Ecology and Evolution of Tropical Troglobites: Management Implications

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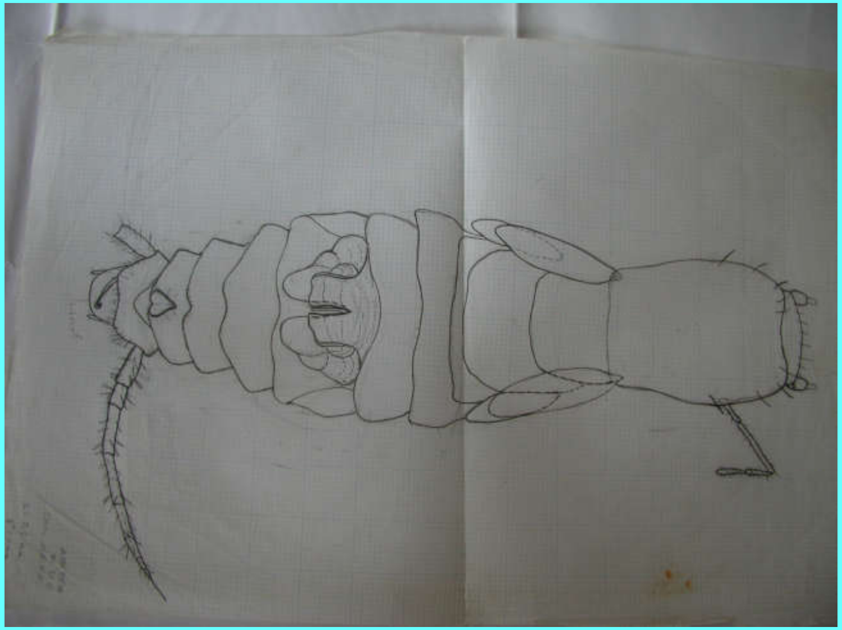
I. Tropical Troglobite Evolution and Ecology

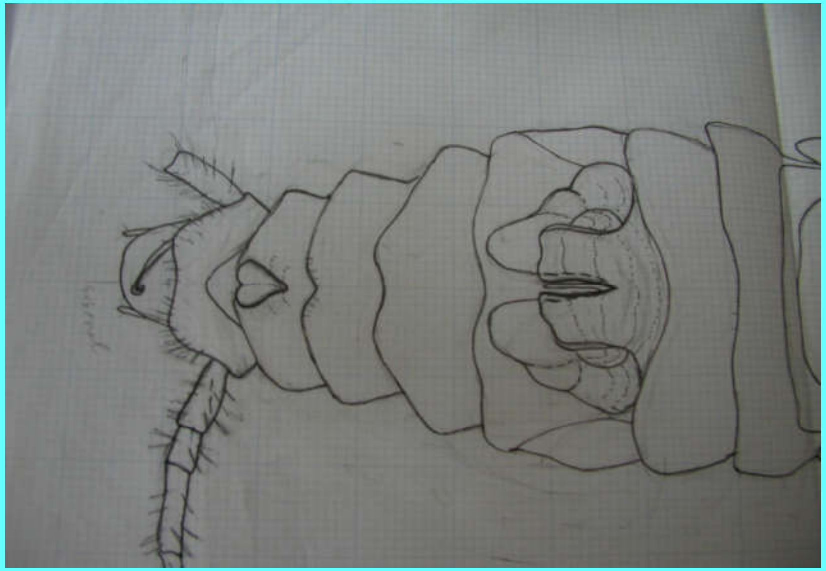
Current understanding: Troglomorphic species occur wherever caves have the essential habitat—high humidity, low air motion, and nutrient sources.

II. Management of Tropical Caves and Karst to preserve the special habitats

- **What do cave and karst managers need to know and do to prevent loss of tropical troglobite communities?**

What is it?



