




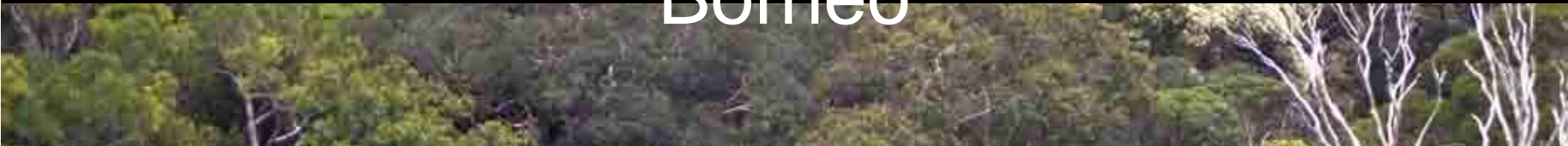
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The diverse consequences of drought observed in an aseasonal forest of Borneo aseasonal forests in Borneo

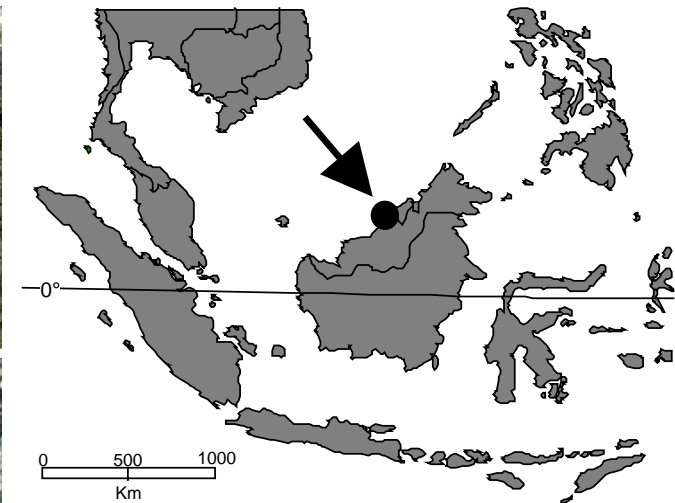


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Lambir Hills National Park, Sarawak



Long-term monitoring at Lambir Hills

since 1992

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- Plant Phenology
 - Plant reproductive (flowering and fruiting) activities -- 300-500 plants, twice a month
- Light traps to monitor insect populations
 - Once in a month 1992-2000

Climate in Borneo is characterized by low seasonality

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Ratios of the variance of the low-pass (< 0.5 yr) filtered precipitation time series to that of the unfiltered precipitation

