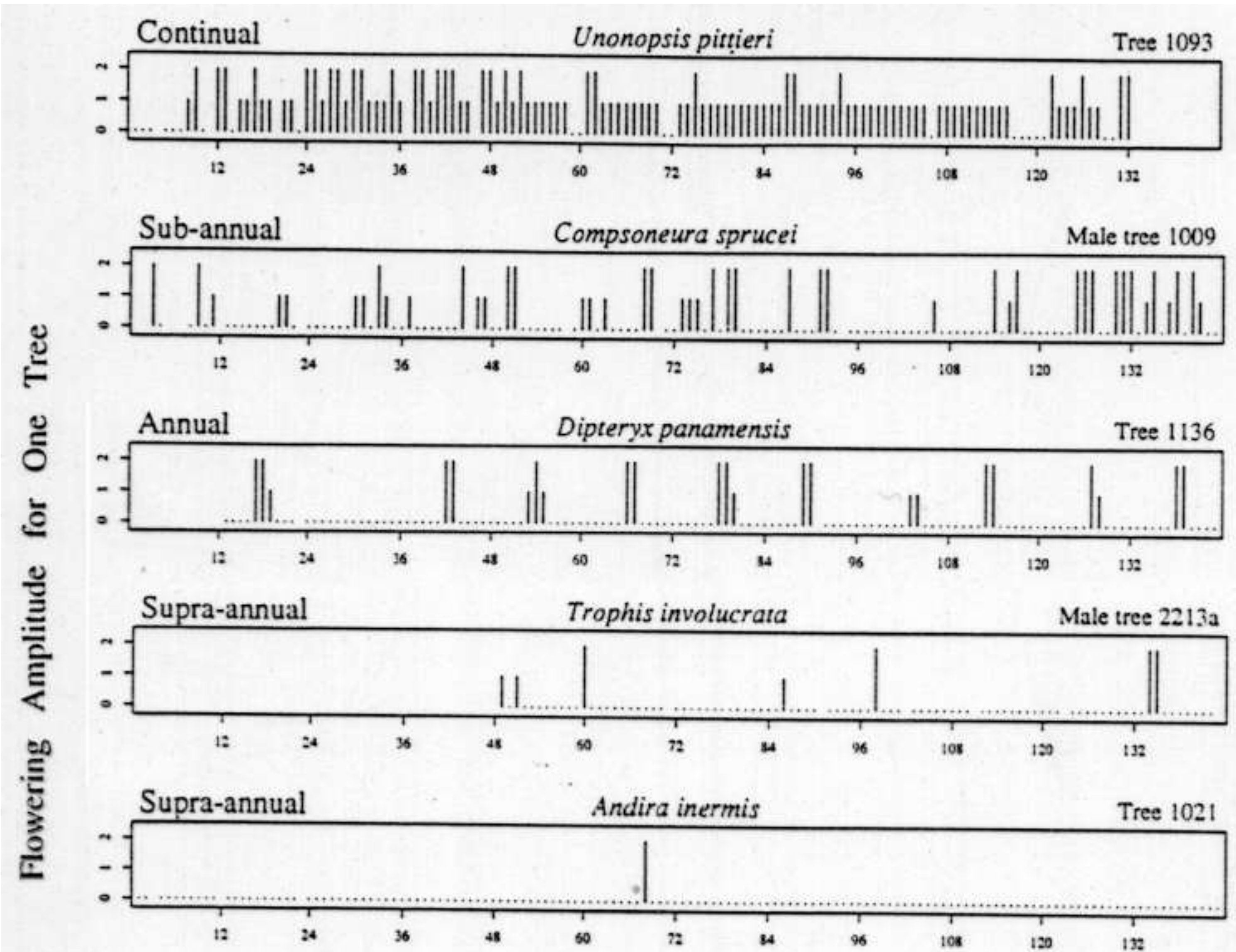
Seasonal and annual variability in tropical ecosystems

Temporal variability in flowering in tropical trees

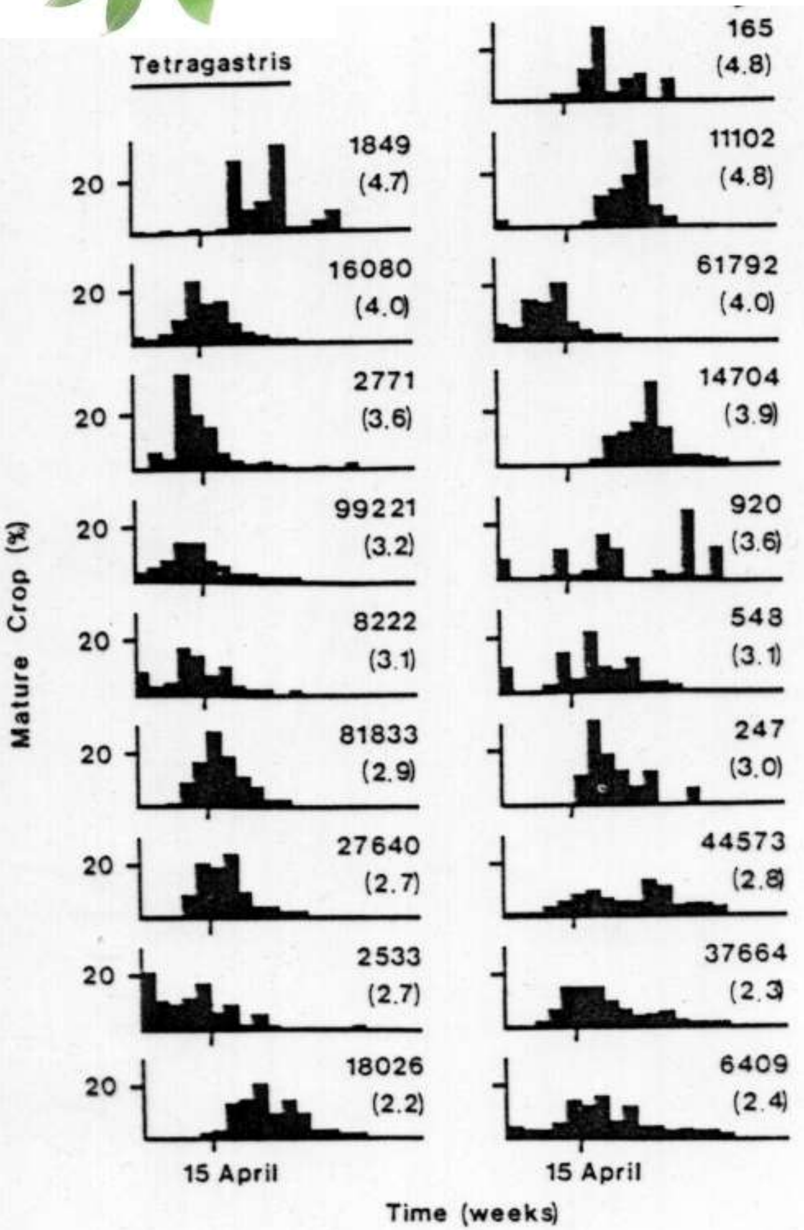
Variability among: parts of individual plant – conspecific plants – species

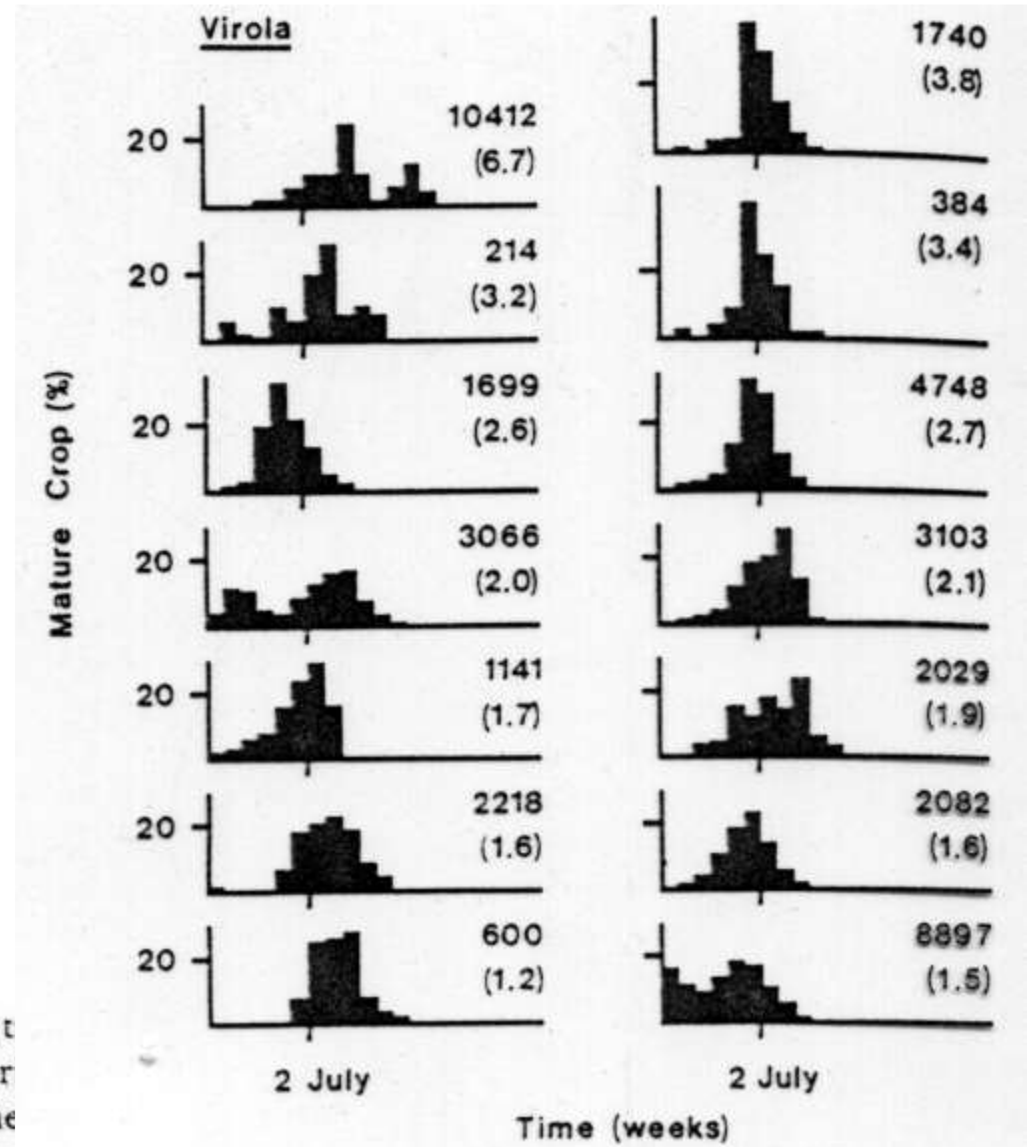
Synchronized over large geographic areas or not?



