Surprizing findings in the acanthomorph large-scale interrelationships

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Acanthomorphs are ‘the bush at the top’

- Rosen (1973)
Acanthomorphs are ‘the bush at the top’

- Rosen (1973)

- Large group: more than 15,000 species
Acanthomorphs are ‘the bush at the top’

Rosen (1982)
Acanthomorphs are ‘the bush at the top’

Introduction

Acanthomorphs are ‘the bush at the top’

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Rosen (1982)
Molecular phylogenies yield new relationships

- Smith and Wheeler (2004, 2006) and Smith and Craig (2007): Other nuclear and mitochondrial markers
Methods

- Using well-selected markers to generate trees: Rhodopsin, MLL4, IRBP and **RNF213** (New!)
- Finding reliable clades by comparing independent trees $\rightarrow$ repetition indices (Li and Lecointre, in press)
Results

- Summary of 3 different supertree approaches taking into account repetition indices
- Letters indicate the most reliable clades
- Only a few results will be detailed
Gobioidei are placed with Apogonidae

- Lampridiformes
- Percopsiformes
- Polymixiiformes
- Gadiformes
- Zeoidei
- Trachichthyoidei
- Berycoidei
- Stephanoberyciformes
- Holocentroidei
- Ophidiiformes
- Batrachoidiformes
- Gobioidei
- Apogonidae
- Other Acanthomorpha
Gobioidei are placed with Apogonidae

- Lampridiformes
- Percopsiformes
- Polymixiiformes
- Gadiformes
- Zeoidei
- Trachichthyoidei
- Berycoidei
- Stephanoberyciformes
- Holocentroidei
- Ophidiiformes
- Batrachoidiformes
- Gobioidei
- Apogonidae
- Other Acanthomorpha
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Gobioidei are placed with Apogonidae

Scombroidei are split into two
Labroidei are split into two
Lophiiformes are not ‘basal’
Gasterosteiformes are polyphyletic

Conclusion

Gobioidei are placed with Apogonidae

λ

Other Acanthomorpha

β

Gobioidei

α

Holocentroidei

Ophidiiformes

Batrachoidiformes

γ

Other Acanthomorpha
Gobioidei are placed with Apogonidae

- Batrachoidiformes
  - Gobioidei
    - Apogonidae

Scombroidei are split in two
Labroidei are split in two
Lophiiformes are not ‘basal’
Gasterosteiformes are polyphyletic
Gobioidei are placed with Apogonidae

Batrachoidiformes + Kurtoidei (Smith and Wheeler, 2006)

Gobioidei

Apogonidae

H

E+E’

Q

Indostomus

Symbranchoidei

Mastacembeloidei

Channoidei

Anabantoidei

L

η
Gobioidei are placed with Apogonidae

- free sensory papillae (Johnson, 1993)

  - Gobioidei
    - Apogonidae

  - Batrachoidiformes

  - H
    - E+E'
      - Q
        - Indostomus
        - Symbranchoidei
          - F
            - Mastacembeloidei
              - Channoidei
                - Anabantoidei
                  - L

  + Kurtoidei (Smith and Wheeler, 2006)

  - Batrachoidiformes

  - Scombroidei are split in two
  - Labroidei are split in two
  - Lophiiformes are not 'basal'
  - Gasterosteiformes are polyphyletic

Conclusion
Gobioidei are placed with Apogonidae

- Gobioidei
  - Apogonidae
  - Batrachoidiformes
    - Gasterosteiformes are polyphyletic

- Channoidei
  - Anabantoidei
  - Indostomus
  - Mastacembeloidei
  - Symbranchoidei

- Scombroidei are split into two
- Labroidei are split into two
- Lophiiformes are not ‘basal’
- Gasterosteiformes are polyphyletic

Adhesive eggs

Breder and Rosen (1966)

Smith and Wheeler, 2006

Breder and Rosen (1966)
Clade Q

- Batrachoidiformes
- Gobioidei
- Apogonidae
- Mugiloidei, Atherinomorpha, Gobiesocoidei, Blennioidei, some Labroidei
- Indostomus
- Symbranchoidei
- Mastacembeloidei
- Channoidei
- Anabantoidei
- L

Relevant phylogenetic relationships:
- Gobioidei are placed with Apogonidae
- Scombroidei are split into two
- Labroidei are split into two
- Lophiiformes are not 'basal'
- Gasterosteiformes are polyphyletic
Other clades