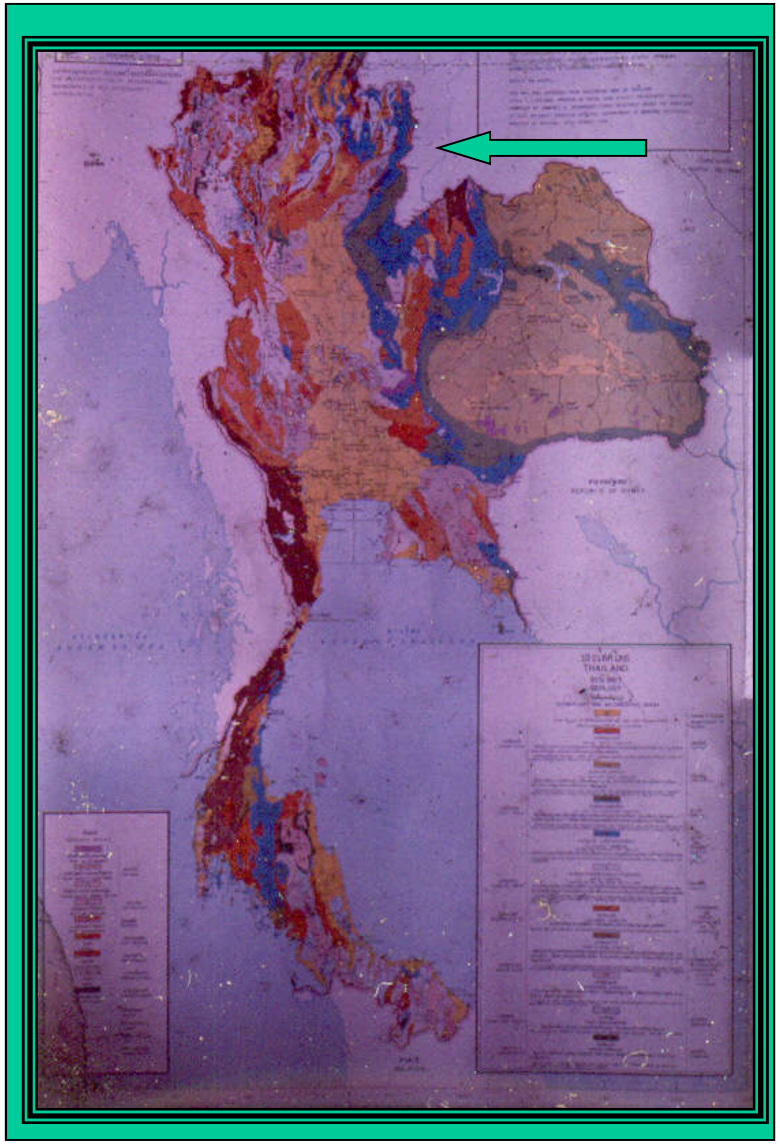


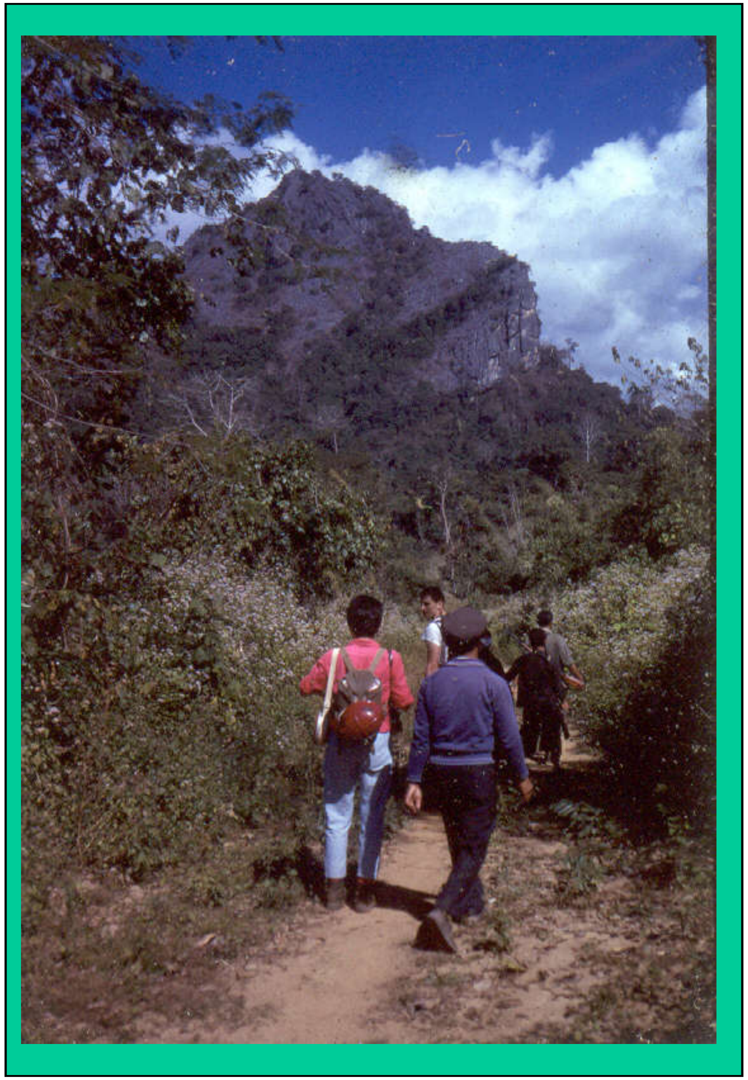
What is it?

Highly troglomorphic Nocticolid cockroach from high humidity/high CO_2 cave in northern Thailand

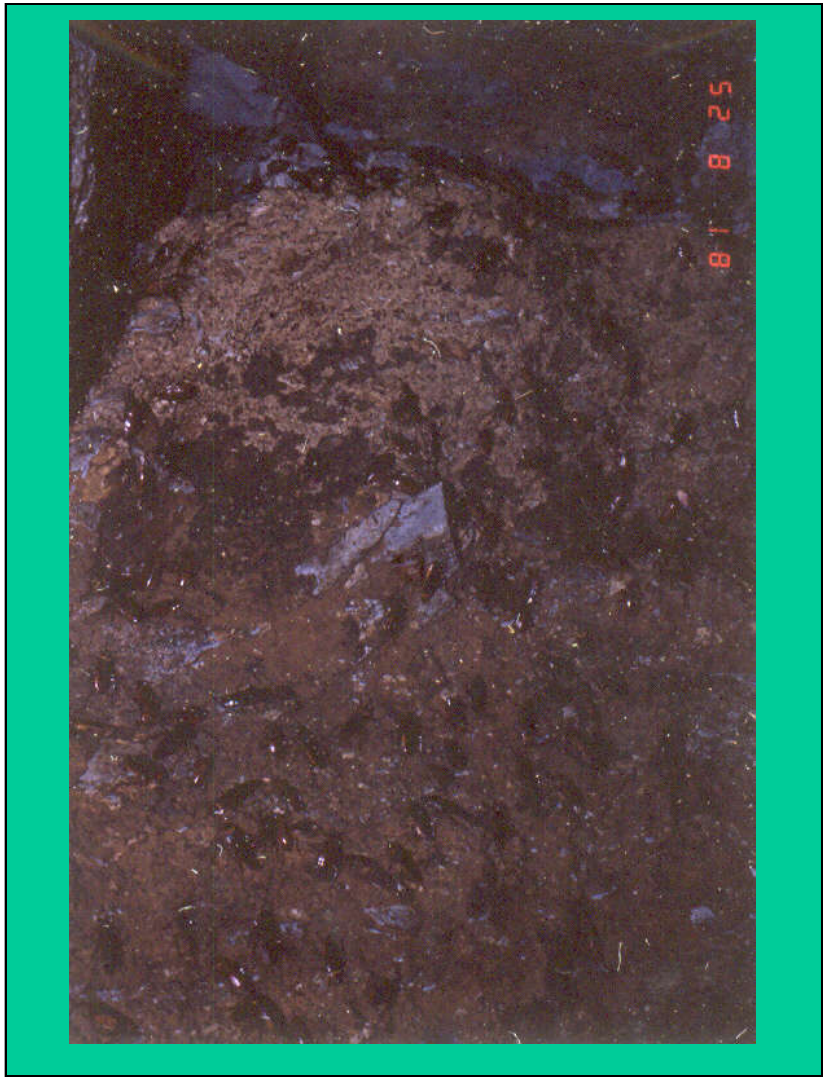
Temperate zone Troglobite

Glacial Relict theory: "No tropical troglobites"



