Chapter 08

Trophic Dynamics in Evolutionary Context

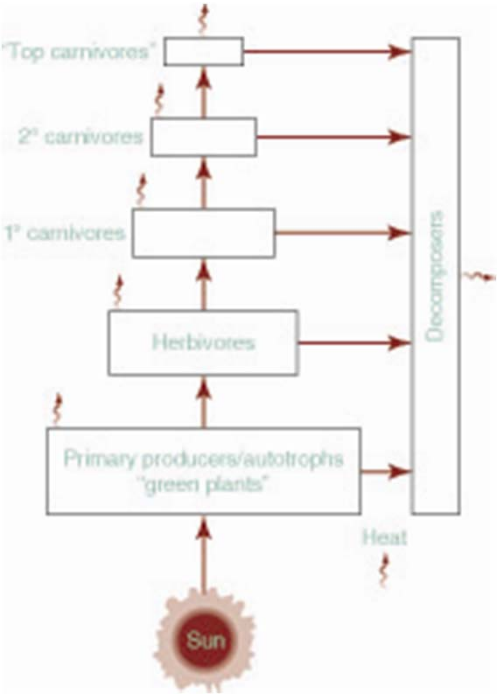


FIGURE 8-1

This simple compartment model illustrates the basic grazing food chain along with the decomposer compartment. Note that decomposers do not fit into the linear food chain, and note further that many animals may occupy more than one trophic level, something that is not evident in the diagram. Red arrows indicate direction of energy flow. Each compartment releases heat energy, and no energy is ever recycled.

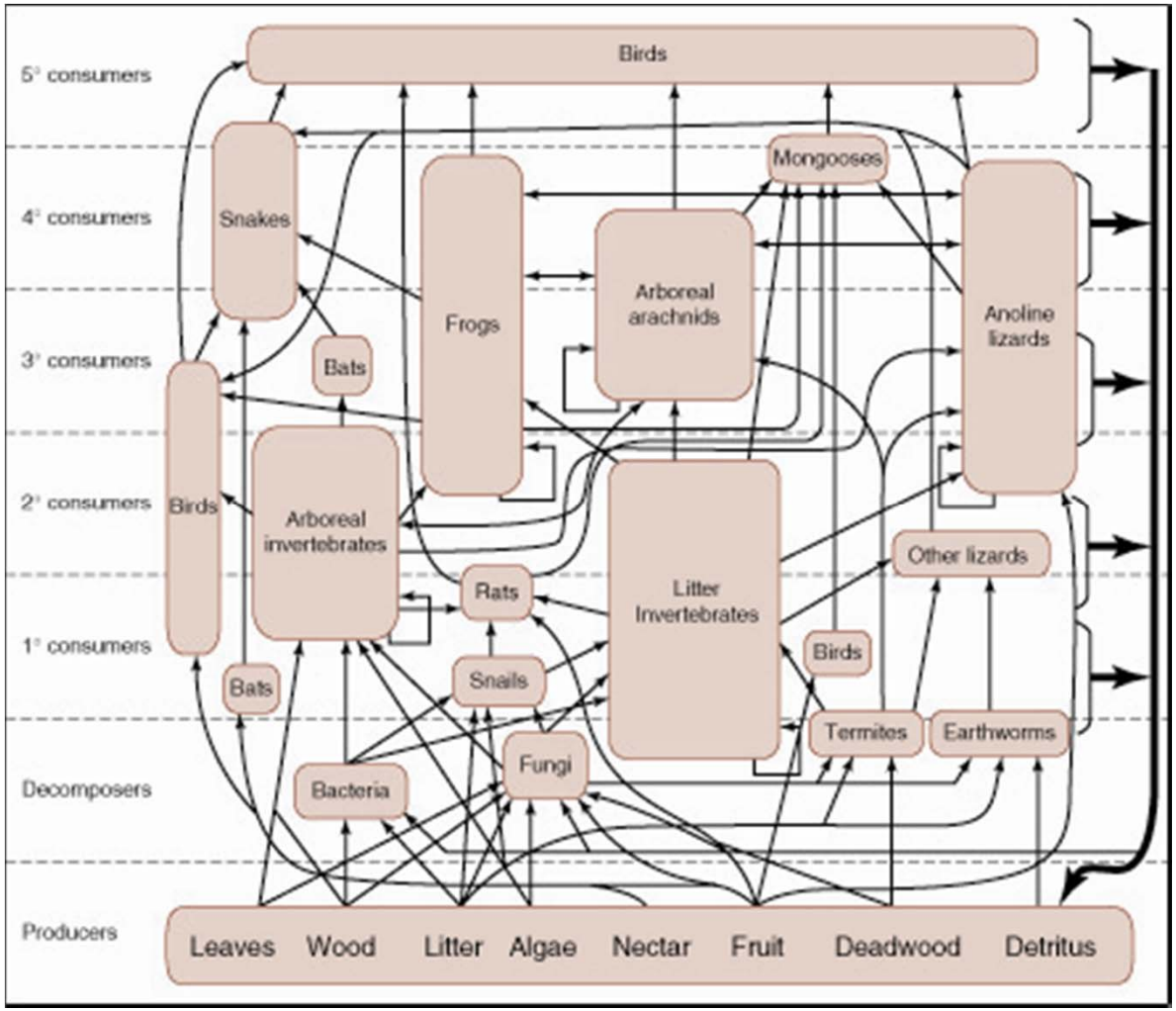


FIGURE 8–2

An aggregated food web of the El Verde community, presenting the groups discussed in this text.

