

Supplementary Material

Bayesian Phylogenetic Estimation of Clade Ages Supports Trans-Atlantic Dispersal of Cichlid Fishes

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1 Supplementary Text

Supplementary Text S1: Sequencing protocols.

Mitochondrial genomes of 26 cichlid species were amplified by long-range PCR followed by the 454 pyrosequencing on a GS Roche Junior platform. The primers for long-range PCR were designed specifically in the mitogenomic regions with low interspecific variability. The whole mitogenome of most species was amplified as three fragments using the following primer sets: for the region between position 2 500 bp and 7 300 bp (of mitogenome starting with tRNA-Phe), we used forward primers ZM2500F (5'-ACG ACC TCG ATG TTG GAT CAG GAC ATC C-3'), L2508KAW (Kawaguchi *et al.* 2001) or S-LA-16SF (Miya & Nishida 2000) and reverse primer ZM7350R (5'-TTA AGG CGT GGT CGT GGA AGT GAA GAA G-3'). The region between 7 300 bp and 12 300 bp was amplified using primers ZM7300F (5'-GCA CAT CCC TCC CAA CTA GGW TTT CAA GAT GC-3') and ZM12300R (5'-TTG CAC CAA GAG TTT TTG GTT CCT AAG ACC-3'). The region between position 12 200 bp and 2 100 bp (spanning the end and beginning of the mitogenome) was amplified using forward primer ZM12200F (5'-CTA AAG ACA GAG GTT AAA ACC CCC TTA TYC ACC-3') and reverse primers ZM2100R (5'-GAC AAG TGA TTG CGC TAC CTT TGC ACG GTC-3') and Muj16SH (TGC ACC AWT AGG ATG TCC TGA TCC AAC ATC). Alternatively, in five species, two longer fragments were amplified instead using the combination of aforementioned primers (ZM7300F + ZM2100R or Muj16SH, and L2508KAW or ZM2500F + ZM7350R). Amplification of the whole mitogenome with a single primer set was successfully performed in three species using the primers ZM2500F and ZM2100R. We used the LA (long & accurate) polymerase Master Mix (TopBio) and the LA PCR Kit (TaKaRa). The amplification protocol consisted of 30 cycles of denaturation step (95 °C / 1 min), annealing step (60 °C / 1 min) and the extension step of 68 °C (15 min). PCR products were subsequently extracted from electrophoresis gel, purified, and pooled equimolarly. The pooled PCR products were individually barcoded by species during the library preparation (GS Rapid Library Preparation Kit, Roche). Emulsion PCR and sequencing were performed with GS Junior Titanium emPCR Kit, Lib-L (Roche) and GS Junior Titanium PicoTiterPlate (Roche) and GS Junior Titanium Sequencing Buffers Kit (Roche) following the manufacturer's protocol. To complete the circular molecule of the mitogenome, we have additionally sequenced the missing region of the 16S gene by conventional Sanger sequencing using mtD-32 and mtD-34 primers (Marescalchi 2005) and 48 °C of annealing temperature. The raw reads were filtered on quality and de-novo assembled in the Geneious 7 software (<http://www.geneious.com>, Kearse *et al.* 2012) to obtain the complete sequence of the mitochondrial genome. Contigs were manually corrected and merged by remapping of the raw reads.

In addition to mitochondrial genomes of 26 species, markers 16S, mt-co1, mt-cyb, mt-nd2, mt-nd4, myh6, ptchd4, enc1, and tbr1b were sequenced for up to 50 species (a total of 305 sequences), following Sanger sequencing protocols given in (Matschiner *et al.* 2011). Of the nine markers, 16S, mt-co1, and mt-nd2 were not included in the study of Matschiner *et al.* (2011). Marker 16S was PCR-amplified using Amplitaq DNA polymerase (Applied Biosystems), primer pair 16Sar/16Sbr (Palumbi 1996), and the following cycling conditions: 94 °C for 2 min, 36 cycles of 94 °C for 30 sec, 48 °C for 30 sec, and 72 °C for 1 min, and finally an elongation time of 7 min at 72 °C. New primer pairs were designed for the two markers mt-co1 and mt-nd2: COIFc (5'-TCT CRA CYA ATC ACA

AAG ACA TCG G), COIR (5'-ATR GGG TCT CCY CCT CCK GC-3'), MET_c (GTT AAA CCC CTT CCT TTA CTA ATG-3'), and TRP_c (G5'-AG ATT TTC ACT CCC GCT TAG-3'). Both markers were amplified with the respective primer pair and the Quiagen Multiplex Kit (Quiagen), following the manufacturer's instructions. Annealing temperatures were 58 °C for mt-co1 and 52 °C for mt-nd2, and 39 PCR cycles were used for both markers.

Supplementary Text S2: Teleost clades used in phylogenetic analyses.

Classification follows Wiley & Johnson (2010) and Betancur-R *et al.* (2013), and diversity information is taken from Nelson (2006) unless otherwise noted. Clade IDs refer to branch labels in the RAxML phylogeny (Supplementary Figure S6) and to IDs specified in Supplementary Table S2. Dagger symbols are used to indicate extinct taxa. The timescale follows Gradstein & Ogg (2009). With the exception of clades listed in Supplementary Table S9, the sum of all 362 mutually exclusive clades listed here represents the entire extant diversity of the teleost supercohort Clupeocephala, combining the two cohorts Otomorpha and Euteleosteiomorpha (Betancur-R *et al.* 2013).

Abbreviations: myr, million years; Ma, million years ago; BS, Bootstrap support; BPP, Bayesian Posterior Probability; JRV, Jackknife resampling value.

Clade 1: Otomorpha

Taxonomy: One out of two cohorts of Clupeocephala. Following Betancur-R *et al.* (2013), we here include Alepocephaliformes in Otomorpha. Thus, Otomorpha are composed of three subcohorts, Clupei, Alepocephali, and Ostariophysi.

Support: The molecular phylogenies of Betancur-R *et al.* (2013), Li *et al.* (2010b), and Lavoué *et al.* (2005) strongly support inclusion of Alepocephaliformes in Otomorpha (BS 100). Our RAxML phylogeny supports the monophyly of Otomorpha with BS 100.

First occurrence: †*Tischlingerichthys viohli* Arratia, 1997, from the upper Solnhofen Limestone Formation, Bayern, Germany. The Tithonian †*Tischlingerichthys viohli* is considered the oldest representative of Otomorpha (=Ostarioclupeomorpha) by Davis & Fielitz (2010), and the earliest ostariophysean by Benton *et al.* (2015). Based on ammonite zonation, the upper Solnhofen Limestone Formation is dated as early Tithonian, 150.8-149.9 Ma (Benton & Donoghue 2007; Benton *et al.* 2009). This is older than the earliest alepocephaloid record, the Oligocene †*Carpathichthys polonicus* Jerzmaska, 1979. Thus, the first occurrence of Otomorpha dates to 150.8-149.9 Ma. See clades 3 (Alepocephali) and 4 (Ostariophysi).

Diversity: 9055 extant species.

Sampled species: All sampled species of clades 2, 3, and 4.

Clade 2: Clupei

Taxonomy: One out of three subcohorts of Otomorpha. Clupei include several fossil lineages and the extant order Clupeiformes.

Support: Synapomorphies are given in Wiley & Johnson (2010). The monophyly of extant Clupei is further supported by the molecular phylogeny of Betancur-R *et al.* (2013) (BS 87). Our RAxML phylogeny supports the monophyly of Clupei with BS 100.

First occurrence: †*Ellimmichthys longicaudatus* Cope, 1886, from the Marfim Formation, Recôncavo Basin, Bahia, Brazil. Clupeomorph fishes appear in the fossil record in the Early Cretaceous, with the genera †*Diplomystus* Cope, 1877, †*Ellimma* Jordan, 1910, †*Ellimmichthys* Jordan, 1919, †*Spratticeps* Patterson, 1970, †*Erichalcis* Forey, 1975, †*Eoknightia* Taverne, 1976, †*Histiurus* Costa, 1850, †*Nolfia* Taverne, 1976, †*Paraclupea* Du, 1950, †*Santanacupea* Maisey, 1993, and †*Pseudoellimma* De Figueiredo, 2009. Of these, the oldest specimens may be †*Diplomystus koku-*

raensis Uyeno, 1979 and †*Diplomystus primotinus* Uyeno, 1979 from the Wakino Formation, Kanmon group, Kyushu Island, Japan, or †*Ellimmichthys longicaudatus* Cope, 1886 from Bahia, north-eastern Brazil. The two specimens of †*Diplomystus* have been discovered in the upper layer (fourth layer) of the Wakino subgroup (Uyeno & Yabumoto 1980), which was claimed to be Neocomian (Berriasian-Hauterivian) by the original authors, but is more likely Barremian (Matsumoto *et al.* 1982) or Hauterivian-Barremian (Kimura *et al.* 1992). †*Ellimmichthys longicaudatus* has been reported from the Marfim Formation, Recôncavo Basin, Bahia, Brazil, which is of Late Hauterivian-Early Barremian age (Maisey 2000). Thus, the first occurrence of Clupei dates to 133.9-130.0 Ma.

Diversity: 364 extant species.

Sampled species: *Chirocentrus dorab*, *Clupea harengus*, and *Pellona flavipinnis*.

Clade 3: Alepocephali

Taxonomy: One out of three subcohorts of Otomorpha. Alepocephali include the single order Alepocephaliformes with three families, Argentinidae, Opisthoproctidae, and Microstomatidae.

Support: Synapomorphies of Alepocephali are given in Johnson and Patterson (1996). The molecular phylogenies of Betancur-R *et al.* (2013), Li *et al.* (2010b), and Nakatani *et al.* (2011) strongly support the monophyly of Alepocephali (BS 100). Our RAxML phylogeny supports the monophyly of Alepocephali with BS 100.

First occurrence: †*Carpathichthys polonicus* Jerzmaska, 1979, from the Menilite Beds of the Carpathian flysch, Poland. †*Carpathichthys polonicus* is considered the earliest record of Alepocephaloidei, and of family Alepocephalidae (Jerzmaska 1979; Patterson 1993b), and thus of order Alepocephaliformes and subcohort Alepocephali. †*Carpathichthys polonicus* occurs in zones IPM 5-6 of the Menilite Beds (Jerzmaska 1979), which range between between 28.0-24.0 Ma (Tyler *et al.* 1993). Thus, the first occurrence of Alepocephali dates to 28.0-24.0 Ma.

Diversity: 131 extant species.

Sampled species: *Alepocephalus bicolor*, *Bathylaco nigricans*, and *Platytroctes apus*.

Clade 4: Ostariophysii

Taxonomy: One out of three subcohorts of Otomorpha. Ostariophysii include two sections, Anotophysa and Otophysa.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogeny of Betancur-R *et al.* (2013) strongly supports monophyly of Ostariophysii (BS 100). Our RAxML phylogeny supports the monophyly of Otomorpha with BS 98.

First occurrence: †*Tischlingerichthys vlohli* Arratia, 1997, from the upper Solnhofen Limestone Formation, Bayern, Germany. †*Tischlingerichthys vlohli* is considered the oldest representative of Ostariophysii (Davis & Fielitz 2010; Benton *et al.* 2015). Based on ammonite zonation, the upper Solnhofen Limestone Formation is dated as early Tithonian, 150.8-149.9 Ma (Benton & Donoghue 2007; Benton *et al.* 2009). See clade 1 (Otomorpha).

Diversity: 8560 extant species.

Sampled species: All sampled species of clades 5 and 11.

Clade 5: Anotophysa

Taxonomy: One out of two sections of Ostariophysi. Anotophysa include a single order, Gonorynchiformes, and three suborders, Gonorynchoidei, Chanoidei, and Knerioidei.

Support: Despite the low bootstrap support for the monophyly of Gonorynchiformes resulting from our molecular phylogeny (BS 27), we assume this group to be monophyletic based on twelve synapomorphies identified by Grande & Poyato-Ariza (1999). Furthermore, monophyly of Gonorynchiformes is strongly supported by the molecular phylogenies of Betancur-R *et al.* (2013) (BS 97), Nakatani *et al.* (2011) (BS 85) and Near *et al.* (2012b) (BS > 90).

First occurrence: †*Rubiesichthys gregalis* Wenz, 1984, from Montsec, Lérida, Spain. The fossil †*Rubiesichthys gregalis* has been described as a chanid (Wenz *et al.* 1993) and a later revision confirmed its similarity to gonorynchiform fishes traditionally considered as Chanidae (Poyato-Ariza 1996). See clade 7 (Chanoidei). The first occurrence of Anotophysa dates to 145.5-136.4 Ma.

Diversity: 37 spp.

Sampled species: All sampled species of clades 6, 7, and 8.

Clade 6: Gonorynchoidei

Taxonomy: One out of three suborders of Gonorynchiformes. Gonorynchoidei include a single family, Gonorynchidae, a single extant genus, *Gonorynchus*, and five extant species.

Support: Synapomorphies are given in Grande (1999) and in Grande & Poyato-Ariza (1999). The molecular phylogeny of Betancur-R *et al.* (2013) includes two species of genus *Gonorynchus*, and strongly supports their monophyly (BS 100). Our RAxML phylogeny supports the monophyly of Gonorynchoidei with BS 100.

First occurrence: †*Charitopsis spinosus* Gayet, 1993, and †*Charitosomus Haqilensis* (Davis, 1887) from the Lithographic Limestone of Haqil, Lebanon. The Middle East localities of Haqil, Jerusalem and Sahel Alma all bear gonorynchid fossils (Grande & Poyato-Ariza 1999). The occurrences of *Mantelliceras mantelli* and the foraminifer *Orbitulina concava* in the Lithographic Limestone of Haqil suggest an age between 99.1 and 97.8 Ma (Benton *et al.* 2009), whereas the Bet-Meir/Amminadav Formation near Jerusalem are reported to be Middle Cenomanian in age, and Sahel Alma dates to the late Santonian (Forey *et al.* 2003). Thus, the Lithographic Limestone of Haqil seems to be slightly older than the Jerusalem formations, and substantially older than Sahel Alma. The phylogenetic placement of †*Charitopsis spinosus* Gayet, 1993, and †*Charitosomus Haqilensis* (Davis, 1887) within Gonorynchidae is corroborated by several synapomorphies and the cladogram of Grande & Poyato-Ariza (1999), based on 94 characters. Thus, the first occurrence of Gonorynchoidei dates to 99.1-97.8 Ma.

Diversity: 5 extant species.

Sampled species: *Gonorynchus greyi* and *Gonorynchus abbreviatus*.

Clade 7: Chanoidei

Taxonomy: One out of three suborders of Gonorynchiformes. Chanoidei include a single family, Chanidae, and a single extant genus with a single extant species, *Chanos chanos*.

Support: Chanoidei include a single extant species.

First occurrence: †*Rubiesichthys gregalis* Wenz, 1984, from Montsec, Lérida, Spain. The fossil †*Rubiesichthys gregalis* has been described as a chanid (Wenz *et al.* 1993) and a later revision confirmed its similarity to gonorynchiform fishes traditionally considered chanids (Poyato-Ariza 1996). The cladogram of Grande & Poyato-Ariza (1999) corroborates the placement of †*Rubiesichthys gregalis* within Chanoidei, based on a matrix of 94 characters. †*Rubiesichthys gregalis* was first discovered in the Early Cretaceous outcrop in Montsec, Lérida, Spain (Berriasian-Valanginian), and subsequently also found to be abundant in the younger outcrop of Las Hoyas, Spain (Hauterivian-Barremian) (Poyato-Ariza 1996). Thus, the first occurrence of Chanoidei dates to 145.5-136.4 Ma.

Diversity: 1 extant species.

Sampled species: *Chanos chanos*.

Clade 8: Knerioidei

Taxonomy: One out of three suborders of Gonorynchiformes. We here follow Nelson (2006) in including Kneridae and Phractolaemidae in Knerioidei, as the latter family has not been examined in Betancur-R *et al.* (2013).

Support: Synapomorphies are given in Grande & Poyato-Ariza (1999). Our RAxML phylogeny supports the monophyly of Knerioidei with BS 100.

First occurrence: Recent.

Diversity: 31 extant species.

Sampled species: All sampled species of clades 9 and 10.

Clade 9: Phractolaemidae

Taxonomy: One of two families of suborder Knerioidei. Phractolaemidae include a single extant genus, *Phractolaemus*, and a single species, *P. ansorgii*.

Support: Phractolaemidae include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Phractolaemus ansorgii*.

Clade 10: Kneriidae

Taxonomy: One of two families of suborder Knerioidei. Kneriidae include four extant genera, *Cromeria*, *Grasseichthys*, *Kneria*, and *Parakneria*.

Support: Synapomorphies are given in Grande & Poyato-Ariza (1999). Our RAxML phylogeny supports the monophyly of Kneriidae with BS 100.

First occurrence: Recent.

Diversity: 30 extant species.

Sampled species: *Parakneria cameronensis*, *Grasseichthys gabonensis*, and *Cromeria nilotica*.

Clade 11: Otophysa

Taxonomy: One of two sections of Ostariophysi. Otophysa include two superorders, Cyprinae and Characiphysae.

Support: Synapomorphies are given in Wiley & Johnson (2010). Also, the molecular phylogenies of Peng *et al.* (2006), Santini *et al.* (2009), Li *et al.* (2010b), Nakatani *et al.* (2011), Near *et al.* (2012b), and Betancur-R *et al.* (2013) strongly support the monophyly of Otophysa (BS 100). Our RAxML phylogeny supports the monophyly of Otophysa with BS 100.

First occurrence: †*Santanichthys diasii* Silva Santos, 1958, from the Santana Formation (Romualdo Member) of the Araripe Basin, northeastern Brazil. †*Santanichthys diasii* has been described as a stem characiform and is considered to be the oldest known otophysan (Filleul & Maisey 2004). The first occurrence of Otophysa dates to 125.0-89.3 Ma. See clade 18 (Characiphysae).

Diversity: 8523 spp.

Sampled species: All sampled species of clades 12 and 18.

Clade 12: Cyprinae

Taxonomy: One of two superorders of Otophysa. Cyprinae include a single order, Cypriniformes, and two superfamilies, Cyprinoidea and Cobitoidea (Nelson 2006).

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogenies of Betancur-R *et al.* (2013), Nakatani *et al.* (2011), and Near *et al.* (2012b), as well as our RAxML phylogeny strongly support monophyly of Cyprinae (BS 100).

First occurrence: †*Molinichthys inopinatus* Gayet, 1982, from the El Molino Formation, Agua Clara, Bolivia, or †*Amyzon* spp. from the Paskapoo Formation, Alberta, Canada. The taxonomic assignment of †*Molinichthys inopinatus* from the Bolivian El Molino Formation (Gayet *et al.* 1991) as a cypriniform is based on a fragment of a pharyngeal bone and has long been debated (Fink *et al.* 1984), in part because the fossil has been discovered in Bolivia, but no extant cypriniforms are known from South America. Besides †*Molinichthys inopinatus*, the oldest known cypriniforms are catostomids of the genus †*Amyzon* from the Paskapoo Formation, Alberta, Canada (Liu & Chang 2009). †*Molinichthys inopinatus* is reported to be Late Campanian to Early Danian in age. Due to the uncertainty in the taxonomic assignment of †*Molinichthys inopinatus*, it is not used as an age constraint in our BEAST analysis and the age of Cyprinae is left unconstrained.

Diversity: 3092 extant species.

Sampled species: All sampled species of clades 13, 14, 15, 16, and 17.

Clade 13: Cyprinoidea

Taxonomy: One out of two superfamilies of Cypriniformes. Cyprinoidea include two families, Cyprinidae and Psilorhynchidae.

Support: The molecular phylogenies of He *et al.* (2008), Nakatani *et al.* (2011), and Betancur-R *et al.* (2013) give strong support for paraphyly of Cyprinidae, and for monophyly of a clade combining Cyprinidae and Psilorhynchidae (BS 100, BPP 1.0). Our RAxML phylogeny supports the monophyly of Cyprinoidea with BS 100.

First occurrence: †*Parabarbus* spp. from the Obailinskaya Formation, Zaissan Basin, Kazakhstan. †*Parabarbus* spp. are considered the earliest record of Cyprinidae (Patterson 1993b; Santini *et al.* 2009). No fossil record is known for Psilorhynchidae. The Obailinskaya Formation is reported to be Early-Middle Eocene in age. Thus, the first occurrence of Cyprinoidea dates to 55.8-37.2 Ma.

Diversity: 2420 extant species.

Sampled species: *Danio rerio*, *Psilorhynchus homaloptera*, and *Cyprinus carpio*.

Clade 14: Gyrinocheilidae

Taxonomy: One out of four families of Cobitoidea (Nelson 2006). Gyrinocheilidae include a single extant genus, *Gyrinocheilus*, and three extant species.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 3 extant species.

Sampled species: *Gyrinocheilus aymonieri*.

Clade 15: Catostomidae

Taxonomy: One out of four families of Cobitoidea (Nelson 2006). Catostomidae include 13 genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Amyzon* spp. from the Paskapoo Formation, Alberta, Canada. According to Patterson (1993b) and Liu & Chang (2009), fossils assigned to genus †*Amyzon* represent the earliest record of Catostomidae. Fossils of the Paskapoo Formation are from the Tiffanian North American Land Mammal Age (NALMA) (Wilson & Williams 1991; Patterson 1993b), which is equivalent to 61.8-56.8 Ma. Thus, the first occurrence of Catostomidae dates to 61.8-56.8 Ma.

Diversity: 72 extant species.

Sampled species: *Catostomus commersonii*.

Clade 16: Cobitidae

Taxonomy: One out of four families of Cobitoidea (Nelson 2006). Cobitidae include 26 genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Cobitis centrochir* Agassiz, 1835, from Öhningen, Germany. †*Cobitis centrochir* is considered the earliest record of Cobitidae (Patterson 1993b). According to Tobien (1977), the deposits of Öhningen are from the European Land Mammal Age (ELMA) MN 7-8 zone, which dates to 12.75-11.1 Ma. Thus, the first occurrence of Cobitidae dates to 12.75-11.1 Ma.

Diversity: 177 extant species.

Sampled species: *Cobitis striata*.

Clade 17: Balitoridae

Taxonomy: One out of four families of Cobitoidea (Nelson 2006). Balitoridae include 59 genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 420 extant species.

Sampled species: *Formosania lacustre*.

Clade 18: Characiphysae

Taxonomy: One out of two superorders of Otophysa. Characiphysae include three orders, Characiformes, Siluriformes, and Gymnotiformes.

Support: Synapomorphies are given in Wiley & Johnson (2010). Furthermore, the monophyly of Characiphysae is strongly supported by the molecular phylogenies of Betancur-R *et al.* (2013), Li *et al.* (2010b), Nakatani *et al.* (2011), and Near *et al.* (2012b) (BS 100). Our RAxML phylogeny also supports monophyly of Characiphysae with BS 100.

First occurrence: †*Santanichthys diasii* Silva Santos, 1958, from the Santana Formation (Romualdo Member) of the Araripe Basin, northeastern Brazil. †*Santanichthys diasii* is the earliest record of Characiformes (Filleul & Maisey 2004). The age of the Santana Formation, and especially that of the Romualdo Member, remains uncertain, and can only be constrained to Aptian-Turonian on the basis of vertebrate palaeontology and palynological data (Martill 2007). Thus, the first occurrence of Characiphysae dates to 125.0-89.3 Ma. As Characiformes may be nonmonophyletic (Nakatani *et al.* 2011), †*Santanichthys diasii* is not used as an age constraint for this order, but only for the superorder Characiphysae.

Diversity: 5431 extant species.

Sampled species: All sampled species of clades 19, 20, 21, and 22.

Clade 19: Gymnotiformes

Taxonomy: One out of three orders of Characiphysae. Gymnotiformes include two suborders, Gymnotoidei and Sternopygoidei.

Support: Synapomorphies are given in Wiley & Johnson (2010). The monophyly of Gymnotiformes is further supported by the molecular phylogenies of Nakatani *et al.* (2011) and Near *et al.* (2012b). Our RAxML phylogeny supports monophyly of Gymnotiformes with BS 100.

First occurrence: †*Humboldtichthys kirschbaumi* (Gayet and Meunier, 1991) from the Yecua Formation, Rio Moile, Bolivia. †*Humboldtichthys kirschbaumi* is considered the earliest record of Sternopygidae and of Gymnotiformes, and the Yecua Formation is reported to be Upper Miocene in age (Patterson 1993b; Nelson 2006). Thus the first occurrence of Gymnotiformes dates to 23.03-15.97 Ma.

Diversity: 173 extant species.

Sampled species: *Brachyhypopomus pinnicaudatus*, *Apteronotus albifrons*, *Electrophorus electricus*, and *Gymnotus carapo*.

Clade 20: Characoidei

Taxonomy: One out of two suborders of Characiformes. Characoidei include 18 families. Monophyly of the order Characiformes is supported by morphological characteristics (Wiley & Johnson 2010), and by some molecular data (Near *et al.* 2012b; BS 100). However, the molecular phylogeny of Nakatani *et al.* (2011) weakly supports paraphyly of Characiformes (BS 79), whereby Citharinoidei appear as the sister group to a clade combining Characoidei and Siluriformes. To the contrary, our RAxML phylogeny weakly supports a citharinoid-siluriform clade (BS 29). Despite the uncertainty regarding the interrelationships of Citharinoidei, Characoidei and Siluriformes, the monophyly of each of the three groups is well-supported by the data presented here, by morphology

(Nelson 2006), and by previous molecular phylogenetic analyses (Li *et al.* 2010b; Nakatani *et al.* 2011).

Support: The molecular phylogenies of Nakatani *et al.* (2011) and Near *et al.* (2012b) strongly support monophyly of Characoidei (BS 100). Our RAxML phylogeny also supports the monophyly of Characoidei with BS 100.

First occurrence: †*Tiupampichthys intermedius* Gayet and Jégu, 2003, from the Lower Member of the El Molino Formation, Agua Clara and Pajcha Pata, Bolivia. According to Gayet *et al.* (2003), the Lower Member of the El Molino Formation is Maastrichtian in age. The characiform †*Sorbinicharax verraesi* Taverne, 2003, from Nardò, Italy, is reported to be Campanian-Maastrichtian in age (Friedman 2009), and may thus be older than †*Tiupampichthys intermedius*, however relationships of †*Sorbinicharax verraesi* within Characiformes are unknown, and it may not represent a member of suborder Characoidei. Thus, we here accept †*Tiupampichthys intermedius* as the first occurrence of Characoidei, which dates to 70.6-66.043 Ma (Renne *et al.* 2013).

Diversity: 1576 extant species.

Sampled species: *Ctenolucius hujeta* and *Pygocentrus nattereri*.

Clade 21: Citharinoidei

Taxonomy: One out of two suborders of Characiformes. Citharinoidei include two families, Citharinidae and Distichodontidae. See clade 20 (Characoidei).

Support: Synapomorphies are given in Vari (1979). The molecular phylogeny of Nakatani *et al.* (2011), as well as our RAxML phylogeny support monophyly of Citharinoidei with BS 100.

First occurrence: †*Eocitharinus macrognathus* Murray, 2003, from Mahenge, Singida, Tanzania. †*Eocitharinus macrognathus* is assigned to the characiform suborder Citharinoidei based on four synapomorphies that could be coded for the fossil, and is 46.0-45.0 myr old (Murray 2003). See clade 384 (Hemichromini). Thus, the first occurrence of Citharinoidei dates to 46.0-45.0 Ma.

Diversity: 98 spp.

Sampled species: *Citharinus congicus* and *Distichodus sexfasciatus*.

Clade 22: Siluriformes

Taxonomy: One out of three orders of Characiphysae. Siluriformes include three suborders, Loricarioidei, Diplomystoidei, and Siluroidei.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogenies of Betancur-R *et al.* (2013), Nakatani *et al.* (2011), and Near *et al.* (2012b) strongly support monophyly of Siluriformes (BS 100). Our RAxML phylogeny also supports monophyly of Siluriformes with BS 100.

First occurrence: Siluriformes *incertae sedis* from the Adamantina Formation, Brazil. Following Santini *et al.* (2009), we here accept *incertae sedis* siluriforms from the Adamantina Formation, Brazil, as the first earliest record of the order. The Adamantina Formation is reported to be Turonian-Santonian in age, thus, the first occurrence of Siluriformes dates to 93.6-83.5 Ma.

Diversity: 3583 extant species.

Sampled species: All sampled species of clades 23, 24, 25, 26, and 27.

Clade 23: Nematogenyidae

Taxonomy: One out of six families of Loricarioidei (Sullivan *et al.* 2006). Nematogenyidae include a single extant genus and species, *Nematogenys inermis*. Sullivan *et al.* (2006) proposed that Siluriformes include two suborders, Loricarioidei and Siluroidei, plus the family Diplomystidae, which is not placed in either of the two suborders. We here follow Nakatani *et al.* (2011) in recognizing a third suborder, Diplomystoidei, for the family Diplomystidae.

Support: Nematogenyidae include a single extant species.

First occurrence: †*Nematogenys cuivi* from the upper Cura-Mallín Formation, Lonquimay, Chile. The only fossil record of Nematogenyidae is represented by †*Nematogenys cuivi* (Azpelicueta & Rubilar 1998; Sullivan *et al.* 2006). The Cura-Mallín Formation is reported to be Miocene in age (Azpelicueta & Rubilar 1998), thus the first occurrence of Nematogenyidae dates to 23.03-5.332 Ma.

Diversity: 1 extant species.

Sampled species: *Nematogenys inermis*.

Clade 24: Loricariidae+allies

Taxonomy: Combines three out of six families of Loricarioidei, Loricariidae, Astroblepidae, and Scoloplacidae (Sullivan *et al.* 2006). See clade 23 (Nematogenyidae).

Support: Whereas the phylogeny presented here includes only two loricariid taxa of the same genus, *Pterygoplichthys*, monophyly of the three families Loricariidae, Astroblepidae, and Scoloplacidae has been strongly supported by the molecular phylogeny of Sullivan *et al.* (2006). Synapomorphies uniting the three families are not known, but each individual family is characterized by synapomorphies as given in Nelson (2006). Our RAxML phylogeny supports monophyly of the two included loricariid species with BS 100.

First occurrence: *Loricaria?* and *Hypostomus* sp. Cione, 1986, from Ituzaingo, Argentina. Fossils assigned to genera *Loricaria* and *Hypostomus* are listed in Patterson (1993b), but not included in Sullivan *et al.* (2006) and Ferraris (2007). Patterson (1993b) assigns a Miocene age to these fossils, therefore the first occurrence of Loricariidae+allies is tentatively assumed to date to 23.03-5.332 Ma.

Diversity: 946 extant species (Sullivan *et al.* 2006).

Sampled species: *Pterygoplichthys disjunctivus* and *Pterygoplichthys multiradiatus*.

Clade 25: Trichomycteridae

Taxonomy: One out of six families of Loricarioidei (Sullivan *et al.* 2006). Trichomycteridae include 41 genera. See clade 23 (Nematogenyidae).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Sullivan *et al.* (2006), as well as our RAxML phylogeny support monophyly of Trichomycteridae with BS 100.

First occurrence: Recent.

Diversity: 221 extant species (Sullivan *et al.* 2006).

Sampled species: *Trichomycterus areolatus* and *Bullockia maldonadoi*.

Clade 26: Callichthyidae

Taxonomy: One out of six families of Loricarioidei (Sullivan *et al.* 2006). Callichthyidae include eight genera. See clade 23 (Nematogenyidae).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Sullivan *et al.* (2006) includes two callichthyid taxa that are resolved as sister lineages with strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Callichthyidae with BS 100.

First occurrence: †*Corydoras revelatus* Cockerell, 1925, from the Maís Gordo Formation, Argentina. †*Corydoras revelatus* is considered the earliest record of Callichthyidae by Patterson (1993b), Reis (1998), and Lundberg *et al.* (2007). The Maíz Gordo Formation has been assigned to the South American Land Mammal Age (SALMA) Riochican (Pascual *et al.* 1981), thus, the first occurrence of Callichthyidae dates to 57.4–55.8 Ma.

Diversity: 231 extant species (Sullivan *et al.* 2006).

Sampled species: *Corydoras rabauti* and *Hoplosternum littorale*.

Clade 27: Siluroidei+Diplomystoidei

Taxonomy: Combines two out of three suborders of Siluriformes, Siluroidei and Diplomystoidei.

Support: The molecular phylogenies of Betancur-R *et al.* (2013), Nakatani *et al.* (2011), and Sullivan *et al.* (2006) strongly support a sister group relationship of Siluroidei and Diplomystoidei (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Siluroidei+Diplomystoidei with BS 98.

First occurrence: “cf. Ariidae” Cione, 1987, from the Los Alamitos Formation, Rio Negro, Argentina, or †*Astephus* sp. Lundberg, 1975, from the Polecat Bench Formation, Big Horn County, Wyoming, USA. Due to the uncertainty in the correct taxonomic assignment of “cf. Ariidae” from the Los Alamitos Formation, “cf. Ariidae” and †*Arius dutemplei* are not used as an age constraint in our BEAST analysis. See clades 42 (Ariidae) and 46 (Ictaluridae).

Diversity: 2184 extant species.

Sampled species: All sampled species of clades 28 and 29.

Clade 28: Diplomystoidei

Taxonomy: One out of three suborders of Siluriformes. Diplomystoidei include a single family, Diplomystidae, and two extant genera, *Diplomystes* and *Olivaichthys*.

Support: Synapomorphies are given in Nakatani *et al.* (2011) for Diplomystidae. No molecular study to date includes the genus *Olivaichthys*.

First occurrence: “cf. Diplomystidae” Cione, 1987, from the Los Alamitos Formation, Rio Negro, Argentina, or Recent. Whereas no named fossils are known of Diplomystoidei, “cf. Diplomystidae” have been reported by Cione (1987) from the Los Alamitos Formation, Rio Negro, Argentina. These occur in the middle section of the Los Alamitos Formation (Cione 1987) and are considered the earliest record of Diplomystidae (Patterson 1993b). However, given the lack of additional information, the family assignment of these fossils may be questioned, and they are not used as an age constraint in our BEAST analysis. Younger fossil occurrences of Diplomystidae are not known.

(Ferraris 2007).

Diversity: 6 extant species.

Sampled species: *Diplomystes nahuelbutaensis*.

Clade 29: Siluroidei

Taxonomy: One out of three suborders of Siluriformes. Siluroidei include 32 families.

Support: The molecular phylogenies of Betancur-R *et al.* (2013), Nakatani *et al.* (2011), and Sullivan *et al.* (2006) strongly support monophyly of Siluroidei (BS 100). All siluroid taxa included in Sullivan *et al.* (2006) share the same three-codon deletion in rag1. No morphological synapomorphies are known that unambiguously support Siluroidei. Our RAXML phylogeny supports monophyly of Siluroidei with BS 100.

First occurrence: “cf. Ariidae” Cione, 1987, from the Los Alamitos Formation, Rio Negro, Argentina, or †*Astephus* sp. Lundberg, 1975, from the Polecat Bench Formation, Big Horn County, Wyoming, USA. Due to the uncertainty in the correct taxonomic assignment of “cf. Ariidae” from the Los Alamitos Formation, “cf. Ariidae” and †*Arius dutemplei* are not used as an age constraint in our BEAST analysis. See clades 42 (Ariidae) and 46 (Ictaluridae).

Diversity: 2178 extant species. (Sullivan *et al.* 2006).

Sampled species: All sampled species of clades 30, 31, 32, 33, 34, 35, 36, 37, 40, 43, 44, 47, 48, 55, 56, 57, 58, 59, 60, and 61.

Clade 30: “Big Asia”

Taxonomy: The informally named “Big Asia” clade of Sullivan *et al.* (2006) includes six families, Bagridae (excluding the genus *Rita*), Horabagridae, Akysidae, Amblycipitidae, Sisoridae, and Erethistidae, as well as an unranked clade combining the two genera *Ailia* and *Laides*.

