marmoset to the black spider monkey, one individual of which is the heaviest recorded South American wild monkey (it was a male from Brazil).

Terborgh's working hypothesis is that many of the behavioral differences between the species can be understood "as adaptations for exploiting food resources with distinct spatial and temporal patterns of abundance." To test his hypothesis it was necessary to accumulate data on activity patterns, ranging and feeding behavior, and species interactions throughout the year. But the study area is heterogeneous to say the least—it contains areas of both riparian and lacustrine successional vegetation, including a fig swamp, as well as tall high-ground forests of various ages. Individual monkeys cannot be identified, and sometimes it is not possible to distinguish among different troops of the same species. Therefore, to make his task manageable Terborgh concentrated his effort on a preliminary but nonetheless intensive study of just five species that range in size from 0.4 to 3.0 kilograms and have similar diets. Fleshy fruits provide their calories and small animal prey their protein requirements. The five species provide challenge enough. There are two tamarins that live in small family groups and defend joint territories (one family of each species per territory), two capuchins that live in larger groups of a dozen or so individuals, and the squirrel monkey, which lives in groups of about 35 individuals that range over enormous undefended and unadvertised areas. To add to the complexity, the squirrel monkeys frequently join with groups of either capuchin species for periods from a few hours to ten days or more.

The rainfall is seasonal, resulting in periods of abundant and scarce fruit supplies. In response to the shifting availability of food both within and between habitats, the monkeys change their feeding, ranging, and social behavior. Terborgh's research team logged about 540 contact hours per species between August 1976 and August 1977. Their observations form the quantitative base for most of this book, though more recent supplementary data are used to test various ideas.

A monkey's body size is an important determinant of its diet. For example, small species cannot subsist on foliage alone. On the other hand, using stealth, the smaller monkeys at Manu catch larger animal prey—the exact opposite of the usual optimal foraging assumption. During the wet season, from about November to April, fruit is widely available and the monkeys' diets are quite similar. But during the dry season the feeding habits of the different species diverge considerably. When searching for animal prey, the larger of the two capuchins (3 kilograms) uses its strength as a destructive forager, breaking hollow twigs and ripping off bark to expose the prey beneath. At the other extreme, the smaller of the tamarins (0.4 kilogram) has great agility and can garner exposed food while clinging to vertical surfaces. However, in general the larger species have a wider range of potential feeding options: they can use their strength to forage, they are less susceptible to predation by raptors and so can feed in the exposed high canopy, and having lower metabolic rates they can use leaves or unripe fruit as protein sources.

Despite different techniques for catching animal prey, it seems likely that fruit eaten during the dry season is the factor most closely associated with the species-typical social behavior. The small tamarins crop a variety of fairly uniformly distributed and predictable fruiting trees. As a consequence they defend territories. Why two species should share a territory is unexplained, but, given that they do, their joint use of the territory by traveling in parallel around it ensures that return times to fruiting trees are maximized. In sharp contrast, the squirrel monkey is a fig specialist *par excellence* and the fruits on a fig tree ripen as a large, concentrated, non-predictable, non-renewable, non-defendable patch. Several groups of squirrel monkeys may descend on a single tree at any one time, together with other primates and several bird species. The resource cannot be defended against the dominant capuchin species, which is also partial to figs. The large group size of squirrel monkeys can have little to do with improving foraging success. It is more likely to be a selfish-herd antipredator defense mechanism, as are the squirrel monkeys' attachments to the capuchin groups whose home ranges they travel through in their incessant search for fruiting fig trees.

