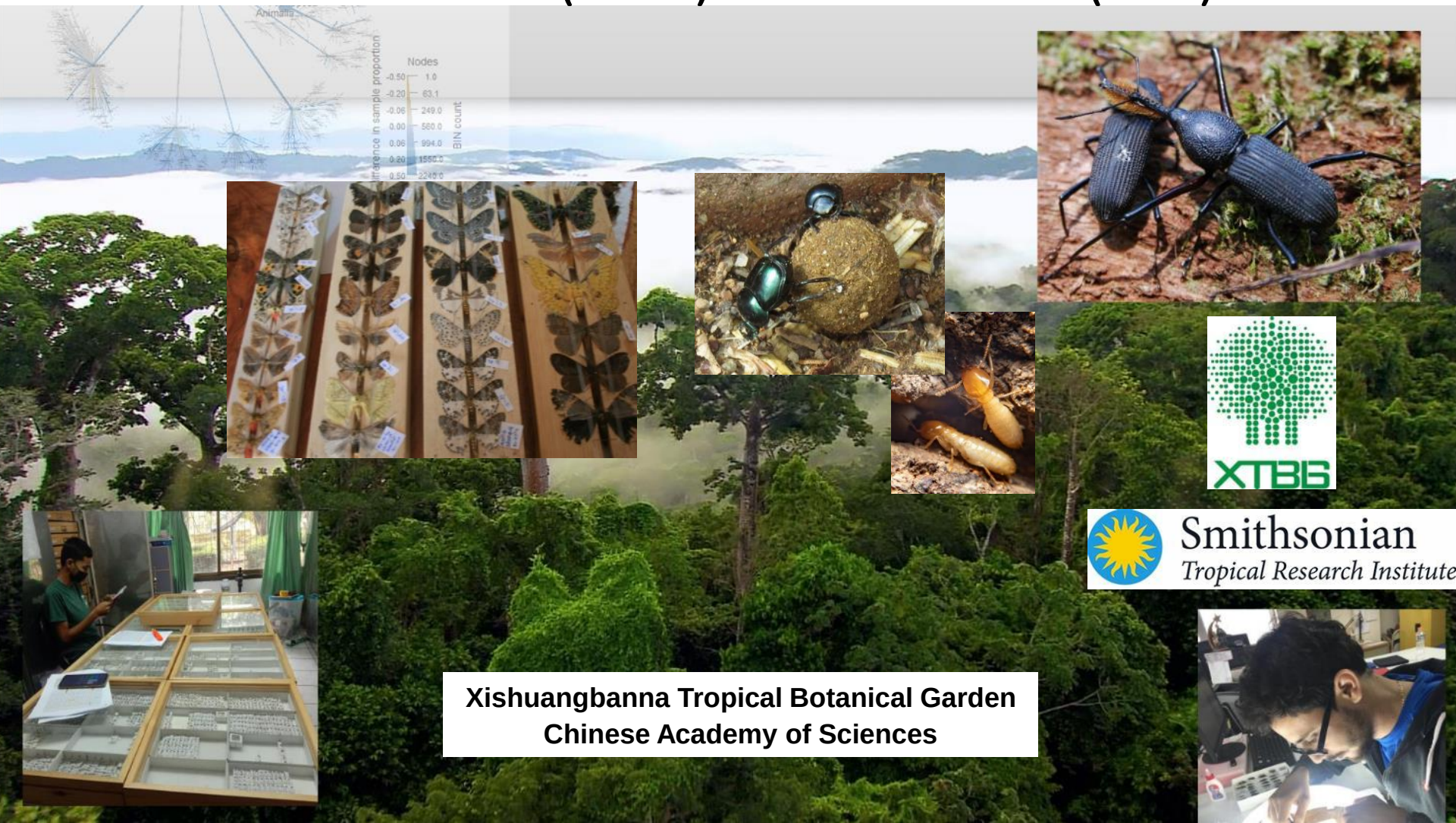
Monitoring tropical forest insects in the 21st century: challenges and opportunities in SE Asia

Aki Nakamura (XTBG) and Yves Basset (STRI)



Insect apocalypse?

Science 2014 Current Issue First release papers Archive Abou

HOME > SCIENCE > VOL. 345, NO. 6195 > DEFAUNATION IN THE ANTHROPOCENE

SPECIAL ISSUE REVIEW

Defaunation in the Anthropocene

RODOLFO DIRZO , HILLARY S. YOUNG, MAURO GALETTI, GERARDO CEBALLOS, NICK J. B. ISAAC, AND BEN COLLEN Authors Info & Affiliations

SCIENCE · 25 Jul 2014 · Vol 345, Issue 6195 · pp. 401-406 · DOI: 10.1126/science.1251817

15,835 2,185

ELSEVIER

Biological Conservation
Volume 242, February 2020, 108426

Perspective

Scientists' warning to humanity on insect extinctions

Pedro Cardoso [a], Philip S. Barton [b], Klaus Birkhofer [c], Filipe Chichorro [a], Charl Deacon [d], Thomas Fartmann [e], Caroline S. Fukushima [a], René Gaigher [d], Jan C. Habel [f], Caspar A. Hallmann [g], Matthew J. Hill [h], Axel Hochkirch [i j], Mackenzie L. Kwak [k], Stefano Mammola [a l], Jorge Ari Noriega [m], Alexander B. Orfinger [n o], Fernando Pedraza [p], James S. Pryke [d], Fabio O. Roque [q r], Josef Settele [s t u]...Michael J. Samways [d]

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Disproportionate declines of formerly abundant species underlie insect loss

Roel van Klink, Diana E. Bowler, Konstantin B. Gongalsky, Minghua Shen, Scott R. Swengel & Jonathan M. Chase

Nature **628**, 359–364 (2024) | Cite this article

32k Accesses | **3** Citations | **357** Altmetric | Metrics

PNAS

INTRODUCTION | BIOLOGICAL SCIENCES

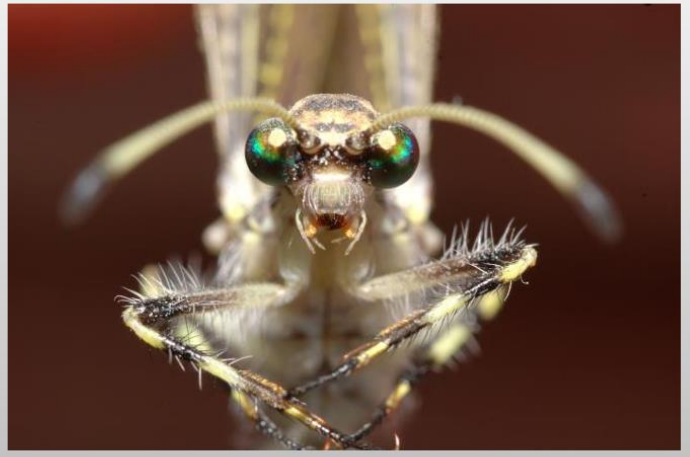
Insect decline in the Anthropocene: Death by a thousand cuts

David L. Wagner, Eliza M. Grames, Matthew L. Forister, and David Stopak Authors Info & Affiliations

January 11, 2021 | 118 (2) e2023989118 | https://doi.org/10.1073/pnas.2023989118

THIS ARTICLE HAS BEEN UPDATED

191,455 | 315 PDF/EPUB



Why insects?

- Most of the animal biomass and diversity on Earth (80%)
- Innumerable interactions with plants in tropical forests
- Hugely influential for plant and vertebrate communities
- Provide crucial ecosystem services:

  pollination, decomposition, waste disposal, nutrient cycling
- Most tropical species unknown to Science

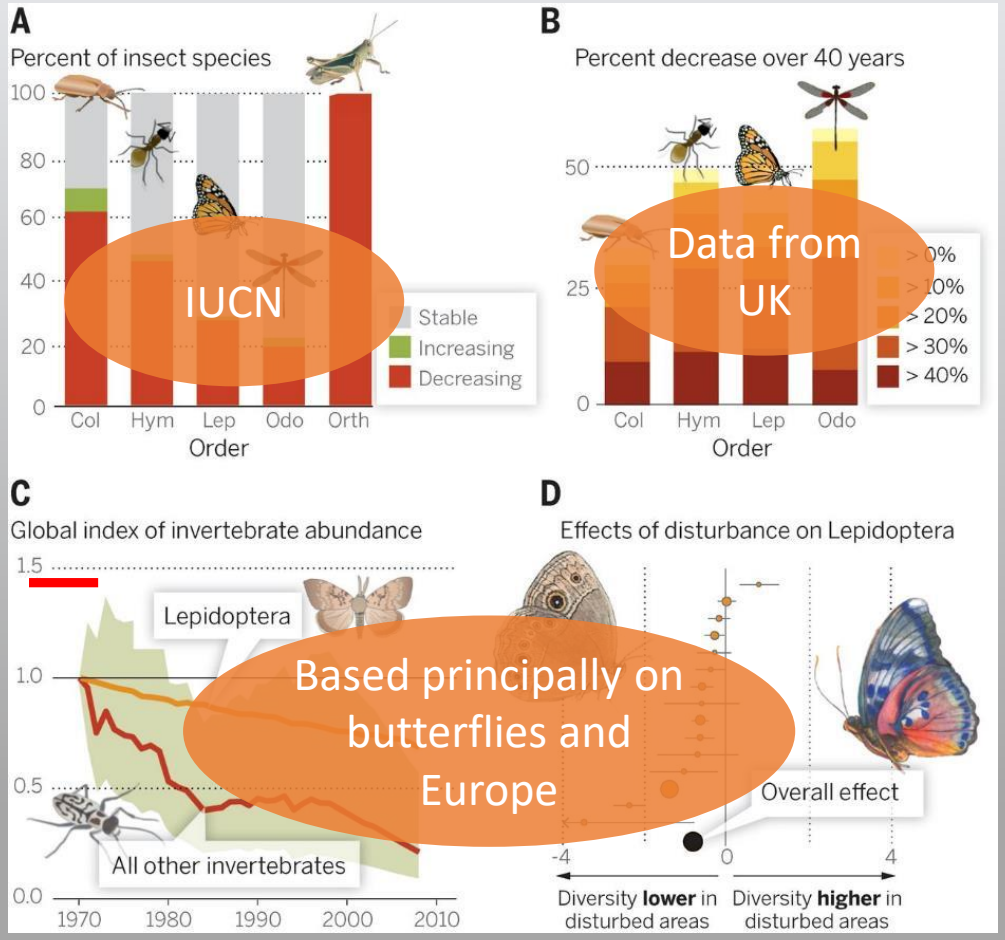
→ Essential share of biodiversity
which is vital, unknown and neglected

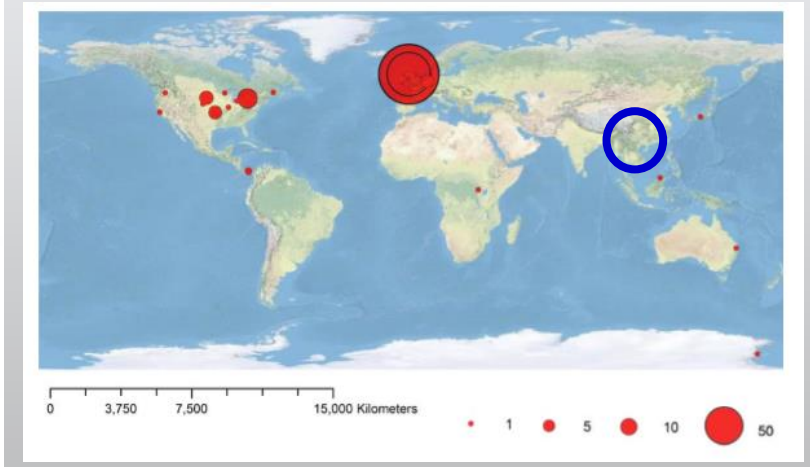
Why monitoring insects?