PLATE 8-1

The ubiquitous coqui, a small tree frog.

PLATE 8-2

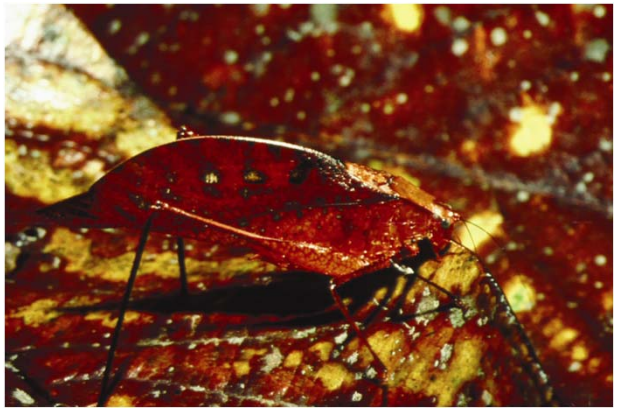
WHITE-WINGED SHRIKE-TANAGER (FEMALE)

PLATE 8-3

Boa constrictor on forest floor, demonstrating cryptic coloration. The photo was taken with flash, at night.

PLATE 8-4

BLUE MORPHO



(a)

(b)

(c)

PLATE 8-5

(a) to (c) These three images of katydids (Orthoptera) demonstrate how various species from the same insect group are adapted to be cryptic in the forest.

PLATE 8-6

This large wolf spider exhibits crypsis as it searches for prey on the forest floor.

(a)

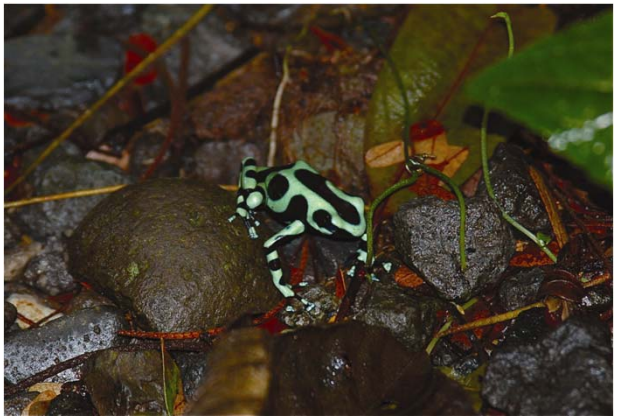
(b)

PLATE 8-7

(a) A great potoo (*Nyctibius grandis*) on a branch in Ecuador. Look very closely and notice the young bird in front of its parent. (b) A Papuan frogmouth (*Podargus papuensis*) at its nest (notice the sticks) in Australia.

PLATE 8-8

Cheetahs (*Acinonyx jubatus*) inhabit savannas in Africa. Their spotting pattern breaks up their outline and renders them more difficult to detect. Note the second animal to the left, in shade and in front of the prominent one.



(a)

(b)

FIGURE 8–3

Ranges of species of poison-dart frog (*Phyllobates*).