Fruiting seasonality: intra-population variability

Shrubs on Barro Colorado Island





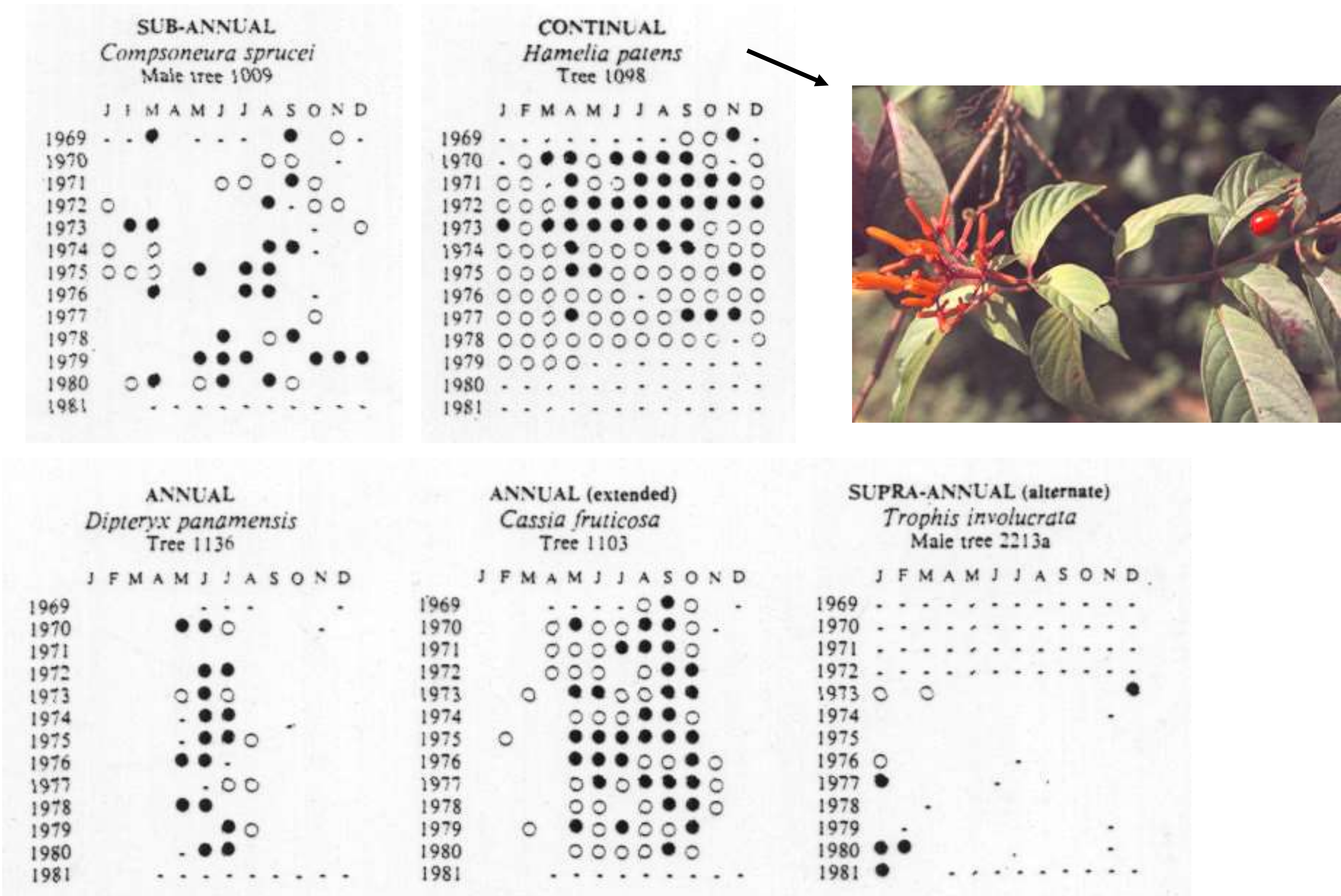
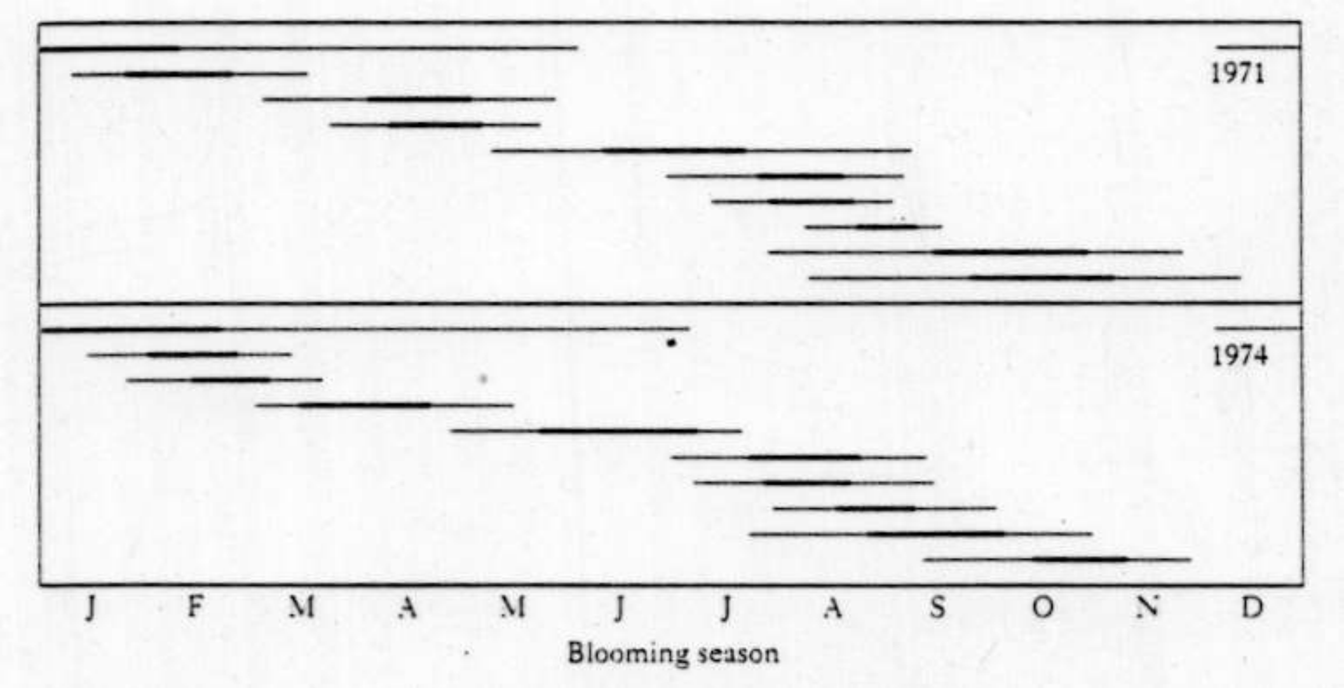
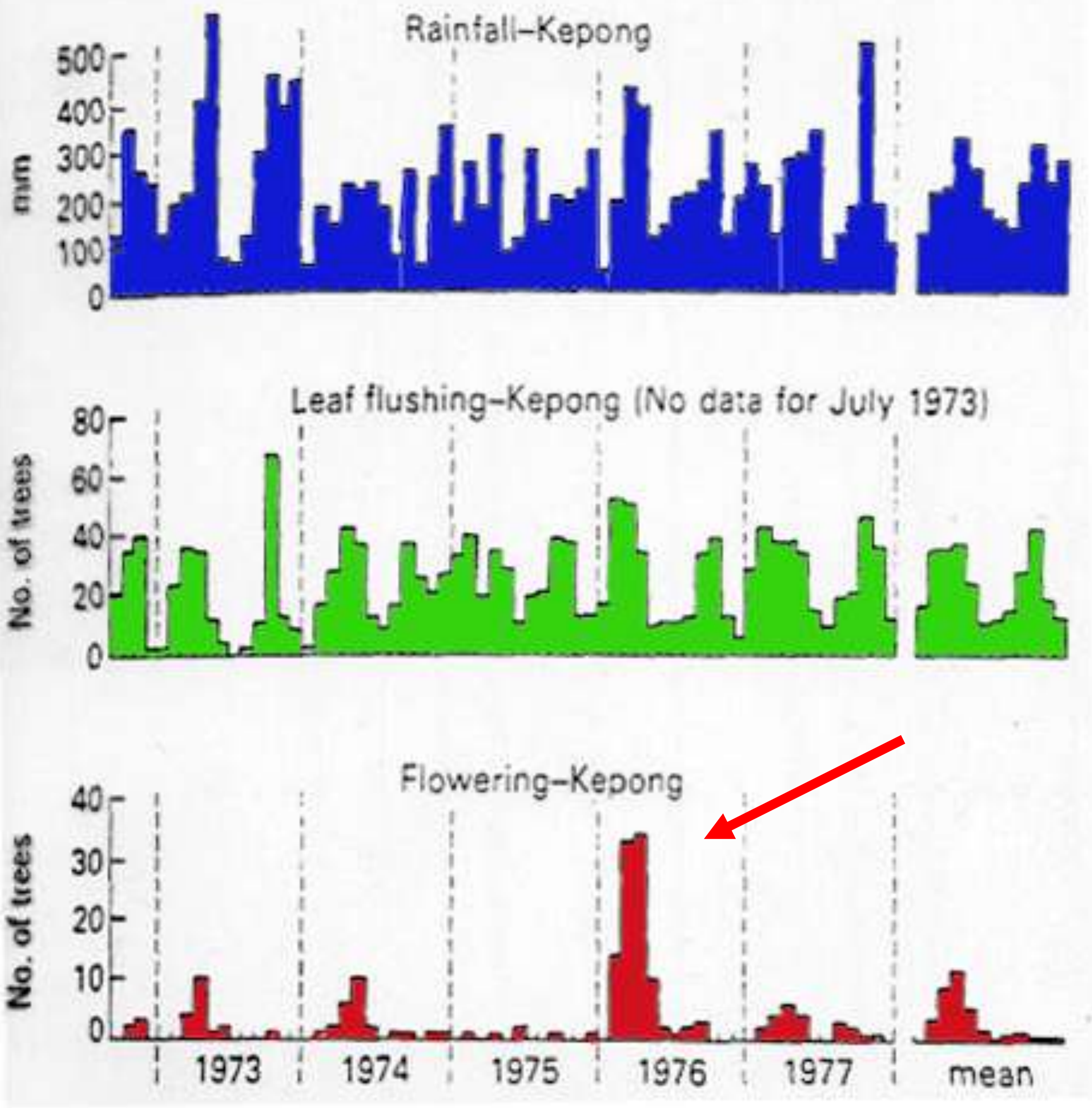


Fig. 11.6. Duration and date of flowering. Matrix graphs (year by month) of flowering for twelve years from 1969 to 1981 in trees of eight species at La Selva Biological Station. Each graph represents flowering in one tree; ● = heavy flowering; ○ = light flowering; blank = no flowering; — = missing data.