- Insect decline (apocalypse) reported in temperate areas → threatens human wellbeing
- Extremely specialized, very sensitive to disturbance, including to climate change
- Short-lived, 2-10 generations per year in the tropics
- Data lacking in the tropics

→ Implement early warning systems
Test for worldwide insect decline
Informed environmental policies

Geographic bias in insect biodiversity information





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Nature **628**, 359–364 (2024) | Cite this article

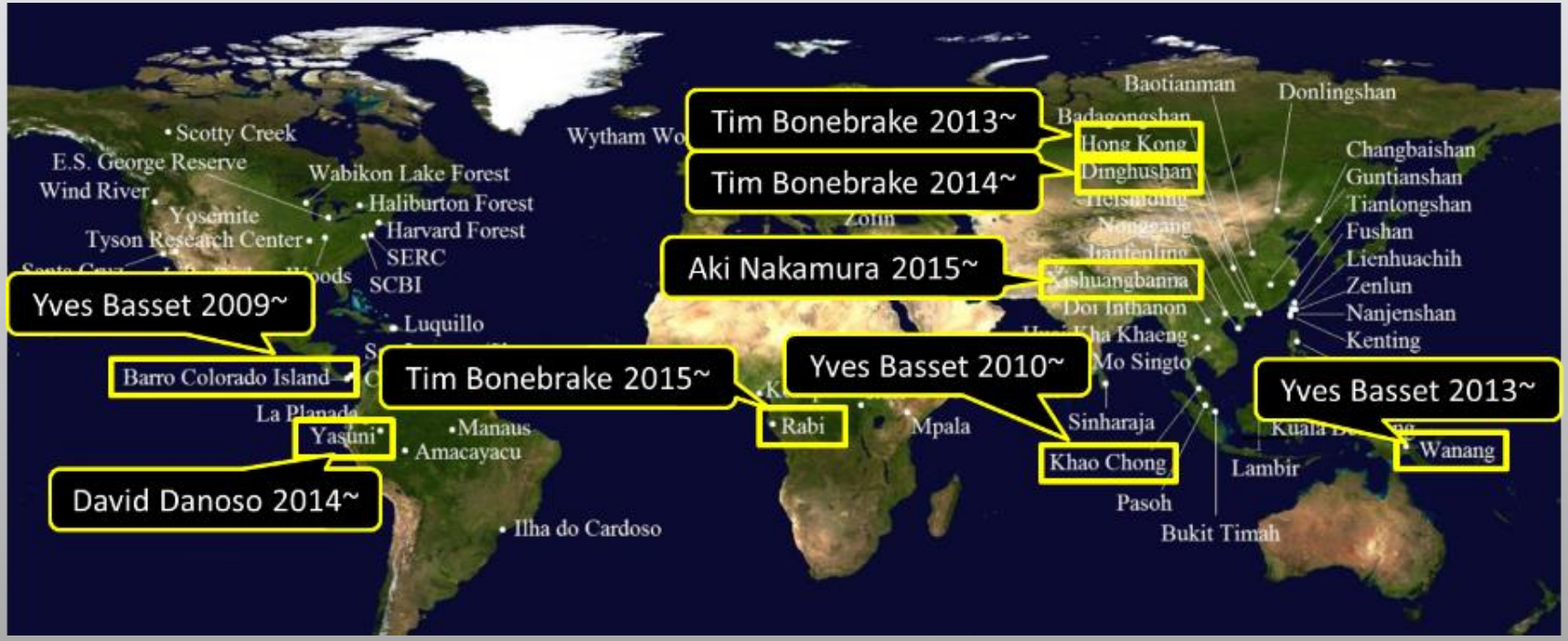
36k Accesses | **10** Citations | **388** Altmetric | Metrics

SE Asian data:
Butterflies in Vietnam
Moths in Malaysia

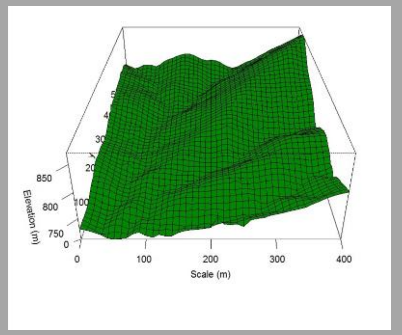
Dirzo 2014 *Science,* van Klink et al. 2024 *Nature*

Worldwide network of insect monitoring

ForestGEO insect monitoring in tropical and subtropical forests



Oldest monitoring site – Barro Colorado Island (Panama) since 2009
Oldest monitoring site in SE Asia – **Khao Chong** (Thailand) since 2010



Why monitoring insects at Khao Chong and Barro Colorado Island?

- KHC and BCI safe from deforestation and pollution (ForestGEO plots)
- Our program has been building insect collections

  for the last 16 years at these two locations (120,000 specimens)
- References libraries for DNA sequences, sound and images
- Meteorological and vegetation records (ForestGEO plots)
- Excellent logistics and safe working conditions

→ Study insects in an environment where climate change is the sole anthropogenic stressor with a unique insect knowledge for the tropics

In numbers: Barro Colorado Island and Khao Chong

	Barro Colorado Island	Khao Chong
Country	Panama	Thailand
Monitoring since	2009 (15 years)	2011 (13 years)
ForestGEO plot	50ha	24ha
Av. daily max Temperature	28.5 °C	30.9 °C
Staff	5	6
No. taxa monitored	23	16
No. focal species	2,572	2,664
% spp. with images	70%	71%
No. samples	8,970	6,161
No insect records	769K	282K
No ind. in collection	81K	41K
No. DNA sequences	12K	2K
DNA metabarcoding	100GB	***
Bioacoustics	1 TB each month	***
Automated monotoring with AI	21K picts each week	***
Publications	70+	8
Training	PhD, MSc, interns, volunteers	Volunteers

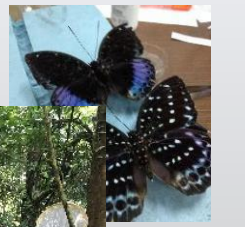
KHC

BCI

Target taxa in Khao Chong (Thailand)

Target groups and traps:

- Butterflies (Pollard walks, 4 x year)
- Moths (Light traps, 4 x year)
- Ants (Winkler extraction, 1 x year)
- Fruit flies (McPhail traps, 4 x year)
- Termites (Manual searching in quadrats, 1 x year)