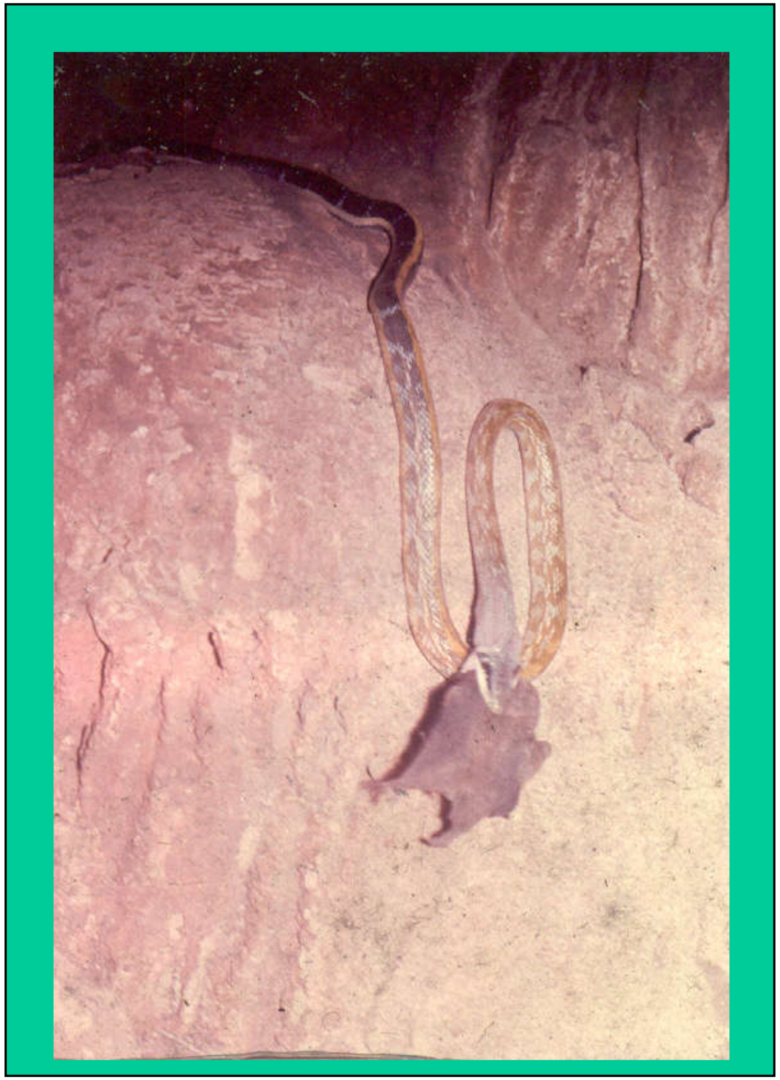


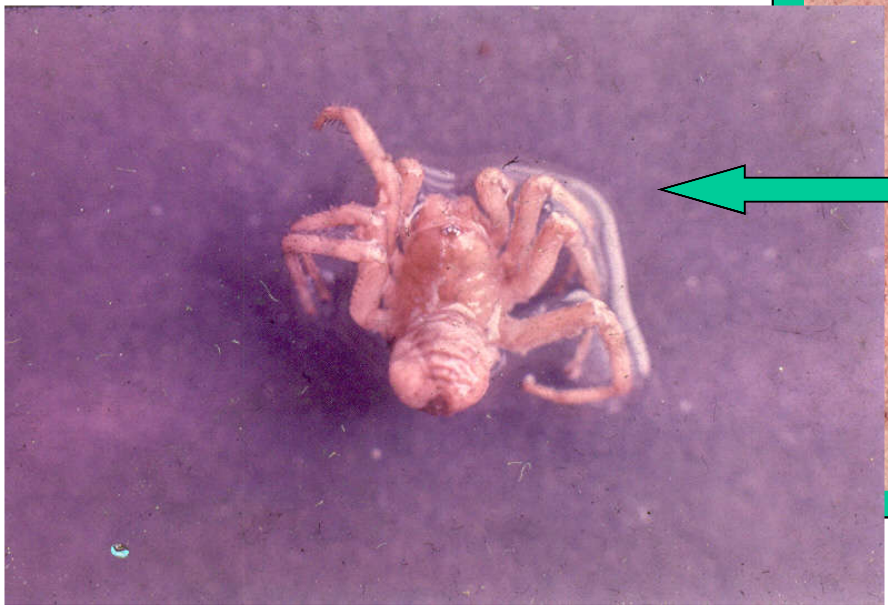
·*Search for troglobites in Southeast Asia: 1960`s & 1970`s*



Troglophiles: cockroaches on bat guano

Troglophile dining on trogloxene: rat snake & bat





Troglophile: Amblypygid with young

Troglophile:

Liphistius spider occurring in epigean and cave habitats

KAUAI
NIIHAU
OAHU
MOLOKAI
LANAI
MAUI
KAHOOLAWE
HAWAII
HONOLULU
Lihue
Kaunakakai
Lanai City
Wailuku
Hilo
Kaula Island
Lehua I.
Kilauea Pt.
Nohili Pt.
Pueo Pt.
Kawaihoa Pt.
Makahuena Pt.
Kaena Pt.
Barbers Pt.
Makapuu Pt.
Ilio Pt.
Laau Pt.
C. Halawa
Nakalele Pt.
Nanualele Pt.
Pohakueaea Pt.
Upolu Pt.
Keahole Pt.
C. Kumakahi
KaLae
KAUAI COUNTY
HONOLULU CITY AND COUNTY
MAUI COUNTY
HAWAII COUNTY
Kaulakahi Channel
Kauai Channel
Waho Shelf
Kaiwi Channel
Penguin Bank
Pailolo Channel
Auau Chan.
Kealaikahiki Chan.
Alenuihaha Channel
Ridge
FRACTURE ZONE
Molokai Fracture Zone
Hawaiian Arch
Hawaiian Deep
Tuscaloosa Seamount 8778
Dutton Seamount −8322
Clark Seamount −9504
Powers Seamount −11,070
Perret Seamount −7092
Indianapolis Seamount −10,608
Jaggar Seamount −5112
Ellis Seamount
−3228
Brigham Seamount −5448
Bishop Seamount −2436
Cross Seamount −1116
Washington Seamount 2952
McCall Seamount −2964
Palmer Seamount −6984
Day Seamount 7332
Dana Seamount-15,624
Apuupuu Seamount 5718
Loihi Seamount −4308
Papau Seamount −14,280
Hohonu Seamount −11,274
Green Seamount 12,762
Wini Seamount −4956
−18,150
−18,270
−4800
5243
1281
4020
4970
3370
10,023
13,796
13,677
160°
158°
156°
154°
22
20




Frank Howarth`s discovery in 1971 of troglobitic planthoppers in Hawaiian lava tubes, followed by over 50 other new troglobitic species, falsified the ``No Tropical Troglobite`` hypothesis.

- *Troglobites were reported from several other tropical areas, including Jamaica, Galapagos, Belgian Congo, Thailand, and Central America.*

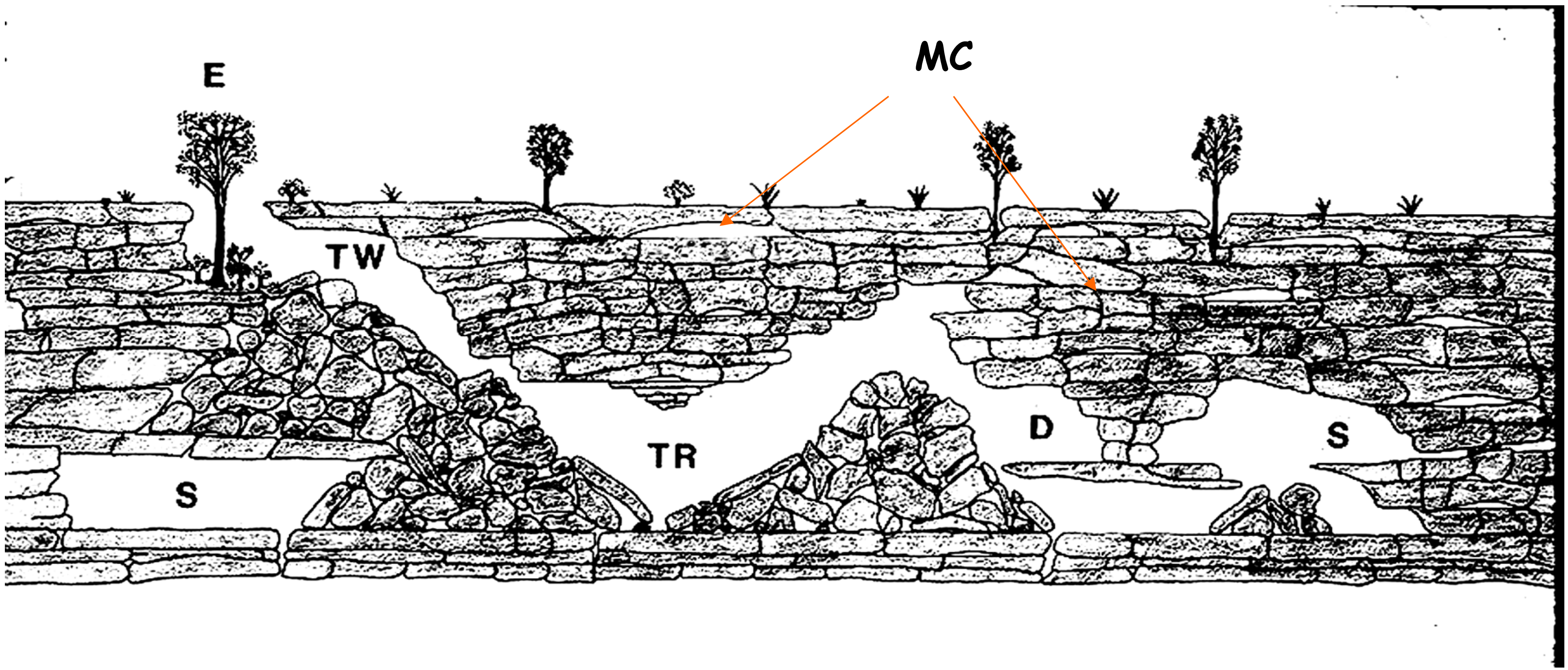
•**Howarth developed the bioclimatic model to explain the distribution of troglobites and the cause of their restricted habitat in tropical troglobites:**

•***Troglomorphic species are restricted to deep cave habitats at or near saturated humidity.***