Heliconia spp. in Costa Rica: staggered flowering to reduce competition for hummingbird pollinators



The blooming seasons of *Heliconia* species in a Costa Rican rain forest are staggered, ensuring that nectar is always available. It has been proposed that the flowering periods of these banana relatives have diverged to reduce competition for the services of their hummingbird pollinators. Note the similar order of flowering in two years.



Dipterocarps: mass flowering at irregular intervals of 2-10 years [El Nino years]

Seed predator saturation

Lowland mixed dipterocarp forests SE Asia

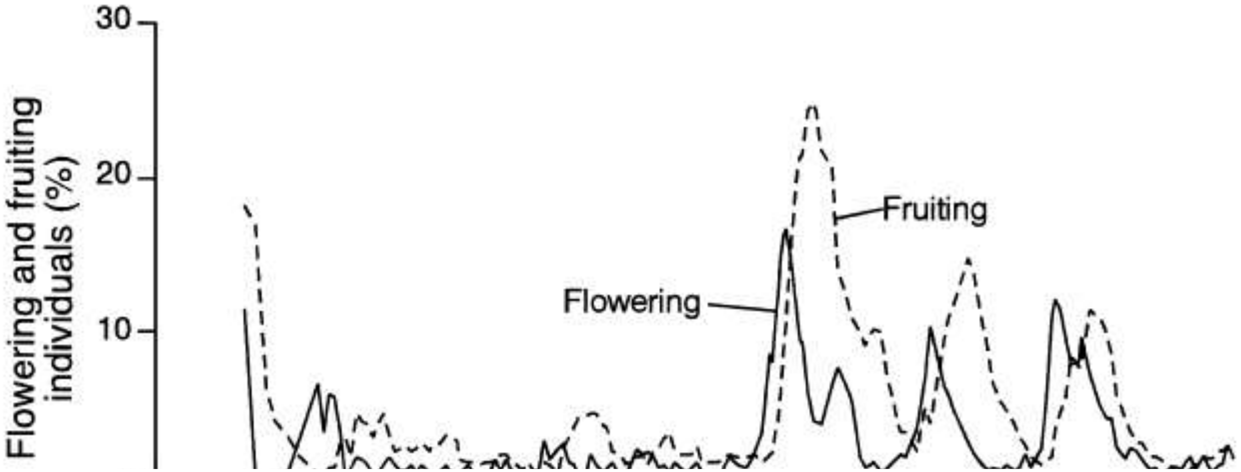
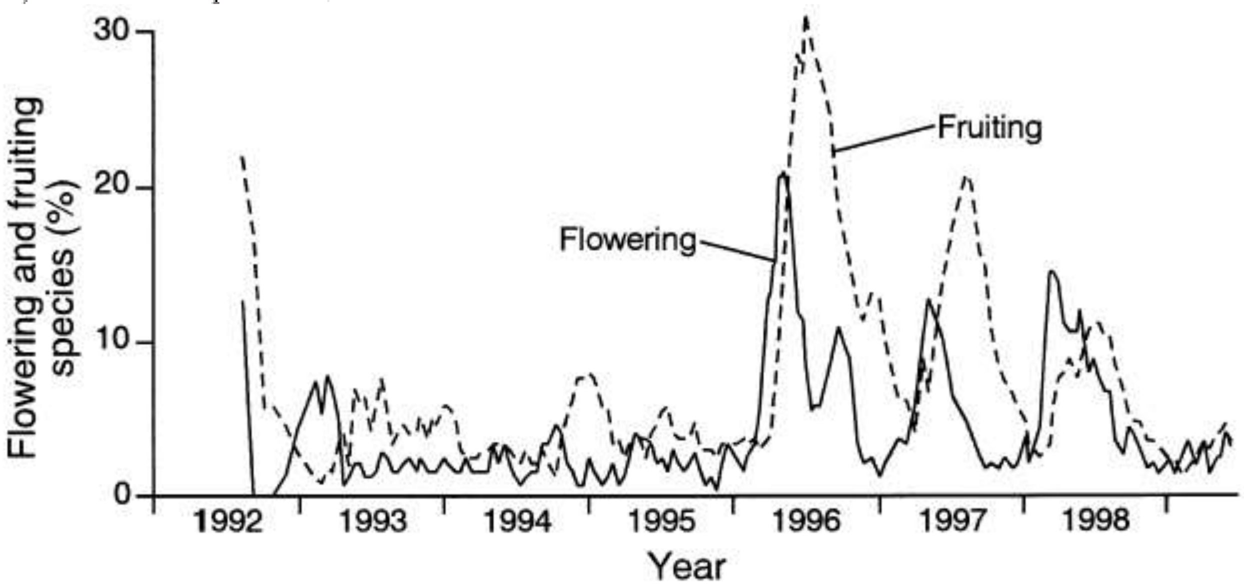
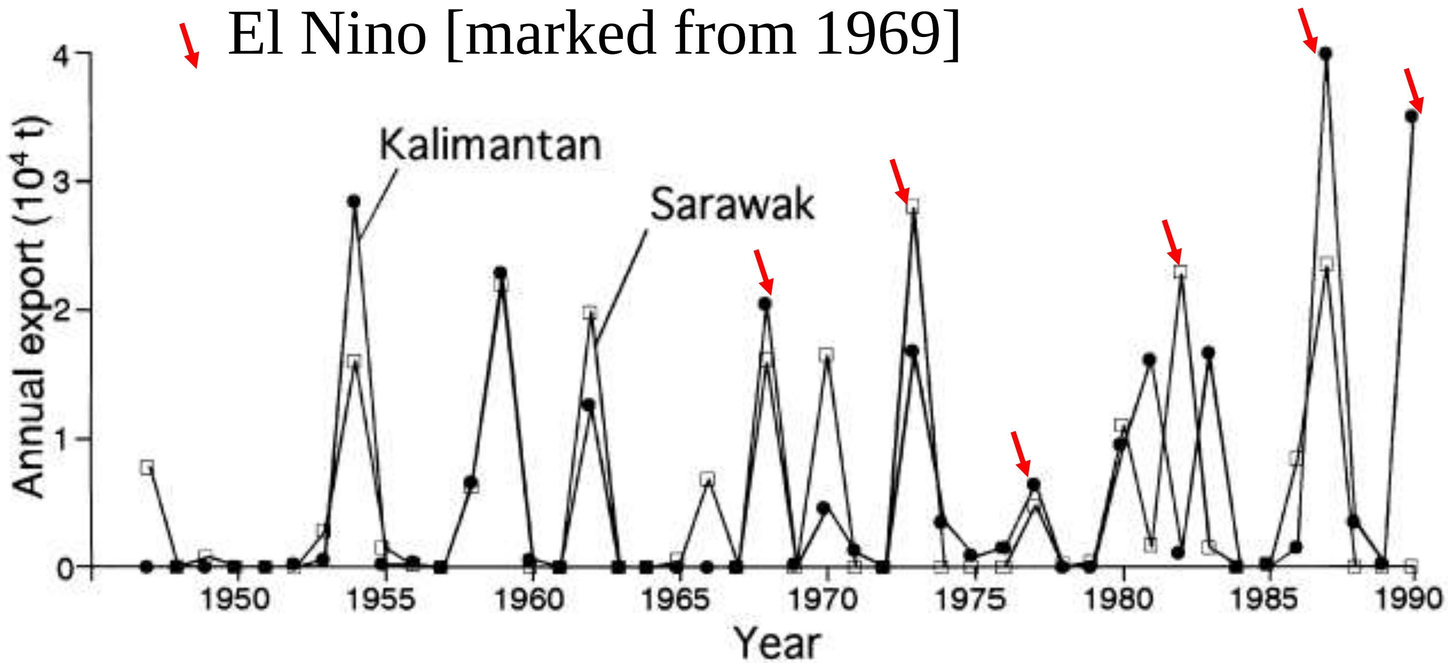


Figure 1. Changes in the percentage of flowering and fruiting species and individuals (237 species, 428 individuals) (Sakai *et al.*, 1999b; Sakai *et al.* unpub. data).