Support: The “Big Asia” clade is strongly supported by the molecular phylogenies of Sullivan *et al.* (2006) (BS 100, BPP 1.0). The predominantly Asian biogeographic distribution further supports the monophyly of this group, however, no synapomorphies are known that unite the “Big Asia” clade. Our RAXML phylogeny supports monophyly of “Big Asia” with BS 95.

First occurrence: †*Eomacrones wilsoni* (White, 1934), †*Nigerium gadense* White, 1934, and †*Nigerium wurnoense* White, 1934, from the Wurno Formation, Wurno and Gada, Nigeria, or †*Mystus dalungshanensis* Li & Wang, 1979, and †*Mystus spinipectoralis* Li & Wang, 1979, from Sanshui Basin, Guangdong, China, and †*Aoria lacus* from Hunan, China. †*Eomacrones wilsoni* (White, 1934), †*Nigerium gadense* White, 1934, and †*Nigerium wurnoense* White, 1934, from the Wurno Formation, Wurno and Gada, Nigeria, are considered to represent the earliest record of Bagridae by Patterson (1993b), Ferraris (2007), and Santini *et al.* (2009). The Wurno Formation is reported to be Thanetian (Patterson 1993b; Santini *et al.* 2009). However, given that the “Big Asia” clade of Sullivan *et al.* (2006) is distributed almost exclusively in Asia, whereas the earliest fossils assigned to this family are reported from Nigeria, the family assignment of these fossils may be questioned, especially since the African Claroteidae were previously included in Bagridae (Mo 1991), but are not closely related (Sullivan *et al.* 2006). Besides the Nigerian fossils assigned to Bagridae, the oldest Asian fossil record of Bagridae is provided by †*Mystus dalungshanensis* Li

& Wang, 1979, and †*Mystus spinipectoralis* Li & Wang, 1979, from Sanshui Basin, Guangdong, China, and †*Aoria lacus* from Hunan, China. These fossils are reported to be Eocene in age (Ferraris 2007). No older fossil record is known of Horabagridae, Akysidae, Amblycipitidae, Sisoridae, and Erethistidae. Therefore, the first occurrence of the “Big Asia” clade is either Thanetian or Eocene, thus 58.7-33.9 Ma. Due to the uncertainty of the taxonomic assignment of †*Eomacrones wilsoni*, †*Nigerium gadense*, and †*Nigerium wurnoense* to the “Big Asia” clade, these fossils are not used as age constraint in our BEAST analysis.

Diversity: 520 extant species (Sullivan *et al.* 2006).

Sampled species: *Hara jerdoni*, *Liobagrus marginatoides*, *Liobagrus obesus*, *Batasio tigrinus*, *Horabagrus brachysoma*, and *Leiocassis poecilopterus*.

Clade 31: *Rita*

Taxonomy: The genus *Rita* has traditionally been placed in the siluroid family Bagridae, however, the molecular phylogeny of Sullivan *et al.* (2006) strongly supported exclusion of *Rita* from Bagridae. The placement of *Rita* within Siluroidei remains ambiguous. The genus *Rita* includes six species.

Support: Synapomorphies are given in Ng (2004).

First occurrence: †*Rita grandiscutata* Lydekker, 1886, from the Siwalik Formation, Punjab, India. According to Ferraris (2007), †*Rita grandiscutata* represents the only known fossil species of genus *Rita*. The Siwalik Formation is reported to be Lower Pliocene in age Ferraris (2007). Thus, the first occurrence of *Rita* dates to 5.332-3.6 Ma.

Diversity: 6 extant species (Ng 2004).

Sampled species: *Rita rita*.

Clade 32: Cetopsidae

Taxonomy: One out of 32 families of Siluroidei. Cetopsidae include seven genera. The placement of the family Cetopsidae is unresolved within Siluroidei (Sullivan *et al.* 2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) and Nakatani *et al.* (2011) strongly support monophyly of all included cetopsid taxa (BS 100).

First occurrence: Recent.

Diversity: 41 extant species (Sullivan *et al.* 2006).

Sampled species: *Helogenes marmoratus*.

Clade 33: Chacidae

Taxonomy: One out of 32 families of Siluroidei. Chacidae include a single genus, *Chaca*, and three species. The placement of the family Chacidae is unresolved within Siluroidei (Sullivan *et al.* 2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) include two out of three described chacid species that are resolved as sister lineages with strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Chacidae with BS 100.

First occurrence: Recent.

Diversity: 4 extant species (Sullivan *et al.* 2006).

Sampled species: *Chaca bankanensis* and *Chaca chaca*.

Clade 34: Plotosidae

Taxonomy: One out of 32 families of Siluroidei. Plotosidae include ten genera. The placement of the family Plotosidae is unresolved within Siluroidei (Sullivan *et al.* 2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) include three out of ten plotosid genera that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Plotosidae with BS 100.

First occurrence: Recent.

Diversity: 35 extant species (Sullivan *et al.* 2006).

Sampled species: *Plotosus japonicus* and *Plotosus lineatus*.

Clade 35: Aspredinidae

Taxonomy: One out of 32 families of Siluroidei. Aspredinidae include twelve genera. The placement of the family Aspredinidae is unresolved within Siluroidei (Sullivan *et al.* 2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) include three out of twelve aspredinid genera that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0).

First occurrence: Recent.

Diversity: 47 extant species (Sullivan *et al.* 2006).

Sampled species: *Bunocephalus coracoideus*.

Clade 36: Doradoidea

Taxonomy: The superfamily Doradoidea, as recognized by Sullivan *et al.* (2006), combines the two siluroid families Doradidae and Auchenipteridae. It thus differs from Nelson's (2006) Doradoidea by exclusion of Mochokidae.

Support: Morphological characteristics supporting the monophyly of Doradoidea are given in Diogo *et al.* (2004). The molecular phylogenies of Sullivan *et al.* (2006) include a total of six doradid and auchenipterid genera that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Doradoidea with BS 100.

First occurrence: "Doradidae *indet.*" Cione, 1986, from the Ituzaingo Formation, Parana, Argentina, or Recent. Patterson (1993b) lists "Doradidae *indet.*" Cione, 1986, from the Ituzaingo Formation, Parana, Argentina, however, given the lack of additional information, the family assignment of these fossils may be questioned. The Ituzaingo Formation is reported to be Miocene in age (Patterson 1993b). No named fossils are known of either Doradidae or Auchenipteridae (Ferraris 2007). Due to the uncertainty in the correct taxonomic assignment of "Doradidae *indet.*" from the Ituzaingo Formation, "Doradidae *indet.*" are not used as an age constraint in our BEAST analysis.

Diversity: 194 extant species (Sullivan *et al.* 2006).

Sampled species: *Amblydoras gonzalezi*, *Acanthodoras cataphractus*, *Centromochlus perugiae*, *Ageneiosus ucayalensis*, and *Tetranematichthys quadrifilis*.

Clade 37: Clarioidea

Taxonomy: The superfamily Clarioidea combines the two siluroid families Clariidae and Heteropneustidae.

Support: Morphological data as cited in Nelson (2006) support the monophyly of Clarioidea. Both families are represented in the molecular phylogenies of Sullivan *et al.* (2006) and their monophyly is strongly supported (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Clarioidea with BS 100.

First occurrence: †*Clarias falconeri* Lydekker, 1886, and †*Heterobranchus palaeindicus* Lydekker, 1886, from the Siwalik Formation, Punjab, India. †*Clarias falconeri* and †*Heterobranchus palaeindicus* are the only known named fossils of Clariidae, and no fossil record is known for Heteropneustidae (Ferraris 2007). The first occurrence of Clarioidea dates to 5.332-2.588 Ma. See clade 38 (Clariidae).

Diversity: 118 extant species (Sullivan *et al.* 2006).

Sampled species: All sampled species of clades 38 and 39.

Clade 38: Clariidae

Taxonomy: One out of two families of the siluroid superfamily Clarioidea. Clariidae include 14 genera.

Support: Synapomorphies are given in Sullivan *et al.* (2006) and Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) strongly support the monophyly of all three included clariid taxa (BS 100, BPP 1.0).

First occurrence: †*Clarias falconeri* Lydekker, 1886, and †*Heterobranchus palaeindicus* Lydekker, 1886, from the Siwalik Formation, Punjab, India. †*Clarias falconeri* and †*Heterobranchus palaeindicus* are the only known named fossils of Clariidae (Ferraris 2007). The Siwalik Formation is reported to be Lower Pliocene in age (Ferraris 2007). Thus, the first occurrence of Clariidae dates to 5.332-2.588 Ma.

Diversity: 116 extant species (Sullivan *et al.* 2006).

Sampled species: *Clarias fuscus*.

Clade 39: Heteropneustidae

Taxonomy: One out of two families of the siluroid superfamily Clarioidea. Heteropneustidae include a single genus, *Heteropneustes*, with two species (Sullivan *et al.* 2006).

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 2 extant species (Sullivan *et al.* 2006).

Sampled species: *Heteropneustes fossilis*.

Clade 40: Arioidea

Taxonomy: The superfamily Arioidea combines the two siluroid families Ariidae and Anchariidae.

Support: Morphological data cited in Sullivan *et al.* (2006) supports the monophyly of Arioidea. The molecular phylogenies of Sullivan *et al.* (2006) include a total of six ariid and anchariid taxa that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Arioidea with BS 100.

First occurrence: “cf. Ariidae” Cione, 1987, from the Los Alamos Formation, Rio Negro, Argentina, or †*Arius dutemplei* Leriche, 1900, from the Paris Basin, France. Due to the uncertainty in the correct taxonomic assignment of “cf. Ariidae” from the Los Alamos Formation, “cf. Ariidae” and †*Arius dutemplei* are not used as an age constraint in our BEAST analysis. See clade 42 (Ariidae).

Diversity: 159 extant species (Sullivan *et al.* 2006).

Sampled species: All sampled species of clades 41 and 42.

Clade 41: Anchariidae

Taxonomy: One out of two families of Arioidea. Anchariidae include two genera, *Ancharius* and *Gogo*.

Support: Morphological data cited in Ng & Sparks (2005) and Sullivan *et al.* (2006).

First occurrence: Recent.

Diversity: 5 extant species (Ng & Sparks 2005).

Sampled species: *Gogo arcuatus*.

Clade 42: Ariidae

Taxonomy: One out of two families of Arioidea. Ariidae include 21 genera.

Support: Monophyly of Ariidae is supported by synapomorphies given in Nelson (2006) and morphological data cited in (Sullivan *et al.* 2006). Our RAxML phylogeny supports monophyly of Ariidae with BS 100.

First occurrence: “cf. Ariidae” Cione, 1987, from the Los Alamos Formation, Rio Negro, Argentina, or †*Arius dutemplei* Leriche, 1900, from the Paris Basin, France. Patterson (1993b) lists undetermined fin-spines of the family Ariidae, reported by Cione (1987), however given the lack of additional information, the family assignment may be questioned. The earliest named fossil of Ariidae is †*Arius dutemplei* (Ferraris 2007). The Los Alamos Formation is reported to be Campanian in age, and †*Arius dutemplei* is from the lowermost Eocene (Ypresian). Due to the uncertainty in the correct taxonomic assignment of “cf. Ariidae” from the Los Alamos Formation, “cf. Ariidae” and †*Arius dutemplei* are both not used as age constraints in our BEAST analysis.

Diversity: 154 extant species (Sullivan *et al.* 2006).

Sampled species: *Ariopsis seemanni* and *Cephalocassis borneensis*.

Clade 43: Pangasiidae

Taxonomy: One out of 32 families of Siluroidei. Pangasiidae include three genera. The placement of the family Pangasiidae is unresolved within Siluroidei (Sullivan *et al.* 2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) include three out of five pangasiid genera and these are resolved as a monophyletic clade with

strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Pangasiidae with BS 100.

First occurrence: †*Pangasius indicus* (van der Marck, 1876), from the Highlands of Padang, Sumatra, Indonesia, or †*Cetopangasius chaetobranchus* Roberts and Jumnonthai, 1999, from Ban Nong Pla, Phetchabun Province, Thailand. Patterson (1993b) considers †*Pangasius indicus* to be the earliest record of Pangasiidae but expresses doubt concerning the reported Eocene age of the fossils. The next-oldest record of Pangasiidae is provided by †*Cetopangasius chaetobranchus* (Ferraris 2007). The fossil deposits of Ban Nong Pla are assumed to be Middle or Late Miocene in age (Roberts & Jumnonthai 1999). Due to the uncertain age of †*Pangasius indicus*, neither †*Pangasius indicus* nor *Cetopangasius chaetobranchus* are used as age constraints in our BEAST analysis.

Diversity: 26 extant species (Sullivan *et al.* 2006).

Sampled species: *Pangasianodon gigas* and *Pangasius larnaudii*.

Clade 44: Ictaluroidea

Taxonomy: The superfamily Ictaluroidea combines the two siluroid families Ictaluridae and Cranoglanididae.

Support: Synapomorphies are cited in Sullivan *et al.* (2006). The molecular phylogenies of Sullivan *et al.* (2006) include a total of five ictalurid and cranoglanid taxa that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0). Our RAxML phylogeny supports the monophyly of Ictaluroidea with BS 99.

First occurrence: †*Astephus* sp. Lundberg, 1975, from the Polecat Bench Formation, Big Horn County, Wyoming, USA. †*Astephus* is considered to be the sister group of all extant Ictaluridae (Grande & Lundberg 1988; Patterson 1993b). No fossil record is known for Cranoglanididae. The first occurrence of Ictaluroidea dates to 58.7-55.8 Ma. See clade 46 (Ictaluridae).

Diversity: 63 extant species (Sullivan *et al.* 2006).

Sampled species: All sampled species of clades 55 and 56.

Clade 45: Cranoglanididae

Taxonomy: One out of two families of Ictaluroidea. Cranoglanididae include a single genus, *Cranoglanis*, and four species.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 4 extant species (Sullivan *et al.* 2006).

Sampled species: *Cranoglanis boudierius*.

Clade 46: Ictaluridae

Taxonomy: One out of two families of Ictaluroidea. Ictaluridae include seven genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Astephus* sp. Lundberg, 1975, from the Polecat Bench Formation, Big Horn County, Wyoming, USA. Genus †*Astephus* is considered the sister lineage of all extant Ictaluridae (Grande & Lundberg 1988; Patterson 1993b). The best characterization of †*Astephus* is based on

†*Astephus antiquus* from the Green River Formation of Wyoming and Utah, USA, however, the earliest record of the genus are fragmentary specimens from Upper Paleocene deposits (Grande & Lundberg 1988). The Polecat Bench Formation is reported to be Thanetian in age (Patterson 1993b), therefore the first occurrence of Ictaluridae dates to 58.7-55.8 Ma.

Diversity: 59 extant species (Sullivan *et al.* 2006).

Sampled species: *Ictalurus punctatus*.

Clade 47: Siluridae

Taxonomy: One out of 32 families of Siluroidei. Siluridae include 11 genera. The placement of the family Siluridae is unresolved within Siluroidei (Sullivan *et al.* 2006).

Support: Monophyly of Siluridae is supported by synapomorphies given in Nelson (2006) and morphological and molecular data cited in Sullivan *et al.* (2006). The molecular phylogenies of Sullivan *et al.* (2006) include five out of twelve genera that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Siluridae with BS 100.

First occurrence: †*Silurus altus* Sytchevskaya, 1989, from China. †*Silurus altus* from China is reported to be Lower-Middle Miocene in age (Ferraris 2007), thus, the first occurrence of Siluridae dates to 23.03-11.608 Ma.

Diversity: 129 extant species (Sullivan *et al.* 2006).

Sampled species: *Silurus glanis* and *Wallago attu*.

Clade 48: Pimelodoidea

Taxonomy: The superfamily Pimelodoidea combines the three siluroid families Pimelodidae, Pseudopimelodidae, Heptapteridae, and the monotypic genus *Conorhynchos* (Sullivan *et al.* 2006).

Support: No synapomorphies uniting Pimelodoidea are known. However, the molecular phylogenies of Sullivan *et al.* (2006) include representatives of Pimelodidae, Pseudopimelodidae, Heptapteridae, and *Conorhynchos*, and strongly support their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Pimelodoidea with BS 100.

First occurrence: †*Brachyplatystoma promagdalena* Lundberg, 2005, from the La Venta Formation, Colombia. No fossil record is known for Pseudopimelodidae, Heptapteridae, and *Conorhynchos* (Patterson 1993b; Ferraris 2007). The first occurrence of Pimelodoidea dates to 15.97-11.608 Ma. See clade 50 (Pimelodidae).

Diversity: 395 extant species (Sullivan *et al.* 2006).

Sampled species: All sampled species of clades 49 and 52.

Clade 49: Pimelodidae+Pseudopimelodidae

Taxonomy: Combines two out of three families of Pimelodoidea, Pimelodidae and Pseudopimelodidae.

Support: No synapomorphies are known to unite Pimelodidae and Pseudopimelodidae, however, a sister group relationship between Pimelodidae and Pseudopimelodidae is strongly supported by the molecular phylogenies of Sullivan *et al.* (2006) and by unpublished work cited in Sullivan *et al.*

(2006). Our RAxML phylogeny supports monophyly of Pimelodidae+Pseudopimelodidae with BS 96.

First occurrence: †*Brachyplatystoma promagdalenae* Lundberg, 2005, from the La Venta Formation, Colombia. No fossil record is known for Pseudopimelodidae (Patterson 1993b; Ferraris 2007). See clade 50 (Pimelodidae).

Diversity: 152 extant species (Sullivan *et al.* 2006).

Sampled species: All sampled species of clades 50 and 51.

Clade 50: Pimelodidae

Taxonomy: One out of three families of Pimelodoidea. Pimelodidae include 31 genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Brachyplatystoma promagdalenae* Lundberg, 2005, from the La Venta Formation, Colombia. The La Venta Formation is reported to be Middle Miocene in age (Ferraris 2007), therefore the first occurrence of Pimelodidae dates to 15.97-11.608 Ma.

Diversity: 112 extant species (Sullivan *et al.* 2006).

Sampled species: *Pimelodus pictus*.

Clade 51: Pseudopimelodidae

Taxonomy: One out of three families of Pimelodoidea. Pseudopimelodidae include five genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 40 extant species (Sullivan *et al.* 2006).

Sampled species: *Batrochoglanis raninus*.

Clade 52: Heptapteridae+ *Conorhynchos*

Taxonomy: Combines the pimelodoid family Heptapteridae with the genus *Conorhynchos*.

Support: No synapomorphies are known to unite Heptapteridae and *Conorhynchos*, however, the molecular phylogenies of Sullivan *et al.* (2006) include four heptapterid genera as well as *Conorhynchos* and strongly support their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Heptapteridae+ *Conorhynchos* with BS 99.

First occurrence: Recent.

Diversity: 243 extant species (Sullivan *et al.* 2006).

Sampled species: All sampled species of clades 63 and 64.

Clade 53: Heptapteridae

Taxonomy: One out of three families of Pimelodoidea. Heptapteridae include 25 genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 242 extant species (Sullivan *et al.* 2006).

Sampled species: *Goeldiella eques*.

Clade 54: *Conorhynchos*

Taxonomy: Genus *Conorhynchos* is part of the siluroid superfamily Pimelodoidea (Sullivan *et al.* 2006). The genus includes a single species, *C. conirostris*.

Support: *Conorhynchos* include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Conorhynchos conirostris*.

Clade 55: Schilbidae

Taxonomy: One out of five families of the informally named “Big Africa” clade of Sullivan *et al.* (2006). We here follow Sullivan *et al.* (2006) in including only African species of Schilbidae *sensu lato* (see Sullivan *et al.* 2006).

Support: No synapomorphies are known to unambiguously unite Schilbidae *sensu stricto*. However, based on morphological data, Mo (1991) recognized three subgroups of his Schilbidae, one of which is identical to the Schilbidae *sensu stricto* of Sullivan *et al.* (2006).

First occurrence: Recent.

Diversity: 31 extant species (Sullivan *et al.* 2006).

Sampled species: *Pareutropius debauwi*.

Clade 56: Auchenoglanididae

Taxonomy: Ranked as family level in Nelson (2006), but considered a subfamily, Auchenoglaninae, of Claroteidae in Sullivan *et al.* (2006), despite weak support of claroteid polyphyly from their molecular phylogeny (BS 50, BPP 56). Auchenoglanididae include six genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) include three out of six auchenoglanidid genera that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Auchenoglanididae with BS 100.

First occurrence: Recent.

Diversity: 28 extant species.

Sampled species: *Auchenoglanis occidentalis*, *Parauchenoglanis balayi*, and *Anaspidoglanis macrostomus*.

Clade 57: Lacantuniidae

Taxonomy: One out of 32 families of Siluroidei. The family Lacantuniidae was erected for the single species of *Lacantunia enigmatica*, a Central American lineage deeply nested within the siluroid “Big Africa” clade (Lundberg *et al.* 2007).

Support: Lacantuniidae include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Lacantunia enigmatica*.

Clade 58: Claroteidae

Taxonomy: One out of 32 families of Siluroidei. Claroteidae include seven genera. Following Nelson (2006), Claroteidae are here considered to exclude the subfamily Auchenoglaninae. The group is thus identical to the Claroteinae of Sullivan *et al.* (2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Sullivan *et al.* (2006) strongly supports monophyly of Claroteidae, in the composition that is used here (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Claroteidae with BS 100.

First occurrence: †*Chrysichthys mahengeensis* Murray & Budney, 2003, from Mahenge, Singida, Tanzania. The ichthyofauna of Mahenge is Eocene in age and can be constrained to 46.0-45.0 Ma (Murray 2000a). See clade 384 (Hemichromini). Thus, the first occurrence of Claroteidae dates to 46.0-45.0 Ma.

Diversity: 59 extant species.

Sampled species: *Chrysichthys* sp., *Chrysichthys dendrophorus*, *Lophiobagrus brevispinis*, *Bathylagus tetranema*, and *Phyllonemus typus*.

Clade 59: Amphiliidae

Taxonomy: One out of five families of the informally named “Big Africa” clade of Sullivan *et al.* (2006). Amphiliidae include nine genera (Sullivan *et al.* 2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) include four out of nine genera that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0).

First occurrence: Recent.

Diversity: 93 extant species (Sullivan *et al.* 2006).

Sampled species: *Amphilius* sp.

Clade 60: Malapteruridae

Taxonomy: One out of five families of the informally named “Big Africa” clade of Sullivan *et al.* (2006). Malapteruridae include two genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Sullivan *et al.* (2006) include two species of genus *Malapterurus* (the second malapterurid genus, *Paradoxoglanis*, is not represented) that are resolved as a monophyletic clade with strong support (BS 100, BPP 1.0).

First occurrence: Recent.

Diversity: 19 extant species.

Sampled species: *Malapterurus* sp.

Clade 61: Mochokidae

Taxonomy: One out of five families of the informally named “Big Africa” clade of Sullivan *et al.* (2006). Mochokidae include eleven genera.

Support: Despite the relatively low bootstrap support for the monophyly of Mochokidae resulting from our molecular phylogeny (BS 93), we nevertheless assume this group to be monophyletic

based on synapomorphies given in Mo (1991), Nelson (2006), and Vigliotta (2008). In addition, the molecular phylogeny of Sullivan *et al.* (2006) strongly supports monophyly of all included mochokid genera (four out of ten genera - the same genera as used here) (BS 100, BPP 1.0).

First occurrence: Undetermined Mochokidae from the Birket Qarun Formation, Fayum Depression, Egypt. Murray *et al.* (2010) report isolated teeth, that based on their characteristic “S”-shape can be assigned to family Mochokidae. The Birket Qarun Formation is considered to be Priabonian in age (Murray *et al.* 2010), therefore the first occurrence of Mochokidae dates to 37.2-33.9 Ma.

Diversity: 210 extant species (Sullivan *et al.* 2006).

Sampled species: *Atopochilus savognani*, *Euchilichthys dybowskii*, *Microsynodontis* sp., *Synodontis schoutedeni*, *Synodontis batesii*, *Synodontis njassae*, *Synodontis granulosus*, *Synodontis multipunctatus*, *Synodontis* aff. *tanganyicae*, *Synodontis petricola*, *Synodontis polli*, and *Synodontis victoriae*.

Clade 62: Euteleosteomopha

Taxonomy: One out of two cohorts of Clupeocephala. Euteleosteomopha include four subcohorts, Lepidogalaxii, Protacanthopterygii, Stomiatii, and Neoteleostei. Following Betancur-R *et al.* (2013), we here exclude the former argentiniform suborder Alepocephaloidei from cohort Euteleosteomopha.

Support: Monophyly of Euteleosteomopha including Alepocephaloidei is supported by synapomorphies as given in Wiley & Johnson (2010). The molecular phylogenies of Lavoué *et al.* (2005), Li *et al.* (2010b), Near *et al.* (2012b), Betancur-R *et al.* (2013), as well as our RAxML phylogeny strongly support monophyly of Euteleosteomopha (BS 100).

First occurrence: †*Leptolepides sprattiformis* Blainville, 1818, from the lithographic limestone of Cerin, France. The Tithonian Solnhofen limestone yields several euteleost fossils, including †*Leptolepides sprattiformis* Blainville, 1818, †*L. haerteisi* Arratia, 1997, †*Orthogonikleithrus hoelli* Arratia, 1997, and †*O. leichi* Arratia, 1987 (Arratia & Tischlinger 2010). Specimens of †*L. sprattiformis* have also been preserved in the lithographic limestone of Cerin, France, which has been assigned a Kimmeridgian age, and is thus older than the Solnhofen Limestone (Wenz *et al.* 1993). Thus, the first occurrence of Euteleosteomopha is here assumed to date to 155.7-150.8 Ma.

Diversity: 17997 extant species.

Sampled species: All sampled species of clades 63, 64, 69, 70, 71, 72, and 73.

Clade 63: Lepidogalaxii

Taxonomy: One out of four subcohorts of Euteleosteomopha. Lepidogalaxii include a single order, Lepidogalaxiiformes, family, Lepidogalaxiidae, genus, and species, *Lepidogalaxias salamandroides*.

Support: Lepidogalaxii include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Lepidogalaxias salamandroides*.

Clade 64: Argentiniformes

Taxonomy: One out of four orders of Protacanthopterygii. Argentiniformes include four families, Argentinidae, Bathylagidae, Microstomatidae, and Opisthoproctidae.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogenies of Li *et al.* (2010b) and Near *et al.* (2012b), as well as our RAXML phylogeny support monophyly of Argentinoidei with BS 100.

First occurrence: †*Nybelinoides brevis* (Traquair, 1911) from Bernissart, Belgium. †*Nybelinoides brevis* was described as a member of family Argentinidae (Taverne 1982), and is considered the earliest record of Argentinoidei by Patterson (1993b) and Santini *et al.* (2009). The first occurrence of Argentiniformes dates to 127.0-124.0 Ma. See clade 66 (Argentinidae).

Diversity: 72 extant species.

Sampled species: All sampled species of clades 65, 66, 67, and 68.

Clade 65: Opisthoproctidae

Taxonomy: One out of four families of Argentiniformes. Opisthoproctidae include six genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Opisthoproctus weitzmani* Nolf, 1988, from Marnes de Brihande, Chalosse, France. †*Opisthoproctus weitzmani* has been described from otolith remains, and is reported to be Priabonian in age (Patterson 1993b). No skeletal fossils are known for Opisthoproctidae. Due to the uncertainty of the taxonomic assignment of otolith fossil, †*Opisthoproctus weitzmani* is not used as an age constraint in our BEAST analysis.

Diversity: 11 extant species.

Sampled species: *Opisthoproctus soleatus*.

Clade 66: Argentinidae

Taxonomy: One out of four families of Argentiniformes. Argentinidae include two genera, *Argentina* and *Glossanodon*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Nybelinoides brevis* (Traquair, 1911) from Bernissart, Belgium. †*Nybelinoides brevis* is considered the earliest record of Argentinidae (Taverne 1982; Patterson 1993b; Santini *et al.* 2009). It is reported from the Lower Wealden facies of Bernissart, which are considered to be Late Barremian to earliest Aptian in age (Godefroit 2012). The first occurrence of Argentinidae therefore dates to approximately 127.0-124.0 Ma (Santini *et al.* 2009).

Diversity: 23 extant species.

Sampled species: *Glossanodon semifasciatus*.

Clade 67: Microstomatidae

Taxonomy: One out of four families of Argentiniformes. Microstomatidae include three genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: *Nansenia* sp. Nolf and Steurbaut, 1983, from Twistringen, Bremen, Germany, or *Nansenia groenlandica* from the Eastern Mediterranean. Otolith remains found in clay of brickyard Sunder were assigned to genus *Nansenia*, a member of subfamily Microstomatinae, and are

considered Serravallian in age (Patterson 1993b). The next-oldest fossils of Microstomatidae are otoliths of the extant species *Nansenia groenlandica* from Eastern Mediterranean deposits of Pleistocene age (Agiadi *et al.* 2011). No skeletal fossils are known of Microstomatidae. Given the taxonomic uncertainty of otolith fossils, *Nansenia* sp. is not used as an age constraint in our BEAST analysis.

Diversity: 18 extant species.

Sampled species: *Nansenia ardesiaca*.

Clade 68: Bathylagidae

Taxonomy: One out of four families of Argentiniformes. Bathylagidae include eight genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 20 extant species.

Sampled species: *Lipolagus ochotensis*.

Clade 69: Esociformes

Taxonomy: One out of four orders of Protacanthopterygii. Esociformes include two families, Esocidae and Umbridae.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Li *et al.* (2010b), Near *et al.* (2012b), and Betancur-R *et al.* (2013), as well as our RAxML phylogeny support monophyly of Esociformes with BS 100.

First occurrence: †*Estesesox foxi* Wilson *et al.*, 1992 and †*Oldmanesox canadensis* Wilson *et al.*, 1992, from the Judith River and Milk River Formations, Alberta, Canada. †*Estesesox foxi* and †*Oldmanesox canadensis* are considered to be members of Esocidae, and both the Judith River and Milk River Formations are reported to be Campanian in age (Patterson 1993b). Therefore, the first occurrence of Esocoidei dates to 83.5–70.6 Ma.

Diversity: 10 extant species.

Sampled species: *Dallia pectoralis* and *Esox lucius*.

Clade 70: Salmoniformes

Taxonomy: One out of four orders of Protacanthopterygii. Salmoniformes include a single family, Salmonidae, and eleven genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Li *et al.* (2010b), Near *et al.* (2012b), and Betancur-R *et al.* (2013), as well as our RAxML phylogeny support monophyly of Salmoniformes with BS 100.

First occurrence: †*Eosalmo driftwoodensis* Wilson, 1977, from the Driftwood Creek Formation, British Columbia, Canada. Several Cretaceous fossils with unclear taxonomic affinities have been assigned to the order Salmoniformes, to the point that the group has been considered a “wastebasket” for fossil fishes (Gallo *et al.* 2009). These include †*Casieroides yamangiensis* Taverne, 1975, †*Chardonius longicaudatus* Taverne, 1975, and †*Pseudoleptolepis minor* Taverne, 1975, from the Loia Beds, Democratic Republic of the Congo (Murray 2000c), †*Helgolandichthys schmidi* Tav-

erne, 1981, from Töck, Helgoland, Germany, †*Barcarenichthys joneti* Gayet, 1981, from Barcarena, Portugal, †*Gaudryella gaudryi* Pictet and Humbert, 1866, †*Pseudoberyx longispina* Pictet and Humbert, 1866, †*Gharbouria libanica* Gayet, 1988, and †*Ginsburgia operta* Patterson, 1970 from Haqil, Lebanon, †*Goudkoffia delicata* David, 1946, and †*Natlandia ornata* David, 1946 from Southern California. However, all Cretaceous “Salmoniformes” remain of questionable taxonomic position (Gallo *et al.* 2009). †*Eosalmo driftwoodensis* is the oldest undebated salmonoid fossil, and is assigned to family Salmonidae (Wilson & Li 1999). The Driftwood Creek Formation is reported to be Middle Eocene in age (Wilson & Li 1999). Thus, the first occurrence of Salmoniformes dates to 48.6-37.2 Ma.

Diversity: 66 extant species.

Sampled species: *Salmo salar*, *Oncorhynchus keta*, and *Oncorhynchus mykiss*.

Clade 71: Stomiati

Taxonomy: One out of four subcohorts of Euteleostei. Stomiati include two orders, Stomiiformes and Osmeriformes. Note that Osmeriformes exclude Galaxiidae, whereas Plecoglossinae and Salangini of Nelson (2006) are treated at family level in Betancur-R *et al.* (2013).

Support: Synapomorphies are given in Wiley & Johnson (2010) for Stomiiformes. The molecular phylogenies of Li *et al.* (2010b), Near *et al.* (2012b), and Betancur-R *et al.* (2013), as well as our RAXML phylogeny support monophyly of Stomiati with BS 100. In Li *et al.* (2010b) and Near *et al.* (2012b), Stomiiformes are treated as Stomiiformes.

First occurrence: †*Telepholis* von der Marck and Schlüter, 1868, from Sendenhorst, Westphalia, Germany. †*Telepholis* is considered to be the sister group of all extant Stomiiformes, and is reported to be Campanian in age (Dietze 2009). Thus, the first occurrence of Stomiati dates to 83.5-70.6 Ma.

Diversity: 427 extant species.

Sampled species: *Diplophos taenia*, *Chauliodus sloani*, and *Sigmops gracilis*.

Clade 72: Galaxiiformes

Taxonomy: One out of four orders of Protacanthopterygii. Galaxiiformes include a single family, Galaxiidae, with eight genera. Note that *Lepidogalaxias* is excluded from Galaxiiformes, thus reducing Galaxiidae to the species included in subfamily Galaxiinae, as recognized in Nelson (2006).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Waters *et al.* (2000) and Betancur-R *et al.* (2013) strongly support monophyly of Galaxiiformes. Our RAXML phylogeny supports monophyly of Galaxiiformes with BS 100.

First occurrence: †*Stompooria rogersmithi* Anderson, 1998, from Karoo, South Africa. †*Stompooria rogersmithi* has been considered the earliest record of Galaxiidae (Santini *et al.* 2009) and is reported to be Maastrichtian in age (Anderson 1998). Thus, the first occurrence of Galaxiiformes dates to 70.6-65.5 Ma.

Diversity: 51 extant species.

Sampled species: *Galaxiella nigrostriata*, *Galaxias maculatus*, and *Galaxias gollumoides*.

Clade 73: Neoteleostei

Taxonomy: One out of four subcohorts of Euteleosteomorpha. Neoteleostei include two infracohorts, Ateleopodia and Eurypterygia, and the latter is composed of Aulopa and Ctenosquamata. Note that Stomiatiformes are excluded from Neoteleostei.

Support: No synapomorphies are known to unite Eurypterygia and Ateleopodiformes, but the molecular phylogenies of Li *et al.* (2010b), Near *et al.* (2012b), and Betancur-R *et al.* (2013) strongly support the sister group relationship of Eurypterygia and Ateleopodiformes (BS 100). Our RAxML phylogeny supports monophyly of Neoteleostei with BS 99.

First occurrence: †*Atolvorator longipectoralis* Gallo and Coelho, 2008, from the Coqueiro Seco Formation of the Sergipe-Alagoas Basin, northeastern Brazil. †*Atolvorator longipectoralis* is considered the earliest record of Aulopiformes and thus Aulopa (Davis & Fielitz 2010), and predates the first occurrence of Ctenosquamata and Ateleopodiformes. The first occurrence of Neoteleostei dates to 130.0–125.0 Ma. See clade 75 (Aulopa).

Diversity: 17383 extant species.

Sampled species: All sampled species of clades 74, 75, 76.