•***The ``Tropical Winter Effect`` (cool, dessicating surface air flowing into caves each night) limits the suitable troglobite habitat to deep cave areas where the entrance effect is minimal or absent.***

CAVE ZONES

E = Entrance
TW = Twilight
TR = Transition
D = Deep Cave
S = Stagnant Air
MC = Mesocaverns



F.G. Howarth

Suitable cave morphology reduces the winter effect and allows water vapor to accumulate:

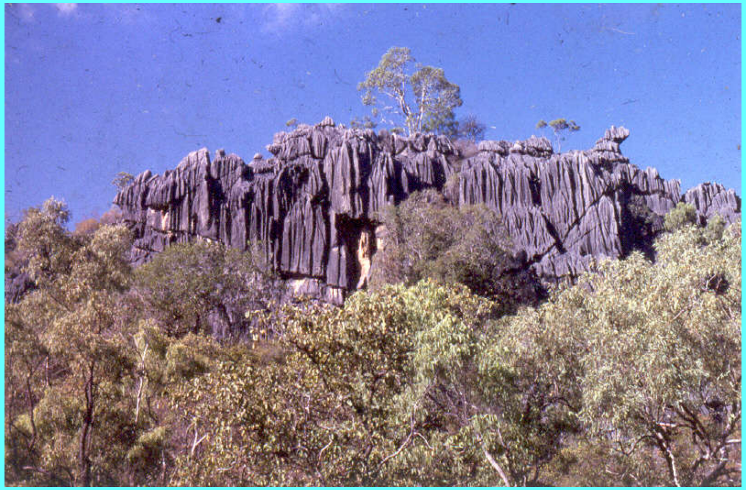
- *goose-neck passages*
- *upward sloping passages and closed domes or cupolas*
- *dead-end passages with reduced air flow*
- *rooms accessed from low crawl passages*
- *areas far from entrances*
- *mesocaverns: small spaces in the substrate have suitable conditions for troglobites*

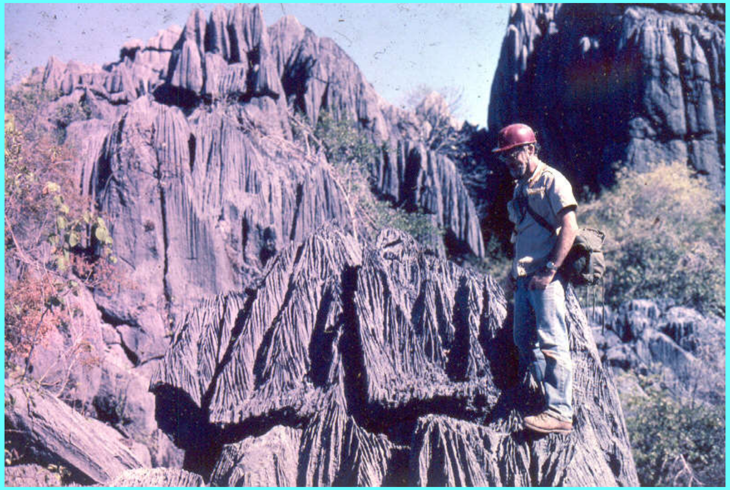
Mesocaverns greatly increase the underground area suitable for troglobites.

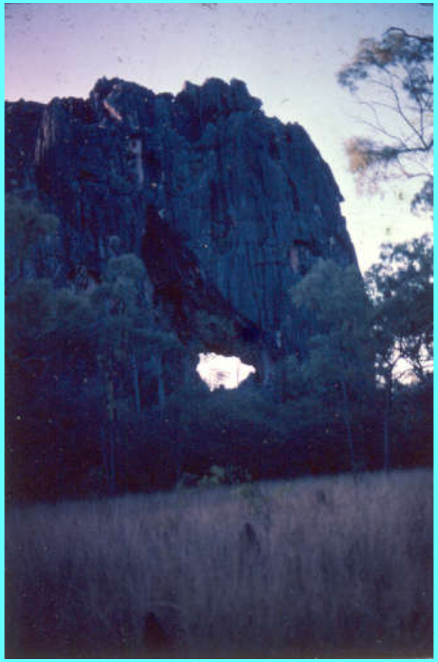
Location of tropical troglobite collections in Australia

