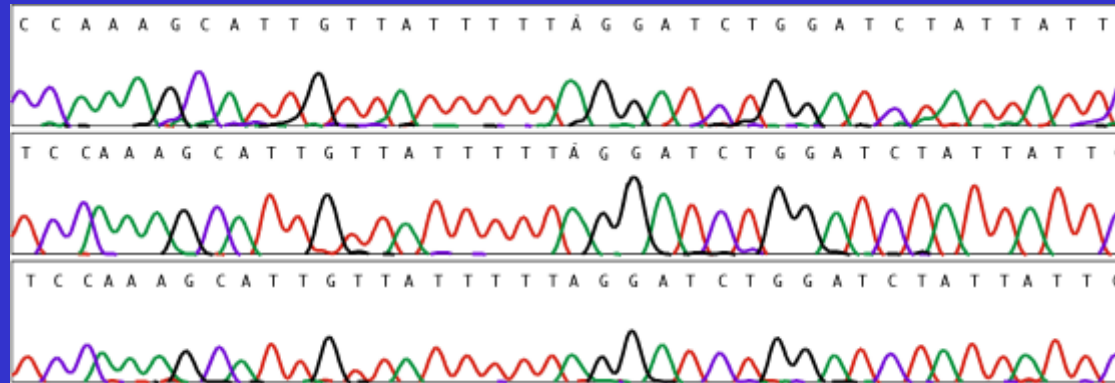


# Global biodiversity: how many species of arthropods are there?

George Weiblen

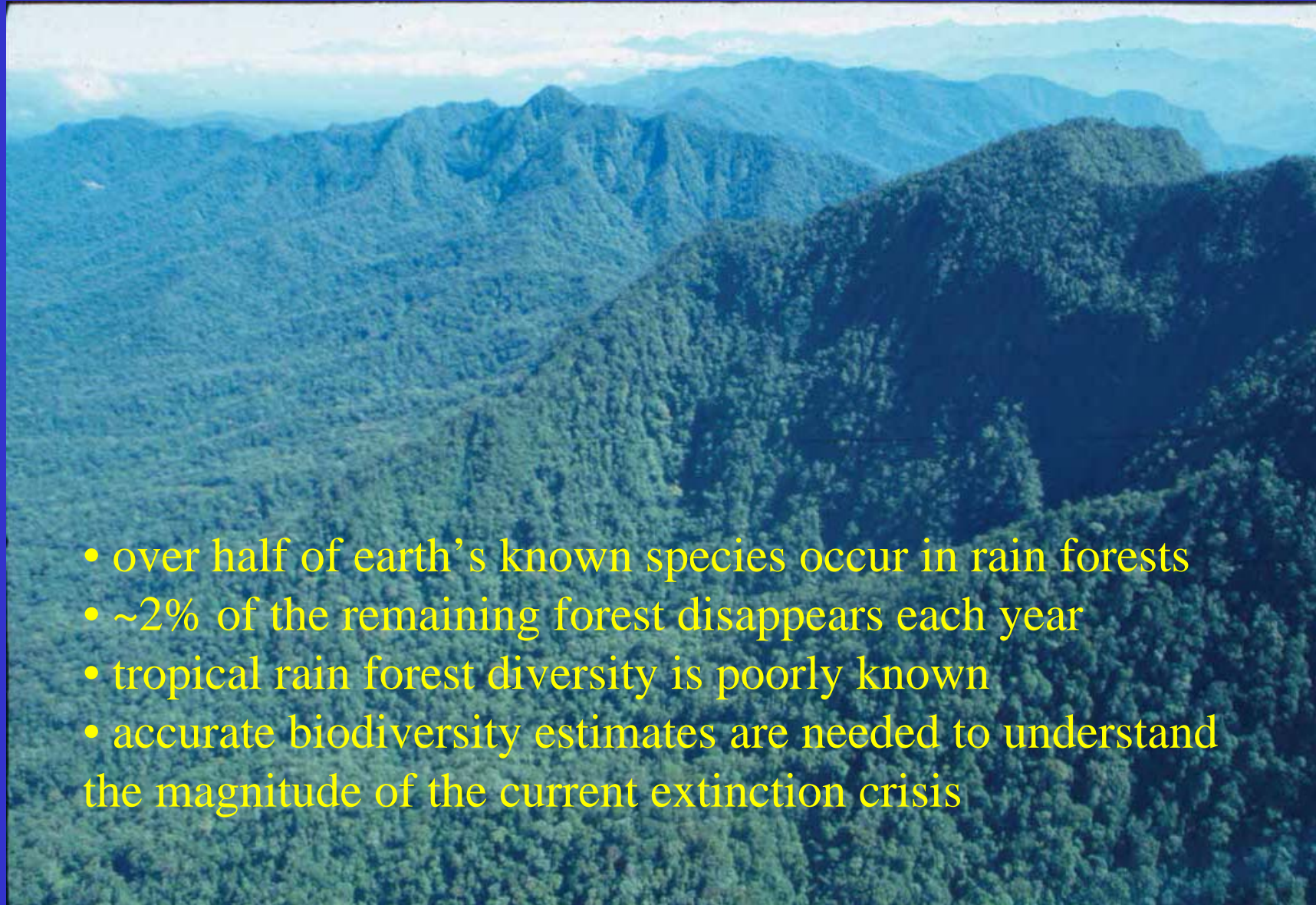
Plant Biology



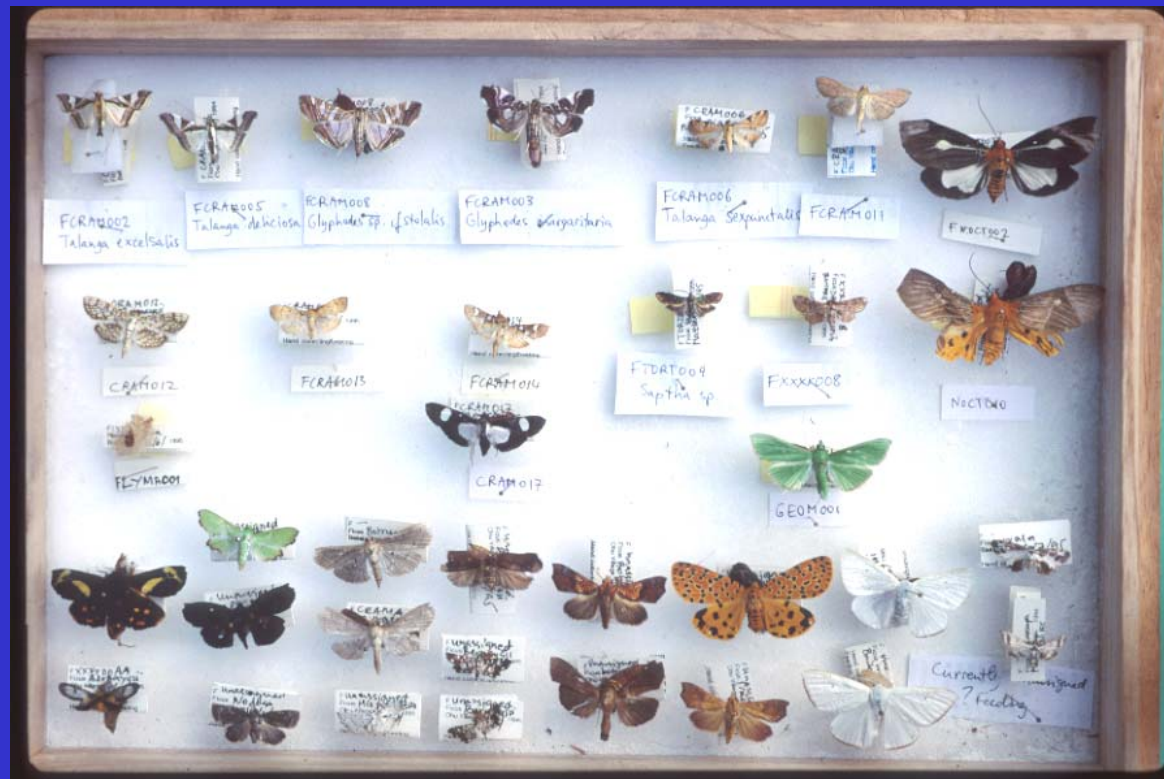
## the biodiversity crisis

- complete sequencing of the human genome illustrates our tremendous capacity to catalogue the diversity of life
- yet, we do not know how many living species inhabit the planet, even after 200 years of systematic study
- uncertainty about the number of species underlies the possibility that a rising tide of species extinction is sweeping the globe
- Harvard biologist Edward O. Wilson predicts that half of earth's species could disappear in the next 50 years given the current pace of human activities.