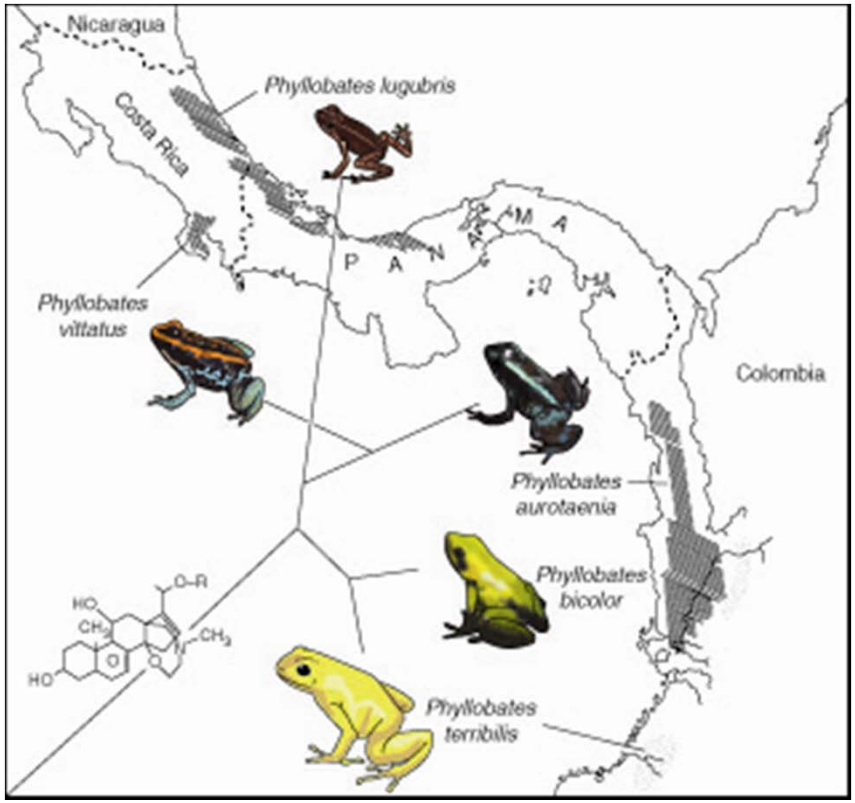


PLATE 8–9

(a) *Dendrobates pumilio*, sometimes called the strawberry poison-dart frog, sometimes called the blue jean frog, both for obvious reasons. (b) Poison-dart frog (*Dendrobates auratus*).

PLATE 8-10

HOODED PITOHUI (*PITOHUI DICHROUS*)

PLATE 8-11
CORAL SNAKE

PLATE 8-12
PSEUDOSPHINX CATERPILLAR

PLATE 8-13

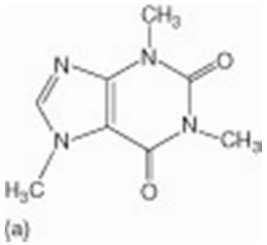
This caterpillar also represents an example of aposematic coloration, and then some. Note its bright coloration (it appears to have “headlights”), but note also that it is covered with dense spines. These are *urticating hairs* that cause extreme itching and discomfort if touched. And if you do pick up this caterpillar, it will spasm such that you are likely to drop it immediately.

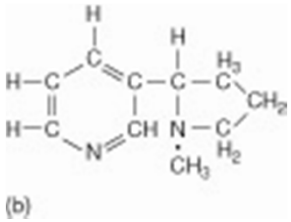
PLATE 8-14

A perched laughing falcon (*Herpetotheres cachinnans*) holding a live coral snake (*Micrurus nigrocinctus*) by the posterior end.

PLATE 8-15

Leaf damage by herbivorous insects is common in tropical leaves.





(a) (b)

FIGURE 8-4

(a) Caffeine molecule; (b) nicotine molecule.

PLATE 8-16

This adult cane toad is well protected by its chemical defenses. The bufo-toxin is secreted by the large parotoid glands posterior to the head, shown as swellings in this image.

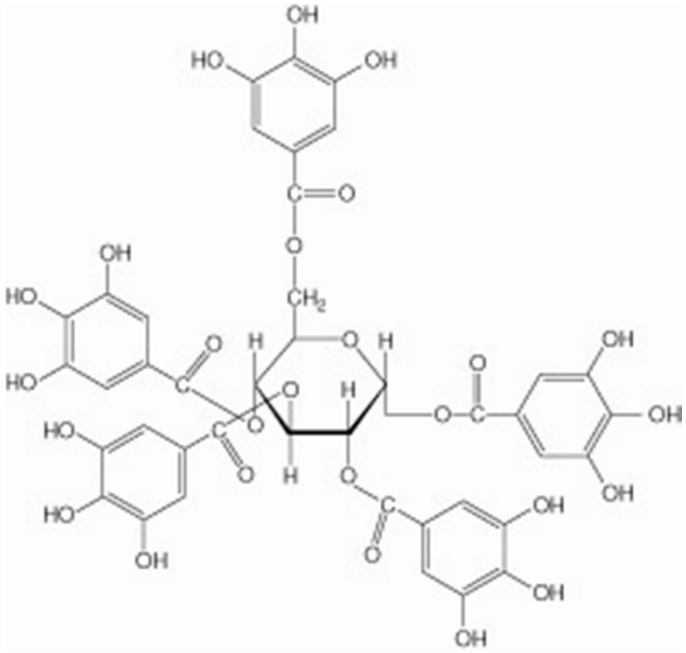


FIGURE 8-5

The basic molecular structure of a tannin molecule.

PLATE 8-17

Manioc cutting, recently planted, will grow into a full-size plant.

PLATE 8-18
Roots of cassava for sale at a market in Manaus, Brazil.

PLATE 8-19
Millipede on forest floor.

PLATE 8-20

Millipede in hand, curling into a ball.

PLATE 8-21

White sandy soil near Manaus, Brazil.

PLATE 8-22

Cecropia leaves, showing extensive damage by herbivorous insects.

(a)

(b)

PLATE 8-23

(a) The branches of this understory acacia look innocent enough until you get close and meet the ants that guard the plant. (b) The swollen, paired hollow thorns of the acacia tree house small but aggressive *Pseudomyrmex* ants, seen here swarming over the branch.

