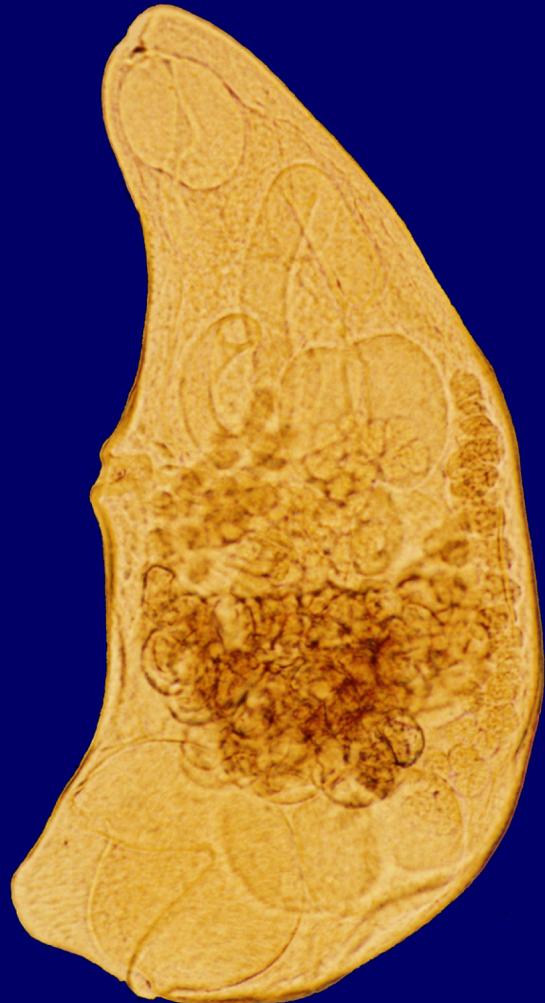


How many bases is that? ITS2 rDNA and ND1 mtDNA sequence diversity of gyliauchenid trematodes across the Indo-West Pacific

Kathryn A. Hall^{1,2}, Thomas H. Cribb²,
Tomoyoshi Yoshinaga¹ & Kazuo Ogawa¹

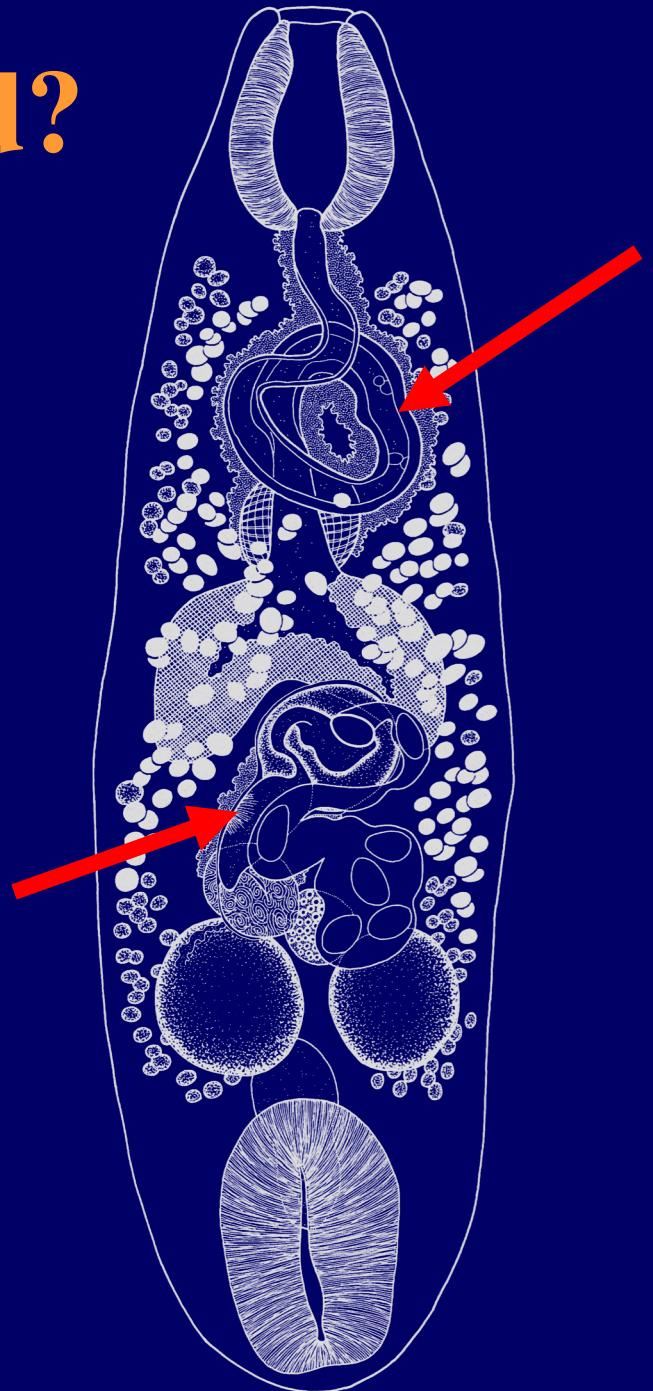
1. *Laboratory of Fish Diseases, Department of Aquatic Bioscience, The University of Tokyo, Japan.*

2. *Department of Microbiology and Parasitology, The University of Queensland, Australia.*



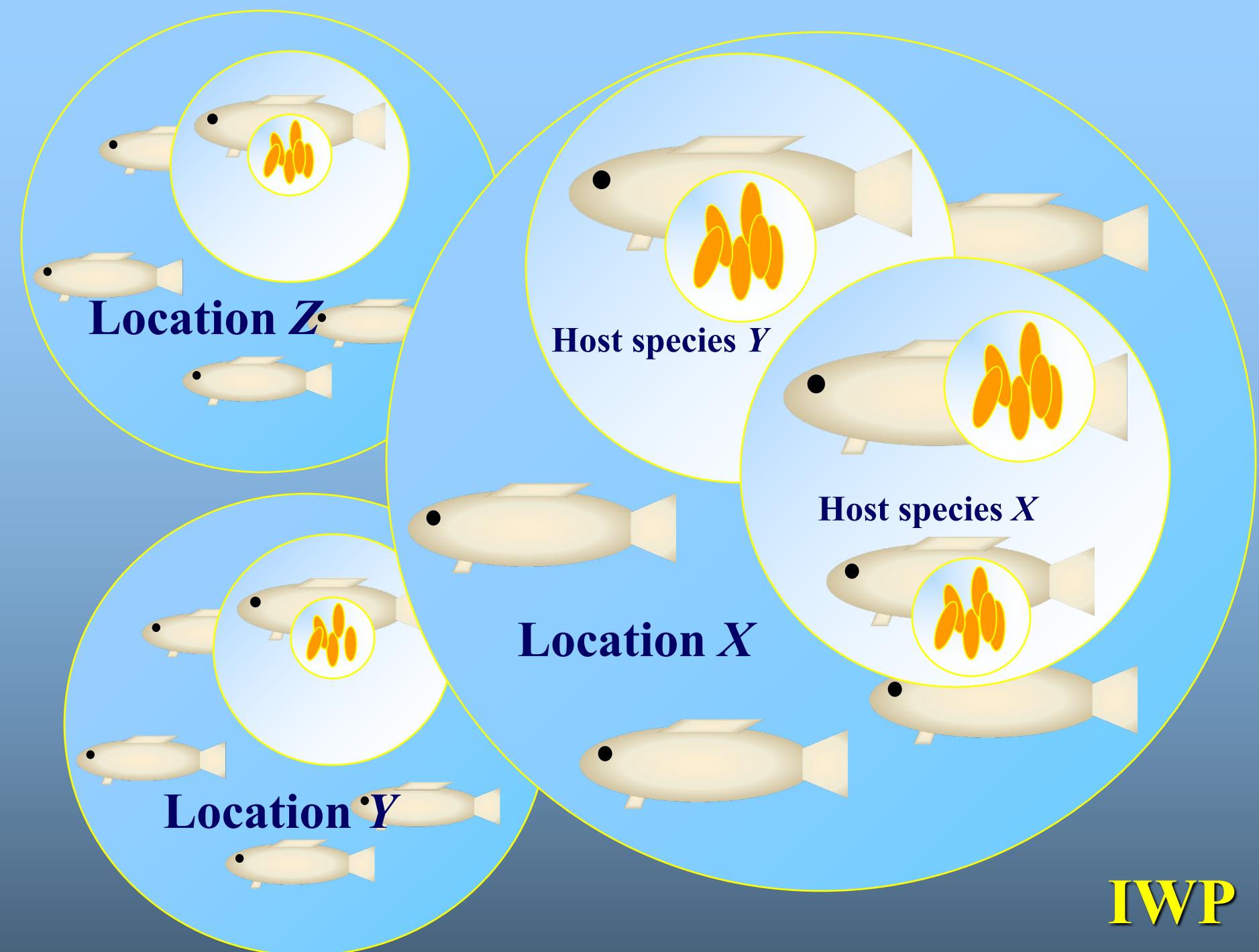
What is a gyliauchenid?

- Platyhelminthes, Digenea
- Indo-West Pacific distribution
- herbivorous fishes
- > 60 spp. in 16 genera
- defined by unusual specialisations of male genitalia and digestive tract



“Gyliauchenid Genome Project”

- aims to assess genetic diversity of gyliauchenids across IWP
- material from Japan, Lizard Island, Heron Island, Ningaloo, New Caledonia and Palau
- DNA extracted from 414 individual worms from 93 collection events (= 1 host at 1 location)
- 6 replicates per collection event (where possible)
- sequence rapidly evolving loci:
ND1 mtDNA and ITS rDNA regions







Host-Location Combinations

| Host Family | Host Genus | Host Species | Location | Heron Island | Kyushu | Lizard Island | New Caledonia | Ningaloo | Okinawa | Palau | Yaeyama | Grand Total |
|----------------------|-----------------------|-----------------------|----------|--------------|--------|---------------|---------------|----------|---------|-------|---------|-------------|
| Acanthuridae | Zebrasoma | <i>scopas</i> | | 1 | | 6 | | | | | | 7 |
| | Zebrasoma Total | | | 1 | | 6 | | | | | | 7 |
| Acanthuridae Total | | | | 1 | | 6 | | | | | | 7 |
| Chaetodontidae | Chaetodon | <i>citrinellus</i> | | | | | | | | 1 | | 1 |
| | Chaetodon Total | <i>kleinii</i> | | | | | | | | 3 | | 3 |
| Chaetodontidae Total | | | | | | | | | | 4 | | 4 |
| Pomacanthidae | Centropyge | <i>vrolikii</i> | | | | 2 | | | | | | 2 |
| | Centropyge Total | | | | | 2 | | | | | | 2 |
| | Chaetodontoplus | <i>meredithi</i> | | 5 | | | | | | | | 5 |
| | Chaetodontoplus Total | | | 5 | | | | | | | | 5 |
| | Pomacanthus | <i>sexstriatus</i> | | | | 6 | 2 | | | | | 8 |
| | Pomacanthus Total | | | | | 6 | 2 | | | | | 8 |
| Pomacanthidae Total | | | | 5 | | 8 | 2 | | | | | 15 |
| Scaridae | Chlorurus | <i>microrhinos</i> | | | | 6 | 1 | | | | | 7 |
| | Chlorurus Total | | | | | 6 | 1 | | | | | 7 |
| | Scarus | <i>rivulatus</i> | | | | 3 | | | | | | 3 |
| | Scarus Total | | | | | 3 | | | | | | 3 |
| Scaridae Total | | | | | | 9 | 1 | | | | | 10 |
| Siganidae | Siganus | <i>argenteus</i> | | | | 9 | | | 11 | 11 | | 31 |
| | | <i>canaliculatus</i> | | | | | 6 | | | | | 6 |
| | | <i>corallinus</i> | | | | 29 | | | 2 | 11 | | 42 |
| | | <i>dotiatus</i> | | | | | 6 | | | 14 | | 20 |
| | | <i>fuscescens</i> | | 61 | 9 | | | | 18 | | 6 | 94 |
| | | <i>guttatus</i> | | | | | | 2 | | | | 2 |
| | | <i>lineatus</i> | | | | 16 | | | | | | 16 |
| | | <i>puellus</i> | | 3 | 12 | | | | | 6 | | 21 |
| | | <i>punctatissimus</i> | | | | 17 | | | | 6 | | 23 |
| | | <i>punctatus</i> | | 6 | | 6 | | | 10 | 5 | | 27 |
| | | <i>spinus</i> | | | | | | | | 12 | | 12 |
| | | <i>trispilos</i> | | | | | | 12 | | | | 12 |
| | | <i>unimaculatus</i> | | | | | | | 16 | | | 16 |
| | | <i>virgatus</i> | | | | | | 10 | 16 | | | 26 |
| | | <i>vulpinus</i> | | | | 24 | | | | 5 | | 29 |
| | Siganus Total | | | 9 | 61 | 122 | 12 | 22 | 75 | 70 | 6 | 377 |
| Siganidae Total | | | | 9 | 61 | 122 | 12 | 22 | 75 | 70 | 6 | 377 |
| Zanclidae | Zanclus | <i>cornutus</i> | | 1 | | | | | | | | 1 |
| | Zanclus Total | | | 1 | | | | | | | | 1 |
| Zanclidae Total | | | | 1 | | | | | | | | 1 |
| Grand Total | | | | 16 | 61 | 145 | 15 | 22 | 75 | 74 | 6 | 414 |

Host-Location Combinations

| Host Family | Host Genus | Host Species | Location | Heron Island | Kyushu | Lizard Island | New Caledonia | Ningaloo | Okinawa | Palau | Yaeyama | Grand Total |
|----------------------|-----------------------|-----------------------|----------|--------------|--------|---------------|---------------|----------|---------|-------|---------|-------------|
| Acanthuridae | Zebrasoma | <i>scopas</i> | | 1 | | 6 | | | | | | 7 |
| | Zebrasoma Total | | | 1 | | 6 | | | | | | 7 |
| Acanthuridae Total | | | | 1 | | 6 | | | | | | 7 |
| Chaetodontidae | Chaetodon | <i>citrinellus</i> | | | | | | | | 1 | | 1 |
| | Chaetodon Total | <i>kleinii</i> | | | | | | | | 3 | | 3 |
| Chaetodontidae Total | | | | | | | | | | 4 | | 4 |
| Pomacanthidae | Centropyge | <i>vrolikii</i> | | | | 2 | | | | | | 2 |
| | Centropyge Total | | | | | 2 | | | | | | 2 |
| | Chaetodontoplus | <i>meredithi</i> | | 5 | | | | | | | | 5 |
| | Chaetodontoplus Total | | | 5 | | | | | | | | 5 |
| | Pomacanthus | <i>sexstriatus</i> | | | | 6 | 2 | | | | | 8 |
| | Pomacanthus Total | | | | | 6 | 2 | | | | | 8 |
| Pomacanthidae Total | | | | 5 | | 8 | 2 | | | | | 15 |
| Scaridae | Chlorurus | <i>microrhinos</i> | | | | 6 | 1 | | | | | 7 |
| | Chlorurus Total | | | | | 6 | 1 | | | | | 7 |
| | Scarus | <i>rivulatus</i> | | | | 3 | | | | | | 3 |
| | Scarus Total | | | | | 3 | | | | | | 3 |
| Scaridae Total | | | | | | 9 | 1 | | | | | 10 |
| Siganidae | Siganus | <i>argenteus</i> | | | | 9 | | | 11 | 11 | | 31 |
| | | <i>canaliculatus</i> | | | | | 6 | | | | | 6 |
| | | <i>corallinus</i> | | | | 29 | | | 2 | 11 | | 42 |
| | | <i>dotiatus</i> | | | | | 6 | | | 14 | | 20 |
| | | <i>fuscescens</i> | | 61 | 9 | | | | 18 | | 6 | 94 |
| | | <i>guttatus</i> | | | | | | | 2 | | | 2 |
| | | <i>lineatus</i> | | | | 16 | | | | | | 16 |
| | | <i>puellus</i> | | 3 | | 12 | | | | 6 | | 21 |
| | | <i>punctatissimus</i> | | | | 17 | | | | 6 | | 23 |
| | | <i>punctatus</i> | | 6 | | 6 | | | 10 | 5 | | 27 |
| | | <i>spinus</i> | | | | | | | | 12 | | 12 |
| | | <i>trispilos</i> | | | | | | 12 | | | | 12 |
| | | <i>unimaculatus</i> | | | | | | | 16 | | | 16 |
| | | <i>virgatus</i> | | | | | | 10 | 16 | | | 26 |
| | | <i>vulpinus</i> | | | | 24 | | | | 5 | | 29 |
| Siganidae Total | Siganus Total | | | 9 | 61 | 122 | 12 | 22 | 75 | 70 | 6 | 377 |
| Zanclidae | Zanclus | <i>cornutus</i> | | 1 | | 122 | 12 | 22 | 75 | 70 | 6 | 377 |
| | Zanclus Total | | | 1 | | | | | | | | 1 |
| Zanclidae Total | | | | 1 | | | | | | | | 1 |
| Grand Total | | | | 16 | 61 | 145 | 15 | 22 | 75 | 74 | 6 | 414 |