Annual variability in dipterocarp seeds (“illipe nuts”) exports



its exports from S

Dipterocarp seeds:

- large, energy rich (used as a source of cooking oil)
- poorly protected chemically
- wind dispersed

SE |Asian forests: many tree species join dipterocarps in their supra-annual mass flowering cycle

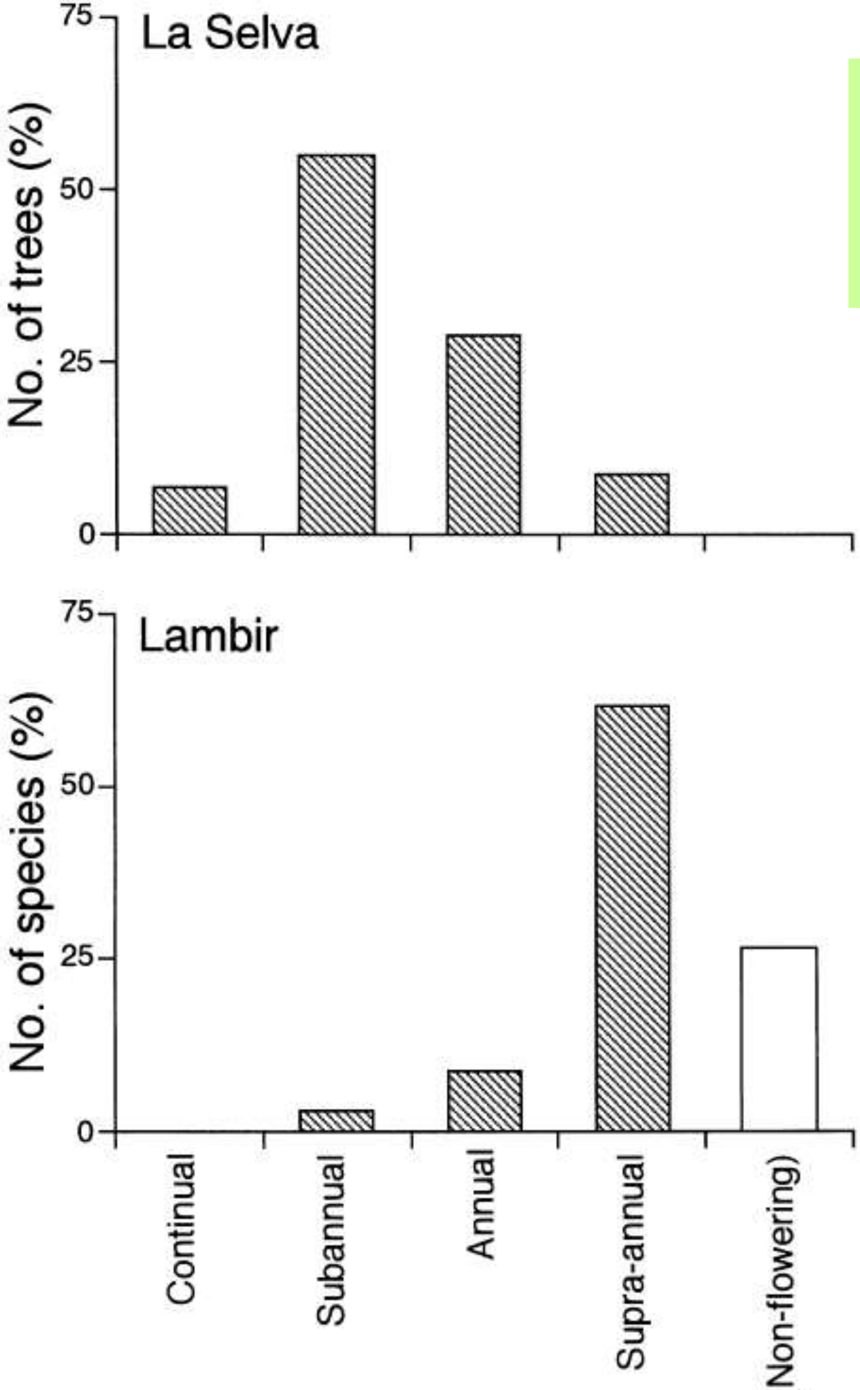


Figure 5. The proportion of subannual, annual, supra-annual and continual flowering types among trees at La Selva, Costa Rica (254 trees, Newstrom *et al*., 1994b) and Lambir (187 tree species, Sakai *et al*., 1999b). In the graph, GF type of Lambir is included in supra-annual type.

Temperature drops by >2°C for at least 3 nights identified as a cue for mass flowering of dipterocarps

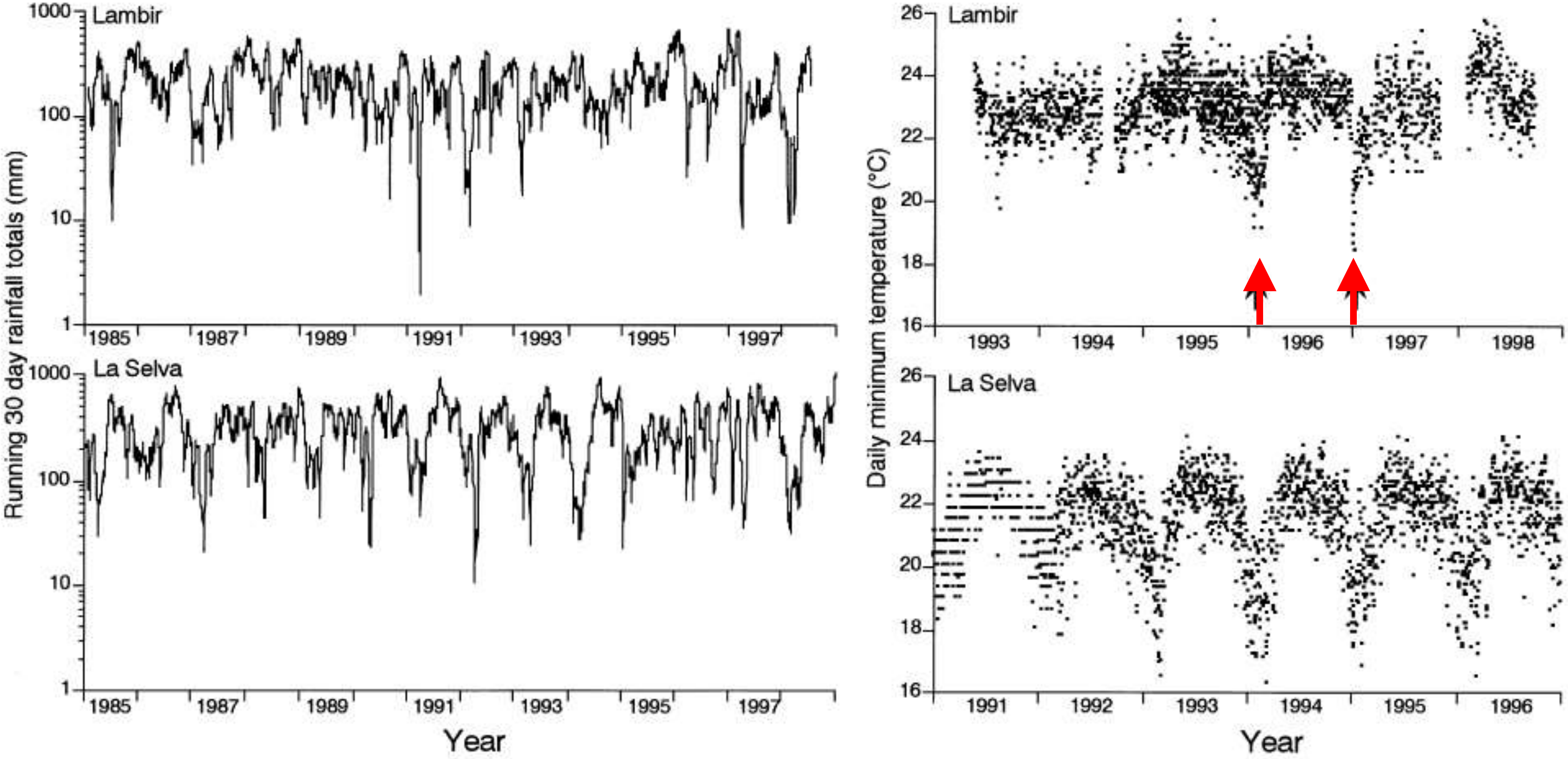


Figure 4. Climate data at Lambir and La Selva. Running 30 day total of rainfall, A: at Lambir; and B: at La Selva from 1985 to 1998. Daily minimum temperature, C: at Lambir from 1993 to 1998; and D: at La Selva from 1991 to 1996. Based on data from Sakai *et al*. (1999b), Sakai *et al*. (unpub. data), and OTS La Selva Biological Station (1999).

Dipterocarps are pollinated by insects (thrips, beetles)

