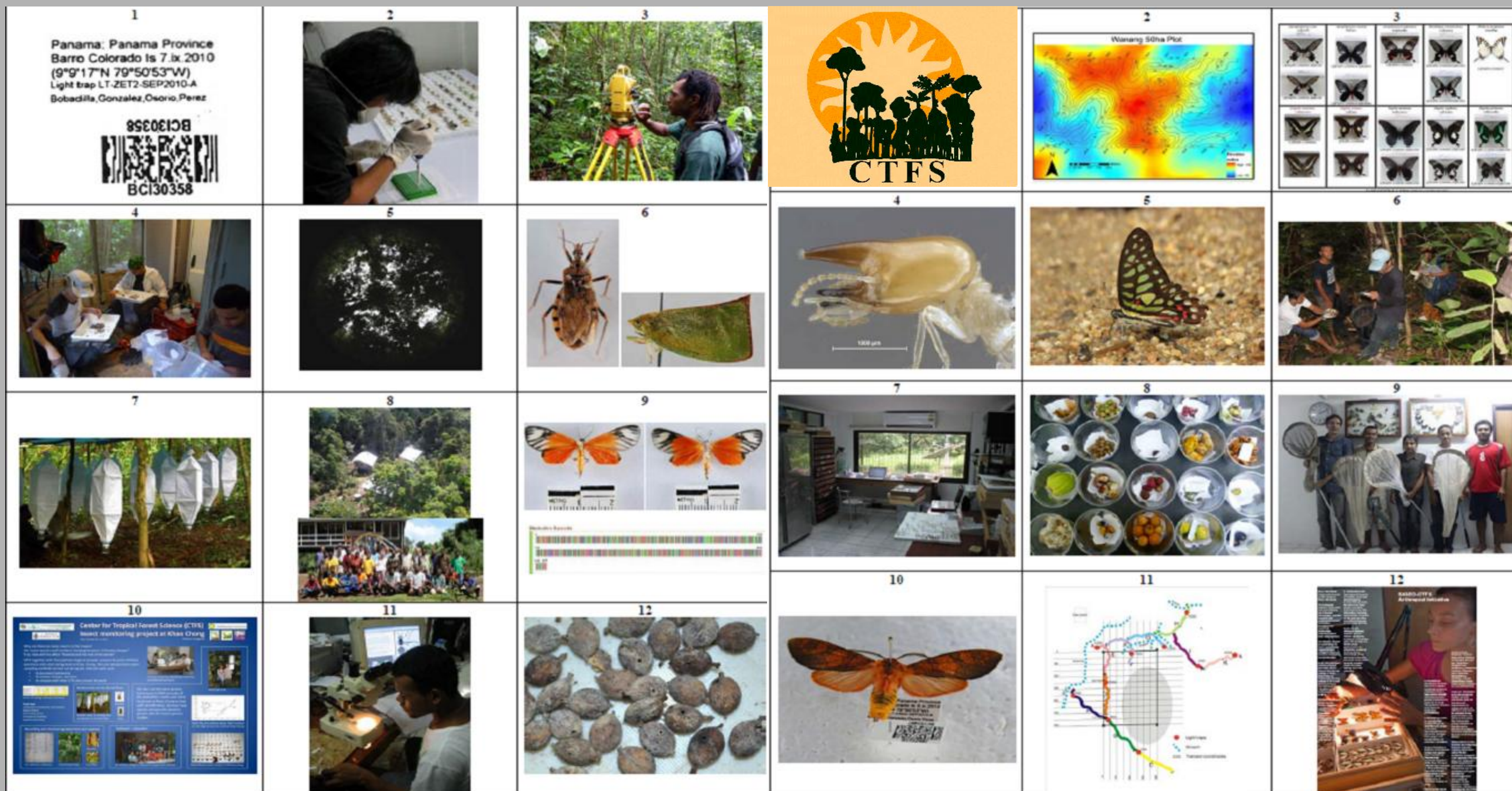
CTFS-ForestGEO ARTHROPOD INITIATIVE 2008-2015:

How to monitor insects in tropical rainforests



Yves Basset, Smithsonian Tropical Research Institute, bassety@si.edu

ForestGEO ®

Currently: 61 sites in 24 countries

6 million of trees monitored, representing 10,000 species

10 science initiatives: Arthropods monitoring: 9 sites

CTFS

Interest of monitoring tropical arthropods

- intimately associated with plant species
- participate in ecosystem processes: herbivory, pollination, seed dispersal, decomposition
- represent huge biomass and most of biodiversity
- results are very amenable to statistical analysis of long-term trends
- short generation times (4-10 gen/yr): interest to develop early warning systems

but

- taxonomic impediment
- cannot study all of them
- poor knowledge about their ecology and effects on plants
- cannot be tagged...