Pollard walk



Winkler extraction

Standardized for each insect group across sites



Light traps

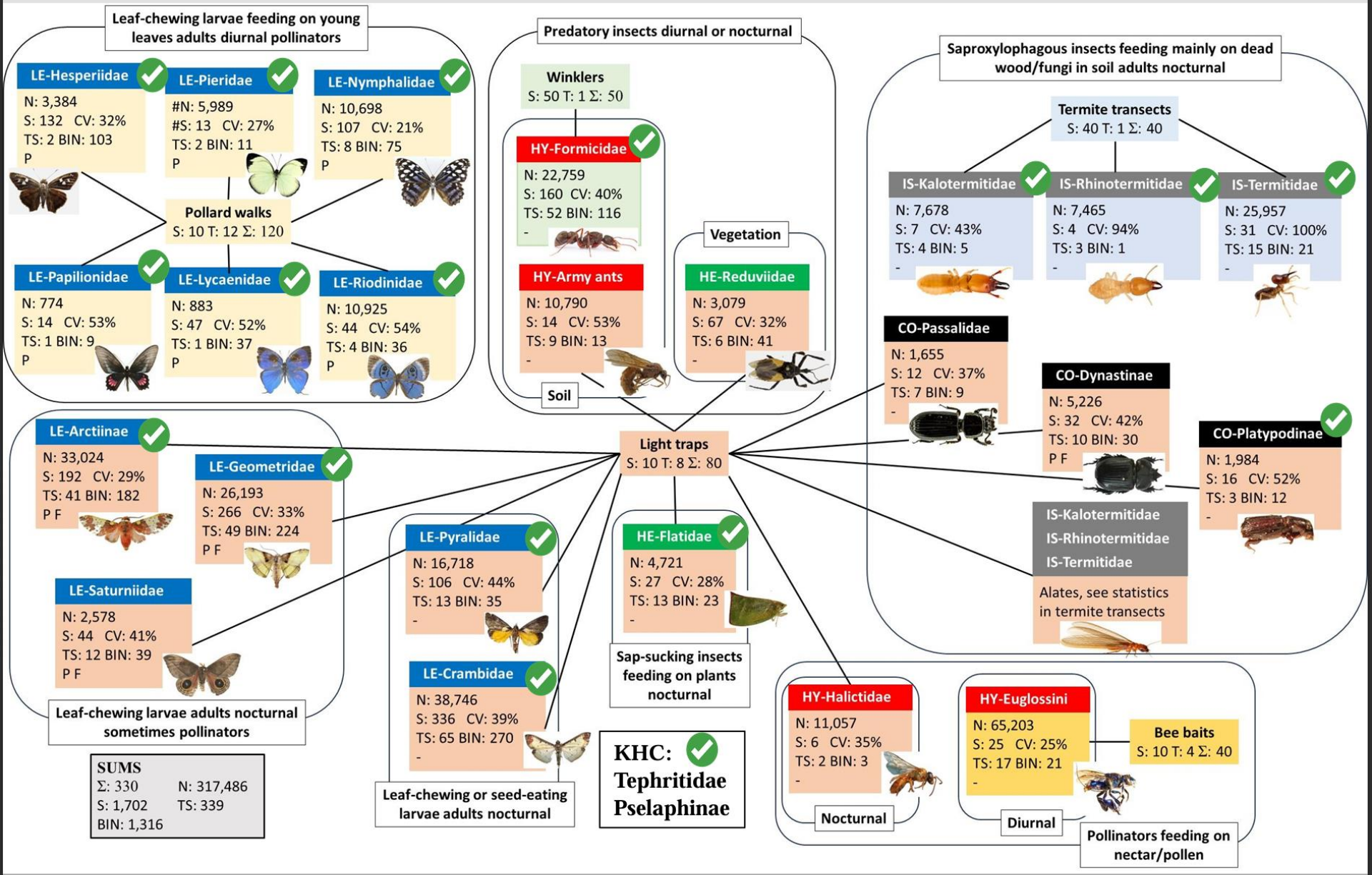


Termite sampling



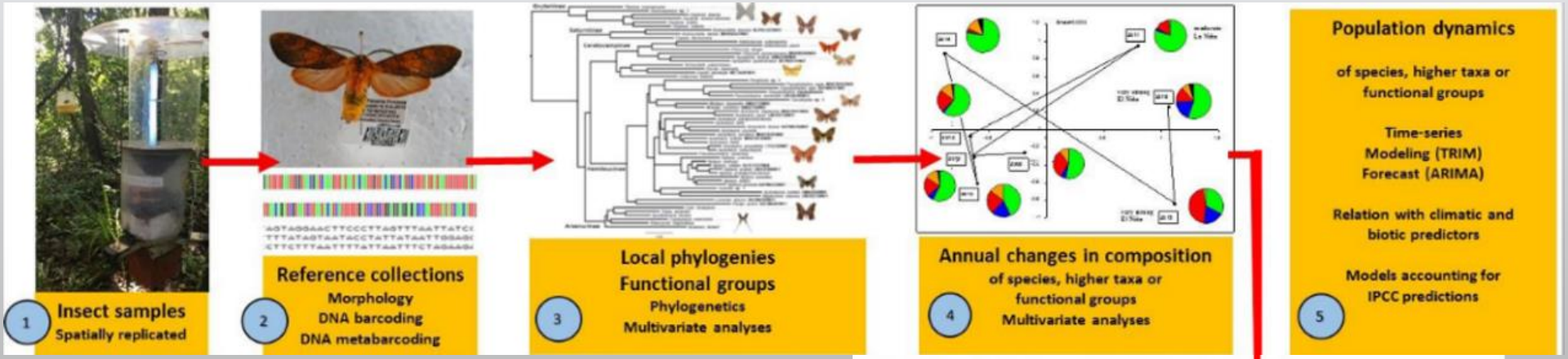
McPhail traps

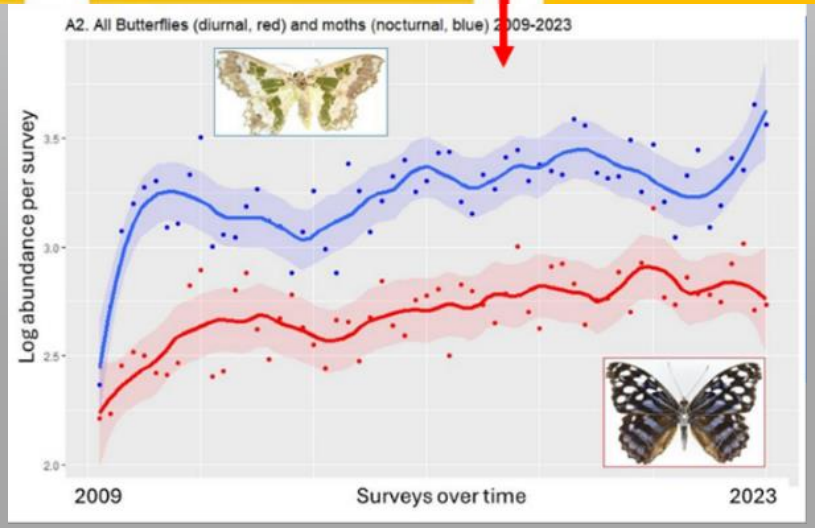
Taxa monitored, BCI (✓ = KHC)



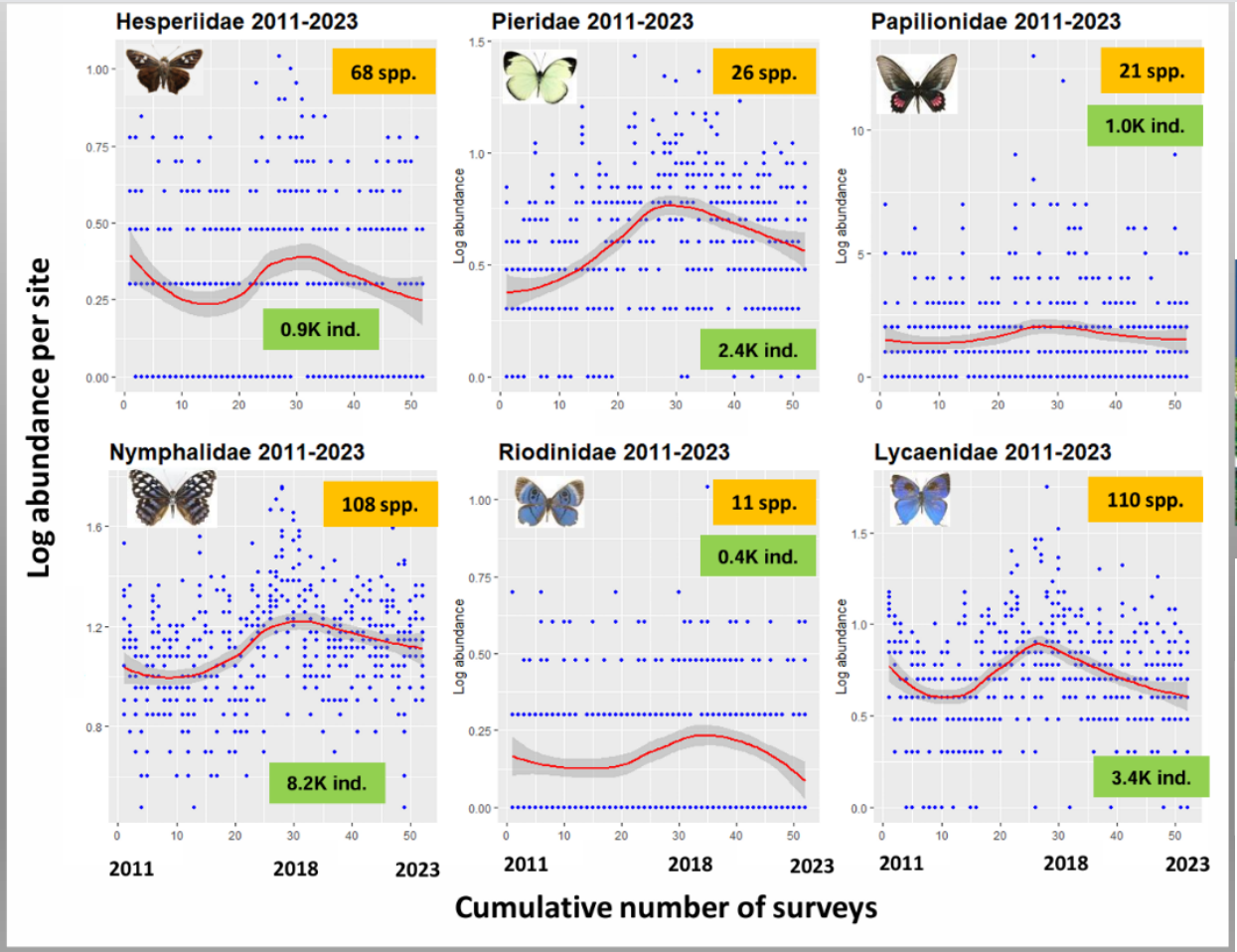
Monitoring methods

- Work at the species or morphospecies level, backed up by DNA barcoding
- Summarize information by functional groups and phylogeny