- Batrachoidiformes
- Gobioidei
  - Apogonidae
- Stromateoidei, some Scombroidei
  - E+E'
  - H
  - Q
  - Indostomus
  - Symbranchoidei
  - Mastacembeloidei
  - Channoidei
  - Anabantoidei
  - L
  - η
  - f1
  - Channoidei
  - Anabantoidei
  - L
  - η
  - β
- Gobioidei are placed with Apogonidae
- Scombroidei are split in two
- Labroidei are split in two
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Other clades

- **Batrachoidiformes**
  - Gobioidei
  - Apogonidae
- **Syngnathoidei, Dactylopteroides, Mullidae**
  - Indostomus
  - Symbranchioidei
  - Mastacembeloidei
  - Channoidei
  - Anabantoidei
  - L
  - η
- **Scombroidei** are split into two
- **Labroidei** are split into two
- **Lophiiformes** are not 'basal'
- **Gasterosteiformes** are polyphyletic

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**Methods**

- Gobioidei are placed with Apogonidae
- Gasterosteiformes are polyphyletic
- other clades
Other clades

- Batrachoidiformes
  - Gobioidei
    - Apogonidae
  - H
    - E+E’
  - Q
    - Indostomus
      - Symbranchoidei
    - F
      - Mastacembeloidei
    - f1
      - Channoidei
      - Anabantoidei
    - L
      - Flatfishes, Carangoidei, other Scombroidei
  - \(\gamma\)
  - \(\delta\)
  - \(\beta\)
Other clades

β
\[ \begin{align*}
&\gamma \\
&\delta \\
&H \\
&E+E' \\
Q \\
\end{align*} \]

Indostomus

Symbranchoidei

Mastacembeloidei

Channoidei

Anabantoidei

L

Tetraodontiformes, Lophiiformes, most Scorpaeniformes and Percoidei
Scombroidei are split in two

- Batrachoidiformes
  - Gobioidei
    - Apogonidae

Labroidei are split in two

Lophiiformes are not 'basal'

Gasterosteiformes are polyphyletic

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- Gobioidei are placed with Apogonidae

- Scombroidei are split in two

- Labroidei are split in two

- Lophiiformes are not 'basal'

- Gasterosteiformes are polyphyletic

Conclusion
Scombroidei are split in two

- Batrachoidiformes
  - Gobioidei
    - Apogonidae
      - Scombroidei are split in two
        - Labroidei are split in two
          - Lophiiformes are not ‘basal’
            - Gasterosteiformes are polyphyletic

- Symbranchoidei
  - Mastacembeloidei
    - Channoidei
      - Anabantoidei
        - L

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Results
- Gobioidei are placed with Apogonidae
- Scombroidei are split in two
- Labroidei are split in two
- Lophiiformes are not ‘basal’
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Scombroidei are split in two

- Trichiuridae
  - Scombridsae
    - Nomeidae
    - Bramidae
    - Centrolophidae
    - Chiasmodontidae
    - Stromateidae
  - Aulostomus
  - Macroramphosus
  - Dactylopterus
  - Other Syngnathoidei
  - Callionymidae
  - Mullidae
Scombroidei are split in two

- Trichiuridae
  - Scombridae
  - Nomeidae
    - Bramidae
      - Centrolophidae
        - Chiasmodontidae
          - Stromateidae
            - Aulostomus
              - Macroramphosus
                - Dactylopterus
                  - Other Syngnathoidei
                    - Callionymidae
                      - Mullidae

Gobioidei are placed with Apogonidae

Labroidei are split in two

Lophiiformes are not ‘basal’

Gasterosteiformes are polyphyletic
Scombroidei are split in two

- Batrachoidiformes
- Gobioidei
  - Apogonidae
  - E+E'
  - H
  - Q
  - Indostomus
    - Symbranchoidei
      - Mastacembeloidei
        - Channoidei
          - Anabantoidei
            - L

Gobioidei are placed with Apogonidae
Scombroidei are split in two
Labroidei are split in two
Lophiiformes are not ‘basal’
Gasterosteiformes are polyphyletic

- Gobioidei
- Apogonidae
- Scombroidei
- Labroidei
- Lophiiformes
Scombroidei are split in two