Interest of monitoring arthropods at ForestGEO sites

Access to:

- **Long-term meteorological data**
- **Vegetation data: floristics**
- **Vegetation data: spatial distribution**

In some cases:

- **Phenological tree data**
- **Other science initiative, eg leaf traits, DNA barcoding, etc.**
- **Insect data and collections**
- **Joining the arthropod mini-network**

CTFS-ForestGEO ARTHROPOD INITIATIVE

Aims:

to monitor key insect assemblages over the long-term at CTFS sites

and

to study insect-plant interactions across the CTFS network

At each CTFS site, 3 phases: - baseline survey to identify common species
- monitoring (modeled on baseline survey)
- interaction studies (different set of protocols)

2015: 9 sites activated: Barro Colorado Island (Panama), Yasuni (Ecuador), Rabi (Gabon), Tai Po Kau (Hong Kong), Dinghushan (China), Xishuangbanna (China), Bukit Timah (Singapore), Khao Chong (Thailand) & Wanang (Papua New Guinea)

Backed by an international panel (steering committee) of 26 experts

CTFS-ForestGEO ARTHROPOD INITIATIVE

Develop a structured program of arthropod studies across the CTFS plots

Integration with ongoing monitoring of plant dynamics within the network

Cause minimum possible impact to the plots

Focus on a priority set of assemblages chosen for their

- **ecological relevance**
- **taxonomic tractability**
- **ease of sampling**

Monitoring
Interactions only

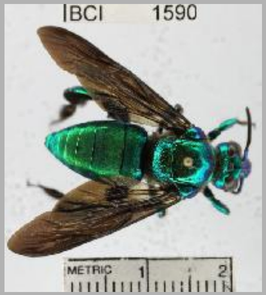
Priority assemblages

Litter ants: **key organisms in tropical forests and often key predators**

[Formicidae]

Selected moths and butterflies: **caterpillars leaf-chewers, adults often pollinators**

[Rhopalocera, Geometridae, Arctiinae & Pyraloidea]



Bees: **important pollinators of many tropical trees**

[Apidae Euglossini]

Termites: **important decomposers in tropical forests**

[Isoptera]

Tephritid fruit-flies: **seed (fruit) predators**

[Tephritidae]

Seed predators: **important influence on fruit/seed survival (whole guild)**

[Varia]

Full suite of 15 taxa studied at BCI, Panama

Methods: baseline survey & monitoring

Litter ants: extraction from litter with Winkler

Bees: attraction to chemical baits,
(only Neotropical sites)

Tephritid fruit-flies: baited McPhail traps
(not in the Neotropics)

Moths and other taxa: light traps

Termites: light traps & hand search in quadrats

Butterflies: walking transects

Butterflies: Pollard transects vs. fruit traps in tropical rainforests

Variable	**Pollard walks**	**Fruit traps**
Easy implementation at most sites = **global program**	Yes ✓	No: does not work well or not at all in Panama, Thailand, Vietnam and New Guinea, for example ✗
Interpretation of results	OK, data can be filtered to reject poor samples if needed (T, wind, RH, cloud) ✓	As long as we do not know why fruit traps do not perform consistently well among locations, this cast doubts on the replicability of the protocol (seasonality of fruit occurrence) ?
Target of local assemblages	All butterflies ✓	Fruit-feeding Nymphalidae 1 out of 6 butterfly families or < 20% of local butterfly species ✗
Costs (other than personal) (costs for personal are similar)	Low ✓	Traps; baits may be locally expensive because unavailable (PNG) ✗
Need for trained personal in field	Yes, depend on observer training and local reference collections ✗	No, unless butterflies are released ✓
Percentage of species identified	Only easily recognizable species, or species which are collected % varies among sites ✗	Normally 100% of individuals ✓

Implement Pollard walks at study sites, supplemented by fruit traps when working well

Summary: sites x protocols as of April 2015

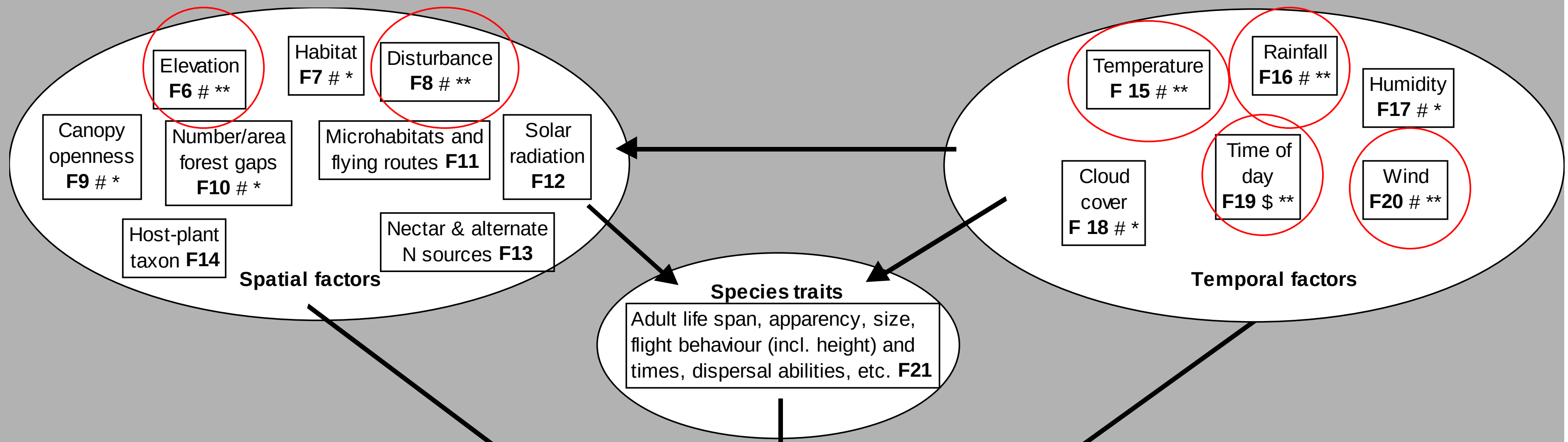
CTFS-ForestGEO site	Country	Year initiated	PI	Butterflies / Transects	Fruit flies / McPhail traps	Euglossine bees / Cineole baits	Litter ants / Winkler	Termites / Transects	Moths and others / Light traps	Seed predators / Rearing seeds	Region
				Monitoring (6)						Interactions (1)	
Barro Colorado Island	Panama	2009	Y. Basset et al.	■		■	■	■	■	■	Neotropical
Yasuni	Ecuador	2014	D. Donoso	▒			■	■			
Rabi	Gabon	2015	T. Bonebrake et al.	■							African
Khao Chong	Thailand	2009	Y. Basset et al.	■	■		■	■	■	■	Oriental
Tai Po Kau	Hong Kong, China	2014	T. Bonebrake	■	▒		▒	▒	■		
Bukit Timah	Singapore	2016	M. Wong/T. Evans				■	▒			
Dinghushan	China	2015	T. Bonebrake	■	▒		▒	▒	▒		
Xishunangbanna	China	2015	A. Nakamura	■	▒		▒	▒	▒	▒	
Wanang	Papua New Guinea	2013	Y. Basset et al.	■	■		■	■		■	Australasian

