Mountain Range, which climbs to its highest point at 3,800mts in Chirripo. Squirrel Monkey habitat is limited to the northwest by the onset of a transition from tropical wet forest (which characterizes southwest Costa Rica) to tropical dry forest (which characterizes northwest Costa Rica).

For use with the Case Study "Si el Norte Fuera el Sur".