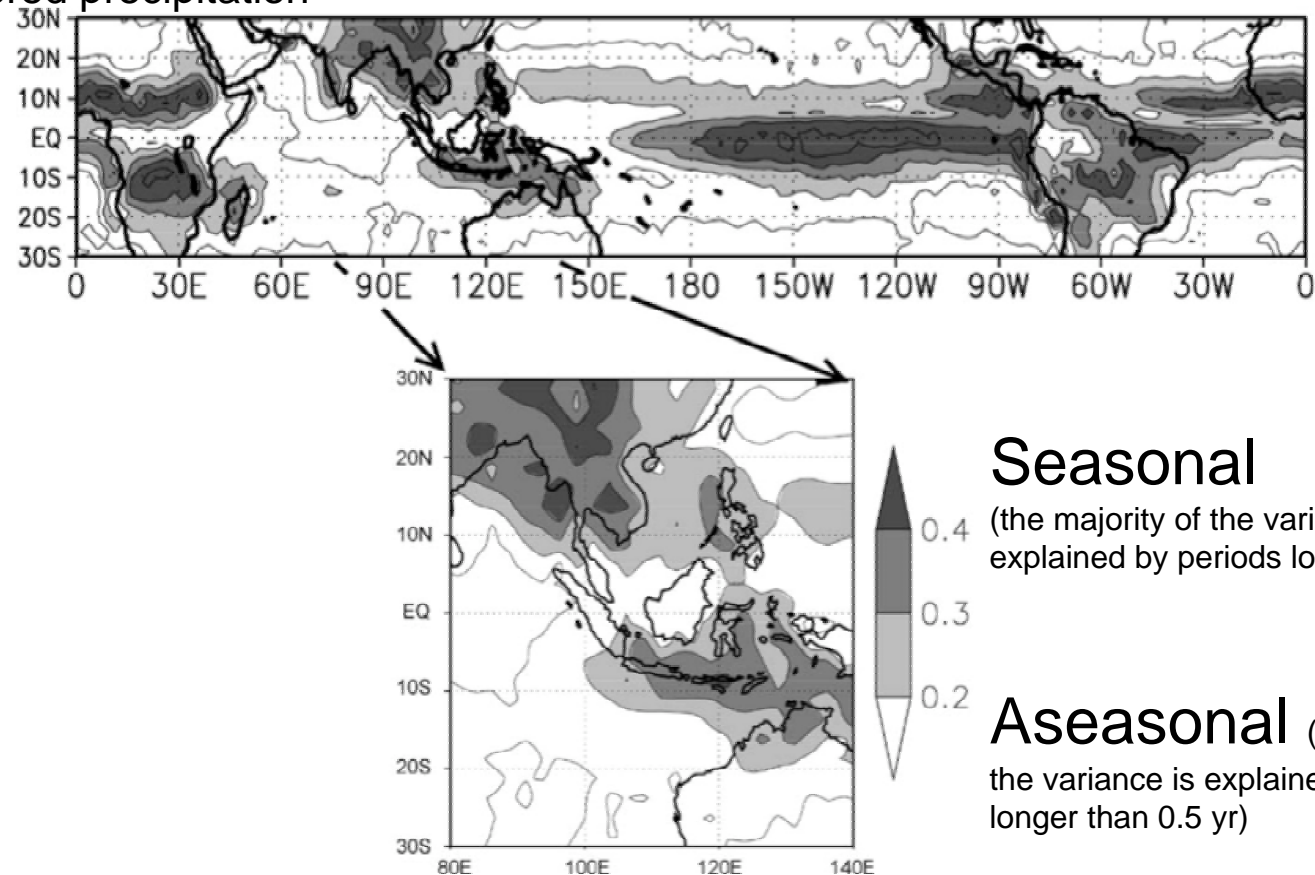


Fig. 3. Ratios of the variance of the low-pass filtered precipitation time series to that of the unfiltered precipitation. A global precipitation map was reproduced using data from the Climate Precipitation Center (CPC) Merged Analysis of Precipitation (CMAP; Xie and Arkin, 1997) for the years 1979–2001.

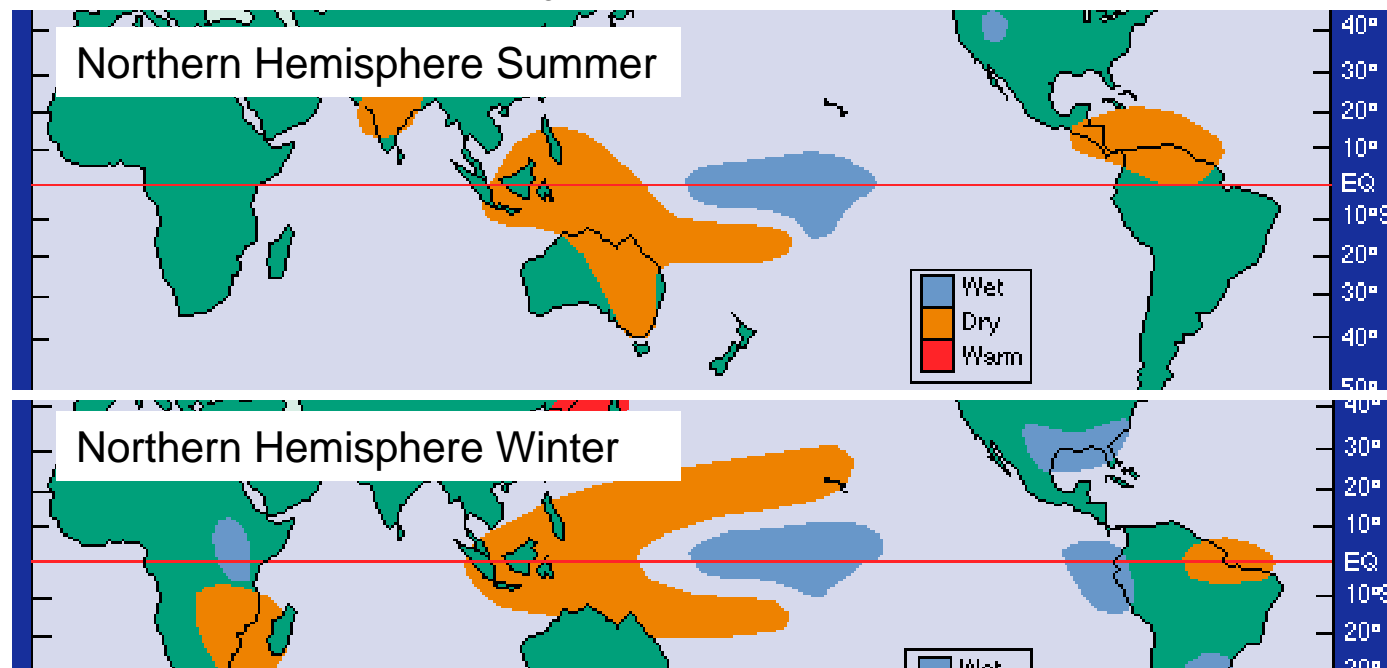
Kumagai et al. 2005

Borneo is under strong influence of El Niño

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- Precipitation decreases in El Niño years.