# tropical rain forest

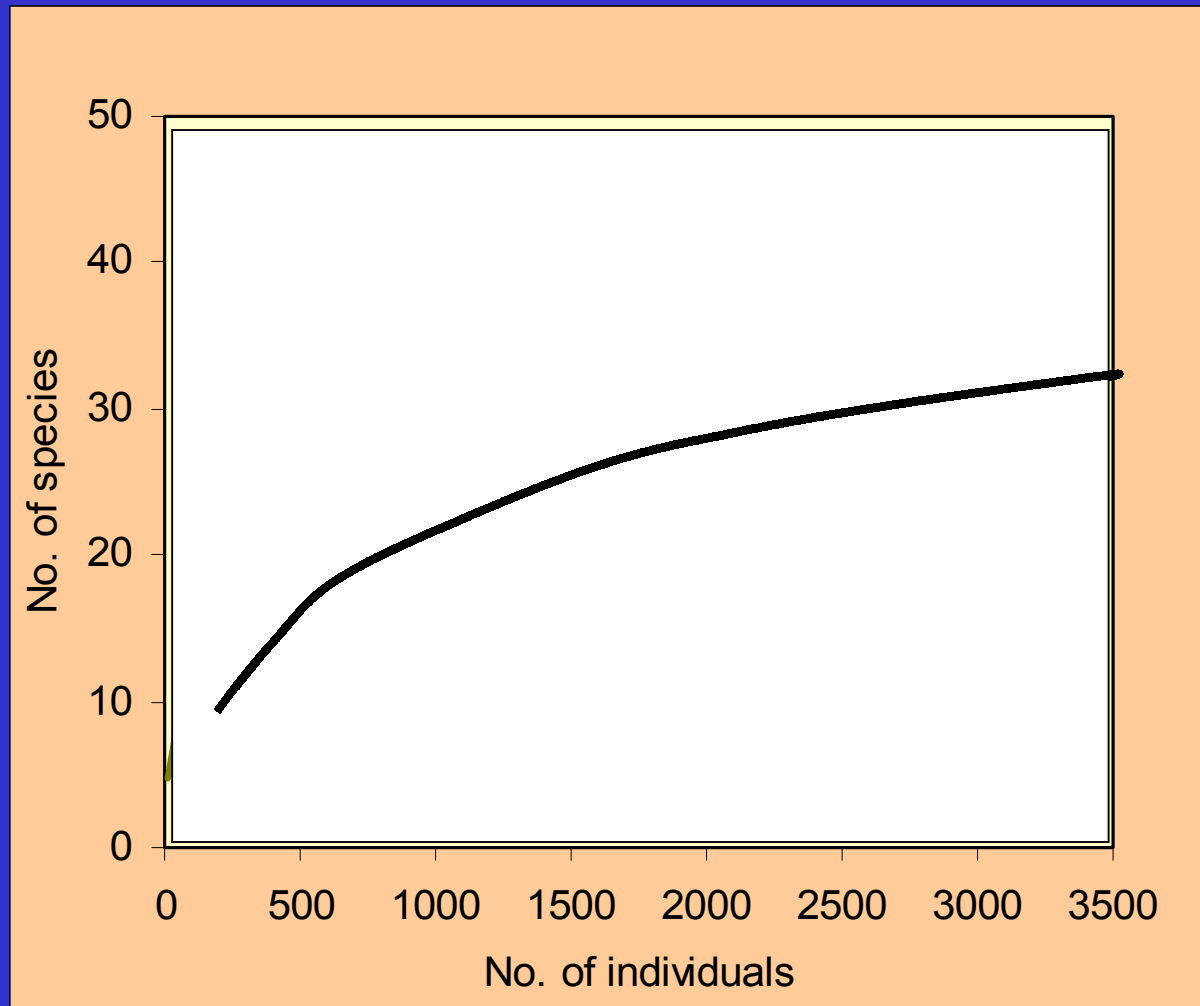


- over half of earth's known species occur in rain forests
- ~2% of the remaining forest disappears each year
- tropical rain forest diversity is poorly known
- accurate biodiversity estimates are needed to understand the magnitude of the current extinction crisis



- insects feeding on plants make up the majority of described species on earth
- estimates of global arthropod diversity range from 3 to 30 million species when extrapolated from from museum collections of named species or from ecological samples

## how to extrapolate numbers of species?



- species accumulation curves for caterpillars feeding on a particular host plant do not approach an asymptote, even after 16 months of daily sampling

## extrapolating from ecological samples

- canopy fogging
- Erwin (1982) found 163 beetle species in a single tree canopy in Panama



- assuming 50,000 species of trees, beetles as 40% of arthropods, and twice as many insects in the canopy as on the ground, Erwin estimated a global total number of arthropods of 30,000,000

## how accurate were Erwin's assumptions?

- the key parameter is whether insects are specialists or generalists, feeding on few or many host plants



- Erwin assumed that insects are extreme specialists, feeding on only one or a few host plants
- Erwin also assumed that insects collected from the canopy of a tree are herbivores of that particular tree species

## herbivore feeding experiments



- many insects are tourists, not feeding on the plants on which they are found
- feeding experiments can test whether insects are true herbivores
- feeding experiments also provide a quantitative measure of host specificity