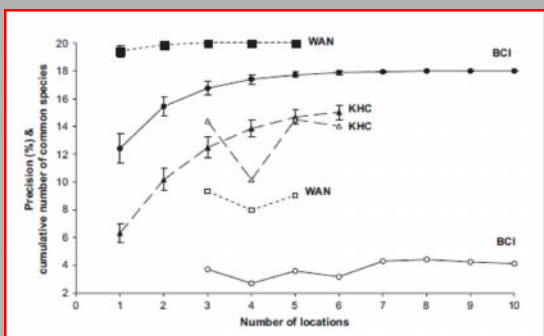
Possible expansion of insect protocols in the near future ▒

Possible expansion of sites in the near future:

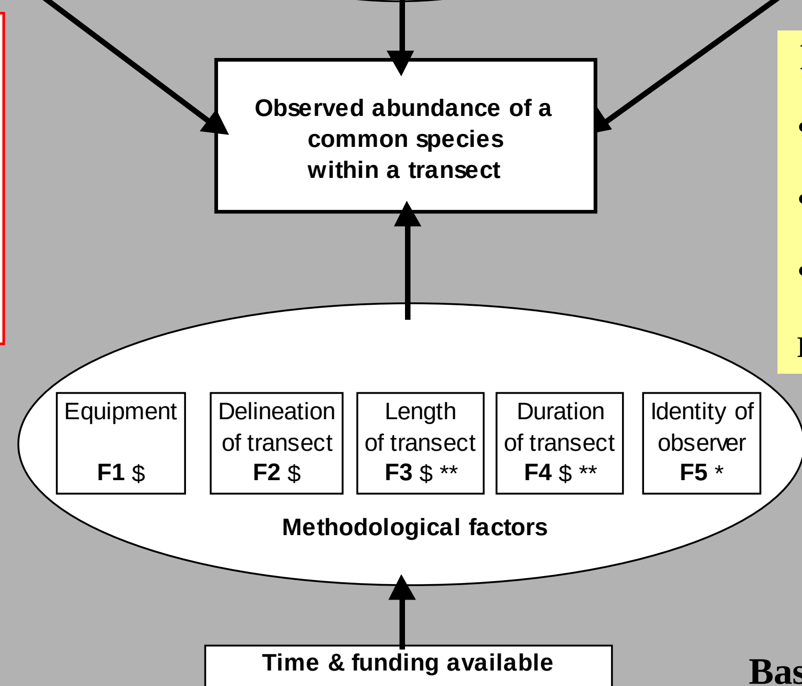
Manaus	Brazil	2016, all protocols?
Doi Inthanon	Thailand	2016, all protocols?

SPATIAL REPLICATION: butterfly transects





Minimum no. of locations to collect most common spp.



10 locations:

- transects
- trap locations
- randomized survey locations

reduce spatial autocorrelation

Basset et al., Ins. Cons. Div., 2013

TIMING OF SURVEYS AND SAMPLING EFFORT

Four surveys a year, timing depends on occurrence of dry/wet seasons

Light traps: one survey: 2 trap-nights at each of the ten locations; 4 surveys; **total 80 samples annually**

Butterfly transects: one survey: 10 timed (30 min.) transects of 500m, 3 replications; 4 surveys; **total 120 samples annually**

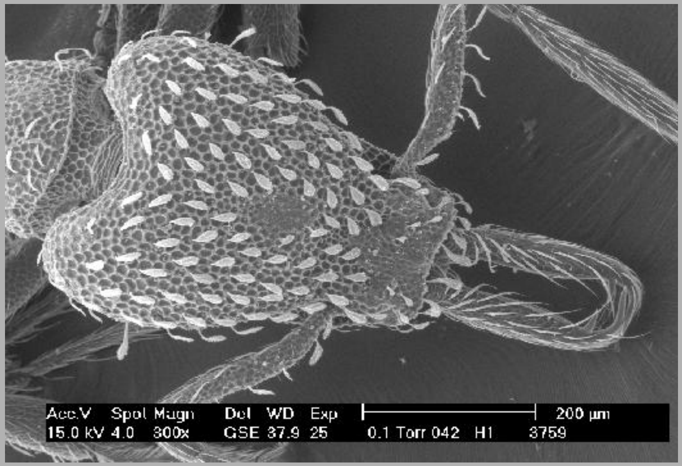
Euglossine baits: one survey: 7 trap-day at each of 10 locations; 4 surveys; **total 40 samples annually**