Tropical Caves with Troglobites

Tropic of Capricorn



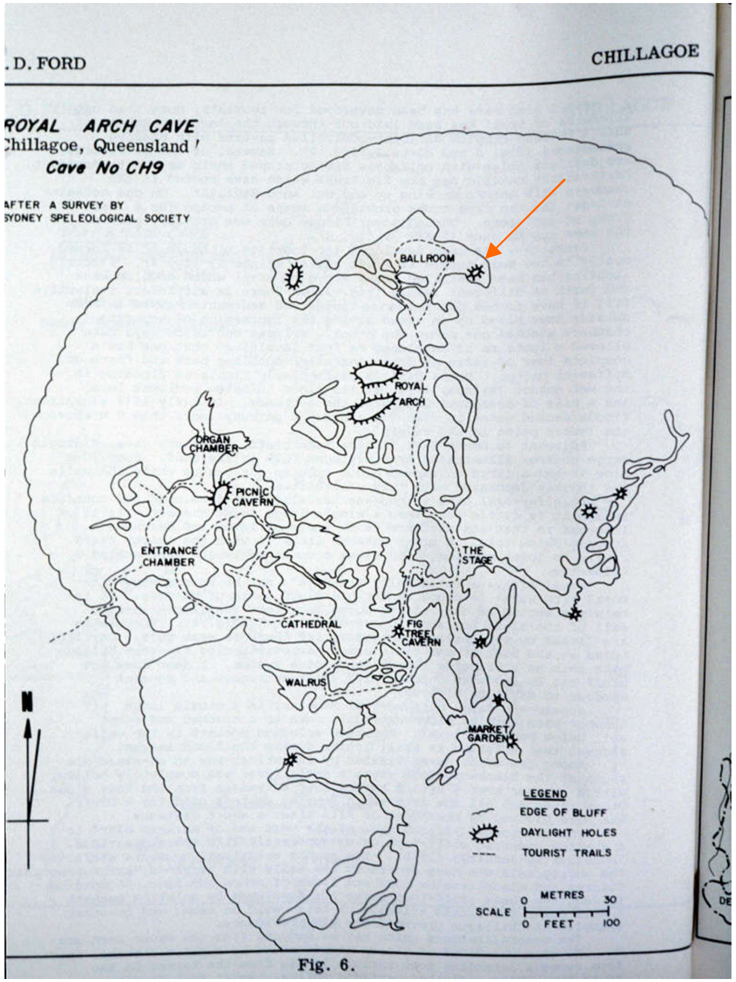


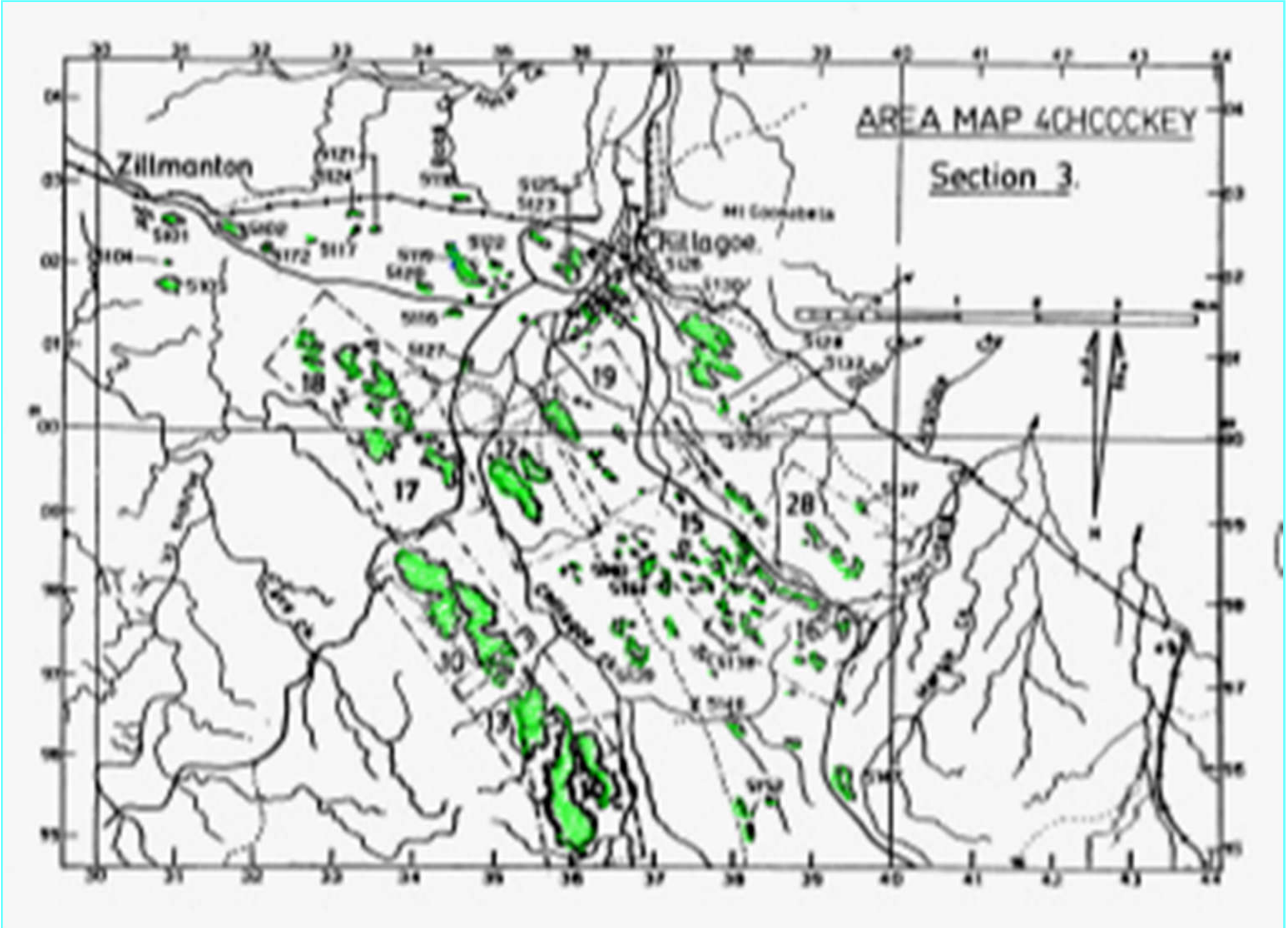


Chillagoe Tower Karst

Royal Arch Tower, Chillagoe

Map of Royal Arch Cave, Royal Arch Tower

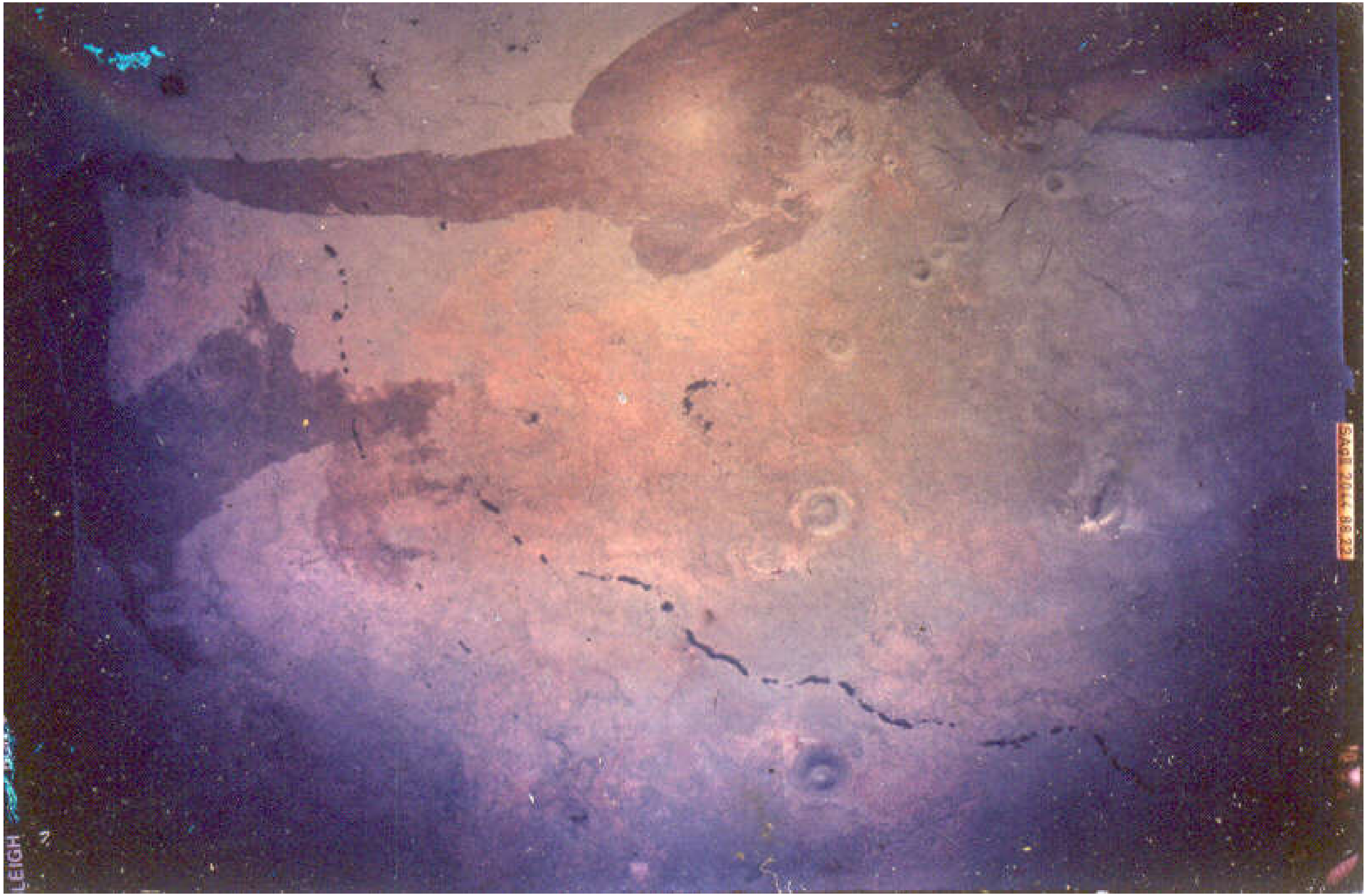




Karst towers south of Chillagoe

Chillagoe tower karst of northern Queensland is an ideal tropical continental karst area for troglobite evolution and biodiversity:

- *Numerous isolated karst towers spread over 200 kilometers*
- *Non-karst substrate between major groups of karst towers*
- *Abundant caves with tree roots*
- *Large and small caves: humid areas are present and troglobites occur*