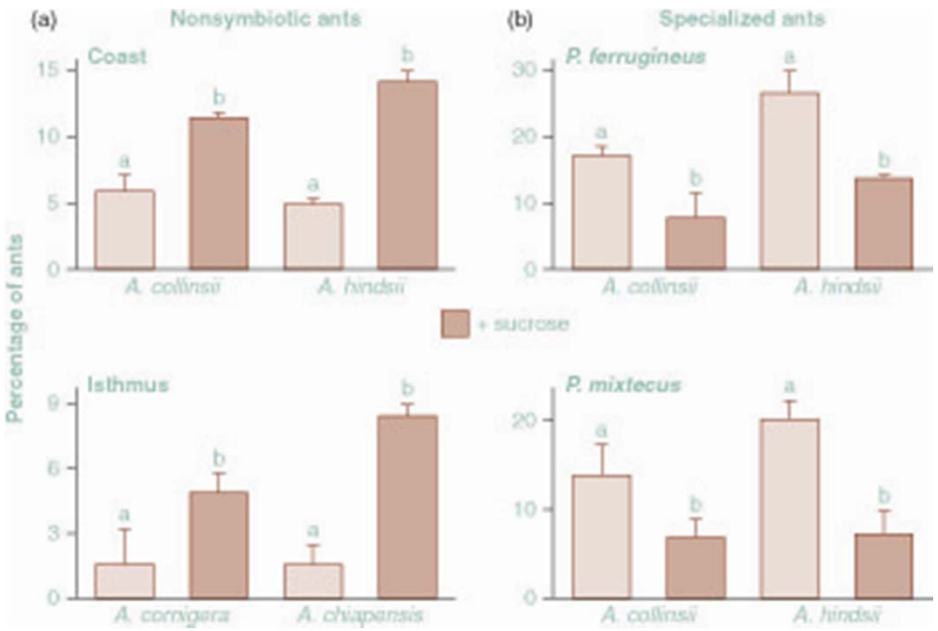


FIGURE 8-6
Responses of ants to EFN nectar of two Acacia myrmecophytes (*A. cornigera* and *A. hindsii*) supplemented with sucrose. Responses of nonsymbiotic (a) and specialized (b) ants to nectars without (tan bars) and with (brown bars) added sucrose (equal volumes of natural nectar and sucrose solution mixed, concentration 2% [weight/volume]) are given as percentages of ants attracted to these two solutions in cafeteria-style experiments. Nonsymbiotic ants were investigated at two sites (coast and isthmus), and the specialized *Acacia* inhabitants (*P. ferrugineus* and *P. mixtecus*) were investigated on *Acacia collinsii* shrubs. Bars represent means +SE. The number of ants attracted to nectar with and without added sucrose differed signi3 cantly (indicated by letters; $P < 0.05$ according to paired t test, $n = 7$ feeding sites [a] or colonies [b] in all cases]).