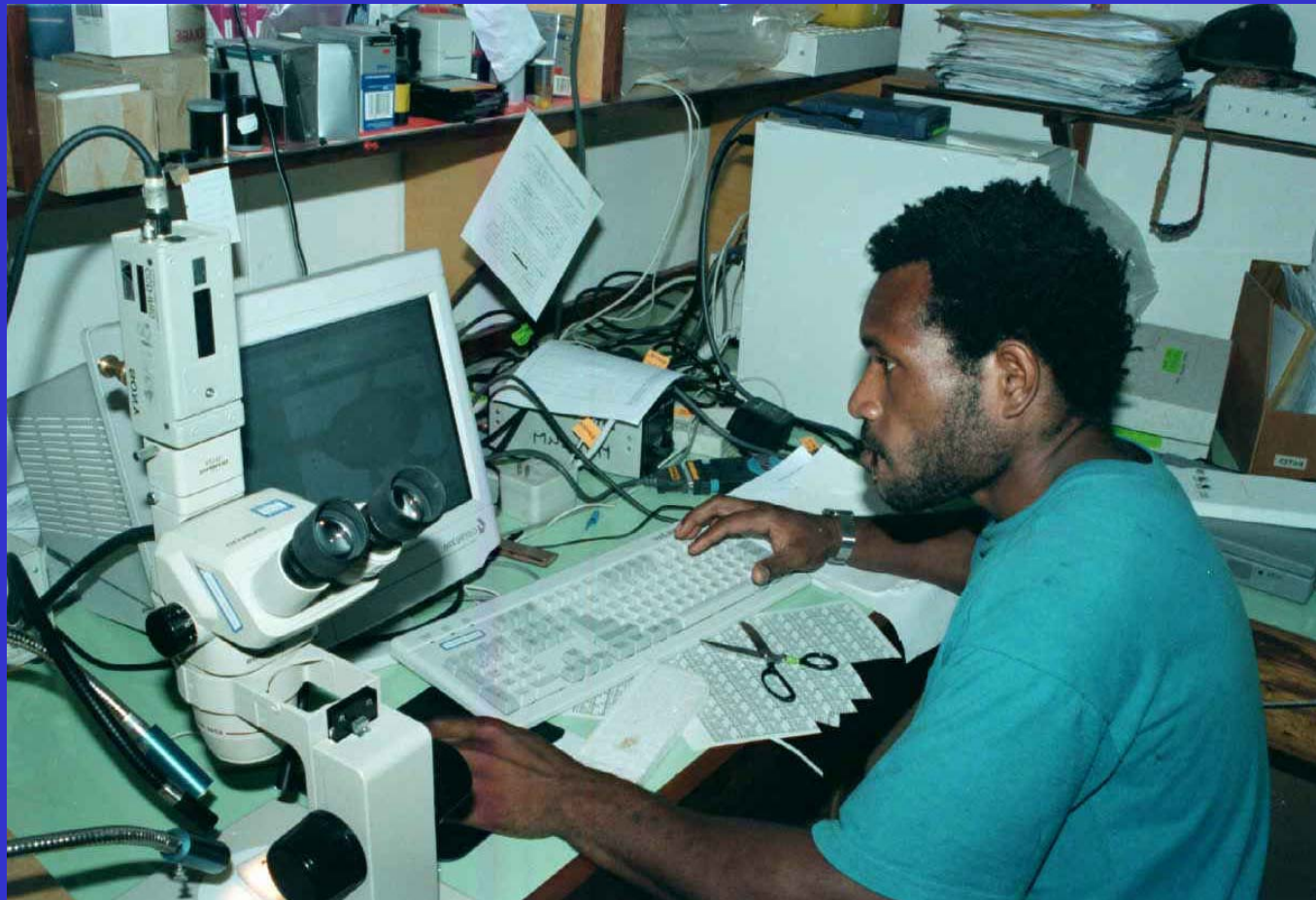
## rearing caterpillars in New Guinea

- intensive field work by 12 parataxonomists (local assistants who are expert in insect & plant taxonomy)
- 36,000 live caterpillars collected from 62 different species of rainforest trees
- most caterpillars were tourists
- only 14,000 caterpillars reared to the adult stage



## results of caterpillar rearing

- many species unknown to science
- 550 species of moths and butterflies (Lepidoptera) fed on 62 plant species
- but far fewer herbivore species per host species than assumed by Erwin



## how host-specific are herbivores?



moths and butterflies (Lepidoptera)



beetles (Coleoptera)