Polynemidae
Sphyraenidae

Trachinotus
Other Carangidae

Coryphaenidae
Echeneidae
Soleidae

Achiridae
Scophthalmidae
Parlichthyidae

Bothidae
Citharidae
Latidae

Psettodidae
Toxotidae
Menidae
Xiphiidae
Centropomidae
Scombroidei are split in two

Polynemidae
Sphyraenidae

Trachinotus
Other Carangidae

Coryphaenidae
Echeneidae
Soleidae

Achiridae
Scophthalmidae
Parlichthyidae

Bothidae
Citharidae
Latidae
Psettodidae
Toxotidae
Menidae
Xiphiidae
Centropomidae
Labroidei are split in two

Gobioidei are placed with Apogonidae

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Conclusion
Labroidei are split in two

- Batrachoidiformes
- Gobioidei
- Apogonidae
- H
- E + E' (with an arrow pointing to Indostomus)
- Q
- Indostomus
  - Symbranchioidei
  - Mastacembeloidei
  - Channioidei
  - Anabantoidei
  - L
  - η (with an arrow pointing to L)

Gobioidei are placed with Apogonidae
Scombroidei are split in two
Lophiiformes are not ‘basal’
Gasterosteiformes are polyphyletic

Conclusion
Labroidei are split in two

- Cichlidae
  - Plesiopidae
  - Mugilidae
  - Pomacentridae
- Gobiesocoidei
  - Blennioidei
    - Cyprinodontiformes
      - Adrianichthyidae
      - Exocoetidae
      - Belonidae
      - Atheriniformes
Labroidei are split in two
Labroidei are split in two

- Cichlidae
- Plesiopidae
- Mugilidae
- Pomacentridae
- Gobiesocoidei
  - Blennioidei
    - Cyprinodontiformes
      - Adrianichthyidae
      - Exocoetidae
      - Belonidae
      - Atheriniformes

(Q) Embiotocidae

(D) Gobioidei are placed with Apogonidae

Scombroidei are split in two

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Gasterosteiformes are polyphyletic

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- Gobioidei are placed with Apogonidae
- Scombroidei are split in two
- Lophiiformes are not ‘basal’
- Gasterosteiformes are polyphyletic

(Chen et al., 2007; Mabuchi et al., 2007)
Labroidei are split in two

- Batrachoidiformes
- Gobioidae
- Apogonidae
- Scombroidei
- Labroidei
- Lophiiformes
- Gasterosteiformes

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- Gobioidae are placed with Apogonidae
- Scombroidei are split in two
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Labroidei are split in two

Gobioidei are placed with Apogonidae
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Labroidei are split in two
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Gasterosteiformes are polyphyletic

Conclusion
Labroidei are split in two

- Lophiiformes
  - Tetraodontiformes
  - Scatophagidae
  - Cepolidae
- Priacanthidae
- Antigonia
- Capros
- Sparidae
- Callanthiidae
- Pomacanthidae
- Acanthuridae
- Luvaridae
- Apsilus
- Lutjanus
- Caesionidae
- Leiognathidae
- Siganidae
- Datnioididae
- Drepaneidae
- Haemulidae
- Chaetodontidae
- Sciaenidae
- Malacanthidae
- Labridae
- Scaridae
- Monodactylidae
- Moronidae
- Centrarchidae
- Elassomatidae
- Cheilodactylidae
- Kyphosidae
- Ammodytidae
- Uranoscopidae
- Cheimarrichthyidae
- Pinguipes
- Lateolabracidae
- Howellidae
- Epigonidae
- Champsodontidae
- X

Labridae
- Scaridae

Gobioidei are placed with Apogonidae
Scombroidei are split in two
Lophiiformes are not ‘basal’
Gasterosteiformes are polyphyletic
Labroidei are split in two

Gobioidei are placed with Apogonidae
Scombroidei are split in two
Labroidei are split in two
Lophiiformes are not ‘basal’
Gasterosteiformes are polyphyletic

Labridae
Scaridae

+ Odacidae
(Mabuchi et al., 2007)
Lophiiformes are not ‘basal’

Gobioidei are placed with Apogonidae
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Lophiiformes are not ‘basal’

- Lophiiformes
  - Tetraodontiformes
    - Scatophagidae
      - Cepolidae
        - Priacanthidae
          - Antigonia
            - Capros
              - Sparidae
                - Callanthiidae
Lophiiformes are not ‘basal’