Winkler: one single survey: 10 transects of 25m, each with 5 samples of $0.25m^2$ **total 50 samples annually**

Termite transects: one single survey, a 400m transects with 40 samples, each $5m^2$; **total 40 samples annually**

Staff: 4 full time assistants at each site

TAXONOMY



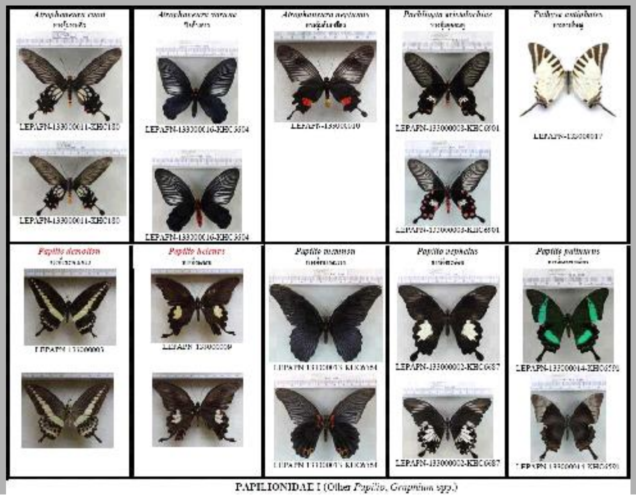
- Local reference collections

- DNA barcoding (sexual dimorphism, social castes, ca 8,000 sequences)

- Collaborating experts (in-country or abroad)

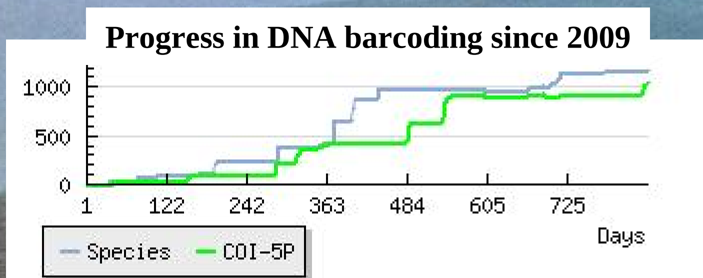
FOCUS OF MONITORING: COMMON SPECIES

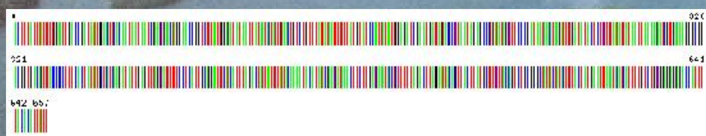
- Common mistake: a monitoring program is **not** an insect survey!
- Monitoring rare species is desirable but totally impractical in tropical rainforests
- Statistical and financial challenges for monitoring rare tropical species
- Only a handful of rare species likely to be “monitored”, at substantial $$
- Instead: focus on **common species** (and community variables), so that they can be used as indicators of early decline of habitats/populations



Example: BARRO COLORADO ISLAND

PANAMA (BCI)





STATUS

2008: baseline survey

2009-2015: on-going monitoring (7th year)

Collections: 35,461 pinned specimens; 1,809 spp.

71% of spp. sequenced for DNA barcodes

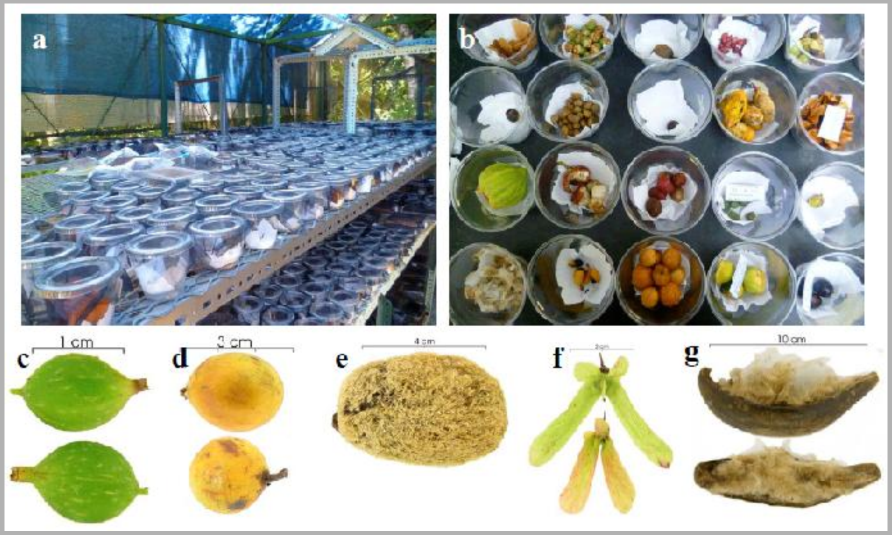
Four full-time research assistants, based at STRI