Clade 74: Ateleopodia

Taxonomy: One out of two infracohorts of Neoteleostei. Ateleopodia include a single order, Ateleopodiformes, a single family, Ateleopodidae, and four genera.

Support: Synapomorphies are given in Nelson (2006) and Wiley & Johnson (2010). The molecular phylogenies of Li *et al.* (2010b), Near *et al.* (2012b), and Betancur-R *et al.* (2013) all include two ateleopodid taxa and strongly support their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Ateleopodia with BS 100.

First occurrence: *Ateleopus* sp. Huyghebaert and Nolf, 1979, from Sables de Zonderschot, Heist-op-den-Berg, Belgium. The earliest record of Ateleopodia is provided by otolith remains that are recorded to be Serravallian in age (Patterson 1993b). No skeletal fossils of Ateleopodia are known. Due to the uncertainty of the taxonomic assignment of otolith fossils, *Ateleopus* sp. is not used as an age constraint in our BEAST analysis.

Diversity: 12 extant species.

Sampled species: *Ateleopus japonicus*, *Ijimaia dofleini*, and *Ijimaia antillarum*.

Clade 75: Aulopa

Taxonomy: One out of two sections of Eurypterygia. Aulopa include a single order, Aulopiformes, and three suborders, Aulopoidei, Paraulopoidei, and Alepisauroides.

Support: Synapomorphies are given in Nelson (2006) and Wiley & Johnson (2010). The molecular phylogenies of Li *et al.* (2010b), Near *et al.* (2012b), and Betancur-R *et al.* (2013), as well as our RAxML phylogeny support monophyly of Aulopiformes with BS 100.

First occurrence: †*Atolvorator longipectoralis* Gallo and Coelho, 2008, from the Coqueiro Seco Formation of the Sergipe-Alagoas Basin, northeastern Brazil. †*Atolvorator longipectoralis* is considered the earliest record of Aulopa (Gallo & Coelho 2008; Davis & Fielitz 2010). The Coqueiro Seco Formation is reported to be Barremian in age, thus, the first occurrence of Aulopa dates to

130.0-125.0 Ma.

Diversity: 236 extant species.

Sampled species: *Chlorophthalmus agassizi*, *Synodus variegatus*, *Hime japonica*, *Saurida undosquamis*, and *Harpadon microchir*.

Clade 76: Ctenosquamata

Taxonomy: One out of two section of Eurypterygia. Ctenosquamata include two subsections, Acanthomorphata and Myctophata.

Support: Synapomorphies are given in Nelson (2006) and Wiley & Johnson (2010). The molecular phylogenies of Near *et al.* (2012b) and Betancur-R *et al.* (2013) strongly support monophyly of Ctenosquamata (BS 100). Our RAxML phylogeny supports monophyly of Ctenosquamata with BS 96.

First occurrence: †*Xenyllion zonensis* Wilson and Murray, 1996, from the Fish Scale Zone of Alberta, Canada and the Mowry Shale Utah, USA, or †*Muhichthys cordobai* from the Muhi Quarry, Hidalgo State, Mexico. Both †*Xenyllion zonensis* and †*Muhichthys cordobai* are assigned to Acanthomorphata and predate the earliest record of Myctophata. Acanthomorphata are abundant in the fossil record of the Cenomanian (Patterson 1993b), and seem to be absent in Lower Cretaceous deposits. Only few recent discoveries suggest the possibility that acanthomorphs could have originated before the Cenomanian. Wilson & Murray (1996) describe the sphenoccephalid †*Xenyllion zonensis* from the Fish Scale Zone of Alberta, Canada, and find Sphenoccephaliformes to be the sister group to all other paracanthopterygiids (Murray & Wilson 1999). The authors report the Fish Scale Zone within the Shaftesbury Formation to be of Albian-Cenomanian age. The same sphenoccephalid genus also occurs in the Mowry Shale in Utah, which is also assigned a late Albian or early Cenomanian age (Stewart 1996). In both cases, acanthomorph fossils were found in the zone of †*Neogastrophiles americanus* (Stewart 1996), that has been dated at 97.92-97.53 Ma (Scott *et al.* 2009), and thus falls into the early Cenomanian. González-Rodríguez & Fielitz (2008) describe the acanthomorph †*Muhichthys cordobai* from the Muhi Quarry, Hidalgo State, Mexico, which is also reported to be Albian-Cenomanian in age (Fielitz & González-Rodríguez 2010). Otolith fossils of “genus *Acanthomorphorum*” *forcallensis* Nolf, 2004, “genus *Aulopiformorum*” *pseudocentrolophus* Nolf, 2004, and “genus *Protacanthopterygiorum*” *scalpillum* Nolf, 2004, from Maestrazgo, Spain, that predate the first skeletal acanthomorph fossils by ~15-25 myr (Early Aptian) are here considered to provide only weak evidence for pre-Albian acanthomorphs. Thus, we here assume that the Acanthomorphata first appeared in the fossil record between 112.0-97.53 Ma.

Diversity: 17131 extant species.

Sampled species: All sampled species of clades 77, 80, 81, 82, 86, and 85.

Clade 77: Myctophata

Taxonomy: One out of two subsections of Ctenosquamata. Myctophata include a single order, Myctophiformes, and two families, Neoscopelidae and Myctophidae.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogenies of Li *et al.* (2010b), Near *et al.* (2012b), and Betancur-R *et al.* (2013) all include representatives of

the two myctophiform families, and strongly support their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Myctophata with BS 100.

First occurrence: †*Sardinioides* spp. van der Marck, 1858, †*Sardinius cordieri* (Agassiz, 1839), or †*Tachynectes* spp. van der Marck, 1863, from Sendenhorst, Westphalia, Germany. Fossils from Sendenhorst, Westphalia, Germany, that were originally described under the name †*Osmeroides monasteri* Agassiz, 1835 were later assigned to the genus †*Sardinioides* (Prokofiev 2006; Dietze 2009). †*Sardinioides* spp., †*Sardinius cordieri*, and †*Tachynectes* spp. are reported to be Campanian in age. Thus, the first occurrence of Myctophiformes dates to 83.5-70.6 Ma.

Diversity: 246 extant species.

Sampled species: All sampled species of clades 91 and 92.

Clade 78: Neoscopelidae

Taxonomy: One of two myctophiform families.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Undescribed otoliths from Aquitaine, France. Patterson (1993b) considers fossils of genus †*Sardinioides* to represent the earliest record of Neoscopelidae, however, the phylogenetic analysis of Dietze (2009) supports a position of †*Sardinioides* in its own family, †Sardinioididae. According to Patterson (1993b), the next-oldest record of Neoscopelidae is provided by undescribed otoliths from Aquitaine, France, that are reported to be Chattian in age. Due to the uncertainty of the taxonomic assignment of otolith fossils, the undescribed otoliths from Aquitaine are not used as an age constraint in our BEAST analysis.

Diversity: 6 extant species.

Sampled species: *Neoscopelus microchir*.

Clade 79: Myctophidae

Taxonomy: One of two myctophiform families.

Support: Synapomorphies are given in Nelson (2006). Our RAxML phylogeny includes representatives of two myctophid genera and supports their monophyly with BS 100.

First occurrence: †*Sardinius cordieri* (Agassiz, 1839), or †*Tachynectes* spp. van der Marck, 1863, from Sendenhorst, Westphalia, Germany. †*Sardinius cordieri* is considered the earliest record of Myctophidae by Patterson (1993b), but not included in the phylogenetic analysis of Dietze (2009). Fossils assigned to genus †*Tachynectes*, however, are considered to be members of Myctophidae by Dietze (2009). Both †*Sardinius cordieri* and †*Tachynectes* spp. are reported to be Campanian in age (Patterson 1993b; Dietze 2009), therefore the first occurrence of Myctophidae dates to 83.5-70.6 Ma.

Diversity: 240 extant species.

Sampled species: *Diaphus splendidus* and *Myctophum affine*.

Clade 80: Polymixiacea

Taxonomy: One out of four divisions of Acanthomorphata. Polymixiacea include a single order, Polymixiiformes, a single family, Polymixiidae, and a single genus, Polymixia.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes two species of Polymixia, and strongly supports their monophyly (BS 100). Our RAxML phylogeny also supports monophyly of Polymixiacea with BS 100.

First occurrence: †*Homonotichthys rotundus* Smith Woodward, 1902 from the English Chalk of Sussex, United Kingdom. Late Cretaceous polymixiid genera listed by Patterson (1993a) are †*Berycopsia* Radovic, 1975, †*Berycopsis* Dixon, 1850, †*Dalmatichthys* Radovic, 1975, †*Homonotichthys* Whitley, 1933, and †*Omosoma* Costa, 1857. The oldest of these are †*Berycopsis elegans* from the English Chalk of Sussex, United Kingdom, †*Homonotichthys* from the English Chalk of Malling and Brighton, United Kingdom and †*Omosoma simum* Arambourg, 1954, from Djebel Tselfat, Morocco. The English Chalk is thought to be of Cenomanian-Turonian age (Patterson 1993b), but †*Berycopsis elegans* Dixon, 1850 and †*Homonotichthys rotundus* Smith Woodward, 1902, were both recorded from the zone of †*Holaster subglobosus* of Kent and Sussex by Woodward (1902), which can be constrained as Middle to Upper Cenomanian (Jacobs *et al.* 2005). An additional species of †*Berycopsis* was described from Hajula, Lebanon, confirming that †*Berycopsis* was present in the Cenomanian (Bannikov & Bacchia 2005). The age of †*Omosoma simum* is somewhat less certain: while Djebel Tselfat is frequently cited as Cenomanian, there are no absolute age assignments, nor has any microfauna been recorded. The Cenomanian age assignment is based on vertebrate assemblages (Arambourg 1954). †*Berycopsis* was removed from Berycopsidae and placed in Polymixiidae by Patterson (1964). However, a recent systematic analysis recovers †*Berycopsis* in a basal position to a clade combining Polymixiiformes and Stephanoberyciformes Dietze (2009). †*Homonotichthys* was initially placed in Berycidae by Woodward (1902), and later transferred to the beryciform family Holocentridae by Regan (1911). Patterson (1964) finally placed †*Homonotichthys* in the family Polymixiidae, due to similarities with the extant genus *Polymixia*, particularly in the structure of the neurocranium and hyoid arch. †*Omosoma* was transferred from Stromateidae to Polymixiidae by Regan (1911), based on its resemblances to †*Berycopsis*. †*Omosoma* was excluded from Dietze's (2009) systematic analysis because of uncertain character states, however, †*Omosoma* is very similar to †*Berycopsis*, and may thus belong to the same ancestral position (Dietze 2009). Thus, the taxonomic assignment of both †*Berycopsis* and †*Omosoma* is questionable. †*Homonotichthys*, on the other hand (together with the Santonian †*Pycnosteroideus* Hay, 1903) seems to be more closely related to *Polymixia* (Patterson 1964), and is thus here accepted as the oldest polymixiiform fossil. As the age of †*Homonotichthys rotundus* can be constrained to Middle-Upper Cenomanian, the first occurrence of Polymixiidae dates to 96.0-93.5 Ma. And since Polymixiidae are the only family of Polymixiacea (Betancur-R *et al.* 2013), the same first occurrence age applies to this division.

Diversity: 10 extant species.

Sampled species: *Polymixia lowei*, *Polymixia japonica*, and *Polymixia nobilis*.

Clade 81: Percopsaria

Taxonomy: One out of two series of Paracanthomorphacea. Percopsaria include a single order, Percopsiformes, and three families, Amblyopsidae, Aphredoderidae, and Percopsidae.

Support: Synapomorphies are given in Nelson (2006) and Wiley & Johnson (2010). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of all three families and strongly sup-

ports monophyly of Percopsaria. Our RAxML phylogeny also supports monophyly of Percopsaria with BS 100.

First occurrence: †*Mcconichthys longipinnis* Grande, 1988, from the Tullock Formation, Montana. The earliest record of Percopsaria is provided by the stem group member †*Mcconichthys longipinnis* from the Tullock Formation, Montana (Murray 1996; Murray & Wilson 1999). The Tullock formation is frequently cited as early Paleocene, and therefore, a Danian age of †*Mcconichthys longipinnis* is assumed here. Thus, the first occurrence of Percopsaria dates to 66.043-61.1 Ma (Renne *et al.* 2013).

Diversity: 9 extant species.

Sampled species: *Percopsis transmontana* and *Aphredoderus sayanus*.

Clade 82: Zeiogadaria

Taxonomy: One out of two series of Paracanthomorphacea. Zeiogadaria include two subseries, Zeariae and Gadariae.

Support: No synapomorphies are known to unite Zeariae and Gadariae, however, the molecular phylogenies of Miya *et al.* (2003) (JRV 95), Miya *et al.* (2005) (BPP 1.0), and Near *et al.* (2012b) (BS 100) strongly support a sister group relationship of the two subseries. Our RAxML phylogeny supports monophyly of Zeiogadaria with BS 99.

First occurrence: †*Cretazeus rinaldii* Tyler *et al.*, 2000, from the Calcare di Mellissano, Nardò, Italy. The first occurrence of Zeiogadaria dates to 76.4-69.2 Ma. See clade 83 (Zeariae).

Diversity: 588 extant species.

Sampled species: All sampled species of clades 83 and 84.

Clade 83: Zeariae

Taxonomy: One out of two subseries of Zeiogadaria. Zeariae include a single order, Zeiformes.

Support: Synapomorphies are given in Nelson (2006) and Wiley & Johnson (2010). The molecular phylogenies of Miya *et al.* (2005), Near *et al.* (2012b) and Betancur-R *et al.* (2013) strongly support monophyly of Zeariae (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Zeariae with BS 100.

First occurrence: †*Cretazeus rinaldii* Tyler *et al.*, 2000, from the Calcare di Mellissano, Nardò, Italy. The earliest zeiform record is †*Cretazeus rinaldii*, according to Tyler & Santini (2005), which is reported to be Middle Campanian-Upper Campanian in age. Therefore, the first occurrence of Zeariae dates to 76.4-69.2 Ma.

Diversity: 32 extant species.

Sampled species: *Parazen pacificus*, *Zenopsis nebulosa*, *Zeus faber*, *Zenion japonicum*, *Neocyttus rhomboidalis*, and *Allocyttus niger*.

Clade 84: Gadariae

Taxonomy: One out of two subseries of Zeiogadaria. Gadariae include two orders, Stylephoriformes and Gadiformes.

Support: No synapomorphies are known to unite Stylephoriformes and Gadiformes, however, the

molecular phylogenies of Miya *et al.* (2007) (BPP 1.0) and Betancur-R *et al.* (2013) (BS 100) strongly support monophyly of Gadariae. Our RAxML phylogeny supports monophyly of Gadariae with BS 100.

First occurrence: †*Coelorhynchus balticus* Koken, 1885, from Sundkrogen, Denmark, or †“*Protacodus*” sp. from Greenland. A large gadiform otolith assemblage is known from the Paleocene deposits of Denmark (Schwarzhan 2003; Kriwet & Hecht 2008), but the only skeletal remains from the Paleocene are †“*Protacodus*” sp. from Greenland, considered to be the most ancient gadiform by Fedotov & Bannikov (1989). According to the description in Kriwet & Hecht (2008), otolith remains from Sundkrogen, Denmark, such as †*Coelorhynchus balticus* Koken, 1885, predate †“*Protacodus*” and are Selandian in age. Due to the uncertainty of the taxonomic assignment of otolith fossils, †*Coelorhynchus balticus* and †“*Protacodus*” sp. are not used as an age constraint in our BEAST analysis. No fossil record is known of Stylephoriformes.

Diversity: 555 extant species.

Sampled species: *Bregmaceros nectabanus*, *Euclichthys polynemus*, *Lota lota*, *Gadus morhua*, *Raniceps raninus*, *Merluccius merluccius*, *Muraenolepis marmorata*, *Physiculus japonicus*, *Melanonus zugmayeri*, *Macruronus magellanicus*, and *Trachyrincus murrayi*.

Clade 85: Lampridacea

Taxonomy: One out of four divisions of Acanthomorphata. Lampridacea include a single order, Lampridiformes, and six families.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of five lampridiform families and strongly supports monophyly of Lampridacea (BS 100).

First occurrence: Undescribed lampridiform remains from Haqil, Lebanon, or †*Nardovelifer altipinnis* Sorbini and Sorbini, 1999, from the Calcare di Mellissano, Nardò, Italy. Members of the extinct lampridiform families Palaeocentrotidae and Turkmenidae are present in the Paleocene Mo-Clay (Fur/Ølst) and Danata formations of Denmark and Turkmenistan (Carnevale 2004). These are predated by †*Nardovelifer altipinnis* from the Campanian Calcare di Mellissano, Nardò, Italy, which is considered the earliest lampridiform by Gottfried *et al.* (2006) and the earliest crown group lampridiform by Santini *et al.* (2009). According to Gayet *et al.* (2012), undescribed lampridiforms are present in the Cenomanian of Haqil, Lebanon, however, the taxonomic assignment of these fossils should be corroborated. Given the uncertainty of the earliest lampridiform appearance, neither undescribed lampridiforms from Haqil nor †*Nardovelifer altipinnis* are used as age constraints in our BEAST analysis.

Diversity: 21 extant species.

Sampled species: *Lampris guttatus*.

Clade 86: Euacanthomorphacea

Taxonomy: One out of four divisions of Acanthomorphata. Euacanthomorphacea include three subdivisions, Berycimorphaceae, Holocentrimorphaceae, and Percomorphaceae. Euacanthomorphacea is nearly identical in taxon composition to Acanthopterygii of Nelson (2006).

Support: No synapomorphies are known to unite Euacanthomorphaea, however, the molecular phylogenies of Miya *et al.* (2005) (BPP 1.0) and Near *et al.* (2012b) (BS 100) strongly support monophyly of Euacanthomorphaea. Our RAxML phylogeny supports monophyly of Euacanthomorphaea with BS 97

First occurrence: †*Plesioberyx maximus* Gayet, 1980, and †*Plectocretacicus clarae* Sorbini, 1979, from the Lithographic Limestone of Haqil, Lebanon, or †*Lissoberyx anceps* Arambourg, 1954, from Djebel Tselfat, Morocco. Disregarding putative beryciform fossils from the Albian Tlayuá Quarry, Puebla, Mexico, the appearance of acanthopterygiids in the fossil record is marked by various beryciforms, trachichthyoids, holocentroids, and a single putative tetraodontiform from the Cenomanian, according to Patterson (1993b). The large number of beryciform, trachichthyoid, and holocentroid fossils from Cenomanian deposits of Lebanon, Israel, Morocco, and the United Kingdom are strong evidence of the presence of Beryceae/Stephanoberyceae in the Cenomanian. While the Moroccan Djebel Tselfat, as well as the Israeli Bet Meir/Amminadav Formation have been dated only to stage level (99.6-93.5 Ma), more precise age assignments are possible for †*Trachichthyoides* Woodward, 1902 from the English Chalk of Bromley, Kent, United Kingdom and the Lebanese localities of Namoura, Hajula, and Haqil, all of which bear beryciform fossils (Forey *et al.* 2003). †*Trachichthyoides* is from the Cenomanian zone of †*Holaster subglossus*, that can be constrained as Middle to Upper Cenomanian (Jacobs *et al.* 2005), the Namoura deposits are placed in the middle portion of the Middle Cenomanian, and a later Lower Cenomanian age is assigned to the fish-bearing layers of both Hajula and Haqil, with Haqil being the older of the two deposits (Forey *et al.* 2003; Wippich & Lehmann 2004). The occurrences of *Mantelliceras mantelli* and the foraminifer *Orbitulina concava* in the Lithographic Limestone of Haqil suggest an age between 99.1 and 97.8 Ma (Benton *et al.* 2009). Beryciform fossils from Haqil include †*Plesioberyx maximus* Gayet, 1980, †*Plesioberyx discoides* Gayet, 1980, †*Caproberyx pharsus* Patterson, 1967, and †*Stichopteryx lewisi* Davis, 1887 (Forey *et al.* 2003). The Lithographic Limestone of Haqil is also the type locality of †*Plectocretacicus clarae* Sorbini, 1979 that has been placed in the superfamily †Plectocretacicoidea, together with †*Protriacanthus gortanii* d’Erasmus, 1946 from Comen, northwestern Slovenia and †*Cretatriacanthus guidottii* from Canale, Nardò, Italy (Tyler & Sorbini 1996). While a phylogenetic analysis of 56 extant and fossil tetraodontiforms (Santini & Tyler 2003) supported the close relationship of the three plectocretacicoidea, and suggested a stem-tetraodontiform position of †Plectocretacicoidea, this position has been questioned on the basis of a preliminary reexamination of fossil material (Betancur-R *et al.* 2013). According to Betancur-R *et al.* (2013), the next-oldest tetraodontiform is †*Cretatriacanthus guidottii*, but see clade 188 (Tetraodontiformes). While the position of †*Plectocretacicus clarae* within Tetraodontiformes remains questionable, we here assume †*Plectocretacicus clarae* to be a member of Euacanthomorphaea and Percomorphaceae. Because †*Lissoberyx anceps* Arambourg, 1954 from Djebel Tselfat, Morocco, could be older than the Haqil Limestone (while still being Cenomanian), the first occurrence of Euacanthomorphaea dates to 99.6-97.8 Ma.

Diversity: 16397 extant species.

Sampled species: All sampled species of clades 87, 93, 94, 95, 96, and 99.

Clade 87: Trachichthyoidei

Taxonomy: Recognized as one out of three beryciform suborders in Nelson (2006), but not classified in Betancur-R *et al.* (2013). Trachichthyoidei include five out of thirteen families assigned to order Beryciformes and subdivision Berycimorphaceae in Betancur-R *et al.* (2013).

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Miya *et al.* (2005) includes all five trachichthyoid families and strongly supports their monophyly (BPP 1.0), and the molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of four out of five trachichthyoid families and also strongly supports their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Trachichthyoidei with BS 99.

First occurrence: *Hoplostethus †densus* Stinton, 1978, from the London Clay Formation, Essex, UK, *Gephyroberyx †hexagonalis* (Leriche, 1905) from the Bruxelles Formation, Belgium, or *Gephyroberyx †robustus* (Bogatshov, 1933) from the Caucasus, Russia (Patterson 1993b). The first occurrence of Trachichthyoidei is here considered unknown. See clade 92 (Trachichthyidae).

Diversity: 45 extant species.

Sampled species: All sampled species of clades 88, 89, 90, 91, and 92.

Clade 88: Diretmidae

Taxonomy: One out of five families of Trachichthyoidei. Diretmidae include three genera, *Diretmichthys*, *Diretmoides*, and *Diretmus*.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Miya *et al.* (2005) includes two out of three genera of Diretmidae and strongly supports their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Diretmidae with BS 100.

First occurrence: *Diretmus* sp. Nolf and Steurbaut, 1987, from the Antognola Formation, Pizzocorno, Italy. Patterson (1993b) lists otoliths assigned to genus *Diretmus* from the Antognola Formation, which is reported to be Rupelian in age. Given the taxonomic uncertainty of otolith fossils, *Diretmus* sp. is not used as an age constraint in our BEAST analysis. No skeletal fossil record is known of Diretmidae.

Diversity: 4 extant species.

Sampled species: *Diretmus argenteus* and *Diretmoides veriginae*.

Clade 89: Anomalopidae

Taxonomy: One out of five families of Trachichthyoidei. Anomalopidae include six genera.

Support: Synapomorphies are given in Baldwin *et al.* (1997) and Nelson (2006).

First occurrence: *Kryptophaneron* sp. Nolf and Steurbaut, 1987, from Montegibbio, Italy. Patterson (1993b) lists otoliths assigned to genus *Kryptophaneron* from Montegibbio, which are reported to be Tortonian in age. Given the taxonomic uncertainty of otolith fossils, *Kryptophaneron* sp. is not used as an age constraint in our BEAST analysis. No skeletal fossil record is known of Anomalopidae.

Diversity: 8 extant species.

Sampled species: *Anomalops katoptron*.

Clade 90: Monocentridae

Taxonomy: One out of five families of Trachichthyoidei. Monocentridae include two genera, *Cleidopus* and *Monocentris*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: *Monocentris erectus* (Schwarzhan, 1980) from Waihao River, Canterbury, New Zealand. *Monocentris erectus* is known only from otoliths (Patterson 1993b), which are reported to be Lutetian in age. Given the taxonomic uncertainty of otolith fossils, *Monocentris erectus* is not used as an age constraint in our BEAST analysis. No skeletal fossil record is known of Monocentridae.

Diversity: 4 extant species.

Sampled species: *Monocentris japonica*.

Clade 91: Anoplogastridae

Taxonomy: One out of five families of Trachichthyoidei. Anoplogastridae include a single genus, *Anoplogaster*, and two species, *A. cornuta* and *A. brachycera*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 2 extant species.

Sampled species: *Anoplogaster cornuta*.

Clade 92: Trachichthyidae

Taxonomy: One out of five families of Trachichthyoidei. Trachichthyidae include seven genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: *Hoplostethus †densus* Stinton, 1978, from the London Clay Formation, Essex, UK, or *Gephyroberyx †hexagonalis* (Leriche, 1905) from the Bruxelles Formation, Belgium, or *Gephyroberyx †robustus* (Bogatshov, 1933) from the Caucasus, Russia (Patterson 1993b). Both *Hoplostethus †densus* and *Gephyroberyx †hexagonalis* are only known from otoliths that have been reported to be of Ypresian or Lutetian age. The earliest skeletal record is *Gephyroberyx †robustus* (Friedman 2009). Given the taxonomic uncertainty of otolith fossils, and the resulting ambiguity regarding the first occurrence of Trachichthyidae, *Hoplostethus †densus*, *Gephyroberyx †hexagonalis*, and *Gephyroberyx †robustus* are not used as age constraints in our BEAST analysis.

Diversity: 39 extant species.

Sampled species: *Hoplostethus japonicus*.

Clade 93: Cetomimoidea

Taxonomy: Recognized as one out of two stephanoberyciform superfamilies in Nelson (2006), but not classified in Betancur-R *et al.* (2013). Cetomimoidea include four out of thirteen families assigned to order Beryciformes, Gibberichthyidae, Rondeletiidae, Barbourisiidae, Cetomimidae, as well as two more families, Mirapinnidae and Megalomycetidae, which are not classified in Betancur-R *et al.* (2013).

Support: Morphological characteristics supporting the monophyly of Cetomimoidea are given in

Nelson (2006). Our RAxML phylogeny supports monophyly of Cetomimoidea with BS 93.

First occurrence: Recent.

Diversity: 54 extant species.

Sampled species: *Rondeletia loricata*, *Danacetichthys galathenus* and *Cetostoma regani*.

Clade 94: Berycoidei

Taxonomy: Recognized as one out of three beryciform suborders in Nelson (2006), but not classified in Betancur-R *et al.* (2013). Berycoidei include one out of thirteen families assigned to order Beryciformes and subdivision Berycimorphaceae in Betancur-R *et al.* (2013), Berycidae, and two genera, *Beryx* and *Centroberyx*.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Colgan *et al.* (2000) and Betancur-R *et al.* (2013) support a sister group relationship of *Beryx* and *Centroberyx* (BS 80). Our RAxML phylogeny includes two species of genus *Beryx* and supports their monophyly with BS 100.

First occurrence: “*Berycidarum*” *senionensis* (Voigt, 1926) from Cöthen, Sachsen-Anhalt, Germany. “*Berycidarum*” *senionensis* is known only from otoliths (Patterson 1993b), which are reported to be Campanian in age. Given the taxonomic uncertainty of otolith fossils, “*Berycidarum*” *senionensis* is not used as an age constraint in our BEAST analysis. No skeletal fossil record is known of Berycoidei.

Diversity: 9 extant species.

Sampled species: *Beryx decadactylus* and *Beryx splendens*.

Clade 95: Stephanoberycoidea

Taxonomy: Recognized as one out of two stephanoberyciform superfamilies in Nelson (2006), but not classified in Betancur-R *et al.* (2013). Stephanoberycoidea include three out of 13 families assigned to order Beryciformes, Melamphaidae, Stephanoberycidae, and Hispidoberycidae.

Support: Morphological characteristics discussed in Paxton *et al.* (2001) and Nelson (2006). Our RAxML phylogeny supports monophyly of Stephanoberycoidea with BS 100.

First occurrence: *Melamphaes* spp. 1 and 2, Nolf, 1988, from Argile de Gan, Gan, Pyrénées-Atlantiques, France, or †*Scopelogadus?* *capistranensis* from the upper Miocene of California. *Melamphaes* spp. 1 and 2 are known only from otoliths (Patterson 1993b), which are reported to be Ypresian in age. The only reliable skeletal record is †*Scopelogadus?* *capistranensis* (Friedman 2009). Given the taxonomic uncertainty of otolith fossils, and the resulting ambiguity regarding the first occurrence of *Melamphaes* spp. 1 and 2, †*Scopelogadus?* *capistranensis* is not used as an age constraint in our BEAST analysis.

Diversity: 40 extant species.

Sampled species: *Scopelogadus mizolepis* and *Poromitra oscitans*.

Clade 96: Holocentrimorphaceae

Taxonomy: One out of three subdivisions of Euacanthomorphacea. Recognized as one out of three beryciform suborders in Nelson (2006). Holocentrimorphaceae include a single family, Holocentri-

dae, and eight genera.

Support: Synapomorphies are given in Nelson (2006) and Dornburg *et al.* (2012). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of seven out of eight genera of Holocentrimorphaceae, and strongly supports their monophyly (BS 100). Our RAxML phylogeny also supports monophyly of Holocentrimorphaceae with BS 100.

First occurrence: †*Caproberyx pharsus* Patterson, 1967, from the Lithographic Limestone of Haqil, Lebanon. According to Friedman (2009), the following named Cretaceous taxa have been associated with extant representatives of Holocentridae: †*Caproberyx*, †*Trachichthyoides*, †*Parospinus*, †*Alloberyx*, †*Adriacentrus*, †*Ctenocephalichthys*, †*Erugocentrus*, †*Peliotus*, †*Plesioberyx*, †*Pattersonoberyx*, †*Kansius*, and †*Stichocentrus*. Of these, †*Caproberyx pharsus*, †*Plesioberyx maximus*, and †*P. discoides* occur in the Lithographic Limestone of Haqil, presumably the oldest of the Cretaceous sites bearing beryciform fossils (see clade 86). Forey *et al.* (2003) place †*Plesioberyx* as *incertae sedis*, but consider †*Caproberyx pharsus* to be a member of Holocentroidei. Thus, the first occurrence of Holocentrimorphaceae dates to 99.1-97.8 Ma.

Diversity: 79 extant species (Dornburg *et al.* 2012).

Sampled species: All sampled species of clades 97 and 98.

Clade 97: Holocentrinae

Taxonomy: One out of two subfamilies of Holocentridae. Holocentrinae include the genera *Holocentrus*, *Neoniphon*, and *Sargocentron*.

Support: Synapomorphies are given in Nelson (2006) and Dornburg *et al.* (2012). The molecular phylogenies of Dornburg *et al.* (2012) and Betancur-R *et al.* (2013) include representatives of all three genera of Holocentrinae and strongly support monophyly of Holocentrinae (BS 100, BPP 1.0).

First occurrence: Recent.

Diversity: 40 extant species (Dornburg *et al.* 2012)

Sampled species: *Sargocentron rubrum*.

Clade 98: Myripristinae

Taxonomy: One out of two subfamilies of Holocentridae. Myripristinae include five genera, *Myripristis*, *Ostichthys*, *Plectrypops*, *Corniger*, and *Pristilepis*.

Support: Synapomorphies are given in Nelson (2006) and Dornburg *et al.* (2012). The molecular phylogenies of Dornburg *et al.* (2012) and Betancur-R *et al.* (2013) include four out of five genera of Myripristinae and strongly support monophyly of Myripristinae (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Myripristinae with BS 100.

First occurrence: †*Eoholocentrum macrocephalum* Sorbini and Tirapelle, 1974, †*Berybolcensis leptacanthus* Sorbini, 1979, and †*Tenuicentrum pattersoni* Sorbini, 1975, from Monte Bolca, Verona, Italy. †*Eoholocentrum macrocephalum*, †*Berybolcensis leptacanthus*, and †*Tenuicentrum pattersoni* are considered members of Myripristinae (Friedman 2009). The age of the Monte Bolca outcrops is derived from the presence of *Discoaster sublodoensis*, which indicates nannoplankton zone NP14 (Monsch 2006). It can be further constrained to SB11 by larger foraminiferal assemblages of *Alveolina cremae*, *A. rugosa*, *A. distefanoi*, and *A. rutimeyeri* (Trevisani *et al.* 2005). The top of SB11

(49.1 Ma) is just above the base of NP14 (49.4 Ma), thus the age of the Monte Bolca outcrops can be dated to 49.4-49.1 Ma.

Diversity: 39 extant species (Dornburg *et al.* 2012).

Sampled species: *Myripristis berndti* and *Ostichthys japonicus*.

Clade 99: Percomorphaceae

Taxonomy: One out of three subdivisions of Euacanthomorphacea. Percomorphaceae include eight series, and are recognized as Percomorpha in Nelson (2006) and Johnson & Patterson (1993), with slightly different composition.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogenies of Miya *et al.* (2005), Azuma *et al.* (2008), Near *et al.* (2012b), and Betancur-R *et al.* (2013) strongly support monophyly of Percomorphaceae. Our RAXML phylogeny supports monophyly of Percomorphaceae with BS 100.

First occurrence: †*Plectocretacicus clarae* Sorbini, 1979, from the Lithografic Limestone of Haqil, Lebanon. The first occurrence of Percomorphaceae dates to 99.1-97.8 Ma. See clade 86 (Euacanthomorphacea).

Diversity: 16145 extant species.

Sampled species: All sampled species of clades 100, 103, 105, 108, 110, 111, 112, 113, 114, 117, 135, 153, 160, 161, 163, 164, 166, 168, 169, 173, 174, 175, 178, 181, 182, 183, 184, 185, 186, 188, 200, 201, 202, 203, 204, 205, 206, 213, 214, 215, 216, 220, 221, 104, 109, 167, 165, 219, 162, 170, 187, 210, 211, 212, 209, 217, 218, 171, and 172.

Clade 100: Ophidiimorpharia

Taxonomy: One out of eight series of Percomorphaceae. Ophidiimorpharia include a single order, Ophidiiformes, and two suborders, Ophidioidei and Bythitoidei.

Support: No unambiguous synapomorphies are known to unite Ophidiimorpharia (Wiley & Johnson 2010), however the molecular phylogenies of Miya *et al.* (2005) and Betancur-R *et al.* (2013) include representatives of both ophidiiform suborders and strongly supports their monophyly (BS 100). Our RAXML phylogeny supports monophyly of Ophidiimorpharia with BS 95.

First occurrence: †*Eolamprogrammus senectus* Danil'chenko, 1968, from the Danata Formation, Uyly-Kushlyuk, Turkmenistan. The first occurrence of Ophidiimorpharia dates to 57.23-55.8 Ma. See clade 102 (Ophidioidei).

Diversity: 385 extant species.

Sampled species: All sampled species of clades 101 and 102.

Clade 101: Bythitoidei

Taxonomy: One out of two suborders of Ophidiiformes. Bythitoidei include three families, Bythitidae, Aphyonidae, and Parabrotulidae.

Support: Morphological characteristics are given in Nelson (2006). Our RAXML phylogeny supports monophyly of Bythitoidei with BS 100.

First occurrence: †*Propteridium* spp. Arambourg, 1967 from Istehbanat, Iran. The earliest skele-

tal record of Bythitoidei is †*Propteridium* Arambourg, 1967 from Istehbanat, Iran (Cohen *et al.* 1990), which is reported to be Rupelian in age (Tyler 2000). The first occurrence of Bythitoidei therefore dates to 33.9–28.4 Ma.