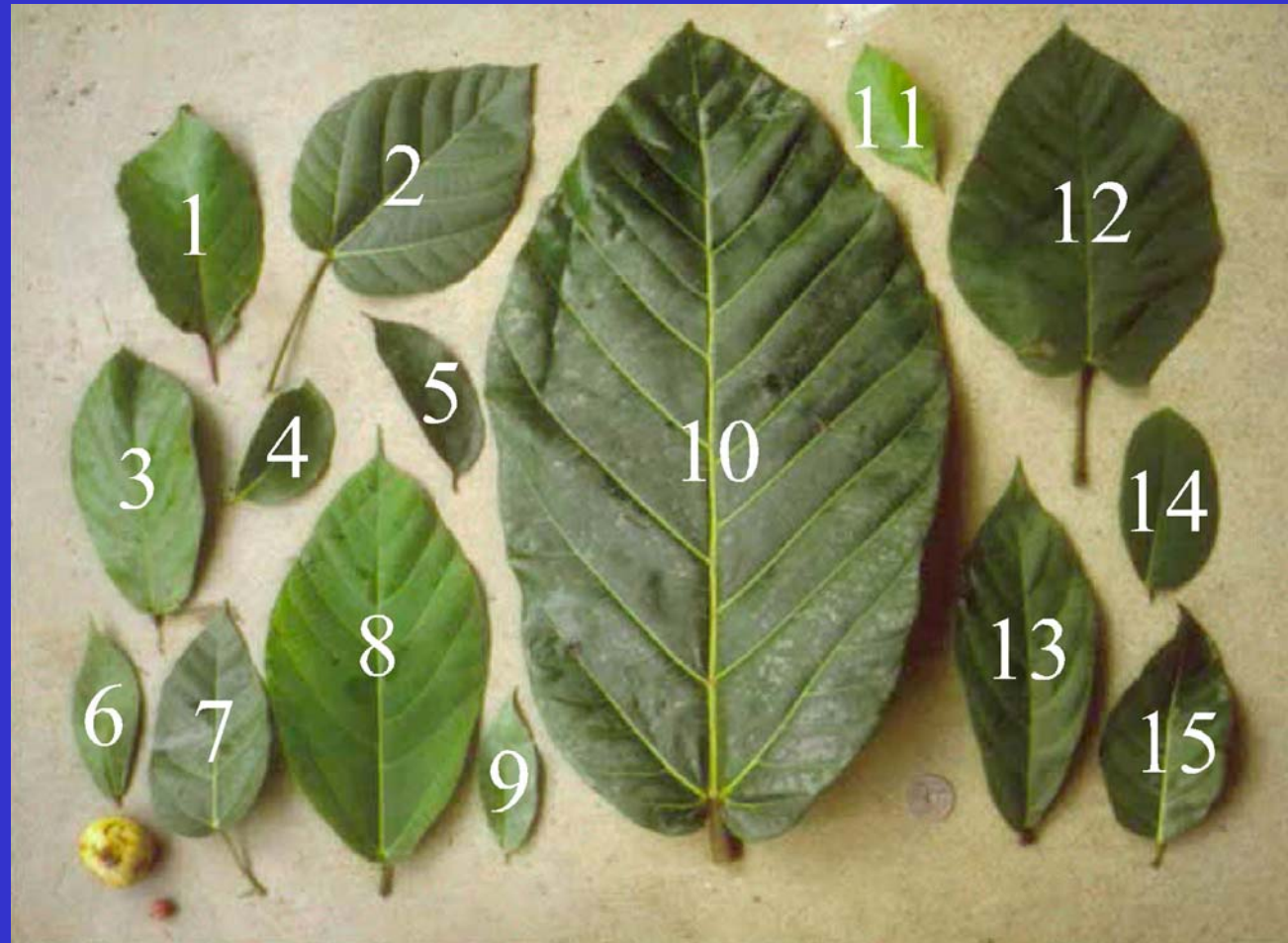


walking sticks and grasshoppers (Orthopteroidea)