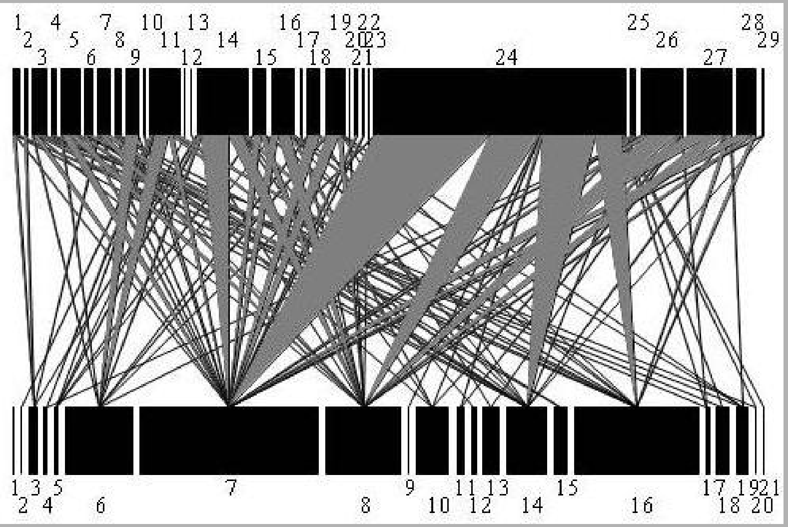
INTERACTION STUDIES

• KHC (2010): Effects of litter composition on ants

• BCI (2010), KHC (2013), WAN (2013):

Insect seed predation: quantitative food webs





RESULTS:

SELECTED EXAMPLES OUT OF 15 TAXA

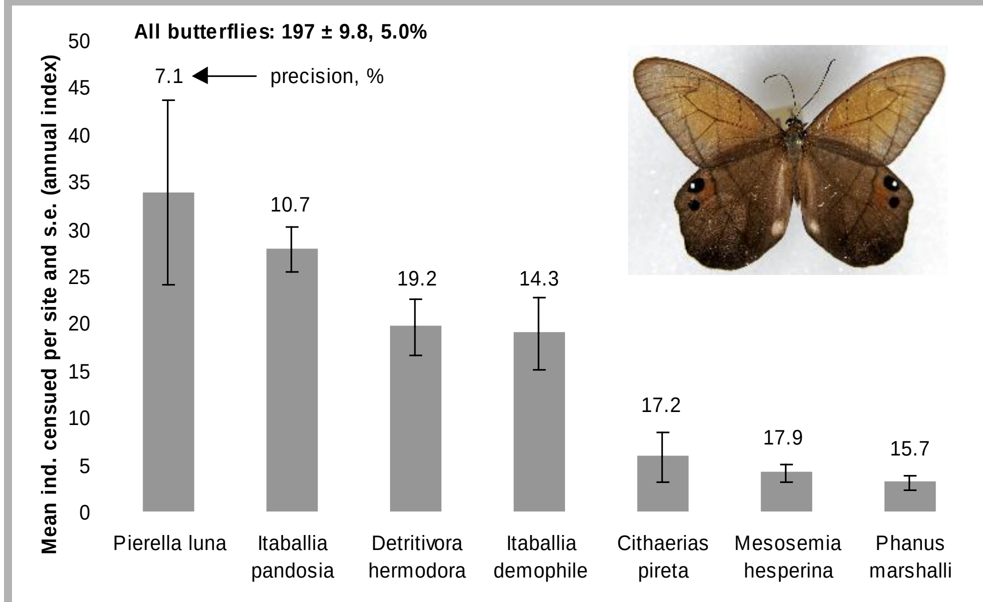
- **Yearly results: annual indices (butterflies & ants)**

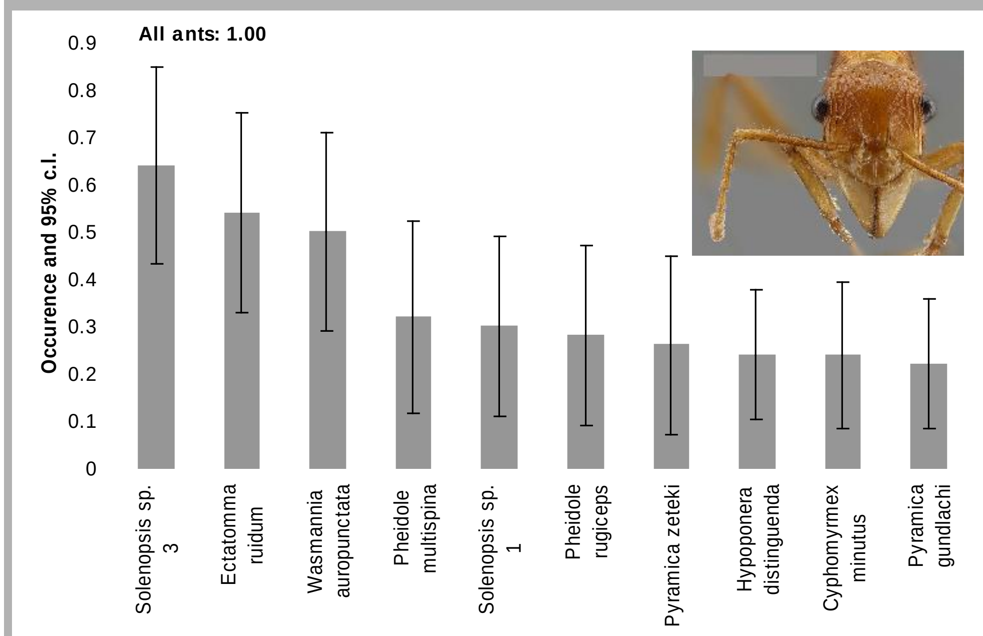
- **Population dynamics (saturniid moths)**

- **Changes in assemblages (6 taxa)**

Immediate significance
vs.
Interpretation of long chronosequences

Annual indices, BCI, Year 2011





60,000 insects collected:
17,000 focal individuals (910 spp.)