There are no similar studies from the New World, and, as with others that have been reported on simian primates from elsewhere (notably Gautier-Hion's from Gabon, Chivers's from Malaysia, and Struhsaker and Leland's from Uganda), it is surprising how much can be achieved with the intelligent interpretation of basic observational data. Very little is known about primate communities in general and New World primate communities in particular, and Terborgh's book is a notable contribution toward furthering our understanding. He may be correct that optimal group sizes result from a balance between predator pressure on the one hand and the spatial and temporal variation in food patch qualities on the other. If he is correct, it should be no surprise that broad interspecies studies have failed to identify ecological correlates of variation in group size—the relevant measures have not been quantified in any single case. Terborgh presents us with a series of preliminary observations. Many of his tentative conclusions and working hypotheses will eventually prove incorrect, as he is the first to admit. Nevertheless, he has already brought us a long way. His useful fusion of natural history observations with carefully argued interpretations derived from a firm matrix of theory provides a substantial foundation for further studies.

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A Biota and Models

Island Biogeography in the Sea of Cortéz. TED J. CASE and MARTIN L. CODY, Eds. University of California Press, Berkeley, 1984. xii, 508 pp., illus. $55. Based on a symposium, Los Angeles, 1977.

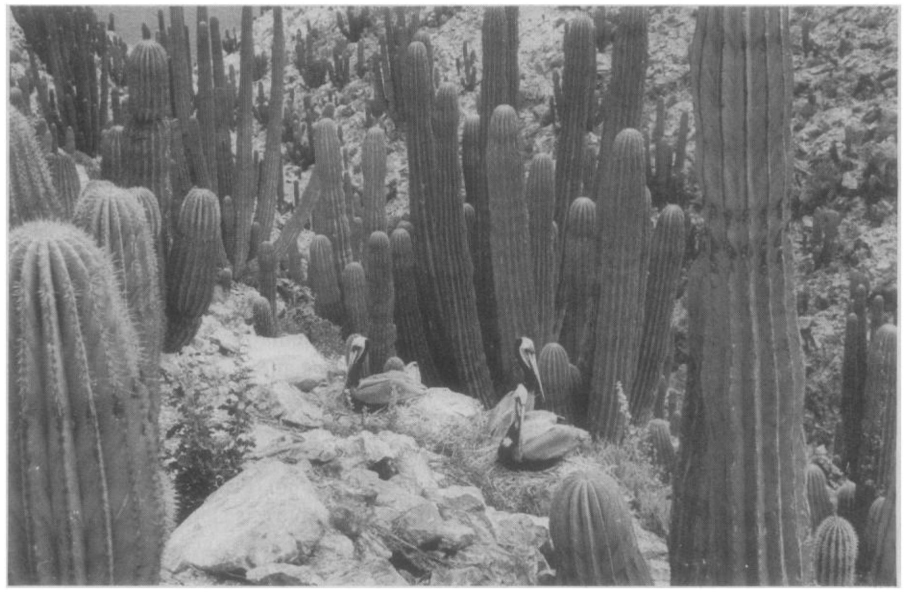
Biogeography has never been a field short on controversy, and throughout its history attempts to explain the distribution of plants and animals on islands have figured prominently. Land bridges, continental drift, sea-level fluctuations, dispersal capabilities of organisms, and the evolutionary roles of competition and resource availability all have been debated. Within the last 15 years, now that plate tectonics is better understood, vicariance biogeography has been revived. Also, the dynamic equilibrium model has brought more quantitative ecological thinking to the forefront and set the stage for controversy on the role of species turnover, stochastic processes, and balanced immigration and extinction rates on the one hand and more deterministic processes and historical legacies on the other. In the middle of the current fray is a growing group that criticizes anyone who does not build quantifiable null models against which to test hypotheses.

It is with this background that Ted Case and Martin Cody have edited an empirically and theoretically well-rounded book on the Gulf of California. The work is important for a number of reasons. It provides information about a unique area that faces threats to its ecosystems. It analyzes, side by side, biogeographic data on the flora and several faunal components of the same geographic region. And it pulls together separate analyses to offer insight into a number of biogeographic principles and competing models. The tables on the distribution of organisms on Gulf islands and, in many cases, the neighboring Baja California peninsula and Sonoran desert provide a valuable biological data base. Most of the contributing authors address current theories, both in biogeography and with regard to episodes of vulcanism and land-bridge connections in the region. Many test their data against different models. However, extensive quantitative testing against null models is neglected, an omission that will rankle some biogeographers.

