Endemic Hawaiian Bark Lice:
Diverse, Abundant, and Undiscovered

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Why are there so many species on Hawaii?

NASA imaging

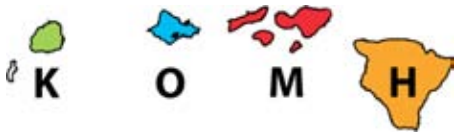
Hawaii's Endemic Species

GOALS:

Count & describe species

Document geographic distributions

Observe natural history & ecological interactions



Hawaii's Endemic Species

GOALS:

Count & describe species

Document geographic distributions

Observe natural history & ecological interactions

→ Conserve species by identifying diversity hotspots & habitats

→ Draw conclusions about the evolutionary history of species

Hawaii's Endemic Species

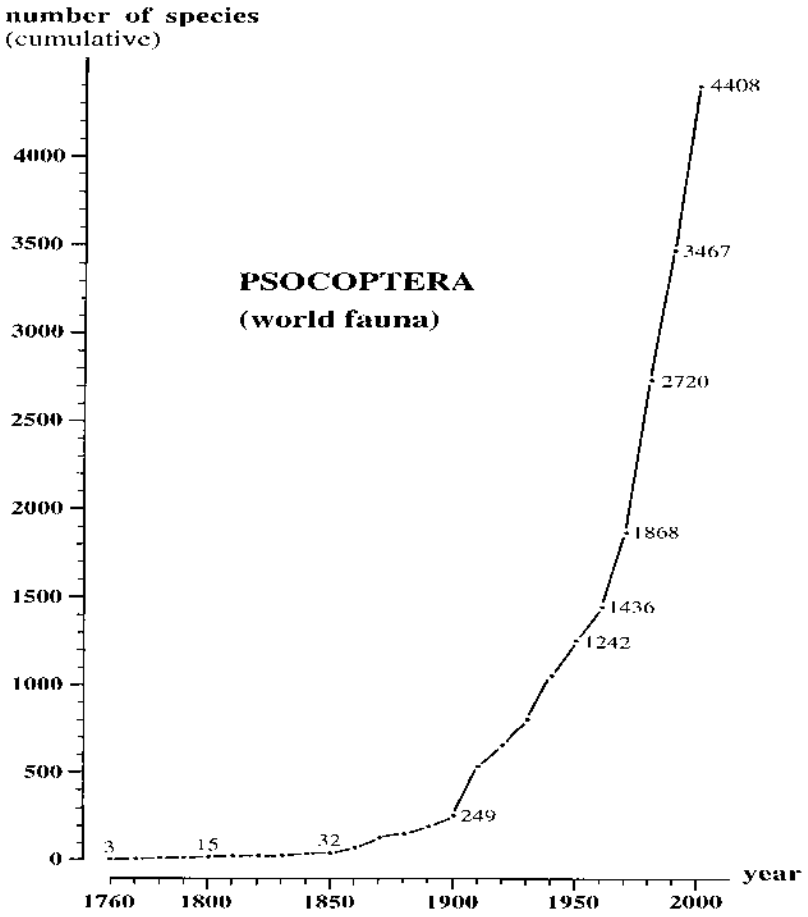
	Endemic spp.	Single-island endemics
Drosophila flies Kaneshiro et al. 1995	~700	97%
Platynini beetles Cryan et al. 2001	128	96%
Tetragnatha spiders Gillespie et al. 1997	60	100%
Laupala crickets Shaw 2002	37	100%
Megalagrion damselflies Jordan et al. 2003	23	65%

Order Psocoptera

- Hemipteroid insects
- ~5000 described species worldwide
- Fungivores or Detritivores:

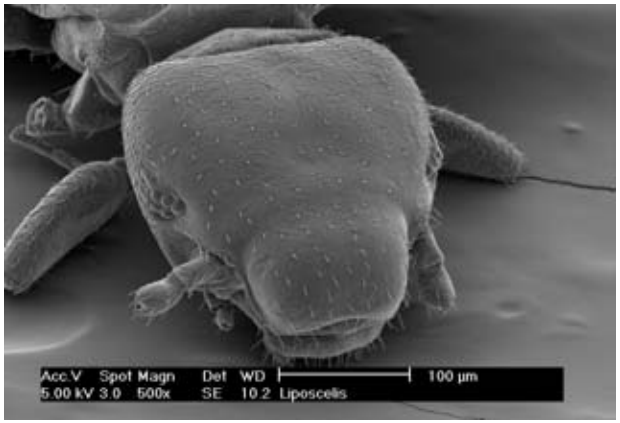
  Eat fungus & algae from plant surface and plant detritus

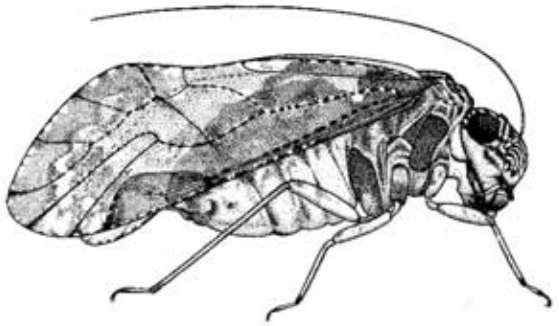
Discovery of species diversity



Lienhard & Smithers 2002

Psocids are pso pretty.



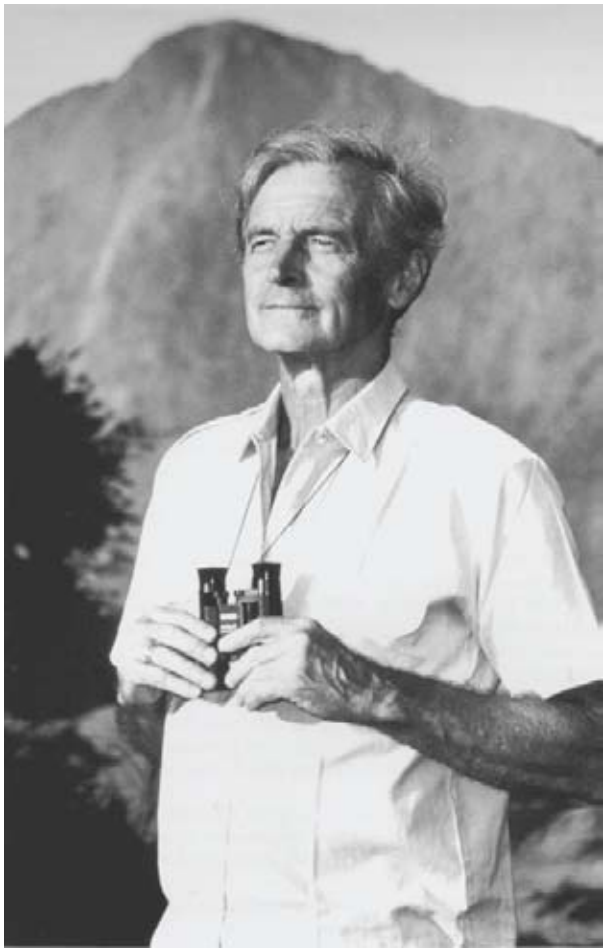


Bark Lice in Hawaii

I.W.B. Thornton (1926-2002)

Collected over 9800 psocid specimens in Hawaii.

Described majority of Hawaiian psocid species.



Bark Lice in Hawaii

- 2 endemic genera of Elipsocidae:
  - *Palistreptus:* 20 species
  - *Kilauella:* 7 spp. described, 100's undescribed
- 1 genus of Psocidae:
  - ***Ptycta:*** 61 spp. Hawaiian endemics
  - ~170 spp. Worldwide
- Non-native bark lice: 20 genera, 50 species

Bark Lice in Hawaii

Ecological roles:

1. Primary consumers of fungus, algae, and lichen

2. Recyclers of dead plant material

3. FOOD FOR BIRDS

Studying Hawaiian Bark Lice

1. Collections & locality data
2. Morphological study
3. DNA extraction & sequencing
4. Molecular phylogenetics: build species trees
5. Describe a bunch of new species

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1. Collections & locality data
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5. Describe a bunch of new species
6. **Think deep thoughts… what can bark lice can tell us about how evolution works?**

Collecting: Where do *Ptycta* live?

Forests above 1000 ft.

Koa or O'hia dominant

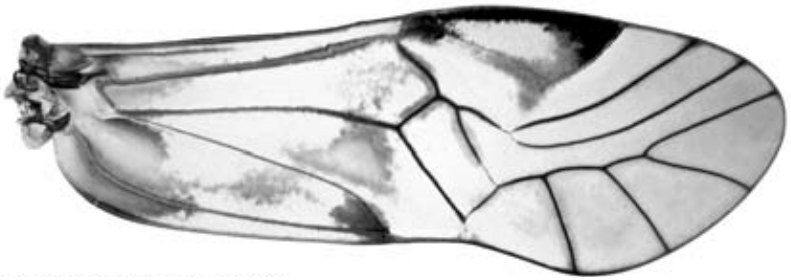
Mesic to damp

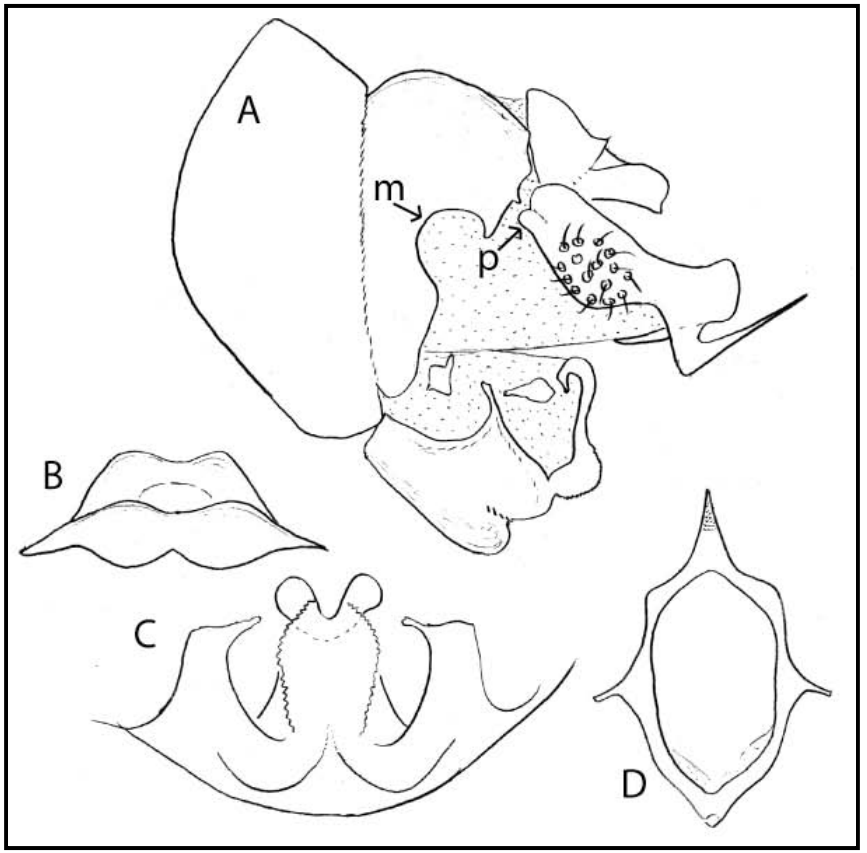
Trees & shrubs

with fungus or lichen on bark & leaves

And wherever else they feel like it!