Diversity: 132 extant species.

Sampled species: *Cataetx rubrirostris* and *Diplacanthopoma brachysoma*.

Clade 102: Ophidioidei

Taxonomy: One out of two suborders of Ophidiiformes. Ophidioidei include two families, Carapidae and Ophidiidae.

Support: Morphological characteristics are given in Nelson (2006). The molecular phylogeny of Miya *et al.* (2005) includes representatives of both ophidioid families and strongly supports their monophyly (BS 100). Our RAxML phylogeny also supports monophyly of Ophidioidei with BS 100.

First occurrence: †*Eolamprogrammus senectus* Danil’chenko, 1968, from the Danata Formation, Ulyya-Kushlyuk, Turkmenistan. According to Rossi *et al.* (2000), †*Eolamprogrammus senectus* can be assigned to the family Ophidiidae, and thus provides the earliest ophidioid record. The fish-bearing layer of the Danata Formation has been considered synchronous with the Upper Thanetian anoxic event (Muzylev 1994). The Upper Thanetian is here interpreted as the interval between the Th-4 boundary and the Thanetian-Ypresian boundary, therefore, the first occurrence of Ophidioidei dates to 57.23–55.8 Ma.

Diversity: 253 extant species.

Sampled species: *Carapus bermudensis*, *Dicrolene introniger*, and *Lamprogrammus niger*

Clade 103: Scombriformes

Taxonomy: One out of two orders of series Scombrimorpharia. Scombriformes include 17 families. Most families previously considered as “stromateoids” (Nelson 2006) are now included in Scombriformes. Scombridae might be more closely related to Acropomatidae instead (Nelson 2006).

Support: No synapomorphies are known to unite this group, however, the molecular phylogenies of Chen *et al.* (2003), Dettai & Lecointre (2005), Smith & Craig (2007), Li *et al.* (2009), Orrell *et al.* (2006), Yagishita *et al.* (2009), Near *et al.* (2012b), and Betancur-R *et al.* (2013) all include representatives of multiple scombriform families, and in combination support monophyly of Scombriformes, as circumscribed here (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Scombriformes with BS 100.

First occurrence: †*Eutrachiurides opiensis* (Leriche 1906) Casier, 1944, from the Phosphates of Morocco, †*Sphyraenodus multidentatus* Darteville and Casier, 1959, from the Landana Cliffs, Cabinda enclave, Angola, or †*Ardiodus mariotti* White 1931, from the Oldhaven Beds, Upnor, Kent, United Kingdom. The oldest “stromateoid” record is probably from the Ypresian or Upper Paleocene: According to Bannikov (1995), two “stromateoids” were reported by Bonde in the Mo-Clay (Fur/Ølst) Formation, Denmark. More recently, Sytchevskaya & Prokofiev (2005) claim the discovery of a centrolophid in the Danata Formation, Turkmenistan. The Mo-Clay (Fur/Ølst) Formation has been assigned an Ypresian age (Willumsen 2004), and the Danata Formation is Upper Thanetian in age (see clade 102). The earliest known scombriform record most likely dates from

the Paleocene. Cretaceous fossils assigned to †Blochiidae, such as †*Cylindracanthus* Leidy, 1856 and †*Congorhynchus* Darteville and Casier, 1949, have probably been misinterpreted as scombriforms (Monsch 2004). Following Monsch (2004) and Fierstine (2006), the next-oldest “scombroid” fossils include †*Trichiurus gulincki* Casier, 1967, from the Tienen Formation, Dormaal, Belgium, †*Scomberomorus* Lacepède, 1802, †*Auxides turkmenita* Danil’chenko, 1968, †*Hemingwaya sarissa* Sytchevskaya and Prokofiev, 2002, †*Eocoelopoma portentosa* Bannikov, 1985, and †*Palaeothunnus parvidentatus* Danil’chenko, 1968, from the Danata Formation, Turkmenistan, and †*Ardiodus mariotti* White, 1931, from the Oldhaven Beds, Upnor, Kent, United Kingdom and from the Phosphates of Morocco (Monsch 2004). Patterson (1993b) further lists †*Eutrichiurides opiensis* (Leriche, 1906) Casier, 1944, described from the Phosphates of Morocco, and its congeneric †*Eutrichiurides africanus* Darteville and Casier, 1949, which was found in the Landana Cliffs of the Cabinda enclave, Angola. †*Eutrichiurides* has been placed in Gempylidae by Patterson (1993b), but Monsch (2004) agrees with Casier (1944) that it is a member of Trichiurinae instead. Furthermore, †*Sarda palaeocenica* Leriche, 1909, †*Sphyrænodus multidentatus* Darteville and Casier, 1959, †*Landanichthys lusitanicus* Darteville and Casier, 1949, and †*Landanichthys moutai* Darteville and Casier, 1949, are all known from the Landana Cliffs. This formation has been considered “Montian” (Danian) in age (Murray 2000c), but may be as young as Ypresian-Bartonian (Figueiredo *et al.* 2011). The age of the Moroccan Phosphates is similarly unclear: The specimen of †*Ardiodus mariotti* described by Monsch (2004) is reported from “Morocco, Phosphates, Late Paleocene-Early Eocene: Thanetian-Ypresian”, whereas specimens of †*Eutrichiurides opiensis* have been discovered in the “Montian Phosphates, Morocco” (Patterson 1993b). However, a reference is not given for this claim, thus it is difficult to substantiate. The Moroccan Phosphates of Khouribga are considered Maastrichtian-Lower Lutetian age (Chernoff & Orris 2002), but it is unclear whether †*Eutrichiurides opiensis* was found in the same locality. In the absence of a more precise dating of Moroccan Phosphates and the Landana Cliffs, Danian-Lutetian age is assumed for both localities. Some evidence for Middle Paleocene presence of Scombriformes comes from otolith remains of “genus *Scombridarum*” sp. from the Tashlik Formation, Luzanivka, Cherkassy Region, Ukraine, which is considered Selandian (NP5-6) in age. A lower limit for the oldest scombriform fossil is given by †*Ardiodus mariotti*: The Oldhaven Beds, near Upnor, Kent, have been assigned to the NP9 nannofossil zone and to chron C25n, which constrains its age at 57.2–56.6 Ma. The earliest records of the families Pomatomidae and Bramidae (previously considered Perciformes, now included in Scombriformes) is provided by the Eocene ?*Carangopsis brevis* (de Blainville, 1818), and *C. dorsalis* Agassiz, 1844, from Monte Bolca, Verona, Italy, *Bramoides brielli* Casier, 1966, and *Goniocranion arambourgi* Casier, 1966, from the London Clay Formation, SE England, UK. Regardless of the questionable family assignments of the latter four taxa the known record of Pomatomidae and Bramidae does not extend to the Paleocene (Patterson 1993b). No fossil record is known for Arripidae, another family now included in Scombriformes. The fossil family Exelliidae, with a first appearance in the Mo-Clay (Fur/Ølst) Formation (Patterson 1993b) and subsequent records in Monte Bolca deposits, is included in Caristiidae in Patterson (1993b), whereas Bannikov & Tyler (1995) consider its affinities to be poorly understood. Excluding Exelliidae, no fossil record is known of Caristiidae. Finally, the earliest record of the “trachinoid” family Chiasmodontidae is

provided by †*Pseudoscopelus grossheimi* (Danil'chenko, 1960) from the Lower Khadum Formation, Stavropol, Russia, which is reported to be Late Eocene (Saintot *et al.* 2006) or Lower Oligocene (Krasheninnikov 1986) in age. In summary, the first occurrence of Scombriformes is likely provided by †*Eutrichiurides opiensis*, †*Sphyraenodus multidentatus*, or †*Ardiodus mariotti*, and dates to 66.043–56.6 Ma (Renne *et al.* 2013).

Diversity: 225 extant species.

Sampled species: *Arripis trutta*, *Euthynnus alletteratus*, *Cubiceps pauciradiatus*, *Psenes cyanophrys*, *Lepidocybium flavobrunneum*, *Pampus* sp., and *Hyperoglyphe japonica*.

Clade 104: Batrachoidimorpharia

Taxonomy: One out of eight series of Percomorphaceae. Batrachoidimorpharia include a single order, Batrachoidiformes, a single family, Batrachoididae, and three subfamilies, Batrachoidinae, Porichthyinae, and Thalassophryninae.

Support: Synapomorphies are given in Wiley & Johnson (2010) for Batrachoidiformes. The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Batrachoidinae and Porichthyinae, and strongly supports the monophyly of Batrachoidimorpharia.

First occurrence: *Halobatrachus didactylus* (Bloch & Schneider, 1801) from Oran, Algeria. According to Carnevale (2004), fossil specimens of the extant species *Halobatrachus didactylus* have been recorded in the Messinian deposits of Oran, Algeria, and represent the only known fossil record of Batrachoididae. Thus, the first occurrence of Batrachoidimorpharia dates to 7.246–5.332 Ma.

Diversity: 78 extant species.

Sampled species: *Porichthys* sp.

Clade 105: Centriskoidea

Taxonomy: One out of four superfamilies of Syngnathoidei, as recognized in Nelson (2006). Centriskoidea include two families, Centriscidae and Macroramphosidae. In Betancur-R *et al.* (2013), Macroramphosidae are apparently considered as a part of Centriscidae.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013), as well as our RAxML phylogeny support monophyly of Centriskoidea with BS 100.

First occurrence: †*Gerpegezhus pavai* Bannikov and Carnevale, 2012, from the Abazinka Formation, Kheu River, Kabardino-Balkaria, northern Caucasus, Russia. The first occurrence of Centriskoidea dates to 55.964–55.788 Ma. See clade 106 (Centriscidae).

Diversity: 15 extant species.

Sampled species: All sampled species of clades 106 and 107.

Clade 106: Centriscidae

Taxonomy: One out of two families of Centriskoidea. Centriscidae include two genera, *Aeoliscus* and *Centriscus*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Gerpegezhus pavai* Bannikov and Carnevale, 2012, from the Abazinka Formation, Kheu River, Kabardino-Balkaria, northern Caucasus, Russia. †*Gerpegezhus pavai* is the sister

group of Centriscidae. Based on microfossil content and geochemical data, the age of the Kheu River sapropelitic layer, and thus the first occurrence of Centriscidae, has been dated to 55.964-55.788 Ma (Bannikov & Carnevale 2012).

Diversity: 4 extant species.

Sampled species: *Aeoliscus strigatus*.

Clade 107: Macroramphosidae

Taxonomy: One out of two families of Centriskoidea. Macroramphosidae include three genera, *Centriscops*, *Macroramphosus*, and *Notopogon*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Gasterorhampus zuppichinii* Sorbini, 1981, from the Calcare di Mellissano, Nardò, Italy, or †*Protorhamphosus* Danil’chenko, 1968, from the Danata Formation, Turkmenistan, or Recent. †*Gasterorhampus zuppichinii* Sorbini, 1981, from the Calcare di Mellissano, Nardò, Italy, has been described as a macrorhamphosid, but has been argued to branch from the common stem of Macrorhamphosidae and Centriscidae (Orr 1995; Friedman 2009), or from the stem of a clade composed of Macrorhamphosidae, Centriscidae, Syngnathidae, Solenostomidae, and Pegasiidae (Natale 2008). Similarly, †*Protorhamphosus* Danil’chenko, 1968, from the Danata Formation, Turkmenistan, has been placed in Macrorhamphosidae, but is treated as *Gasterosteiformes incertae sedis* in Patterson (1993b). Thus, no unambiguous fossil record of Macroramphosidae is known, and neither †*Gasterorhampus zuppichinii* nor †*Protorhamphosus* are used as age constraints in our BEAST analysis.

Diversity: 11 extant species.

Sampled species: *Macroramphosus scolopax*.

Clade 108: Solenostomidae

Taxonomy: One out of seven families of Syngnathoidei, as recognized in Nelson (2006). Not examined in Betancur-R *et al.* (2013), but there assumed to have affinities with Callionymidae. Solenostomidae include a single genus, *Solenostomus*, and five species.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent. The Eocene †*Solenorhynchus solenostomus* (Heckel, 1853), †*Prosolenostomus lessinii* (Blot, 1981), †*Calamostoma breviculum* (Agassiz, 1833), and †*Calamostoma bolcensis* (Agassiz, 1833) from Monte Bolca, Verona, Italy, have been considered as the earliest record of Solenostomidae (Patterson 1993b), but are more likely to represent intermediate lineages between Solenostomatidae and Syngnathidae, or within Syngnathidae (Orr 1995).

Diversity: 5 extant species.

Sampled species: *Solenostomus cyanopterus*.

Clade 109: Callionymidae+Draconettidae

Taxonomy: Combines two out of four families of Callionymoidei. Identical to suborder Callionymoidei of Nelson (2006).

Support: Synapomorphies are given in Nelson (2006). Draconettidae have never been included in

a molecular phylogenetic analysis.

First occurrence: *Callionymus †lerenardi* Nolf and Lapierre, 1979, from Calcaire Grossier, Paris Basin, France, or “*Diplogrammus*” sp. from the Tarkhan-Chokrak beds, Maykop Formation, Adygea, Russia. Eocene otolith remains of *Callionymus †lerenardi* provide the earliest record of Callionymidae (Sytchevskaya & Prokofiev 2007). The oldest skeletal fossils are represented by “*Diplogrammus*” sp., which is reported to be Middle Miocene in age (Sytchevskaya & Prokofiev 2007). Given the questionable assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Callionymidae+Draconettidae, *Callionymus †lerenardi* and “*Diplogrammus*” sp. are not used to constrain the age of Callionymidae+Draconettidae in our BEAST analysis.

Diversity: 94 extant species.

Sampled species: *Callionymus* sp.

Clade 110: Pegasidae

Taxonomy: One out of seven families of Syngnathoidei, as recognized in Nelson (2006). Not examined in Betancur-R *et al.* (2013), but there assumed to have affinities with Callionymidae. Pegasidae include two genera, *Eurypegasus* and *Pegasus*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent. The extinct syngnathoid family †Ramphosidae, which first appears in the Mo-Clay (Fur/Ølst) Formation, Denmark, with †*Ramphosus rosenkrantzi* Agassiz, 1842, has been considered the sister lineage of Pegasidae (Friedman 2009; Wilson & Orr 2011), but may be ancestral to a clade combining Pegasidae, Solenostomidae, and Syngnathidae (Nelson 2006).

Diversity: 5 extant species.

Sampled species: *Pegasus volitans*.

Clade 111: Aulostomidae

Taxonomy: One out of seven families of Syngnathoidei, as recognized in Nelson (2006). Considered *incertae sedis* within Syngnathiformes in Betancur-R *et al.* (2013). Aulostomidae include a single genus, *Aulostomus*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: “Fur aulostomid” from the Mo-Clay (Fur/Ølst) Formation, Denmark, or unnamed Aulostomidae from Monte Bolca, Verona, Italy. An unnamed aulostomid from the Mo-Clay (Fur/Ølst) Formation, Denmark, is listed in Friedman (2009). Given the lack of additional information, the record is here considered questionable. The next-oldest fossils of Aulostomidae are known from Monte Bolca, Verona, Italy. The Mo-Clay (Fur/Ølst) Formation is reported to be Ypresian in age, and the age of the Monte Bolca deposits can be constrained to 49.4–49.1 Ma (see clades 98 and 103), therefore the first occurrence of Aulostomidae dates to 55.8–49.1 Ma.

Diversity: 3 extant species.

Sampled species: *Aulostomus chinensis*.

Clade 112: Mulloidei+allies

Taxonomy: Mulloidei is one out of four syngnathiform suborders and includes three families,

Creediidae, Mullidae, and Leptoscopidae. Here, clade Mulloidei+allies is considered to include the three families of Mulloidei plus Trichonotidae, the percophid subfamily Hemerocoetinae, Callanthiidae, Sillaginidae, Dactylopteridae, and Malacanthidae, for the following reasons: Trichonotidae and the percophid subfamily Hemerocoetinae are assumed to cluster with Leptoscopidae and Creediidae on the basis of 17 shared morphological characters, of which four are rare (Odani & Imamura 2011). Further, we here assume close relationship of Mullidae, Dactylopteridae, Callanthiidae, and Sillaginidae based on the molecular phylogenies of Smith & Craig (2007) and Lautrédou *et al.* (2013). A sister group relationship of Dactylopteridae and Malacanthidae is supported by 20 synapomorphies given in Imamura (2000).

Support: Synapomorphies are given in Wiley & Johnson (2010) for the order Dactylopteriformes. The molecular phylogenies of Smith & Craig (2007), Betancur-R *et al.* (2013), and Lautrédou *et al.* (2013) support monophyly of Mulloidei+allies. Our molecular phylogeny includes two dactylopterid species and supports their monophyly with BS 100.

First occurrence: †*Pterygocephalus paradoxus* Agassiz, 1839, or unnamed Mullidae from Monte Bolca, Verona, Italy. According to Springer (1993), the fossil family †Pterygocephalidae could be the sister lineage of Dactylopteridae, and thus included in Mulloidei+allies. However, this relationship has been questioned by Imamura (2000). †Pterygocephalidae is monotypic and the earliest occurrence of †*Pterygocephalus paradoxus* is known from Monte Bolca, Italy. Patterson (1993b) considers †*Prevolutans faedoensis*, reported to be Priabonian in age, to be the oldest record of Dactylopteridae. The earliest record of Callanthiidae, Sillaginidae, Mullidae, and Malacanthidae appears to be provided by unnamed Mullidae that are present in the Monte Bolca deposits. Therefore, the first occurrence of Mulloidei+allies dates to 49.4-49.1 Ma.

Diversity: 203 extant species.

Sampled species: *Dactyloptena tiltoni* and *Dactyloptena peterseni*.

Clade 113: Fistulariidae

Taxonomy: One out of seven families of Syngnathoidei, as recognized in Nelson (2006). Fistulariidae include a single genus, *Fistularia*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Fistularioides veronensis* Blot, 1980, †*F. phyllolepis* Blot, 1980, †*Parasynarcualis longirostris* (de Blainville, 1818), ?*Aulostomoides tyleri* Blot, 1980, from Monte Bolca, Verona, Italy. Representatives of three genera from Monte Bolca are considered the earliest record of Fistulariidae (Patterson 1993b; Goatley *et al.* 2010). Therefore, the first occurrence of Fistulariidae dates to 49.4-49.1 Ma.

Diversity: 4 extant species.

Sampled species: *Fistularia commersonii*.

Clade 114: Syngnathidae

Taxonomy: One out of seven families of Syngnathoidei, as recognized in Nelson (2006). Following Wilson & Orr (2011), we recognize two unranked subgroups of Syngnathidae, the abdominal-bearing Gastrophori and the tail-bearing Urophori.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013), strongly supports monophyly of Syngnathidae (BS 100). Our RAxML phylogeny supports monophyly of Syngnathidae with BS 94.

First occurrence: †*Prosolenostomus lessinii* (Blot, 1981), from Monte Bolca, Verona, Italy. †*Prosolenostomus lessinii* has been treated as a member of Solenostomidae (Patterson 1993b), but has been placed in family Syngnathidae by Orr (1995), and is considered a stem lineage of Syngnathidae in Wilson & Orr (2011). Therefore, the first occurrence of Syngnathidae dates to 49.4–49.1 Ma.

Diversity: 298 extant species (Froese & Pauly 2015)

Sampled species: All sampled species of clades 125 and 126.

Clade 115: Gastrophori

Taxonomy: One out of two unranked subgroups of Syngnathidae. Gastrophori include the syngnathid genera *Nerophis*, *Entelurus*, *Doryrhamphus*, *Dunckerocampus*, *Heraldia*, *Maroubra*, *Choroichthys*, *Leptoichthys*, and *Microphis*.

Support: Synapomorphies are given in Wilson & Orr (2011), based on the work of Duncker (1912, 1915). The molecular phylogeny of Wilson & Orr (2011) supports the monophyly of Gastrophori (BS 93). Our RAxML phylogeny supports monophyly of Gastrophori with BS 98.

First occurrence: †*Hipposyngnathus neriticus* Jerzmańska, 1968, from the Menilite Formation (Jamna Dolma Member), outer Carpathian basin, Poland. †*Hipposyngnathus neriticus* is considered to provide the earliest record of Gastrophori (Wilson & Orr 2011). The Jalmna Dolma Member of the Menilite Formation, Poland, is synchronous with nannofossil zone NP22 (Kotlarczyk *et al.* 2006), which is earliest Rupelian in age (33.1–32.5 Ma). †*Hipposyngnathus convexus* Danil’chenko, 1960, from the Maikop Group, Perekishkyul, northern Azerbaijan, has also been considered as an Oligocene gastrophorine by Wilson & Orr (2011), however, the age of the fish-bearing layers of the Maikop Group may have been misinterpreted and be Miocene rather than Oligocene (Popov *et al.* 2008). Therefore, the first occurrence of Gastrophori dates to 33.1–32.5 Ma.

Diversity: 49 extant species (Froese & Pauly 2015)

Sampled species: *Nerophis ophidion* and *Microphis brachyurus*.

Clade 116: Urophori

Taxonomy: One out of two unranked subgroups of Syngnathidae. Urophori include 47 syngnathid genera (all syngnathids that are not included in Gastrophori): *Phycodurus*, *Phyllopteryx*, *Solegnathus*, *Syngnathoides*, *Anarchopterus*, *Apterygocampus*, *Bhanotia*, *Bryx*, *Bulbonaricus*, *Campichthys*, *Corythoichthys*, *Cosmocampus*, *Enneacampus*, *Festucalex*, *Filicampus*, *Halicampus*, *Hippichthys*, *Histiogamphelus*, *Hypsognathus*, *Ichthyocampus*, *Idiotropiscis*, *Kaupus*, *Kimblaeus*, *Kyonemichthys*, *Leptonotus*, *Lissocampus*, *Micrognathus*, *Minyichthys*, *Mitotichthys*, *Nannocampus*, *Notiocampus*, *Penetopteryx*, *Phoxocampus*, *Pseudophallus*, *Pugnaso*, *Siokunichthys*, *Stigmatopora*, *Stipecampus*, *Syngnathus*, *Trachyrhamphus*, *Urocampus*, *Vanacampus*, *Haliichthys*, *Acentronura*, *Amphelikurus*, *Idiotropiscis*, *Hippocampus*.

Support: Synapomorphies are given in Wilson & Orr (2011), based on the work of Duncker (1912,

1915). The molecular phylogeny of Wilson & Orr (2011) supports the monophyly of Urophori (BS 71). Our RAxML phylogeny supports monophyly of Urophori with BS 100.

First occurrence: †*Syngnathus incompletus* Cosmovici, 1887, from the Menilite Formation (IPM2 zone) outer Carpathian basin, Poland. †*Syngnathus incompletus* is considered the earliest record of Urophori (Wilson & Orr 2011). It first occurs in the IPM2 zone, corresponding to nannofossil zones NP22 and NP23 (Kotlarczyk *et al.* 2006), and is thus early Rupelian in age (33.1–30.0 Ma). †*Syngnathus incertus* Danil’chenko, 1960, from the Maikop Group is probably Miocene in age, and therefore younger than †*Syngnathus incompletus* (Popov *et al.* 2008). Thus, the first occurrence of Urophori dates to 33.1–32.5 Ma.

Diversity: 249 extant species (Froese & Pauly 2015)

Sampled species: *Syngnathus rostellatus*, *Hippocampus kuda*, and *Hippocampus abdominalis*.

Clade 117: Perciformes

Taxonomy: One out of eleven orders of Percomorpharia. Following Betancur-R *et al.* (2013), Perciformes includes 60 families, not all of which seem to be monophyletic. These are placed in suborders as follows: Suborder Serranoidei includes Serranidae; suborder Percoidei includes Percidae and Trachinidae, which are not examined by Betancur-R *et al.* (2013), but tentatively placed there; suborder Notothenioidei includes Pseudaphritidae, Elegendopsidae, Nototheniidae, Artedidraconidae, Harpagiferidae, Bathydraconidae, Channichthyidae, and Bovichtidae; suborder Scorpaenoidei includes Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae, and Tetrarogidae; suborder Triglinoidei includes Triglidae and Peristediidae, suborder Cottioidei includes Trichodontidae, Anoplopomatidae, Aulorhynchidae, Gasterosteidae, Hypoptychidae, Anarhichadidae, Bathymasteridae, Cryptacanthodidae, Stichaeidae, Pholidae, Zaproridae, Zoarcidae, Ptilichthyidae, Scytalinidae, Agonidae, Cyclopteridae, Cottidae, Hexagrammidae, Liparidae, Psychrolutidae, Abyssocottidae, Bathylutichthyidae, Comephoridae, Ereuniidae, Hemitriptidae, Normanichthyidae, Parabembridae, and Rhamphocottidae. In addition, 16 families are considered *incertae sedis* by Betancur-R *et al.* (2013), these are Platycephalidae, Percophidae, Apistidae, Aploactinidae, Bembridae, Champsodontidae, Congiopodidae, Cottocomephoridae, Eschmeyeridae, Gnathanacanthidae, Hoplichthyidae, Neosebasteidae, Pataecidae, Perryenidae, Plectrogeniidae, and Zanclophynchidae. We here accept the classification of Betancur-R *et al.* (2013) with the following exceptions: Cottocomephoridae are considered part of Cottidae (Nelson 2006), Perryenidae and Zanclophynchidae are considered part of Congiopodidae (Nelson 2006), the percophid subfamily Hemeroetinae is considered to have affinities elsewhere (see clade 112), Psychrolutidae are considered to be divided between suborders Scorpaenoidei and Cottioidei, so that the psychrolutid subfamily Psychrolutinae are part of Scorpaenoidei, and Cottunculinae are part of Cottioidei (see clades 132 and 133), and the serranid subfamilies Epinephelinae and Anthiinae are considered at family level as Epinephelidae and Anthiidae (see clade 118), after exclusion of tribe Nipponini from Epinephelinae, and after transferring *Zalanthias kelloggi* from Anthiinae to Serraninae, which is supported by the molecular phylogeny of Smith & Craig (2007). Nipponini are considered at family level, too, as Nipponidae. The genus *Acanthistius* is also excluded from Anthiidae, following Smith & Craig (2007). Both Epinephelidae and Nipponidae are not assigned to suborders, but considered as *incertae sedis* within Perciformes.

Finally, of the families listed as *incertae sedis* by Betancur-R *et al.* (2013), we consider the following to be included in Scorpaenoidei, based on their traditional placement in Scorpaenoidei and Scorpaeniformes (Nelson 2006): Platycephalidae, Apistidae, Aploactinidae, Bembridae, Congiopodidae, Eschmeyeridae, Gnathanacanthidae, Neosebastidae, Pataecidae, and Plectrogenidae. Thus, we here consider only Hoplichthyidae, Champsodontidae, Anthiidae, Epinephelidae, Nipponidae, Percophidae without Hemerocoetinae, and the genus *Acanthistius* to remain as *incertae sedis*.

Support: No synapomorphies are known, however, the molecular phlogenies of Li *et al.* (2009), Betancur-R *et al.* (2013), and Lautrédou *et al.* (2013) include a large number of species assigned to Perciformes, as well as outgroup taxa, and strongly support the monophyly of Perciformes. Our RAxML phylogeny supports monophyly of Perciformes with BS 97.

First occurrence: †*Plesioserranus wemmeliensis* from the London Clay Formation of Kent, United Kingdom. The first occurrence of Perciformes dates to 55.2-50.8 Ma. See clade 130 (Serranoidei).

Diversity: 2154 extant species.

Sampled species: All sampled species of clades 118, 119, 126, 127, 128, 129, 130, 132, 133, 131, and 134.

Clade 118: Epinephelidae

Taxonomy: One out of four families *incertae sedis* in Perciformes. After exclusion of Nipponini, Epinephelidae includes four tribes, Epinephelini, Diploprionini, Liopropomini, and Grammistini (Nelson 2006). Epinephelidae are considered as separate from Serranidae following Smith & Craig (2007).

Support: The molecular phylogeny of Smith & Craig (2007) includes representatives of all five epinepheline tribes and strongly supports the monophyly of a clade combining the four tribes Epinephelini, Diploprionini, Liopropomini, and Grammistini (JRV ≥ 95). Further support comes from the molecular phylogeny of (Craig & Hastings 2007), that includes over 100 epinepheline taxa of all five tribes and recovers them as monophyletic (BS 92). Our RAxML phylogeny supports monophyly of Epinephelidae with BS 100.

First occurrence: †*Epinephelus casottii* Costa, 1858, from Retznei, Steiermark, Austria. †*Epinephelus casottii* is the earliest record of Nelson's (2006) serranid subfamily Epinephelinae (Schultz 2000). The fossil-bearing deposits of Retznei, Austria, are reported to be Langhian in age (Schultz 2000). Thus, the first occurrence of Epinephelidae dates to 15.97-13.65 Ma.

Diversity: 221 extant species (Froese & Pauly 2015)

Sampled species: *Plectropomus leopardus*, *Paranthias colonus*, *Cephalopholis taeniops*, *Hyporthodus septemfasciatus*, *Epinephelus akaara*, *Mycteroperca fusca*, *Epinephelus bruneus*, *Anyperodon leucogrammicus*, and *Epinephelus aeneus*.

Clade 119: Notothenioidei

Taxonomy: One out of six suborders of Perciformes. Notothenioidei include eight families.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogenies of Betancur-R *et al.* (2013) and Matschiner *et al.* (2011) include representatives of all notothenioid families and strongly support their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports

monophyly of Notothenioidei with BS 100.

First occurrence: Recent. The fossil history of Notothenioidei is limited to the single putative record of †*Proeleginops grandeastmanorum* from the La Meseta Formation, Seymour Island, Antarctic Peninsula. The fossil has originally been described as a gadiform (Eastman & Grande 1991), but was claimed to be a notothenioid (of the eleginopid family) by (Balushkin 1994). The fossil has been used in a molecular dating study (Near 2004), however, its taxonomic assignment remains questionable. The type locality is reported as RV-8200, which has been considered to be ~40 Ma (Eastman & Grande 1991). However, according to Long (1992), RV-8200 corresponds to the lower section of “Tertiary Eocene La Meseta” (Telm) 4, the age of which has been reevaluated and is now estimated between 52.5–51.0 Ma (Ivany *et al.* 2008). This age is older than the molecular date estimate for the split between Eleginopidae and the notothenioid families of the Antarctic Clade (42.9 Ma; Matschiner *et al.* 2011). In their molecular analysis aimed at dating notothenioid divergences, Matschiner *et al.* (2011) deliberately excluded †*Proeleginops grandeastmanorum* as a constraint due to its debated taxonomic assignment. The presumed fit of their results with the age of †*Proeleginops grandeastmanorum* (there assumed to be ~40.0 Ma) suggested correctness of the notothenioid interpretation, however, this does not hold if †*Proeleginops grandeastmanorum* is in fact 52.5–51.0 myr old. Thus, Notothenioidei are here considered to have no fossil record.

Diversity: 131 extant species (Damerau *et al.* 2012).

Sampled species: All sampled species of clades 130 and 131.

Clade 120: Bovichtidae

Taxonomy: One out of eight notothenioid families. Bovichtidae include three genera, *Bovichtus*, *Cottoperca*, and *Halaphritis*.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Near *et al.* (2012a) includes representatives of *Bovichtus* and *Cottoperca* and strongly supports a sister group relationship of the two genera (BS 100, BP 1.0). However, the phylogenetic placement of the monotypic genus *Halaphritis* is questionable, as the taxon has never been included in a molecular phylogeny and only few specimens of *H. platycephala* have ever been found (Last *et al.* 2002).

First occurrence: Recent.

Diversity: 11 extant species.

Sampled species: *Bovichtus diacanthus*.

Clade 121: “Antarctic Clade”+allies

Taxonomy: Part of Notothenioidei. The five predominantly Antarctic notothenioid families Channichthyidae, Bathydraconidae, Artedidraconidae, Harpagiferidae, and Nototheniidae are often collectively termed “Antarctic Clade” (Eastman 2005; Matschiner *et al.* 2011). “Antarctic Clade”+allies combines the “Antarctic Clade” with the two monotypic notothenioid families Pseudaphritidae and Eleginopidae.

Support: No synapomorphies are known to unite the “Antarctic Clade”, Pseudaphritidae, and Eleginopidae, however, the molecular phylogenies of Matschiner *et al.* (2011) and Near *et al.* (2012a) strongly supports monophyly of a clade combining the three groups (BS 100, BPP 1.0). Our RAxML

phylogeny also supports monophyly of “Antarctic Clade”+allies with BS 100.

First occurrence: Recent. See clade 119 (Notothenioidei)

Diversity: 120 extant species (Damerau *et al.* 2012).

Sampled species: All sampled species of clades 132 and 133.

Clade 122: Pseudaphritidae

Taxonomy: One out of eight notothenioid families. Pseudaphritidae include a single genus, *Pseudaphritis*, and a single species, *P. urvillii*.

Support: Pseudaphritidae include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Pseudaphritis urvillii*.

Clade 123: “Antarctic Clade”+Eleginopidae

Taxonomy: Part of Notothenioidei. Combines the monotypic notothenioid family Eleginopidae with the “Antarctic Clade”. See clade 121 (“Antarctic Clade”+allies).

Support: Synapomorphies are given in Balushkin (2000). The molecular phylogenies of Matschiner *et al.* (2011), Rutschmann *et al.* (2011), and Near *et al.* (2012a) strongly support a sister group relationship of Eleginopidae and the “Antarctic Clade”. Our RAxML phylogeny supports monophyly of “Antarctic Clade”+Eleginopidae with BS 100.

First occurrence: Recent. See clade 119 (Notothenioidei)

Diversity: 119 extant species (Damerau *et al.* 2012).

Sampled species: All sampled species of clades 124 and 125.

Clade 124: Eleginopidae

Taxonomy: One out of eight notothenioid families. Eleginopidae include a single genus, *Eleginops*, and a single species, *E. maclovinus*.

Support: Eleginopidae includes a single species.

First occurrence: Recent. See clade 119 (Notothenioidei)

Diversity: 1 extant species.

Sampled species: *Eleginops maclovinus*.

Clade 125: “Antarctic Clade”

Taxonomy: Part of Notothenioidei. The “Antarctic Clade” of notothenioid fishes includes the five predominantly Antarctic notothenioid families Channichthyidae, Bathydraconidae, Artedidraconidae, Harpagiferidae, and Nototheniidae (Eastman 2005; Matschiner *et al.* 2011).

Support: Synapomorphies are given in Balushkin (2000). The molecular phylogenies of Matschiner *et al.* (2011), Rutschmann *et al.* (2011), and Near *et al.* (2012a) strongly support monophyly of the “Antarctic Clade” (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of the “Antarctic Clade” with BS 100.

First occurrence: Recent.

Diversity: 118 extant species (Damerau *et al.* 2012).

Sampled species: *Notothenia coriiceps*, *Pleuragramma antarctica*, and *Chaenocephalus aceratus*.

Clade 126: Niphonidae

Taxonomy: One out of four families *incertae sedis* in Perciformes. Niphonidae include a single genus and a single extant species, *Niphon spinosus*.

Support: Niphonidae include a single extant species.

First occurrence: *Niphon* †*macrocephalus* Kon and Yoshino, 1997, from the Shinzato Formation, Okinawa Prefecture, Japan *Niphon* †*macrocephalus* is the only fossil record known of Niphonidae, and is reported to be Late Pliocene in age. Thus, the first occurrence of Niphon dates to 3.6-2.588 Ma.

Diversity: 1 extant species.

Sampled species: *Niphon spinosus*.

Clade 127: Percidae

Taxonomy: One out of two families of Percoidei. Percidae include ten genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Matschiner *et al.* (2011) strongly supports monophyly of Percidae (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Percidae with BS 100.