Setting the physical scene is a paper on the geology and ages of the islands by Gordon Gastil, John Minch, and Richard Phillips. Physical oceanography is covered by Linda Maluf. George Lindsay provides a chapter on the history of scientific exploration of the area. Donald Thomson and Matthew Gilligan analyze an impressive set of data to ask if Gulf islands are "biogeographic islands" to rocky-shore fishes. The results do not conform to predictions from the dynamic equilibrium model.

Understanding of terrestrial faunas usually depends on knowledge of the flora. Cody, Reid Moran, and Henry Thompson provide important work on the plants, looking at generalities as well as more specific ecological and evolutionary considerations for selected genera. Robert Murphy examines origins and evolution in reptiles and finds that patterns of extinction and deterministic aspects of the distribution suggest explanations deriving from paleogeographic legacy, rather than equilibrium theory. In a second excellent chapter on reptiles, Case does not entirely disagree with Murphy, but his approach is ecological and his style more along the lines of those involved with equilibrium theory.

Cody's chapter on land birds is an important study on the ecology and evolution of Gulf and adjacent mainland avifaunas. Daniel Anderson discusses distribution and feeding ecology of seabirds, for which food and predator-free nesting substrates are the most important determinants of distribution and abundance. A chapter by Timothy Lawlor is a major summary of the ecology and evolution of land mammals in the area, which seem to conform to legacy rather than to equilibrium theory explanations. Of special interest are Lawlor's ideas on the evolution of body size on islands and refinements of earlier thoughts on the relation of size to food availability, diet, and feeding behavior.



"Breeding brown pelicans (*Pelecanus occidentalis*) on Isla San Pedro Martír. Dense populations of pelicans and several other seabirds breed on this small and steep island." [From *Island Biogeography in the Sea of Cortéz*]

Conrad Bahre, writing on human impacts on the midriff islands, provides an interesting overview of occupation and use from earliest times, up through the egging and guano-gathering periods of more recent time. Commercial and sport fishing and the taking of sea turtles for food are cause for continuing concern.

The concluding chapter by Case and Cody addresses all of the current models in biogeography, providing a concise summary of the theory and practical aspects and comparing the results obtained by each of the contributors. Ultimately, the islands in the Sea of Cortéz are limited with respect to testing the equilibrium model. Instead, we are reminded that support or confirmation of competing theories in biology often depends on which organisms are studied. Brief overviews are also given of competition, predation, coevolution, historical legacies, and the taxon cycle as they relate to island biogeography in the Gulf. There is still much to debate, but it is not a matter of what Case, Cody, and the contributing authors say, or fail to say. Rather it is a manifestation of the dynamic state in which biogeography is found at the present time.

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Biological Structures and Processes

A Mammalian Appendage

Deer Antlers. Regeneration, Function, and Evolution. RICHARD J. GOSS. Illustrated by Wendy Andrews. Academic Press, New York, 1983. xvi, 316 pp. $45.

One of the beauties of biology is the plethora of apparently erudite topics that, in the hands of an appropriately literate author, can form the basis of a book of the "cannot-be-put-down-until-finished" variety. Deer antlers are such a topic; R. J. Goss is such an author; and this is such a book.

Goss, widely known for his publications on regenerative phenomena in animals, here summarizes his 25-year fascination with the only known mammalian appendage capable of total regeneration.

The first three chapters introduce the topic, familiarize the uninitiated with the "dramatis cervidae" in thumbnail sketches, and distinguish between antlers and the more widespread horns and tusks. The chapter reviewing the evolution of deer reveals that, though cervid artiodactyls are the only extant forms with renewable antlers, several extinct