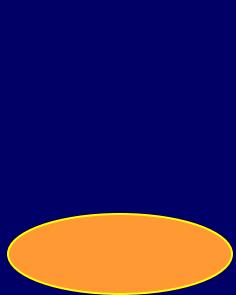
Grand total = 414



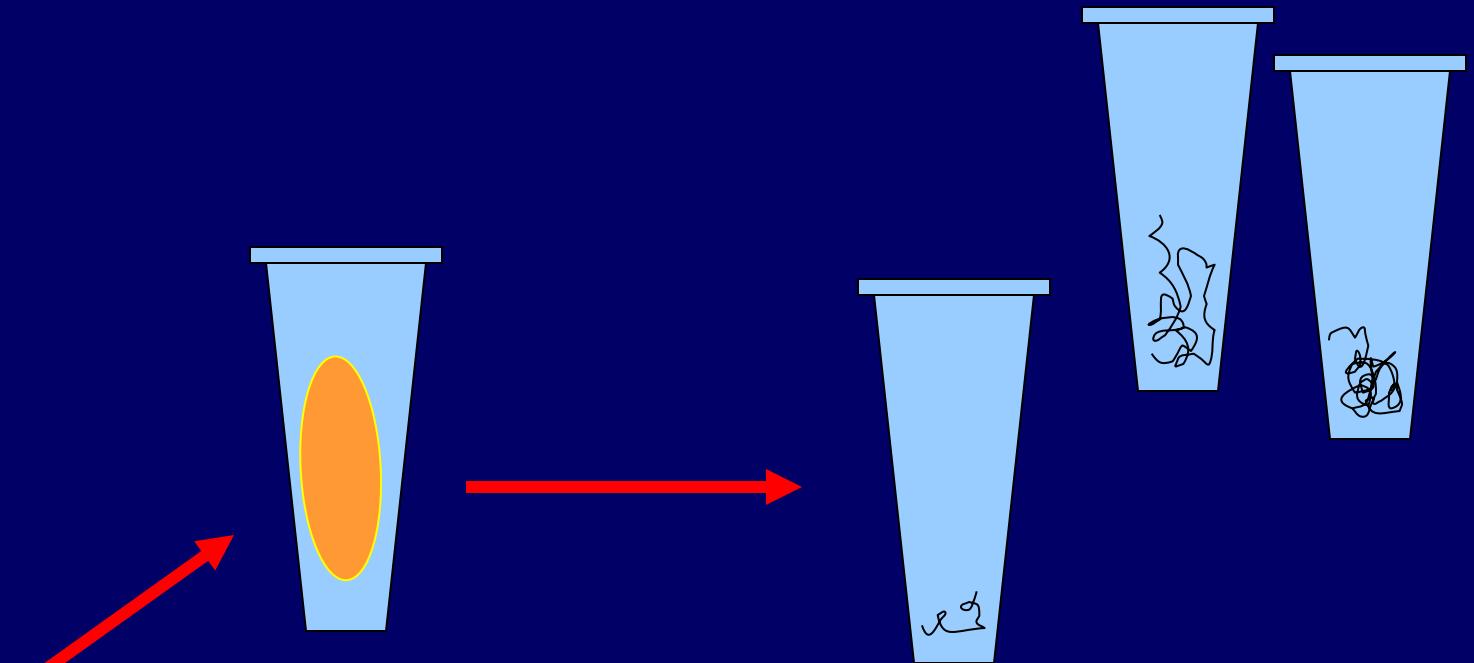
| | | | Heron Island | Lizard Island | New Ningaloo | Caledonia | Palau | Okinawa | Kyushu | Yaeyama |
|----------------|------------------------|-----------------------|-----------------|------------------|-----------------|-----------|-------|---------|--------|---------|
| Acanthuridae | <i>Zebrasoma</i> | <i>scopas</i> | • | • | | | | | | |
| Chaetodontidae | <i>Chaetodon</i> | <i>citrinellus</i> | | | | | • | | | |
| | | <i>kleinii</i> | | | | | • | | | |
| Pomacanthidae | <i>Centropyge</i> | <i>vrolikii</i> | | • | | | | | | |
| | <i>Chaetodontoplus</i> | <i>meredithi</i> | • | | | | | | | |
| | <i>Pomacanthus</i> | <i>sexstriatus</i> | | • | | • | | | | |
| Scoridae | <i>Chlorurus</i> | <i>microrhinos</i> | | • | | • | | | | |
| | <i>Scarus</i> | <i>rivulatus</i> | | • | | • | | | | |
| Siganidae | <i>Siganus</i> | <i>argentatus</i> | | • | | | • | • | • | |
| | | <i>canaliculatus</i> | | | | • | | | | |
| | | <i>corallinus</i> | | • | | | • | • | • | |
| | | <i>doliatus</i> | | | | • | • | • | | |
| | | <i>fuscescens</i> | | • | | | | • | | |
| | | <i>guttatus</i> | | | | | | • | | |
| | | <i>lineatus</i> | | • | | | | | | |
| | | <i>puillus</i> | • | • | | | | • | | |
| | | <i>punctatissimus</i> | | • | | | | • | | |
| | | <i>punctatus</i> | • | • | | | | • | • | |
| | | <i>spinus</i> | | | | | | • | | |
| | | <i>trispilos</i> | | | | • | | | | |
| | | <i>unimaculatus</i> | | | | | | | | |
| | | <i>virgatus</i> | | | • | | | | | |
| | | <i>vulpinus</i> | | | | • | | | | |
| Zandidae | <i>Zandus</i> | <i>cornutus</i> | • | | | | • | | | |



43 unique host/location combinations



whole worm in
90% EtOH



ND1 mtDNA
ITS2 rDNA
28S (D1-D3) rDNA

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | | | | | | | | | | |
| 5 | 6 | 1 | 3 | 6 | 7 | 2 | 5 | 6 | 8 | 9 | 7 | | |
| 0 | 6 | 0 | 5 | 8 | 2 | 3 | 9 | 0 | 2 | 2 | 8 | 2 | 1 |

| | | | | | | | | | | | | | | | | | | |
|-----------------------|--------|------|---|---|---|---|---|------|----|---|---|-------|-----|-----|-----|----|-------|-----|
| <i>C. meredithi</i> | Heron | 16.1 | . | . | . | . | . | C | G | C | A | GCTAG | G | C | CTA | A | AACAT | G |
| <i>C. meredithi</i> | Heron | 22.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>C. meredithi</i> | Heron | 22.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>C. meredithi</i> | Heron | 22.3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | T |
| <i>C. meredithi</i> | Heron | 14.1 | . | . | . | . | . | T | A | T | . | . | . | . | T | .. | G.. | CC. |
| <i>C. bicolor</i> | Lizard | 1 | . | . | . | . | . | A | .. | . | . | T | TC. | G | G.. | CC | N | |
| <i>P. sexstriatus</i> | Lizard | 17.1 | . | . | . | . | . | A | A | . | . | T | .G. | G.. | C.. | . | . | |
| <i>P. sexstriatus</i> | Lizard | 17.2 | . | . | . | . | . | A | A | . | . | T | .G. | G.. | C.. | . | . | |
| <i>P. sexstriatus</i> | Lizard | 17.3 | . | . | . | . | G | | A | A | . | T | .G. | G.. | C.. | . | . | |
| <i>P. sexstriatus</i> | Lizard | 17.4 | . | . | . | . | . | A | A | . | . | T | .G. | G.. | C.. | . | . | |
| <i>P. sexstriatus</i> | Lizard | 17.5 | . | . | . | . | . | A | A | . | . | T | .G. | G.. | C.. | . | . | |
| <i>P. sexstriatus</i> | Lizard | 17.6 | . | . | . | . | G | | A | A | . | T | .G. | G.. | C.. | . | . | |

ITS2 rDNA ~ 475 bp

samples from pomacanthid fishes of the GBR

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | | | | | | | | | | |
| 5 | 6 | 1 | 3 | 6 | 7 | 2 | 5 | 6 | 8 | 9 | 7 | | |
| 0 | 6 | 0 | 5 | 8 | 2 | 3 | 9 | 0 | 2 | 2 | 8 | 2 | 1 |

| | | | |
|-----------------------|--------|------|---------------------------------|
| <i>C. meredithi</i> | Heron | 16.1 | C G C A GCTAG G C CTA A AACAT G |
| <i>C. meredithi</i> | Heron | 22.1 | |
| <i>C. meredithi</i> | Heron | 22.2 | |
| <i>C. meredithi</i> | Heron | 22.3 | T |
| <i>C. meredithi</i> | Heron | 14.1 | T A T |
| <i>C. bicolor</i> | Lizard | 1 | A ... T TC G G.. CC N |
| <i>P. sexstriatus</i> | Lizard | 17.1 | A A T G G.. C . |
| <i>P. sexstriatus</i> | Lizard | 17.2 | A A T G G.. C . |
| <i>P. sexstriatus</i> | Lizard | 17.3 | ... G A A T G G.. C . |
| <i>P. sexstriatus</i> | Lizard | 17.4 | A A T G G.. C . |
| <i>P. sexstriatus</i> | Lizard | 17.5 | A A T G G.. C . |
| <i>P. sexstriatus</i> | Lizard | 17.6 | ... G A A T G G.. C . |

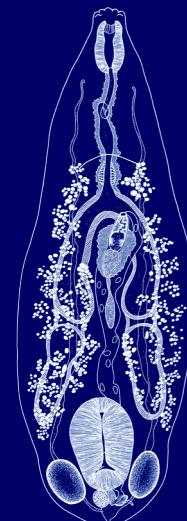
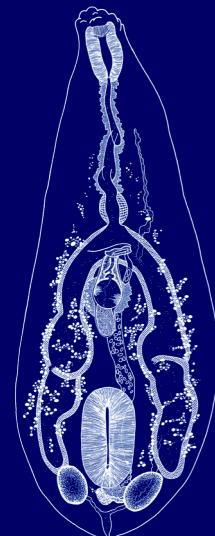
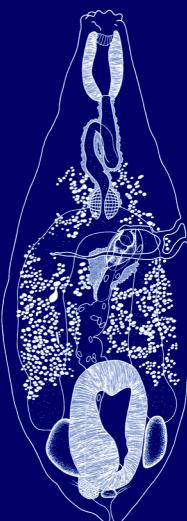
| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | | | | | | | | | | |
| 5 | 6 | 1 | 3 | 6 | 7 | 2 | 5 | 6 | 8 | 9 | 7 | | |
| 0 | 6 | 0 | 5 | 8 | 2 | 3 | 9 | 0 | 2 | 2 | 8 | 2 | 1 |

| | | | | | | | | | | | | | | | | | | | |
|-----------------------|--------|------|---|---|---|---|-----|-----|-----|---|---|-------|----|---|-----|---|-------|----|---|
| <i>C. meredithi</i> | Heron | 16.1 | . | . | . | . | . | C | G | C | A | GCTAG | G | C | CTA | A | AACAT | G | |
| <i>C. meredithi</i> | Heron | 22.1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| <i>C. meredithi</i> | Heron | 22.2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| <i>C. meredithi</i> | Heron | 22.3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | T | |
| <i>C. meredithi</i> | Heron | 14.1 | . | . | . | . | . | T | A | T | . | . | . | . | T | . | . | . | |
| <i>C. bicolor</i> | Lizard | 1 | . | . | . | . | . | A | ... | . | . | T | TC | . | G | G | . | CC | . |
| <i>P. sexstriatus</i> | Lizard | 17.1 | . | . | . | . | . | A | A | . | . | T | . | G | . | G | . | C | . |
| <i>P. sexstriatus</i> | Lizard | 17.2 | . | . | . | . | . | A | A | . | . | T | . | G | . | G | . | C | . |
| <i>P. sexstriatus</i> | Lizard | 17.3 | . | . | . | . | G | ... | A | A | . | T | . | G | . | G | . | C | . |
| <i>P. sexstriatus</i> | Lizard | 17.4 | . | . | . | . | . | A | A | . | . | T | . | G | . | G | . | C | . |
| <i>P. sexstriatus</i> | Lizard | 17.5 | . | . | . | . | . | A | A | . | . | T | . | G | . | G | . | C | . |
| <i>P. sexstriatus</i> | Lizard | 17.6 | . | . | . | G | ... | A | A | . | . | T | . | G | . | G | . | C | . |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | | | | | | | | | | |
| 5 | 6 | 1 | 3 | 6 | 7 | 2 | 5 | 6 | 8 | 9 | 7 | | |
| 0 | 6 | 0 | 5 | 8 | 2 | 3 | 9 | 0 | 2 | 2 | 8 | 2 | 1 |

| | | | |
|-----------------------|--------|------|---------------------------------|
| <i>C. meredithi</i> | Heron | 16.1 | C G C A GCTAG G C CTA A AACAT G |
| <i>C. meredithi</i> | Heron | 22.1 | |
| <i>C. meredithi</i> | Heron | 22.2 | |
| <i>C. meredithi</i> | Heron | 22.3 | T |
| <i>C. meredithi</i> | Heron | 14.1 | T A T |
| <i>C. bicolor</i> | Lizard | 1 | A.... T TC. G G.. CC N |
| <i>P. sexstriatus</i> | Lizard | 17.1 | A A. T. G. G.. C. . |
| <i>P. sexstriatus</i> | Lizard | 17.2 | A A. T. G. G.. C. . |
| <i>P. sexstriatus</i> | Lizard | 17.3 | ... G.... A A. T. G. G.. C. . |
| <i>P. sexstriatus</i> | Lizard | 17.4 | A A. T. G. G.. C. . |
| <i>P. sexstriatus</i> | Lizard | 17.5 | A A. T. G. G.. C. . |
| <i>P. sexstriatus</i> | Lizard | 17.6 | ... G.... A A. T. G. G.. C. . |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|--------------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| 1. <i>C. meredithi</i> Heron 16.1 | - | | | | | | | | | | | |
| 2. <i>C. meredithi</i> Heron 22.1 | 0 | - | | | | | | | | | | |
| 3. <i>C. meredithi</i> Heron 22.2 | 0 | 0 | - | | | | | | | | | |
| 4. <i>C. meredithi</i> Heron 22.3 | 1 | 1 | 1 | - | | | | | | | | |
| 5. <i>C. meredithi</i> Heron 14.1 | 7 | 7 | 7 | 8 | - | | | | | | | |
| 6. <i>C. bicolor</i> Heron 1 | 8 | 8 | 8 | 8 | 7 | - | | | | | | |
| 7. <i>P. sexstriatus</i> Lizard 171 | 6 | 6 | 6 | 7 | 7 | 8 | - | | | | | |
| 8. <i>P. sexstriatus</i> Lizard 172 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | - | | | | |
| 9. <i>P. sexstriatus</i> Lizard 173 | 7 | 7 | 7 | 8 | 8 | 9 | 1 | 1 | - | | | |
| 10. <i>P. sexstriatus</i> Lizard 174 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | 0 | 1 | - | | |
| 11. <i>P. sexstriatus</i> Lizard 175 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | 0 | 1 | 0 | - | |
| 12. <i>P. sexstriatus</i> Lizard 176 | 7 | 7 | 7 | 8 | 8 | 9 | 1 | 1 | 0 | 1 | 1 | - |