Butterfly families in Khao Chong 2011-2023

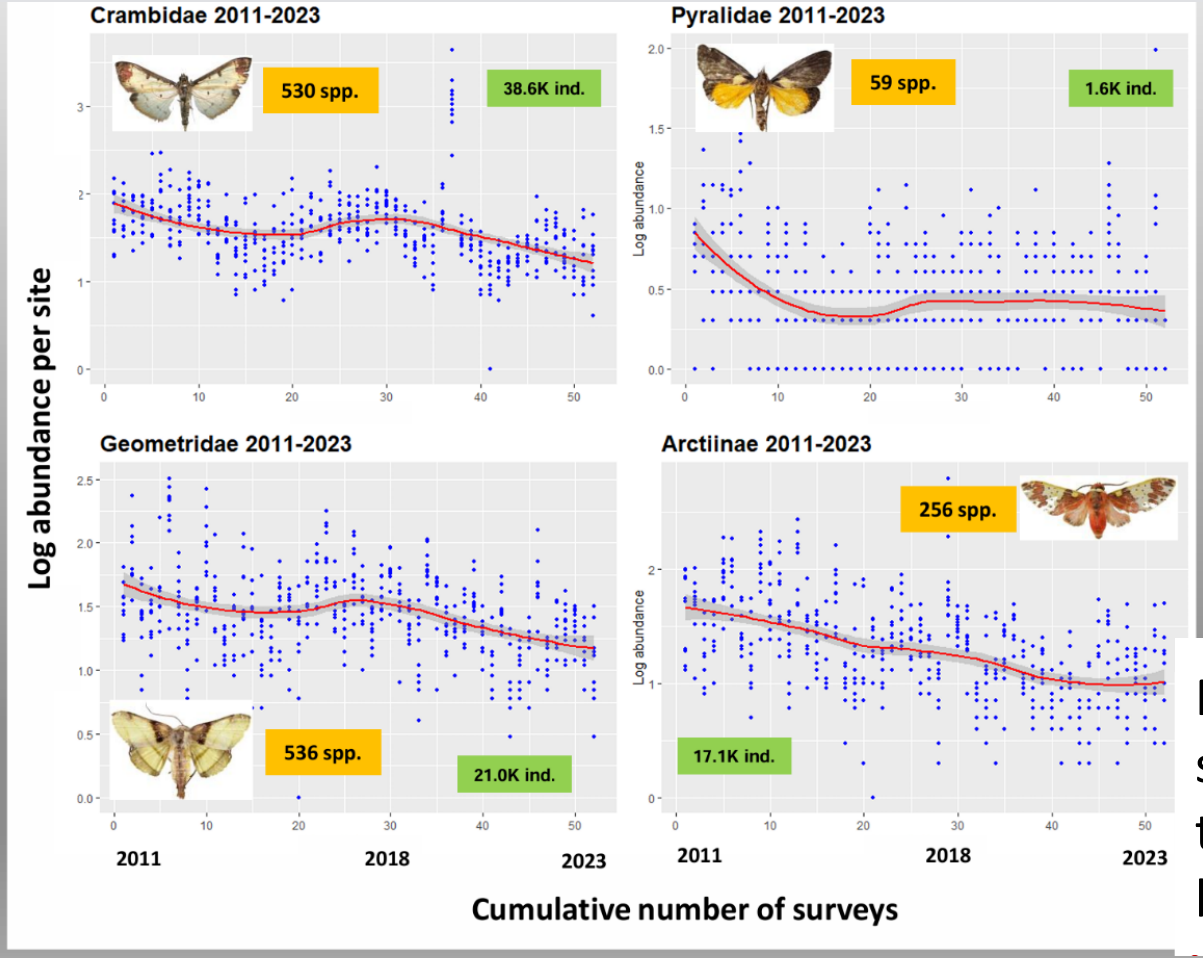


10 sites (3 days per survey)
4 surveys per year
120 samples per year!

Decline since 2018?

But more long-term data is required to detect their true trends

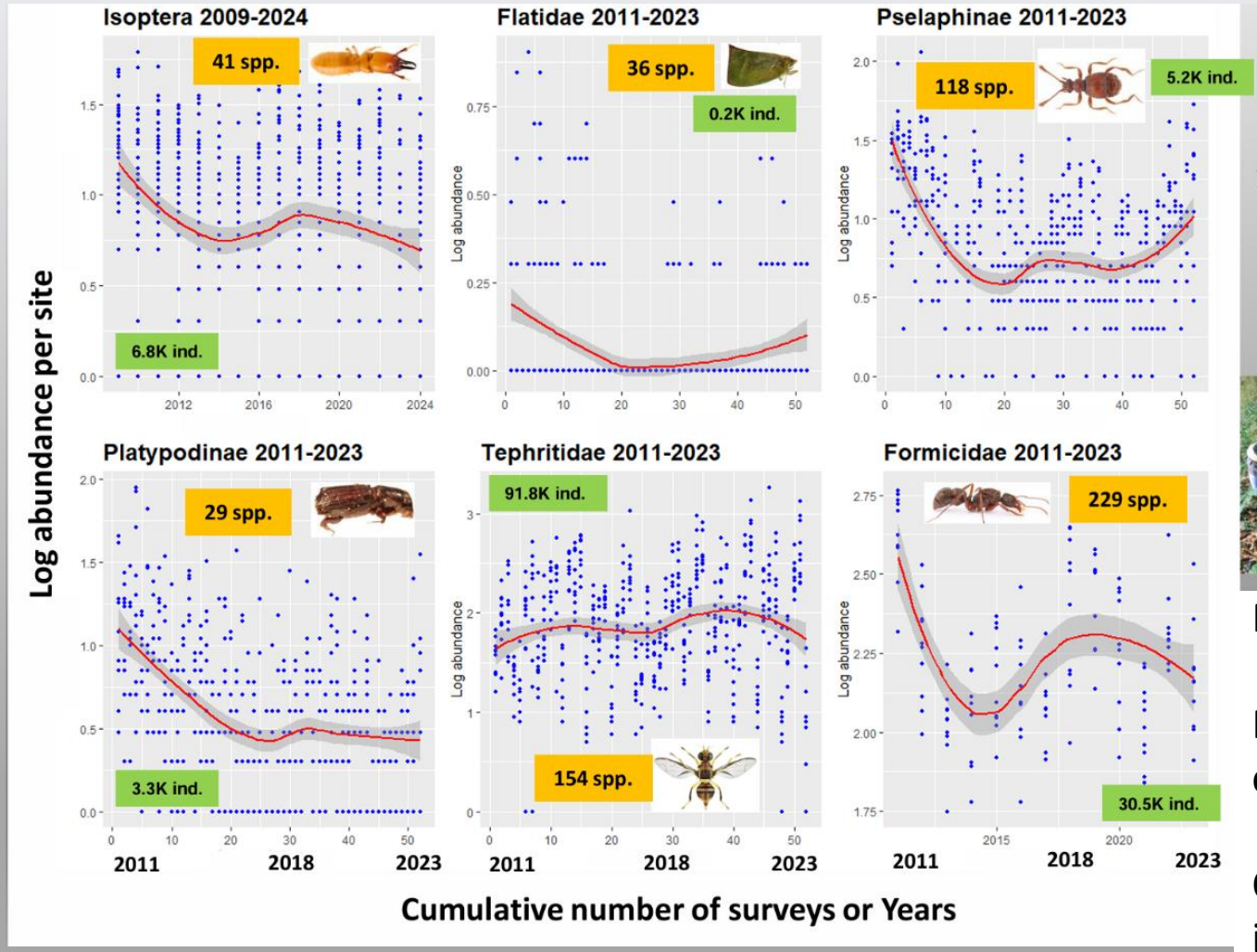
Moth families in Khao Chong 2011-2023



10 sites (2 replications)
4 surveys per year
80 samples per year

Moths may be more sensitive to changing temperatures than butterflies ?

Other insects in Khao Chong 2011-2023



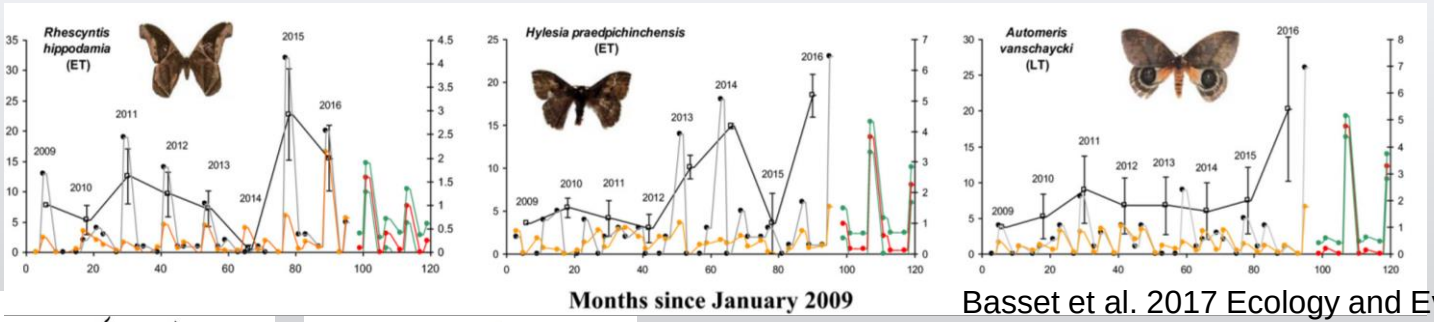
Occurrence for social insects

Mixed results

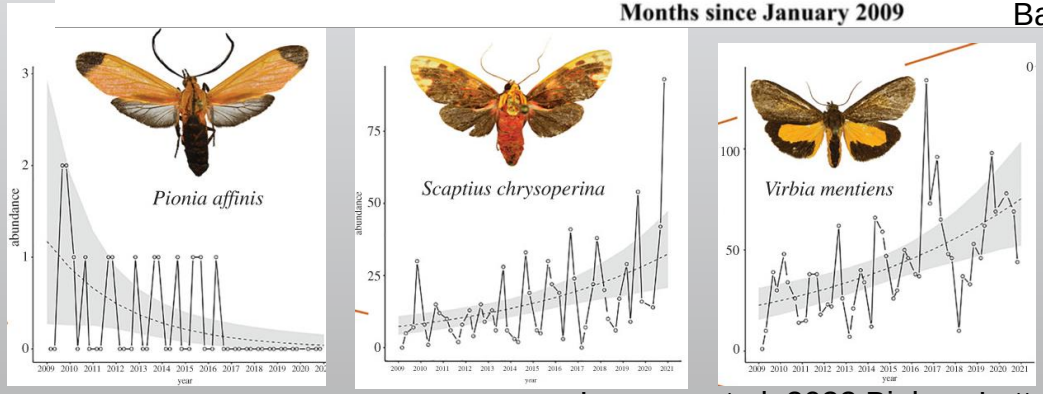
Resistant to climate change?

Other drivers more important?

Insect monitoring – what are we monitoring?



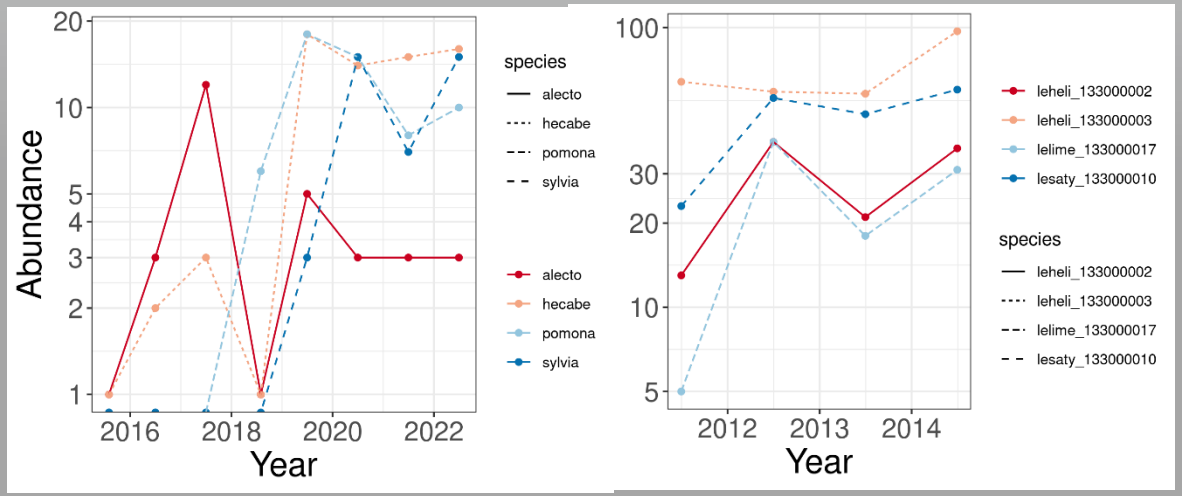
Basset et al. 2017 Ecology and Evolution