- Lophiiformes
  - Tetraodontiformes
    - Scatophagidae
    - Cepolidae
      - Priacanthidae
        - Antigonia
          - Capros
          - Sparidae
            - Callanthiidae
Gasterosteiformes are polyphyletic

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Gasterosteiformes are polyphyletic
Gobioidei are placed with Apogonidae
Scombroidei are split in two
Labroidei are split in two
Lophiiformes are not ‘basal’

Conclusion
Gasterosteiformes are polyphyletic

(Miya et al., 2003)

E+E'
Gasterosteiformes are polyphyletic

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- Labroidei are split in two
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- Gasterosteiformes are polyphyletic

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Lophiiformes are not ‘basal’

Gasterosteiformes are polyphyletic

Conclusion
Gasterosteiformes are polyphyletic

Kawahara et al. (2008): Dactylopteroidei + Syngnathoidei

- Trichiuridae
- Scombridae
- Nomeidae
- Bramidae
- Centrolophidae
- Chiasmodontidae
- Stromateidae
- Aulostomus
- Macroramphosus
- Dactylopterus
- Other Syngnathoidei
- Callionymidae
- Mullidae

Gasterosteiformes are polyphyletic
Gasterosteiformes are polyphyletic

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Gasterosteiformes are polyphyletic
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Gasterosteiformes are polyphyletic

Conclusion
Gasterosteiformes are polyphyletic

- Gasterosteidae
- Pholididae
- Anarhichadidae
- Zoarcidae
- Cyclopteridae
- Liparidae
- Agonidae
- Cottidae
- Psychrolutidae
- Triglidae
- Congiopodidae
- Synanceiidae
- Scorpaenidae
  - Parapercis
  - Rypticus
  - Pogonoperca
  - Serranus
  - Epinephelus
  - Holanthias
  - Trachinidae
  - Bovichtidae
  - Eleginopsidae
  - Nototheniidae
  - Channichthyidae
  - Percidae

- Zoarcoidei
- Cottoidei
- Scorpaenoidei

- Gobioidae are placed with Apogonidae
- Scombroidei are split into two
- Labroidei are split into two
- Lophiiformes are not ‘basal’
- Gasterosteiformes are polyphyletic
Gasterosteiformes are polyphyletic

- Gasterosteidae
- Pholidae
- Zoarhichadidae
- Zoarcidae
- Cyclopteridae
- Liparidae
- Agonidae
- Cottidae
- Psychrolutidae
- Triglidae

- Congiopodidae
- Synanceiidae
- Scorpaenidae

- Parapercis
- Rypticus
- Pogonoperca
- Serranus
- Epinephelus
- Holanthias
- Trachinidae

- Bovichtidae
- Eleginopsidae
- Nototheniidae
- Channichthyidae
- Percidae

- Anarhichadidae
- Zoarcoidei
- Cottoidei
- Liparidae
- Agonidae

X

Notothenioidei
- Bovichtidae
- Eleginopsidae
- Nototheniidae
- Channichthyidae
- Percidae

Gasterosteiformes are polyphyletic
Gasterosteiformes are polyphyletic
Gasterosteiformes are polyphyletic

Kawahara et al. (2008):
Zoarcoidei +
Gasterosteioidei

Lsc

Isc

Gasterosteidae
Pholidae
Anarhichadidae
Zoarcidae
Cyclopteridae
Liparidae
Agonidae
Cottidae
Psychrolutidae
Triglidae

Gasterosteiformes are polyphyletic
Conclusion

- Many morphologically unexpected relationships are now well corroborated.

- Comparing between independent sources is essential to distinguish reliable and doubtful results: it’s a good thing that several teams work on the same group with diverse markers.
Thank you!

For more information (methodology, big summary tree):
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Zeoidei are grouped with Gadiformes
Zeoidei are grouped with Gadiformes

Echinoids are grouped with Gadiformes

Lampridiformes
Percopsiformes
Polymixiiformes
Gadiformes
Zeoidei
Trachichthyoidei
Berycoidei
Stephanoberyciformes
Holocentroidei
Ophidiiformes
Batrachoidiformes
Gobioidei
Apogonidae
Other Acanthomorpha

Already in Chen et al. (2000), Wiley et al. (2000)