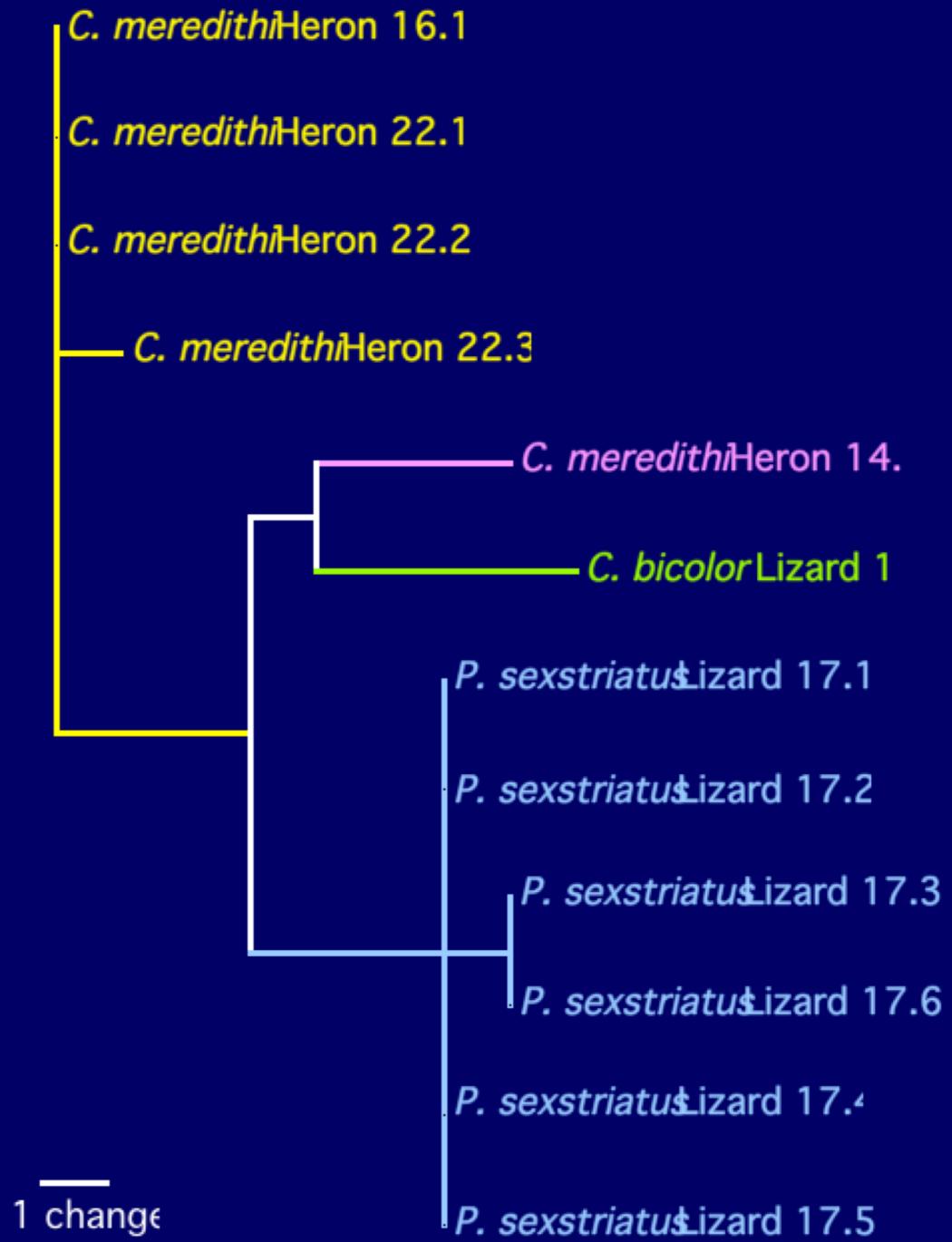
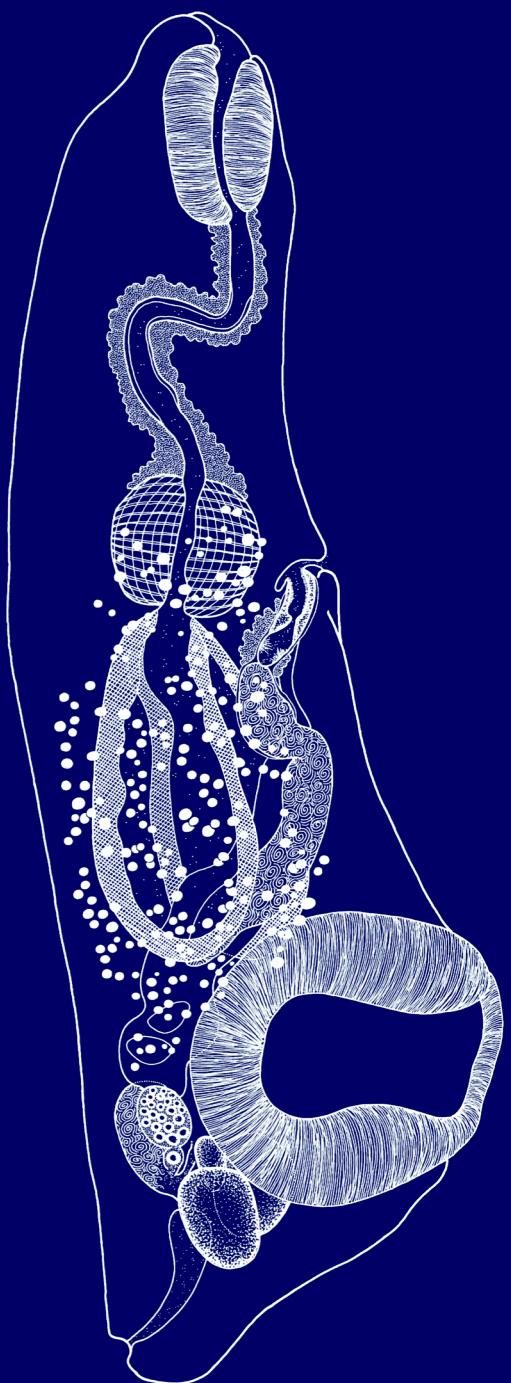
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|--------------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| 1. <i>C. meredithi</i> Heron 16.1 | - | | | | | | | | | | | |
| 2. <i>C. meredithi</i> Heron 22.1 | 0 | - | | | | | | | | | | |
| 3. <i>C. meredithi</i> Heron 22.2 | 0 | 0 | - | | | | | | | | | |
| 4. <i>C. meredithi</i> Heron 22.3 | 1 | 1 | 1 | - | | | | | | | | |
| 5. <i>C. meredithi</i> Heron 14.1 | 7 | 7 | 7 | 8 | - | | | | | | | |
| 6. <i>C. bicolor</i> Heron 1 | 8 | 8 | 8 | 8 | 7 | - | | | | | | |
| 7. <i>P. sexstriatus</i> Lizard 171 | 6 | 6 | 6 | 7 | 7 | 8 | - | | | | | |
| 8. <i>P. sexstriatus</i> Lizard 172 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | - | | | | |
| 9. <i>P. sexstriatus</i> Lizard 173 | 7 | 7 | 7 | 8 | 8 | 9 | 1 | 1 | - | | | |
| 10. <i>P. sexstriatus</i> Lizard 174 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | 0 | 1 | - | | |
| 11. <i>P. sexstriatus</i> Lizard 175 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | 0 | 1 | 0 | - | |
| 12. <i>P. sexstriatus</i> Lizard 176 | 7 | 7 | 7 | 8 | 8 | 9 | 1 | 1 | 0 | 1 | 1 | - |

~0-0.21%
variation

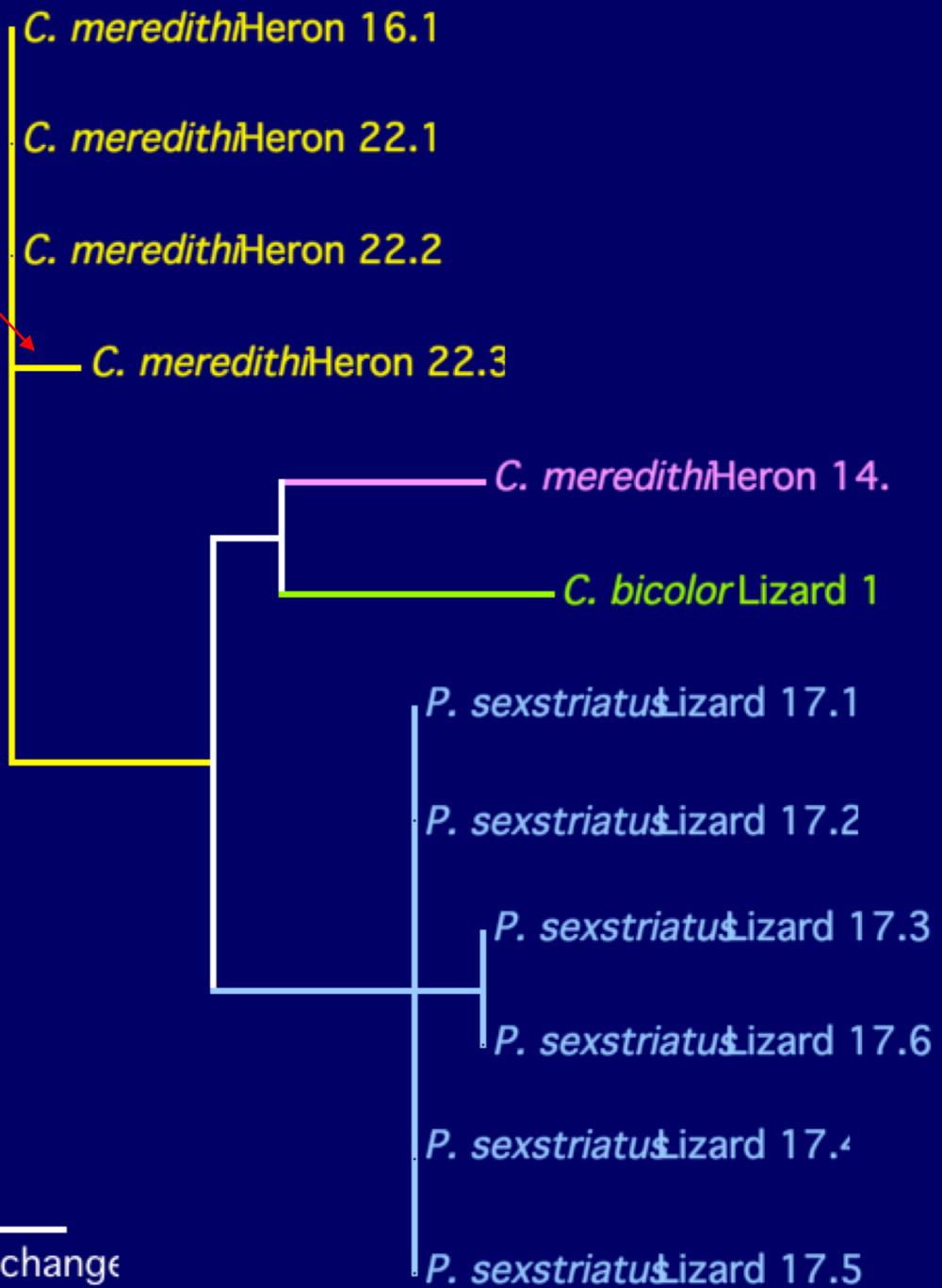
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|--------------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|
| 1. <i>C. meredithi</i> Heron 16.1 | - | | | | | | | | | | | |
| 2. <i>C. meredithi</i> Heron 22.1 | 0 | - | | | | | | | | | | |
| 3. <i>C. meredithi</i> Heron 22.2 | 0 | 0 | - | | | | | | | | | |
| 4. <i>C. meredithi</i> Heron 22.3 | 1 | 1 | 1 | - | | | | | | | | |
| 5. <i>C. meredithi</i> Heron 14.1 | 7 | 7 | 7 | 8 | - | | | | | | | |
| 6. <i>C. bicolor</i> Heron 1 | 8 | 8 | 8 | 8 | 7 | - | | | | | | |
| 7. <i>P. sexstriatus</i> Lizard 171 | 6 | 6 | 6 | 7 | 7 | 8 | - | | | | | |
| 8. <i>P. sexstriatus</i> Lizard 172 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | - | | | | |
| 9. <i>P. sexstriatus</i> Lizard 173 | 7 | 7 | 7 | 8 | 8 | 9 | 1 | 1 | - | | | |
| 10. <i>P. sexstriatus</i> Lizard 174 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | 0 | 1 | - | | |
| 11. <i>P. sexstriatus</i> Lizard 175 | 6 | 6 | 6 | 7 | 7 | 8 | 0 | 0 | 1 | 0 | - | |
| 12. <i>P. sexstriatus</i> Lizard 176 | 7 | 7 | 7 | 8 | 8 | 9 | 1 | 1 | 0 | 1 | 1 | - |