Lamarre et al. 2022 Biology Letters

- Some ecological patterns often manifest in overall abundance and common species
- But overall abundance is a coarse and common species occupy a small proportion of the total diversity

Butterfly monitoring data



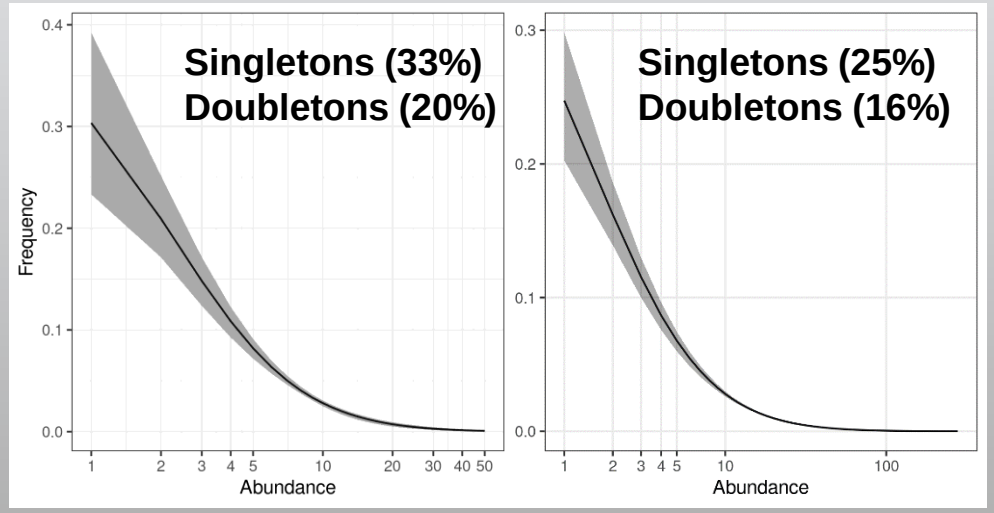
Xishuangbanna, China (2015-2022)

Khao Chong, Thailand (2011-2014)

Are we seeing what we are seeing?

- Monitoring samples are dominated by singletons and doubletons
- The proportions of rare species is highly variable among insect groups
- The nature of sampling methods may contribute to the presence of rare species?

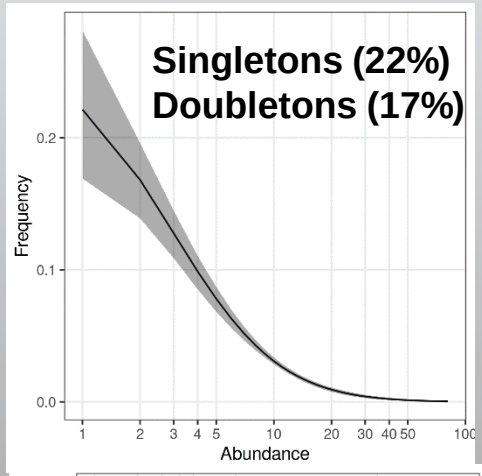
Butterflies

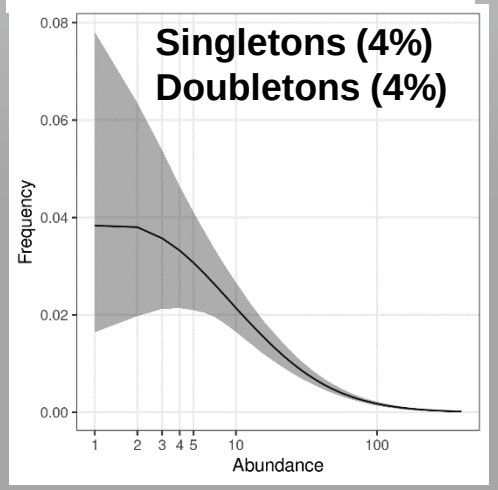


Xishuangbanna, China (2015-2022)

Khao Chong, Thailand (2011-2014)

Ants





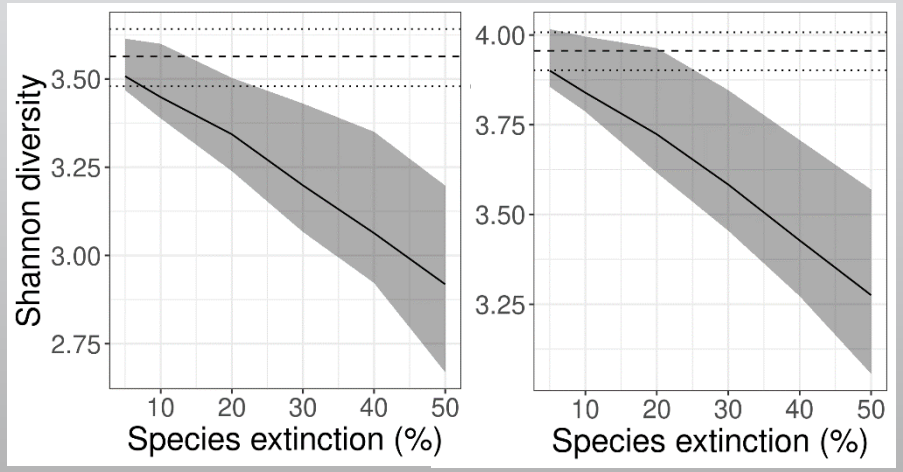
Termites

- Mismatched habitats/microhabitats?
- Mismatched phenology?
- Identification errors?
- Vagrants/"tourists"?

Can our insect monitoring detect the loss of biodiversity?

- Butterfly data from both China and Thailand suggest that we cannot detect the loss of biodiversity until we lose over 20% of the species

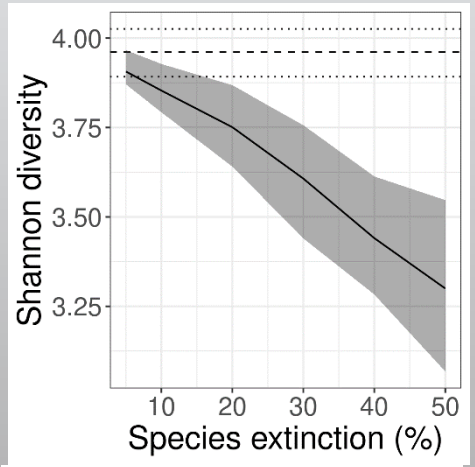
Butterflies

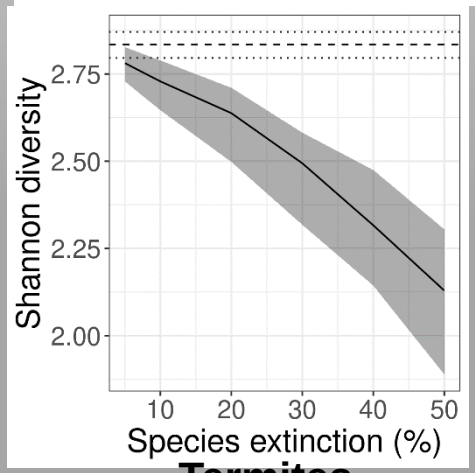


Xishuangbanna, China (2015-2022)

Khao Chong, Thailand (2011-2014)

Ants





Termites

- Ants - the loss of >10% of species may be detectable
- Termites – monitoring may detect changes as soon as a few species are lost

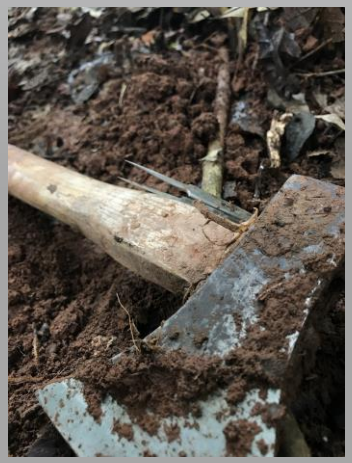
Can our insect monitoring detect the loss of biodiversity?

- The “detectability” of the changes in diversity varies across insect groups

- The nature of sampling may be the most important factor
  Butterflies: area-based **passive** sampling to capture mobile species
  Ants: area-based **passive** sampling to capture relatively less mobile species
  Termites: manual surveys targeting their colonies (dead woods)

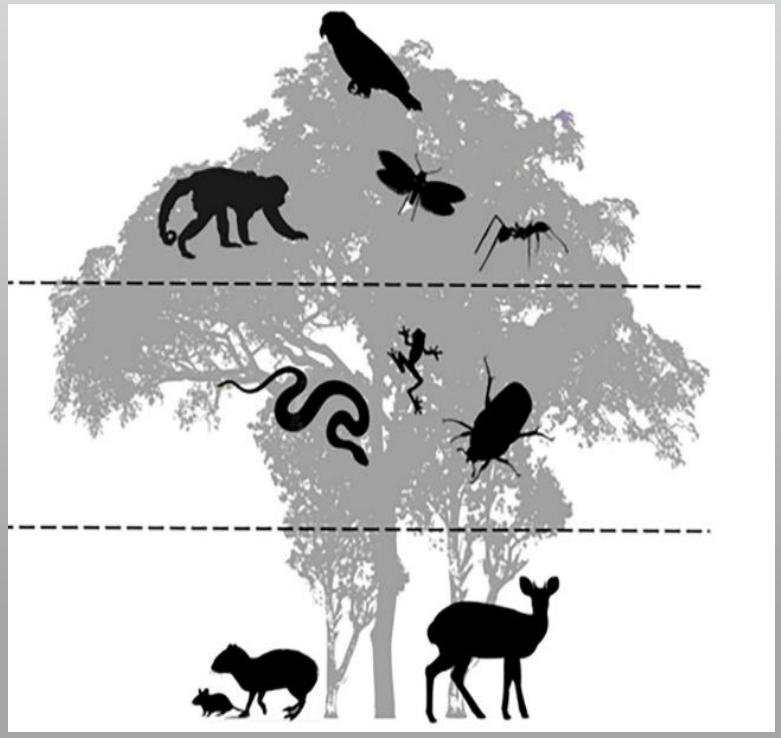
- Some target insects may not reflect their changes in the monitoring data






Vertical stratification in insect monitoring?