First occurrence: *Perca* †*hassiacae* Weiler, 1961, and *Perca* †“sp. 1” from the Upper Rhine Graben and the Mainz Basin, Germany, or *Perca fluviatilis* Linné, 1758, from La Montagne d’Andance, France, and from Murzak-Koba, Crimea, Ukraine. Reports of Miocene fossils of *Perca fluviatilis* are mentioned in Carney & Dick (2000), but their age is given as 26 Ma, which would be in the Oligocene. While the original studies of Lebedev (1952) and Mein *et al.* (1983) were unavailable, their titles show that the reported fossils date from the Upper Miocene (Tortonian-Messinian). This date agrees with the earliest skeletal record listed in Patterson (1993b). The earliest known otolith remains of Percidae belong to *Perca* †*hassiacae* Weiler, 1961, and *Perca* †“sp. 1” from the Upper Rhine Graben and the Mainz Basin, Germany, which are reported to be Rupelian in age (Martini & Reichenbacher 2007). Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Percidae, *Perca* †*hassiacae*, *Perca* †“sp. 1”, and *Perca fluviatilis* are all not used as age constraints in our BEAST analysis.

Diversity: 201 extant species.

Sampled species: *Percina macrolepida*, *Etheostoma caeruleum*, *Perca fluviatilis*, *Sander lucioperca*, and *Gymnocephalus cernua*.

Clade 128: Percophidae

Taxonomy: One out of four families *incertae sedis* in Perciformes. After exclusion of Hemero-coetinae, Percophidae include two subfamilies, Bembropinae and Percophinae.

Support: Synapomorphies supporting the monophyly of Bembropinae are given in Nelson (2006). Three morphological synapomorphies strongly support a sister group relationship between Bembropinae and Percophinae (Odani *et al.* 2006). Our RAxML phylogeny includes two species of

genus *Bembrops* and supports their monophyly with BS 100.

First occurrence: Recent.

Diversity: 23 extant species.

Sampled species: *Bembrops heterurus*, *Bembrops greyi*.

Clade 129: Trachinidae

Taxonomy: One out of two families of Percoidei. Trachinidae include two genera, *Echiichthys* and *Trachinus*.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Li *et al.* (2009), as well as our RAxML phylogeny support monophyly of Trachinidae with BS 100.

First occurrence: †*Callipteryx speciosus* Agassiz, 1838, and †*C. recticaudatus* Agassiz, 1838, from Monte Bolca, Verona, Italy. Following Patterson (1993b), we consider the taxonomic assignment of †*Trachinus* sp. Casier, 1946, from Sables de Forest, Forest-lez-Bruxelles, Belgium, which is known only from an isolated opercular, as questionable. The next-oldest record of Trachinidae is provided by †*Callipteryx speciosus* and †*C. recticaudatus* from Monte Bolca, Verona, Italy (Patterson 1993b). Thus, the first occurrence of Trachinidae dates to 49.4–49.1 Ma.

Diversity: 6 extant species.

Sampled species: *Trachinus draco* and *Trachinus radiatus*.

Clade 130: Serranoidei

Taxonomy: One out of six suborders of Perciformes. Serranoidei include a single family, Serranidae, and 14 genera. Here, Serranidae is identical to subfamily Serraninae of Nelson (2006), except that *Zalanthias kelloggi* is transferred from Anthiinae to Serraninae (see clade 117; Smith & Craig 2007).

Support: Synapomorphies are given in (Smith & Craig 2007) for Serranidae. The molecular phylogeny of (Smith & Craig 2007) strongly supports the monophyly of Serranoidei (JRV 95). Our RAxML phylogeny supports monophyly of Serranoidei with BS 100.

First occurrence: †*Plesioserranus wemmeliensis* from the London Clay Formation of Kent, United Kingdom. A large number of fossils has been assigned to Serranidae, or even the genus *Serranus* (Schultz 2000). The Cretaceous †*Eoserranus hislopi* Woodward, 1908, from the Maastichtian Lameta Formation, India, is considered the oldest serranid by (Pondella II *et al.* 2003), but is classified as “Percoidei *incertae sedis*” by Arratia *et al.* (2004). Similarly, †*Tretoperca vestita* Sytchevskaya, 1986, from a drill hole near Boltyska village, Ukraine (Schultz 2000), which is reported to be Late Paleocene or Early Eocene in age (Skutschas & Gubin 2011), as well as other genera assigned to serranids, such as †*Bilinia* Obrhelova, 1971, †*Blabe* White, 1936, and †*Kiinkerishia* Sytchevskaya, 1986, should be considered Percoidei *incertae sedis* (Prokofiev 2009) rather than serranids. Furthermore, Bannikov (2006) concludes that none of the fossils described as Serranidae, such as †*Serranus rugosus* Heckel, 1953, from Monte Bolca, belong to this family. This is corroborated by the comparative analysis of Schultz (2000), who found that the taxonomic assignment of nearly all fossil “Serraninae” is questionable. However, he reports that the denticulation of the edge of the preoperculum of the serranine †*Plesioserranus wemmeliensis* Storms, 1897, resembles that of

Serranus, which is here taken as evidence for their relatedness, and for the correct assignment of †*Plesioserranus wemmeliensis* in Serraninae (Schultz 2000). The earliest record of †*Plesioserranus wemmeliensis* is from the London Clay Formation of Kent, United Kingdom (Casier 1966), which is Ypresian and MP8-9 in age (Mlíkovský 1996). The European Land Mammal Age MP8-9 ranges from 55.2 to 50.8 Ma, and therefore the first occurrence of Serranoidei dates to 55.2-50.8 Ma.

Diversity: 84 extant species (Froese & Pauly 2015)

Sampled species: *Serranus baldwini*, *Serranus atricauda*, and *Hypoplectrus gemma*.

Clade 131: *Acanthistius*

Taxonomy: Following Smith & Craig (2007), we here consider the genus *Acanthistius* as *incertae sedis* in Perciformes. See clade 117 (Perciformes). The genus *Acanthistius* includes eleven species.

Support: Synapomorphies are given in Hutchins & Kuitert (1982).

First occurrence: Recent.

Diversity: 11 extant species.

Sampled species: *Acanthistius* sp.

Clade 132: Scorpaenoidei

Taxonomy: One out of six suborders of Perciformes. As recognized here, Scorpaenoidei include 15 families. These are Scorpaenidae, Sebastidae, Setarchidae, Synanceiidae, Tetraogoniidae, Platycephalidae, Apistidae, Aploactinidae, Bembridae, Congiopodidae, Eschmeyeridae, Gnathanacanthidae, Neosebastidae, Pataecidae, and Plectrogeniidae (Plectrogenidae in Nelson 2006). In addition, the psychrolutid subfamily Psychrolutinae is here considered to be part of Scorpaenoidei. See clade 117 (Perciformes).

Support: No synapomorphies are known to unite Scorpaenoidei as recognized here. However, the extensive molecular phylogeny of Lautrédou *et al.* (2013) strongly supports monophyly of a clade combining all included members of Scorpaenoidea of Nelson (2006), except Aploactinidae and Congiopodidae, but with addition of a psychrolutid genus, *Ebininia* (their Clade C in Fig. 3, BS 100, BPP 1.0). The same phylogeny also supports a more extensive clade combining all included members of Scorpaenoidei, Bembridae, Platycephalidae, and Psychrolutinae (30 included taxa), albeit with lower support (BS < 70, BPP < 0.9). Monophyly of Scorpaenoidei is further supported by the molecular phylogeny of Betancur-R *et al.* (2013) (BS 83). Our RAxML phylogeny supports monophyly of Scorpaenoidei with BS 100.

First occurrence: †*Scorpaenoides popovicii* Priem, 1899, from Valea Caselor, Romania, or *Scorpaena* sp. Weiler, 1928, from the Mainz Basin and the Embayment of Leipzig, Germany. †*Scorpaenoides popovicii* has been placed in genus *Scorpaena* by Woodward (1901), but is not a member of Scorpaeninae according to Schultz (1993). Unnamed specimens of genus *Scorpaena* have been described from the Mainz Basin and the Embayment of Leipzig by Weiler (1928, also see Schultz 1993), however their generic assignment has been questioned by Schultz (1993). Despite these taxonomic uncertainties, we here assume that both †*Scorpaenoides popovicii* and *Scorpaena* sp. from the Mainz Basin and the Embayment of Leipzig are representatives of Scorpaenoidei. The fossil-bearing deposits of Valea Caselor are reported to be Oligocene in age (Schultz 1993), and the age of

the localities in the Mainz Basin and the Embayment of Leipzig has been given as Mid-Oligocene by Schultz (1993), and is reported to be Rupelian by Standke *et al.* (2005). No skeletal fossils of Bembridae, Platycephalidae, and Psychrolutinae predate the Oligocene (Patterson 1993b). Thus, the first occurrence of Scorpaenoidei dates to 33.9–28.4 Ma.

Diversity: 568 extant species (Nelson 2006; Froese & Pauly 2015)

Sampled species: *Helicolenus dactylopterus*, *Helicolenus hilgendorffii*, *Sebastiscus marmoratus*, *Sebastes schlegelii*, *Sebastes norvegicus*, and *Sebastes ruberrimus*.

Clade 133: Cottioidei

Taxonomy: One out of six suborders of Perciformes. Cottioidei include one family *incertae sedis*, Trichodontidae, and four infraorders, Anoplopomatales (with a single family, Anoplopomatidae), Gasterosteales (= Gasterosteioidei without Indostomidae in Nelson 2006), Zoarcales (= Zoarcoidei in Nelson 2006), and Cottales (= Cottoidei plus Hexagrammidae, Normanichthyidae, and *Parabembras* in Nelson 2006). The psychrolutid subfamily Psychrolutinae (Nelson 2006) is here considered to have affinities elsewhere. See clades 117 (Perciformes) and 132 (Scorpaenoidei).

Support: No synapomorphies are known to unite Cottioidei, but Wiley & Johnson (2010) list synapomorphies for Cottiformes, and for Gasterosteioidei in the less restricted sense, including Indostomidae (Kawahara *et al.* 2008). The molecular phylogeny of Betancur-R *et al.* (2013) strongly supports monophyly of Cottioidei (BS 100). The exclusion of Psychrolutinae from Cottioidei is strongly supported by the molecular data of Lautrédou *et al.* (2013) (BS 100). Inclusion of Trichodontidae, traditionally considered part of Trachinoidei, is supported by morphological and molecular data of Betancur-R *et al.* (2013), Imamura *et al.* (2005), Thacker (2009; BS 100), and Imamura & Odani (2013). Our RAxML phylogeny supports monophyly of Cottioidei with BS 100.

First occurrence: *Cottus* †*cervicornis* Storms, 1984, from Argile de Boum, Belgium. The earliest cottoid record is provided by *Cottus* †*cervicornis*, which is reported to be Rupelian in age (Patterson 1993b), and the earliest zoarcoid fossils are the pholids †*Agneveichthys gretchinae* and †*Palaeopholis laevis* (Nazarkin 2002). In the absence of aulorhynchid and hypoptychid fossils, the earliest record of Gasterosteioidei is provided by skeletal fossils of the extant *Gasterosteus aculeatus* Linné, 1758, from the Monterey Formation, California, which is reported to be Miocene in age (Bell *et al.* 2009). No fossil record is known of Trichodontidae and Anoplopomatidae. Thus, the first occurrence of Cottioidei dates to 33.9–28.4 Ma.

Diversity: 767 extant species.

Sampled species: *Anoplopoma fimbria*, *Aulorhynchus flavidus*, *Culaea inconstans*, *Gasterosteus aculeatus*, *Aulichthys japonicus*, *Hypoptychus dybowskii*, *Pholis crassispina*, *Anarhichas lupus*, *Zoarces viviparus*, *Lycodes toyamensis*, *Pachycara crossacanthum*, *Lycodes diapterus*, *Hexagrammos decagrammus*, *Trichodon trichodon*, *Arctoscopus japonicus*, *Zaniolepis latipinnis*, *Marukawichthys ambulator*, *Liparis liparis*, *Aptocyclus ventricosus*, *Hemitripteris americanus*, *Careproctus melanurus*, *Hemitripteris villosus*, *Rhamphocottus richardsonii*, *Aspidophoroides monopterygius*, *Cottus reinii*, *Cottus poecilopus*, *Cottus hangiongensis*, *Cottus gobio*, *Cottus cognatus*, *Cottus bairdii*, *Cottocomephorus inermis*, *Comephorus baikalensis*, *Comephorus dybowskii*, *Procottus jettelesii*, *Leocottus kesslerii*, *Paracottus knerii*, *Cyphocottus eurystomus*, *Limnocottus pallidus*, *Batrachocottus nikolskii*,

Cottinella boulengeri, *Asprocottus pulcher*, and *Abyssocottus korotneffi*.

Clade 134: Triglioidei

Taxonomy: One out of six suborders of Perciformes. Triglioidei include two families, Triglidae and Peristediidae.

Support: No synapomorphies are known to unite Triglioidei, however the molecular phylogenies of Betancur-R *et al.* (2013) and Lautrédou *et al.* (2013) include representatives of Triglidae and Peristediidae and strongly support their monophyly (BS 100).

First occurrence: “*Lepidotrigla*” †*cadenati* Steurbaut, 1984, from Couches de Cauneille, Cauneille, Chalosse, France, or †“*Triglidarum*” *cor* (Koken, 1888), from Jackson, Mississippi, USA, or an undescribed triglid from the Boom Clay Formation, Northern Belgium. Otolith fossils of “*Lepidotrigla*” †*cadenati* and †“*Triglidarum*” *cor* from the Eocene deposits of Cauneille, France and Jackson, USA, provide the earliest records of Triglidae (Carnevale 2008). No fossil record is known of Peristediidae. The earliest skeletal records are Rupelian in age (Carnevale 2008). Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Triglioidei, “*Lepidotrigla*” †*cadenati*, and †“*Triglidarum*” *cor* are not used to constrain the age of Triglioidei in our BEAST analysis.

Diversity: 141 extant species.

Sampled species: *Peristedion* sp.

Clade 135: Centrarchiformes+allies

Taxonomy: Clade Centrarchiformes+allies, as recognized here, is mostly identical to clade Centrarchiformes of Near *et al.* (2012c), as this clade is strongly supported in the molecular phylogeny of Near *et al.* (2012c), but less so in the phylogeny of Betancur-R *et al.* (2013). As circumscribed in Near *et al.* (2012c), Centrarchiformes combine the families Centrarchidae (including *Elassoma*), Kyphosidae, Oplegnathidae, Terapontidae, Kuhliidae, Percichthyidae (excluding *Howella*), Perciliidae, Enoplosidae, Cheilodactylidae, Cirrhitidae, and Sinipercidae. In contrast, Betancur-R *et al.* (2013) consider Centrarchiformes to include only Centrarchidae and Elassomatidae, with the latter family being reerected for genus *Elassoma*. Betancur-R *et al.* (2013) further recognize order Cirrhitiformes, which includes five families, Cheilodactylidae, Cirrhitidae, Aplodactylidae, Chironemidae, and Latridae. Of the families included in Centrarchiformes of Near *et al.* (2012c), the following families are not included in Centrarchiformes or Cirrhitiformes of Betancur-R *et al.* (2013), but considered *incertae sedis* in Percomorpharia: Kyphosidae, Oplegnathidae, Terapontidae, Kuhliidae, Percichthyidae, Enoplosidae, and Sinipercidae. In addition, Perciliidae are considered *incertae sedis* in Percomorphaceae (Betancur-R *et al.* 2013), but included in Centrarchiformes of Near *et al.* (2012c). Here, we consider Centrarchiformes+allies to include all families included in Centrarchiformes of Near *et al.* (2012c) (whereby Elassomatidae are recognized at family level), plus Aplodactylidae, Chironemidae, and Latridae.

Support: No synapomorphies are known to unite Centrarchiformes+allies, however, the molecular phylogeny of Near *et al.* (2012c) strongly supports monophyly of all families of this clade, except Aplodactylidae and Chironemidae, which are not included in the data set of Near *et al.* (2012c)

(BS 100). Inclusion of Aplodactylidae and Chironemidae is strongly supported by the molecular phylogenies of Smith & Craig (2007) and Li *et al.* (2009) that both include most families of Centrarchiformes, as recognized in Near *et al.* (2012c), and recover a monophyletic clade combining Cheilodactylidae, Aplodactylidae and Chironemidae (Smith & Craig 2007; JRV ≥ 95), or Cheilodactylidae and Aplodactylidae (Li *et al.* 2009; BS 98; Chironemidae are not included in the data set of Li *et al.* 2009). Our RAxML phylogeny supports monophyly of Centrarchiformes+allies with BS 99.

First occurrence: †*Properca angusta* (Agassiz, 1834), from Menat, Puy-de-Dôme, France. Whereas †*Properca angusta* may not necessarily be part of Percichthyidae+Perciliidae, given the nonmonophyly of Percichthyidae, we here consider it to be a member of Centrarchiformes+allies. The first occurrence of Centrarchiformes+allies dates to 61.0-60.0 Ma. See clade 139 (Percichthyidae+Perciliidae).

Diversity: 251 extant species.

Sampled species: All sampled species of clades 143, 144, 147, 148, 149, 150, 151, and 154.

Clade 136: *Percalates*

Taxonomy: One out of eleven genera of Percichthyidae. The genus *Percalates* includes two species: *P. novemaculeata* and *P. colonorum*. Both species were previously included in the percichthyid genus *Macquaria*, based on allozyme and morphological analyses (Near *et al.* 2012c).

Support: The molecular phylogeny of Near *et al.* (2012c) strongly supports a sister group relationship of *P. novemaculeata* and *P. colonorum*, and a position of the two taxa outside of *Macquaria*, and even outside of Percichthyidae. Our RAxML phylogeny supports monophyly of *Percalates* with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (Near *et al.* 2012c).

Sampled species: *Percalates novemaculeata* and *Percalates colonorum*.

Clade 137: Kyphosidae+allies

Taxonomy: Part of Centrarchiformes+allies. As recognized here, Kyphosidae+allies include four out of 15 families of Centrarchiformes+allies, Kyphosidae, Oplegnathidae, Terapontidae, and Kuhlidae. We here follow Nelson (2006) in including *Parascorpius* in Kyphosidae rather than treating it at family level, as Parascorpididae (Betancur-R *et al.* 2013).

Support: Monophyly of family Kyphosidae is supported by synapomorphies as given in Nelson (2006), but not by the molecular phylogenies of Yagishita *et al.* (2002, 2009) and Near *et al.* (2012c). Yagishita *et al.* (2002, 2009) include representatives of four out of five kyphosid subfamilies, as well as Terapontidae, Kuhlidae, and Oplegnathidae, and find the latter two families in a nested position within Kyphosidae (BS 88). Near *et al.* (2012c) include two kyphosid subfamilies, Terapontidae, Kuhlidae, and Oplegnathidae, and recover all three families nested between Kyphosidae (BS 100). However, the monophyly of the combined four families (Kyphosidae+allies as it is defined here) is strongly supported by both analyses (BS 100). Moreover, all members of this group share the *Ramus lateralis accessorius* (RLA) pattern 10 (Yagishita *et al.* 2002, 2009). Our RAxML phylogeny

supports monophyly of Kyphosidae+allies with BS 100.

First occurrence: ?*Pelates* †*quindecimalis* Agassiz, 1834, from Monte Bolca, Verona, Italy. ?*Pelates* †*quindecimalis* is considered the earliest record of Terapontidae (Patterson 1993b). No skeletal fossils of Kyphosidae, Oplegnathidae, and Kuhlidae predate the Miocene. Thus, the first occurrence of Kyphosidae+allies dates to 49.4-49.1 Ma.

Diversity: 110 extant species.

Sampled species: *Kyphosus cinerascens*, *Oplegnathus punctatus*, *Kuhlia rupestris*, *Kuhlia marginata*, *Girella mezina*, *Terapon jarbua*, *Hephaestus fuliginosus*, and *Scortum barcoo*.

Clade 138: Enoplosidae

Taxonomy: One out of 15 families of Centrarchiformes+allies. Enoplosidae include a single genus and a single species, *Enoplosus armatus*.

Support: Enoplosidae include a single extant species.

First occurrence: *Enoplosus* †*pygopterus* Agassiz, 1836, from Monte Bolca, Verona, Italy. Patterson (1993b) lists *Enoplosus* †*pygopterus* as the earliest record of Enoplosidae, but considers it to be in need of revision. However, according to Bellwood (1996) and Friedman (2009), Enoplosidae are present in the Monte Bolca deposits. Thus, the first occurrence of Enoplosidae dates to 49.4-49.1 Ma.

Diversity: 1 extant species.

Sampled species: *Enoplosus armatus*.

Clade 139: Percichthyidae+Perciliidae

Taxonomy: Percichthyidae+Perciliidae combine two out of 15 families of Centrarchiformes+allies. Both families are considered *incertae sedis* in Betancur-R *et al.* (2013). Whereas Perciliidae include a single genus with two species and their monophyly has not been questioned, nonmonophyly of Percichthyidae is supported by molecular data. Following Near *et al.* (2012c), we here recognize a clade combining Percichthyidae and Perciliidae, whereby Percichthyidae include only those taxa forming a well-supported clade in the molecular phylogeny of Near *et al.* (2012c), plus additional percichthyid genera that are likely to fall into this clade based on the molecular data of Jerry *et al.* (2001). The clade recovered by Near *et al.* (2012c) includes the percichthyid genera *Percichthys*, *Gadopsis*, *Maccullochella*, *Macquaria* (without *Percalates*, see notes for clade 136), *Nannoperca* (including *Edelia*, see Jerry *et al.* 2001), as well as the only perciliid genus, *Percilia*. According to the molecular phylogeny of Jerry *et al.* (2001), we further include the monotypic percichthyid genera *Nannatherina*, that forms a strongly supported group with *Nannoperca* (BS 99), and *Guyu*, which is nested within *Macquaria* (BS 99). Other genera that were previously included in Percichthyidae, but are not here considered to be part of this clade, are *Percalates* (Near *et al.* 2012c) and *Howella* (Prokofiev 2007). The affinities of one remaining percichthyid genus, *Bostockia*, are uncertain, but expected to be either with this clade, or with *Percalates* (see Supplementary Table S9).

Support: No synapomorphies are known to unite this clade, however, the molecular phylogeny of Near *et al.* (2012c), as well as our RAxML phylogeny support monophyly of Percichthyidae+Perciliidae, as defined here, with BS 100.

First occurrence: †*Properca angusta* (Agassiz, 1834), from Menat, Puy-de-Dôme, France. Patterson (1993b) considers †*Properca angusta* to be one of the earliest records of Percichthyidae, together with fossils assigned to genus *Percichthys* from the deposits of the Chilean Lonquimay Mountains. He reports both localities to be Thanetian in age, however, according to Wappler *et al.* (2009), the deposits of Menat, France, are even older and date to 61.0-60.0 Ma. The extinct genus †*Properca* has previously been included in Serranidae, but is reported to be a member of Percichthyidae by Schultz (2000). However, given the non-monophyly of Percichthyidae and the fact that as many as four out of 13 percichthyid genera may have affinities elsewhere, †*Properca angusta* may not be a member of Percichthyidae+Perciliidae, as recognized here. Therefore, we consider †*Percichthys lonquimayensis* to be the earliest member of Percichthyidae+Perciliidae. Thus, the first occurrence of Percichthyidae+Perciliidae dates to 58.7-55.8 Ma.

Diversity: 20 extant species.

Sampled species: *Maccullochella peelii*, *Gadopsis marmoratus*, *Nannoperca australis*, *Macquaria ambigua*, *Percilia irwini*, and *Percichthys trucha*.

Clade 140: Cheilodactylidae+allies

Taxonomy: Cheilodactylidae+allies combine four out of five families of Cirrhitiformes. These are Cheilodactylidae, Latridae, Aplodactylidae, and Chironemidae. As Cirrhitiformes are part of clade Centrarchiformes+allies, as recognized here, Cheilodactylidae+allies also represent four out of 15 families of Centrarchiformes+allies.

Support: No synapomorphies are known to unite the four families, however the molecular phylogeny of Smith & Craig (2007) includes representatives of Cheilodactylidae, Aplodactylidae, and Chironemidae, as well as of most other centrarchiform families (Centrarchidae, Oplegnathidae, Terapontidae, Kuhliidae, Percichthyidae, Cheilodactylidae, Cirrhitidae, and Sinipercidae) and recovers Aplodactylidae and Chironemidae as deeply nested within Centrarchiformes, forming a monophyletic group with Cheilodactylidae (JRV ≥ 95). In addition, the molecular phylogeny of Li *et al.* (2009) includes representatives of Centrarchidae, Kyphosidae, Terapontidae, Percichthyidae, Cheilodactylidae, Aplodactylidae, and strongly supports a sister group relationship of Cheilodactylidae and Aplodactylidae (BS 98). Following BurrIDGE & Smolenski (2004), we assume that Latridae are included in Cheilodactylidae, thus rendering the latter non-monophyletic. Our RAxML phylogeny supports monophyly of Cheilodactylidae+allies with BS 100.

First occurrence: Recent.

Diversity: 40 extant species.

Sampled species: *Cheilodactylus paxi*, *Chirodactylus brachydactylus*, and *Cheilodactylus variegatus*.

Clade 141: Cirrhitidae

Taxonomy: One out of five families of Cirrhitiformes. Cirrhitidae include twelve genera. As Cirrhitiformes are part of clade Centrarchiformes+allies, as recognized here, Cirrhitidae also represents one out of 15 families of Centrarchiformes+allies.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Near *et al.*

(2012c) includes representatives of four out of twelve cirrhitid genera and strongly supports their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Cirrhitidae with BS 100.

First occurrence: Recent.

Diversity: 33 extant species.

Sampled species: *Cirrhitichthys falco*, *Neocirrhites armatus*, *Amblycirrhitus pinos*, and *Paracirrhites arcatus*.

Clade 142: Sinipercidae

Taxonomy: One out of 15 families of Centrarchiformes+allies. Sinipercidae include two genera, *Siniperca*, and *Coreoperca*, that are mentioned only briefly, and not explicitly assigned to any family in Nelson (2006). In Liu & Chen (1994) and in Froese & Pauly (2015), the two genera are included in family Percichthyidae. We here follow Li *et al.* (2010a), Near *et al.* (2012c), and Betancur-R *et al.* (2013) in recognizing both genera as family Sinipercidae.

Support: Synapomorphies are given in Li *et al.* (2010a). The molecular phylogenies of Li *et al.* (2010a) and Near *et al.* (2012c) include both sinipercid genera and strongly support their monophyly (BS ≥ 99). Our RAxML phylogeny supports monophyly of Cirrhitidae with BS 100.

First occurrence: *Coreoperca* †*shandongensis* Chen, Liu, and Yan, 1999, from the Shanwang Formation, Shandong Province, China. The first occurrence of Sinipercidae dates to 20.43-15.97 Ma. See clade 143 (*Coreoperca*).

Diversity: 12 extant species Li *et al.* (2010a).

Sampled species: All sampled species of clades 143 and 144.

Clade 143: *Coreoperca*

Taxonomy: One out of two genera of Sinipercidae. The genus *Coreoperca* includes three species, *C. herzi*, *C. kawamebari*, and *C. whiteheadi*.

Support: Synapomorphies are given in Liu & Chen (1994). The monophyly of *Coreoperca* is supported by the morphology-based phylogeny of Liu & Chen (1994).

First occurrence: *Coreoperca* †*shandongensis* Chen, Liu, and Yan, 1999, from the Shanwang Formation, Shandong Province, China. *Coreoperca* †*shandongensis* is considered to be the earliest record of genus *Coreoperca* (Chen *et al.* 1999). The Shanwang Formation is reported to be late Early Miocene in age (Chen *et al.* 1999), which is here assumed to be Burdigalian. This is older than *Coreoperca* †*maruoi*, Yabumoto and Uyeno, 2009, which is described from the Chojabaru Formation, Iki Island, Japan, that has been dated to ~ 15.3 Ma (Yabumoto 2009). Thus, the first occurrence of *Coreoperca* dates to 20.43-15.97 Ma.

Diversity: 3 extant species (Li *et al.* 2010a).

Sampled species: *Coreoperca whiteheadi*.

Clade 144: *Siniperca*

Taxonomy: One out of two genera of Sinipercidae. The genus *Siniperca* includes nine species.

Support: Synapomorphies are given in Liu & Chen (1994). The monophyly of *Siniperca* is supported by the morphology-based phylogeny of Liu & Chen (1994). Our RAxML phylogeny supports

monophyly of *Siniperca* with BS 100.

First occurrence: Sinipercinae spp. from the Chojabaru Formation, Iki Island, Japan. Sinipercine fossil material from the Miocene Chojabaru Formation provides the earliest record of Sinipercinae, according to Chen *et al.* (1999). The Chojabaru Formation has been dated to ~15.3 Ma (Yabumoto 2009), which is here assumed to be 15.4-15.2 Ma. Thus the first occurrence of *Siniperca* dates to 15.4-15.2 Ma.

Diversity: 9 extant species (Li *et al.* 2010a).

Sampled species: *Siniperca scherzeri*, *Siniperca chuatsi*, *Siniperca kneri*, *Siniperca undulata*, *Siniperca obscura*, *Siniperca roulei*.

Clade 145: Centrarchidae+Elassomatidae

Taxonomy: Combines two out of 15 families of Centrarchiformes+allies, Centrarchidae and Elassomatidae.

Support: Similarities in the vertebral column support the monophyly of Centrarchidae+Elassomatidae (Near *et al.* 2012a). The molecular phylogeny of Near *et al.* (2012a) strongly supports a sister group relationship between Centrarchidae and Elassomatidae (BS 100). Our RAxML phylogeny supports monophyly of Centrarchidae+Elassomatidae with BS 100.

First occurrence: †*Plioplarchus sexspinosus* Cope, 1883, and †*P. whitei*, Cope, 1883, from the contact between the Chadron and Brule Formations, USA. The first occurrence of Centrarchidae+Elassomatidae dates to 32.0-30.0 Ma. See first occurrence notes for clade 147 (Centrarchidae).

Diversity: 40 extant species (Near & Koppelman 2009).

Sampled species: All sampled species of clades 146 and 147.

Clade 146: Elassomatidae

Taxonomy: One out of two families of Centrarchidae+Elassomatidae. Elassomatidae include a single genus, *Elassoma*. Ranked as order Elassomatiformes in Wiley & Johnson (2010), and as suborder Elassomatoidei in Nelson (2006).

Support: Synapomorphies are given in Nelson (2006) and in Wiley & Johnson (2010). The molecular phylogeny of Near *et al.* (2012c) includes two out of six ellassomatid species and strongly supports their monophyly (BS 100). Our RAxML phylogeny also supports monophyly of Elassomatidae with BS 100.

First occurrence: Recent.

Diversity: 6 extant species.

Sampled species: *Elassoma okefenokee*, *Elassoma evergladei*, *Elassoma zonatum*.

Clade 147: Centrarchidae

Taxonomy: One out of two families of Centrarchidae+Elassomatidae. Centrarchidae include two subfamilies, Centrarchinae and Lepominae, as well as two genera without subfamilial assignment, *Acantharchus* and *Micropterus* (Nelson 2006).

Support: Synapomorphies are given in Nelson (2006) and Near & Koppelman (2009). The molecular phylogenies of Near *et al.* (2005) and Near *et al.* (2012c) strongly support monophyly of Cen-

trarchidae (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Centrarchidae with BS 100.

First occurrence: †*Plioplarchus sexspinosus* Cope, 1883, and †*P. whitei*, Cope, 1883, from the contact between the Chadron and Brule Formations, USA. †*Plioplarchus sexspinosus* and †*P. whitei* are considered the earliest record of Centrarchidae by Near & Koppelman (2009). The contact between the Chadron and Brule Formations can be dated to approximately 31 Ma (Near & Koppelman 2009), which is here assumed to be 32.0-30.0 Ma. Thus, the first occurrence of Centrarchidae dates to 32.0-30.0 Ma.

Diversity: 34 extant species (Near & Koppelman 2009).

Sampled species: All sampled species of clades 148, 149, and 150.

Clade 148: Centrarchinae

Taxonomy: One out of two subfamilies of Centrarchidae (the family further includes two genera without subfamilial assignment, *Acantharchus* and *Micropterus*). Centrarchinae include five genera, *Ambloplites*, *Archoplites*, *Centrarchus*, *Enneacanthus*, and *Pomoxis*.

Support: Morphological characteristics supporting the monophyly of Centrarchinae are given in Roe *et al.* (2002). The molecular phylogeny of Roe *et al.* (2002) includes all five genera of Centrarchinae and supports the monophyly of the subfamily (BS 70). Our RAxML phylogeny supports monophyly of Centrarchinae with BS 100.

First occurrence: *Archoplites* †*clarki* (Smith and Miller, 1985) from the Clarkia Beds, Idaho, USA. *Archoplites* †*clarki* is considered the earliest record of genus *Archoplites*, and predates fossils of *Ambloplites* and *Pomoxis* (Near & Koppelman 2009). No fossil record is known of *Centrarchus* and *Enneacanthus*. The Clarkia Beds are reported to be 15.5 Ma (Near & Koppelman 2009), which is here assumed to be 15.75-15.25 Ma. Therefore, the first occurrence of Centrarchinae dates to 15.75-15.25 Ma.

Diversity: 11 extant species.

Sampled species: *Ambloplites rupestris* and *Archoplites interruptus*.

Clade 149: *Acantharchus*

Taxonomy: One out of two genera that are not placed in either of two subfamilies of Centrarchidae (Centrarchinae and Lepominae). The genus *Acantharchus* includes a single species, *A. pomotis*.

Support: *Acantharchus* include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Acantharchus pomotis*.

Clade 150: Lepominae+*Micropterus*

Taxonomy: Combines one out of two subfamilies of Centrarchidae (Lepominae) with one out of two genera that are not placed in either of two subfamilies of Centrarchidae, *Micropterus*.

Support: No synapomorphies are known to unite Lepominae and *Micropterus*, however the molecular phylogenies of Near *et al.* (2004, 2005, 2012c) strongly support a sister group relationship

between Lepominae and *Micropterus* (BS 100, BPP 1.0). Our RAxML phylogeny also supports monophyly of Lepominae+*Micropterus* with BS 100.

First occurrence: *Micropterus* †sp. A Matthew, 1924, from the Lower Snake Creek, Nebraska, USA. The first occurrence of Lepominae+*Micropterus* dates to 16.0-15.0 Ma. See clade 151 (*Micropterus*).

Diversity: 23 extant species (Near & Koppelman 2009).

Sampled species: All sampled species of clades 151 and 152.

Clade 151: *Micropterus*

Taxonomy: One out of two genera that are not placed in either of the two subfamilies of Centrarchidae (Centrarchinae and Lepominae).

Support: Morphological characteristics and the molecular phylogenies reviewed in Near & Koppelman (2009) strongly support monophyly of *Micropterus* (BS 100). Our RAxML phylogeny also supports monophyly of *Micropterus* with BS 100.

First occurrence: *Micropterus* †sp. A Matthew, 1924, from the Lower Snake Creek, Nebraska, USA. *Micropterus* †sp. A is considered the earliest record of genus *Micropterus* (Near & Koppelman 2009). The fossil-bearing deposits of the Lower Snake Creek are reported to be 16.0-15.0 Ma (Near & Koppelman 2009). Therefore, the first occurrence of *Micropterus* dates to 16.0-15.0 Ma.

Diversity: 10 extant species (Near & Koppelman 2009).

Sampled species: *Micropterus dolomieu* and *Micropterus salmoides*.

Clade 152: Lepominae

Taxonomy: One out of two subfamilies Centrarchidae. Lepominae include a single genus, *Lepomis*.

Support: Morphological characteristics and the molecular phylogenies reviewed in Near & Koppelman (2009) strongly support monophyly of Lepominae (BS 100).