~1.26-1.89%
difference

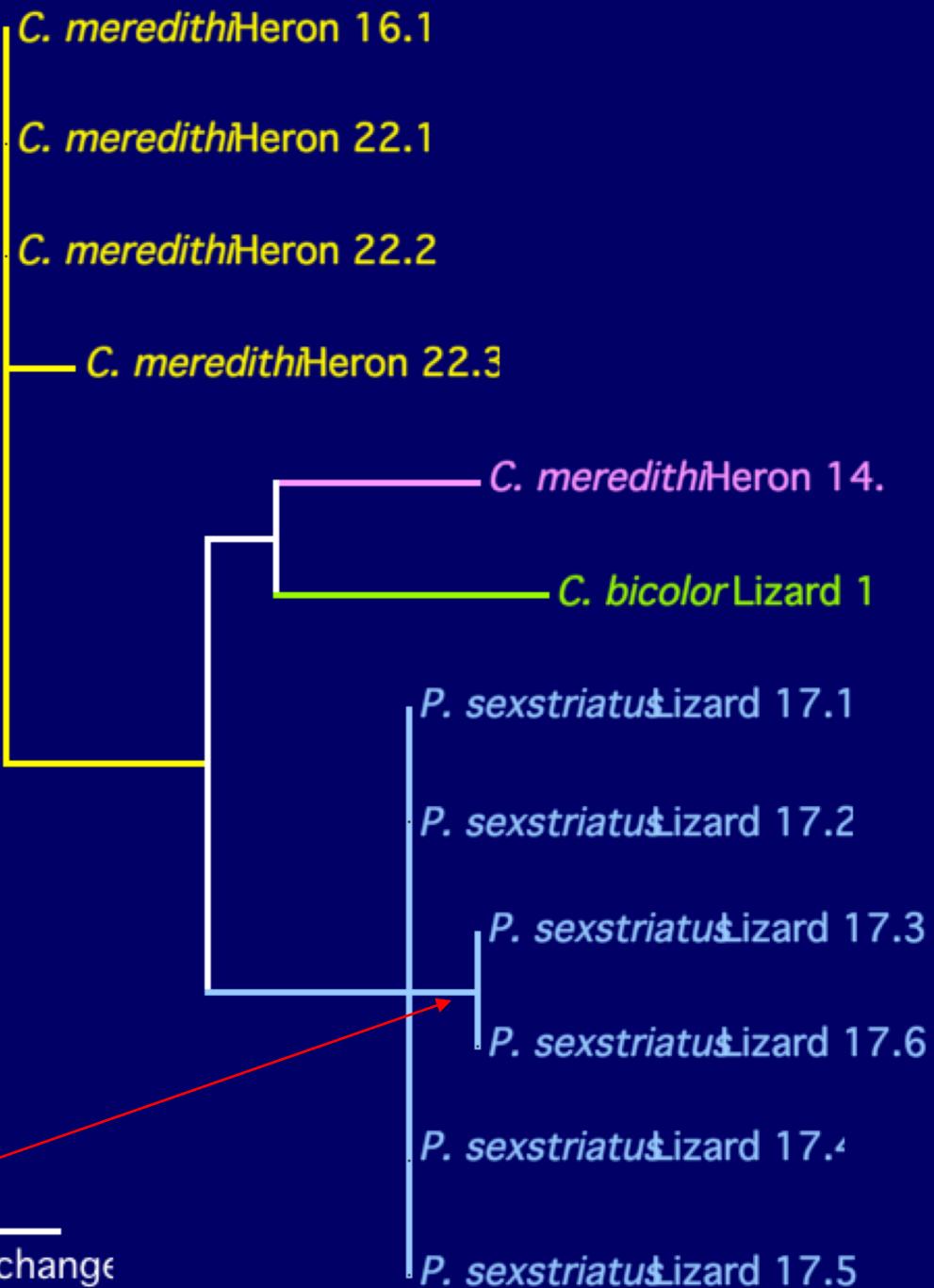


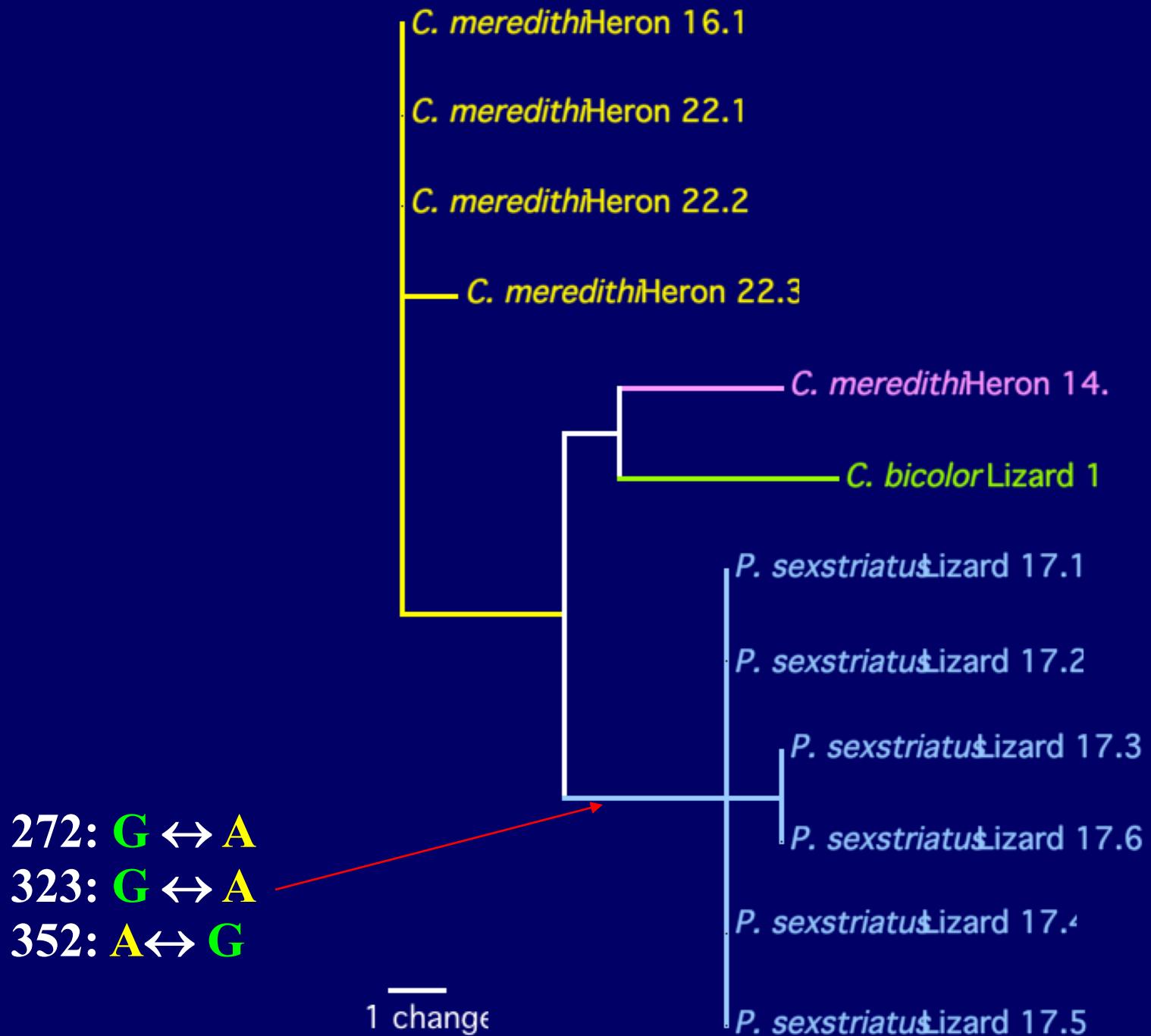
471: G ↔ T

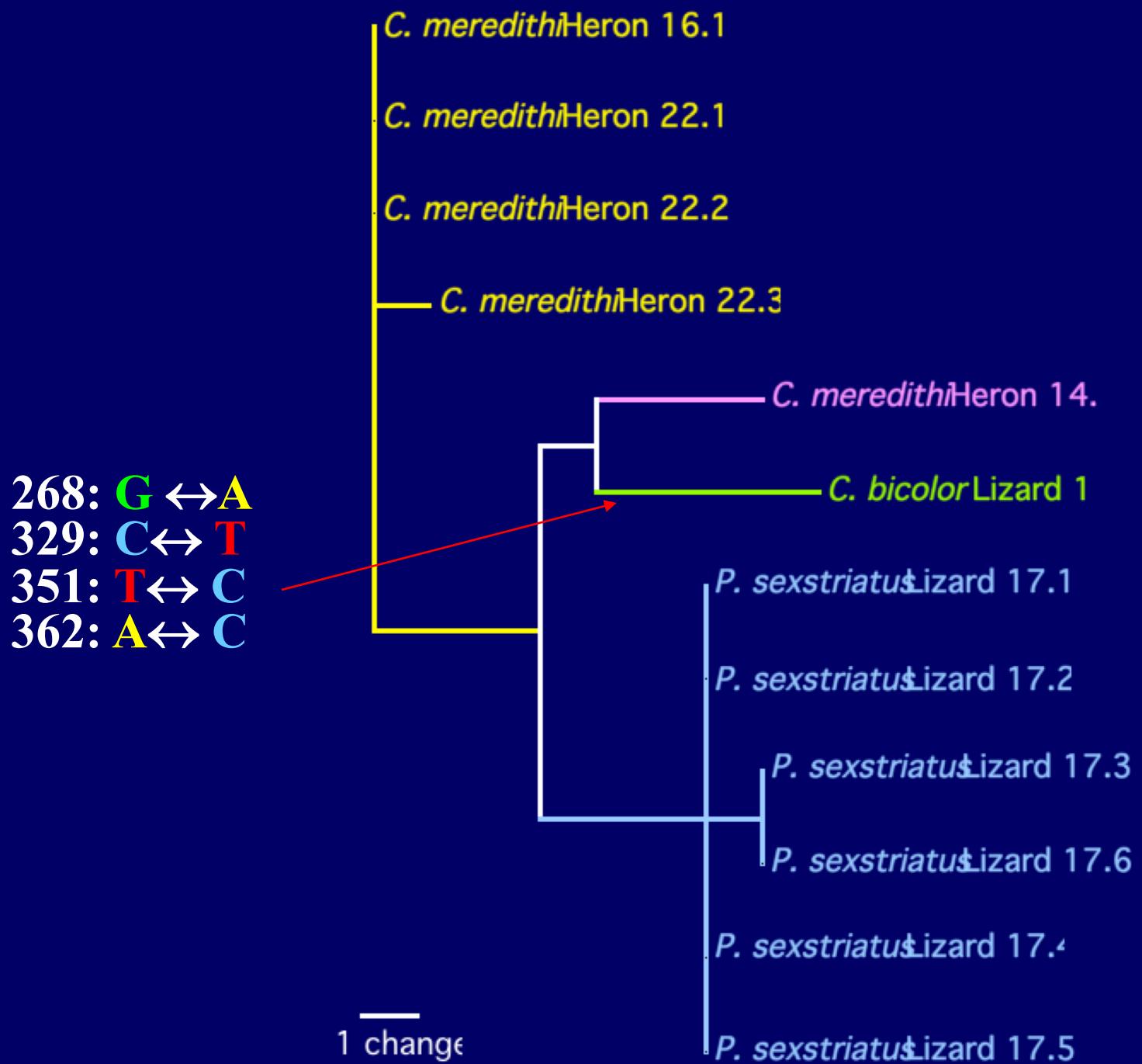


235: A↔G

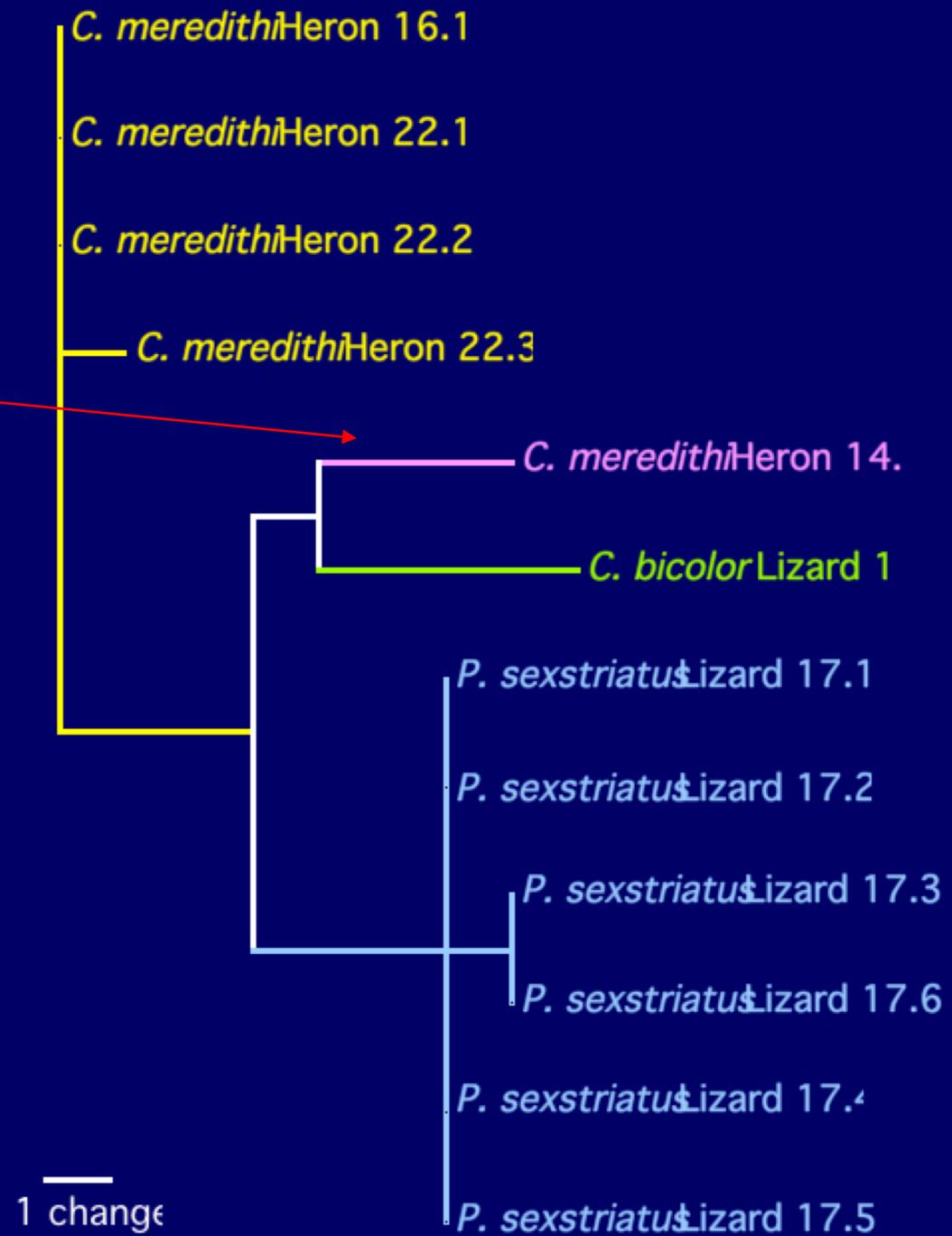
1 change

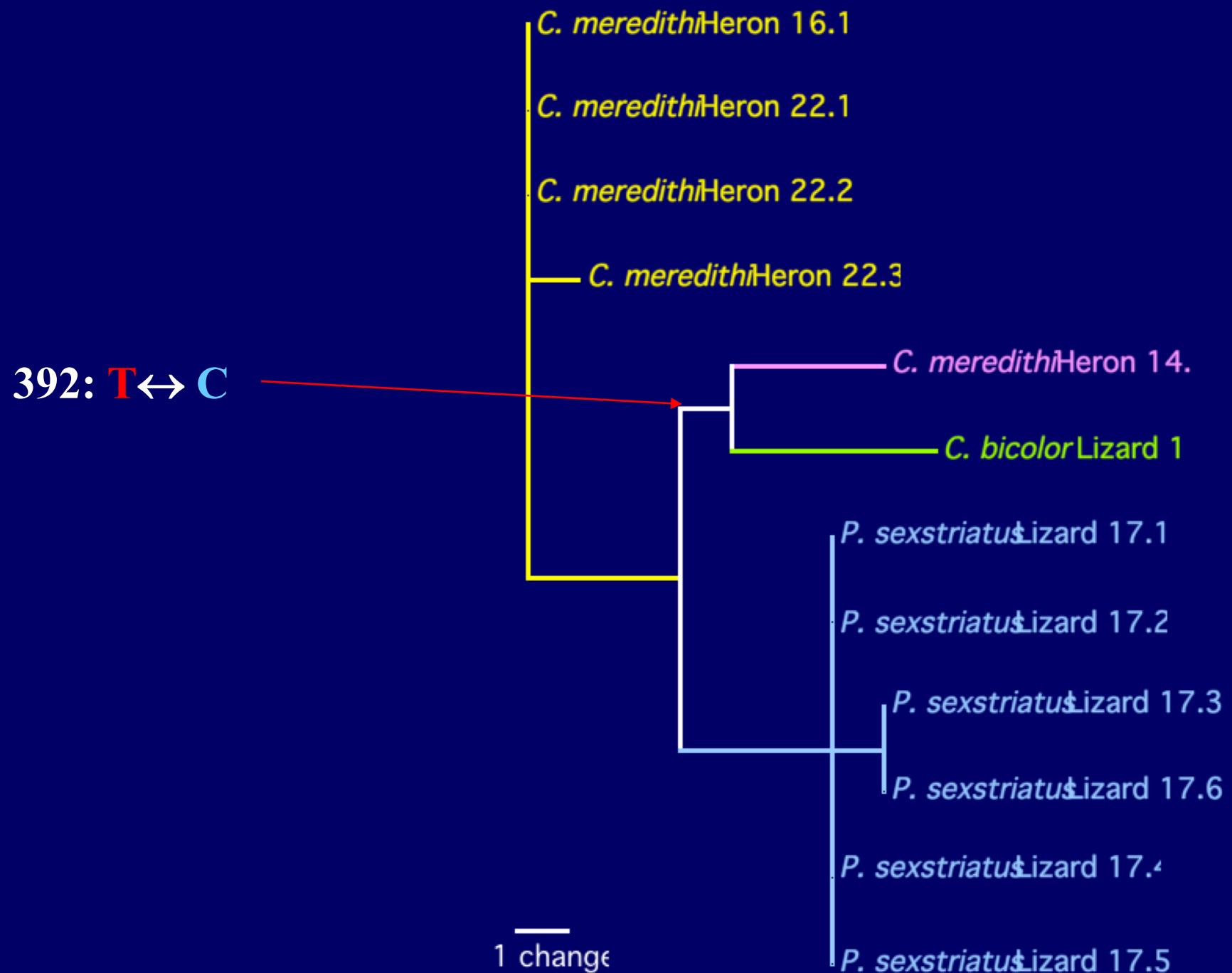


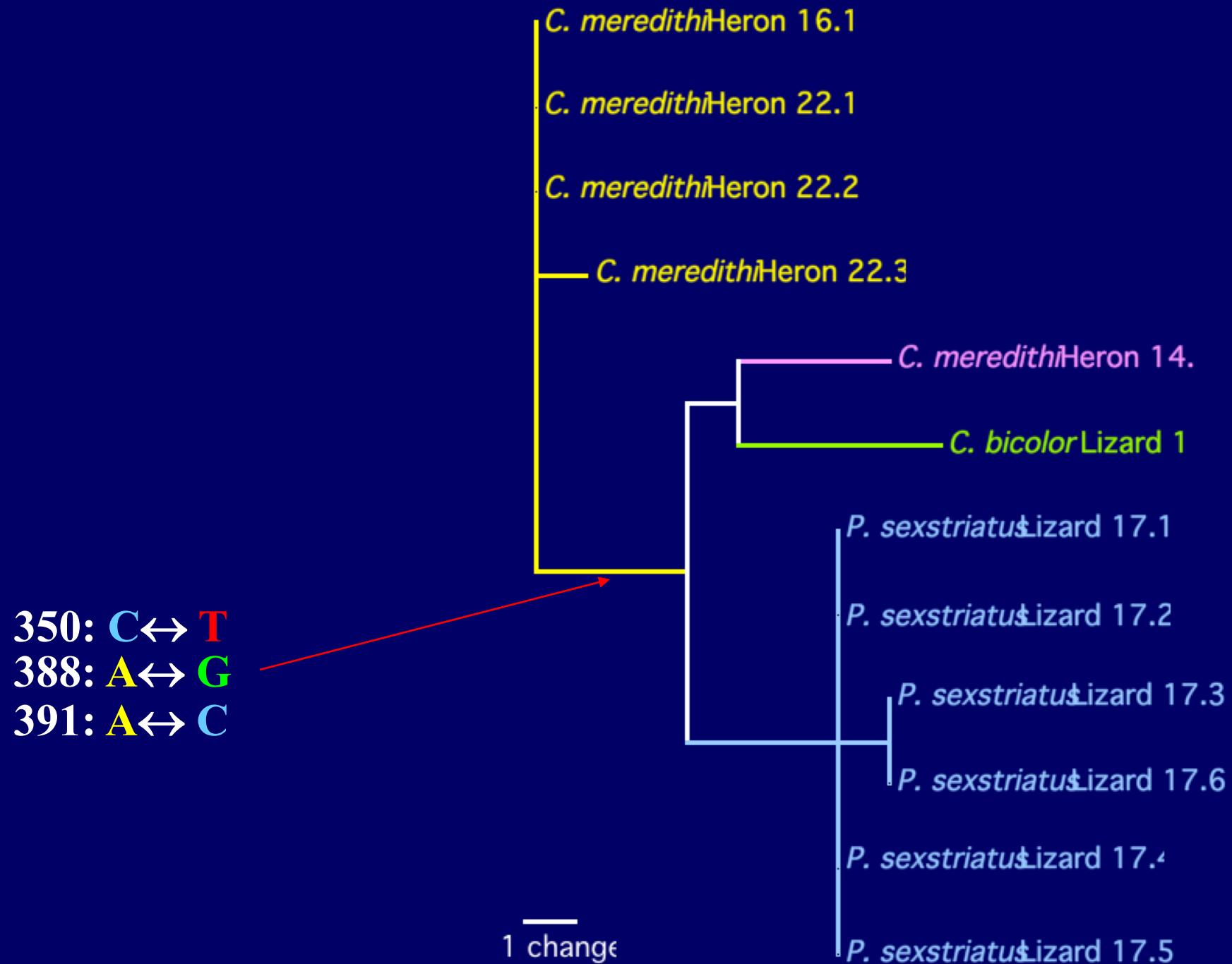


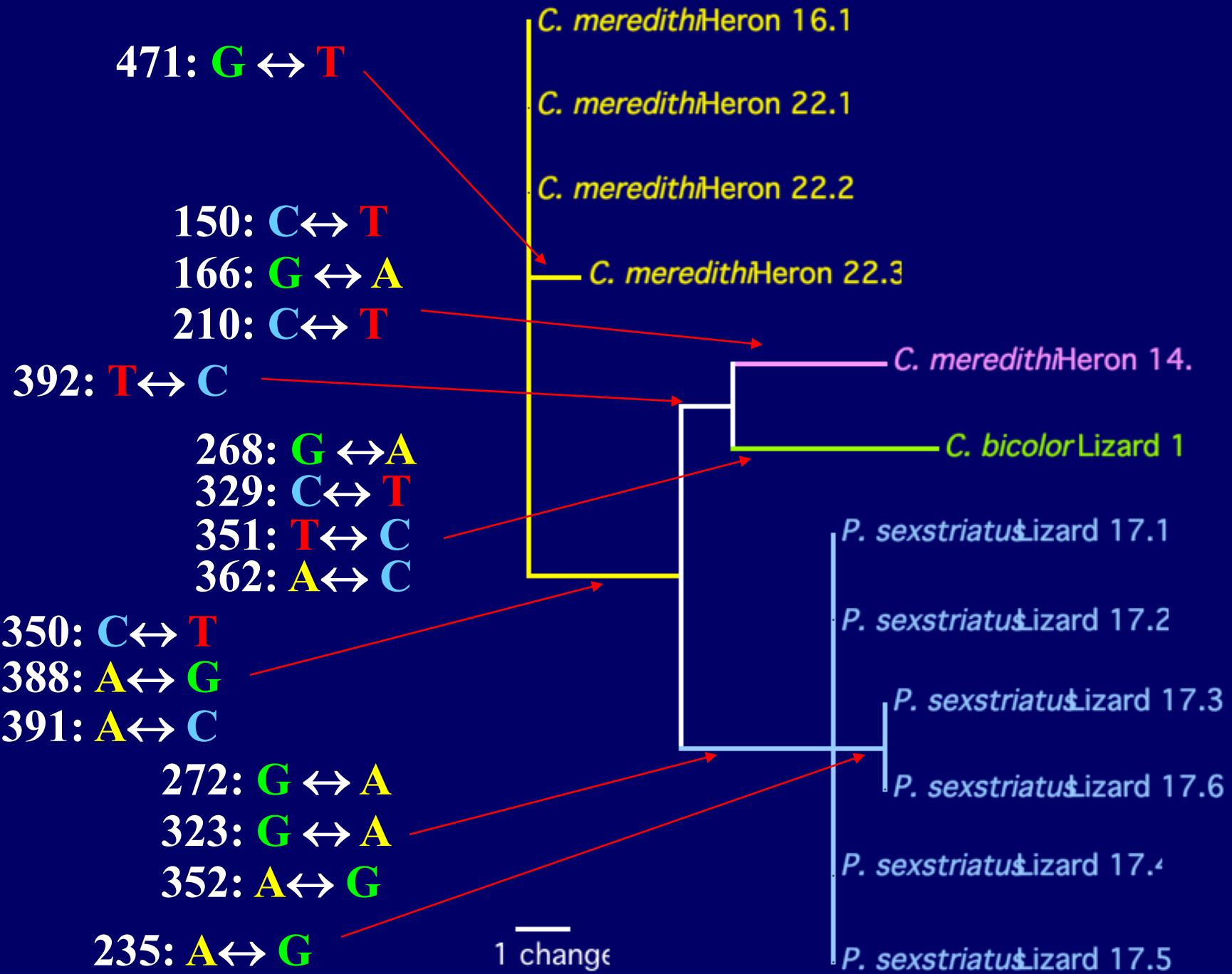


150: C↔T
166: G↔A
210: C↔T

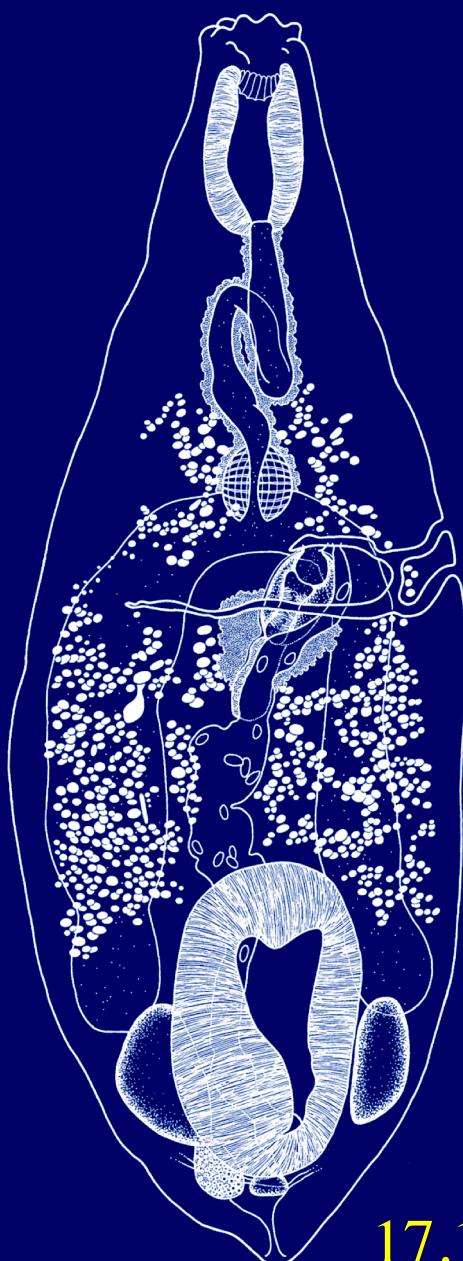




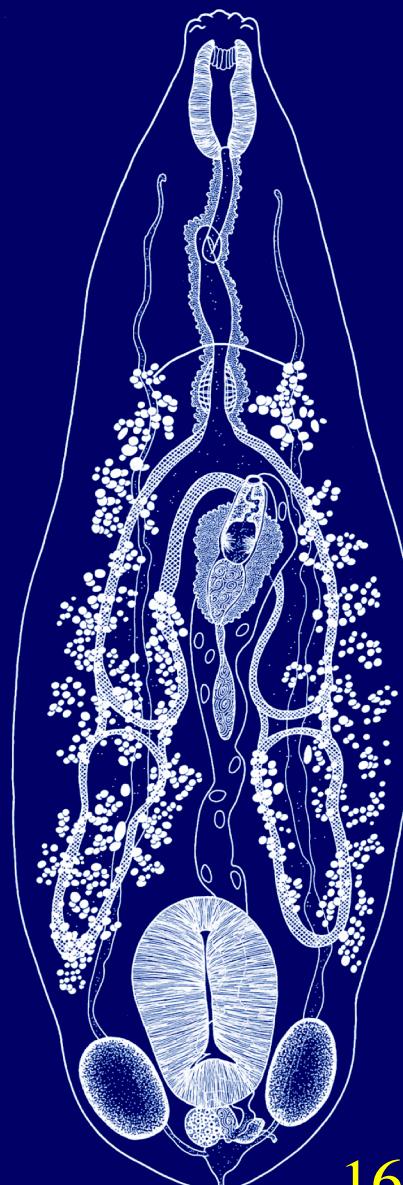




Chaetodontoplus meredithi, Heron Island



17.1-17.6



16.1



22.1-22.3

Pomacanthus sexstriatus, Lizard Island

14.1

| | | | | | | |
|--------------------------------------|------|---|--|---|--|--|
| | 1 | 2 | | 3 | | |
| <i>S. p uellus</i> Heron | 21.1 | | | | | |
| <i>S. p uellus</i> Heron | 21.2 | | | | | |
| <i>S. p unctatus</i> Heron | 12.1 | | | | | |
| <i>S. p unctatus</i> Heron | 12.4 | | | | | |
| <i>S. p unctatus</i> Heron | 12.6 | | | | | |
| <i>S. v ulpis nus</i> Heron | 1 | | | | | |
| <i>S. a rgenteus</i> Li zar d | 6.2 | | | | | |
| <i>S. a rgenteus</i> Li zar d | 6.3 | | | | | |
| <i>S. a rgenteus</i> Li zard | 6.4 | | | | | |
| <i>S. a rgenteus</i> Li zard | 6.5 | | | | | |
| <i>S. f uscescens</i> Li zar d | 7.1 | | | | | |
| <i>S. f uscescens</i> Li zar d | 7.2 | | | | | |