Nakamura et al., 2022



Gamez and Harris, 2022

1

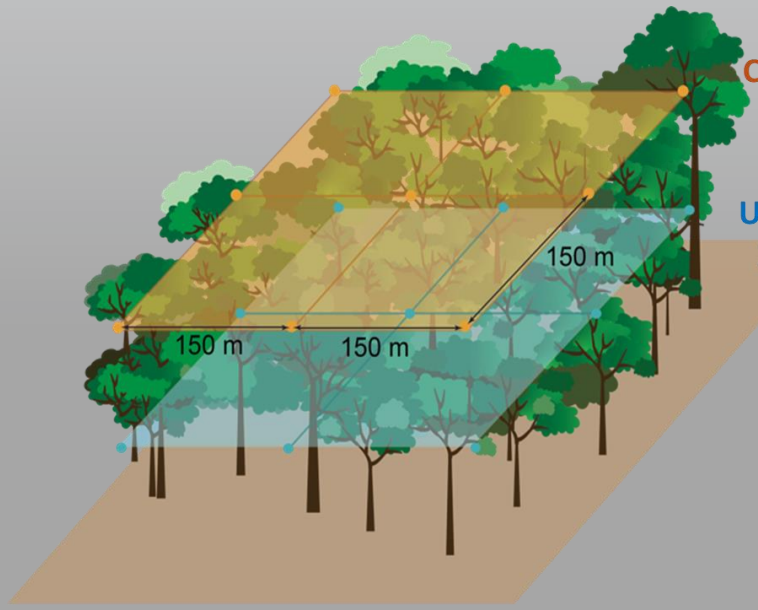
Vertical stratification across latitudes

Sampling methods (primary targets – flying insects)

SLAM trap

Light trap

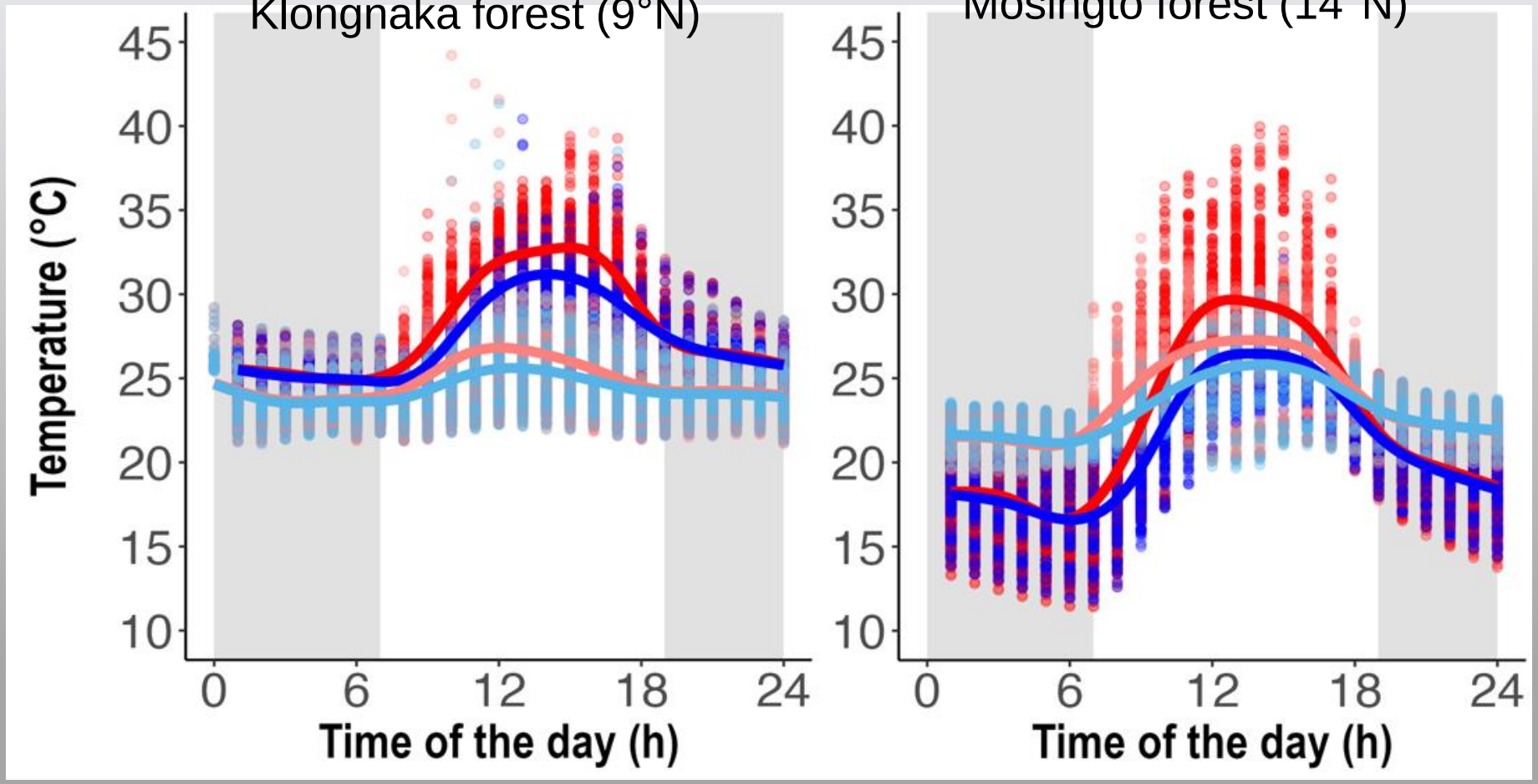
Yellow pan FIT



Canopy
12-30 m immediately below the canopy surface

Understory
2 m above the ground

Climate is more variable in the canopy during the day

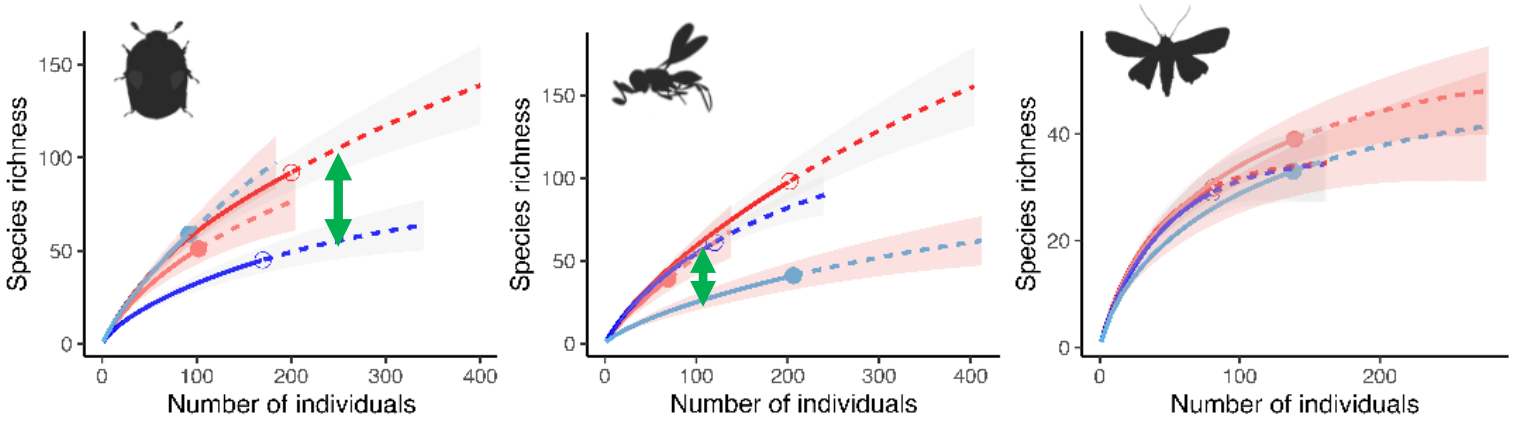


Similar gamma diversity between the canopy and understory

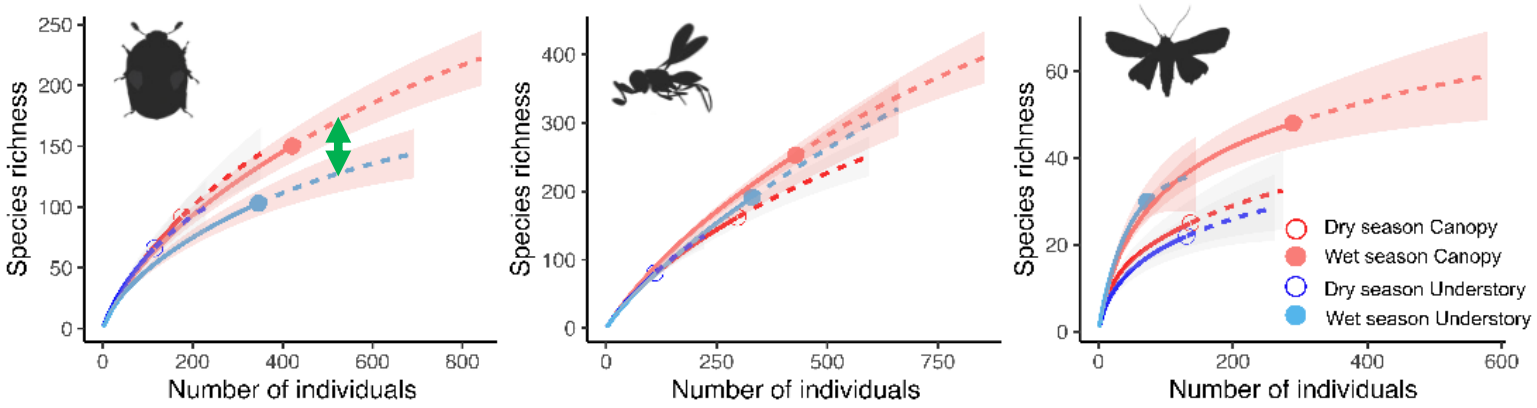
But when sig. differences were found, the canopy harboured greater diversity

Punthuwat et al. 2024 Integrative Cons

Klongnaka forest (9°N)



Mosingto forest (14°N)