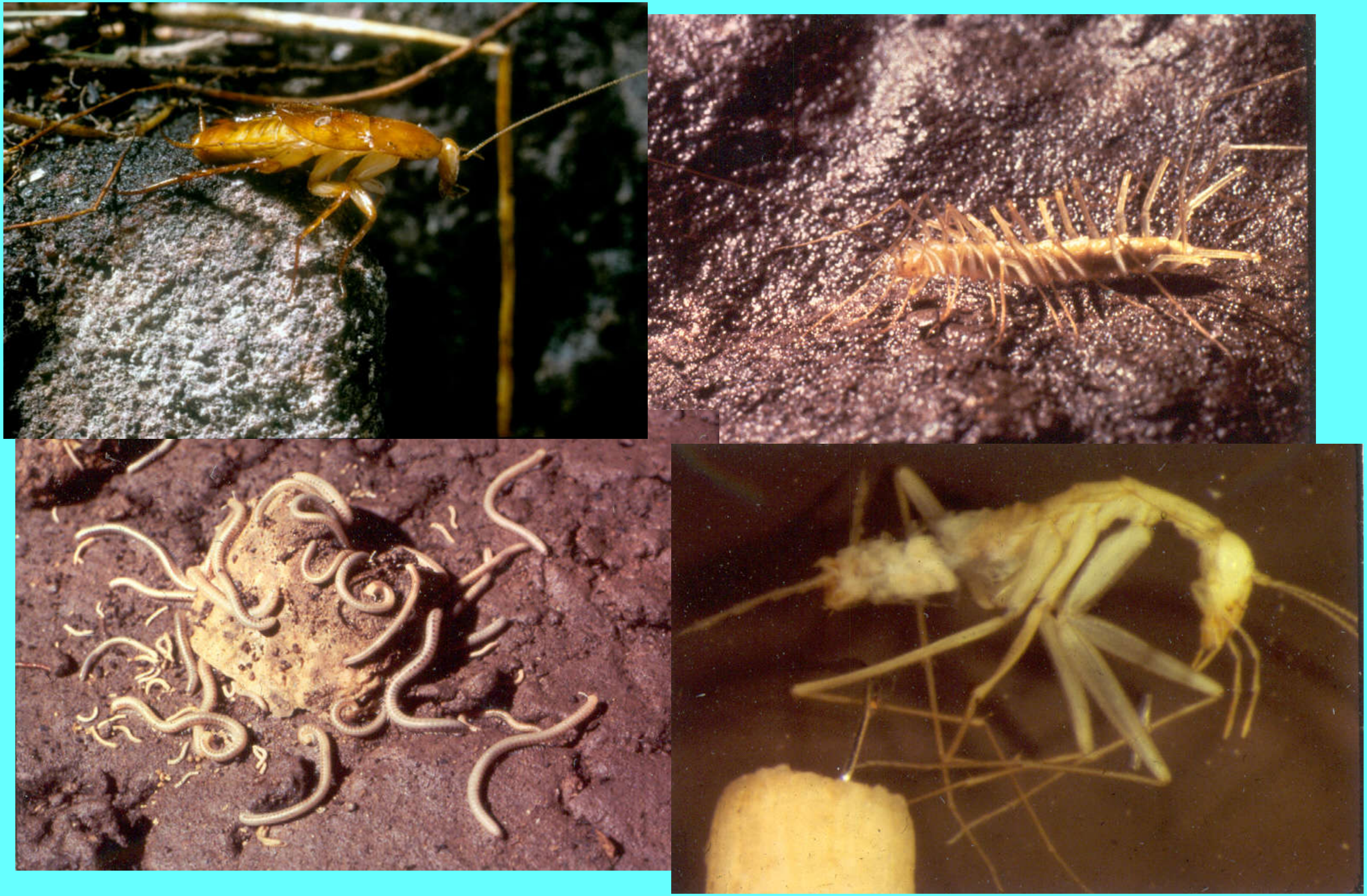
UNDARA LAVA FLOW
QUEENSLAND, AUSTRALIA

Dark Passage before Duckunder, Bayliss Cave

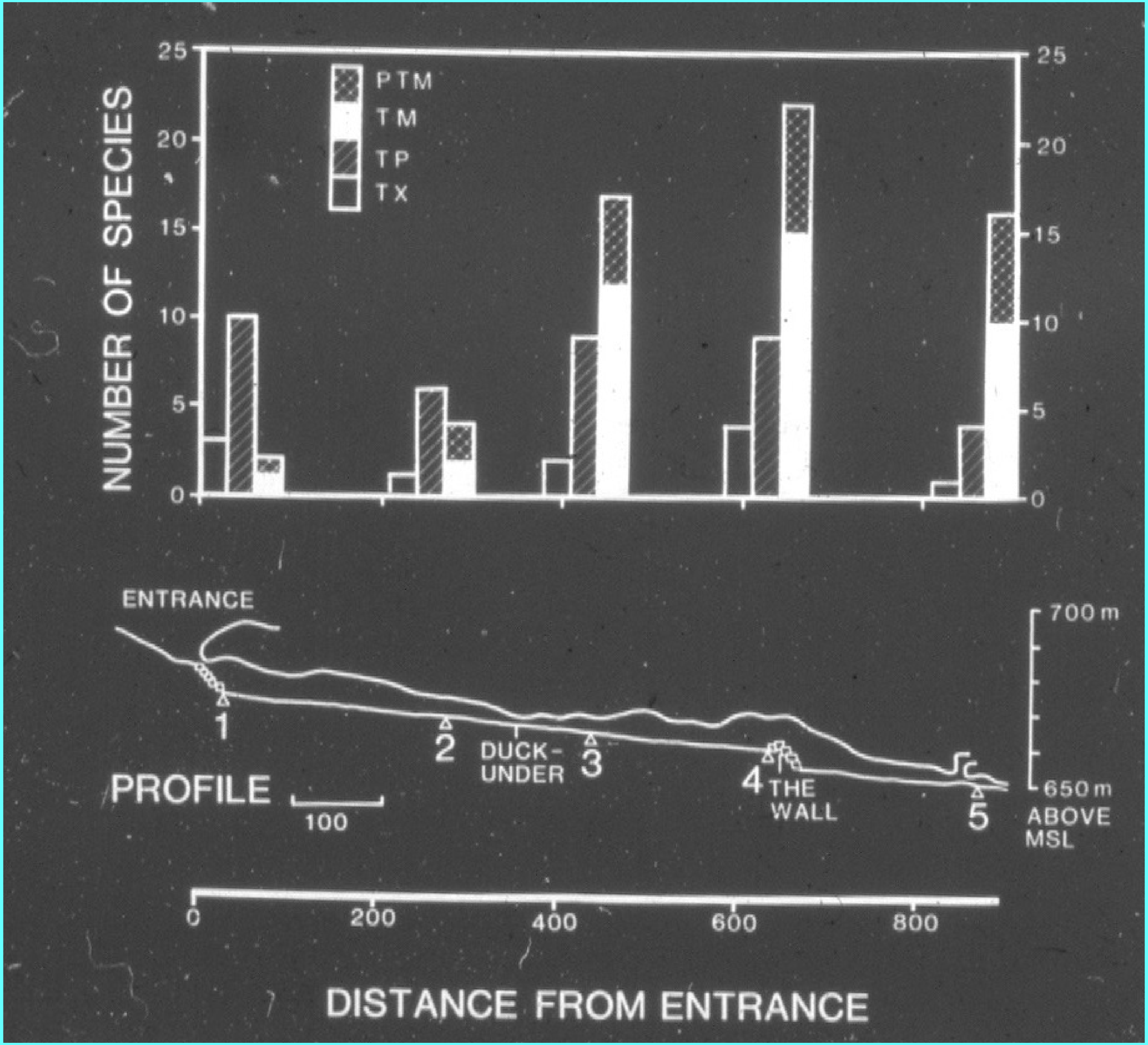
Dark Passage beyond Duckunder, Bayliss Cave