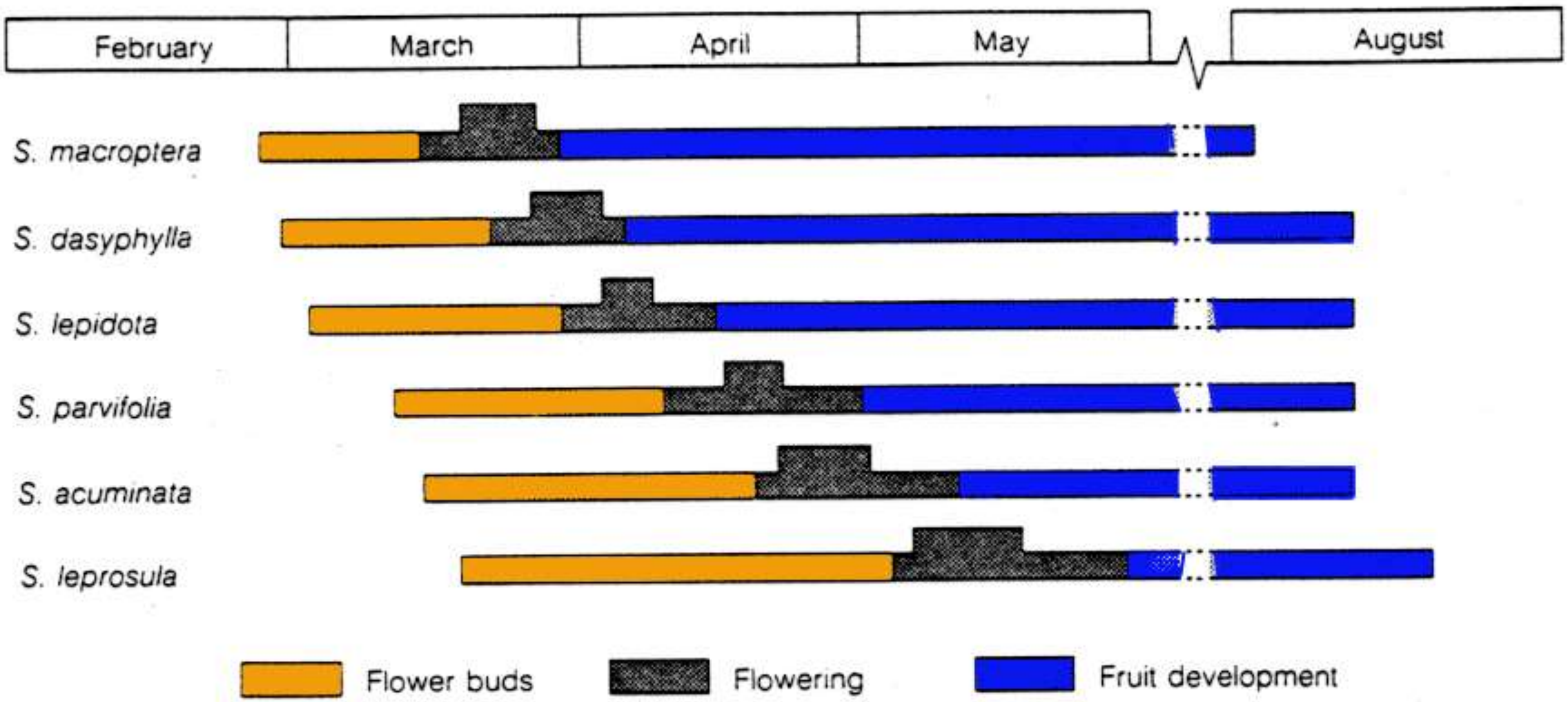
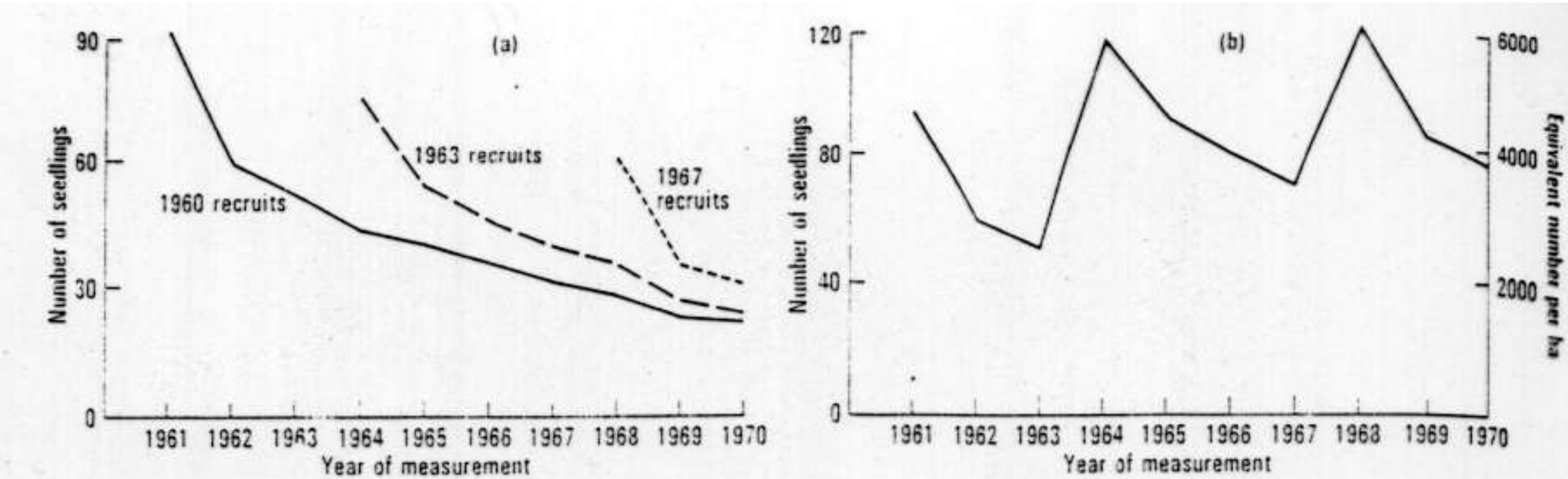


Figure 2.25 Sequential blooming and simultaneous fruiting in related species of *Shorea* during a year with gregarious flowering. Peak flowering time is indicated by the wider bar. (After Longman, 1985.) (Adapted from Fig. 2, p. 31, K. A. Longman, Tropical forest trees, in *CRC Handbook of Flowering*, Vol. 1, ed. A. H. Halevy; published by CRC Press, 1985.)

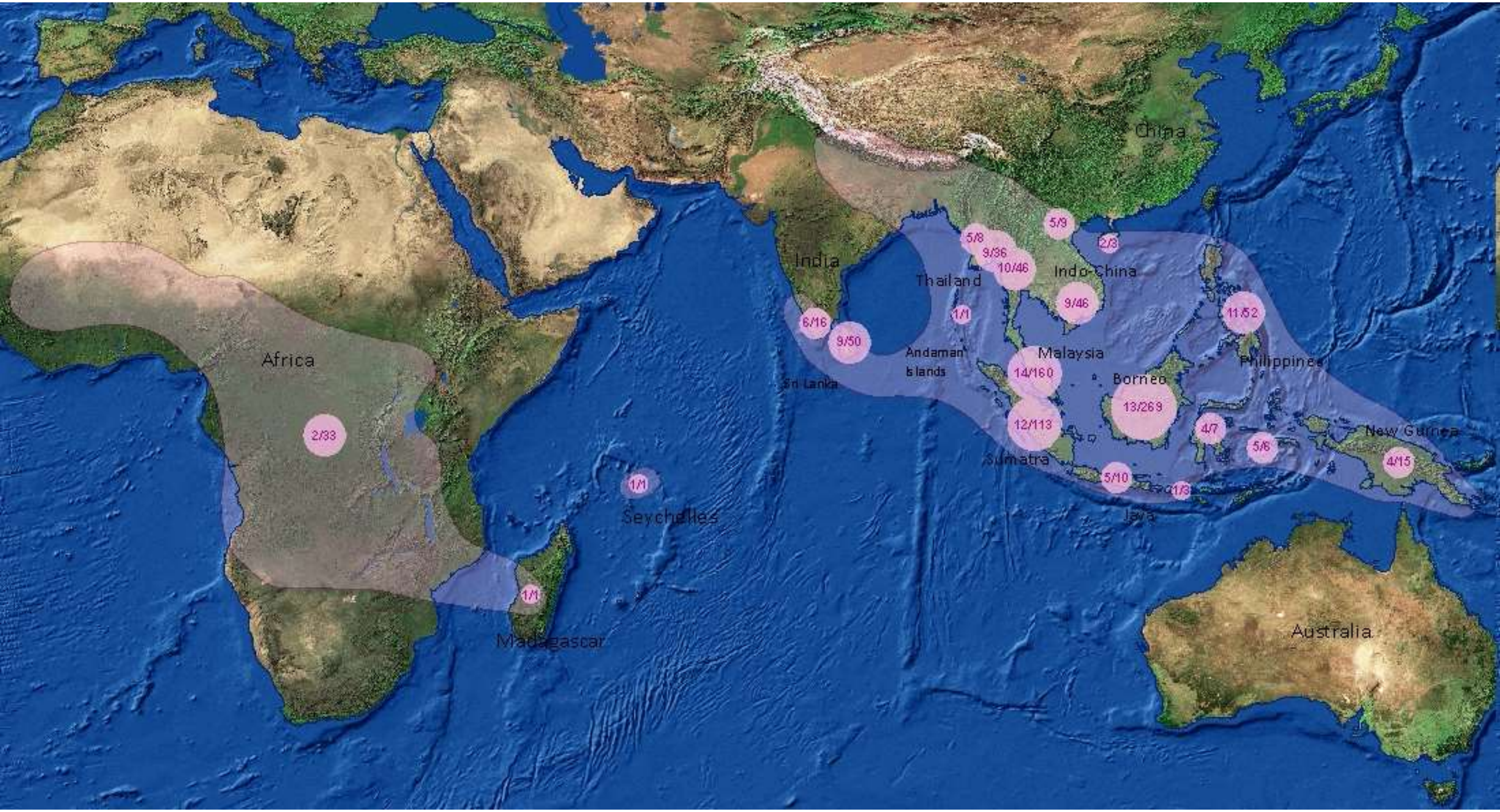
Sakai et al. (1999)

Parashorea tomentella: seedling cohorts following mass fruiting



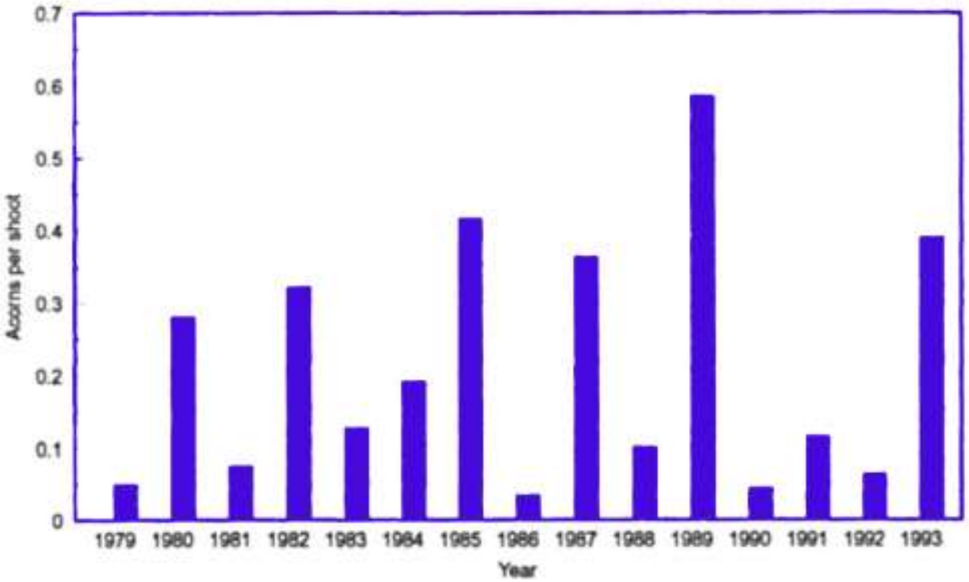
Seed year in a dipterocarp forest (Sabah)

Distribution of Dipterocarpaceae (genera/species)