| <i>S. f uscescens</i> Li zar d | 7.3 | | | | | |
| <i>S. l in eatus</i> Li zard | 3 | | | | | |
| <i>S. l in eatus</i> Li zard | 4.2 | | | | | |
| <i>S. l in eatus</i> Li zard | 4.3 | | | | | |
| <i>S. l in eatus</i> Li zard | 4.4 | | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 1.3 | | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 1.4 | | | | | |
| <i>S. p unctati ssi mus</i> Li zard | 1.5 | | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 23.1 | | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 23.3 | | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 23.4 | | | | | |
| <i>S. v ulpis nus</i> Li zar d | 2 | | | | | |
| <i>S. v ulpis nus</i> Li zar d | 9.1 | | | | | |
| <i>S. c oral l in us</i> Pal au | 5.1 | | | | | |
| <i>S. c oral l in us</i> Pal au | 5.2 | | | | | |
| <i>S. c oral l in us</i> Pal au | 5.3 | | | | | |
| <i>S. c oral l in us</i> Pal au | 5.4 | | | | | |
| <i>S. c oral l in us</i> Pal au | 5.5 | | | | | |
| <i>S. v ulpis nus</i> Pal au | 8.1 | | | | | |
| <i>S. v ulpis nus</i> Pal au | 8.2 | | | | | |
| <i>Z. c ornutus</i> Heron | 5 | | | | | |
| <i>S. v ulpis nus</i> Li zar d | 9.2 | | | | | |
| <i>S. v ulpis nus</i> Li zar d | 9.3 | | | | | |
| <i>S. v ulpis nus</i> Li zar d | 9.4 | | | | | |
| <i>S. v ulpis nus</i> Li zar d | 9.5 | | | | | |