Precipitation anomalies during El Niño in (a) Summer and (b) Winter



http://www.pmel.noaa.gov/tao/el_nino/impacts.html

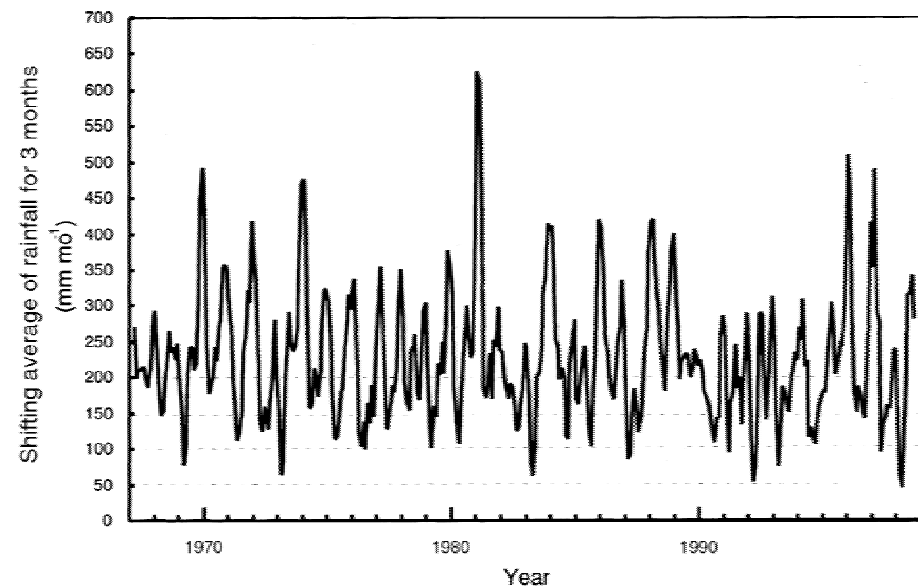
Precipitation is aseasonal but variable

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Average monthly rainfall 1967-1993 at Miri



Shifting average of rainfall for 3 months 1967-1999 at Miri



Nakagawa et al. 2000

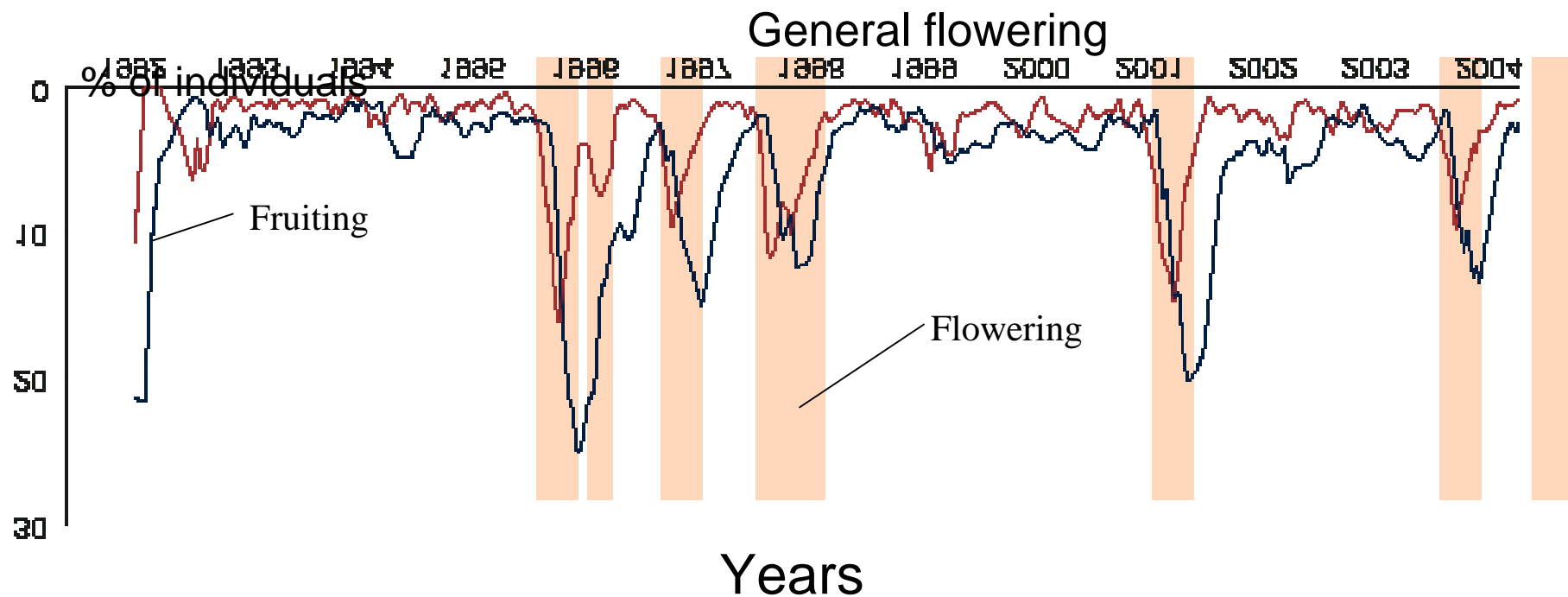
General flowering

- Community-wide supra annual mast flowering and fruiting especially among the dominant canopy trees of the Dipterocarpaceae
- Phenomenon unique to lowland dipterocarp forests
- In GF, most dipterocarp species and many other plants come into flower and set fruit massively; these plants rarely flower except during GF events