## evolutionary analysis of host specificity

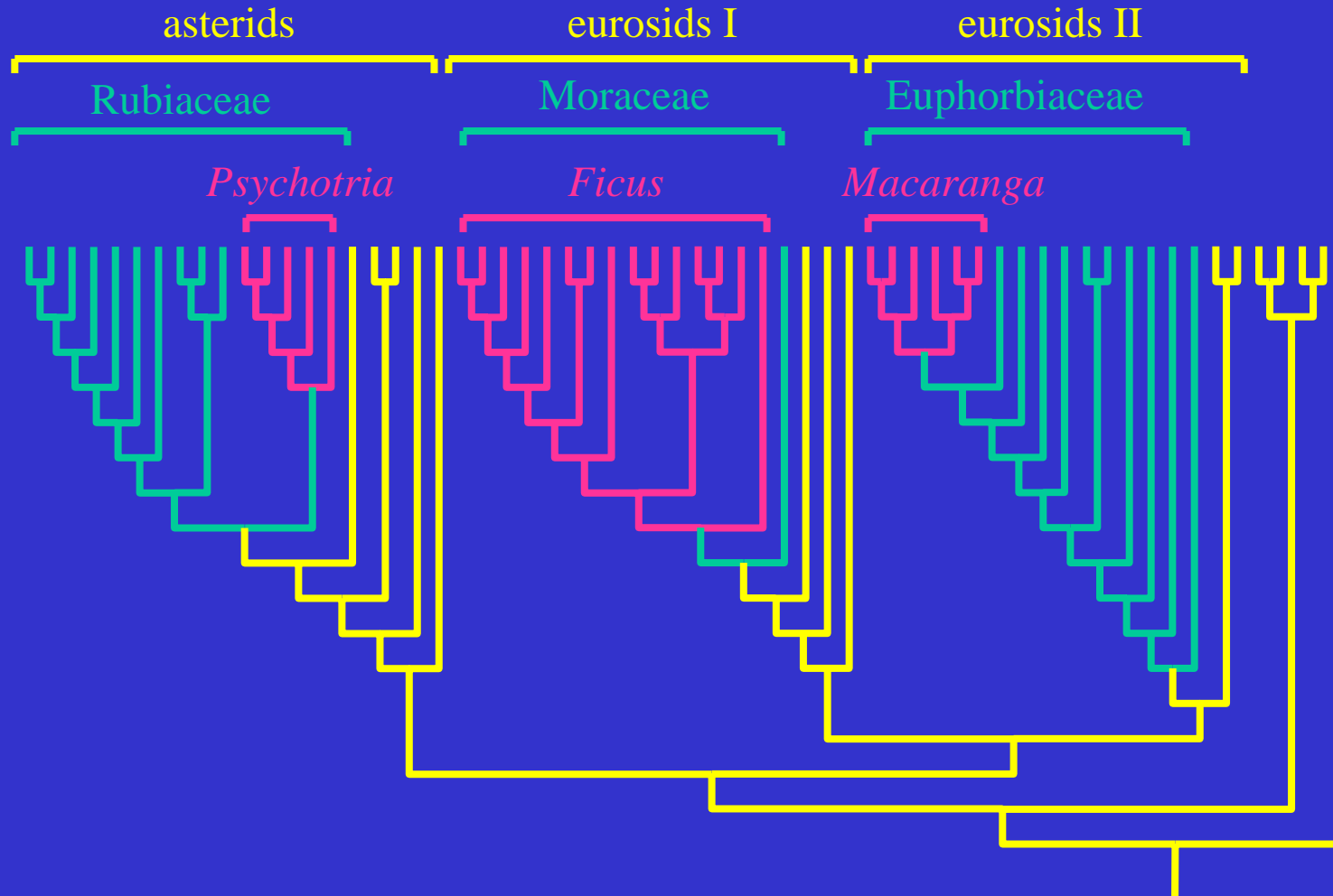
host plants:

- 62 species
- 41 genera
- 17 families
- all major flowering plant lineages



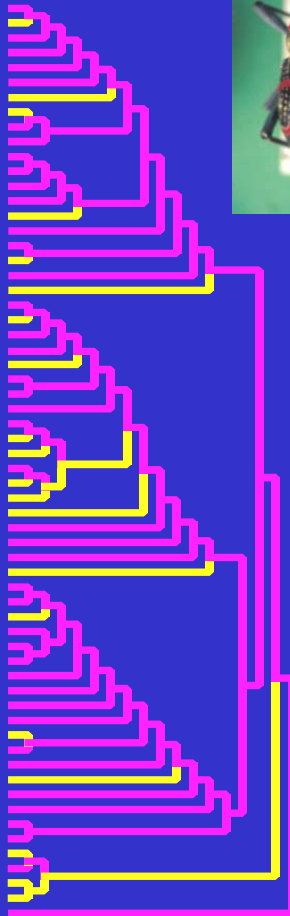
- herbivores were sampled from closely related hosts (e.g. species of *Ficus*) and distantly related hosts (e.g. species from different plant families)

# evolutionary relationships of host plants



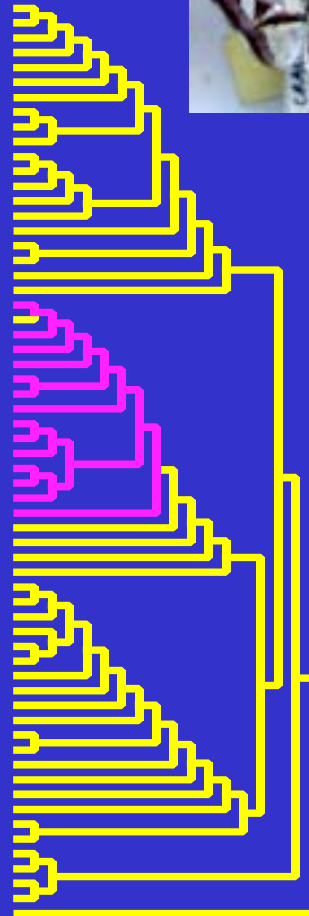
three examples of herbivore associations