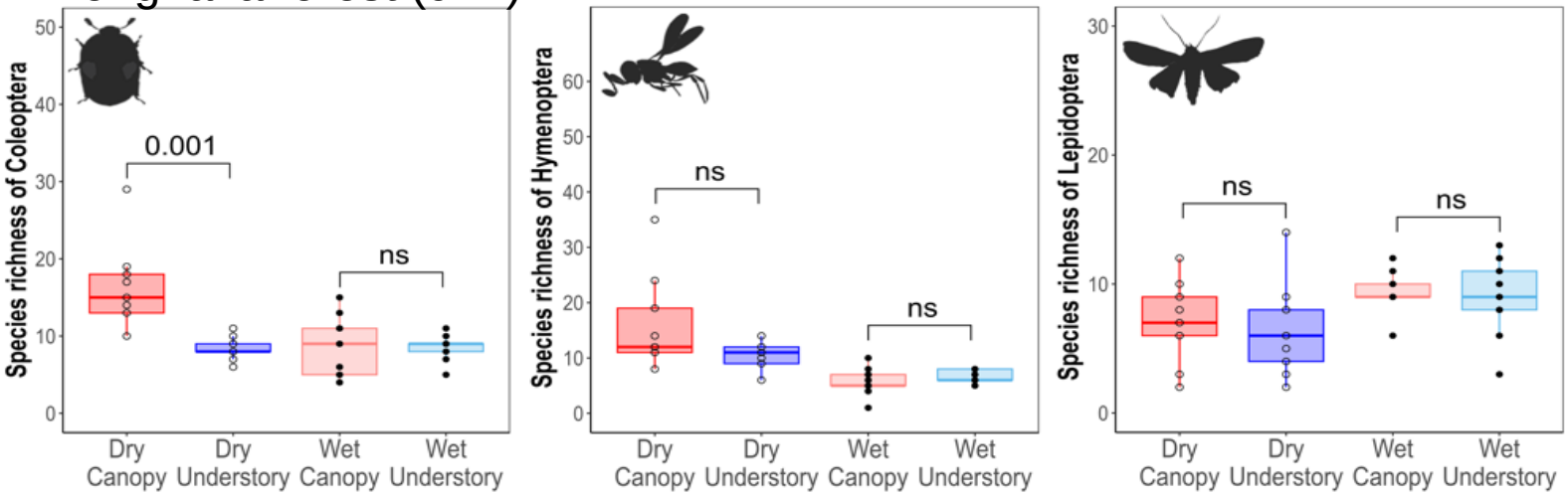


Similar alpha diversity between the canopy and understory

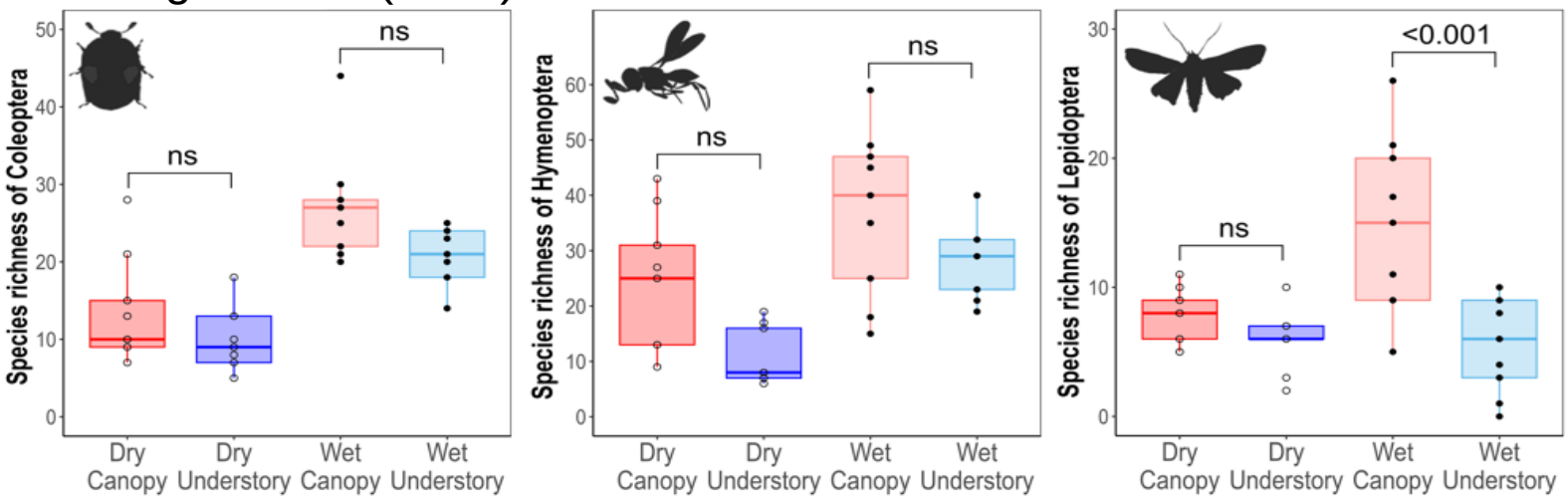
But when sig. differences were found, the canopy harboured greater diversity

Klongnaka forest (9°N)

Punthuwat et al. 2024 Integrative Cons

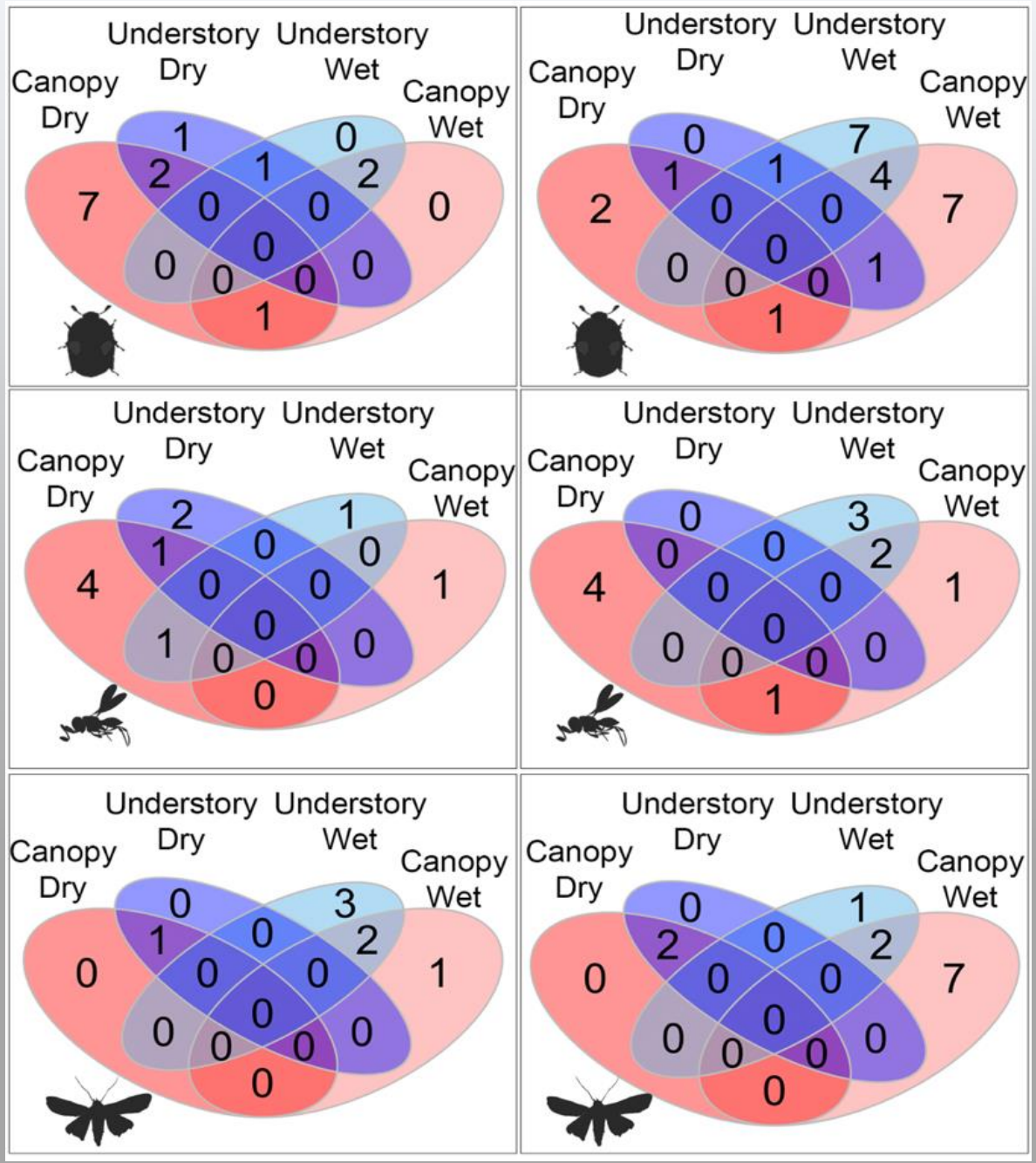


Mosingto forest (14°N)



Classical Indicator Value Protocol

Several species were restricted to the canopy or understory but they were also restricted to certain seasons



Punthuwat et al. unpublished

New technologies for hyper diverse insect monitoring

- Expansion of monitoring network (across latitude in SE Asia) means more work
- Traditional monitoring cannot handle numerous specimens and data
- New tech: DNA metabarcoding, bioacoustics, and automated visual monitoring with AI
- Enlarging taxonomic scope (more species)
- Increasing sampling frequency (diel activity patterns)
- Non-lethal protocols

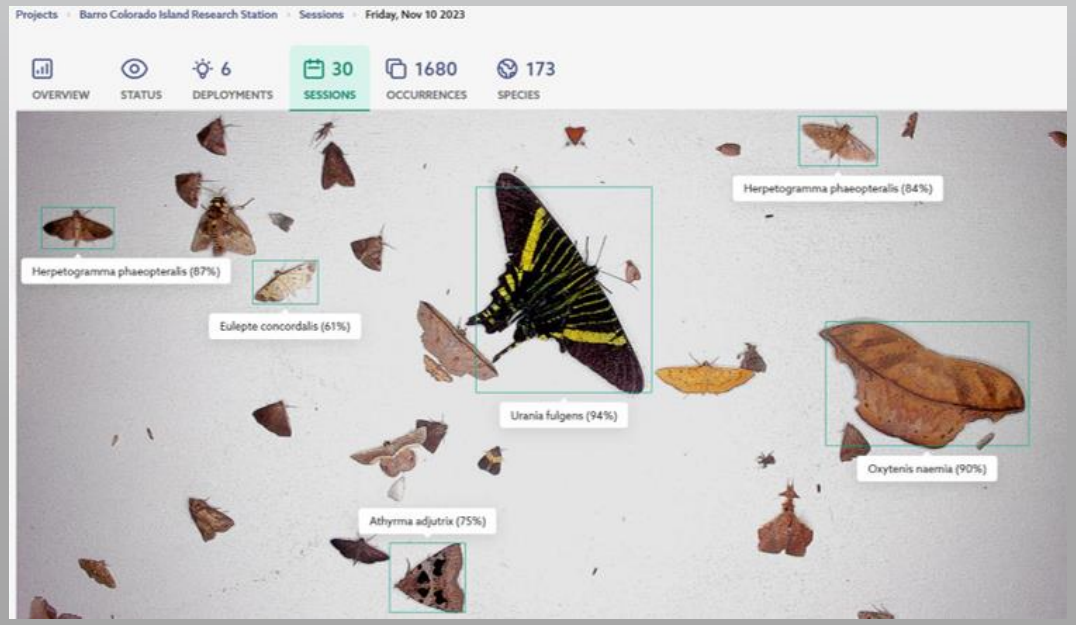
In collaboration with:

McGill

espace pour la vie montréal

UK Centre for Ecology & Hydrology

The Alan Turing Institute



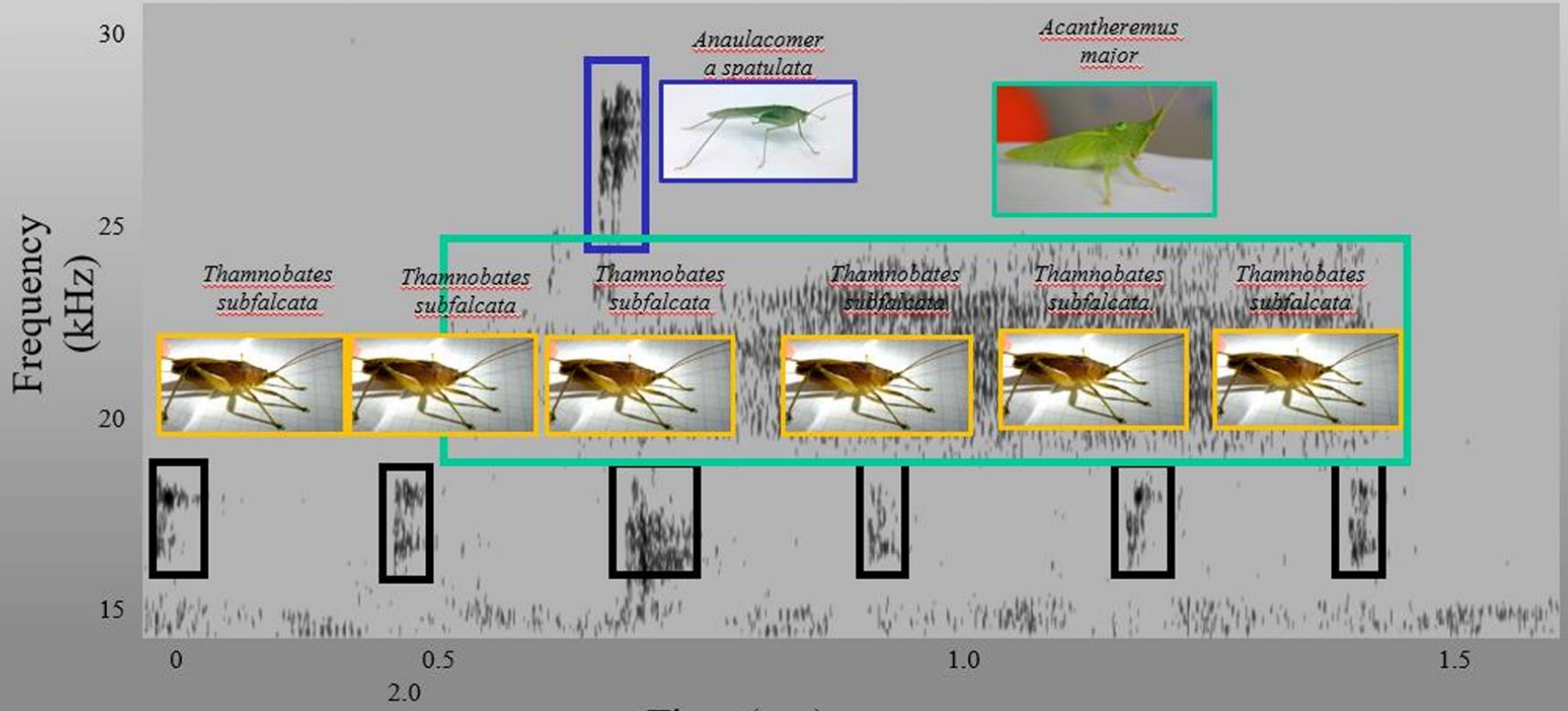
AI based Automated Monitoring of Insects (AMI)

Bioacoustics: non-lethal monitoring of sound-producing insects

2023 -

25 sound recorders:
1TB data generated each month

TheCornellLab of Ornithology



~8 kHz

Audio at 8.5% of original speed

BCI:

Katydids ✓

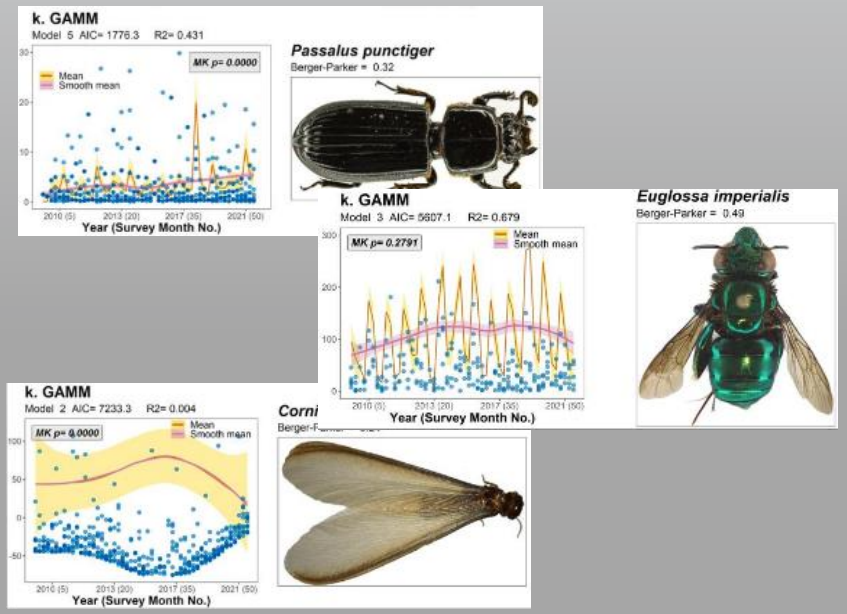
Cicadas –

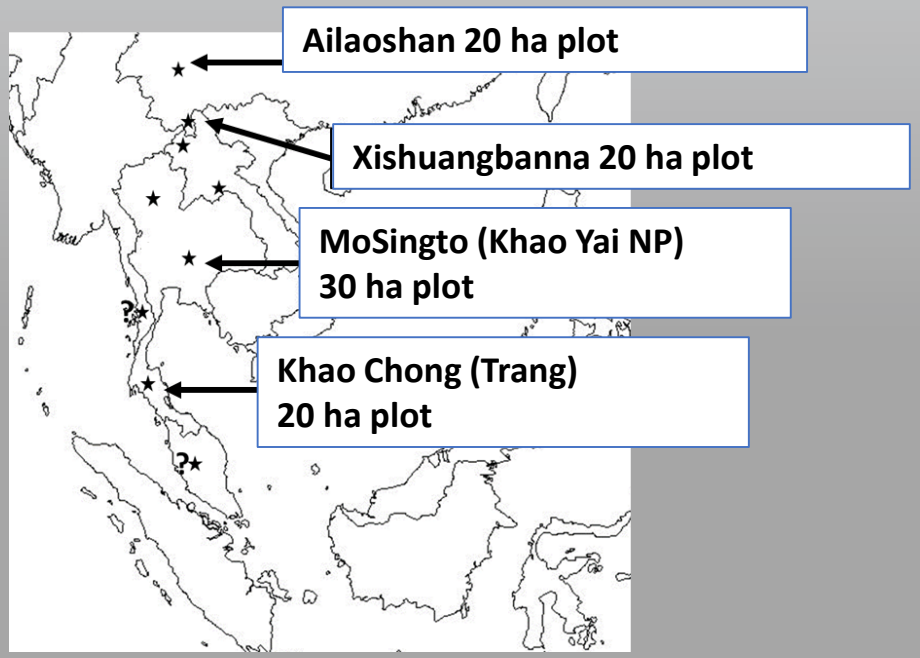
Crickets –

Grasshoppers –

Conclusion

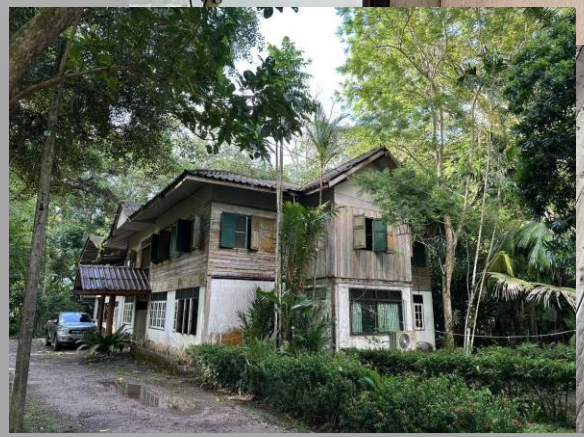
- Insect declines in response to climate change already happening in southern Thailand?
- Setting global standards for whole-forest insect monitoring in conjunction with next-generation tools
- Using insects as warning systems of climate change
- Real impacts on policy making
- Outreach and education to raise awareness of insect conservation and enhance citizen science in tropical Asia





A New Chapter for Khao Chong

- Smithsonian Tropical Research Institute ceased funding KCH insect monitoring in December 2023
- XTGB took over the KCH laboratory and continue monitoring from February 2024 in collaboration with MU
- Funding for 2024 and 2025 provided by XTBG and CAS
- The laboratory upgrading and maintenance finalized in Aug 2025
- New funding provided by Yunnan Provincial Government (2025-2028)



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- Chinese Academy of Sciences (CAS)
- National Natural Science Foundation of China (NSFT)
- Southeast Asian Biodiversity Research Institute (SEABRI-CAS)
- Xishuangbanna Tropical Botanical Garden (XTBG)

Our collaborators:

- Mahidol University
- Chulalongkorn University
- National Science Museum Thailand
- Queen Sirikit Botanic Garden
- Prince of Songkra University
- Kasetsart University
- Biotechnology and Ecology Institute, Laos