METHODS
Morphological Study





METHODS

Phylogenetic Relationships

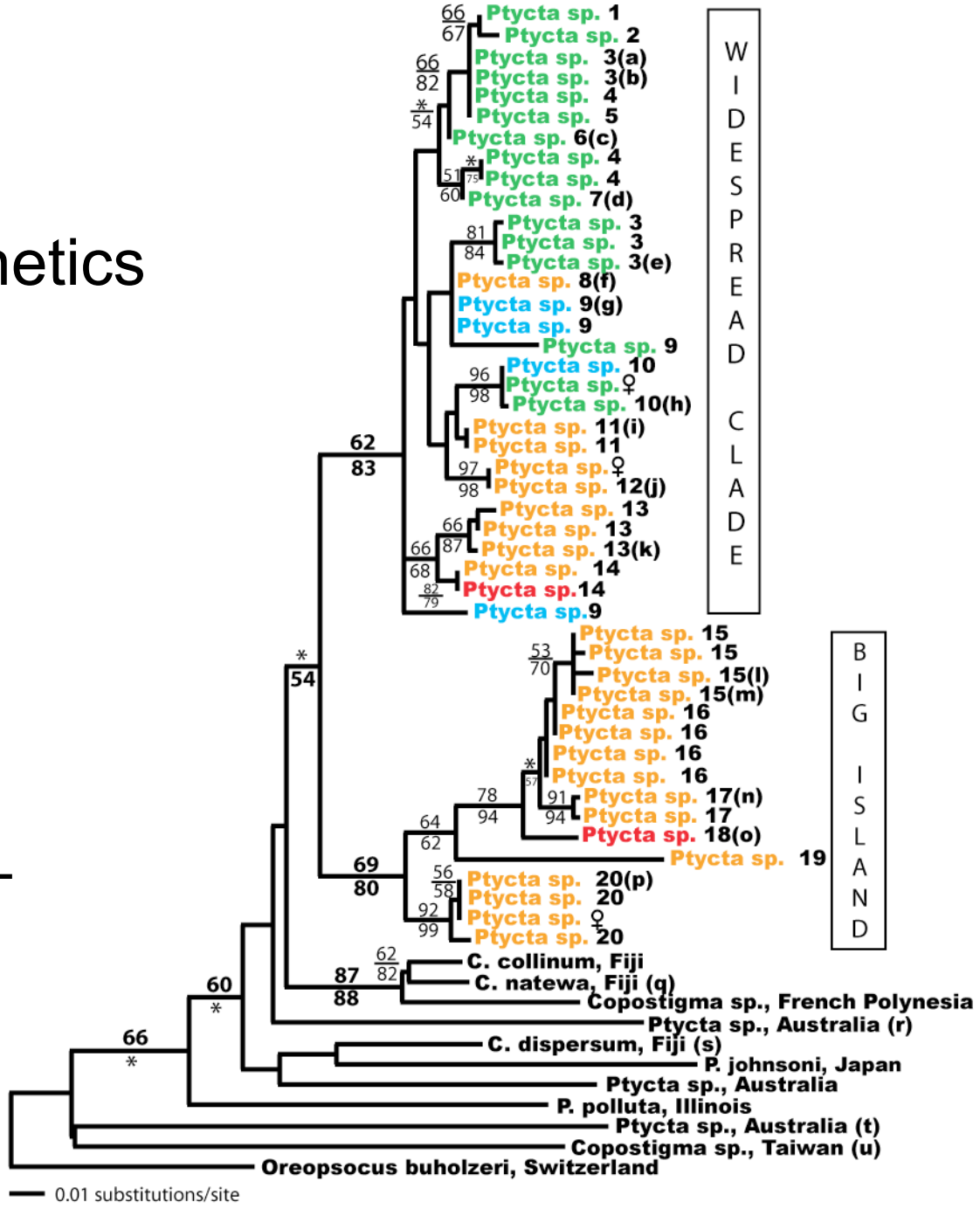
- Morphology: matrix of ~70 characters
- Mitochondrial genes: **12S**, 16S, COI, ND5
- Nuclear genes: **wingless**, Ef1α

- Outgroups: *Ptycta* from outside Hawaii and closely related genera

RESULTS

Molecular phylogenetics

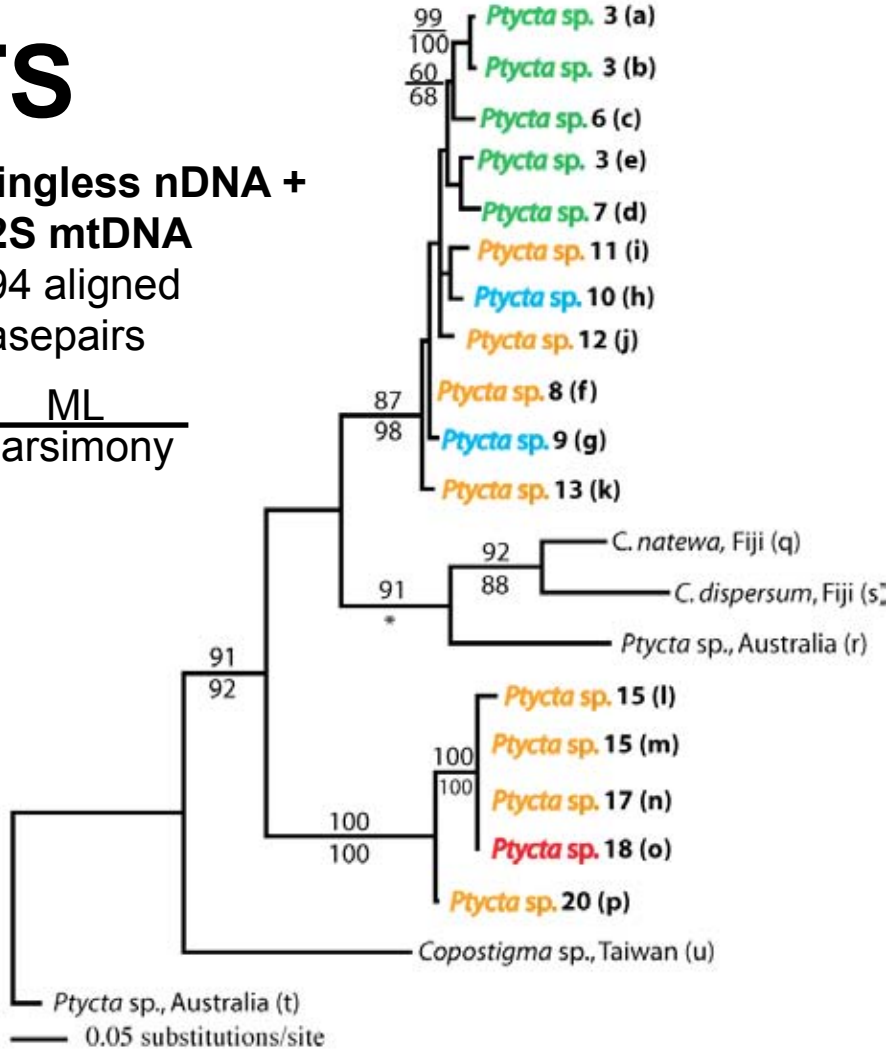
12S mtDNA
373 aligned basepairs
ML tree (GTR+I+G)
Bootstrap values: ML / parsimony