*Rhinoscapa tricolor*



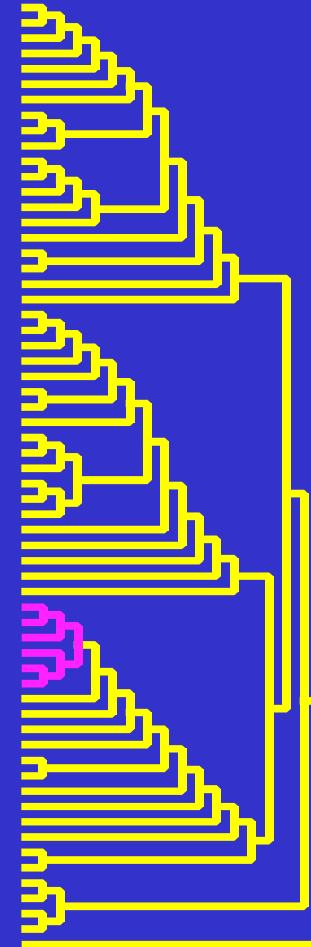
curculionid beetle  
generalist

*Talanga excelsalis*



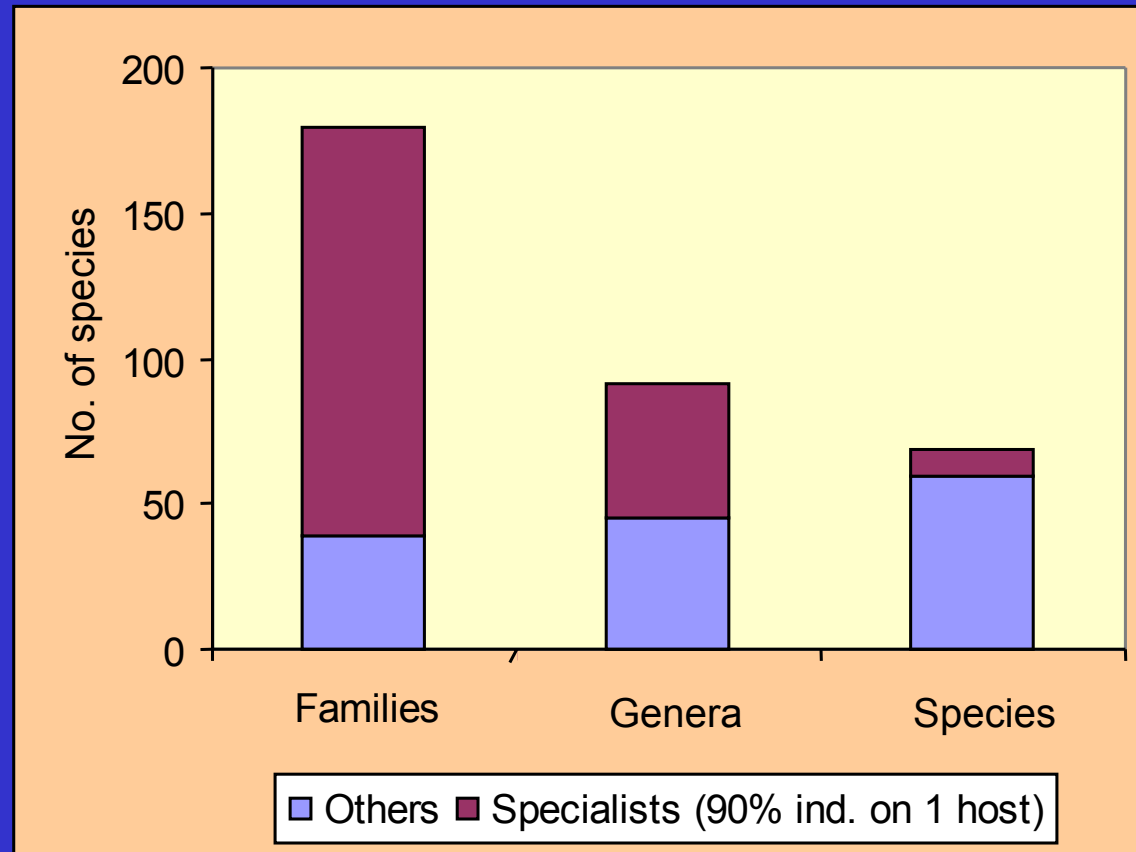
crambid moth  
*Ficus* specialist

*Cleorina* sp.