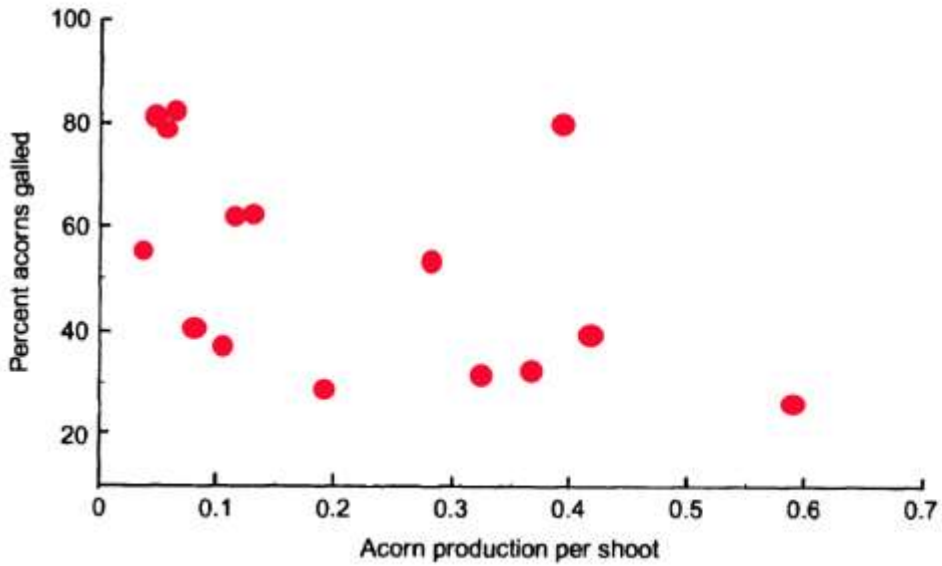


Manual of Dipterocarps by C.F. Symington

Mass fruiting in temperate forests and seed predator saturation: *Quercus robur* and cynipid wasp *Andricus quercuscalicis* in UK



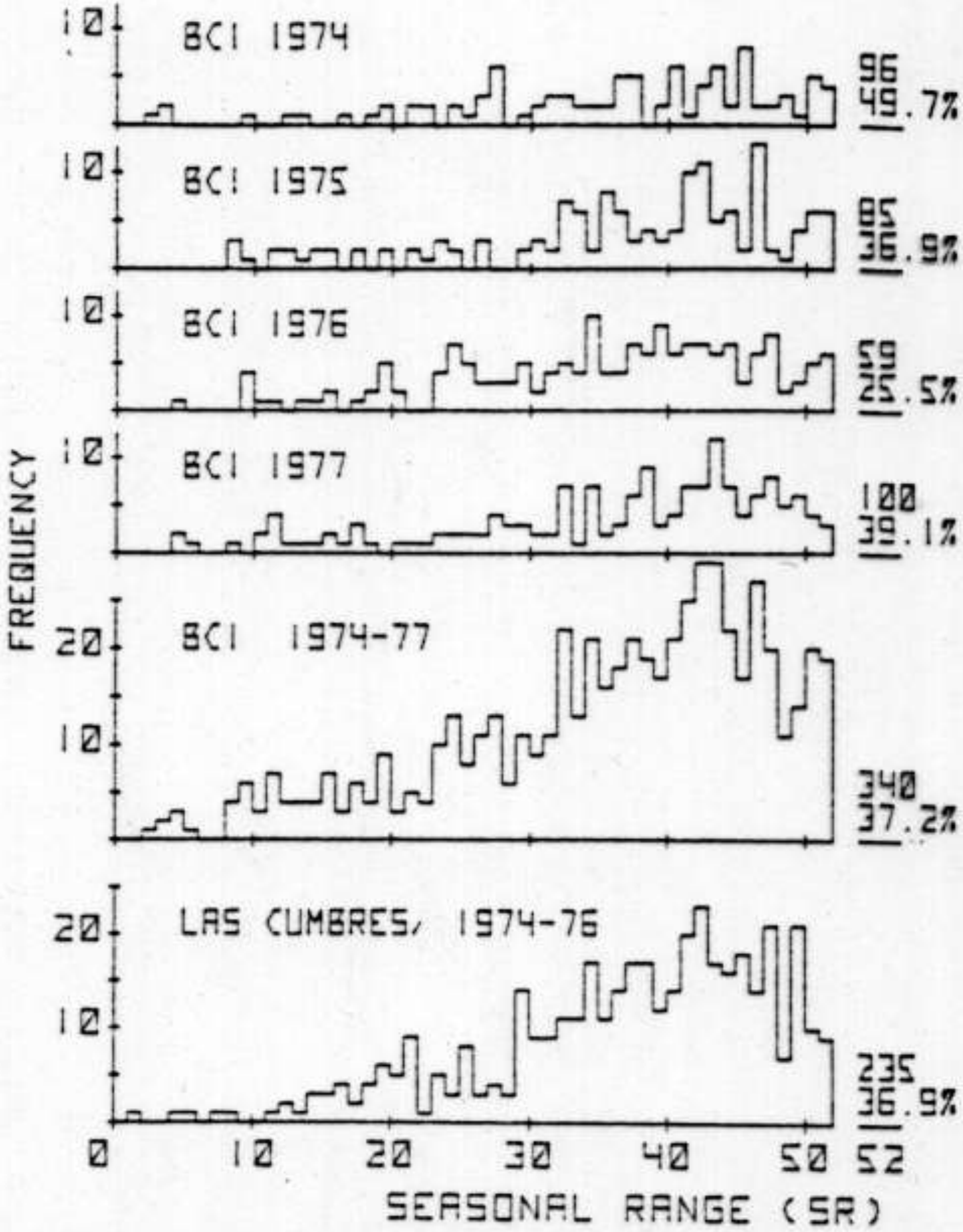
Acorn production highly variable between years



% of galled acorns decreases with acorn production

Crawley & Long Journal of Ecology 1995, 83, 683-696

Length of active season of adult Homoptera on Barro Colorado Island



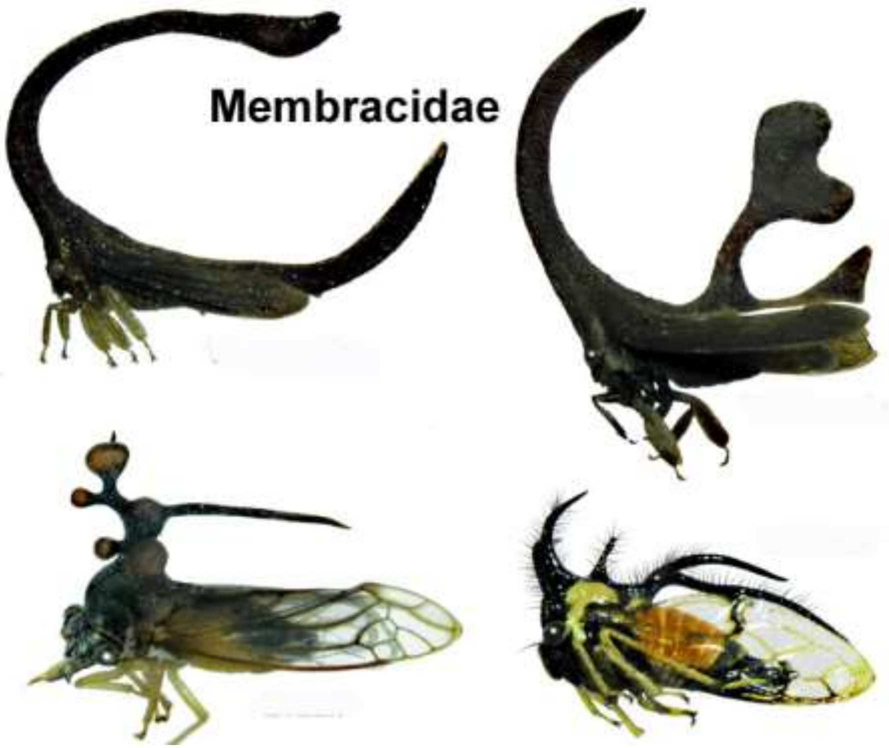


Figure 5. The length of the active season of the adults of the Homoptera on Barro Colorado Island, Panama, as measured by the seasonal range. The data are given per year and for the 4 years combined. Data from Las Cumbres are included for comparison. The week numbers refer to the calendar year.

Cicada emergence in lowland rainforest, Costa Rica: synchronization driven by the need to find mates