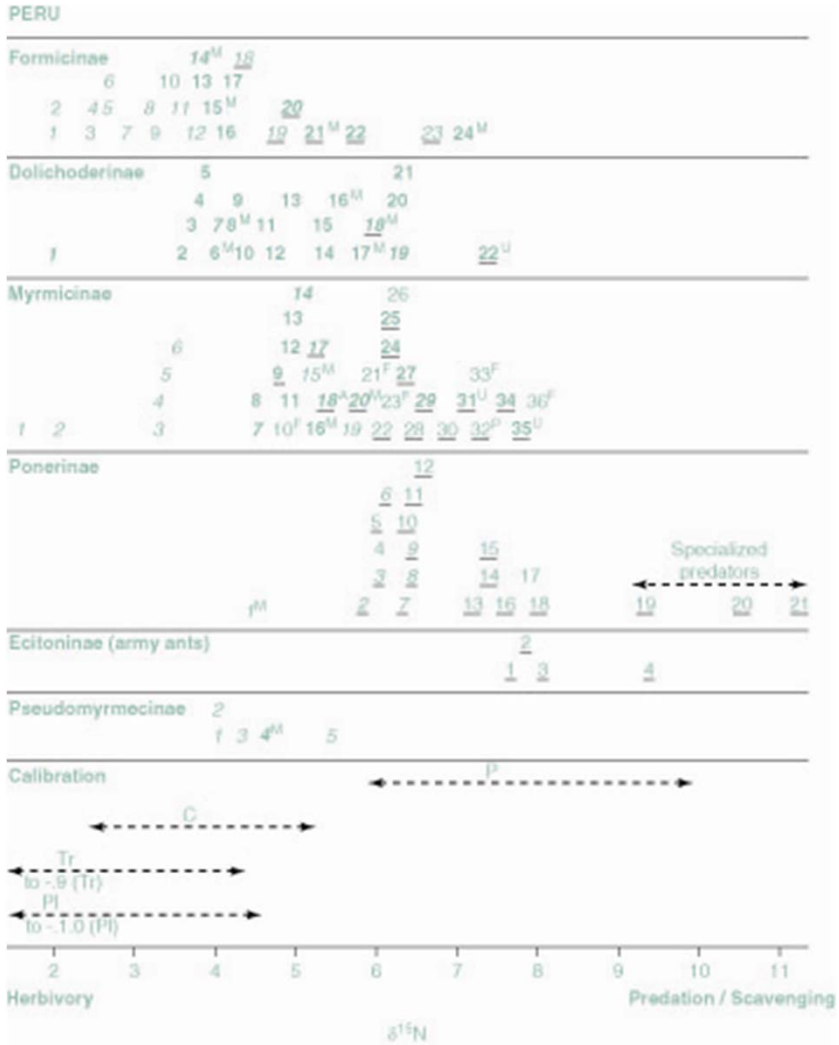


FIGURE 8–7

Mean $\delta^{15}N$ values (‰, by subfamily) for numbered Peruvian species. Predominant foraging modes are shown as follows: italics, leaf foraging; bold, trophobiont tending; underlined, predation; none of the above, poorly studied. Superscripts: A, ant-garden resident; F, attine fungus cultivators; M, specialized associate of myrmecophytes; P, brood parasite; U, unicolonial species. Calibration: Pl, 36 nonmyrmeco-phytic plant samples; Tr, 26 sap-feeding trophobionts, not from myrmecophytes; C, 13 chewing herbivores (Coleoptera, Orthoptera, and Diptera); P, 7 arthropod predators (Acari, Araneida, Hemiptera, and Pseudoscorpionida).

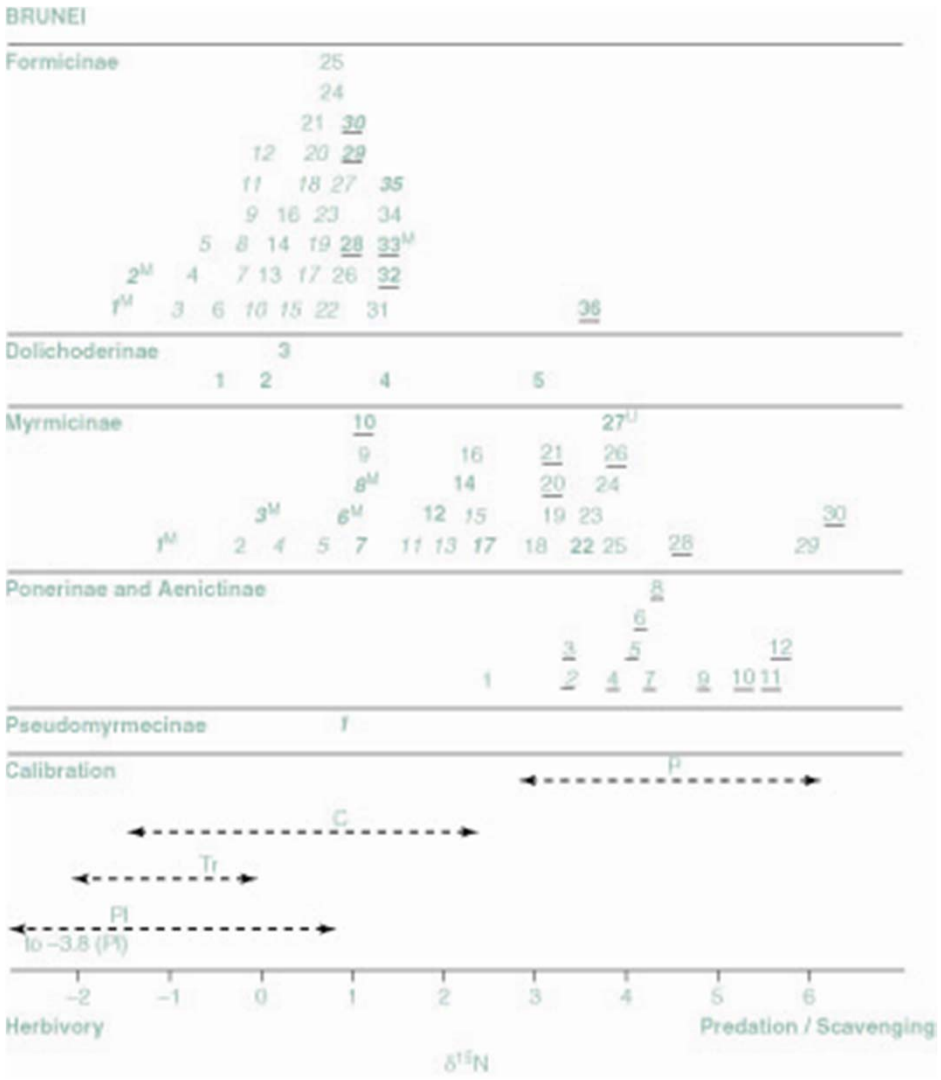


FIGURE 8-8

Mean $\delta^{15}N$ values (‰, by subfamily) for numbered Bornean species. Predominant foraging modes are shown as in Figure 8-7. Calibration: Pl, 20 nonmyrmecophytic plant samples; Tr, 9 sap-feeding trophobionts, not from myrmecophytes; C, 9 chewing herbivores (Coleoptera, Myrlapoda, Orthoptera, and Gastropoda); P, 9 arthropod predators (Acari, Araneida, Phalangida, Pseudoscorpionida, Chilopoda, and Coleoptera).