RESULTS

wingless nDNA +
12S mtDNA
694 aligned
basepairs

ML
parsimony



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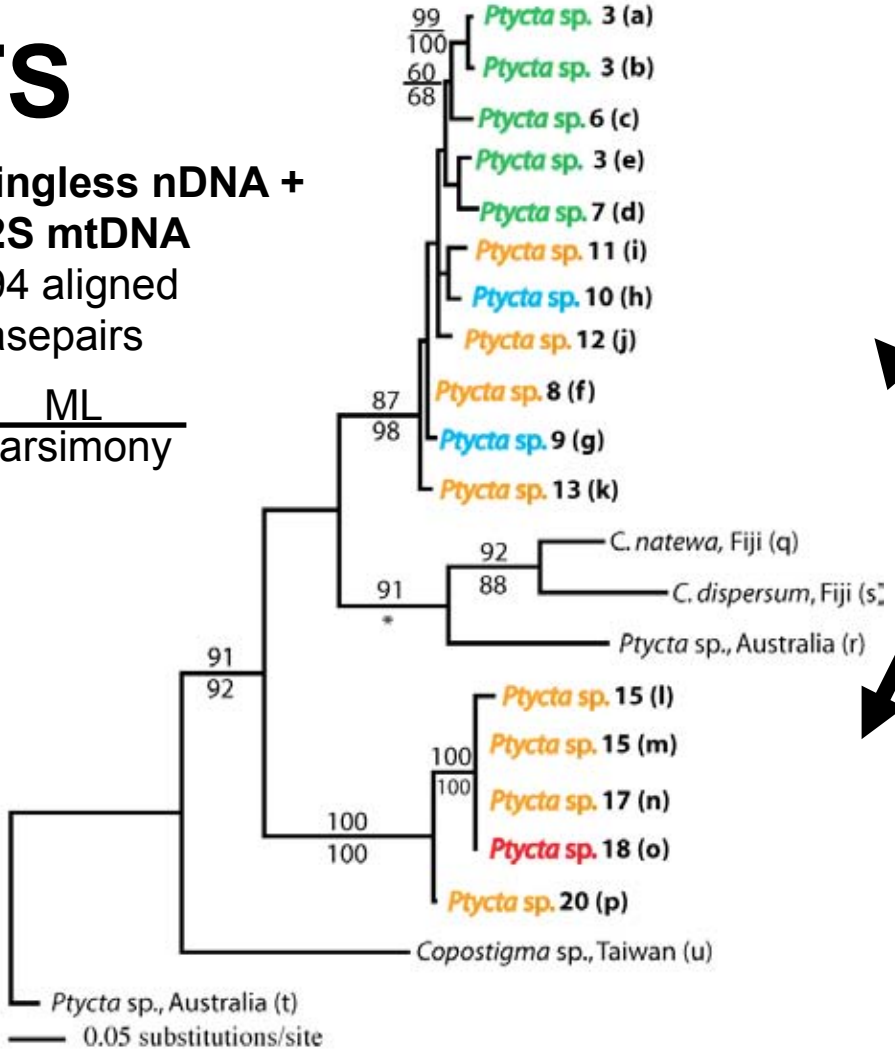
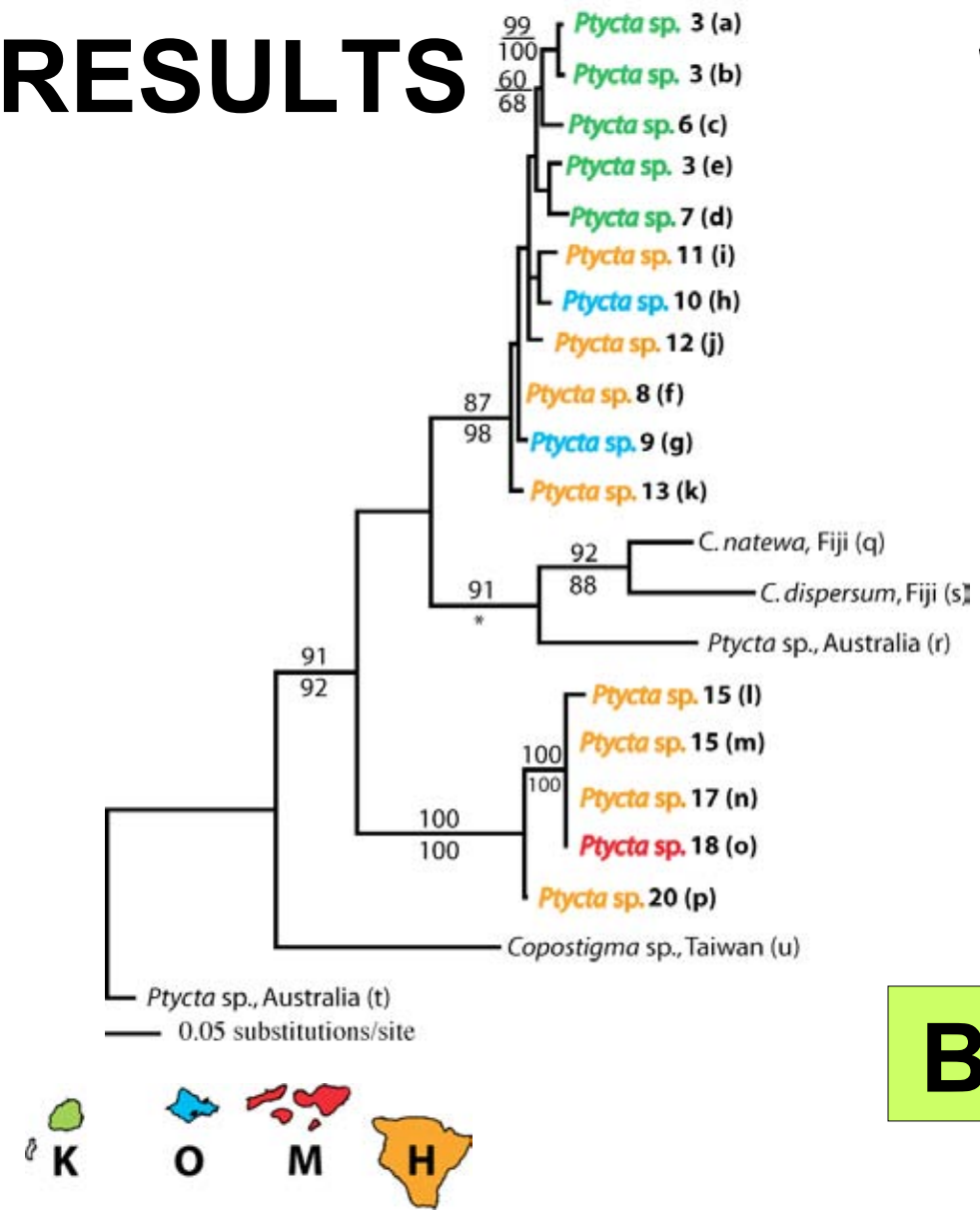
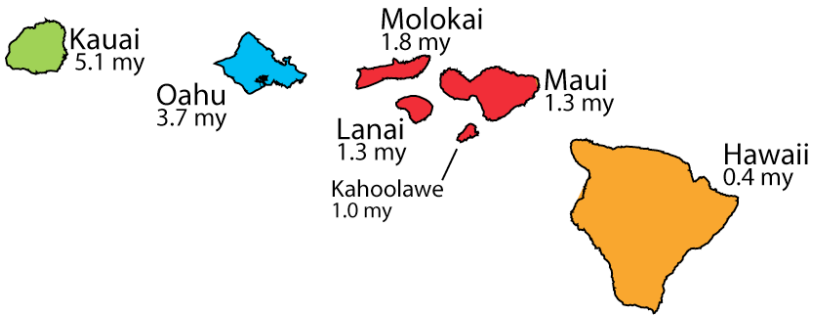


Ptycta colonized Hawaii twice

RESULTS





Back to Fiji

Rates of speciation

How quickly can new species evolve?

$$\frac{\text{Number of } \textbf{endemic} \text{ species on an island}}{\text{age of the island}}$$

Rates of speciation

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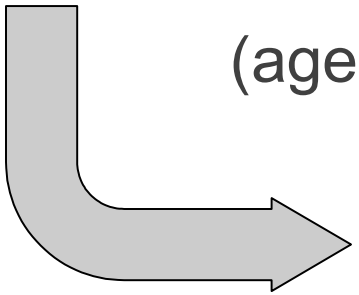

$$\frac{\ln(\text{sp\#})}{\text{age of island}}$$

(McCune 1997)

Rates of speciation

	species	rate of speciation
Drosophila flies Coyne & Orr 2004	~700	**1.20** spp/my
Tetragnatha spiders Gillespie et al. 1997	60	**0.82** spp/my
Laupala crickets Mendelson & Shaw 2006	6 (Big Island only)	**4.17** spp/my
Hyleaus bees Magnacca & Danforth 2006	60	**9.23** spp/my
***Ptycta* barklice** Current study	>100	**~ 9** spp/my (2 lineages) **>11** spp/my (1 lineage)

Results Summary

1. Hawaiian *Ptycta* are more diverse than currently described.
2. *Ptycta* may have colonized Hawaii twice.
3. *Ptycta* may have colonized the youngest island first.
4. Speciation rates of *Ptycta* may be exceptionally high.

How can you help?

- Collecting continues!
  - Seeking collecting sites on the Big Island and Oahu
  - Keep an eye out for bark lice. Let me know if you see some nice ones.

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A boatload of thanks…

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Lisa Hadway

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Holly McEldowney

Wayne Souza

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Patti Welton

Rhonda Loh

BISHOP MUSEUM

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Dan Polhemus

Hunter Polhemus

Diana Crow

Paul Krushelnycky

Dan Rubinoff

Becca Carter

Diana Percy

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University of Illinois Graduate School