Dark Passage top of Wall, Bayliss Cave

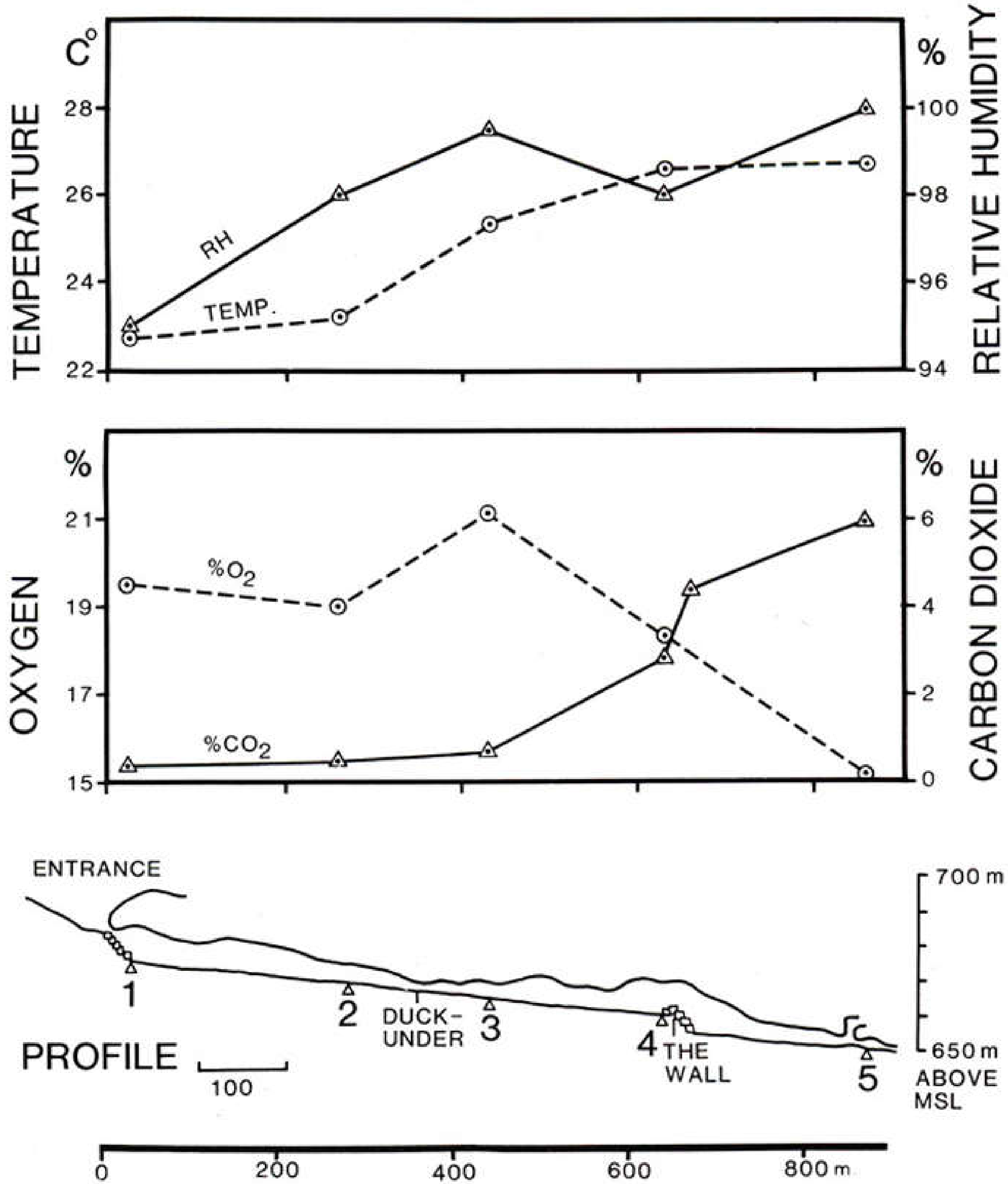
Blind Cave Cixiid Planthopper *(Solonaima baylissa*), Bayliss Cave



Bayliss Lava Tube Troglobites


NUMBER OF SPECIES
25
20
15
10
5
0
PTM
TM
TP
TX
ENTRANCE
1
2
DUCK-
UNDER
3
4
THE
WALL
5
PROFILE
100
700 m
650 m
ABOVE
MSL
0
200
400
600
800
DISTANCE FROM ENTRANCE

Temperature,
Relative Humidity,
Oxygen and
Carbon Dioxide
Profiles in
Bayliss Cave
14-15 June 1985