First occurrence: *Lepomis* †sp. A (Smith, 1962) from the Lower Valentine Formation, Nebraska, USA. *Lepomis* †sp. A is considered the earliest record of genus *Leptomis*, and is reported to be 13.5 Ma (Near & Koppelman 2009), which is here assumed to be 13.75-13.25 Ma. Therefore, the first occurrence of Lepominae dates to 13.75-13.25 Ma.

Diversity: 13 extant species Near & Koppelman (2009).

Sampled species: *Lepomis cyanellus* and *Lepomis gulosus*.

Clade 153: Labriformes

Taxonomy: One out of eleven orders of Percomorpharia. Labriformes include three families, Labridae, Odacidae, and Scaridae. Of these, Labridae are presumably nonmonophyletic. Of eight tribes included in Labridae, all but Hysiginyini appear monophyletic.

Support: The morphological data of Gomon (1997), as well as a large number of molecular phylogenies strongly support monophyly of Labridae including Odacidae and Scaridae (Hanel *et al.* 2002; Westneat & Alfaro 2005; Mabuchi *et al.* 2007; Wainwright *et al.* 2012).

First occurrence: †*Eocoris bloti* Bannikov and Sorbini, 1991, †*Phyllopharyngodon longipinnis* Bellwood, 1990, and †*Bellwoodilabrus landinii* Bannikov and Carnevale, 2010, from Monte Bolca,

Verona, Italy. The oldest fossils of Labridae are from Monte Bolca, Italy, including †*Eocoris bloti*, †*Phyllopharyngodon longipinnis*, and †*Bellwoodilabrus landinii* (Patterson 1993b; Cowman *et al.* 2009; Cowman & Bellwood 2011). Therefore, the first occurrence of Labridae dates to 49.4-49.1 Ma.

Diversity: 632 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 154, 157, 158, and 159.

Clade 154: Hypsigenyini+Odacidae

Taxonomy: Combines one out of eight tribes of Labridae with one out of three families of Labri-formes. Odacidae appear to be nested within Hypsigenyini, thus rendering Hypsigenyini nonmono-phyletic. As defined by Gomon (1997) on the basis of morphology, the labrid tribe Hypsigenyini includes the following genera: *Polylepion*, *Decodon*, *Xiphocheilus*, *Choerodon*, *Semicossyphus*, *Achoerodus*, *Clepticus*, *Bodianus*, and *Anchichoerops*. Following Westneat & Alfaro (2005), we further include *Lachnolaimus* and *Pseudodax* in Hypsigenyini, and all four genera of Odacidae (Nelson 2006) in Hypsigenyini+Odacidae, these are *Haletta*, *Neodax*, *Odax*, and *Siphonognathus*.

Support: Morphological characteristics supporting the monophyly of Hypsigenyini+Odacidae are given in Gomon (1997). The molecular phylogenies of Westneat & Alfaro (2005) and Wainwright *et al.* (2012) strongly support monophyly of Hypsigenyini+Odacidae (BS \geq 99). Our RAxML phylogeny supports monophyly of Hypsigenyini+Odacidae with BS 100.

First occurrence: †*Phyllopharyngodon longipinnis* Bellwood, 1990, from Monte Bolca, Verona, Italy. †*Phyllopharyngodon longipinnis* from Monte Bolca is considered to be the earliest record of Hypsigenyini+Odacidae by Cowman & Bellwood (2011). Thus, the first occurrence of Hypsigenyini+Odacidae dates to 49.4-49.1 Ma.

Diversity: 97 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 155 and 156.

Clade 155: *Lachnolaimus*

Taxonomy: One out of eleven genera of Hypsigenyini. The genus *Lachnolaimus* includes a single extant species, *L. maximus*.

Support: *Lachnolaimus* include a single extant species.

First occurrence: *Lachnolaimus* †*multidens* (Munster, 1846), from the Cluj Limestone Formation, Cluj-Napoca, Romania, and from the Nisului Valley Formation, Turnu Rosu, Romania. *Lachnolaimus* †*multidens* represents the only known fossil record of genus *Lachnolaimus* (Dica 2002). Fossils of *Lachnolaimus* †*multidens* are reported to be Lower Eocene in age (Dica 2002). Therefore, the first occurrence of *Lachnolaimus* dates to 40.4-33.9 Ma.

Diversity: 1 extant species.

Sampled species: *Lachnolaimus maximus*.

Clade 156: Odacidae+allies

Taxonomy: Combines ten out of eleven genera of Hypsigenyini with one out of three families of Labri-formes, Odacidae.

Support: No synapomorphies are known that unite all Hypsigenyini except *Lachnolaimus* with Odacidae, however, the molecular phylogenies of Westneat & Alfaro (2005), Alfaro *et al.* (2009b), Cowman *et al.* (2009), and Wainwright *et al.* (2012) consistently recover *Lachnolaimus* as the sister to Odacidae+allies (BS ≥ 94). Our RAxML phylogeny supports monophyly of Odacidae+allies with BS 97.

First occurrence: †*Trigonodon jugleri* Schultz and Bellwood, 2004, from Prambachkirchen and Aussertreffling near Linz, Austria, and from the Congeria-Rzehakia-bearing sand, Hungary. †*Trigonodon jugleri* is considered to provide the earliest record of Trigonodontinae (syn.: Pseudodacinae) by Schultz & Bellwood (2004). No earlier records are known of other members of Odacidae+allies. Following Schultz & Bellwood (2004), we consider the taxonomic assignment of †*Trigonodon serratus* (Gervais, 1852) and †*T. laevis* (Priem, 1907), known from the Eocene of Belgium and Egypt, questionable. The deposits of Prambachkirchen and Aussertreffling near Linz, Austria, and the Congeria-Rzehakia-bearing sand, Hungary, are reported to be Early Miocene in age. Thus, the first occurrence of Odacidae+allies dates to 23.03-15.97 Ma.

Diversity: 96 extant species.

Sampled species: *Pseudodax moluccanus*, *Achoerodus viridis*, *Bodianus rufus*, *Semicossyphus pulcher*, *Clepticus parrae*, *Heteroscarus acroptilus*, *Neodax balteatus*, *Xiphocheilus typus*, *Choerodon schoenleinii*, and *Choerodon anchorago*.

Clade 157: Scaridae+allies

Taxonomy: Combines two out of eight tribes of Labridae, Labrini and Cheilini, with one out of three families of Labriformes, Scaridae.

Support: No synapomorphies are known to unite Scaridae+allies, however, the molecular phylogenies of Cowman *et al.* (2009), Alfaro *et al.* (2009b), and Wainwright *et al.* (2012) strongly support monophyly of a clade combining Labrini, Cheilini, and Scaridae (BS 100). Of the three phylogenies, the data sets of Cowman *et al.* (2009) and Alfaro *et al.* (2009b) include representatives of all eight labrid tribes, and of Odacidae and Scaridae. Our RAxML phylogeny supports monophyly of Scaridae+allies with BS 95.

First occurrence: *Labrus agassizi* Münster, 1846, *Labrus* †*parvulus* Heckel, 1856, and *Calotomus* †*preisli* Bellwood and Schultz, 1991 from the Bay of Eisenstadt, Austria. *Labrus agassizi*, and *Labrus* †*parvulus* likely are the oldest members of Labrini, and *Calotomus* †*preisli* has been considered the oldest record of Scaridae (Westneat & Alfaro 2005). The deposits of the Bay of Eisenstadt are reported to be Badenian in age (Bellwood & Schultz 1991), which ranges from 13.7 to 12.7 Ma (Harzhauser & Piller 2004). Thus, the earliest record of Scaridae+allies dates to 13.7-12.7 Ma.

Diversity: 142 extant species (Froese & Pauly 2015).

Sampled species: *Sparisoma cretense*, *Labrus merula*, and *Tautogolabrus adspersus*.

Clade 158: Pseudocheilini

Taxonomy: One out of eight tribes of Labridae. Pseudocheilini include six genera, *Cirrhilabrus*, *Paracheilinus*, *Pseudocheilinops*, *Pseudocheilinus*, *Conniella*, and *Pteragogus*.

Support: Synapomorphies are given in Westneat (1993). The morphology-based and molecular

phylogenies of Westneat (1993), Westneat & Alfaro (2005; BS 100), Cowman *et al.* (2009; BS 100, BPP 1.0), and Alfaro *et al.* (2009a) strongly support the monophyly of Pseudocheilini. Our RAxML phylogeny supports monophyly of Pseudocheilini with BS 100.

First occurrence: Recent.

Diversity: 84 extant species (Froese & Pauly 2015).

Sampled species: *Pteragogus enneacanthus*, *Pteragogus cryptus*, *Pseudocheilinus octotaenia*, and *Cirrhitilabrus lubbocki*.

Clade 159: Novaculini+allies

Taxonomy: Combines four out of eight tribes of Labridae, Novaculini, Pseudolabrini, Labrichthyini, and Julidini, with two monotypic genera that are not assigned to any labrid tribe, *Malapterus* and *Cheilio*.

Support: No synapomorphies are known to unite Novaculini, Pseudolabrini, Labrichthyini, Julidini, *Malapterus*, and *Cheilio*, however, the molecular phylogenies of Westneat & Alfaro (2005; BS 99) and Cowman *et al.* (2009; BSS 100, BPP 1.0) strongly support monophyly of this clade, as it is defined here. Our RAxML phylogeny supports monophyly of Novaculini+allies with BS 100.

First occurrence: *Julis* †*sigismundi* Kner, 1862, from the Bay of Eisenstadt, Austria. The earliest record of this clade may be provided by *Julis* †*sigismundi* (Bellwood & Schultz 1991). While *Julis* is no longer a valid genus, *Julis* †*sigismundi* is here assumed to be a julidine, and therefore part of Novaculini+allies. The deposits of the Bay of Eisenstadt are reported to be Badenian in age (Bellwood & Schultz 1991), which ranges from 13.7 to 12.7 Ma (Harzhauser & Piller 2004). Thus the first occurrence of Novaculini+allies dates to 13.7-12.7 Ma.

Diversity: 298 extant species (Froese & Pauly 2015).

Sampled species: *Novaculichthys taeniourus*, *Novaculoides macrolepidotus*, *Xyrichtys martiniensis*, *Cymolutes praetextatus*, *Cymolutes torquatus*, *Iniistius aneitensis*, *Notolabrus gymnogenis*, *Pseudolabrus gayi*, *Pictilabrus laticlavius*, *Austrolabrus maculatus*, *Thalassoma pavo*, *Coris julis*, *Labrichthys unilineatus*, *Diproctacanthus xanthurus*, *Labroides bicolor*, and *Labroides dimidiatus*.

Clade 160: Polyprionidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Polyprionidae include two genera, *Polyprion* and *Stereolepis*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Stereolepis gigas*.

Clade 161: Acropomatidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Following Prokofiev (2007), we here consider the monotypic genus *Pseudohowellia* to have affinities elsewhere. After exclusion of *Pseudohowellia*, Acropomatidae include seven genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: *Acropoma* †*lepidotus* (Agassiz, 1836) from Monte Bolca, Verona, Italy. *Acropoma* †*lepidotus* has been described from Monte Bolca (Bellwood 1996; Schultz 2000). Thus, the first occurrence of Acropomatidae dates to 49.4-49.1 Ma.

Diversity: 30 extant species.

Sampled species: *Acropoma japonicum*.

Clade 162: Epigonidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Epigonidae include six genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes two species of the same genus of Epigonidae, *Epigonus*, and supports their sister group relationship. The five remaining genera of Epigonidae have never been included in molecular phylogenies.

First occurrence: *Epigonus* †*polli* Nolf, 1988, †“*Epigonarum*” *malamphoides* Nolf, 1988, and “aff. †*Scombrophyraena*” *ganensis* Nolf, 1988, from Argile de Gan, Gan, Pyrénées-Atlantiques, France, or Recent. The fossil record of Epigonidae is limited to otolith remains from the deposits of Argile de Gan, France (Patterson 1993b). Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Epigonidae, *Epigonus* †*polli*, †“*Epigonarum*” *malamphoides*, and “aff. *Scombrophyraena*” *ganensis* are not used as age constraints in our BEAST analysis.

Diversity: 25 extant species.

Sampled species: *Epigonus telescopus*.

Clade 163: Lateolabracidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Lateolabracidae include a single genus, *Lateolabrax*, and two species, *L. japonicus*, and *L. latus*. Genus *Lateolabrax* was formerly placed in Moronidae (Nelson 2006; Smith & Craig 2007).

Support: No synapomorphies are known to unite *L. japonicus*, and *L. however*, the molecular phylogeny of Orrell *et al.* (2002) strongly supports a sister lineage relationship of the two species (JSV 100).

First occurrence: ?*Avitolabrax denticulatus* Takai, 1942, from the Siramizu Formation, Hukusima, Japan. According to Patterson (1993b), ?*Avitolabrax denticulatus* is said to be “ancestral” to *Lateolabrax*. It is reported to be Aquitanian in age. Thus, the first occurrence of Lateolabracidae dates to 23.03-20.43 Ma.

Diversity: 2 extant species.

Sampled species: *Lateolabrax japonicus*.

Clade 164: Howellidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Following Prokofiev (2007), we here recognize Howellidae to include the three genera *Howella* (formerly Percichthyidae), *Pseudohowella* (formerly Acropomatidae), and *Bathysphyraenops* (formerly Percichthyidae).

Support: Synapomorphies are given in Prokofiev (2007).

First occurrence: †*Synagropoides steparenkorum* Bannikov, 2002, from the Kuma horizon of the Northern Caucasus, Russia. Following Prokofiev (2007), †*Synagropoides steparenkorum* is considered a stem lineage of Howellidae. The Kuma horizon is reported to be Middle Eocene in age (Prokofiev 2007). Thus, the first occurrence of Howellidae dates to 48.6-37.2 Ma.

Diversity: 9 extant species (Froese & Pauly 2015).

Sampled species: *Howella brodiei* and *Howella zina*.

Clade 165: Uranoscopiformes

Taxonomy: One out of eleven orders of Percomorpharia. Uranoscopiformes include four families, Ammodytidae, Pinguipedidae, Uranoscopidae, and Cheimarrichthyidae.

Support: No synapomorphies are known to unite Uranoscopiformes, however, the molecular phylogenies of (Li *et al.* 2009) and Betancur-R *et al.* (2013) strongly support monophyly of Uranoscopiformes (BS 98).

First occurrence: †*Ammodytes vasseuri* Nolf and Lapierre, 1977, from the Sables de Bois-Gouet, Loire-Atlantique, France, or Recent. The fossil record of Uranoscopiformes is limited to otolith remains of Ammodytidae and Uranoscopidae, the earliest of which are known from the Lutetian. However, given the questionable taxonomic assignment of otolith remains, and the resulting uncertainty regarding the first occurrence age of Uranoscopiformes, †*Ammodytes vasseuri* is not used as an age constraint in our BEAST analysis.

Diversity: 128 extant species.

Sampled species: *Ammodytes hexapterus*.

Clade 166: Sciaenidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Sciaenidae include 70 genera.

Support: A large number of synapomorphies support monophyly Sciaenidae (Sasaki 1989).

First occurrence: †*Jefitchia claybornensis* (Koken, 1888), from Claiborne, Mississippi, USA. According to Huddleston & Takeuchi (2006) and Patterson (1993b), otolith remains from the Middle to Late Eocene Gulf Coast region, including *Jefitchia claybornensis* (“*Sciaenidarum*” *claybornensis*), provide the earliest record of Sciaenidae. Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Sciaenidae, †*Jefitchia claybornensis* is not used as an age constraint in our BEAST analysis.

Diversity: 270 extant species.

Sampled species: *Sciaenops ocellatus*.

Clade 167: Ephippiformes

Taxonomy: One out of eleven orders of Percomorpharia. Ephippiformes include two families, Drepaneidae and Ephippidae.

Support: On the basis of morphology, Greenwood *et al.* (1966) assumed a close relationship between Drepaneidae and Ephippidae. The molecular phylogenies of Yamanoue *et al.* (2007), Holcroft

& Wiley (2008), and Betancur-R *et al.* (2013) include representatives of both families, and strongly support the monophyly of Ephippiformes (BS 100).

First occurrence: †*Eoplatax papilio* Blot, 1969, from Monte Bolca, Verona, Italy. According to Bellwood *et al.* (2010), †*Eoplatax papilio* from Monte Bolca provides the earliest record of Ephippidae. No fossils are known of Drepaneidae, a family with only two extant species. The age of fossils from Monte Bolca can be constrained to 49.4–49.1 Ma (see clade 98). Thus, the first occurrence of Ephippiformes dates to 49.4–49.1 Ma.

Diversity: 18 extant species.

Sampled species: *Platax orbicularis*.

Clade 168: Emmelichthyidae+allies

Taxonomy: Combines three out of 38 families considered *incertae sedis* in Percomorpharia, Emmelichthyidae, Caesionidae, and Lutjanidae. Following Rocha *et al.* (2008), we assume that the family Inermiidae is no longer valid and that the monotypic genus *Emmelichthyops* should be included in Emmelichthyidae.

Support: Synapomorphies of the three individual families are given in Nelson (2006). Monophyly of a clade combining Caesionidae and Lutjanidae is strongly supported by the molecular phylogenies of Orrell *et al.* (2002; JRV 100), Yamanoue *et al.* (2007; BPP 1.0), Li *et al.* (2009; BS 100), and Miya *et al.* (2010; BS 100), whereby Caesionidae may be nested within a non-monophyletic Lutjanidae (Li *et al.* 2009; BS 98). Synapomorphies for Lutjanidae including Caesionidae are given in Nelson (1994). The sister group relationship of Emmelichthyidae and a clade combining Lutjanidae and Caesionidae is strongly supported by the molecular phylogenies of Miya *et al.* (2003; JRV 100), Miya *et al.* (2005; BPP 1.0), Mabuchi *et al.* (2007; BS 100), Yamanoue *et al.* (2007; BPP 0.91), Kawahara *et al.* (2008; BS 100, BPP 1.0), Setiamarga *et al.* (2008; BS 100, BPP 1.0) and Miya *et al.* (2010; BS < 50).

First occurrence: *Emmelichthys* sp. Nolf and Lapierre, 1977, from the Sables du Bois-Gouet, Loire-Atlantique, France, or †*Apsilus latus* Stinton, 1980, from the Selsey Formation, southern England, UK, or “*Caesio*” *bourdoti* (Priem, 1906), from Calcaire Grossier, Paris Basin, France. The simultaneous appearance of all three families, Emmelichthyidae, Caesionidae, Lutjanidae in the Lutetian is here taken as support for the correct taxonomic assignment of otolith remains from Sables du Bois-Gouet, the Selsey Formation, and the Calcaire Grossier (Patterson 1993b). Thus, the first occurrence of Emmelichthyidae+allies dates to 48.6–40.4 Ma.

Diversity: 141 extant species.

Sampled species: *Erythrocles monodi*.

Clade 169: Haemulidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Haemulidae include 17 genera. Following Rocha *et al.* (2008), we assume that the family Inermiidae is no longer valid and that the monotypic genus *Inermia* should be included in Haemulidae. We here follow Nelson (2006) in including *Haplogenyys* in Haemulidae rather than treating it at family level, as Haplogenyidae (Betancur-R *et al.* 2013).

Support: Synapomorphies are given in Nelson (2006).

First occurrence: “genus †*Haemulidarum*” *gullentopsi* Nolf, 1978, and “genus †*Haemulidarum*” *makarenkoi* Schwarzhans and Bratishko, 2011, from the Tashlik Formation, Luzanivka, Cherkassy Region, Ukraine, or †*Parapristopoma prohumile* Arambourg, 1927, from the Messinian Oran-Ravin blanc Formation, Algeria. Otolith remains assigned to “genus †*Haemulidarum*” have been considered the earliest record of Haemulidae in Patterson (1993b). Disregarding presumed haemulids from Monte Bolca (Bannikov 2006), it seems that no skeletal remains of Haemulidae older than the Miocene are known. The first skeletal remains of Haemulidae are provided by †*Parapristopoma prohumile* (Gaudant 2008). The Tashlik Formation is reported to be Selandian in age and coincides with nannofossil zone NP5-6 (Schwarzhans & Bratishko 2011), which is dated to 60.5-58.3 Ma. Given the uncertainty of the taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Haemulidae, otolith remains of “genus †*Haemulidarum*” are not used as an age constraint in our BEAST analysis.

Diversity: 146 extant species.

Sampled species: *Plectorhinchus mediterraneus*.

Clade 170: Leiognathidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Leiognathidae include three genera, *Gazza*, *Leiognathus*, and *Secutor*.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of *Gazza* and *Leiognathus* and strongly supports their sister group relationship (BS 100).

First occurrence: †“*Leiognathidarium*” *bercherensis* Nolf and Lapierre, 1979, and “aff. *Gazza*” *pentagonalis* Nolf and Lapierre, 1979, from Calcaire Grossier, Paris Basin, France, or Recent. The fossil record of Leiognathidae is limited to otolith remains from the Calcaire Grossier, France (Patterson 1993b). Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Leiognathidae, †“*Leiognathidarium*” *bercherensis* and “aff. *Gazza*” *pentagonalis* are not used as age constraints in our BEAST analysis.

Diversity: 30 extant species.

Sampled species: *Leiognathus equulus*.

Clade 171: Pomacanthidae

Taxonomy: One out of 38 families that are considered *incertae sedis* in Percomorpharia. Pomacanthidae include eight genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes six out of eight genera of Pomacanthidae, and strongly supports monophyly of Pomacanthidae (BS 100).

First occurrence: *Pomacanthus* †*fitchi* Nolf, 1973, from the Calcaire Grossier, Paris Basin, France, or Recent. The fossil record of Pomacanthidae is limited to otolith remains, the oldest of which are known from the Calcaire Grossier, France, which is reported to be Lutetian in age (Patterson 1993b). Given the questionable taxonomic assignment of otolith fossils, and the resulting uncer-

tainty regarding the first occurrence age of Pomacanthidae, *Pomacanthus* †*fitchi* is not used as an age constraint in our BEAST analysis.

Diversity: 82 extant species.

Sampled species: *Centropyge* sp.

Clade 172: Chaetodontidae

Taxonomy: One out of 38 families that are considered *incertae sedis* in Percomorpharia. Chaetodontidae include eleven genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of six out of eleven genera of Chaetodontidae and strongly supports the monophyly of Chaetodontidae (BS 100).

First occurrence: *Chaetodon* †*hoeferi* Gorjanovic-Kramberger, 1895, from the Lasko-Trbovlje syncline, Sava Basin, Slovenia. A number of Eocene otolith and skeletal fossil have been placed in Chaetodontidae, however, a recent revision of fossil material suggested that all of these should be excluded from the family. According to Carnevale (2006), the earliest record of Chaetodontidae is instead provided by *Chaetodon* †*hoeferi* from the Lasko-Trbovlje syncline, Slovenia. Deposits of the Lasko-Trbovlje are reported to be Rupelian in age. Thus, the first occurrence of Chaetodontidae dates to 33.9-30.7 Ma.

Diversity: 122 extant species.

Sampled species: *Heniochus* sp.

Clade 173: Spariformes+allies

Taxonomy: Combines one out of eleven orders of Percomorpharia, Spariformes, with two out of 38 families considered *incertae sedis* in Percomorpharia, Cepolidae and Priacanthidae. Spariformes includes four families, Nemipteridae, Lethrinidae, Sparidae, and Centrarchidae.

Support: No synapomorphies are known to unite Spariformes with Priacanthidae and Cepolidae, however, the molecular phylogeny of Smith & Craig (2007) includes representatives of Lethrinidae and Priacanthidae, as well as most related families, and strongly supports their monophyly (JRV ≥ 95). Cepolidae are not included in the molecular phylogeny of Smith & Craig (2007), but are recovered as the sister group of Priacanthidae in the molecular phylogeny of Lautrédou *et al.* (2013; BS 100, BPP 1.0) The monophyly of Spariformes is supported by synapomorphies given in Johnson (1980), and by the molecular phylogenies of Yamanoue *et al.* (2007; BPP 1.0) and Miya *et al.* (2010; BS 97) which include representatives of all four families of Spariformes.

First occurrence: “genus †*Sparidarum*” *spatiatus* Schwarzhans and Bratishko, 2011, from the Tashlik Formation, Luzanivka, Cherkassy Region, Ukraine, or †*Sciaenurus bowerbanki* Agassiz, 1845, from the London Clay Formation, Bognor Regis, Sussex, United Kingdom. Otolith remains from the Ukrainian Tashlik Formation have been assigned to “genus †*Sparidarum*” *spatiatus* (Schwarzhans & Bratishko 2011), and provide the earliest record of Spariformes+allies if the taxonomic assignment is correct. The oldest skeletal fossils of Spariformes+allies have been described as †*Sciaenurus bowerbanki*, and occur in the London Clay Formation (Patterson 1993b). The age of the Ukrainian Tashlik Formation is 60.5-58.3 Ma, whereas the London Clay Formation

at Bognor Regis coincides with “European Land Mammal Age” (ELMA) MP8-9, and therefore is 55.2–50.8 Ma (Mlíkovský 1996). The presence of sparids and priacanthids in the Monte Bolca deposits is questionable (Bannikov 2006; Schultz 2000), but further otolith fossils of Centranchidae, Priacanthidae, and Cepolidae are known from Ypresian deposits (Patterson 1993b). Given the uncertainty of the taxonomic assignment of otolith fossils, otolith remains of “genus †*Sparidarum*” *spatiatus* and †*Sciaenurus bowerbanki* are not used as an age constraint in our BEAST analysis.

Diversity: 226 extant species.

Sampled species: *Sparus aurata* and *Pagrus auriga*.

Clade 174: Moronidae+Lobotidae

Taxonomy: Combines two out of 38 families considered *incertae sedis* in Percomorpharia, Moronidae and Lobotidae. We here follow Nelson (2006) in including genus *Datnioides* in Lobotidae rather than treating it at family level, as Datnioididae (Betancur-R *et al.* 2013).

Support: No synapomorphies are known to unite Moronidae and Lobotidae, however, the molecular phylogeny of Smith & Craig (2007) includes multiple representatives of the two families, as well as most closely related groups, and strongly supports the sister group relationship of Moronidae and Lobotidae (JRV ≥ 95). Monophyly of a clade combining *Morone* and *Dicentrarchus* is strongly supported by the molecular data of Williams *et al.* (2012; BPP 1.0), including a shared translocation of the mitochondrial ND6 gene. The monophyly of Lobotidae has been considered questionable by Nelson (2006), but corroborated by the molecular phylogeny of Smith & Craig (2007) (JRV ≥ 95). Our RAxML phylogeny supports monophyly of Moronidae+Lobotidae with BS 100.

First occurrence: *Morone* †sp. Nolf and Dockery, 1990, from the Coffee Sand, Mississippi, USA, or *Morone* †*vogdtii*, (Bogatshov, 1942), from Taman, Russia. According to Santini *et al.* (2009), otolith remains assigned to genus *Morone* provide the earliest record of Moronidae. The Coffee Sand deposits are reported to be Campanian in age (Santini *et al.* 2009). The earliest unambiguous skeletal fossil record of Moronidae is provided by *Morone* †*vogdtii*, from Lower Miocene deposits of Russia (Patterson 1993b). No fossil record is known of Lobotidae. Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Moronidae+Lobotidae, otolith remains of *Morone* †sp. are not used as an age constraint in our BEAST analysis.

Diversity: 6 extant species.

Sampled species: *Dicentrarchus labrax*, *Morone chrysops*, and *Morone saxatilis*.

Clade 175: Caproidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Caproidae includes two subfamilies, Antigoniinae and Caproinae. Both subfamilies were previously included in Zeiformes (Rosen 1984).

Support: A single synapomorphy uniting *Antigonia* and *Capros* was identified by Rosen (1984). The molecular phylogeny of Yamanoue *et al.* (2007) strongly supports a sister group relationship of the two genera (BPP 1.0). Our RAxML phylogeny supports monophyly of Caproidae with BS 99.

First occurrence: †*Eoantigonia veronensis* (Sorbini 1983) from Monte Bolca, Verona, Italy.

†*Eoantigonia veronensis* from Monte Bolca is the earliest record of Caproidae according to Baciú *et al.* (2005a,b). The first occurrence of Caproidae dates to 49.4-49.1 Ma. See clade 177 (*Antigoniinae*).

Diversity: 11 extant species.

Sampled species: All sampled species of clades 176 and 177.

Clade 176: Caproinae

Taxonomy: One out of two subfamilies of Caproidae. Caproinae include a single genus, *Capros*, and a single extant species, *C. aper*.

Support: Caproinae include a single extant species.

First occurrence: *Capros* †*radobojanus* (Kramberger, 1882) from Oligocene deposits of Romania and Poland. According to Swidnicki (1986), the earliest records of genus *Capros* are provided by *C. †radobojanus* from Early Oligocene deposits of Romania and Poland. Thus, the first occurrence of Caproinae dates to 33.9-28.4 Ma.

Diversity: 1 extant species.

Sampled species: *Capros aper*.

Clade 177: Antigoniinae

Taxonomy: One out of two subfamilies of Caproidae. Antigoniinae include a single extant genus, *Antigonia*, and ten species.

Support: Morphological characteristics given in Rosen (1984).

First occurrence: †*Eoantigonia veronensis* (Sorbini 1983) from Monte Bolca, Verona, Italy. †*Eoantigonia veronensis* from Monte Bolca is the sister lineage of *Antigonia* (Baciú *et al.* 2005a,b). Thus, the first occurrence of Antigoniinae dates to 49.4-49.1 Ma.

Diversity: 10 extant species.

Sampled species: *Antigonia capros*.

Clade 178: Lophioidei

Taxonomy: One out of five suborders of Lophiiformes. Include a single family, Lophiidae, and four genera, *Lophius*, *Lophiodes*, *Lophiomus*, and *Sladenia*.

Support: Synapomorphies are given in Nelson (2006) for family Lophiidae. The molecular phylogeny of Miya *et al.* (2010) includes representatives of all four lophiid genera and strongly supports their monophyly (BS 100). Our RAxML phylogeny also supports monophyly of Lophioidei with BS 100.

First occurrence: †*Sharfia mirabilis* Pietsch and Carnevale, 2011, and †*Caruso brachysomus* Carnevale and Pietsch, 2012, from Monte Bolca, Verona, Italy. The genera †*Sharfia* and †*Caruso* provide the earliest fossil record of Lophiidae, and thus of Lophioidei (Pietsch & Carnevale 2011; Carnevale & Pietsch 2012). The first occurrence of Lophioidei dates to 49.4-49.1 Ma. See clade 179 (*Sladenia*).

Diversity: 25 extant species.

Sampled species: All sampled species of clades 187 and 188.

Clade 179: *Sladenia*

Taxonomy: One out of four genera of Lophiidae. The genus *Sladenia* includes three species, *S. remiger*, *S. shaeferi*, and *S. zhui*.

Support: Synapomorphies are given in Caruso (1985).

First occurrence: †*Caruso brachysomus* Carnevale and Pietsch, 2012, from Monte Bolca, Verona, Italy. Based on a matrix of 38 characters, Carnevale & Pietsch (2012) recover †*Caruso brachysomus* from Monte Bolca as the sister lineage of the extant genus *Sladenia*. Thus, the first occurrence of a lineage combining *Sladenia* and †*Caruso*, but excluding *Lophius*, *Lophiodes*, and *Lophiomus*, dates to 49.4–49.1 Ma.

Diversity: 3 extant species.

Sampled species: *Sladenia zhui*.

Clade 180: *Lophius*+allies

Taxonomy: Combines three out of four genera of Lophiidae, *Lophius*, *Lophiodes*, and *Lophiomus*.

Support: Synapomorphies are given in Caruso (1985). The molecular phylogeny of Miya *et al.* (2010) includes representatives of all three genera of *Lophius*+allies plus *Sladenia*, and strongly supports a sister group relationship between *Sladenia* and a clade combining *Lophius*, *Lophiodes*, and *Lophiomus* (BS 100). Our RAXML phylogeny includes two representatives of genus *Lophius* and supports their sister group relationship with BS 100.

First occurrence: †*Eosladenia caucasica* Bannikov, 2004, from the Northern Caucasus, Russia. According to Carnevale & Pietsch (2012), the Middle Eocene †*Eosladenia caucasica* is phylogenetically nested among *Lophius*, *Lophiomus*, and *Lophiodes*. No other fossils are known of this clade. Thus, the first occurrence of *Lophius*+allies dates to 48.6–37.2 Ma.

Diversity: 22 extant species.

Sampled species: *Lophius americanus* and *Lophius vaillanti*.

Clade 181: Ceratiidae+allies

Taxonomy: Combines ten out of eleven families of Ceratioidei, Ceratiidae, Gigantactinidae, Himantolophidae, Melanocetidae, Oneirodidae, Centrophrynidae, Diceratiidae, Linophrynidae, Neoceratiidae, Thaumathichthyidae.

Support: No synapomorphies are known to unite Ceratiidae+allies, however, the molecular phylogeny of Miya *et al.* (2010) includes representatives of all eleven ceratioid families, and supports monophyly of Ceratiidae+allies (BS 53). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Ceratiidae, Gigantactinidae, Himantolophidae, Melanocetidae, and Oneirodidae, and supports monophyly of a clade combining these except the ceratiid genus *Cryptopsaras*, which appears more closely related to Lophioidei than to Ceratiidae+allies. This contradicts the molecular phylogeny of Miya *et al.* (2010), where the sister group relationship of *Ceratias* and *Cryptopsaras*, and thus the monophyly of Ceratiidae is strongly supported (BS 100). We here assume monophyly of Ceratiidae, following Miya *et al.* (2010), and thus monophyly of Ceratiidae+allies.

First occurrence: *Chaenophryne* aff. *melanorhabdus* Regan and Trewavas, 1932, *Leptacanthichthys*

cf. *gracilispinis* Regan 1925, and *Oneirodes* †sp. Lütken, 1871, from the Puente Formation (Yorba Member), Los Angeles Basin, California. The recently described fossils of *Chaenophryne* aff. *melanorhabdus*, *Leptacanthichthys* cf. *gracilispinis*, and *Oneirodes* †sp. have been placed in family Oneirodidae, and provide the only fossil record known of Ceratiidae+allies (Carnevale *et al.* 2008). The Yorba Member of the Puente Formation is reported to be Mohnian, and 8.6-7.6 myr old (Carnevale *et al.* 2008). Thus, the first occurrence of Ceratiidae+allies dates to 8.6-7.6 Ma.

Diversity: 147 extant species.

Sampled species: *Melanocetus johnsonii*.

Clade 182: Chaunacoidei

Taxonomy: One out of five suborders of Lophiiformes. Chaunacoidei include a single family, Chaunacidae, and two genera, *Bathychaunax* and *Chaunax*.

Support: Synapomorphies are given in Nelson (2006) for the family Chaunacidae. Our RAxML phylogeny includes two representatives of genus *Chaunax* and supports their sister group relationship with BS 100.

First occurrence: *Chaunax* †*semiangularatus* Stinton, 1978, from the Barton Formation, Hampshire, United Kingdom, or Recent. Otolith remains of *Chaunax* †*semiangularatus* provide the only known fossil record of Chaunacidae (Patterson 1993b). The Barton Formation is Bartonian in age (Patterson 1993b). No skeletal fossils are known of Chaunacoidei. Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Chaunacoidei, *Chaunax* †*semiangularatus* is not used as an age constraint in our BEAST analysis.

Diversity: 16 extant species.

Sampled species: *Chaunax suttkusi* and *Chaunax pictus*.

Clade 183: Antennarioidei

Taxonomy: One out of five suborders of Lophiiformes. Antennarioidei include four families, Antennariidae, Tetrabrachiidae, Brachionichthyidae, and Lophichthyidae.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Miya *et al.* (2010) includes representatives of all antennarioid families except Lophichthyidae, and strongly supports their monophyly (BS 100).