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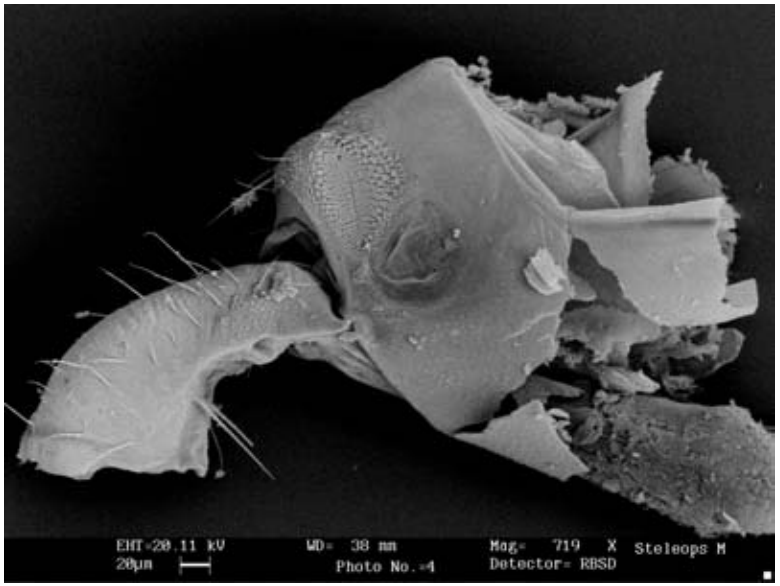
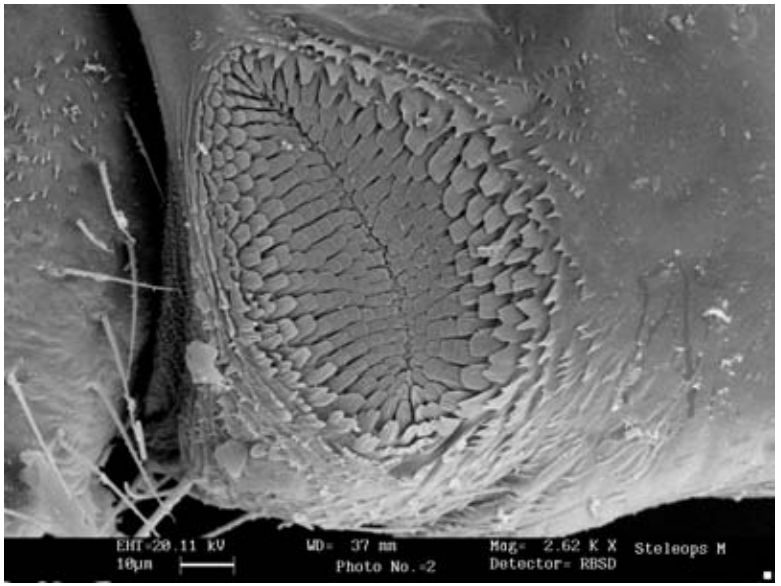
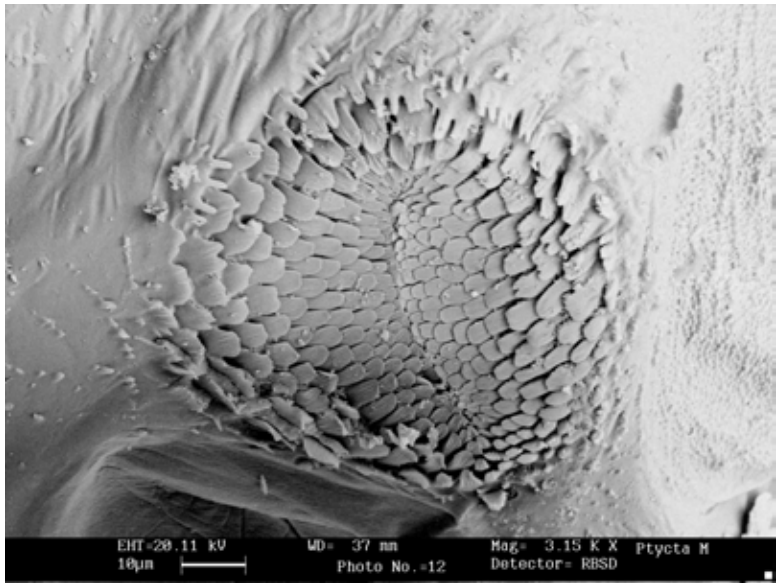
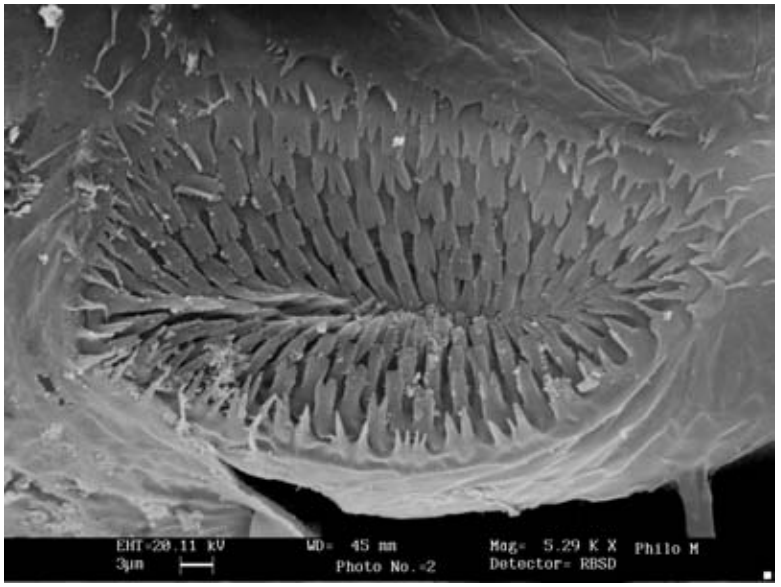
the end

Coxal organ morphology

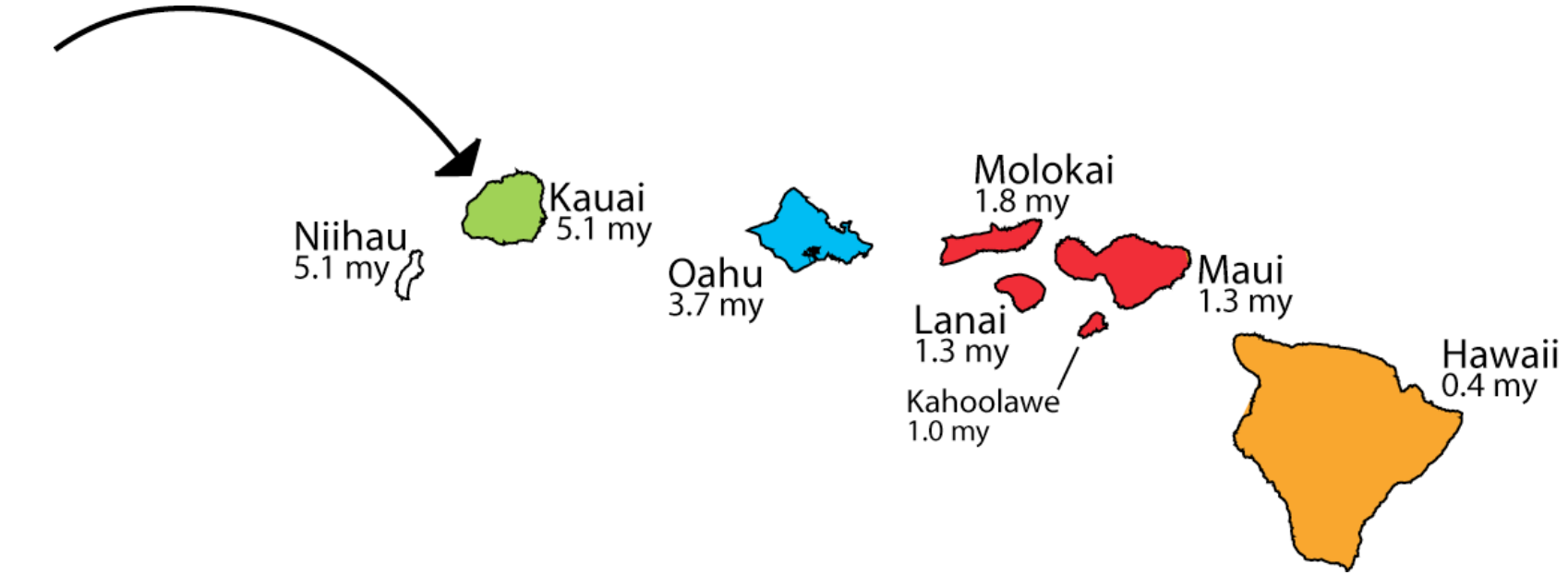








HYPOTHESIS
Stepping-stone pattern



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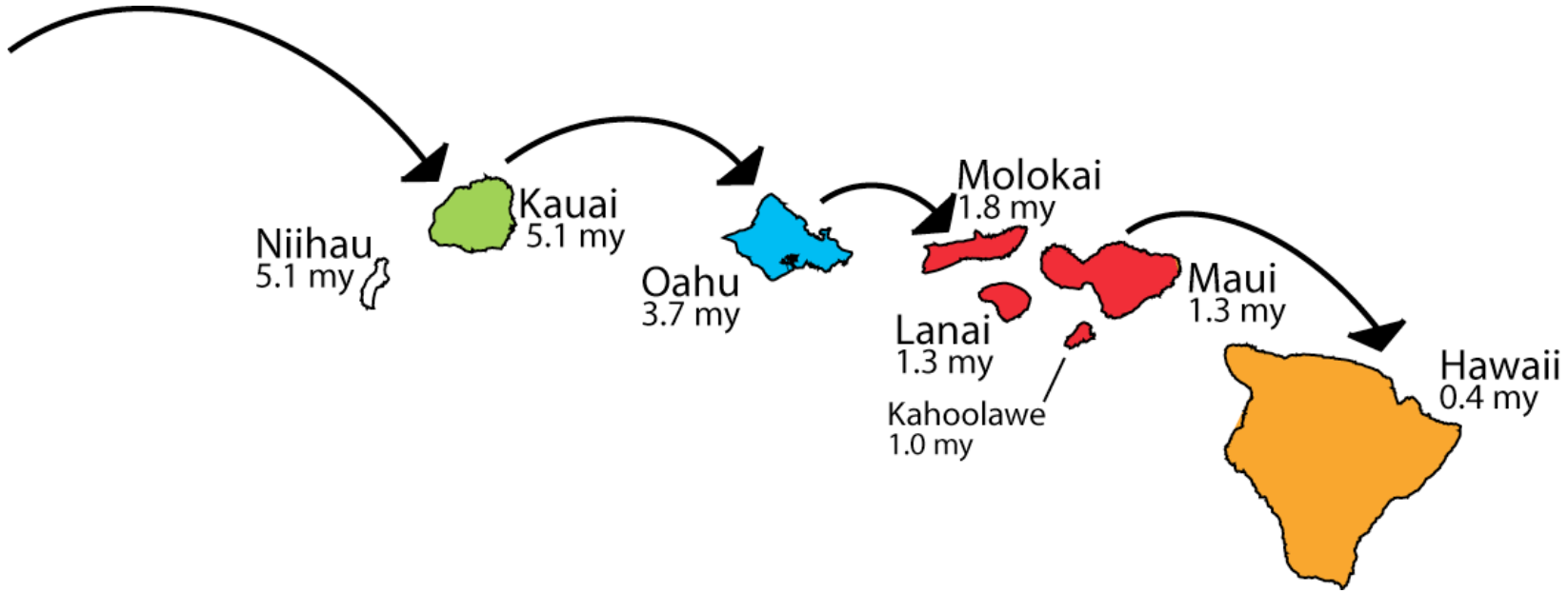