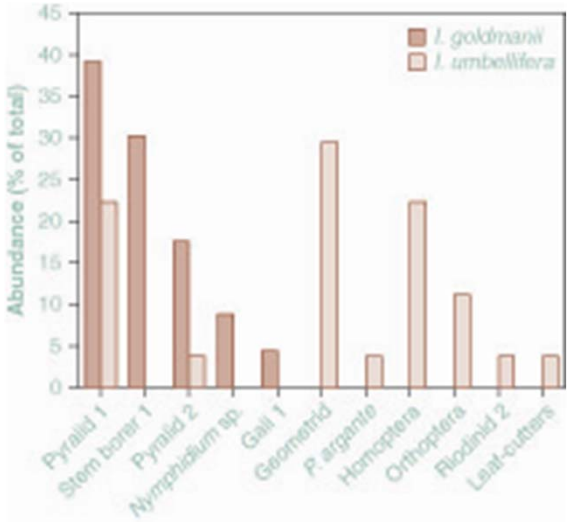


FIGURE 8-9

Herbivore communities on *Inga goldmanii* and *Inga umbellifera*. Data include only those herbivores that were identified to morphospecies, or to order in the case of Homoptera and Orthoptera (n = 50). Abundance is the percentage of the total observations assigned to a particular herbivore morphospecies (i.e., sums to 100% for each plant species).

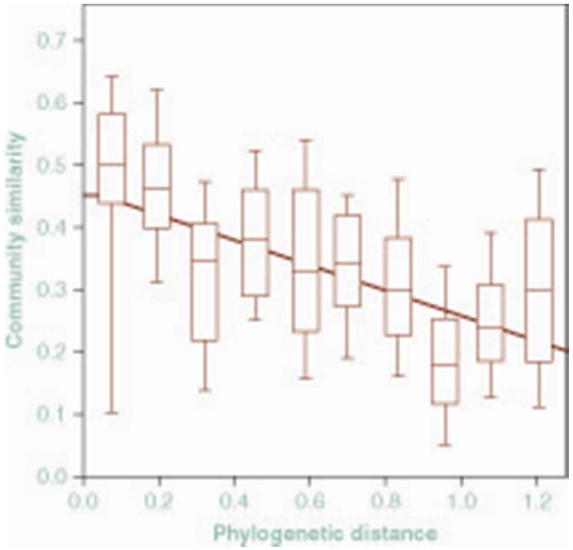
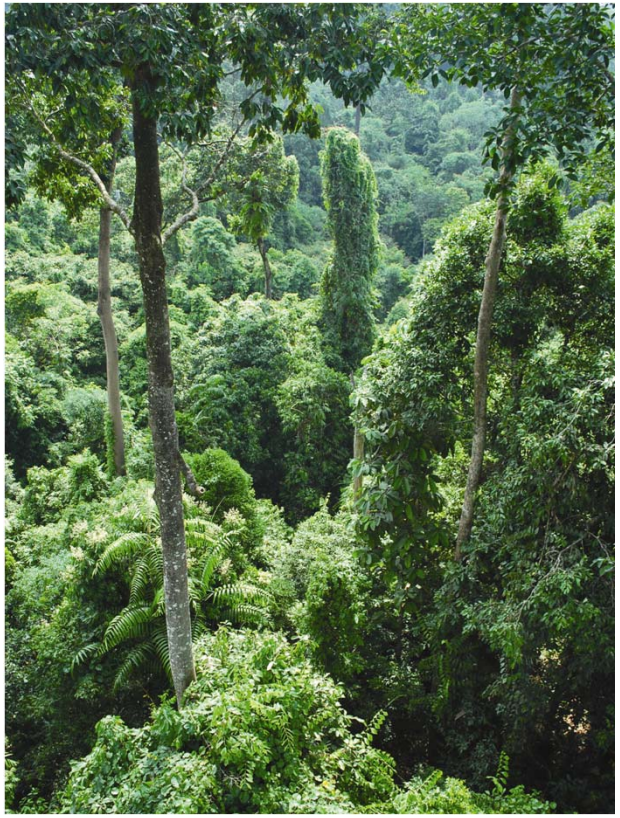


FIGURE 8–10

Herbivore community similarity as a function of the phylogenetic distance between host plants. Similarity is the fraction of the total fauna on two hosts that is shared between the hosts. Phylogenetic distance was derived from a penalized-likelihood ultrametric phylogram. Means, standard deviations, and ranges of community similarity are shown for selected distance intervals. The outgroup is excluded from the regression.



(a)

(b)

PLATE 8-24

DIPTEROCARP FOREST

PLATE 8-25

Palm nuts form a keystone resource for many animal species.

PLATE 8-26

These two blue and yellow macaws (*Ara ararauna*) are attracted to a “macaw feeder” at this field station in Peru. But they are naturally attracted to feed on palm nuts and figs.