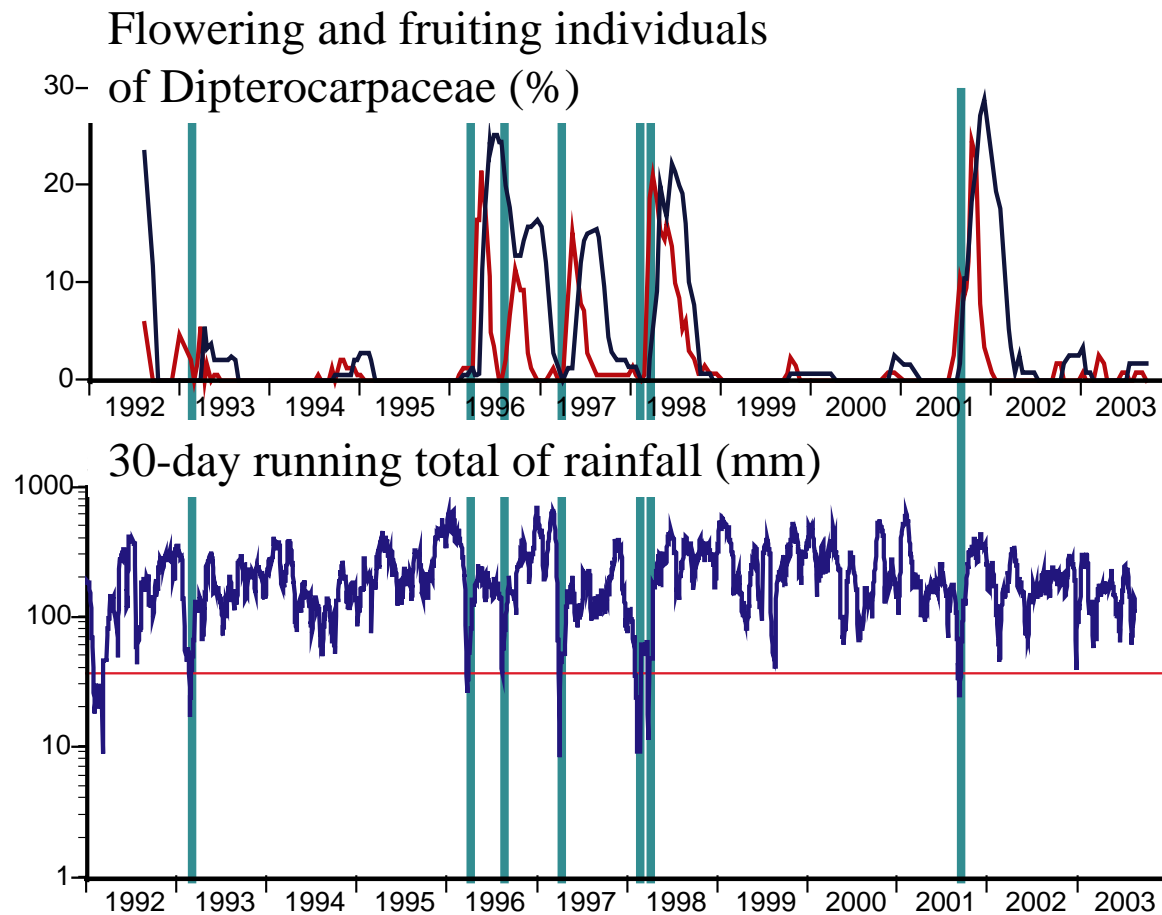
(Ashton et al. 1988; Sakai 2001)

Plant reproductive phenology in Lambir Hills

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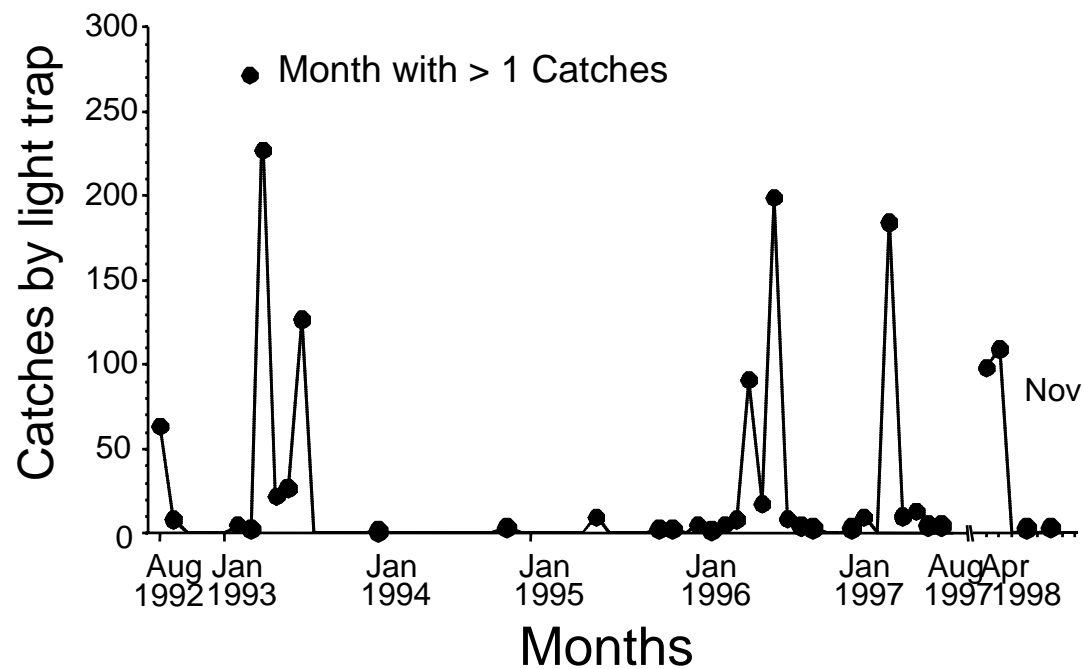


Drought triggers GF



Lambir, Sarawak: Sakai et al. 2006
(Central Kalimantan: Brearley et al. 2007)