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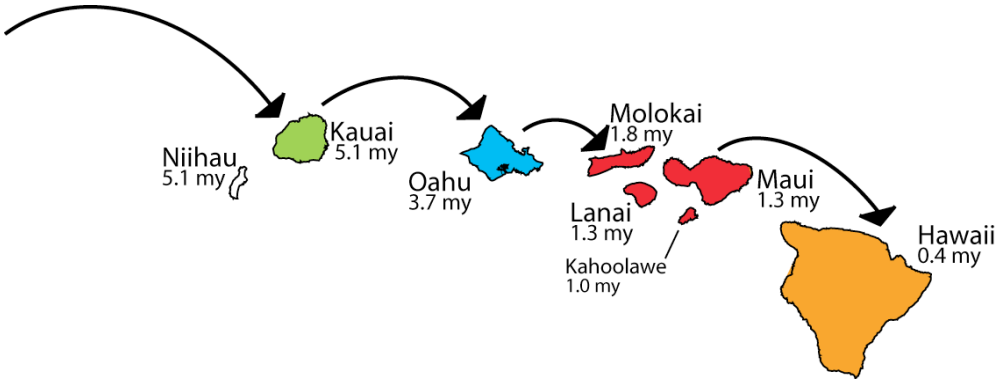
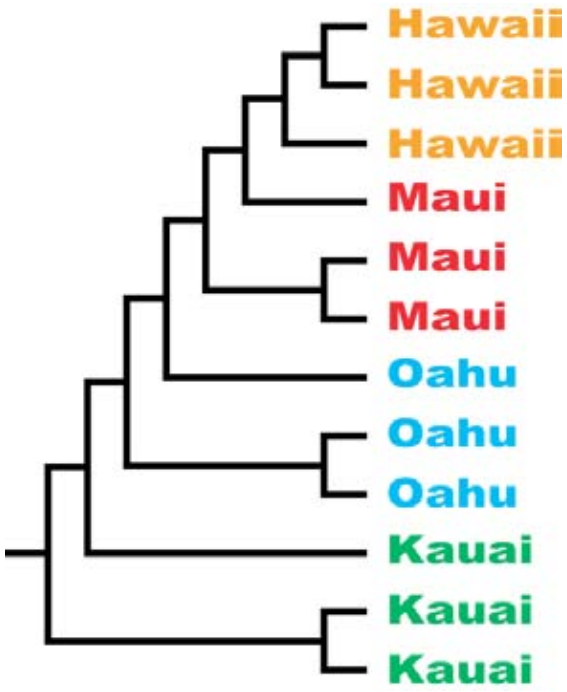
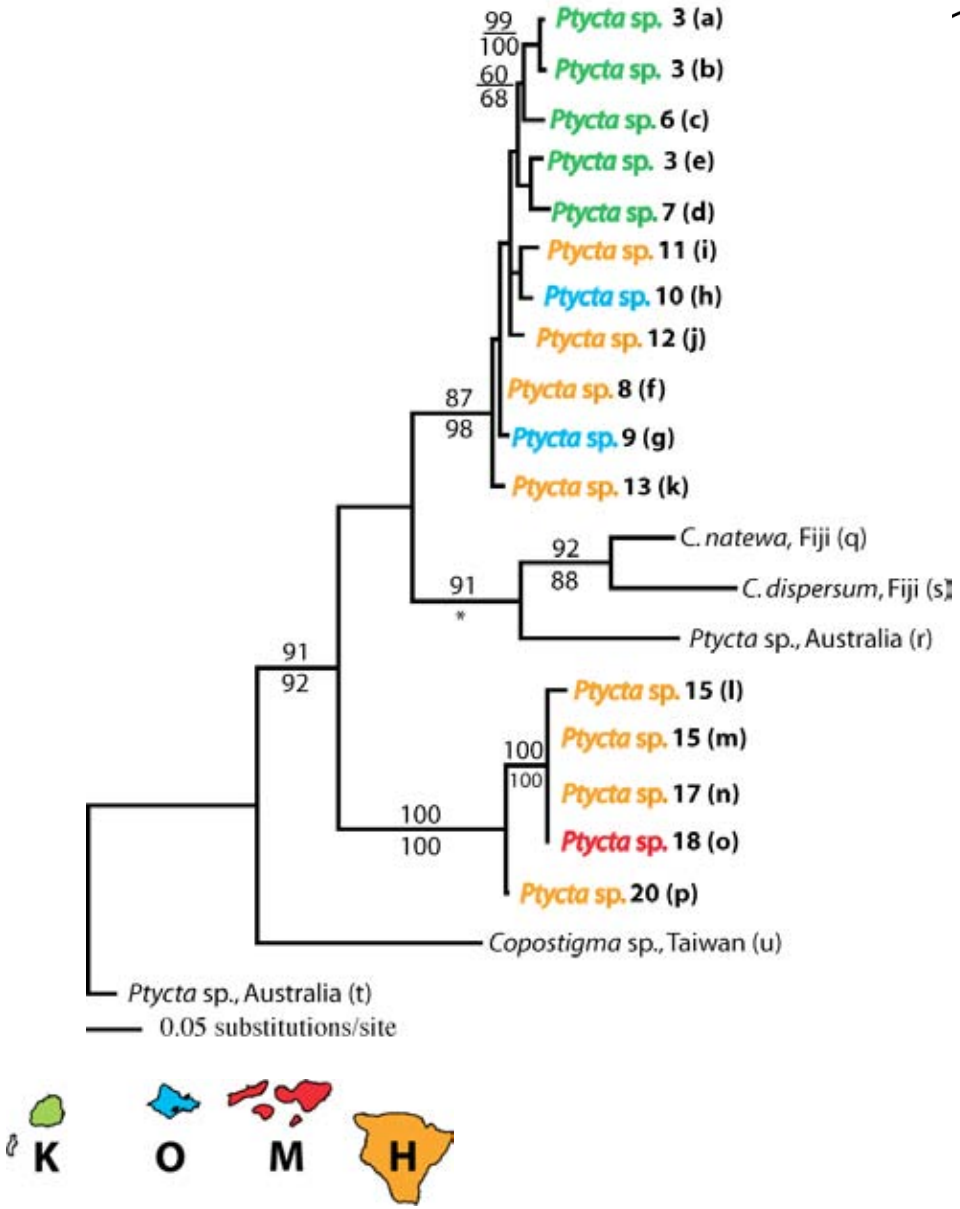
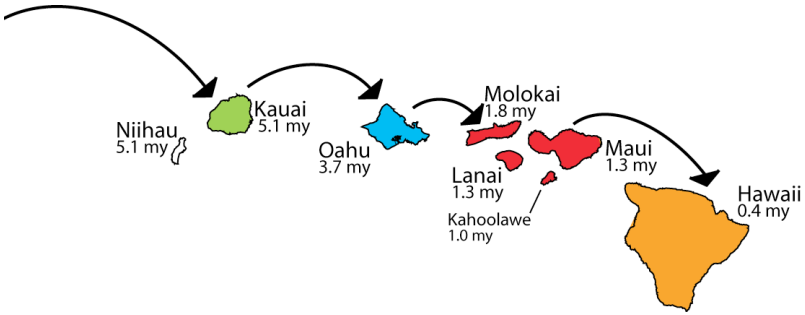
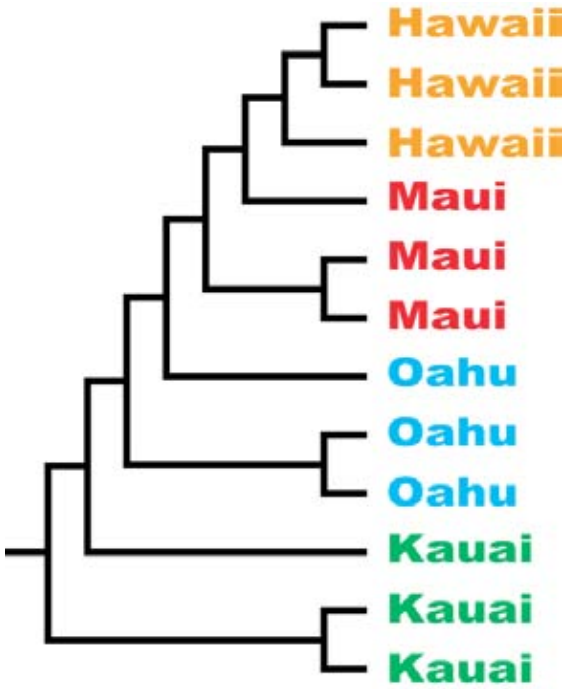