First occurrence: †*Histionotophorus bassani* De Zigno, 1887, and †*Orrichthys longimanus* Carnevale and Pietsch, 2010, from Monte Bolca, Verona, Italy. The earliest record of Antennarioidei is provided by brachionichthyid fossils from Monte Bolca, †*Histionotophorus bassani* and †*Orrichthys longimanus* Carnevale & Pietsch (2010). Thus, the first occurrence of Antennarioidei dates to 49.4-49.1 Ma.

Diversity: 51 extant species.

Sampled species: *Histrio histrio*.

Clade 184: Caulophrynidae

Taxonomy: One out of eleven families of Ceratioidei. Caulophrynidae include two genera, *Caulophryne* and *Robia*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Caulophryne pelagica*.

Clade 185: Ogcocephaloidei

Taxonomy: One out of five lophiiform suborders. Ogcocephaloidei include a single family, Ogcocephalidae, and ten genera.

Support: Synapomorphies are given in Nelson (2006) for Ogcocephalidae. The molecular phylogeny of Miya *et al.* (2010) includes representatives of four out of ten ogcocephaloid genera, and strongly supports their monophyly (BS 100).

First occurrence: †*Tarkus squirei* Carnevale and Pietsch, 2011, from Monte Bolca, Verona, Italy. †*Tarkus squirei* is the earliest record of family Ogcocephalidae, and thus of Ogcocephaloidei (Carnevale & Pietsch 2011). Thus, the first record of Ogcocephaloidei dates to 49.4–49.1 Ma.

Diversity: 68 extant species.

Sampled species: *Coelophrys brevicaudata* and *Halieutaea stellata*.

Clade 186: Siganidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Siganidae include a single genus, *Siganus*, and 27 species.

Support: Synapomorphies are given in Nelson (2006). Our RAxML phylogeny supports monophyly of Siganidae with BS 100.

First occurrence: †*Siganopygaeus rarus* Danil’chenko, 1968, from the Danata Formation, Uyly-Kushlyuk, Turkmenistan. According to Tyler & Bannikov (1997), †*Siganopygaeus rarus* is the earliest record of Siganidae. The Danata Formation is Upper Thanetian in age (see clade 102). Thus, the first occurrence of Siganidae dates to 57.23–55.8 Ma.

Diversity: 27 extant species.

Sampled species: *Siganus unimaculatus* and *Siganus fuscescens*.

Clade 187: Acanthuriformes

Taxonomy: One out of eleven orders of Percomorpharia. Acanthuriformes include three families, Acanthuridae, Luvaridae, and Zaclidae.

Support: Of the synapomorphies listed by Wiley & Johnson (2010) for their Acanthuriformes, which also includes Siganidae, a single synapomorphy unites the three families here included in Acanthuriformes: Trough-shaped nasal bone bearing serrations along both edges. The molecular phylogenies of Holcroft & Wiley (2008) and Betancur-R *et al.* (2013) strongly support monophyly of Acanthuriformes, as recognized here (BS 100). Based on these molecular studies, we constrain Acanthuriformes as monophyletic for our BEAST analysis, despite the relatively low Bootstrap support resulting from our RAxML phylogeny (BS 91).

First occurrence: †*Kushlukia permira* Danil’chenko, 1968, and †*Avitoluvarus* spp. Bannikov and Tyler, 1995, from the Danata Formation, Uyly-Kushlyuk, Turkmenistan. According to Bannikov &

Tyler (1995, 2001), †*Kushlukia permira* and †*Avitoluvarus* spp. of the extinct family †Kushlukiidae represent the sister lineage of Luvaridae, and mark the appearance of superfamily Luvaroidea. This predates the earliest records of Acanthuridae and Zancidae, that are represented by *Naso* †spp. Agassiz, 1839, 1842, 1844, †*Eozanclus brevirostris* Agassiz, 1842, and *Acanthurus* †spp. Agassiz, 1839, 1842, 1844, all from Monte Bolca, Verona, Italy (Tyler 1970; Tyler & Bannikov 1997). Thus, the first occurrence of Acanthuriformes dates to 57.23-55.8 Ma.

Diversity: 80 extant species.

Sampled species: *Luvarus imperialis*, *Zebrasoma flavescens*, *Naso lopezi*, *Zanclus cornutus*, *Acanthurus leucosternon*, and *Acanthurus lineatus*.

Clade 188: Tetraodontiformes

Taxonomy: One out of eleven orders of Percomorpharia. Tetraodontiformes include six suborders, Triacanthodoidei, Tetraodontoidei, Moloidei, Balistoidei, Ostracioidei, Triacanthoidei, and one family without subordinal assignment, Triodontidae.

Support: Synapomorphies are given in Wiley & Johnson (2010). Molecular phylogenies consistently recover monophyletic Tetraodontiformes (e.g. Wainwright *et al.* 2012, Near *et al.* 2012b, Betancur-R *et al.* 2013) (BS 100). Our RAxML phylogeny supports monophyly of Tetraodontiformes with BS 99.

First occurrence: †*Protriacanthus gortanii* d'Erasmus, 1946, from Comen, Slovenia. †*Plectocretacicus clarae* Sorbini, 1979, has often been considered the earliest record of Tetraodontiformes (Benton *et al.* 2009), however, the taxonomic assignment of this fossil in the stem-tetraodontiform superfamily †Plectocretacicoidea has been questioned on the basis of a preliminary reexamination of fossil material (Betancur-R *et al.* 2013). According to Betancur-R *et al.* (2013), the next-oldest tetraodontiform is another member of †Plectocretacicoidea, †*Cretatriacanthus guidottii* from Canale, Nardò, Italy (Tyler & Sorbini 1996), however, †*Cretatriacanthus guidottii* has been reported to be Upper Campanian to Lower Maastrichtian in age (Tyler & Sorbini 1996), which postdates the age of the third member of †Plectocretacicoidea, †*Protriacanthus gortanii* d'Erasmus, 1946, from Comen, Slovenia. The age of the Comen ichthyofauna has been reported as Upper Cenomanian-Lower Turonian by Tyler & Sorbini (1996), whereas according to Cavin *et al.* (2000), the fossils studied by d'Erasmus range in age from the Cenomanian to the Upper Santonian. Thus, the first occurrence of Tetraodontiformes dates to 99.6-83.5 Ma.

Diversity: 357 extant species.

Sampled species: All sampled species of clades 189, 192, 193, 194, 195, 197, 196, and 190.

Clade 189: Triacanthodoidei

Taxonomy: One out of six suborders of Tetraodontiformes. Triacanthodoidei include a single family, Triacanthodidae, and eleven genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Yamanoue *et al.* (2008) includes two out of eleven triacanthodid genera and strongly supports their monophyly (BPP 1.0). Our RAxML phylogeny supports monophyly of Triacanthodoidei with BS 100.

First occurrence: †*Carpathospinosus propheticus* Tyler, Jerzmanska, Bannikov, and Swidnicki,

1993, from the Menilite Beds, outer Carpathian basin, Poland. According to Tyler *et al.* (1993) and Santini & Tyler (2003), the earliest record of Triacanthodidae is provided by †*Prohollardia avita* and †*Carpathospinosus propheticus*. Both species occur in the Menilite Beds of Poland, however, †*Carpathospinosus propheticus* appears to be the older one as it is present in IPM zone 4, whereas †*Prohollardia avita* is known only from IPM zone 6. IPM zone 6 is reported to be 29.0-28.0 Ma (Tyler *et al.* 1993). Thus, the first occurrence of Triacanthodidae dates to 29.0-28.0 Ma.

Diversity: 21 extant species.

Sampled species: *Triacanthodes anomalus*, *Macrorhamphosodes uradoi*.

Clade 190: Triacanthoidei

Taxonomy: One out of six suborders of Tetraodontiformes. Triacanthoidei include a single family, Triacanthidae, and four genera, *Pseudotriacanthus*, *Triacanthus*, *Tripodichthys*, and *Trixiphichthys*.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Yamanoue *et al.* (2008) includes representatives of two out of four genera of Triacanthidae, and strongly supports their monophyly (BS 100).

First occurrence: †*Protacanthodes ombonii* Zigno, 1887, and †*Protacanthodes nimesensis* Tyler and Santini, 2001, from Monte Bolca, Verona, Italy. †*Protacanthodes ombonii* and †*Protacanthodes nimesensis* represent the only Eocene record of Triacanthidae, and mark the appearance of the family (Santini & Tyler 2003). Both taxa are known from Monte Bolca. Thus, the first occurrence of Triacanthoidei dates to 49.4-49.1 Ma.

Diversity: 7 extant species.

Sampled species: *Triacanthus biaculeatus*.

Clade 191: Balistoidei

Taxonomy: One out of six suborders of Tetraodontiformes. Balistoidei include two families, Monacanthidae and Balistidae.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Betancur-R *et al.* (2013), Yamanoue *et al.* (2008) and Matschiner *et al.* (2011) strongly support monophyly of superfamily Balistoidea (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Balistoidei with BS 100.

First occurrence: †*Gornylistes prodigiosus* Bannikov and Tyler, 2008, from Gorny Luch, Krasnodar Region, Ukraine. The first occurrence of Balistoidei dates to 40.4-37.2 Ma. See clade 193 (Balistidae).

Diversity: 142 extant species.

Sampled species: All sampled species of clades 192 and 193.

Clade 192: Monacanthidae

Taxonomy: One out of two families of Balistoidei. Monacanthidae include 32 genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes six out of 32 monacanthid genera and strongly supports their monophyly (BS 100). Our RAxML phylogeny includes two representatives of genus *Stephanolepis* and supports

their sister group relationship with BS 100.

First occurrence: †*Frigocanthus stroppanobili* Sorbini and Tyler, 2004 and †*Frigocanthus margaritatus* Sorbini and Tyler, 2004 from the Metauro River, Marche, Italy, and Crete, Greece. The earliest skeletal record of monacanthids are †*Frigocanthus stroppanobili* and †*Frigocanthus margaritatus* from the Metauro River, Italy, and from Crete, Greece, which are reported to be Pliocene in age (Sorbini & Tyler 2004). Otolith fossils described as †*Amaneses sulcifer* Stinton, 1966, from the London Clay Formation, Kent, United Kingdom, were found reliable according to the fossil cross-validation of Matschiner *et al.* (2011), however, the authors were unaware of the reanalysis of Schwarzhans (2003), which suggested that the otoliths represent a zeiform, instead of a tetraodontiform species. Thus, the results of Matschiner *et al.* (2011) are here taken as evidence for a Paleocene-Eocene divergence of balistids and monacanthids rather than a corroboration of the †*Amaneses sulcifer* assignment as a monacanthid. According to the skeletal fossil record, the first occurrence of Monacanthidae dates to 5.332-2.588 Ma.

Diversity: 102 extant species.

Sampled species: *Stephanolepis cirrhiifer* and *Stephanolepis hispidus*.

Clade 193: Balistidae

Taxonomy: One out of two families of Balistoidei. Balistidae include eleven genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes ten out of eleven balistid genera and strongly supports their monophyly (BS 100). Our RAxML phylogeny includes two representatives of genus *Balistes* and supports their sister group relationship with BS 100.

First occurrence: †*Gornylistes prodigiosus* Bannikov and Tyler, 2008, from Gorny Luch, Krasnodar Region, Ukraine. †*Gornylistes prodigiosus* Bannikov and Tyler, 2008 from Gorny Luch (Kuma Horizon), Ukraine, is the oldest member of Balistidae (Bannikov & Tyler 2008). The Kuma Horizon at Gorny Luch is characterized by foraminiferans *Turborotalia centralis*, *Globigerina praebulloides*, *Globigerina turkmenica*, and *Globanomalina micra* (Tyler & Bannikov 1992), which indicate a Bartonian age Tyler & Bannikov (1997). Thus, the first occurrence of Balistidae dates to 40.4-37.2 Ma.

Diversity: 40 extant species.

Sampled species: *Balistes capriscus* and *Balistes vetula*.

Clade 194: Triodontidae

Taxonomy: The only family without subordinal assignment of Tetraodontiformes. Triodontidae include a single genus and species, *Triodon macropterus*.

Support: Triodontidae include a single extant species.

First occurrence: *Triodon* †*antiquus* Leriche, 1905, from the London Clay Formation, UK. According to Tyler & Patterson (1991), *Triodon* †*antiquus* from the Ypresian London Clay represents the earliest record of Triodontidae. Thus, the first occurrence of Triodontidae dates to 55.8-48.6 Ma.

Diversity: 1 extant species.

Sampled species: *Triodon macropterus*.

Clade 195: Tetraodontoidei

Taxonomy: One out of six suborders of Tetraodontiformes. Tetraodontoidei include two families, Diodontidae and Tetraodontidae.

Support: No synapomorphies are known to unite Tetraodontoidei, however, the morphology-based and molecular phylogenies of Betancur-R *et al.* (2013), Santini & Tyler (2003), Alfaro *et al.* (2007), and Yamanoue *et al.* (2008, 2011; BPP 1.0) strongly support monophyly of a clade combining Tetraodontidae and Diodontidae. Our RAxML phylogeny supports monophyly of Tetraodontoidei with BS 100.

First occurrence: †*Heptadiodon echinus* Heckel, 1853, and †*Zignodon fornasieroae* Tyler and Santini, 2002 from Monte Bolca, Verona, Italy. Of the tetraodontiform fossils included in the phylogenetic analysis of Santini & Tyler (2003), three Eocene taxa appear closely related to extant diodontids: †*Heptadiodon echinus* Heckel, 1853, and †*Zignodon fornasieroae* Tyler and Santini, 2002, from Monte Bolca, Italy, as well as †*Pshekhadiodon parini* Bannikov and Tyler, 1997 from Gorny Luch, Ukraine (Tyler & Bannikov 2009). The deposits of Gorny Luch postdate those of Monte Bolca, therefore the first occurrence of Tetraodontoidei dates to 49.4-49.1 Ma.

Diversity: 149 extant species.

Sampled species: *Takifugu rubripes* and *Tetraodon nigroviridis*.

Clade 196: Moloidei

Taxonomy: One out of six suborders of Tetraodontiformes. Moloidei include a single family, Molidae, and three genera, Masturus, Mola, and Ranzania.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of all three genera of Molidae, and strongly supports their monophyly (BS 100).

First occurrence: †*Eomola bimaxillaria* Tyler and Bannikov, 1992, from Gorny Luch, Krasnodar Region, Ukraine. †*Eomola bimaxillaria* represents the earliest record of Molidae (Alfaro *et al.* 2007). The Kuma Horizon at Gorny Luch is Bartonian in age. See clade 193 (Balistidae). The first occurrence of Moloidei dates to 40.4-37.2 Ma.

Diversity: 4 extant species.

Sampled species: *Mola mola*.

Clade 197: Ostracioidei

Taxonomy: One out of six suborders of Tetraodontiformes. Ostracioidei include two families, Aracanidae and Ostraciidae.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Betancur-R *et al.* (2013) and Yamanoue *et al.* (2008) include representatives of both ostracioid families and strongly supports their sister group relationship (BPP 1.0). Our RAxML phylogeny supports monophyly of Ostracioidei with BS 100.

First occurrence: †*Spinacanthus cuneiformis* (Blainville), †*Protobalistum imperialis* (Zigno, 1885), †*Eolactoria sorbinii* Tyler, 1976, and †*Proaracana dubia* (Blainville, 1818), from Monte Bolca,

Verona, Italy. According to Santini & Tyler (2003), †*Spinacanthus cuneiformis*, †*Protobalistum imperialis*, †*Eolactoria sorbinii*, and †*Proaracana dubia* represent the earliest record of Ostracioidei. Thus, the first occurrence of Ostracioidei dates to 49.4–49.1 Ma.

Diversity: 33 extant species.

Sampled species: All sampled species of clades 198 and 199.

Clade 198: Aracanidae

Taxonomy: One out of two families of Ostracioidei. Aracanidae include seven genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogenies of Betancur-R *et al.* (2013) and Yamanoue *et al.* (2008) include representatives of two out of seven genera of Aracanidae and strongly support their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Aracanidae with BS 100.

First occurrence: †*Proaracana dubia* (Blainville, 1818), from Monte Bolca, Verona, Italy. Following Santini and Tyler (2003) and Alfaro *et al.* (2009), †*Proaracana dubia* is here considered to be the earliest record of Aracanidae. Thus, the first occurrence of Aracaninae dates to 49.4–49.1 Ma.

Diversity: 13 extant species.

Sampled species: *Anoplocapros lenticularis* and *Kentrocapros aculeatus*.

Clade 199: Ostraciidae

Taxonomy: One out of two families of Ostracioidei. Ostraciidae include seven genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of three out of seven genera of Ostraciidae and strongly supports their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Ostraciidae with BS 100.

First occurrence: †*Eolactoria sorbinii* Tyler, 1976, from Monte Bolca, Verona, Italy. Following Santini & Tyler (2003) and Alfaro *et al.* (2009b), †*Eolactoria sorbinii* is here considered to be the earliest record of Ostraciidae. Thus, the first occurrence of Ostraciidae dates to 49.4–49.1 Ma.

Diversity: 20 extant species.

Sampled species: *Lactoria diaphana* and *Ostracion immaculatus*.

Clade 200: Nandidae

Taxonomy: One out of two families of Channoidei. Channoidei is one out of two suborders of Anabantiformes. We here follow Nelson (2006) in recognizing three subfamilies: Nandinae, Badinae, and Pristolepidinae. All three groups are recognized at family level in Betancur-R *et al.* (2013). Of these, only Nandinae are included in the phylogenetic dataset of Betancur-R *et al.* (2013), while Badinae and Pristolepidinae are assumed to be part of suborder Anabantoidei without being examined.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Rüber *et al.* (2004) strongly supports monophyly of the individual genera *Nandus*, *Dario*, and *Badis*, as well as of the nandid subfamily Badinae (BS 100). The molecular data set of Li *et al.* (2006) includes *Badis* and *Nandus*, and strongly supports a sister group relationship of the two taxa (BPP 1.0).

First occurrence: Recent.

Diversity: 21 extant species.

Sampled species: *Nandus nandus*.

Clade 201: Anabantoidei

Taxonomy: One out of two suborders of Anabantiformes. Anabantoidei include five families according to Betancur-R *et al.* (2013), Anabantidae, Helostomatidae, Osphronemidae, Badidae, and Pristolepididae. However, as the latter two are not examined by Betancur-R *et al.* (2013), we here follow Nelson (2006) in recognizing them as subfamilies of Nandidae.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Anabantidae, Helostomatidae, and Osphronemidae, and strongly supports their monophyly (BS 100).

First occurrence: †*Osphronemus goramy* Lacépède, 1802, from the Sangkarewang Formation, Sumatra, Indonesia. The only articulated anabantoid fossil has been described as †*Osphronemus goramy* from Sumatra, and is reported to be 37.0-28.5 Ma (Rüber 2009). Thus, the first occurrence of Anabantoidei dates to 37.0-28.5 Ma.

Diversity: 120 extant species.

Sampled species: *Anabas testudineus*.

Clade 202: Channidae

Taxonomy: One out of two families of Channoidei. Channidae include two genera, *Channa* and *Parachanna*.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogeny of Li *et al.* (2006) includes all three species of genus *Parachanna*, and 17 out of 31 species of genus *Channa*, and strongly supports a sister group relationship between the two genera (BS 92).

First occurrence: †*Eochanna chorlakkensis* Roe, 1991, from the Kuldana Formation, Chorlakk, Kohat, Pakistan. The earliest record of Channoidei is provided by †*Eochanna chorlakkensis* (Roe 1991; Santini *et al.* 2009). The Kuldana Formation is reported to be Early Eocene in age (Roe 1991; Patterson 1993b), and can be constrained to Shallow Benthic Foraminifer Zones SB 11 to SB 13 (Gingerich 2003). Thus, the first occurrence of Channoidei dates to 50.7-45.5 Ma.

Diversity: 34 extant species (Froese & Pauly 2015).

Sampled species: *Channa melasoma*.

Clade 203: Mastacembeloidei

Taxonomy: One out of three suborders of Synbranchiformes. Mastacembeloidei include two families, Mastacembelidae and Chaudhuriidae.

Support: Synapomorphies are given in Wiley & Johnson (2010).

First occurrence: Recent.

Diversity: 82 extant species.

Sampled species: *Mastacembelus faves*.

Clade 204: Indostomoidei

Taxonomy: One out of three suborders of Synbranchiformes. Indostomoidei include a single family, Indostomidae, a single genus, *Indostomus*, and three species, *I. paradoxus*, *I. crocodilus*, and *I. spinosus*.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: Recent.

Diversity: 3 extant species.

Sampled species: *Indostomus paradoxus*.

Clade 205: Synbranchoidei

Taxonomy: One out of three suborders of Synbranchiformes. Synbranchoidei include a single family, Synbranchidae, and four genera, *Macrotrema*, *Ophisternon*, *Synbranchus*, and *Monopterus*.

Support: Synapomorphies are given in Wiley & Johnson (2010).

First occurrence: Recent.

Diversity: 17 extant species.

Sampled species: *Monopterus albus* and *Synbranchus marmoratus*.

Clade 206: Centropomidae

Taxonomy: One out of six families considered *incertae sedis* in Carangimorphariae. Centropomidae include two subfamilies, Centropominae and Latinae (Li *et al.* 2011).

Support: Synapomorphies proposed by Greenwood (1976) should be considered questionable (Li *et al.* 2011). However, the molecular phylogenies of Li *et al.* (2011) and Betancur-R *et al.* (2013) include representatives of both centropomid subfamilies and strongly support the monophyly of Centropomidae (BS 98, BPP 0.74). Our RAxML phylogeny supports monophyly of Centropomidae with BS 98.

First occurrence: †*Eolates gracilis* (Agassiz, 1843), from Monte Bolca, Verona, Italy. †*Eolates gracilis* is considered to provide the earliest record of Centropomidae, and to be a member of Latinae (Otero 2004). Thus, the first occurrence of Centropomidae dates to 49.4-49.1 Ma.

Diversity: 21 extant species.

Sampled species: All sampled species of clades 207 and 208.

Clade 207: Latinae

Taxonomy: One out of two subfamilies of Centropomidae. Latinae include two genera, *Lates* and *Psammoperca*.

Support: Synapomorphies are given in Otero (2004). The molecular phylogeny of Li *et al.* (2011) strongly supports a sister group relationship between *Lates* and *Psammoperca* (BS 100, BPP 1.0).

First occurrence: †*Eolates gracilis* (Agassiz, 1843), from Monte Bolca, Verona, Italy. †*Eolates gracilis* from Monte Bolca is considered to provide the earliest record of Latinae (Otero 2004). Thus, the first occurrence of Latinae dates to 49.4-49.1 Ma.

Diversity: 9 extant species.

Sampled species: *Lates calcarifer*.

Clade 208: Centropominae

Taxonomy: One out of two subfamilies of Centropomidae. Centropominae include a single genus, *Centropomus*, and twelve species.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Li *et al.* (2011) includes four out of twelve species of genus *Centropomus* and strongly supports their monophyly (BS 100, BPP 1.0).

First occurrence: ?*Centropomus* †sp. Albright, 1994, from the Fleming Formation, Texas, USA. Albright (1994) tentatively assigns fossils from the Miocene of Texas to ?*Centropomus*, and suggests that they represent the earliest record of the genus *Centropomus*, which is accepted by Donaldson & Wilson Jr (1999). Otolith remains of “*Centropomidarum*” *annectens*, Stinton, 1978, and “*Centropomidarum*” *excavatus* Stinton, 1966, from the London Clay Formation are listed as the earliest record of Centropomidae in Patterson (1993b), but may have been misidentified (Albright 1994). The Fleming Formation is reported to be earliest Miocene, and Arikareean in age (Albright 1994). Thus, the first occurrence of Centropominae dates to 23.03-18.5 Ma.

Diversity: 12 extant species.

Sampled species: *Centropomus undecimalis*.

Clade 209: Nematistiidae

Taxonomy: One out of five families of Carangiformes. Nematistiidae include a single genus, *Nematistius*, and a single species, *N. pectoralis*.

Support: Nematistiidae include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Nematistius pectoralis*.

Clade 210: Polynemidae

Taxonomy: One out of six families considered *incertae sedis* in Carangimorphariae. Polynemidae include eight genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of three out of eight genera of Polynemidae and strongly supports monophyly of Polynemidae (BS 100).

First occurrence: Recent.

Diversity: 41 extant species.

Sampled species: *Polydactylus* sp.

Clade 211: Sphyraenidae

Taxonomy: One out of six families that are considered *incertae sedis* in Carangimorphariae. Sphyraenidae include a single genus, *Sphyraena*, and 21 species.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes four out of 21 species of *Sphyraena* and strongly supports the monophyly of

Sphyraena (BS 100).

First occurrence: *Sphyraena* †*bolcensis* Agassiz, 1835, from Monte Bolca, Verona, Italy. Sphyraenidae present in the Lower Eocene deposits of Monte Bolca (Bellwood 1996) represent the earliest record of Sphyraenidae, according to Friedman & Sallan (2012). Thus, the first occurrence of Sphyraenidae dates to 49.4-49.1 Ma.

Diversity: 21 extant species.

Sampled species: *Sphyraena barracuda*.

Clade 212: Istiophoriformes

Taxonomy: One out of three orders of Carangimorphariae. Istiophoriformes include two families, Istiophoridae and Xiphiidae.

Support: According to Nelson (2006), “there is abundant evidence that the Xiphiidae and Istiophoridae are sister groups”. The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Istiophoridae and Xiphiidae and strongly supports monophyly of Istiophoriformes (BS 100).

First occurrence: †*Hemingwaya sarissa* Sytchevskaya and Prokofiev, 2002, from Danata Formation, Uyly-Kushlyuk, Turkmenistan. According to Fierstine (2006), the monotypic family †Hemingwayidae represents the earliest record of billfishes (Xiphioidae), whereby he considers Xiphioidae to include three extinct families (Hemingwayidae, Blochiidae, and Palaeorhynchidae), as well as the extant families Xiphiidae and Istiophoridae. The Danata Formation is Upper Thanetian in age (see clade 102). Thus, the first occurrence of Istiophoriformes dates to 57.23-55.8 Ma.

Diversity: 12 extant species.

Sampled species: *Xiphias gladius*.

Clade 213: Pleuronectoidei

Taxonomy: One out of two suborders of Pleuronectiformes. Pleuronectoidei include ten families.

Support: Synapomorphies are given in Wiley & Johnson (2010). The morphology-based and molecular phylogenies of Chapleau (1993), Berendzen & Dimmick (2002), and Betancur-R *et al.* (2013) strongly support monophyly of Pleuronectoidei (BS 100). Our RAxML phylogeny supports monophyly of Pleuronectoidei with BS 98.

First occurrence: †*Eobothus minimus* (Agassiz, 1842) from Monte Bolca, Verona, Italy. †*Eobothus* has been recognized as a member of Bothidae (Chanet & Schultz 1994), and is nested among crown-group Pleuronectoidei according to the phylogeny of Friedman (2008). The earliest records of †*Eobothus* are provided by †*Eobothus minimus* from Monte Bolca. Thus, the first occurrence of Pleuronectoidei dates to 49.4-49.1 Ma.

Diversity: 675 extant species.

Sampled species: *Scophthalmus maximus*, *Solea senegalensis*, *Paralichthys olivaceus*, *Platichthys stellatus*, and *Pleuronectes platessa*.

Clade 214: Psettodoidei

Taxonomy: One out of two suborders of Pleuronectiformes. Psettodoidei include a single family,

Psettodidae, a single genus (*Psettodes*), and three species, *P. erumei*, *P. bennetti*, and *P. belcheri*.

Support: Synapomorphies are given in Chapleau (1993) and Wiley & Johnson (2010).

First occurrence: †*Joleaudichthys sadeki* Chabanaud, 1937, from Djebel Turah, Egypt. †*Joleaudichthys sadeki* is considered to be the earliest skeletal record of Psettodidae in Patterson (1993b), and is confirmed to be a member of Psettodoidei by the phylogenetic analysis of Friedman (2008). The deposits of Djebel Turah are reported to be lower Mokkatam, and therefore upper Lutetian in age, which is here interpreted as 45.0-40.4 Ma. Thus, the first occurrence of Psettodoidei dates to 45.0-40.4 Ma.

Diversity: 3 extant species.

Sampled species: *Psettodes erumei*.

Clade 215: Carangidae+allies

Taxonomy: Combines four out of five families of Carangiformes. These are Carangidae, Coryphaenidae, Rachycentridae, and Echineidae (Echineidae in Betancur-R *et al.* 2013). Based on the results of Betancur-R *et al.* (2013), we here consider the monotypic family Nematistiidae to have affinities elsewhere.

Support: Synapomorphies are given in Wiley & Johnson (2010) for Carangiformes. Morphology and molecular phylogenies strongly support monophyly of Carangidae+allies (Johnson 1993; Smith & Wheeler 2006), whereby Carangidae are recovered as the sister group to a clade combining Coryphaenidae, Rachycentridae, and Echineidae (Smith & Wheeler 2006; JRV 100).

First occurrence: †*Trachicarax tersus* Danil'chenko, 1968, from the Danata Formation, Uyly-Kushlyuk, Turkmenistan. The earliest record of Carangidae+allies is provided by fossils of †*Trachicarax tersus* from the Danata Formation, as well as †*Teratichthys antiquitatis* and †*Eothynnus salmoneus* from the London Clay Formation, UK (Patterson 1993b). Given that the London Clay Formation is younger than the Danata Formation (see clades 102 and 173), the appearance of Carangidae+allies in the fossil record is marked by †*Trachicarax tersus*. Thus, the first occurrence of Carangidae+allies dates to 57.23-55.8 Ma.

Diversity: 151 extant species.

Sampled species: *Carangoides armatus*, *Caranx melampygus*, *Trachurus japonicus*, *Trachurus trachurus*, and *Trachurus picturatus*.

Clade 216: Kurtoidei

Taxonomy: One out of two suborders of Kurtiformes. Kurtoidei include a single family, Kurtidae, a single genus, *Kurtus*, and two species, *K. gulliveri* and *K. indicus*.

Support: Morphological characteristics supporting the monophyly of Kurtoidei are given in Berra (2003).

First occurrence: Recent.

Diversity: 2 extant species.

Sampled species: *Kurtus gulliveri*.

Clade 217: Pempheriformes

Taxonomy: One out of eleven orders of Percomorpharia. Pempheriformes include two families, Pempheridae and Glaucosomatidae.

Support: Homologous features of the cranium and the swimbladder (Betancur-R *et al.* 2013). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Pempheridae and Glaucosomatidae and strongly supports their monophyly (BS 100).

First occurrence: “Pempheridae *indet.*” Samant and Bajpai, 2001, from Surat, Gujarat, India, or Recent. Otolith remains of undescribed pempherids represent the earliest fossil record of Pempheridae. Deposits of the Surat lignite field, India, are reported to be Lower Eocene in age (Samant & Bajpai 2001). No skeletal fossils are known of Pempheridae and Glaucosomatidae. Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Pempheridae, “Pempheridae *indet.*” are not used as age constraints in our BEAST analysis.

Diversity: 30 extant species.

Sampled species: *Pempheris vanicolensis*.

Clade 218: Apogonoidei

Taxonomy: One out of two suborders of Kurtiformes. Apogonoidei include a single family (Apogonidae) and two subfamilies, Apogoninae and Pseudaminae.

Support: Synapomorphies are given in Nelson (2006) for family Apogonidae. The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Apogoninae and Pseudaminae, and strongly supports their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Apogonoidei with BS 100.

First occurrence: †*Apogon spinosus* Agassiz, 1836, from Monte Bolca, Verona, Italy. †*Apogon spinosus* provides the earliest skeletal record of Apogonoidei, according to Patterson (1993b). Thus, the first occurrence of Apogonoidei dates to 49.4-49.1 Ma.

Diversity: 273 extant species.

Sampled species: *Pristiapogon exostigma* and *Apogon doederleini*.

Clade 219: Gerreidae

Taxonomy: One out of 38 families considered *incertae sedis* in Percomorpharia. Gerreidae include eight genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Chen *et al.* (2007) includes representatives of four out of eight genera of Gerreidae, and strongly supports their monophyly (BS 100).

First occurrence: *Gerres* †*latidens* Stinton, 1980, from the Wittering Formation, London Clay, UK, or †“*Gerreidarum*” *aquitanicus* Nolf, 1988, from Argile de Gan, Gan, Pyrénées-Atlantiques, France, or Recent. Otolith remains described as *Gerres* †*latidens* are considered the earliest record of Gerreidae (Santini *et al.* 2009). Both the Wittering Formation and the deposits of Argile de Gan have been reported to be Ypresian in age (Patterson 1993b). No skeletal fossils of Gerreidae are known (Patterson 1993b). Given the questionable taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Gerreidae, neither *Gerres* †*latidens* nor

†“*Gerreidarum*” *aquitanicus* are used as age constraints in our BEAST analysis.

Diversity: 44 extant species.

Sampled species: *Eugerres plumieri*.

Clade 220: Gobiiformes

Taxonomy: One out of eleven orders of Percomorphaceae. Gobiiformes include three suborders, Odontobutoidei, Eleotroidei, and Gobioidi.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogeny of Thacker (2009) includes representatives of all gobioid families and strongly supports monophyly of Gobiiformes (BS 100).

First occurrence: “*Gobius*” *gracilis* (Laube, 1901) from Seifhennersdorf-Varnsdorf, Bohemia, Czech Republic. “*Gobius*” *gracilis* represents the earliest skeletal record of Eleotridae (Böhme 2007), and of Gobiiformes. At Seifhennersdorf, the top of the fossiliferous layer has been dated as 30.7 Ma, and the formation is assigned a Rupelian age (Gaudant 2009). Thus, the first occurrence of Gobiiformes dates to 33.9-30.7 Ma.

Diversity: 2044 extant species (Froese & Pauly 2015).

Sampled species: *Giuris margaritacea*, *Eleotris acanthopoma*, *Rhyacichthys aspro*, *Milyeringa veritas*, *Odontobutis platycephala*, *Oxyeleotris lineolata*, *Butis butis*, *Boleophthalmus pectinirostris*, *Oxudercus dentatus*, *Gymnogobius petschiliensis*, *Gillichthys seta*, *Gillichthys mirabilis*, *Synechogobius hasta*, *Tridentiger bifasciatus*, *Bathygobius cocosensis*, and *Kraemeria cunicularia*.

Clade 221: Ovalentariae

Taxonomy: One out of three subseries of Carangimorpharia. Ovalentariae include four superorders, Cichlomorphae, Atherinomorphae, Mugilomorphae, and Blenniimorphae, and seven families that are considered *incertae sedis*. These are Ambassidae, Embiotocidae, Grammatidae, Plesiopidae, Polycentridae, Pomacentridae, and Pseudochromidae. The monotypic family Notograptidae is suspected to be closely related to Grammatidae, Plesiopidae, and Opisthognathidae by Nelson (2006), but may also be closely related to Pomacentridae, Pseudochromidae, and Blenniiformes, according to the molecular phylogeny of Wainwright *et al.* (2012) (see Supplementary Table S9).

Support: Ovalentariae have a unique synapomorphy of demersal, adhesive eggs with chorionic filaments. The molecular phylogenies of Wainwright *et al.* (2012) and Betancur-R *et al.* (2013) strongly support monophyly of Ovalentariae (BS 100). Our RAxML phylogeny weakly supports monophyly of Ovalentariae with BS 69.