For 56 spp. we can estimate annual indices with good precision

56 spp. = 6% of total spp. but
55% of total abundance of focal taxa

Annual indices:
Non-social insects: mean per site (n=10)
Precision = s.e./mean
(< 20% very good, economic entomology)

Social insects: occurrence in samples, transects or quadrats
Precision = 95% c.l. on occurrence data, assuming a binomial distribution

Annual indices

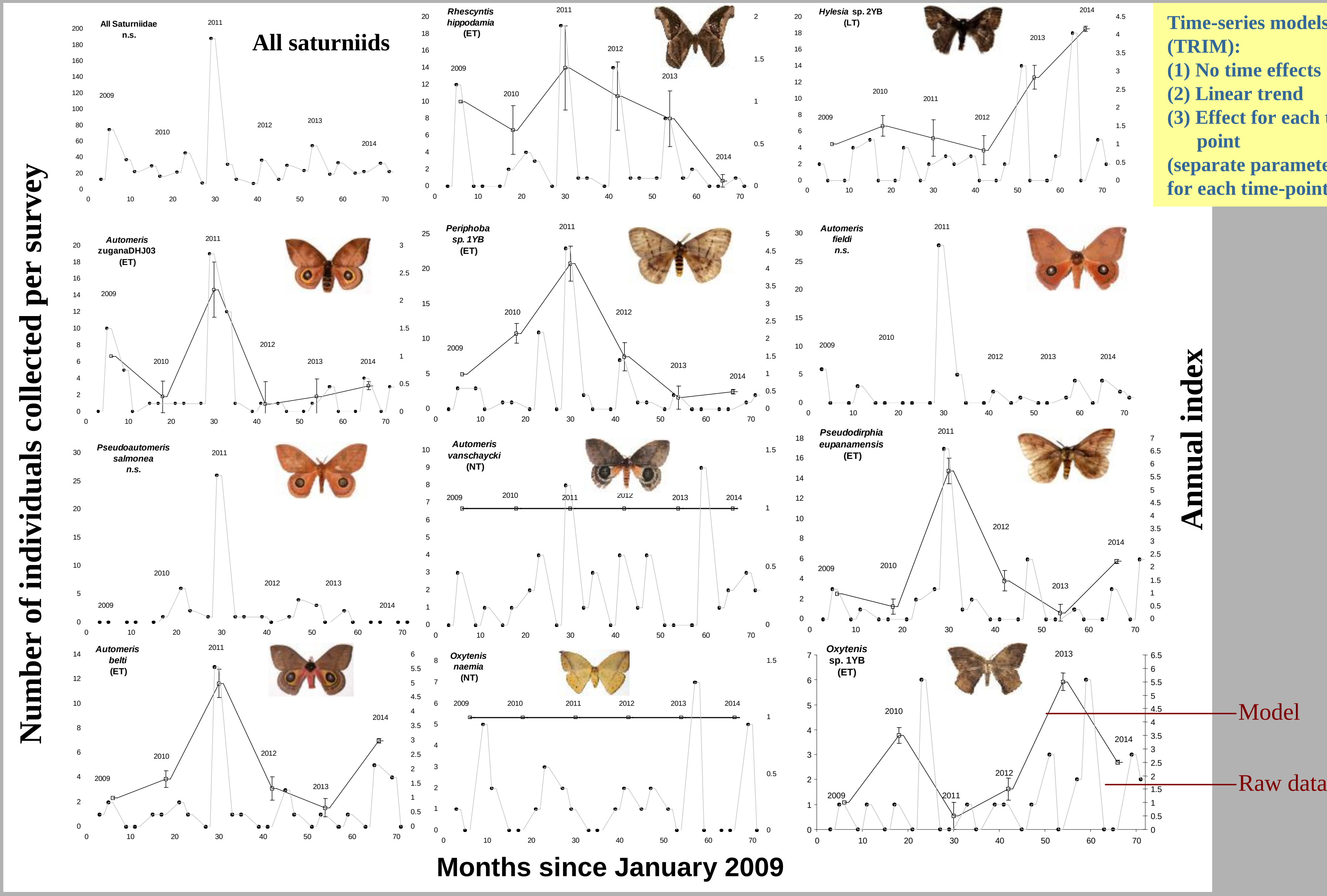
Immediate significance:

- **Common spp. can be monitored with relative precision, even in tropical rainforests**

- **Few long-term monitoring programs in the tropics (butterflies: 10-11 years: Leidner *et al.* 2010, Grøtan *et al.* 2012)**

- **Indices for social insects need to be reported differently than for non-social insects (refinements needed for social insects; geometric mean for non-social insects)**