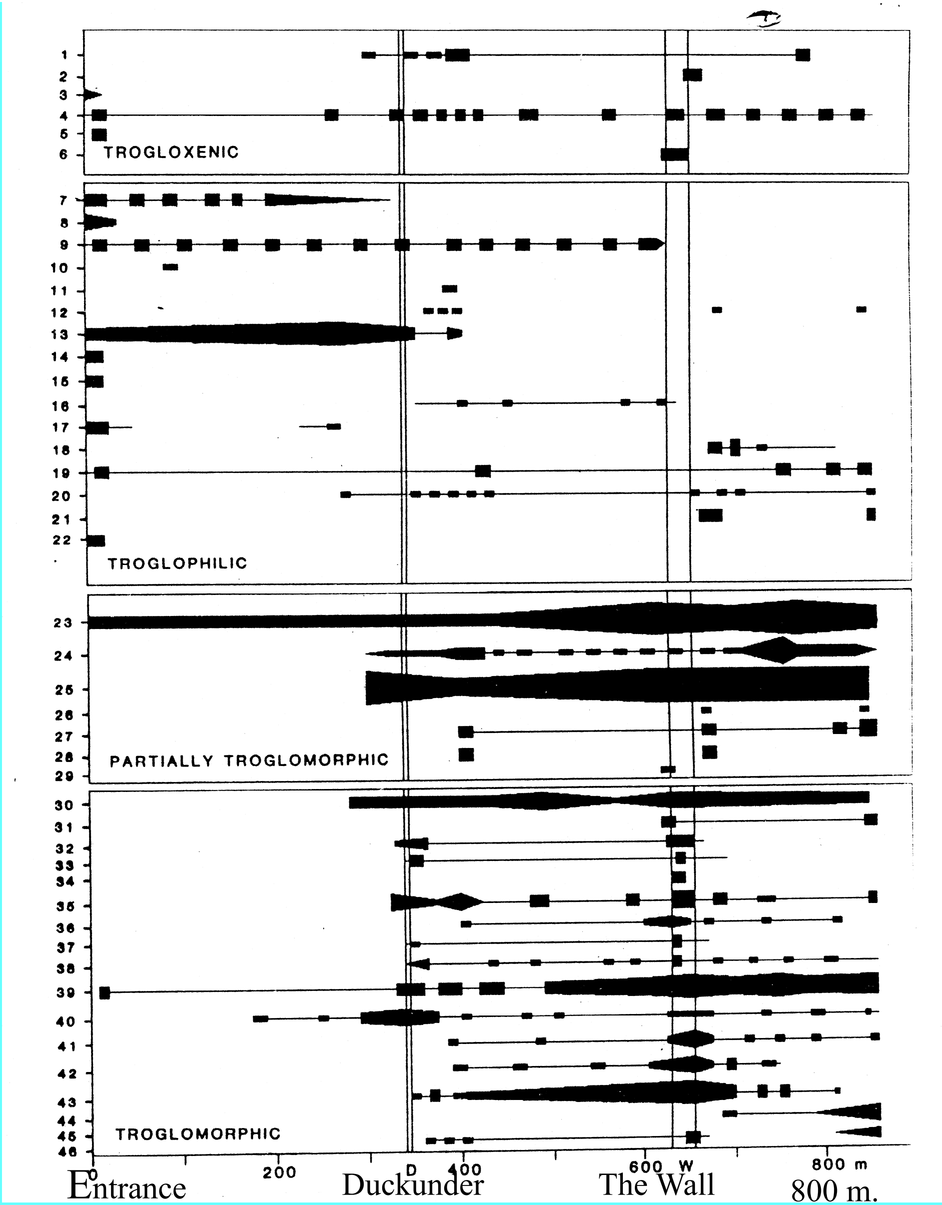


TROGLOXENIC

TROGLOPHILIC

PARTIALLY TROGLOMORPHIC

TROGLOMORPHIC

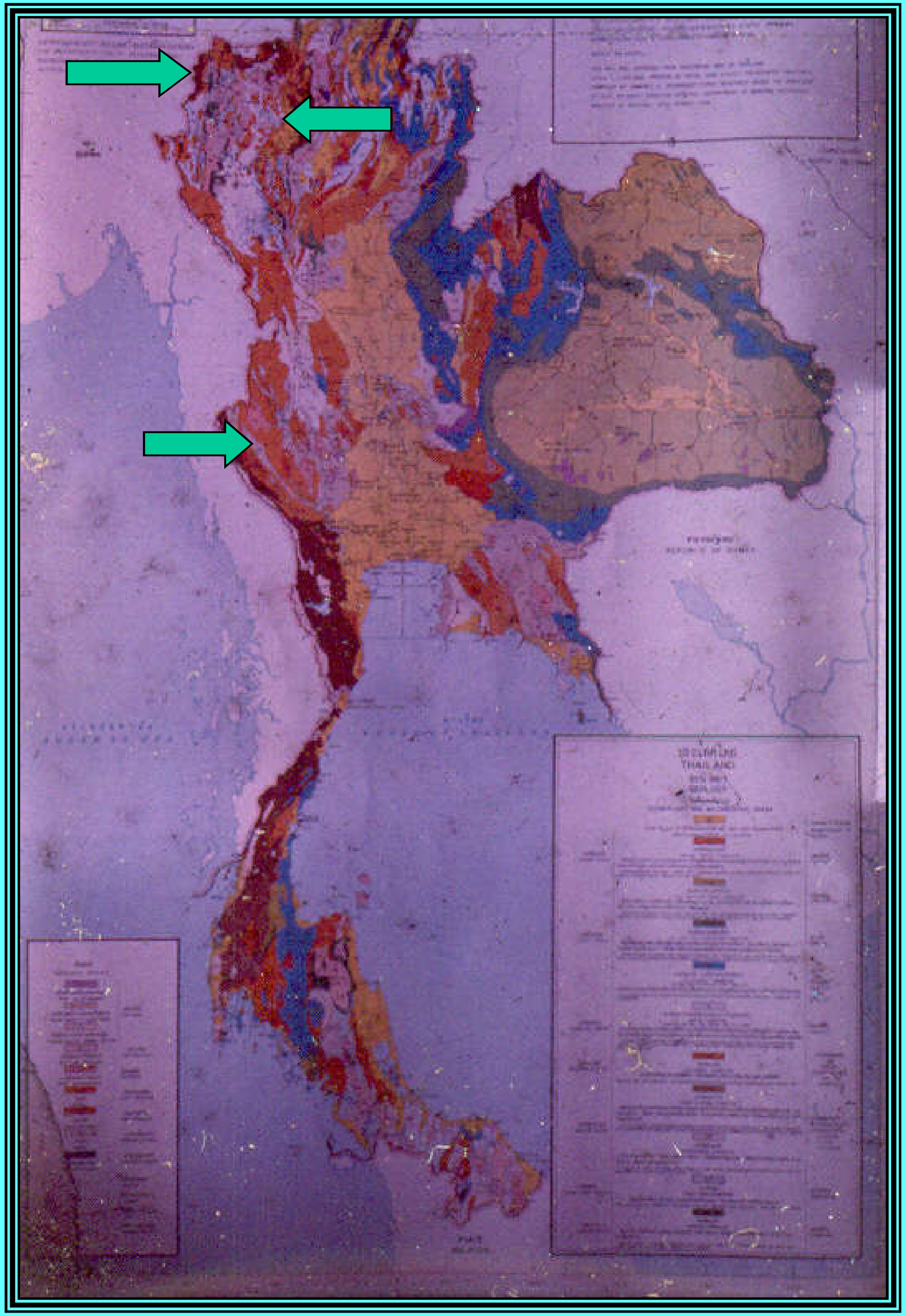


Bayliss Cave Species:

Distance from Entrance

Undara Lava Caves are an important site for tropical troglobite biodiversity:

- *Undara lava flow is one of the longest on Earth*
- *It contains large, open lava tubes and lava tubes with restricted entrances: Bayliss Lava Tube is large but it has a crawlway entrance*
- *With over 25 highly troglomorphic species, Bayliss exhibits one of the highest biodiversities of any tropical cave*



Return to Thailand, 1986:

French expeditions recorded caves with high CO_2 in North Thailand.

With Louis DeHarveng, I visited those caves and we found highly troglomorphic species in most of them.

This is confirmation that the results in Bayliss Lava Tube are not an exception.

Highly troglomorphic Nocticola from Mae Hong Sorn Province, North Thailand

II. Management of Tropical Caves and Karst with Specialized Troglobite Ecosystems

A. Survey of species, habitats and ecosystems

B. Determine the threats and develop a management plan

Surface Management

Subsurface Management

A. Survey of species, habitats and ecosystems

1. Locate the areas with essential conditions:

High humidity

Low air motion

Nutrient sources; roots, guano

2. Survey and describe the species present

3. Characterize the ecosystems

4. Communicate and coordinate with managers and administrators

Surface Alteration & Management

1. Vegetation: Removal of native vegetation by cutting and burning

   Management: Restoration of native ecosystems

2. Cultivation and grazing

   Management: Protect areas over caves by purchase or improved agricultural practices

3. Erosion and sedimentation

   Management: Implement conservation practices to reduce erosion and prevent increased sedimentation in caves


Naracoorte Caves National Park

Surface Alteration & Management

4. **Surface water modification:** Drainage, impoundment, change of stream channels

   Management: Restore natural drainage systems where possible

5. **Quarrying:** Removal of cave, open entrances

   Management: Restoration of entrances to original state

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Subsurface Alteration & Management

1. Alteration of cave entrances and passages: Changes the cave microclimate

   Management: Restoration to original condition to the extent possible

2. Modification of groundwater level:

   Raising or lowering water table changes the cave moisture levels and the aquatic communities

   Management: Long-term and large areas involved

3. Pollution

   - Human and animal waste, fertilizer, pesticides

     Management: Improved treatment and disposal practices

Subsurface Alteration & Management

4. Change in trogloxene populations: Bats, swiftlets, crickets, snakes, lizards

Changes nutrient input for cave species

Management: Determine causes of population change, develop and implement plans for reversing changes.

5. Introduced species

- **Rats, cane toads, cockroaches, millipedes: competitors or predators of cave species**

Management: Trapping/baiting where necessary

CANE TOAD

Many people assisted with my study of Australian troglobites including:

- ***Ramsar for the invitation to speak and IGCP448, Dr. Yuan Daoxian and***
- ***Dr. Elery Hamilton-Smith for making it possible to attend this meeting***
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- Anne and Verne Atkinson at Undara
- The Collins brothers who allowed access to lava tubes on Spring Creek and Emu Plains stations
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