Migration of Giant honeybees



Lambir, Sarawak
Itioka et al. 2001

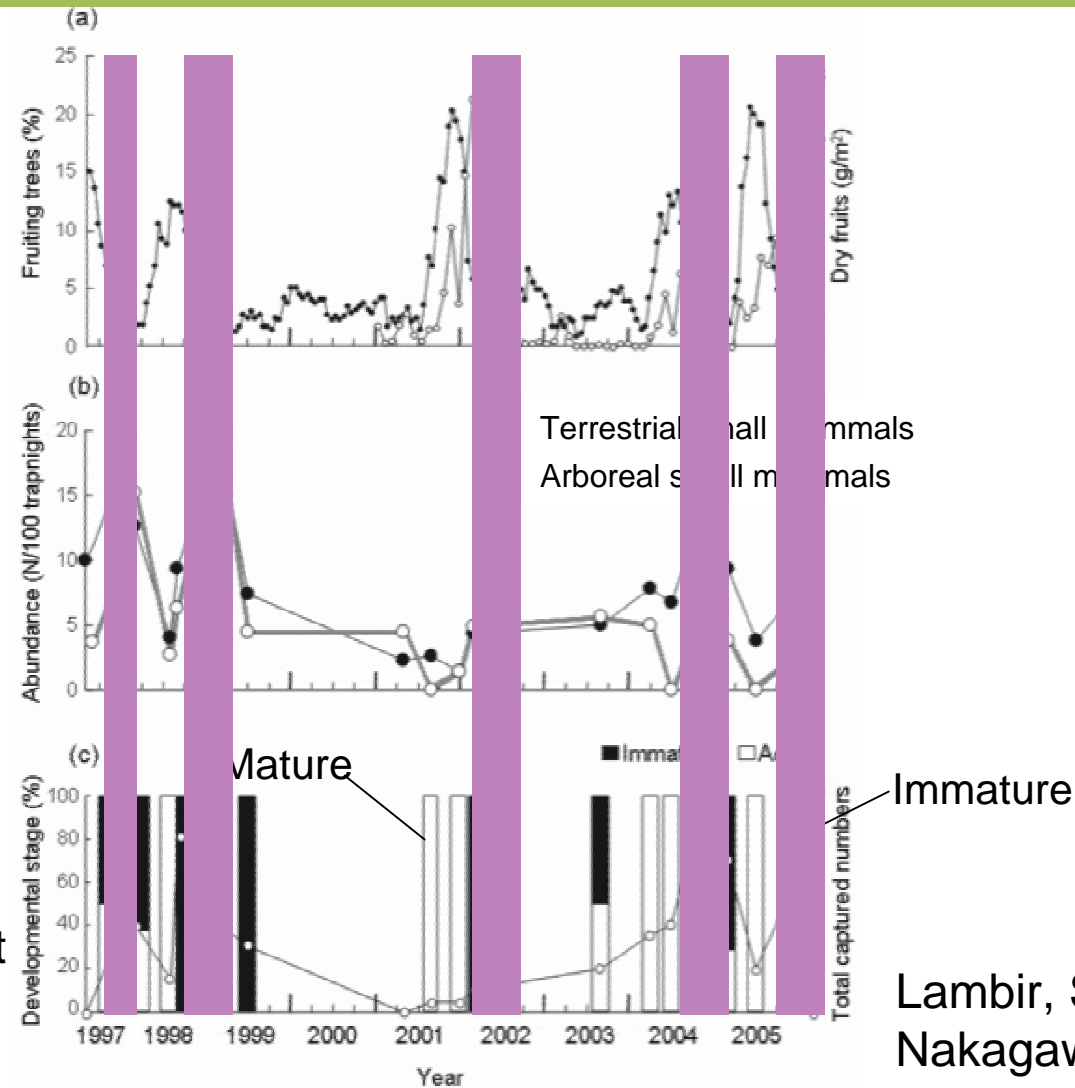


Mammals increase following masting

Fruiting
phenology

Population
dynamics

Generation
structure of
Brown spiny rat



Lambir, Sarawak
Nakagawa et al. 2007

Strong drought in 1998

- The climatic perturbation associated with the 1997-1998 El Nino was one of the biggest in this century, causing a severe drought in this region
- Total rainfall during January-March 1998 (138.5 mm) was c. 24% of the usual rainfall (Nakagawa et al. 2000)