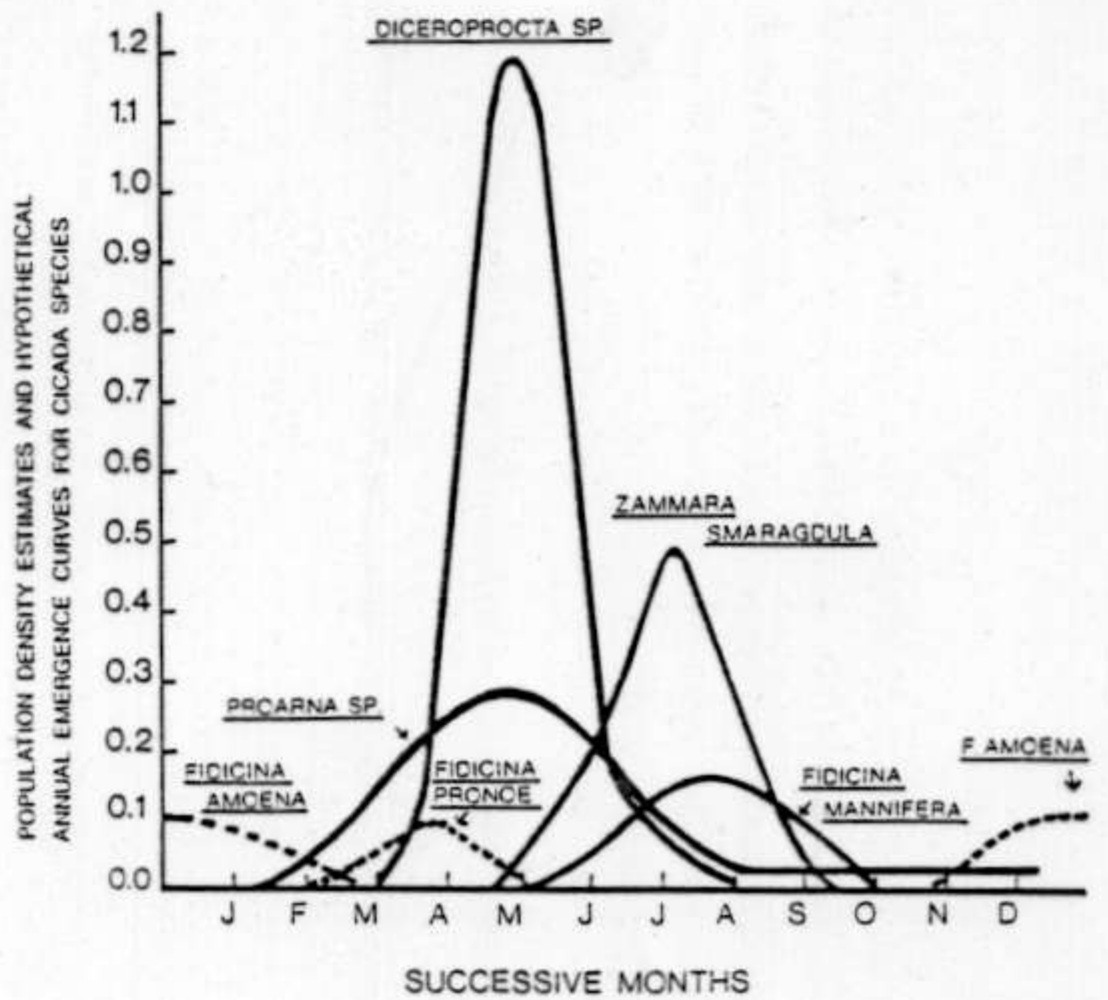
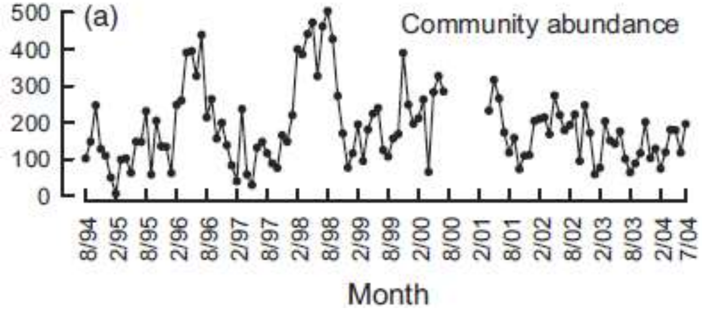
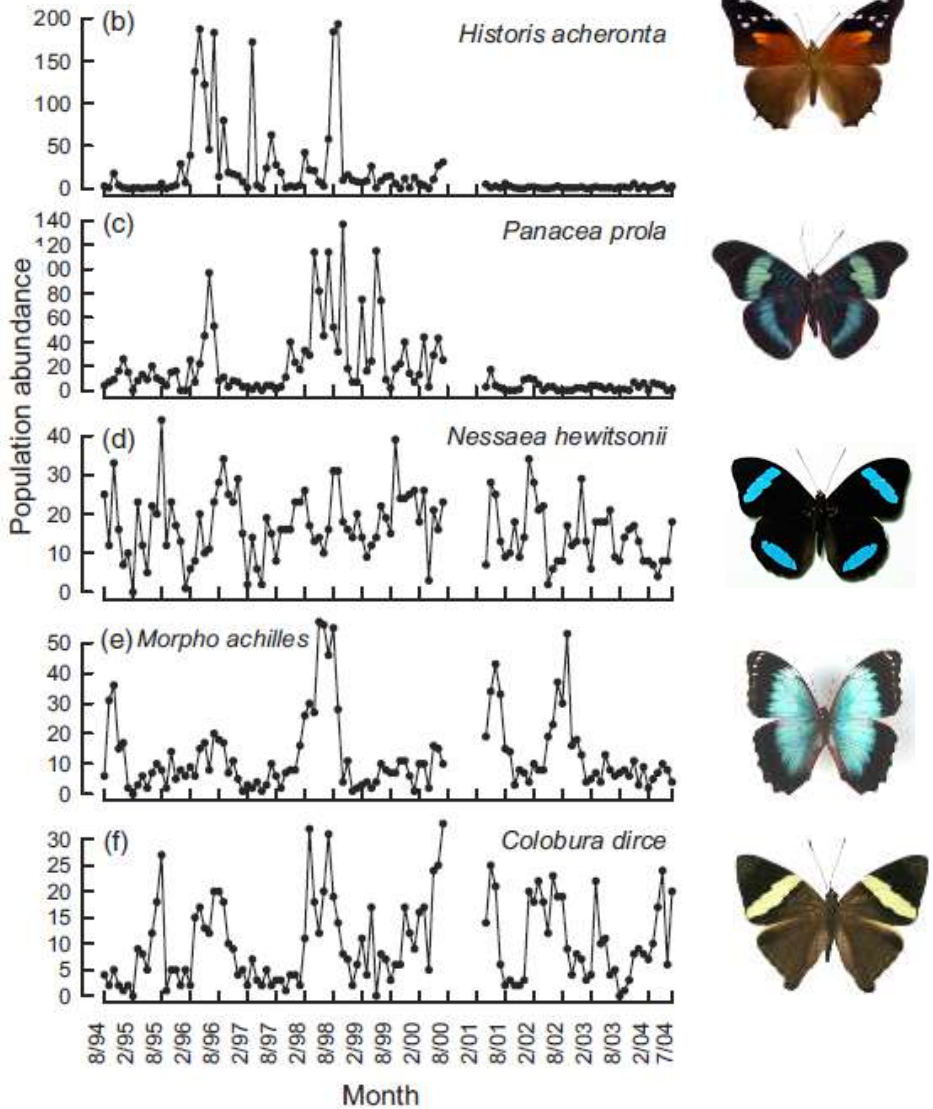


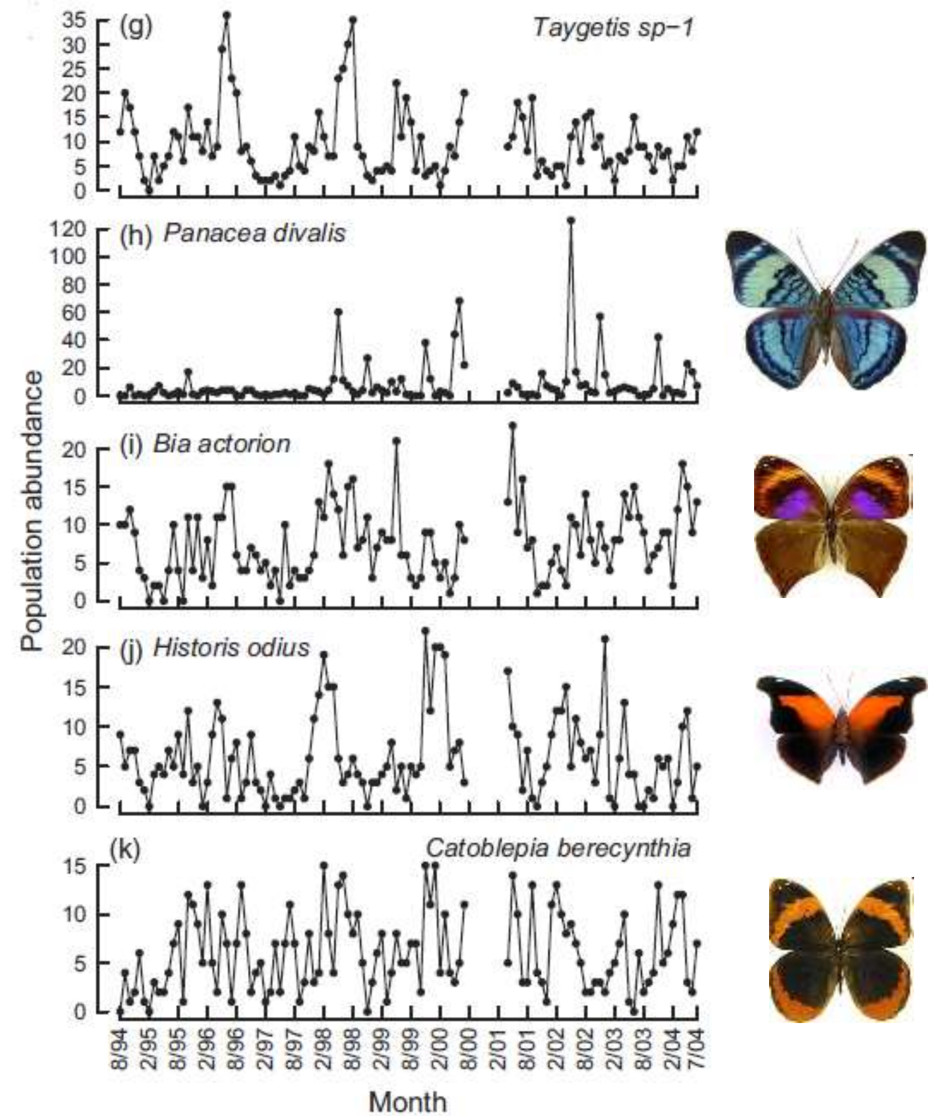
FIGURE 7.16. Predicted annual emergence curves for adults of several species of cicadas (Homoptera: Cicadidae) in the lowland tropical dry forest zone of northwestern Costa Rica. The positions of the peaks of these curves are based on actual observed densities, but the end points in several instances are hypothetical projections. The dashed-line curves for two species represent data from other localities and projected for this region. [From A. M. Young, *Milwaukee Publ. Mus. Contrib. Biol. Geol.* No. 40 (1980). Copyright 1980 by the Milwaukee Public Museum.]

Diceroprocta sp.