Population dynamics, BCI, Years 2009-2014, saturniid moths



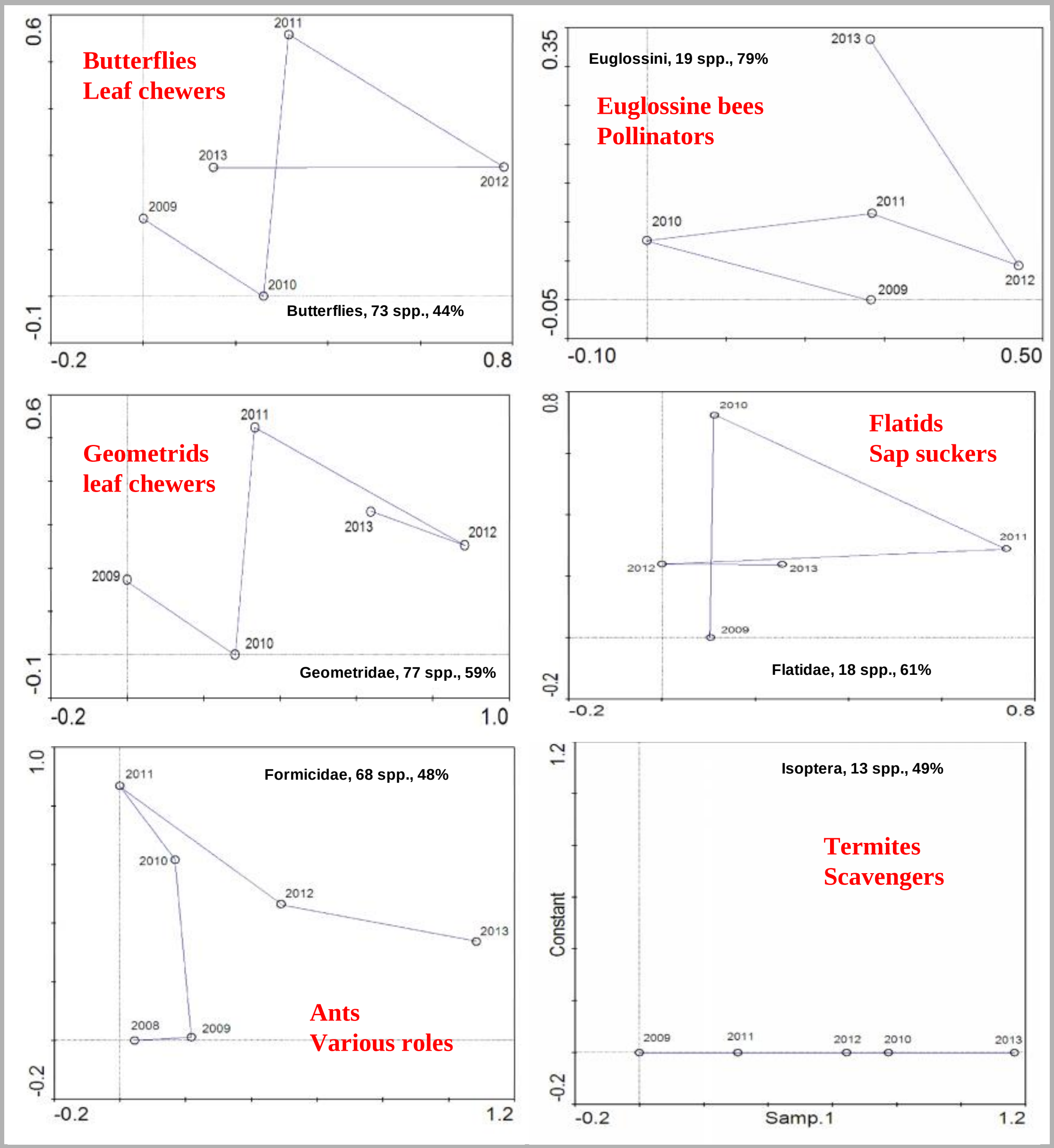
Time-series models (TRIM):
(1) No time effects
(2) Linear trend
(3) Effect for each time point
(separate parameters for each time-point)

Population dynamics

Immediate significance:

- **We can detect significant (short-term) trends**
- **Nearly a quarter of species show significant changes with time (different groups tested)**

Changes in assemblages, BCI, 2009-2013



Matrices Spp. x Years
DCA (6 out of 16 assemblages)

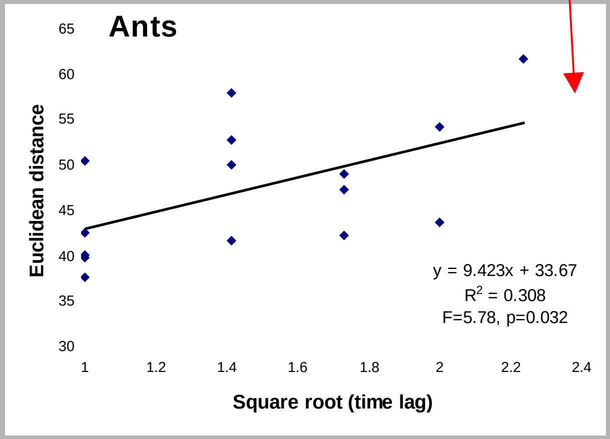
Mantel tests, p-values:

	Bees	Geometrids	Flatids	Ants
Butterflies	0.639	0.102	0.571	0.966
Bees		0.570	0.754	0.751
Geometrids			0.735	0.794
Flatids				0.637

Trajectories are independent

Directional changes are few

Regression of Euclidean distances vs. time lag:



Changes in assemblages

Immediate significance:

- Trajectories appear largely independent: need to monitor an array of taxa

- Directional changes appear also to be few

Scientific output

Training of 15 assistants and 5 interns

Insect collections and collateral info: pictures, DNA barcodes, etc.