High tree mortality caused by drought

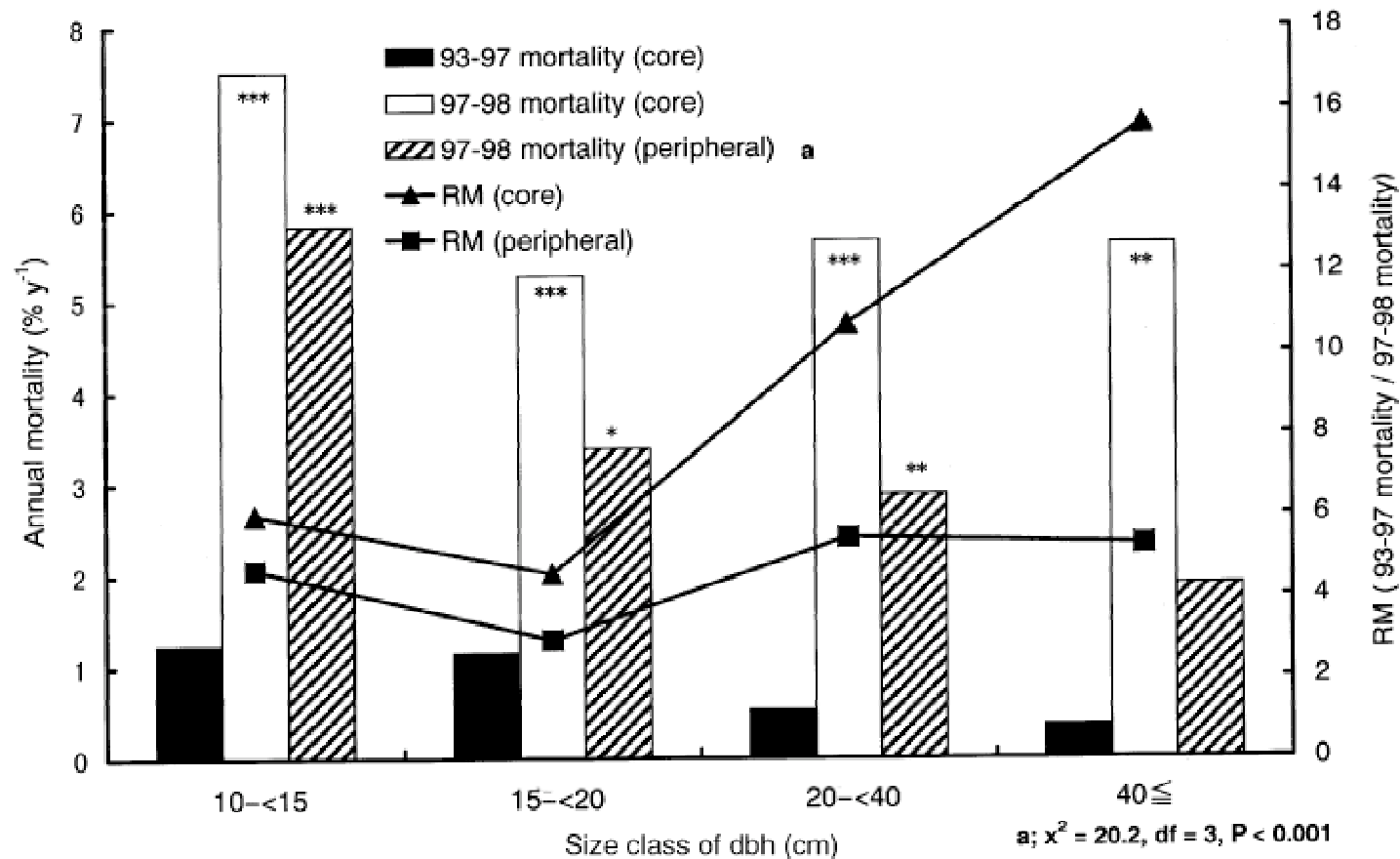
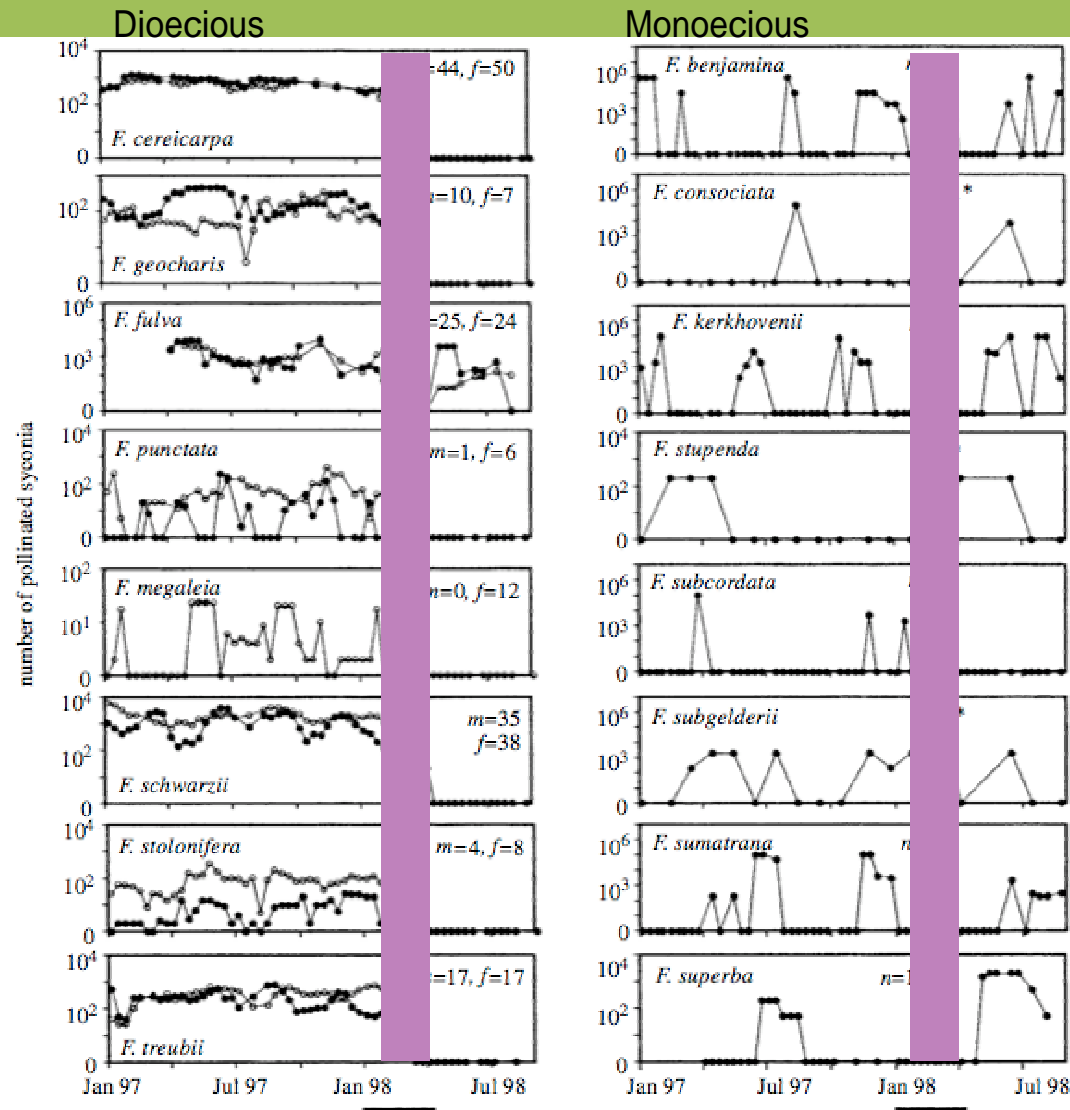