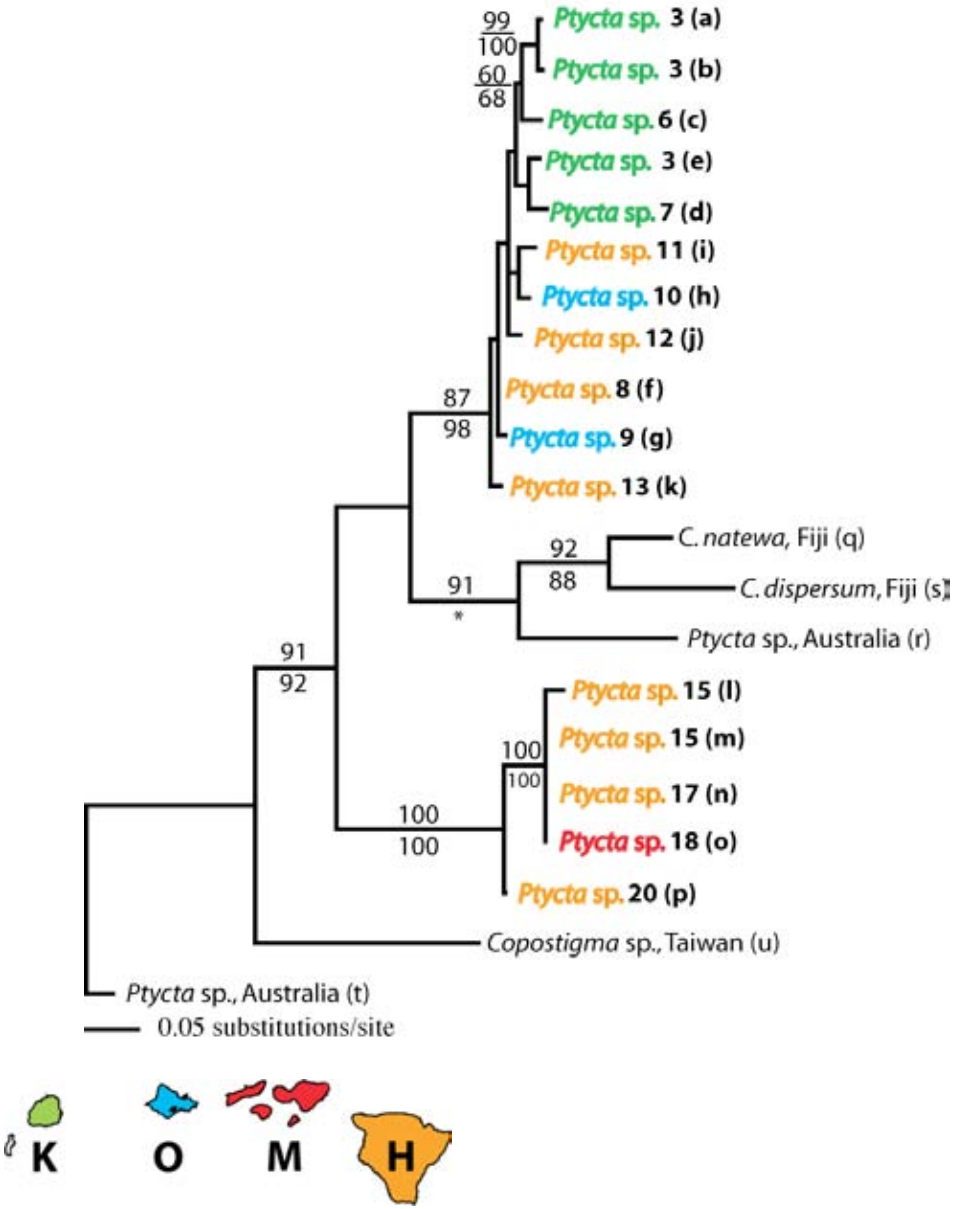


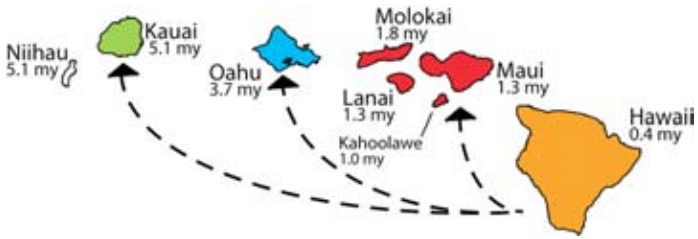




Does *Ptycta* follow the stepping stone pattern?




99
100
Ptycta sp. 3 (a)
60
68
Ptycta sp. 3 (b)
Ptycta sp. 6 (c)
Ptycta sp. 3 (e)
Ptycta sp. 7 (d)
Ptycta sp. 11 (i)
Ptycta sp. 10 (h)
Ptycta sp. 12 (j)
87
98
Ptycta sp. 8 (f)
Ptycta sp. 9 (g)
Ptycta sp. 13 (k)
92
88
C. natewa, Fiji (q)
91
*
C. dispersum, Fiji (s)
Ptycta sp., Australia (r)
91
92
Ptycta sp. 15 (l)
Ptycta sp. 15 (m)
100
100
Ptycta sp. 17 (n)
100
100
Ptycta sp. 18 (o)
Ptycta sp. 20 (p)
Copostigma sp., Taiwan (u)
Ptycta sp., Australia (t)
0.05 substitutions/site
K
O
M
H


Niihau
5.1 my
Kauai
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Oahu
3.7 my
Molokai
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Lanai
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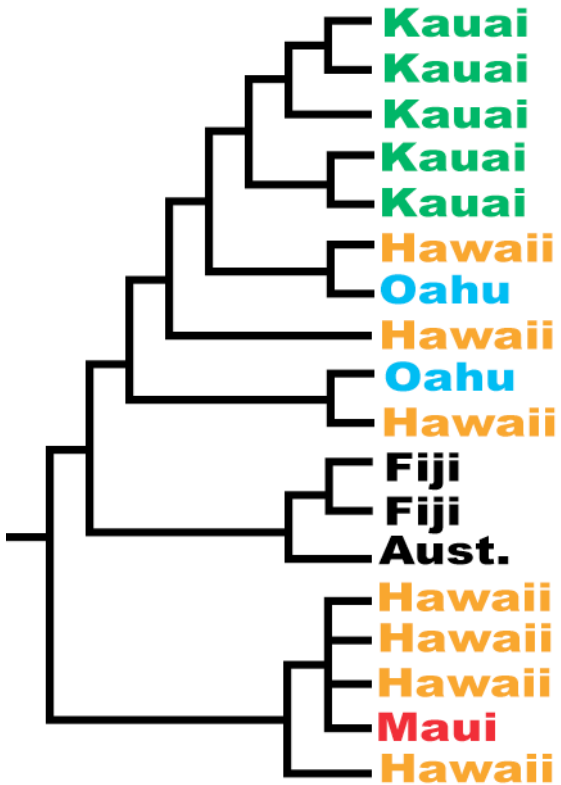
Kahoolawe
1.0 my
Maui
1.3 my
Hawaii
0.4 my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Fiji
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Aust.
Hawaii
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Maui
Hawaii