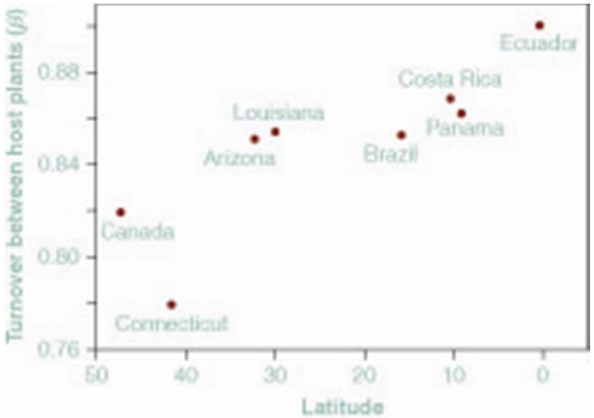


FIGURE 8-11

Caterpillar species turnover among host plant species for eight forest and woodland sites across a latitudinal gradient. Modified Whittaker's β is shown for two temperate (Canada and Connecticut), two subtropical (Arizona and Louisiana), and four tropical (Brazil, Costa Rica, Panama, and Ecuador) sites, ordered by an approximate modal latitude for each site. With this measure, insect species turnover across host plants is used as an index of host plant specialization, with higher values of β indicating higher levels of specialization. Symbol size was greater than the 95% CI for all sites except Connecticut.

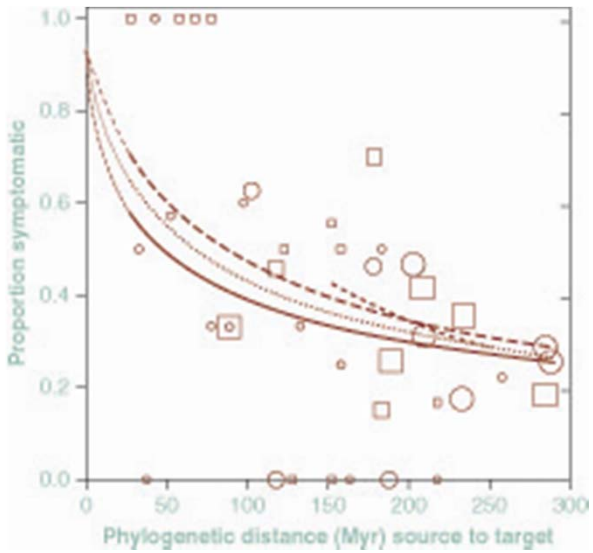


FIGURE 8-12

Proportion of target plant species that developed disease symptoms after inoculation with fungal pathogens from source plant species. Note how proportion drops with phylogenetic distance of source to target.

PLATE 8-27

Heliconid butterflies (this one is *H. doris*) are found throughout the Neotropics and have been the object of much coevolutionary study.

PLATE 8-28

Passionflower vines (*Passiflora*) are fed upon by caterpillars (larvae) of *heliconius* butterflies. Photo shows the plant and its inflorescence.

PLATE 8-29

HELICONID CATERPILLAR

PLATE 8-30

Even from a considerable distance, *heliconius* butterflies are obvious.
This one is either *H. melpomene* or *H. erato*. They are very difficult to distinguish (see text).

PLATE 8-31

This caligo butterfly (*Caligo eurilochus*) shows substantial damage along the lower edge of its wings. The bite marks of one or more bird beaks are clearly visible.

PLATE 8-32

RUFOUS-TAILED JACAMAR

PLATE 8-33

Heliconius doris adult on a milkweed flower.

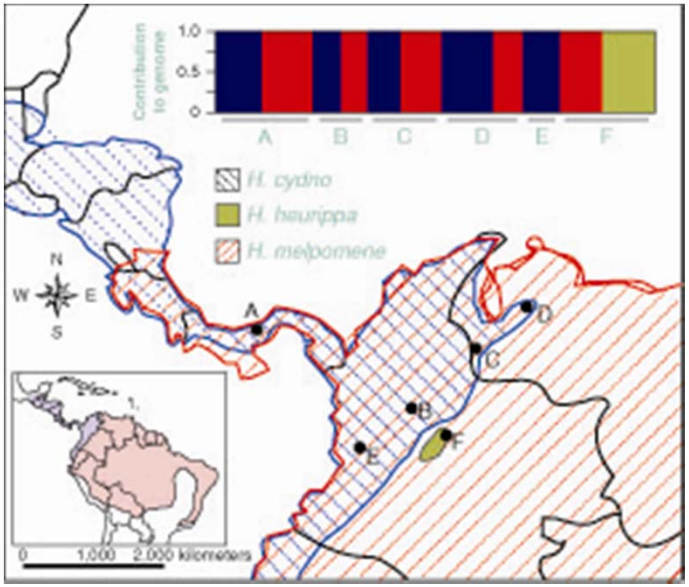


FIGURE 8-13

The geographic distributions and genetic differentiation among the three *heliconius* species in the study. The letters signify field areas where the animals were collected for the study. The upper inset shows the relative contributions of the three clusters to each individual's genome: blue—*H. cydno*; red—*H. melpomene*; green—*H. heurippa*.

FIGURE 8-14

The three wing patterns of the species used in the study. Note that *H. heurippa* is intermediate in pattern between the two parent species.

PLATE 8-34

VICEROY (LEFT) AND MONARCH (RIGHT)

(a)

FIGURE 8-15

Comparison of distributions of *H. erato* and *H. melpomene*. Note the divergence within each species' convergence over its range but the convergence in pattern between the two species wherever they co-occur.