Figure 2. Size dependent annual mortality and the ratio of mortality (RM) during the 1998 drought in Sarawak to that in a previous non-drought period. Differences between periods are shown by the chi-squared test (*, $P < 0.01$; **, $P < 0.001$; ***, $P < 0.0001$). (Nakagawa et al. 2000)

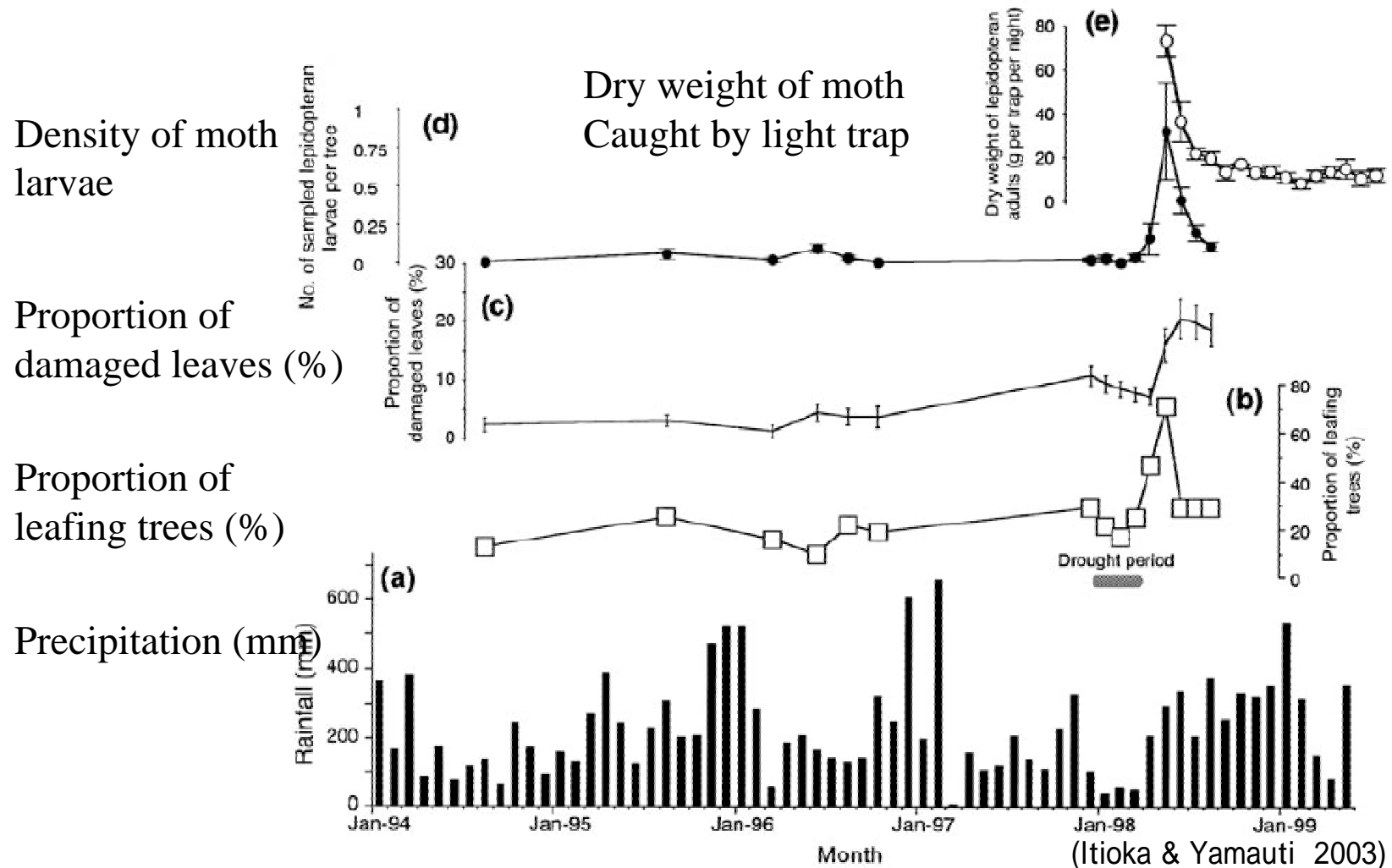
Local extinction of fig pollinator wasps