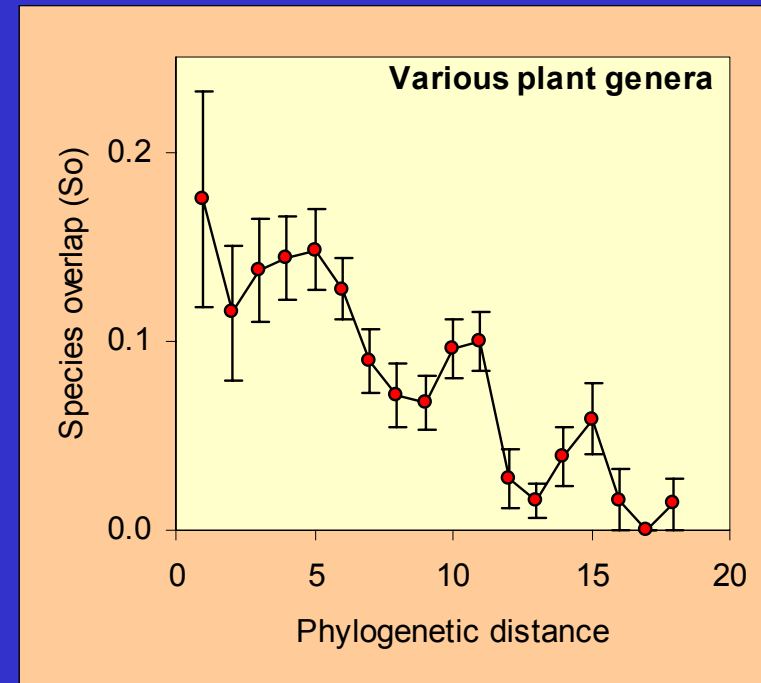
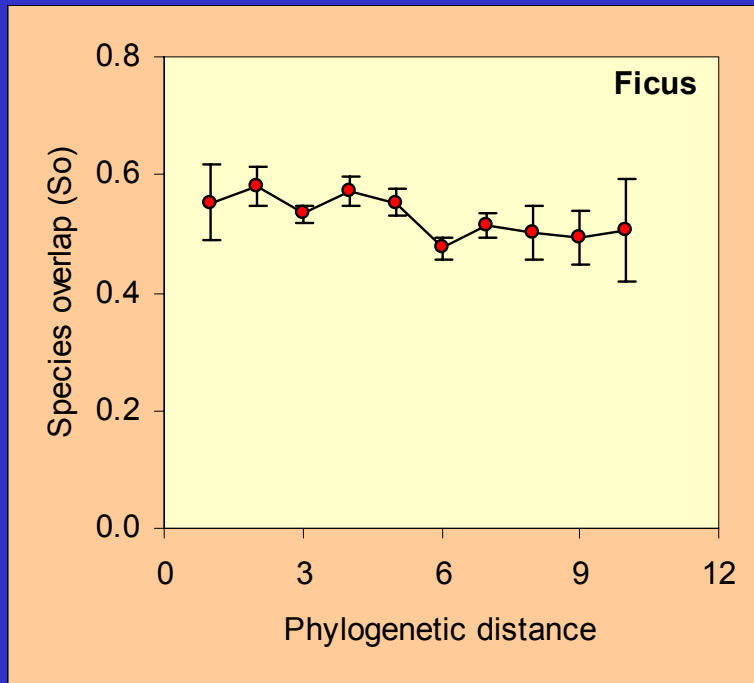
chrysomelid beetle  
*Macaranga* specialist

## host specificity of caterpillars



- most herbivores are specialized on a single host plant family or genus
- few herbivores are extreme specialists, feeding on a single host species

## similarity of caterpillar communities on different host plants



- similarity of the insect faunal declines as the phylogenetic distance between host plants increases
- herbivore overlap among congeneric host species is very high
- herbivore overlap among host genera is lower and declines to zero

## estimating the global number of arthropod species

	Erwin 1982	NG beetles
A. # herbivores per tree sp.	682	32.9
B. effective specialization	0.20	0.24
C. correction for non-herbivores	1.20	1.20
D. % species from arthropods	0.40	0.23
E. % canopy faunal from total	0.66	0.42
F. # tropical tree species	50,000	50,000
Total arthropods (A x B x C x F) / (D x E)	31,000,000	4,900,000

- our estimates based on New Guinea beetles reconcile the order of magnitude difference between Erwin's ecological estimate and museum collection estimates
- the same is true for New Guinea caterpillars and under differing assumptions

## conclusions

- most insect herbivores feed on several closely related plant species rather than a single host plant species
- most insects specialize on a particular genus or family of host plants
- when evolutionary relationships of food plants are considered, the global number of arthropod species is 4-6 million.
- integrating ecology with evolution, the new figure reconciles an order of magnitude difference between previous estimates
- while there appear to be fewer arthropods on earth than we thought, the finding is important for developing realistic strategies for biodiversity conservation

# Acknowledgements

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