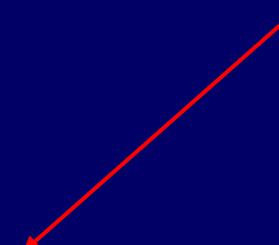
T A T T G G T C T A T G A T A T A T C G
N N N
A C G G G T
A C G G G T
A C G G N T
A C G G G T



ITS2 rDNA ~ 455 bp
samples from siganid
and zanclid fishes of
the GBR

| | | | | | |
|--------------------------------------|------|---|-----|-----|-----|
| | 1 | 2 | | 3 | |
| <i>S. p uellus</i> Heron | 21.1 | | 1 | 3 | 6 |
| <i>S. p uellus</i> Heron | 21.2 | 0 | 6 | 6 | 8 |
| <i>S. p unctatus</i> Heron | 12.1 | 9 | 1 | 3 | 6 |
| <i>S. p unctatus</i> Heron | 12.4 | | 7 | 2 | 5 |
| <i>S. p unctatus</i> Heron | 12.6 | | 7 | 1 | |
| <i>S. v ulpi nus</i> Heron | 1 | | | | |
| <i>S. a rgenteus</i> Li zar d | 6.2 | | T | A | T |
| <i>S. a rgenteus</i> Li zar d | 6.3 | | TTT | GGT | CAT |
| <i>S. a rgenteus</i> Li zard | 6.4 | | G | A | T |
| <i>S. a rgenteus</i> Li zard | 6.5 | | | | |
| <i>S. f uscescens</i> Li zar d | 7.1 | | | | |
| <i>S. f uscescens</i> Li zar d | 7.2 | | | | |
| <i>S. f uscescens</i> Li zar d | 7.3 | | | | |
| <i>S. l in eatus</i> Li zard | 3 | | | | |
| <i>S. l in eatus</i> Li zard | 4.2 | | | | |
| <i>S. l in eatus</i> Li zard | 4.3 | | | | |
| <i>S. l in eatus</i> Li zard | 4.4 | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 1.3 | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 1.4 | | | | |
| <i>S. p unctati ssi mus</i> Li zard | 1.5 | | | | |
| <i>S. p unctati ssi mus</i> Li zar d | 23.1 | | N | . | . |
| <i>S. p unctati ssi mus</i> Li zar d | 23.3 | | . | . | . |
| <i>S. p unctati ssi mus</i> Li zar d | 23.4 | | . | . | . |
| <i>S. v ulpi nus</i> Li zar d | 2 | | . | . | . |
| <i>S. v ulpi nus</i> Li zar d | 9.1 | | N | N | N |
| <i>S. c oral l in us</i> Pal au | 5.1 | | . | . | . |
| <i>S. c oral l in us</i> Pal au | 5.2 | | . | . | . |
| <i>S. c oral l in us</i> Pal au | 5.3 | | . | . | . |
| <i>S. c oral l in us</i> Pal au | 5.4 | | . | . | . |
| <i>S. c oral l in us</i> Pal au | 5.5 | | . | . | . |
| <i>S. v ulpi nus</i> Pal au | 8.1 | | . | . | . |
| <i>S. v ulpi nus</i> Pal au | 8.2 | | . | . | . |
| <i>Z. c ornutus</i> Heron | 5 | | . | . | . |
| <i>S. v ulpi nus</i> Li zar d | 9.2 | A | C | G | G T |
| <i>S. v ulpi nus</i> Li zar d | 9.3 | A | C | G | G T |
| <i>S. v ulpi nus</i> Li zar d | 9.4 | A | C | G | N T |
| <i>S. v ulpi nus</i> Li zar d | 9.5 | A | C | G | G T |

6 fixed differences
~1.3% difference



S. doliatus Li zard s p. 1 3
S. doliatus Li zard s p. 1 4
S. vulgaris Heron sp. 1 1
S. vulgaris Li zard s p. 1 2
S. vulgaris Li zard s p. 2 2
S. lineatus Li zard s p. 2 3
S. lineatus Li zard s p. 2 4
Z. cornutus Heron sp. 2 5

| | | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 011 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| 000 | 000 | 111 | 111 | 122 | 444 | 444 | 444 | 455 | 677 | 888 | 999 | 900 | 000 | 001 | 111 | 222 | 333 | 444 | 444 | | | |
| 123 | 789 | 012 | 678 | 901 | 012 | 345 | 678 | 901 | 901 | 789 | 678 | 901 | 234 | 890 | 789 | 012 | 567 | 123 | 456 | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|-----------|--------|-------|------|-----|-----|--------|--------|------|------|------|------|-------|---------|------|------|------|------|-----|-----|---|---|
| GTA | ATT | TTG | TTA | TTG | ATG | AAG | CTT | GTG | ATT | TTG | TTG | GGG | AGG | TTT | AGT | TTT | TTA | TAT | GAT | | |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| .. G G .. | | C. | R. | RN | . | . | R | . | . | Y. | R | . | . | . | . | . | . | . | . | . | . |
| .. G .. | A .. | G .. | . | . | . | . | A T .. | G .. | . | A .. | G .. | . | GA .. | . | C .. | T .. | A .. | . | . | . | . |
| .. G .. | A .. | GT .. | C .. | . | . | C .. | A T .. | G .. | . | A .. | G .. | . | C GA .. | . | C .. | T .. | A .. | . | . | . | . |
| .. G .. | A .. | G .. | . | . | . | A T .. | G .. | . | A .. | G .. | . | GA .. | . | C .. | T .. | A .. | . | . | . | . | . |
| .. G .. | A .. | G .. | T .. | . | . | A T .. | G .. | . | A .. | G .. | . | GA .. | . | C .. | T .. | A .. | . | . | . | . | . |

| | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 111 | 111 | 111 | 111 | 111 | 111 | 111 | 122 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 333 | 333 |
| 666 | 666 | 666 | 677 | 777 | 778 | 999 | 900 | 000 | 000 | 001 | 111 | 333 | 444 | 444 | 777 | 888 | 999 | 223 | 333 | | |
| 012 | 345 | 678 | 901 | 567 | 890 | 012 | 901 | 234 | 567 | 890 | 123 | 567 | 456 | 789 | 789 | 345 | 567 | 890 | 123 | | |

| | | | | | | | | | | | | | | | | | | | | | |
|---------|------|------|------|-------|-------|------|------|--------|------|------|------|------|------|------|------|------|------|--------|--------|------|----|
| CAA | AGT | GGT | GTT | GCT | AAT | TTA | TTA | GTT | ATT | ACT | AGA | AGT | TGG | GGT | TGC | CGG | GGC | ATA | GTT | | |
| . | . | . | . | . | . | . | . | . | . | . | G | . | . | A | . | . | . | . | . | . | . |
| .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. | .. |
| .. G .. | G .. | G .. | G .. | TG .. | GA .. | G .. | G .. | G G .. | G .. | G .. | G .. | A .. | A .. | A .. | T .. | T .. | T .. | G G .. | T .. | | |
| .. G .. | G .. | G .. | G .. | TG .. | GA .. | G .. | G .. | G G .. | G .. | G .. | G .. | A .. | A .. | A .. | T .. | T .. | T .. | T .. | G G .. | T .. | |
| .. G .. | G .. | A .. | G .. | TG .. | GA .. | G .. | G .. | G G .. | G .. | G .. | G .. | A .. | A .. | A .. | T .. | T .. | T .. | T .. | G G .. | T .. | |
| .. G .. | G .. | G .. | G .. | TG .. | GA .. | G .. | G .. | G G .. | G .. | G .. | G .. | A .. | A .. | A .. | C .. | T .. | T .. | T .. | G G .. | T .. | |

| | | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | |
| 555 | 555 | 777 | 777 | 788 | 888 | 889 | 999 | 000 | 111 | 111 | 111 | 333 | 344 | | | | | | | | | |
| 234 | 567 | 345 | 678 | 901 | 234 | 890 | 123 | 678 | 234 | 567 | 678 | 901 | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|---------|------|------|------|------------|------|------|----------|--------|------|-----|-----|-----|---|---|---|---|---|---|---|---|---|
| TGA | AGT | AGT | ACT | TTA | GAG | AGC | TGG | CTT | CCT | CTG | GTT | GGT | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | T | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| .. | .. | .. | .. | .. | .. | .. | T | . | . | . | . | C | . | . | . | . | . | . | . | . | . |
| .. | .. | .. | .. | .. | .. | .. | T | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| .. G .. | G .. | G .. | A .. | T G A T .. | A .. | T .. | A T G .. | G T .. | A .. | . | . | . | . | . | . | . | . | . | . | . | . |
| .. G .. | G .. | G .. | A .. | T G A T .. | A .. | T .. | A T G .. | G T .. | A .. | . | . | . | . | . | . | . | . | . | . | . | . |
| .. G .. | G .. | G .. | A .. | T G A T .. | A .. | T .. | A T G .. | G T .. | A .. | . | . | . | . | . | . | . | . | . | . | . | . |
| .. G .. | G .. | G .. | A .. | T G A T .. | A .. | T .. | A T G .. | G T .. | A .. | . | . | . | . | . | . | . | . | . | . | . | . |

ND1 mtDNA

~453 bp

samples from
siganid and
zanclid fishes
of the GBR

| | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 000 | 011 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 |
| 000 | 000 | 111 | 111 | 122 | 444 | 444 | 444 | 455 | 677 | 888 | 999 | 900 | 000 | 001 | 111 | 222 | 333 | 444 | 444 | | |
| 123 | 789 | 012 | 678 | 901 | 012 | 345 | 678 | 901 | 901 | 789 | 678 | 901 | 234 | 890 | 789 | 012 | 567 | 123 | 456 | | |

| | | | | | | | | | | | | | | | | | | | | | | |
|------------------------------------|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <i>S. doliatus</i> Li zard s p. | 1 | 3 | GTA | ATT | TTG | TTA | TTG | ATG | AAG | CTT | GTG | ATT | TTG | TTG | GGG | AGG | TTT | AGT | TTT | TTA | TAT | GAT |
| <i>S. doliatus</i> Li zard s p. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulgaris</i> Heron sp. | 1 | 1 | . | G | G | . | . | C | . | R | . | RN | . | . | . | . | Y | . | R | . | . | |
| <i>S. vulgaris</i> Li zard s p. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | |
| <i>S. vulgaris</i> Li zard s p. | 2 | 2 | . | G | . | . | A | . | G | . | . | . | A | T | . | G | . | A | . | G | . | |
| <i>S. l. in eatus</i> Li zard s p. | 2 | 3 | . | G | . | . | A | . | GT | C | . | . | C | . | A | T | . | G | . | C | GA | |
| <i>S. l. in eatus</i> Li zard s p. | 2 | 4 | . | G | . | . | A | . | G | . | . | . | A | T | . | G | . | A | . | G | . | |
| <i>Z. cornutus</i> Heron sp. | 2 | 5 | . | G | . | . | A | . | G | . | T | . | . | A | T | . | G | . | A | . | GA | |

| | | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| 111 | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 122 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 333 | 333 | |
| 666 | 666 | 666 | 677 | 777 | 778 | 999 | 900 | 000 | 000 | 000 | 001 | 111 | 333 | 444 | 444 | 777 | 888 | 999 | 223 | 333 | | |
| 012 | 345 | 678 | 901 | 567 | 890 | 012 | 901 | 234 | 567 | 890 | 123 | 567 | 456 | 789 | 789 | 345 | 567 | 890 | 123 | | | |

| | | | | | | | | | | | | | | | | | | | | | | |
|------------------------------------|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| <i>S. doliatus</i> Li zard s p. | 1 | 3 | CAA | AGT | GGT | GTT | GCT | AAT | TTA | TTA | GTT | ATT | ACT | AGA | AGT | TGG | GGT | TGC | CGG | GGC | ATA | GTT |
| <i>S. doliatus</i> Li zard s p. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulgaris</i> Heron sp. | 1 | 1 | . | . | . | . | . | . | . | . | . | . | . | G | . | . | . | A | . | . | . | . |
| <i>S. vulgaris</i> Li zard s p. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulgaris</i> Li zard s p. | 2 | 2 | . | G | . | G | . | G | . | TG | GA | . | G | . | G | G | . | G | . | A | A | . |
| <i>S. l. in eatus</i> Li zard s p. | 2 | 3 | . | G | . | G | . | G | . | TG | GA | . | G | . | G | G | . | G | . | A | A | . |
| <i>S. l. in eatus</i> Li zard s p. | 2 | 4 | . | G | . | G | . | A | . | TG | GA | . | G | . | G | G | . | G | . | A | A | . |
| <i>Z. cornutus</i> Heron sp. | 2 | 5 | . | G | . | G | . | G | . | TG | GA | . | G | . | G | G | . | A | . | G | A | . |

| | | | | | | | | | | | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--|
| 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | |
| 555 | 555 | 777 | 777 | 788 | 888 | 889 | 999 | 900 | 111 | 111 | 111 | 333 | 333 | 344 | | | | | | | | |
| 234 | 567 | 345 | 678 | 901 | 234 | 890 | 123 | 678 | 234 | 567 | 678 | 901 | | | | | | | | | | |

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|------------------------------------|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---|---|---|---|---|---|---|
| <i>S. doliatus</i> Li zard s p. | 1 | 3 | TGA | AGT | AGT | ACT | TTA | GAG | AGC | TGG | CTT | CCT | CTG | GTT | GGT | . | . | . | . | . | . | . |
| <i>S. doliatus</i> Li zard s p. | 1 | 4 | . | . | . | . | . | . | . | T | . | . | . | . | . | . | . | . | . | . | . | |
| <i>S. vulgaris</i> Heron sp. | 1 | 1 | . | . | . | . | . | . | . | T | . | . | . | . | C | . | . | . | . | . | . | |
| <i>S. vulgaris</i> Li zard s p. | 1 | 2 | . | . | . | . | . | . | . | T | . | . | . | . | . | . | . | . | . | . | . | |
| <i>S. vulgaris</i> Li zard s p. | 2 | 2 | . | G | G | G | A | T | G | A | T | . | A | T | G | . | G | T | . | A | . | |
| <i>S. l. in eatus</i> Li zard s p. | 2 | 3 | . | G | G | A | T | G | A | T | . | A | T | G | . | G | T | A | . | . | . | |
| <i>S. l. in eatus</i> Li zard s p. | 2 | 4 | . | G | G | A | T | G | A | T | . | A | T | G | . | G | T | A | . | . | . | |
| <i>Z. cornutus</i> Heron sp. | 2 | 5 | . | G | G | A | T | G | A | T | . | A | T | G | . | G | T | A | . | . | . | |