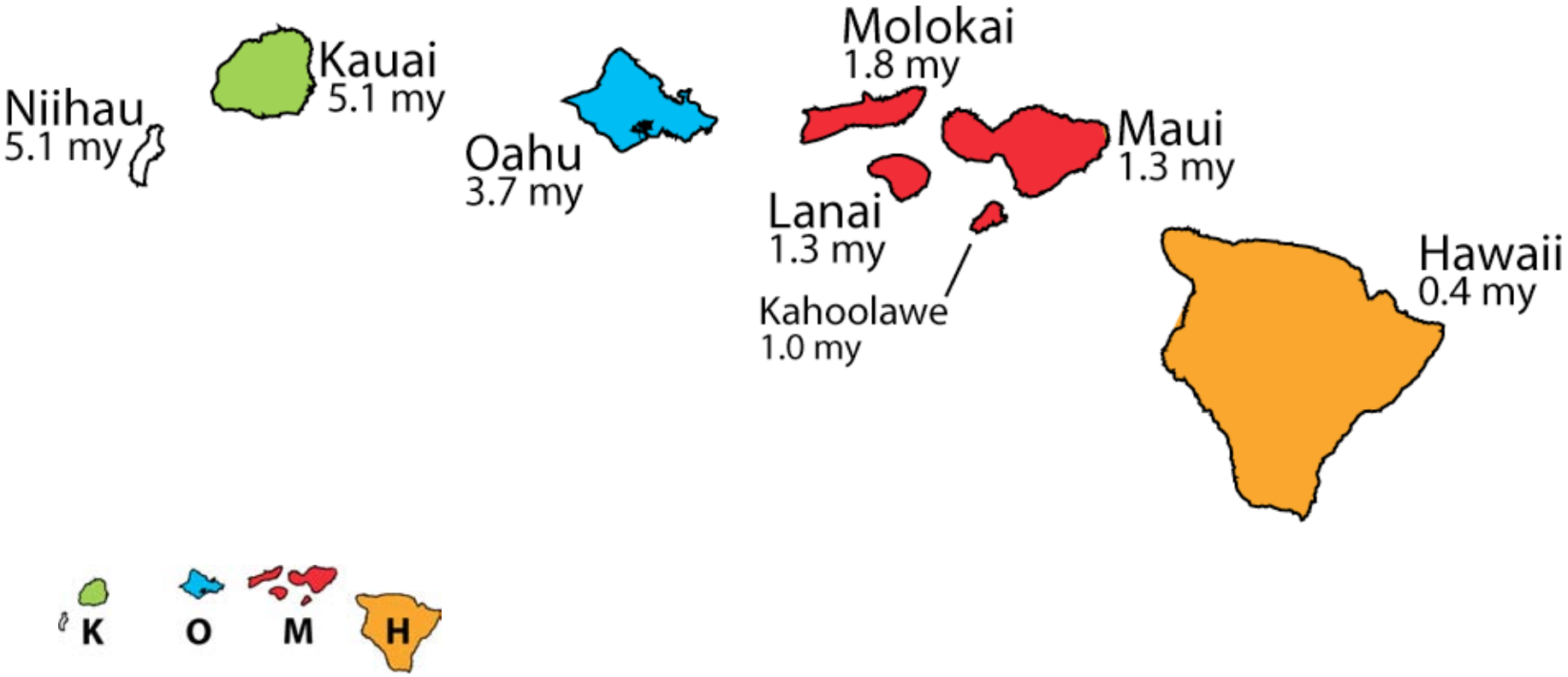
Endemicity in Hawaii

>9000 endemic species

~6000 endemic arthropods

Descended from ~250 ancestral immigrants

Geologic Isolation



Order Psocoptera

- Hemipteroid insects
- ~5000 described species worldwide

Bark Lice in Hawaii

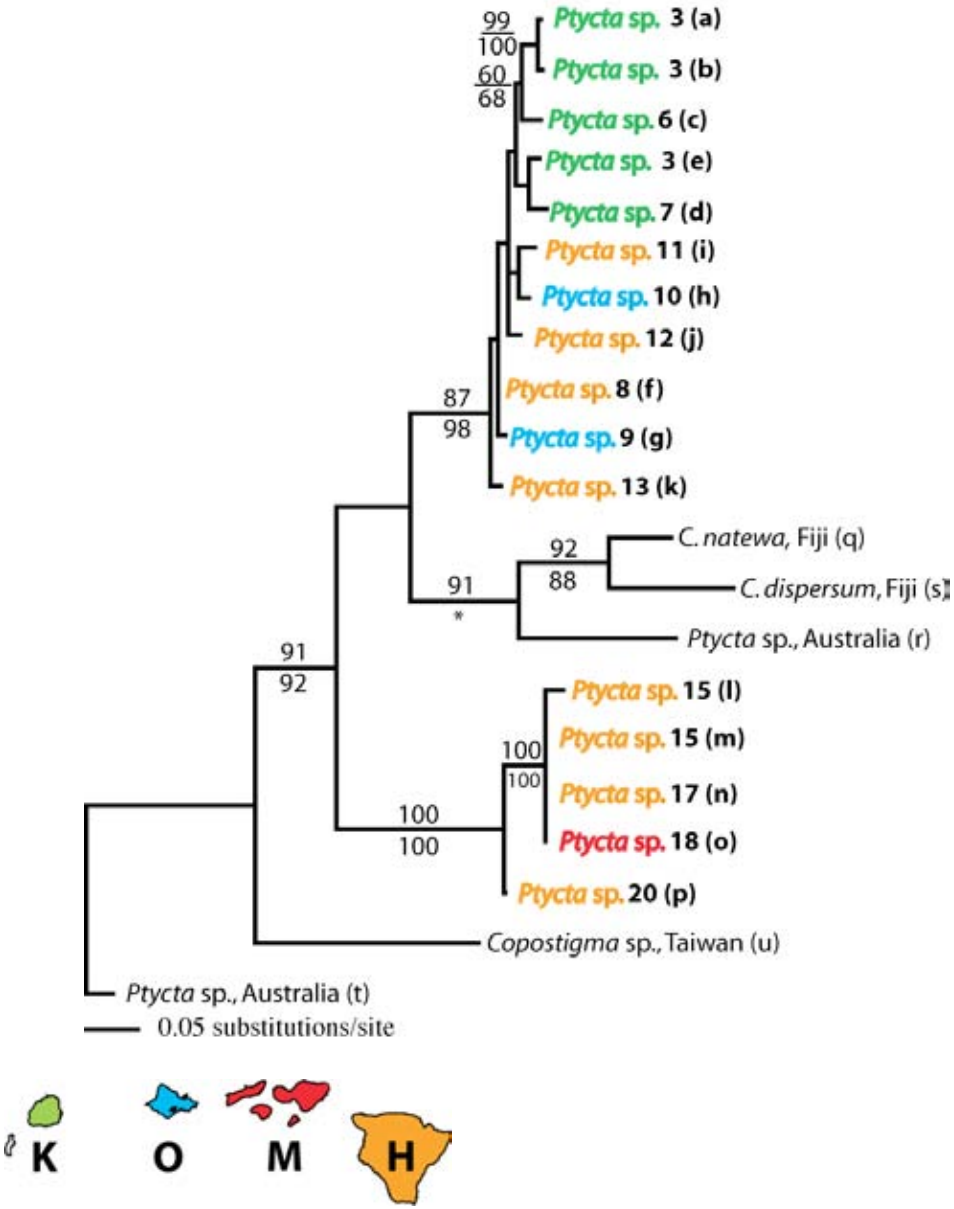
2 endemic genera (7 spp. & 20 spp.)

1 native genus: ***Ptycta***

61 spp. in Hawaii

170 spp. worldwide

Center of diversity Pacific Islands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Ptycta sp. 18 (o)
Ptycta sp. 20 (p)
Copostigma sp., Taiwan (u)
Ptycta sp., Australia (t)
0.05 substitutions/site
K
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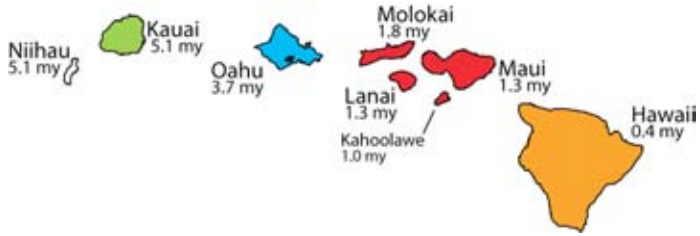
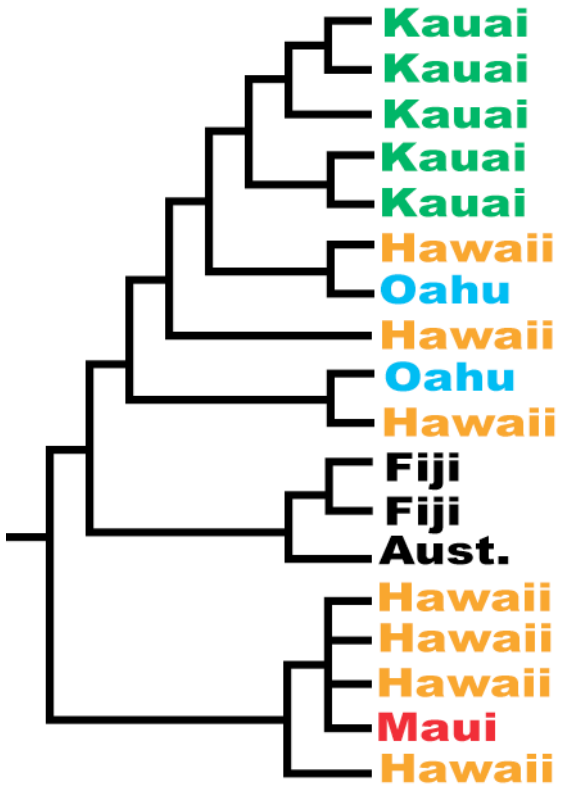
M
H


Niihau
5.1 my
Kauai
5.1 my
Oahu
3.7 my
Molokai
1.8 my
Lanai
1.3 my
Kahoolawe
1.0 my
Maui
1.3 my
Hawaii
0.4 my


Kauai
Kauai
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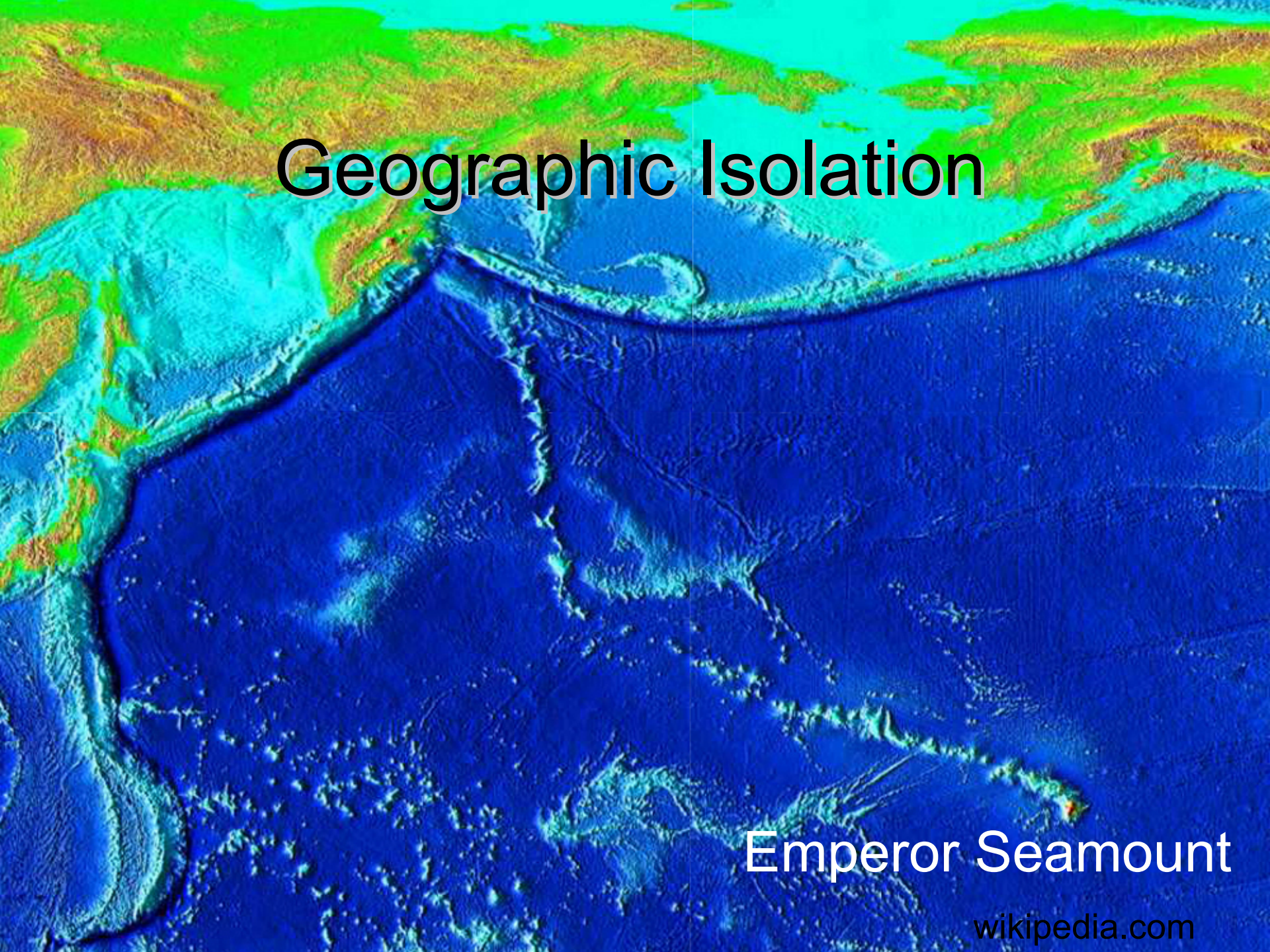
Hawaii
Oahu
Hawaii
Oahu
Hawaii
Fiji
Fiji
Aust.
Hawaii
Hawaii
Hawaii
Maui
Hawaii

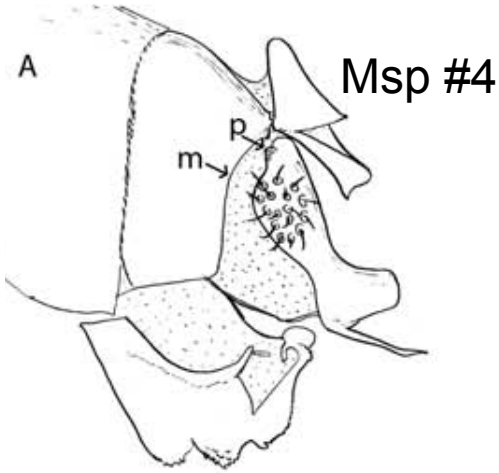
Rates of speciation

How quickly can new species evolve?