Educational outreach and student volunteers at BCI, KHC

Scientific publications

Insect Conservation and Diversity

Insect Conservation and Diversity (2012) doi: 10.1111/j.1752-4598.2012.00205.x

Cross-continental comparisons of butterfly assemblages in tropical rainforests: implications for biological monitoring

YVES BASSET,[1] ROD EASTWOOD,[2] LEGI SAM,[3] DAVID J. LOHMAN,[2,4] VOJTECH NOVOTNY,[5] TIM TREUER,[2] SCOTT E. MILLER,[6] GEORGE D. WEIBLEN,[7] NAOMI E. PIERCE,[2] SARAYUDH BUNYAVEJCHEWIN,[8] WATANA SAKCHOOWONG,[8] PITOON KONGNOO[9] and MIGUEL A. OSORIO-ARENAS[1] [1]Smithsonian Tropical Research Institute, Panama City, Panama, [2]Museum of Com-

TREE-1927; No. of Pages 13 ARTICLE IN PRE

Review

Trends in Ecology & Evolution

Whole-ecosystem experimental manipulations of tropical forests

Tom M. Fayle[1,2,3], Edgar C. Turner[4], Yves Basset[1,5], Robert M. Ewers[2], Glen Reynolds[6], and Vojtech Novotny[1]

Influence of leaf litter composition on ant assemblages in a lowland tropical rainforest in Thailand

Watana Sakchoowong[1], Sasitorn Hasin[2, 3], Nongphanga Pachey[1], Weerawan Amornsak[4], Suksawat Ponpinij[4], Sarayudh Bunyavejchewin[1], Pitoon Kongnoo[5] and Yves Basset[6]

Asian Myrmecology

14

A global perspective on conserving butterflies and moths and their habitats

Thomas Merckx[1], Blanca Huertas[2], Yves Basset[3] and Jeremy Thomas[4]

LRF JRL The Journal of Research on the Lepidoptera Volume 44: 17-28

THE LEPIDOPTERA RESEARCH FOUNDATION, 4 May 2011

ISSN 0022-4324 (print)
ISSN 2156-5457 (online)

Comparison of rainforest butterfly assemblages across three biogeographical regions using standardized protocols

Yves Basset[1,*], Rod Eastwood[2], Legi Sam[3], David J. Lohman[2,4], Vojtech Novotny[5], Tim Treuer[2], Scott E. Miller[6], George D. Weiblen[7], Naomi E. Pierce[2], Sarayudh Bunyavejchewin[8], Watana Sakchoowong[8], Pitoon Kongnoo[9] and Miguel A. Osorio-Arenas[1]

Publish or perish

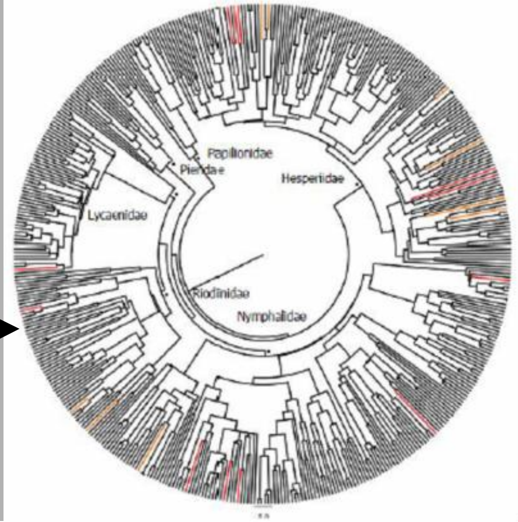
- **Challenge: initial wait for quality data may be long (long chronosequences)**

- **Remedy: (a) comparison of insect data with other sites**
  (b) faunistical surveys (if reasonably complete)
  (c) mine historical data

Example:

The butterflies of Barro Colorado Island, Panama: local extinction since the 1930s

1923-2013: 600 species
(actualized list with DNA barcodes)
< 6% prob. extinct
no relation with phylogeny →



Future goals

- **Distribute MySQL arthropod database to participating sites**
- **Expansion of the mini-network**
- **Publish actively the first results of insect monitoring in the tropics**
- **Compare insect and plant monitoring data**
- **How arthropod monitoring can best complement tree monitoring?**

=> Develop protocols for early warning systems based on arthropods

(Communities of long-lived organisms (trees) appear more "stable")

Acknowledgments

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BCI: Universidad de Panama (Maestria de Entomologia), H. Barrios

KHC: S. Bunyavejchewin, K. Somboon, W. Sackchoowong, P. Kongnoo

WAN: V. Novotny, G. Weiblen, C. Dahl

R. Eastwood, D. Lohman, L. Sam, M. Leponce, D. Donoso, D. Roubik, S. Gripenberg, O. Lewis, S.J. Wright, T. Bonebrake, A. Nakamura