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|--------------------|--------|------|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---|
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| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>S. doliatus</i> | Lizard | s p. | 1 | 3 | GTA | ATT | TTG | TTA | TTG | ATG | AAG | CTT | GTG | ATT | TTG | TTG | GGG | AGG | TTT | AGT | TTT | TTA | TAT | GAT | | | | | |
| <i>S. doliatus</i> | Lizard | s p. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | | | | | |
| <i>S. vulgaris</i> | Heron | sp. | 1 | 1 | . | G | G | . | . | C | . | R | RN | . | R | . | . | Y | . | R | . | . | | | | | | | |
| <i>S. vulgaris</i> | Lizard | s p. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | | | | | | |
| <i>S. vulgaris</i> | Lizard | s p. | 2 | 2 | . | G | . | A | G | . | . | . | . | A | T | G | . | A | G | . | GA | . | C | T | A | | | | |
| <i>S. linearis</i> | Lizard | s p. | 2 | 3 | . | G | . | A | GT | C | . | . | C | . | A | T | G | . | A | G | . | C | GA | C | T | A | | | |
| <i>S. linearis</i> | Lizard | s p. | 2 | 4 | . | G | . | A | G | . | . | . | A | T | G | . | A | G | . | GA | . | C | T | A | | | | | |
| <i>Z. cornutus</i> | Heron | sp. | 2 | 5 | . | G | . | A | G | T | . | . | . | A | T | G | . | A | G | . | GA | . | C | T | A | | | | |
| | | | | | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 122 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 333 | 333 | | | | | |
| | | | | | 666 | 666 | 666 | 677 | 777 | 778 | 999 | 900 | 000 | 000 | 001 | 111 | 333 | 444 | 444 | 777 | 888 | 999 | 223 | 333 | | | | | |
| | | | | | 012 | 345 | 678 | 901 | 567 | 890 | 012 | 901 | 234 | 567 | 890 | 123 | 567 | 456 | 789 | 789 | 345 | 567 | 890 | 123 | | | | | |
| <i>S. doliatus</i> | Lizard | s p. | 1 | 3 | CAA | AGT | GGT | GTT | GCT | AAT | TTA | TTA | GTT | ATT | ACT | AGA | AGT | TGG | GGT | TGC | CGG | GGC | ATA | GTT | | | | | |
| <i>S. doliatus</i> | Lizard | s p. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | | | | | |
| <i>S. vulgaris</i> | Heron | sp. | 1 | 1 | . | . | . | . | . | . | . | . | . | . | G | . | . | A | . | . | . | . | . | | | | | | |
| <i>S. vulgaris</i> | Lizard | s p. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | | | | | | |
| <i>S. vulgaris</i> | Lizard | s p. | 2 | 2 | . | G | . | G | G | TG | GA | . | G | . | G | G | G | G | A | A | . | T | T | T | G | G | T | | |
| <i>S. linearis</i> | Lizard | s p. | 2 | 3 | . | G | . | G | G | TG | GA | . | G | . | G | G | G | G | A | A | . | T | T | T | G | G | T | | |
| <i>S. linearis</i> | Lizard | s p. | 2 | 4 | . | G | . | G | A | G | TG | GA | . | G | . | G | G | G | A | A | . | T | T | T | T | G | G | T | |
| <i>Z. cornutus</i> | Heron | sp. | 2 | 5 | . | G | . | G | G | TG | GA | . | G | . | G | G | G | A | G | A | A | C | T | T | T | T | G | G | T |
| | | | | | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | | | | |
| | | | | | 555 | 555 | 777 | 777 | 788 | 888 | 889 | 999 | 000 | 111 | 111 | 111 | 333 | 333 | 344 | 344 | 344 | 344 | 344 | 344 | 344 | 344 | 344 | 344 | |
| | | | | | 234 | 567 | 345 | 678 | 901 | 234 | 890 | 123 | 678 | 234 | 567 | 678 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | 901 | |
| <i>S. doliatus</i> | Lizard | s p. | 1 | 3 | TGA | AGT | AGT | ACT | TTA | GAG | AGC | TGG | CTT | CCT | CTG | GTT | GGT | . | . | . | . | . | . | . | . | . | . | | |
| <i>S. doliatus</i> | Lizard | s p. | 1 | 4 | . | . | . | . | . | . | . | T | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Heron | sp. | 1 | 1 | . | . | . | . | . | . | . | . | . | T | . | . | . | C | . | . | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Lizard | s p. | 1 | 2 | . | . | . | . | . | . | . | . | . | T | . | . | . | . | . | . | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Lizard | s p. | 2 | 2 | . | G | G | G | A | T | G | A | T | A | T | G | G | T | A | . | . | . | . | . | . | | | | |
| <i>S. linearis</i> | Lizard | s p. | 2 | 3 | . | G | G | A | T | G | A | T | A | T | G | G | T | A | . | . | . | . | . | . | . | . | | | |
| <i>S. linearis</i> | Lizard | s p. | 2 | 4 | . | G | G | A | T | G | A | T | A | T | G | G | T | A | . | . | . | . | . | . | . | . | | | |
| <i>Z. cornutus</i> | Heron | sp. | 2 | 5 | . | G | G | A | T | G | A | T | A | T | G | G | T | A | . | . | . | . | . | . | . | . | | | |

“bad” sequence?

| | | | | | | | | | | | | | | | | | | | | | | | | | |
|--------------------|-------------|---|---|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|---|
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| | | | | | | | | | | | | | | | | | | | | | | | | | |
| <i>S. doliatus</i> | Lizard s.p. | 1 | 3 | GTA | ATT | TTG | TTA | TTG | ATG | AAG | CTT | GTG | ATT | TTG | TTG | GGG | AGG | TTT | AGT | TTT | TTA | TAT | GAT | | |
| <i>S. doliatus</i> | Lizard s.p. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Heron sp. | 1 | 1 | . | G | G | . | . | C | . | R | . | RN | . | . | R | . | . | Y | . | R | . | . | | |
| <i>S. vulgaris</i> | Lizard s.p. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Lizard s.p. | 2 | 2 | . | G | . | A | . | G | . | . | . | . | A | T | . | G | . | A | . | G | . | GA | | |
| <i>S. linearis</i> | Lizard s.p. | 2 | 3 | . | G | . | A | . | GT | C | . | . | C | . | A | T | . | G | . | A | . | GA | . | C | |
| <i>S. linearis</i> | Lizard s.p. | 2 | 4 | . | G | . | A | . | G | . | . | . | A | T | . | G | . | A | . | G | . | GA | . | C | |
| <i>Z. cornutus</i> | Heron sp. | 2 | 5 | . | G | . | A | . | G | . | T | . | . | A | T | . | G | . | A | . | G | . | GA | . | C |
| | | | | 111 | 111 | 111 | 111 | 111 | 111 | 111 | 122 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 222 | 333 | 333 | | |
| | | | | 666 | 666 | 666 | 677 | 777 | 778 | 999 | 900 | 000 | 000 | 000 | 001 | 111 | 333 | 444 | 444 | 777 | 888 | 999 | 223 | 333 | |
| | | | | 012 | 345 | 678 | 901 | 567 | 890 | 012 | 901 | 234 | 567 | 890 | 123 | 567 | 456 | 789 | 789 | 345 | 567 | 890 | 123 | | |
| <i>S. doliatus</i> | Lizard s.p. | 1 | 3 | CAA | AGT | GGT | GTT | GCT | AAT | TTA | TTA | GTT | ATT | ACT | AGA | AGT | TGG | GGT | TGC | CGG | GGC | ATA | GTT | | |
| <i>S. doliatus</i> | Lizard s.p. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Heron sp. | 1 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | G | . | . | A | . | . | . | | |
| <i>S. vulgaris</i> | Lizard s.p. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Lizard s.p. | 2 | 2 | . | G | . | G | . | G | . | TG | . | GA | . | G | . | G | G | . | G | . | A | A | | |
| <i>S. linearis</i> | Lizard s.p. | 2 | 3 | . | G | . | G | . | G | . | TG | . | GA | . | G | . | G | G | . | G | . | A | A | | |
| <i>S. linearis</i> | Lizard s.p. | 2 | 4 | . | G | . | G | . | A | . | TG | . | GA | . | G | . | G | G | . | G | . | A | A | | |
| <i>Z. cornutus</i> | Heron sp. | 2 | 5 | . | G | . | G | . | G | . | TG | . | GA | . | G | . | G | G | . | A | . | G | A | | |
| | | | | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | 444 | | |
| | | | | 555 | 555 | 777 | 777 | 788 | 888 | 889 | 999 | 900 | 000 | 111 | 111 | 111 | 333 | 344 | 344 | 344 | 344 | 344 | 344 | | |
| | | | | 234 | 567 | 345 | 678 | 901 | 234 | 890 | 123 | 678 | 234 | 567 | 678 | 901 | | | | | | | | | |
| <i>S. doliatus</i> | Lizard s.p. | 1 | 3 | TGA | AGT | AGT | ACT | TTA | GAG | AGC | TGG | CTT | CCT | CTG | GTT | GGT | . | . | . | . | . | . | . | | |
| <i>S. doliatus</i> | Lizard s.p. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | T | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Heron sp. | 1 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | T | . | . | . | . | C | . | | |
| <i>S. vulgaris</i> | Lizard s.p. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | T | . | . | . | . | . | . | . | | |
| <i>S. vulgaris</i> | Lizard s.p. | 2 | 2 | . | G | G | G | A | T | G | A | T | A | T | G | . | G | T | A | . | . | . | | | |
| <i>S. linearis</i> | Lizard s.p. | 2 | 3 | . | G | G | A | T | G | A | T | A | T | G | . | G | T | A | . | . | . | . | | | |
| <i>S. linearis</i> | Lizard s.p. | 2 | 4 | . | G | G | A | T | G | A | T | A | T | G | . | G | T | A | . | . | . | . | | | |
| <i>Z. cornutus</i> | Heron sp. | 2 | 5 | . | G | G | A | T | G | A | T | A | T | G | . | G | T | A | . | . | . | . | | | |

“bad” sequence?



| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|------------------------------------|----|----|----|----|---|---|---|---|
| 1 <i>S. ddiatus</i> Lizard sp1 #3 | - | | | | | | | |
| 2 <i>S. ddiatus</i> Lizard sp1 #4 | 1 | - | | | | | | |
| 3 <i>S. vupinus</i> Heron sp. 1#1 | 7 | 6 | - | | | | | |
| 4 <i>S. vupinus</i> Lizard sp1 #2 | 1 | 0 | 6 | - | | | | |
| 5 <i>S. vupinus</i> Lizard sp2 #2 | 51 | 50 | 48 | 50 | - | | | |
| 6 <i>S. lineatus</i> Lizard sp2 #3 | 54 | 53 | 51 | 53 | 6 | - | | |
| 7 <i>S. lineatus</i> Lizard sp2 #4 | 51 | 50 | 48 | 50 | 3 | 7 | - | |
| 8 <i>Z. cornutus</i> Heron sp. 2#5 | 52 | 51 | 49 | 51 | 4 | 8 | 5 | - |

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|------------------------------------|----|----|----|----|---|---|---|---|
| 1 <i>S. ddiatus</i> Lizard sp1 #3 | - | | | | | | | |
| 2 <i>S. ddiatus</i> Lizard sp1 #4 | 1 | - | | | | | | |
| 3 <i>S. vupinus</i> Heron sp. 1#1 | 7 | 6 | - | | | | | |
| 4 <i>S. vupinus</i> Lizard sp1 #2 | 1 | 0 | 6 | - | | | | |
| 5 <i>S. vupinus</i> Lizard sp2 #2 | 51 | 50 | 48 | 50 | - | | | |
| 6 <i>S. lineatus</i> Lizard sp2 #3 | 54 | 53 | 51 | 53 | 6 | - | | |
| 7 <i>S. lineatus</i> Lizard sp2 #4 | 51 | 50 | 48 | 50 | 3 | 7 | - | |
| 8 <i>Z. cornutus</i> Heron sp. 2#5 | 52 | 51 | 49 | 51 | 4 | 8 | 5 | - |

~0-1.55%
variation

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|------------------------------------|----|----|----|----|---|---|---|---|
| 1 <i>S. ddiatus</i> Lizard sp1 #3 | - | | | | | | | |
| 2 <i>S. ddiatus</i> Lizard sp1 #4 | 1 | - | | | | | | |
| 3 <i>S. vupinus</i> Heron sp. 1#1 | 7 | 6 | - | | | | | |
| 4 <i>S. vupinus</i> Lizard sp1 #2 | 1 | 0 | 6 | - | | | | |
| 5 <i>S. vupinus</i> Lizard sp2 #2 | 51 | 50 | 48 | 50 | - | | | |
| 6 <i>S. lineatus</i> Lizard sp2 #3 | 54 | 53 | 51 | 53 | 6 | - | | |
| 7 <i>S. lineatus</i> Lizard sp2 #4 | 51 | 50 | 48 | 50 | 3 | 7 | - | |
| 8 <i>Z. cornutus</i> Heron sp. 2#5 | 52 | 51 | 49 | 51 | 4 | 8 | 5 | - |



~0.66-1.77%
variation

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|------------------------------------|----|----|----|----|---|---|---|---|
| 1 <i>S. ddiatus</i> Lizard sp1 #3 | - | | | | | | | |
| 2 <i>S. ddiatus</i> Lizard sp1 #4 | 1 | - | | | | | | |
| 3 <i>S. vupinus</i> Heron sp. 1#1 | 7 | 6 | - | | | | | |
| 4 <i>S. vupinus</i> Lizard sp1 #2 | 1 | 0 | 6 | - | | | | |
| 5 <i>S. vupinus</i> Lizard sp2 #2 | 51 | 50 | 48 | 50 | - | | | |
| 6 <i>S. lineatus</i> Lizard sp2 #3 | 54 | 53 | 51 | 53 | 6 | - | | |
| 7 <i>S. lineatus</i> Lizard sp2 #4 | 51 | 50 | 48 | 50 | 3 | 7 | - | |
| 8 <i>Z. cornutus</i> Heron sp. 2#5 | 52 | 51 | 49 | 51 | 4 | 8 | 5 | - |



~10.60-11.92%
difference

| | | | | | | | | | | | | | | | | | |
|-----------------------------------|---|----|----|---|----|---|----|---|---|---|---|---|---|---|---|---|---|
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| | | | | | | | | | | | | | | | | | |
| <i>S. doliatus</i> Lizard sp. 1 3 | . | I | L | L | L | M | K | L | L | V | F | A | N | I | I | S | S |
| <i>S. doliatus</i> Lizard sp. 1 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulpinus</i> Heron sp. 1 1 | V | .. | . | . | I | N | .. | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulpinus</i> Lizard sp. 1 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulpinus</i> Lizard sp. 2 2 | . | * | .. | . | . | . | . | I | L | V | S | V | V | G | N | S | I |
| <i>S. lineatus</i> Lizard sp. 2 3 | . | * | C | S | .. | P | S | I | L | V | S | V | V | G | N | S | I |
| <i>S. lineatus</i> Lizard sp. 2 4 | . | * | .. | . | . | . | . | I | L | V | S | V | V | G | N | S | I |
| <i>Z. cornutus</i> Heron sp. 2 5 | . | * | . | F | .. | . | . | I | L | V | S | V | V | G | N | S | I |

ND1 mtDNA translated to amino acids ~ 151 aa
samples from siganid and zanclid fishes of the GBR

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 4 | 4 | 5 | 6 | 6 | 1 | 1 | 2 | 2 |
| 3 | 4 | 6 | 7 | 4 | 5 | 6 | 7 | 0 | 1 | 9 | 0 | 9 | 0 | 9 | 5 | 6 |
| 7 | 6 | | | | | | | | | | | | | | | |

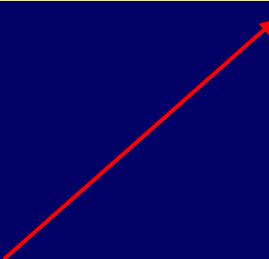
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|---|---|----|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | L | L | L | M | K | L | L | V | F | A | N | I | I | S | S | T |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | L |
| . | V | .. | . | . | I | N | . | . | . | . | . | . | . | . | . | V |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | * | . | . | . | . | . | . | I | L | V | S | V | V | G | N | S |
| . | * | C | S | . | . | . | P | S | I | L | V | S | V | V | G | N |
| . | * | . | . | . | . | . | . | I | L | V | S | V | V | G | N | S |
| . | * | . | F | . | . | . | . | I | L | V | S | V | V | G | N | S |