(b)

FIGURE 8–15

(*continued from page 314*)

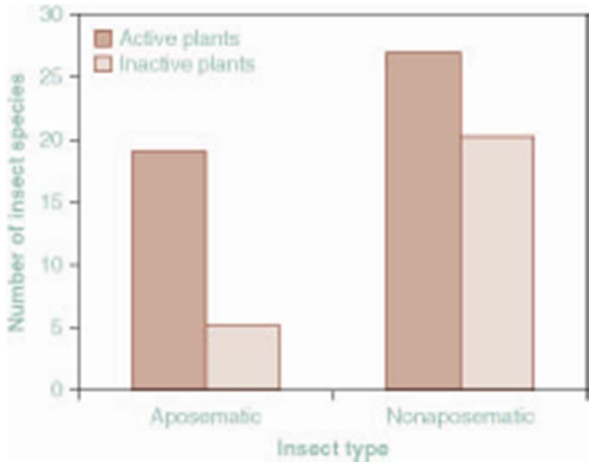


FIGURE 8–16

Number of aposematic and nonaposematic insect species found to feed on the 10 biologically active and 10 biologically inactive tropical plants studied.

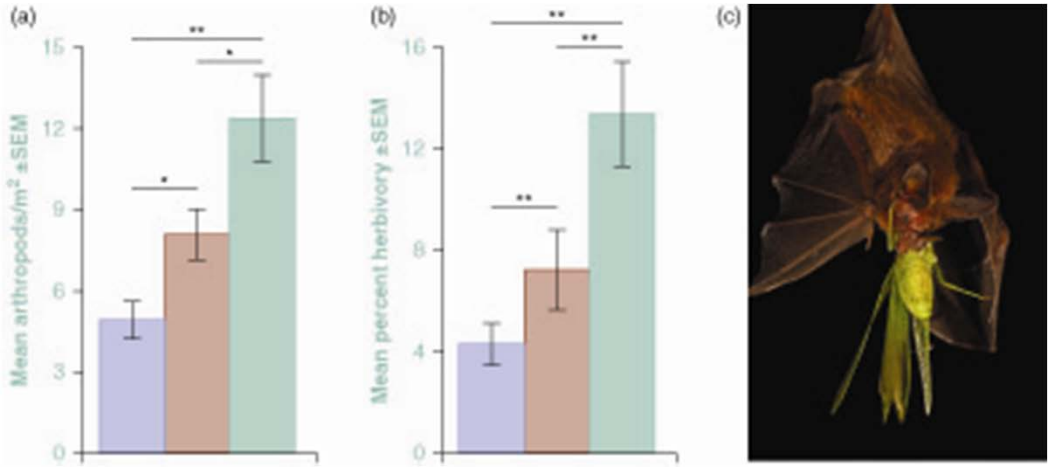


FIGURE 8–17

(a) Mean number of arthropods per square meter per census. (b) Mean herbivory as percent of total leaf area. Blue bars represent controls (birds and bats present); brown bars, diurnal exclosures (birds absent and bats present); green bars, nocturnal exclosures (bats absent and birds present); $*P < 0.05$ and $**P < 0.005$ according to Tukey's HSD. (c) A bat (*Micronycteris microtis*) consuming a katydid, Barro Colorado Island, Panama.

PLATE 8-35

ECITON SOLDIER

(a)

(b)

(c)

PLATE 8-36

(a) OCELLATED ANTBIRD (*PHAENOSTICTUS MCLEANNANI*) (b) BICOLORED ANTBIRD (*GYMNOPITHYS LEUCASPIS*) (c) RUFOUS-VENTED GROUND-CUCKOO (*NEOMORPHUS GEOFFREYI*)

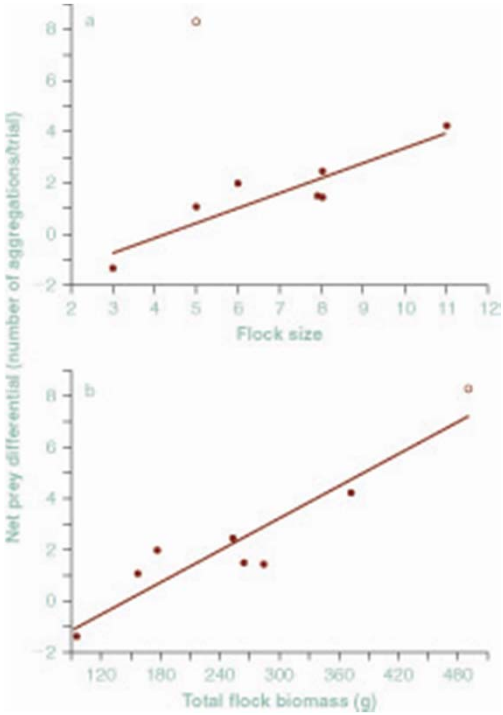


FIGURE 8-18

Costs to *Eciton burchelli* increase with number and species composition of ant-following birds. The open symbol shows the disproportionate effect of participation by the large rufous-vented ground-cuckoo.

PLATE 8-37

COILED FER-DE-LANCE

Notice the poison-dart frog atop the snake. This frog appears to be very well protected.