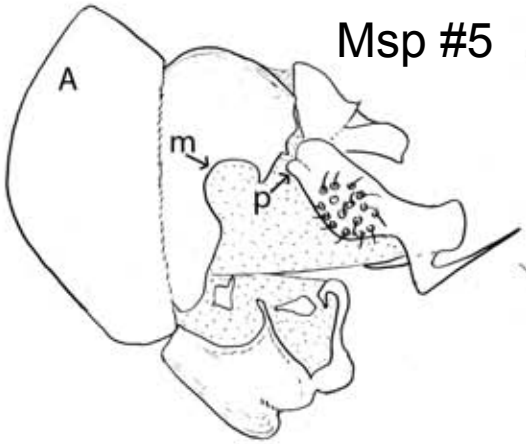
Geographic Isolation



Morphology vs Molecules

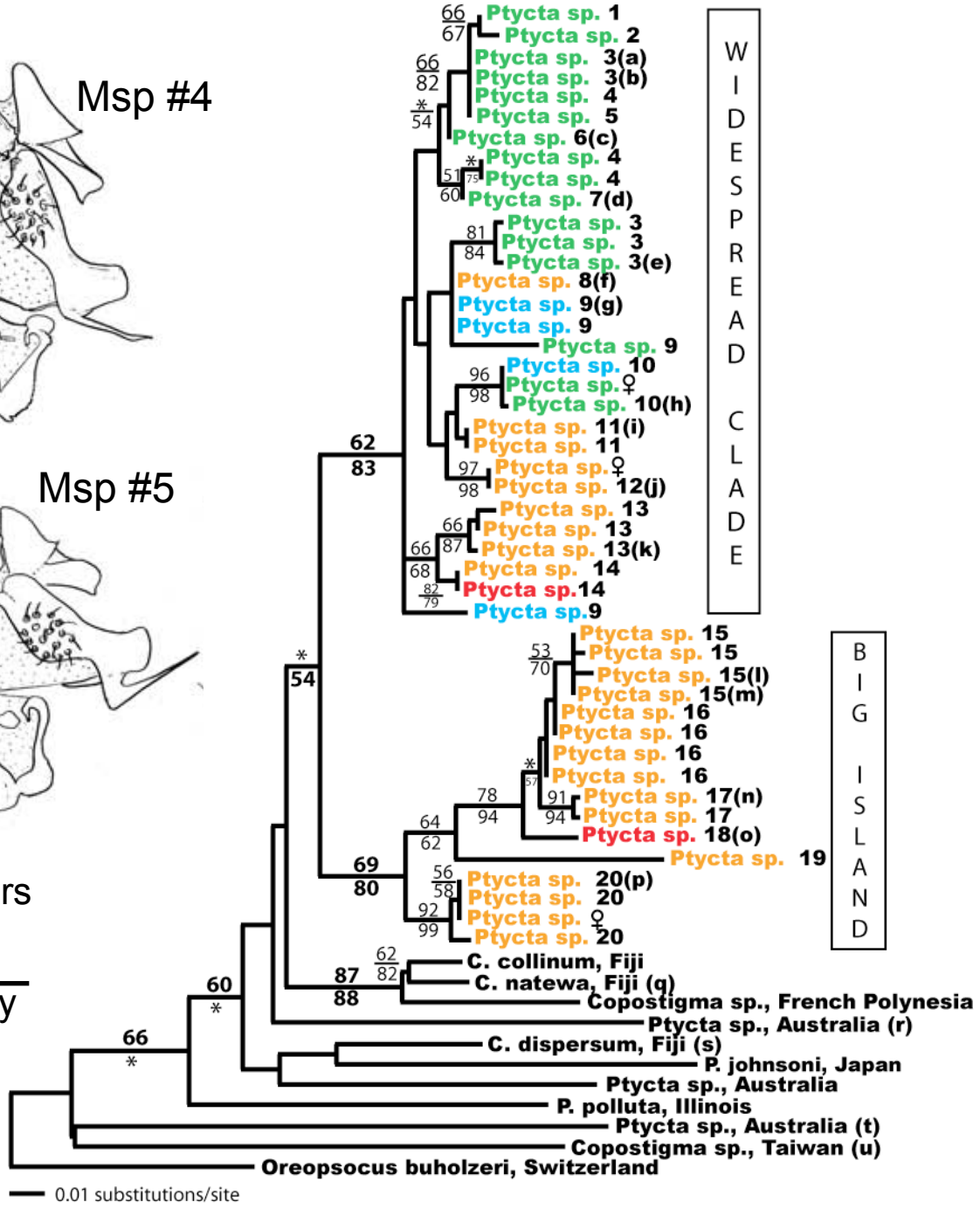


Msp #4

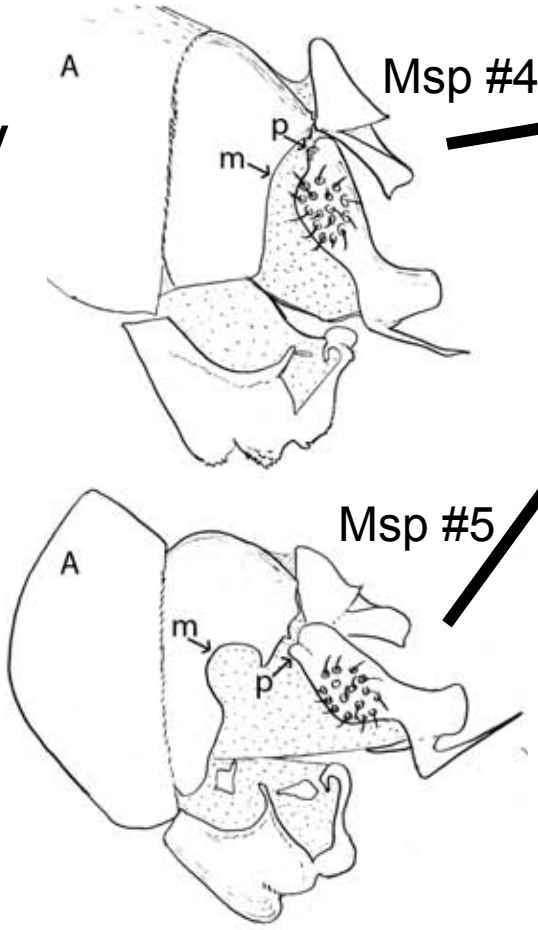


Msp #5

12S mtDNA, 373 aligned basepairs
ML tree (GTR+I+G)
Bootstrap values: ML / parsimony



Morphology vs Molecules



12S mtDNA, 373 aligned basepairs
ML tree (GTR+I+G)
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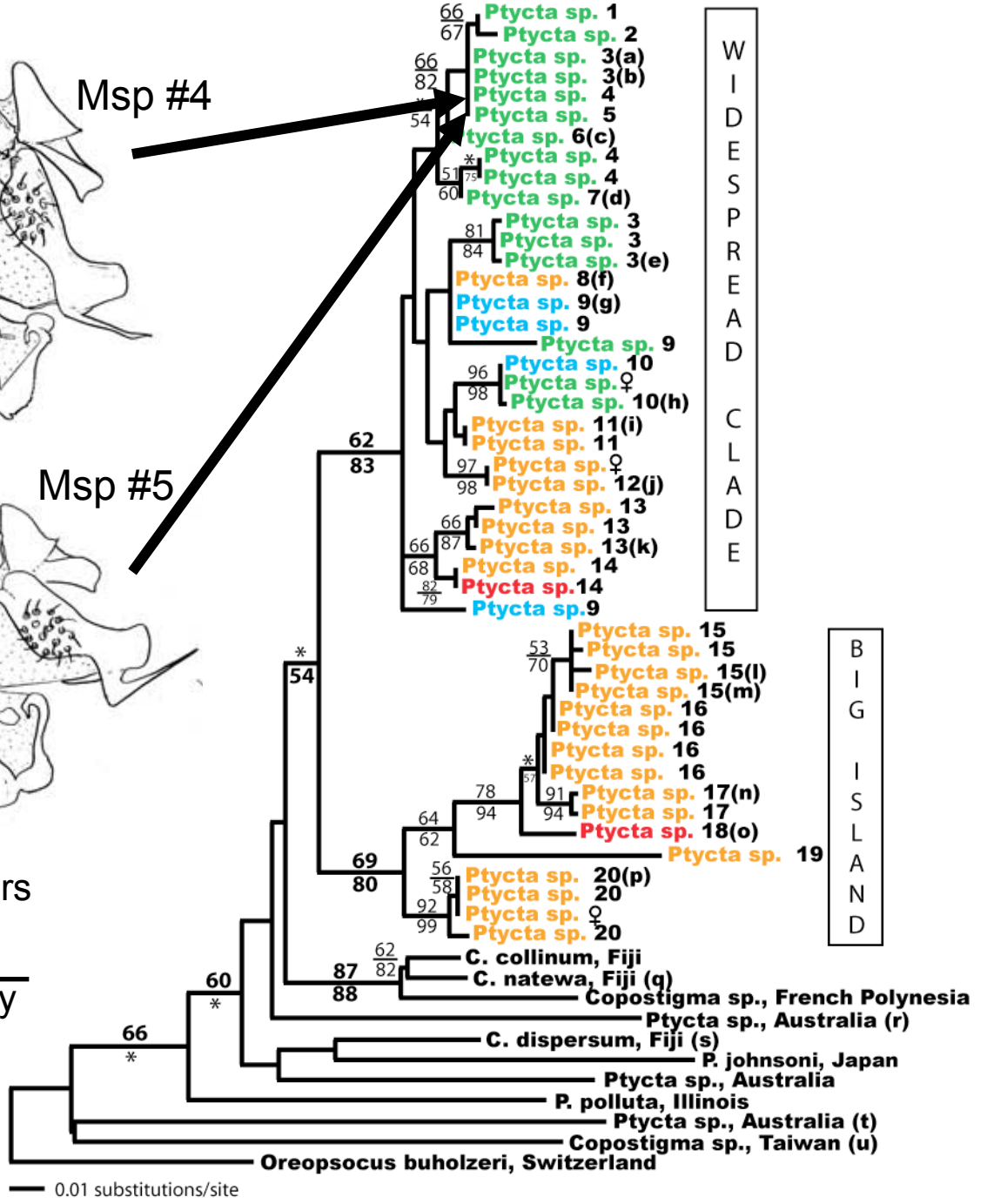

Cryptic species

12S mtDNA, 373 aligned basepairs
ML tree (GTR+I+G)
Bootstrap values: ML / parsimony