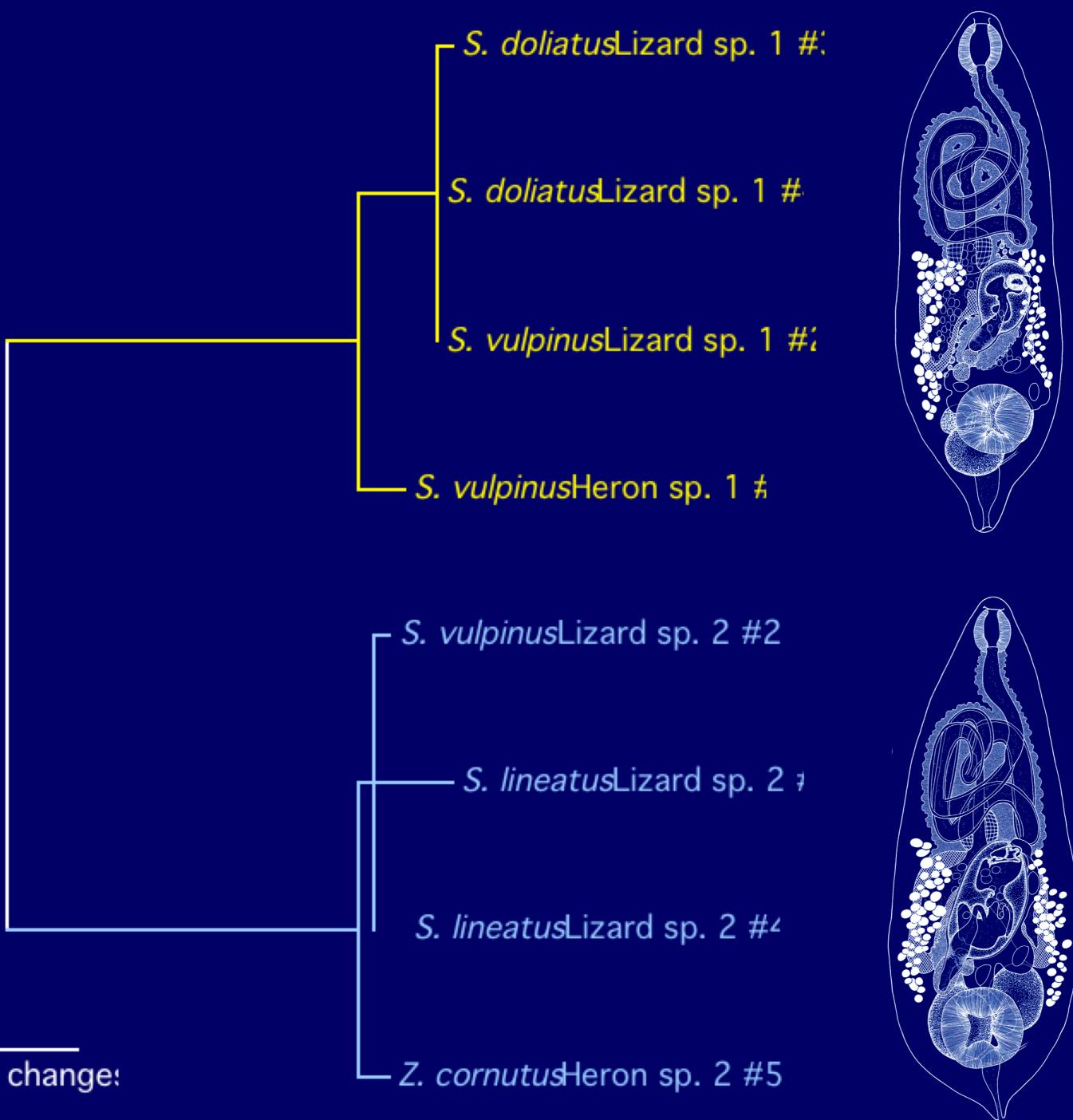
S. doliatus Lizard sp. 1 3
S. doliatus Lizard sp. 1 4
S. vulpinus Heron sp. 1 1
S. vulpinus Lizard sp. 1 2
S. vulpinus Lizard sp. 2 2
S. lineatus Lizard sp. 2 3
S. lineatus Lizard sp. 2 4
Z. cornutus Heron sp. 2 5

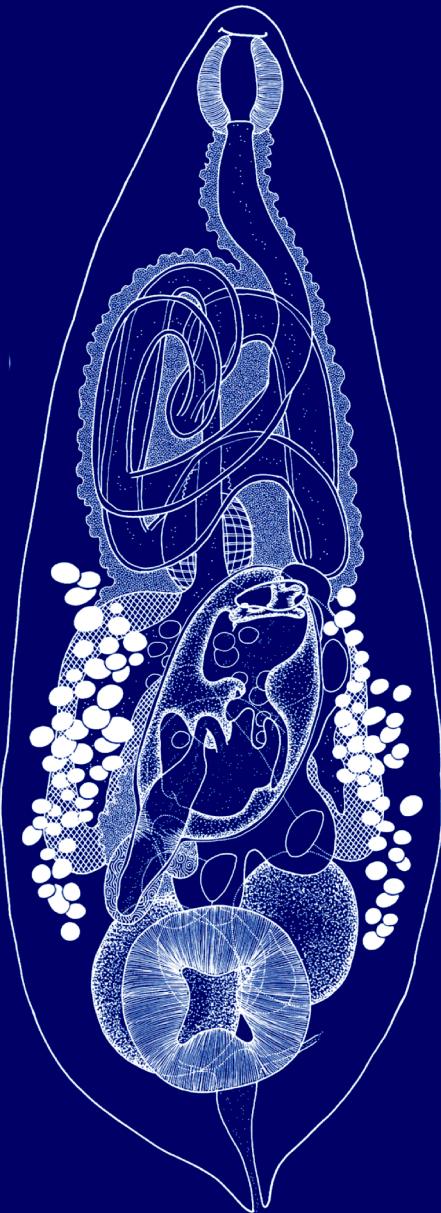
| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 0 | 0 | 1 | 1 | 1 | 3 | 4 | 4 | 5 | 6 | 6 | 1 | 1 | 2 | 2 |
| 3 | 4 | 6 | 7 | 4 | 5 | 6 | 7 | 0 | 1 | 9 | 0 | 9 | 0 | 9 | 5 | 6 |
| 7 | 6 | | | | | | | | | | | | | | | |

| | | | | | | | | | | | | | | | | | | | | | |
|-------------------------------|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| <i>S. doliatus</i> Lizard sp. | 1 | 3 | . | L | L | L | M | K | L | L | V | F | A | N | I | I | S | S | T | L | V |
| <i>S. doliatus</i> Lizard sp. | 1 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulpinus</i> Heron sp. | 1 | 1 | . | V | . | . | . | I | N | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulpinus</i> Lizard sp. | 1 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| <i>S. vulpinus</i> Lizard sp. | 2 | 2 | . | * | . | . | . | . | . | I | L | V | S | V | V | G | N | S | I | I | |
| <i>S. lineatus</i> Lizard sp. | 2 | 3 | . | * | C | S | . | . | P | S | I | L | V | S | V | V | G | N | S | I | |
| <i>S. lineatus</i> Lizard sp. | 2 | 4 | . | * | . | . | . | . | I | L | V | S | V | V | G | N | S | I | I | | |
| <i>Z. cornutus</i> Heron sp. | 2 | 5 | . | * | . | F | . | . | I | L | V | S | V | V | G | N | S | I | I | | |

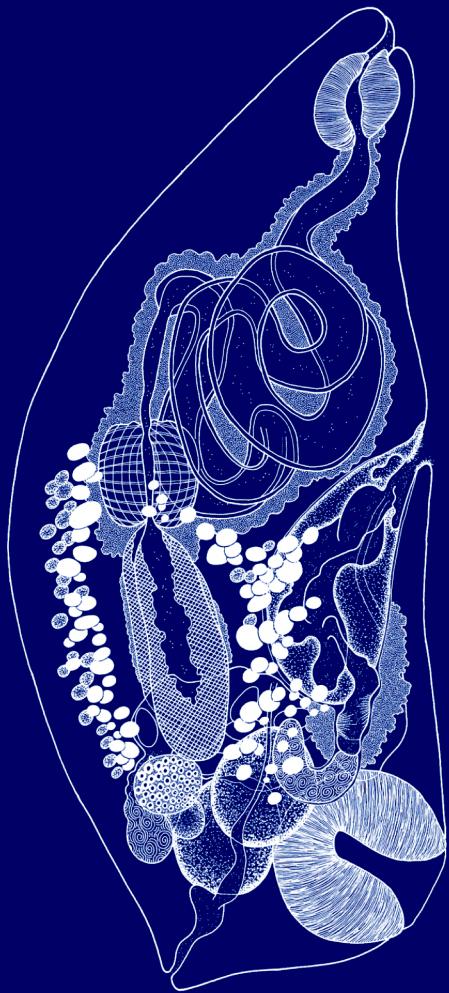
11 fixed differences
~7.28% difference



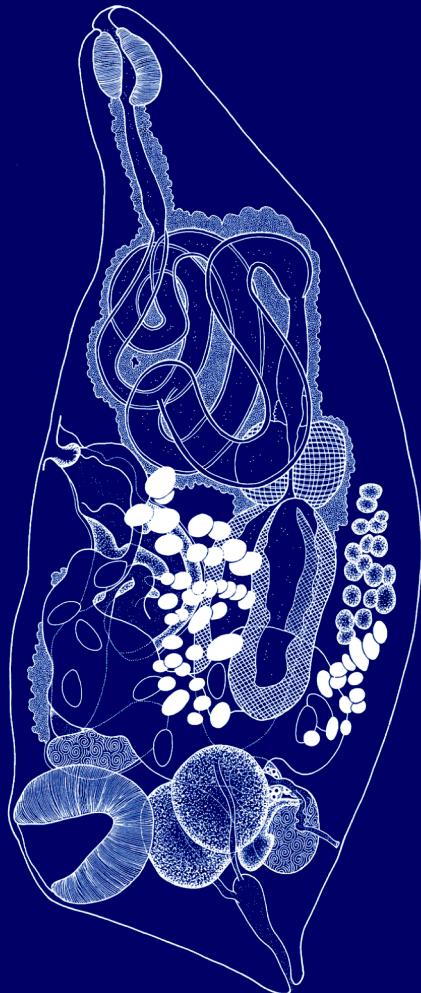




Siganus vulpinus
Lizard Island



Zanclus cornutus
Heron Island



Siganus vulpinus
Lizard Island



Siganus corallinus
Green Island

Species 1

Great Barrier Reef

Lizard Island

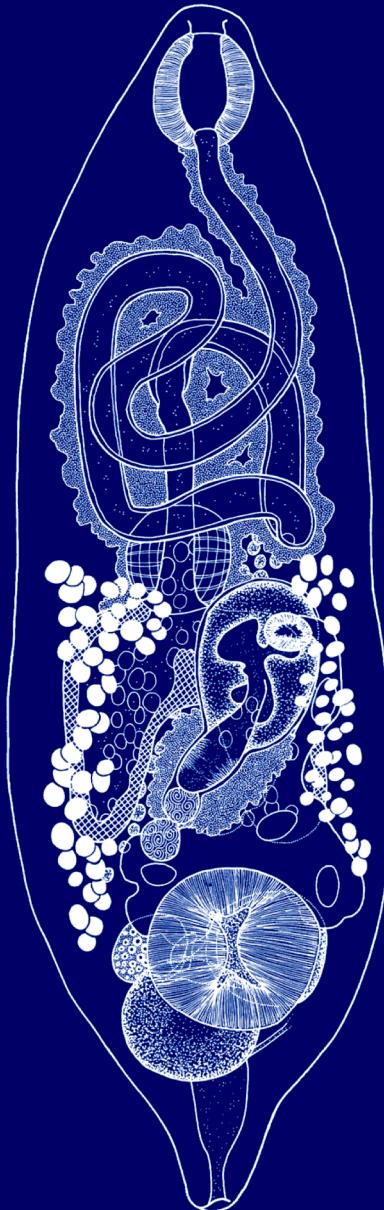
Siganus doliatus

Siganus vulpinus

Heron Island

Siganus vulpinus

ITS2 rDNA sequences: complete identity
ND1 mtDNA sequences: $\leq 1.77\%$ variation



Species 2

Great Barrier Reef

Lizard Island

Siganus argenteus

Siganus fuscescens

Siganus lineatus

Siganus punctatissimus

Siganus vulpinus

Heron Island

Siganus puillus

Siganus punctatus

Siganus vulpinus

Zanclus cornutus

Micronesia

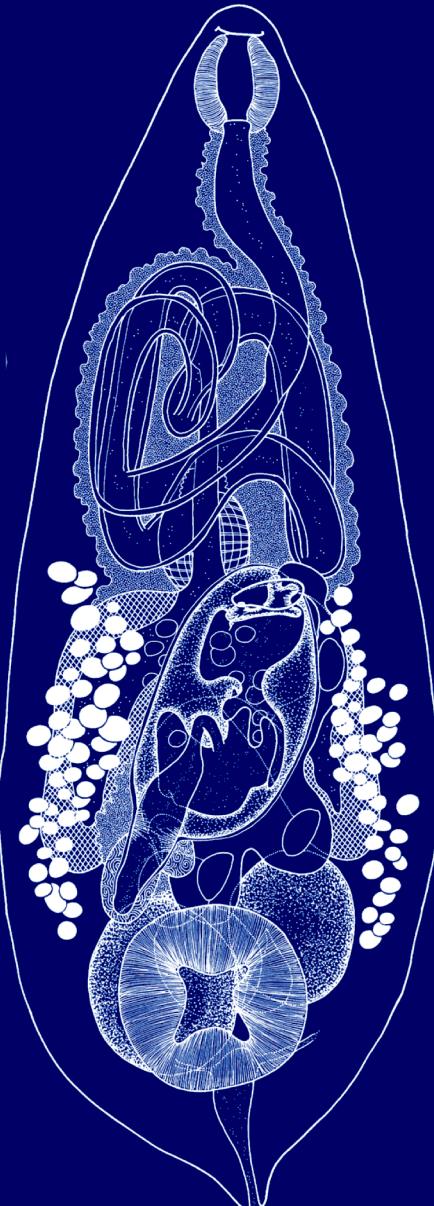
Palau

Siganus corallinus

Siganus vulpinus

ITS2 rDNA sequences: complete identity

ND1 mtDNA sequences: ≤1.55% variation



Verdict: ITS2 rDNA

- pomacanthid worms:
 - 0-0.21% *intraspecific* variation
 - 1.26-1.89% *interspecific* difference
 - siganid worms:
 - 0% *intraspecific* variation
 - 1.32% *interspecific* difference
- 
- differences are fixed over wide host range
 - differences are fixed over wide geographic areas
 - low level of variation makes locus sensitive to errors in sequencing

Verdict: ND1 mtDNA

- siganid worms:
 - 0-1.77% *intraspecific* variation
 - 10.60-11.92% *interspecific* difference
 - differences are fixed over host range
 - differences are fixed over geographic areas
 - internal variation in addition to fixed differences
 - magnitude of interspecific difference increases confidence in taxonomy
- 

How many bases is that?

ITS2 rDNA:

about 5 fixed

ND1 mtDNA:

about 45 bp (or 10 $\alpha\alpha$)