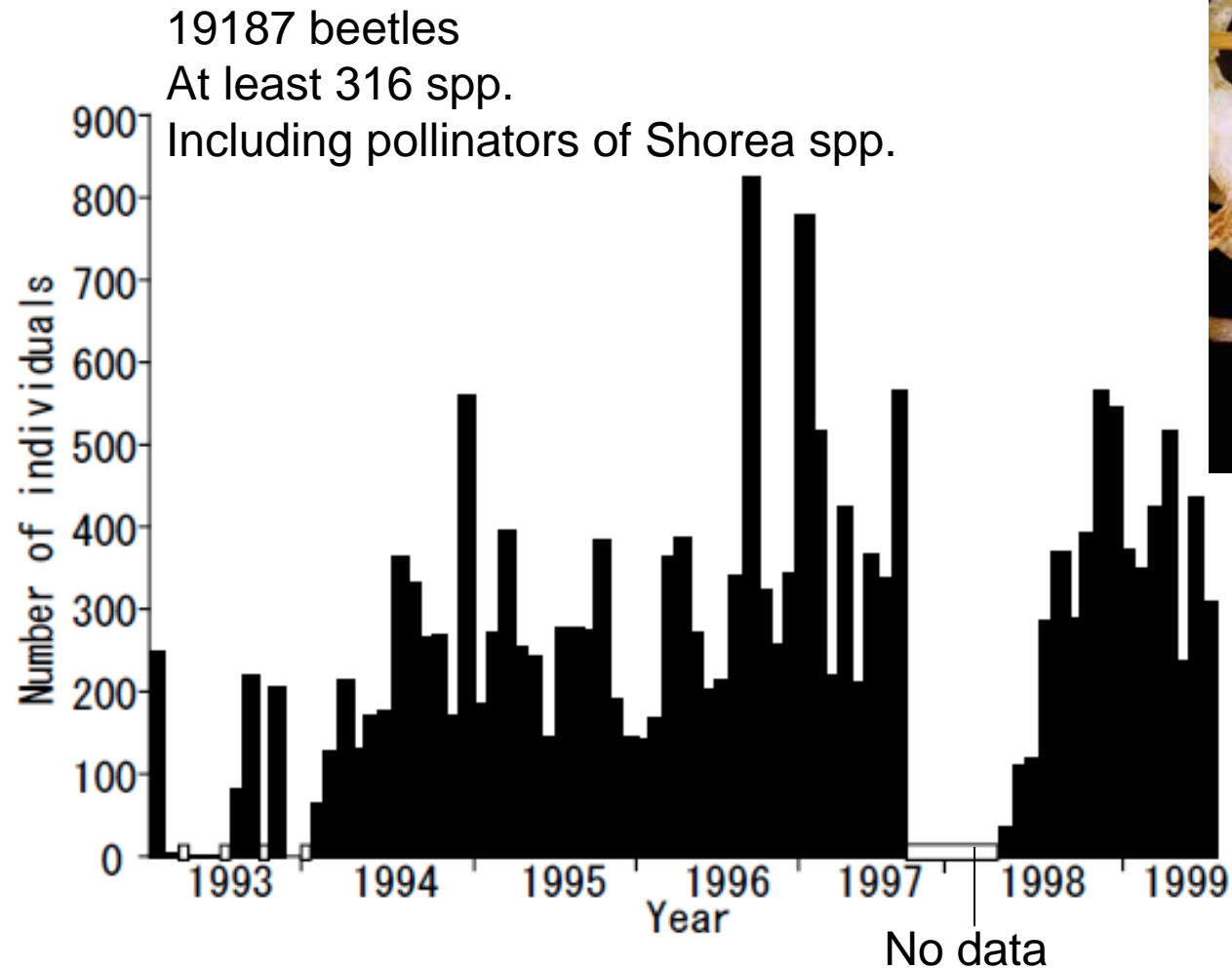
Number of pollinated syconia at each census on (left) (filled circles, male tree, open circles, female trees), and (right) monoecious figs at Lambir

(Harrison 2000)

Outbreak of moth population



Drought caused decrease leaf beetles (Chrysomelideae)



Kishimoto-Yamada (submitted)

Biological consequences of droughts in Borneo

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- (Minor) Drought triggers general flowering (mass flowering and fruiting)
 - General flowering affects pollinators, seed dispersers and predators
- Severe drought
 - Direct
 - High tree mortality
 - Forest fires
 - Indirect
 - Through impacts on physiological conditions of plants, drought causes extinction /outbreak and changes in species composition of insects

Several factors may change the effects of drought

- Climate change
 - Change frequencies and intensities of droughts
- Land-cover change: Deforestation and forest fragmentation
 - Higher probability of local extinction and lower probability of recruitment
 - Change local climate

Monitoring of direct and indirect effects of droughts is essential for conservation of the tropical forests of very high biodiversity