Fruit-feeding butterfly community Ecuador idiosyncratic variation of each species over 10 years

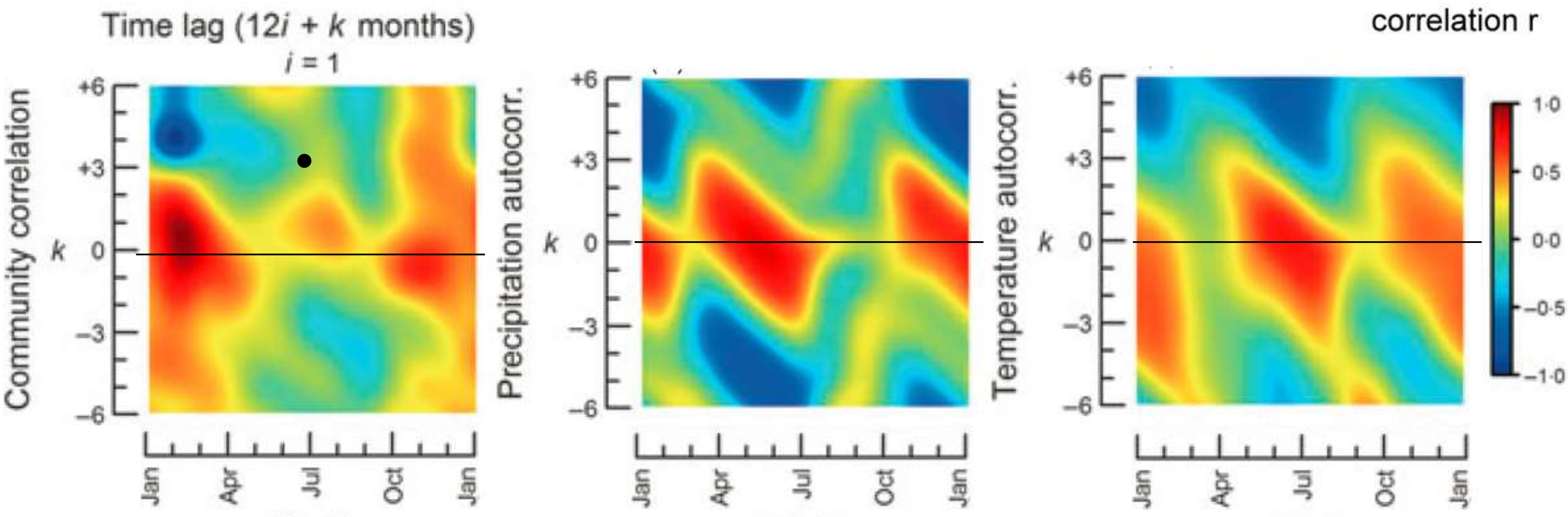






Grotan et al. Journal of Animal Ecology 2012, 81, 714–723

Fruit-feeding butterfly community Ecuador

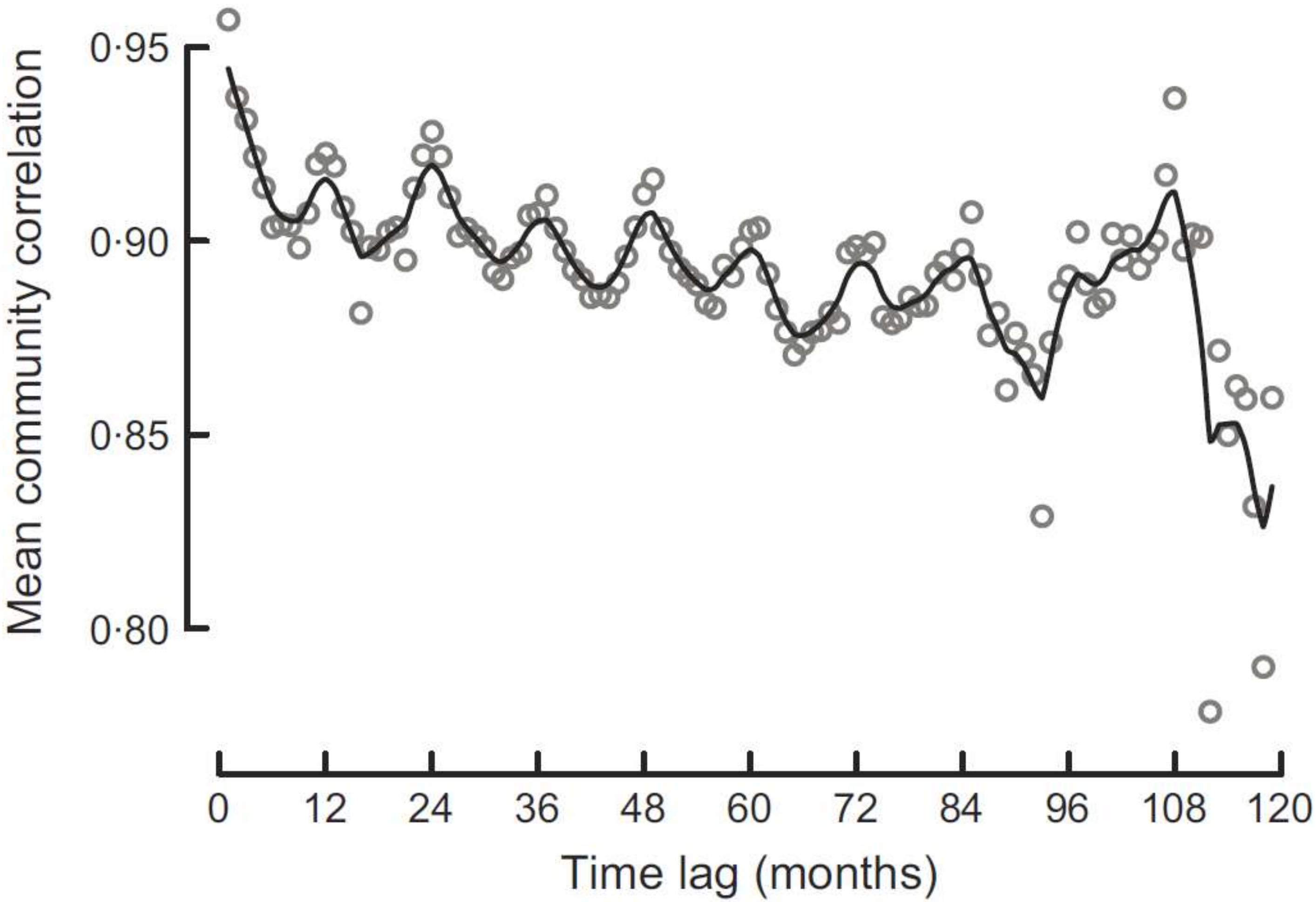


Correlation of community composition, precipitation and temperature with the same month [k=0] next year +/- additional months

(e.g., the black dot shows community correlation between July and next year’s October)

Grotan et al. Journal of Animal Ecology 2012, 81, 714–723

Fruit-feeding butterfly community Ecuador



Seasonality combined with a long-term drift in community composition, shown by decreasing community correlation

Grotan et al. Journal of Animal Ecology 2012, 81, 714–723

Dry forest during dry season, Queensland

Tropical extreme seasonal, i.e. monsoonal, forest during dry season. Cape York Peninsula, Queensland. Lyn Webb image.

Dry x humid forests: leaf life span

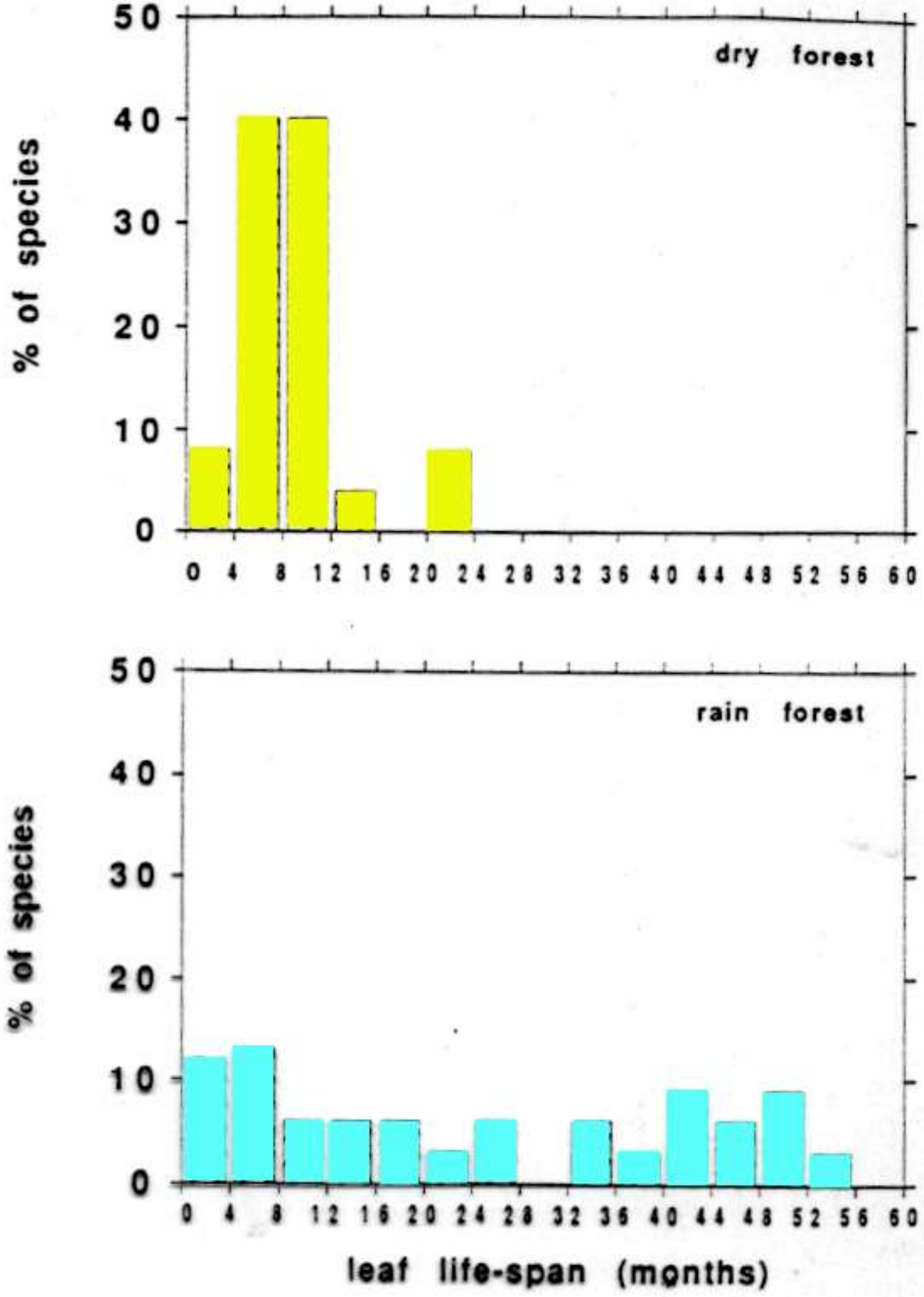


Fig. 4. Frequency distribution of leaf life-spans among species in dry, wet, and rain forests. Data for dry forests from Reich and Borchert (1982, 1984, P.B. Reich and ?. Borchert, unpublished data), Olivares (1987), Borchert .994*b*), and Sobrado (1991); for wet forests from Coley (1988) and Mulkey et al. (1991, 1993); for rain forests from Reich et al. (1991) and Williams et al. (1989).

Acer sp. in montane rainforest in Vietnam:

one of a few deciduous species

Example of a phylogenetic constraint – Acer spp are deciduous, even when environment does not require that