First occurrence: †*Dapalis erici* Nolf, Rana, and Prasad, 2008, and †“genus *Ambassidarum*” *cappettai* Rana and Sani, 1989, or “Poeciliidae indet.” from the Maíz Gordo Formation, Argentina, or †*Palaeopomacentrus orphae* Bellwood and Sorbini, 1996, †*Lorenzichthys olihan* Bellwood, 1999, †? *Oncolepis isseli* Bassani, 1898, †*Rhamphexocoetus volans* Bannikov *et al.*, 1985, from Monte Bolca, Verona, Italy. The first occurrence age of Ovalentariae is uncertain, and the above fossils are not used as age constraints in our BEAST analysis. See clades 222 (Ambassidae), 226 (Pomacentridae), 233 (Blenniidae), 245 (Exocoetoidei), 246 (Cyprinodontoidei), and 257 (Poeciliidae).

Diversity: 6108 extant species.

Sampled species: All sampled species of clades 222, 223, 225, 226, 227, 229, 230, 231, 232, 233, 234, 235, 236, 237, 238, 239, 240, 242, 243, 244, 245, 246, 258, 265, 266, 224, 264, 228, and 241.

Clade 222: *Ambassidae*

Taxonomy: One out of seven families that are considered *incertae sedis* in Ovalentariae. *Ambassidae* include eight genera.

Support: Synapomorphies are given in Nelson (2006).

First occurrence: †*Dapalis erici* Nolf, Rana, and Prasad, 2008, and †“genus *Ambassidarum*” *cappettai* Rana and Sani, 1989, or Recent. No skeletal fossils are known of *Ambassidae*, but otolith remains assigned to *Ambassidae* occur as early as the Maastrichtian (Nolf *et al.* 2006, 2008). Given the ambiguous taxonomic assignment of otolith remains, and resulting uncertainty regarding the first occurrence age of *Ambassidae*, †*Dapalis erici* and “genus *Ambassidarum*” *cappettai* are not used as an age constraint in our BEAST analysis.

Diversity: 46 extant species.

Sampled species: *Ambassis* sp.

Clade 223: *Mugilomorphae*

Taxonomy: One out of four superorders of Ovalentariae. *Mugilomorphae* include a single order, *Mugiliformes*, a single family, *Mugilidae*, and 17 genera.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogeny of Betancur-R *et al.* (2013) includes seven out of 17 genera of *Mugilidae* and strongly supports monophyly of *Mugilomorphae* (BS 100). Our RAxML phylogeny supports monophyly of *Mugilomorphae* with BS 100.

First occurrence: †“*Mugilidarum*” *debilis* Koken, 1888 from Jackson River, Mississippi, or *Mugil* †*princeps* Agassiz, 1843 from the Menilite Beds, Poland and Ukraine. The earliest mugilid fossils are otolith remains of †“*Mugilidarum*” *debilis*, and skeletal remains of *Mugil* †*princeps* (Patterson 1993b). The deposits of Jackson River are reported to be Priabonian in age, and *Mugil* †*princeps* is Rupelian in age (Patterson 1993b). Given the ambiguous taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of *Mugilomorphae*, †“*Mugilidarum*” *debilis* and *Mugil* †*princeps* are not used as an age constraint in our BEAST analysis.

Diversity: 72 extant species.

Sampled species: *Crenimugil crenilabis*, *Mugil cephalus*, and *Mugil curema*.

Clade 224: *Lipogramma*

Taxonomy: One out of two genera of Grammatidae. The genus *Lipogramma* includes eight species.

Support: Synapomorphies are given in Gill & Mooi (1993).

First occurrence: Recent.

Diversity: 8 extant species.

Sampled species: *Lipogramma trilineata*.

Clade 225: *Embiotocidae*

Taxonomy: One out of seven families that are considered *incertae sedis* in Ovalentariae. Embiotocidae include 13 genera.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Wainwright *et al.* (2012) includes five out of 13 embiotocid genera and strongly supports their monophyly (BS 100). Our RAxML phylogeny supports monophyly of Embiotocidae with BS 100.

First occurrence: †*Eriquius plectrodes* Jordan, 1924, from the Monterey Formation (Lompoc Quarry), California, USA. †*Eriquius plectrodes* is considered the only fossil species of Embiotocidae by Tarp (1952), and the earliest record of the family by Patterson (1993b). The Lompoc Quarry has been correlated with diatom zone NPD7A (Barron *et al.* 2002), which is 7.7-6.8 myr old. Thus, the first occurrence of Embiotocidae dates to 7.7-6.8 Ma.

Diversity: 23 extant species.

Sampled species: *Ditrema temminckii* and *Cymatogaster aggregata*.

Clade 226: Pomacentridae

Taxonomy: One out of seven families that are considered *incertae sedis* in Ovalentariae. Pomacentridae include four subfamilies, Amphiprioninae, Chrominae, Lepidozyginae, and Pomacentrinae.

Support: Synapomorphies are given in Tang (2001). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Amphiprioninae, Chrominae, Lepidozyginae, and Pomacentrinae, and strongly supports monophyly of Pomacentridae (BS 100). Our RAxML phylogeny supports monophyly of Pomacentridae with BS 100.

First occurrence: †*Palaeopomacentrus orphae* Bellwood and Sorbini, 1996, and †*Lorenzichthys olihan* Bellwood, 1999, from Monte Bolca, Verona, Italy. †*Palaeopomacentrus orphae* and †*Lorenzichthys olihan* have been described as pomacentrids, and represent the earliest record of the family (Santini *et al.* 2009; Cowman & Bellwood 2011). Thus, the first occurrence of Pomacentridae dates to 49.4-49.1 Ma.

Diversity: 348 extant species.

Sampled species: *Abudefduf vaigiensis* and *Amphiprion ocellaris*.

Clade 227: Pseudochromidae

Taxonomy: One out of seven families that are considered *incertae sedis* in Ovalentariae. Pseudochromidae include four subfamilies, Pseudochrominae, Pseudoplesiopinae, Anisochrominae, and Congrogadinae.

Support: Synapomorphies are given in Nelson (2006). The morphology-based phylogeny of Godkin & Winterbottom (1985) supports monophyly of Pseudochromidae.

First occurrence: †*Haliophis colletti* Nolf and Lapierre, 1979, from the Calcaire Grossier and Auvers Formation, Paris, France, or Recent. The fossil record of Pseudochromidae is limited to otolith remains. The earliest otolith fossils assigned to Pseudochromidae are described as †*Haliophis colletti*, and are reported to be Lutetian in age (Patterson 1993b). Thus, depending on the correct taxonomic assignment of †*Haliophis colletti*, the first occurrence of Pseudochromidae dates to 48.6-40.4 Ma or Recent. Given the ambiguous taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Pseudochromidae, †*Haliophis colletti* is not used

as an age constraint in our BEAST analysis.

Diversity: 119 extant species.

Sampled species: *Labracinus cyclophthalmus*.

Clade 228: Plesiopidae

Taxonomy: One out of seven families that are considered *incertae sedis* in Ovalentariae. Plesiopidae include two subfamilies, Plesiopinae and Acanthoclininae.

Support: Synapomorphies are given in Nelson (2006). The morphology-based phylogeny of Mooi (1993) includes representatives of Plesiopinae and Acanthoclininae and supports monophyly of Plesiopidae.

First occurrence: Recent.

Diversity: 46 extant species.

Sampled species: *Plesiops* sp.

Clade 229: Gramma

Taxonomy: One out of two genera of Grammatidae. The genus *Gramma* includes five species, *G. brasiliensis*, *G. dejongi*, *G. linki*, *G. loreto*, and *G. melacara*.

Support: Synapomorphies are given in Gill & Mooi (1993).

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Gramma loreto*.

Clade 230: Opistognathidae

Taxonomy: One out of two families that are considered *incertae sedis* in Blennioiidae. Opistognathidae include three genera, *Opistognathus*, *Lonchopisthus*, and *Stalix*.

Support: Synapomorphies are given in Nelson (2006) and egg morphology as described in Mooi (1990).

First occurrence: †“*Opistognathidarium*” *bloti* Nolf and Lapierre, 1979, from the Calcaire Grossier and Auvers Formation, Paris, France, or Recent. The fossil record of Opistognathidae is limited to otolith remains. The earliest otolith fossils assigned to Opistognathidae are described as †“*Opistognathidarium*” *bloti*, and are reported to be Lutetian in age (Patterson 1993b). Given the ambiguous taxonomic assignment of otolith fossils, and the resulting uncertainty regarding the first occurrence age of Opistognathidae, †“*Opistognathidarium*” *bloti* is not used as an age constraint in our BEAST analysis.

Diversity: 80 extant species.

Sampled species: *Opistognathus aurifrons*.

Clade 231: Tripterygiidae

Taxonomy: One out of six families of Blennioidei. Tripterygiidae include 23 genera.

Support: Synapomorphies are given in Springer (1993). The molecular phylogenies of Betancur-R *et al.* (2013) and Kocher & Stepien (1997) include four to five out of 23 tripterygiid genera and

strongly support their monophyly (BS 100).

First occurrence: †*Tripterygion pronasus* Arambourg, 1927, from Oran, Algeria. According to Carnevale (2004), †*Tripterygion pronasus* is the only known fossil species of the family Tripterygiidae. The deposits of the Oran region are reported to be Messinian in age (Patterson 1993b; Carnevale 2004). Thus, the first occurrence of Tripterygiidae dates to 7.246-5.332 Ma.

Diversity: 150 extant species.

Sampled species: *Tripterygion delaisi*.

Clade 232: Gobiesocoi

Taxonomy: One out of two suborders of Blennioformes. Gobiesocoi include a single family, Gobiesocidae.

Support: Synapomorphies are given in Wiley & Johnson (2010), and detailed morphological characteristics described in Springer & Fraser (1976). Moreover, all molecular studies that have included more than one member of Gobiesocidae consistently support the monophyly of the family (Dettai & Lecointre 2005, Mabuchi *et al.* 2007, Kawahara *et al.* 2008, Li *et al.* 2009, Wainwright *et al.* 2012, Betancur-R *et al.* 2013; BS 100). Our RAxML phylogeny weakly supports monophyly of Gobiesocoi with BS 87.

First occurrence: Recent.

Diversity: 140 extant species.

Sampled species: *Opeatogenys gracilis* and *Aspasma minima*.

Clade 233: Blenniidae

Taxonomy: One out of six families of Blennioidei. Blenniidae include five tribes.

Support: Synapomorphies (some of them unique among Perciformes) are given by Springer (1993) and Williams (1990). Monophyly of Blenniidae is corroborated by all molecular phylogenies to date that include more than one blenniid species (Kawahara *et al.* 2008, Li *et al.* 2009, Matschiner *et al.* 2011, Wainwright *et al.* 2012, Betancur-R *et al.* 2013; BS 100). Our RAxML phylogeny supports monophyly of Blenniidae with BS 93.

First occurrence: †*Oncolepis isseli* Bassani, 1898, from Monte Bolca, Verona, Italy. While the genus level assignment of *?Oncolepis isseli* may be questionable, it is frequently cited as a blenniid (Bellwood 1996), and is here accepted as such. Thus, the first occurrence of Blenniidae dates to 49.4-49.1 Ma.

Diversity: 360 extant species.

Sampled species: *Salarias fasciatus*, *Petroscirtes breviceps*, *Salaria fluviatilis*, and *Coryphoblennius galerita*.

Clade 234: Labrisomidae+allies

Taxonomy: Combines four out of six families of Blennioidei, Labrisomidae, Dactyloscopidae, Clinidae, and Chaenopsidae.

Support: No synapomorphies are known to unite Labrisomidae, Dactyloscopidae, Clinidae, and Chaenopsidae. The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of

Labrisomidae, Dactyloscopidae, Clinidae, and Chaenopsidae, and strongly supports monophyly of Labrisomidae+allies, as defined here (BS 100). Our RAxML phylogeny supports monophyly of Labrisomidae+allies with BS 97.

First occurrence: †*Clinitrachoides gratus* (Bannikov, 1989), from Romania. †*Clinitrachoides gratus* is considered the earliest record of Clinidae, and Sarmatian in age (Stepien *et al.* 1997). No fossil record is known of Dactyloscopidae and Chaenopsidae, and the earliest record of Labrisomidae is Messinian in age (Patterson 1993b). The age of the Sarmatian can be constrained to 12.2-11.3 Ma (Harzhauser & Piller 2004; Vasiliev *et al.* 2010). Thus, the first occurrence of Labrisomidae+allies dates to 12.2-11.3 Ma.

Diversity: 308 extant species.

Sampled species: *Neoclinus blanchardi*, *Chaenopsis alepidota*, *Gillellus sp.*, *Muraenoclinus dorsalis*, and *Heterostichus rostratus*.

Clade 235: Atherinopsidae+Notocheiridae

Taxonomy: Combines two out of ten families of Atheriniformes, Atherinopsidae and Notocheiridae. Atherinopsidae include two subfamilies, Atherinopsinae and Menidiinae, and Notocheiridae include a single genus, *Notocheirus*, and a single species, *N. hubbsi*.

Support: No synapomorphy is known to unite Atherinopsidae and Notocheiridae, however, the molecular phylogeny of Bloom *et al.* (2012) includes representatives of Atherinopsinae and Menidiinae, as well as *Notocheirus hubbsi*, and strongly support monophyly of Atherinopsidae+Notocheiridae (BPP 1.0).

First occurrence: Recent.

Diversity: 109 extant species (Nelson 2006; Bloom *et al.* 2012).

Sampled species: *Menidia menidia*.

Clade 236: *Atherion*

Taxonomy: Family Atherionidae, with the single genus *Atherion*, is recognized in Nelson (2006), but not classified in Betancur-R *et al.* (2013). The genus *Atherion* includes three species, *A. africanum*, *A. elymus*, and *A. maccullochi*. Genus *Atherion* has previously been included in Atherinidae, and is apparently considered part of Atherinidae in Betancur-R *et al.* (2013). We here follow Nelson (2006) and consider *Atherion* as separate from Atherinidae.

Support: Synapomorphies are given in Nelson (2006) and morphological characteristics described in Dyer & Chernoff (1996).

First occurrence: Recent.

Diversity: 3 extant species.

Sampled species: *Atherion elymus*.

Clade 237: Isonidae

Taxonomy: One out of ten families of Atheriniformes. Isonidae include a single genus (*Iso*) and five species, *I. flosmaris*, *I. hawaiiensis*, *I. natalensis*, *I. nesiotes*, and *I. rhothophilus*.

Support: Synapomorphies are given in Saeed *et al.* (2006).

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Iso hawaiiensis*.

Clade 238: Phallostethidae

Taxonomy: One out of ten families of Atheriniformes. Phallostethidae include four genera, *Neostethus*, *Phallostethus*, *Phenacostethus*, and *Gulaphallus*.

Support: Monophyly of Phallostethidae is strongly supported by the unique synapomorphic priapium of phallostethids (Parenti 1989). Additional synapomorphies are listed in Dyer & Chernoff (1996).

First occurrence: Recent.

Diversity: 21 extant species.

Sampled species: *Neostethus bicornis*.

Clade 239: Atherinidae

Taxonomy: One out of ten families of Atheriniformes. Atherinidae include three subfamilies, Atherinomorinae, Craterocephalinae, and Atherininae.

Support: Synapomorphies are given in Dyer & Chernoff (1996). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of Atherinomorinae and Craterocephalinae and supports their sister group relationship.

First occurrence: Recent.

Diversity: 60 extant species.

Sampled species: *Hypoatherina harringtonensis*.

Clade 240: Bedotiidae

Taxonomy: One out of ten families of Atheriniformes. Bedotiidae include two genera, *Bedotia* and *Rheocles*.

Support: Synapomorphies are given in Nelson (2006) for Bedotiinae. The molecular phylogenies of Sparks & Smith (2004b) and Bloom *et al.* (2012) include both bedotiid genera and strongly support their monophyly (BPP 1.0, JRV 100).

First occurrence: Recent.

Diversity: 13 extant species.

Sampled species: *Rheocles wrightae*.

Clade 241: Pseudomugilidae

Taxonomy: One out of ten families of Atheriniformes. Pseudomugilidae include three genera, *Kiunga*, *Pseudomugil*, and *Scaturiginichthys*.

Support: Synapomorphies are given in Nelson (2006). Monophyly of Pseudomugilidae has previously been challenged by the molecular phylogeny of Sparks & Smith (2004b), which supported inclusion of *Marosatherina*. However, the more extensive phylogeny of Betancur-R *et al.* (2013) includes the same representatives of Pseudomugilidae as the study of Sparks & Smith (2004b), as

well as *Marosatherina ladigesii*, and recovers Pseudomugilidae as monophyletic. Thus, we here assume monophyly of Pseudomugilidae. Our RAxML phylogeny includes two representatives of genus *Pseudomugil* and weakly supports their sister group relationship with BS 63.

First occurrence: Recent.

Diversity: 15 extant species.

Sampled species: *Pseudomugil tenellus* and *Pseudomugil signifer*.

Clade 242: Melanotaeniidae

Taxonomy: One out of ten families of Atheriniformes. Melanotaeniidae include eight genera.

Support: Synapomorphies are given in Nelson (2006). The phylogeny of Sparks & Smith (2004b), based on both morphological and molecular data, includes seven out of eight genera of Melanotaeniidae and supports their monophyly (JRV 77). Our RAxML phylogeny includes two representatives of genus *Melanotaenia* and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 68 extant species.

Sampled species: *Melanotaenia lacustris* and *Melanotaenia splendida*.

Clade 243: Telmatherinidae

Taxonomy: One out of ten families of Atheriniformes. Telmatherinidae include five genera, *Kalyptatherina*, *Marosatherina*, *Paratherina*, *Telmatherina*, and *Tominanga*.

Support: Synapomorphies are given in Nelson (2006) and Herder *et al.* (2006). According to Nelson (2006), “the monophyly and distinctiveness of this group are not in dispute”. Our RAxML phylogeny supports monophyly of Telmatherinidae with BS 93.

First occurrence: Recent.

Diversity: 19 extant species.

Sampled species: *Tominanga sanguicauda*, *Telmatherina celebensis*, *Telmatherina antoniae*, *Telmatherina sarasinorum*, and *Paratherina wolterecki*.

Clade 244: Adrianichthyoidei

Taxonomy: One out of two suborders of Beloniformes. Adrianichthyoidei include a single family, Adrianichthyidae, and two subfamilies, Adrianichthyinae and Oryziinae.

Support: Parenti (2008) lists 17 unambiguous synapomorphies that strongly support monophyly of Adrianichthyidae. Our RAxML phylogeny includes three representatives of genus *Oryzias* and supports their monophyly with BS 100.

First occurrence: †?*Lithopoecilus brouweri* de Beaufort, 1934, from the Gimpoe Basin, Sulawesi, Indonesia. †?*Lithopoecilus brouweri* is the oldest representative of Adrianichthyidae, and thus of Adrianichthyoidei, according to Patterson (1993b). Its age can only be constrained as “presumably Neogene” (Patterson 1993b). Thus, the first occurrence of Adrianichthyoidei likely dates to 23.03–2.588 Ma.

Diversity: 28 extant species.

Sampled species: *Oryzias celebensis*, *Oryzias latipes*, and *Oryzias javanicus*.

Clade 245: Exocoetoidei

Taxonomy: One out of two suborders of Beloniformes. Exocoetoidei include five families, Belontiidae, Exocoetidae, Hemiramphidae, Scomberesocidae, and Zenarchopteridae.

Support: Synapomorphies are given in Wiley & Johnson (2010). The molecular phylogeny of Betancur-R *et al.* (2013) includes representatives of all families of Exocoetoidei and strongly supports monophyly of Exocoetoidei (BS 100). Our RAxML phylogeny supports monophyly of Exocoetoidei with BS 100.

First occurrence: †*Rhamphexocoetus volans* Bannikov *et al.*, 1985, from Monte Bolca, Verona, Italy. †*Rhamphexocoetus volans* is considered to provide the earliest record of family Exocoetidae, and of Exocoetoidei (Patterson 1993b). Thus, the first occurrence of Exocoetoidei dates to 49.4–49.1 Ma.

Diversity: 199 extant species.

Sampled species: *Ablennes hians*, *Cololabis saira*, *Hyporhamphus sajori*, *Exocoetus volitans*, and *Cypselurus hiraii*.

Clade 246: Cyprinodontoidei

Taxonomy: One out of two suborders of Cyprinodontiformes. It includes seven families, Profundulidae, Goodeidae, Fundulidae, Valenciidae, Cyprinodontidae, Anablepidae, and Poeciliidae.

Support: Synapomorphies are given in Parenti (1981), Costa (1998), and Wiley & Johnson (2010). Our RAxML phylogeny supports monophyly of Cyprinodontoidei with BS 96.

First occurrence: “Poeciliidae *indet.*” from the Maíz Gordo Formation, Argentina, or †*Prolebias stenoura* Sauvage, 1874, from Corent, Puy-de-Dôme, France, and †*Francolebias aymardi* (Sauvage, 1869) from Haute-Loire, Ronzon, France, and †*Francolebias delphinensis* (Gaudant, 1989) from Montbrun-les-Bains, Drôme, France. Undescribed poeciliid fossils are apparently present in the Argentinian Lumbrera (Alano Perez *et al.* 2010) and Maíz Gordo Formations (Cione 1986). Both formations are part of the Santa Barbara Group. The Maíz Gordo Formation is older than the Lumbrera Formation (see clades 26 and 283) and is Thanetian in age. Without additional information about these fossils, their taxonomic assignment as poeciliids may be questioned, especially since Cione & Báez (2007) do not include poeciliids in their list of paleocene fishes from Argentina. According to López-Fernández & Albert (2011), the only confirmed fossils of poeciliids are from the Middle-Late Miocene Río Salí and San José Formations, Argentina. The Río Salí Formation is older than the San José Formation with an age around 14 Ma (Hernández *et al.* 2005). The European record of Cyprinodontidae extends to the Lower Oligocene, with †*Francolebias aymardi* from Haute-Loire, Ronzon, France and †*Francolebias delphinensis* from Puy-de-Dôme, Corent, France (Costa 2012b), and thus provides a minimum age of Cyprinodontoidei, if the Argentinian poeciliid records should have been misidentified. Thus, depending on the correct taxonomic assignment of “Poeciliidae *indet.*”, the first occurrence of Cyprinodontoidei dates to 57.4–55.8 Ma or to 33.9–28.4 Ma. Due to this wide uncertainty in the age of the oldest record of Cyprinodontoidei, Poeciliidae *indet.* and †*Francolebias* spp. are not used as an age constraint in our BEAST analysis.

Diversity: 523 extant species.

Sampled species: All sampled species of clades 247, 250, 251, 252, 253, 256, and 257.

Clade 247: Profundulidae+Goodeidae

Taxonomy: Combines two out of seven families of Cyprinodontoidae, Profundulidae and Goodeidae.

Support: The morphology-based phylogeny of Costa (1998), and the molecular phylogeny of Webb *et al.* (2004) support the sister group relationship between Profundulidae and Goodeidae. Our RAXML phylogeny supports monophyly of Profundulidae+Goodeidae with BS 96.

First occurrence: †*Tapatia occidentalis* Alvarez and Arriola-Longoria, 1972, from Santa Rosa, Jalisco, Mexico. †*Tapatia occidentalis* is considered to provide the earliest record of Goodeidae, and is reported to be Miocene in age (Patterson 1993b). No fossil record is known of Profundulidae. Thus, the first occurrence of Profundulidae+Goodeidae dates to 23.03-5.332 Ma. See clade 248 (Goodeidae).

Diversity: 44 extant species.

Sampled species: All sampled species of clades 248 and 249.

Clade 248: Goodeidae

Taxonomy: One out of seven families of Cyprinodontoidae. Goodeidae include 16 genera.

Support: Synapomorphies are given in Parenti (1981) and Nelson (2006). The molecular phylogeny of Webb *et al.* (2004) supports the monophyly of Goodeidae (BS 85).

First occurrence: †*Tapatia occidentalis* Alvarez and Arriola-Longoria, 1972, from Santa Rosa, Jalisco, Mexico. †*Tapatia occidentalis* is considered to provide the earliest record of Goodeidae, and is reported to be Miocene in age (Patterson 1993b). Thus, the first occurrence of Goodeidae dates to 23.03-5.332 Ma.

Diversity: 39 extant species.

Sampled species: *Xenotoca eiseni*.

Clade 249: Profundulidae

Taxonomy: One out of seven families of Cyprinodontoidae. Profundulidae include a single genus, *Profundulus*, and five species.

Support: Synapomorphies are given in Parenti (1981) and Nelson (2006).

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Profundulus labialis*.

Clade 250: Cyprinodontidae

Taxonomy: One out of seven families of Cyprinodontoidae. We here assume Cyprinodontidae to exclude the two freshwater genera *Orestias* and *Aphanius*, based on the molecular phylogeny of Hrbek & Meyer (2003). Thus, Cyprinodontidae includes six genera, *Cubanichthys*, *Cualac*, *Cyprinodon*, *Floridichthys*, *Jordanella*, and *Megupsilon*. Of these six genera, five are included in our molecular dataset.

Support: Synapomorphies are given in Nelson (2006), whereby these must be considered to have evolved independently in *Orestias* and *Aphanius*. The morphology-based phylogeny of Costa (2012a) includes representatives of *Floridichthys*, *Jordanella*, and *Cyprinodon*, and supports their monophyly (BS < 50). Our RAxML phylogeny supports monophyly of Cyprinodontidae excluding *Orestias* with BS 100.

First occurrence: Recent. Following Patterson (1993b), *Cyprinodon ?primulus* Cockerell, 1936, from the Maíz Gordo Formation is here treated as Cyprinodontiformes *incertae sedis* and excluded from Cyprinodontidae.

Diversity: 62 extant species.

Sampled species: *Floridichthys carpio*, *Jordanella floridae*, *Cualac tessellatus*, *Cyprinodon rubroflavialis*, and *Megupsilon aporus*.

Clade 251: Fundulidae

Taxonomy: One out of seven families of Cyprinodontoidae. Fundulidae include four genera, *Adinia*, *Fundulus*, *Leptolucania*, and *Lucania*.

Support: Synapomorphies are given in Parenti (1981) and in Parenti & Hartel (2011).

First occurrence: †*Fundulus lariversi* Lugaski, 1977, from the Siebert Tuff, Nevada, USA. †*Fundulus lariversi* is considered to provide the earliest record of Fundulidae, and is reported to be Langhian in age (Patterson 1993b). Thus, the first occurrence of Fundulidae dates to 15.97-13.82 Ma.

Diversity: 46 extant species.

Sampled species: *Fundulus grandis*.

Clade 252: Orestias

Taxonomy: One out of two cyprinodontoid genera that we consider without familial assignment (see clade 250). The genus *Orestias* includes 45 species.

Support: Synapomorphies are given in Parenti (1984). All published phylogenies to date that include more than one representative of *Orestias* support monophyly of the genus (Costa 2012a; see also Lüssen *et al.* 2003). Our RAxML phylogeny supports monophyly of *Orestias* with BS 100.

First occurrence: †*Carrionellus diumortuus* White, 1927, from Loja, Ecuador. †*Carrionellus diumortuus* is considered as the sister lineage of the extant genus *Orestias*, and is reported to be Lower Miocene in age (Costa 2012b). Thus, the first occurrence of *Orestias*, including stem lineages, dates to 11.608-5.332 Ma.

Diversity: 45 extant species.

Sampled species: *Orestias agassizii*, *Orestias imarpe*, *Orestias gilsoni*.

Clade 253: Aphanius+Valenciidae

Taxonomy: Combines the two Mediterranean groups of Cyprinodontoidae, the genus *Aphanius*, that we consider without familial assignment (see clade 250), and the family Valenciidae.

Support: No synapomorphies uniting *Aphanius* and Valenciidae are known. However, the biogeographic distribution supports a sister group relationship of the two groups, as these represent

the only non-American cyprinodontoid lineages, with the exception of two poeciliid groups. Our RAxML phylogeny supports monophyly of *Aphanius*+Valenciidae with BS 95.

First occurrence: †*Prolebias stenoura* Sauvage, 1874, from Corent, Puy-de-Dôme, France, and †*Francolebias aymardi* (Sauvage, 1869) from Haute-Loire, Ronzon, France, and †*Francolebias delphinensis* (Gaudant, 1989) from Montbrun-les-Bains, Drôme, France. According to the phylogenetic analysis of Costa (2012a), †*Prolebias stenoura*, †*Francolebias aymardi*, and †*Francolebias delphinensis* form a monophyletic clade with Valenciidae. The earliest record of all three species is from the Lower Oligocene Costa (2012a). Thus, the first occurrence of *Aphanius*+Valenciidae dates to 33.9-28.4 Ma. See clade 255 (Valenciidae).

Diversity: 37 extant species.

Sampled species: All sampled species of clades 254 and 255.

Clade 254: *Aphanius*

Taxonomy: One out of two genera of Cyprinodontoidei that we consider without familial assignment (see clade 246). The genus *Aphanius* includes 35 species (Froese & Pauly 2015).

Support: Synapomorphies are given in Parenti (1984). The molecular phylogeny of Hrbek & Meyer (2003) includes 12 out of 30 species of genus *Aphanius*, and strongly supports their monophyly (BS 100).

First occurrence: *Aphanius* spp. Gaudant, 1979-2011, from Lower Miocene deposits, Western Europe and Middle East. According to Costa (2012a), abundant fossil material has been assigned to genus *Aphanius*, and at least some of these fossils are reported to be Lower Miocene in age. Thus, the first occurrence of *Aphanius* dates to 23.03-15.97 Ma.

Diversity: 35 extant species.

Sampled species: *Aphanius anatoliae*.

Clade 255: Valenciidae

Taxonomy: One out of seven families of Cyprinodontoidei. Valenciidae include a single genus, *Valencia*, and two species, *V. hispanica* and *V. letourneuxi*.

Support: Synapomorphies are given in Parenti (1981) and Nelson (2006). The molecular phylogeny of Hrbek & Meyer (2003) includes both *V. hispanica* and *V. letourneuxi*, and strongly supports their sister group relationship (BS 100).

First occurrence: †*Prolebias stenoura* Sauvage, 1874, from Corent, Puy-de-Dôme, France, and †*Francolebias aymardi* (Sauvage, 1869) from Haute-Loire, Ronzon, France, and †*Francolebias delphinensis* (Gaudant, 1989) from Montbrun-les-Bains, Drôme, France. See clade 253 (*Aphanius*+Valenciidae). Thus, the first occurrence of Valenciidae dates to 33.9-28.4 Ma.

Diversity: 2 extant species.

Sampled species: *Valencia hispanica*.

Clade 256: Anablepidae

Taxonomy: One out of seven families of Cyprinodontoidei. Anablepidae include two subfamilies, Anablepinae and Oxyzygonectinae.

Support: Synapomorphies are given in Parenti (1981). The molecular phylogeny of Hrbek & Meyer (2003) includes representatives of both subfamilies and strongly supports their monophyly (BS 98). Our RAxML phylogeny also includes representatives of Anablepinae and Oxyzygonectinae and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 15 extant species.

Sampled species: *Jenynsia maculata* and *Oxyzygonectes dovii*.

Clade 257: Poeciliidae

Taxonomy: One out of seven families of Cyprinodontoidae. Poeciliidae include three subfamilies, Aplocheilichthyinae, Procatopodinae, and Poeciliinae (Ghedotti 2000; Nelson 2006).

Support: Synapomorphies are given in Parenti (1981). The morphology-based phylogenies of Ghedotti (2000) and Costa (2012a) support monophyly of Poeciliidae with two unique and unreversed synapomorphies (Ghedotti 2000). Our RAxML phylogeny includes representatives of two genera of Poeciliinae and supports their monophyly with BS 100.

First occurrence: “Poeciliidae *indet.*” from the Maíz Gordo Formation, Argentina, or *Pantanodon* †*cephalotes* (Agassiz, 1939) from d’Aix-en-Provence, France. See clade 246 (Cyprinodontoidae) regarding the questionable taxonomic assignment of “Poeciliidae *indet.*”. According to the phylogenetic analysis of Costa (2012a), *Pantanodon* †*cephalotes* and *Pantanodon* †*egeranus* form a monophyletic group with the extant *Pantanodon stuhlmanni*, nested within Poeciliidae. *Pantanodon* †*cephalotes* is older than *Pantanodon* †*egeranus* and appears in the Upper Oligocene. Thus, depending on the correct taxonomic assignment of “Poeciliidae *indet.*”, the first occurrence of Cyprinodontoidae dates to 57.4–55.8 Ma or to 28.4–23.03 Ma. Due to this wide uncertainty in the age of the oldest record of Poeciliidae, “Poeciliidae *indet.*” and *Pantanodon* †*cephalotes* are not used as an age constraint in our BEAST analysis.

Diversity: 304 extant species.

Sampled species: *Gambusia affinis*, *Xiphophorus maculatus*, and *Xiphophorus hellerii*.

Clade 258: Aplocheiloidei

Taxonomy: One out of two cyprinodontiform suborders. Aplocheiloidei include three families, Aplocheilidae, Nothobranchiidae, and Rivulidae.

Support: A large number of synapomorphies are given in Parenti (1981) and Wiley & Johnson (2010), and the morphology-based phylogeny of Hertwig (2008) strongly supports monophyly of Aplocheiloidei (BS 99). Our RAxML phylogeny supports monophyly of Aplocheiloidei with BS 94.

First occurrence: †*Kenyaichthys kipkechi* from the Lukeino Formation, Tugen Hills, Kenya. Fossils from the Lukeino Formation have been considered to provide the earliest record of Aplocheiloidei (Altner & Reichenbacher 2015). The Lukeino Formation is reported to be 6.0–5.7 Ma (Sawada *et al.* 2002).

Diversity: 661 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 259, 260, 261, 262, and 263.

Clade 259: Rivulidae

Taxonomy: One out of three families of the cyprinodontiform suborder Aplocheiloidei. Rivulidae include 36 genera.

Support: Synapomorphies are given in Parenti (1981) and Nelson (2006). The molecular and morphology-based phylogenies of Murphy *et al.* (1999) and Hertwig (2008) strongly support monophyly of Rivulidae. Our RAxML phylogeny supports monophyly of Rivulidae with BS 99.

First occurrence: Recent.

Diversity: 385 extant species (Froese & Pauly 2015).

Sampled species: *Notholebias minimus*, *Campellolebias dorsimaculatus*, *Nematolebias whitei*, *Kryptolebias caudomarginatus*, *Kryptolebias ocellatus*, *Kryptolebias marmoratus*, *Laimosemion recticaudatus*, *Laimosemion lyricauda*, *Laimosemion frenatus*, *Laimosemion agillae*, *Laimosemion geayi*, *Rivulus cylindraceus*, *Rivulus roloffi*, *Plesiolebias aruana*, *Papiliolebias bitteri*, *Pituna poranga*, *Maratecoara lacortei*, *Atlantirivulus santensis*, *Cynodonichthys uroflammeus*, *Cynodonichthys magdalenae*, *Cynodonichthys tenuis*, *Cynodonichthys weberi*, *Melanorivulus punctatus*, *Anablepsoides jucundus*, *Anablepsoides hartii*, *Anablepsoides deltaphilus*, *Moema staecki*, *Aphyolebias peruensis*, *Trigonectes balzanii*, *Moema piriana*, *Renova oscari*, *Pterolebias phasianus*, *Pterolebias longipinnis*, *Micromoema xiphophora*, *Rachovia maculipinnis*, *Austrofundulus transilis*, *Terranatos dolichopterus*, *Llanolebias stellifer*, *Gnatholebias zonatus*, *Austrolebias bellottii**, *Austrolebias viarius**, *Campellolebias chrysolineatus**, *Cynolebias* sp., *Cynopoecilus melanotaenia**, *Hypsolebias guanambi**, *Lepotolebias aureoguttatus**, *Ophthalmolebias ilheusensis**, *Plesiolebias glaucopterus**, *Hypsolebias antenori**, and *Simpsonichthys costai**.

*Excluded from sequence selection for BEAST analyses to save computation time.

Clade 260: Pachypanchax

Taxonomy: One out of two genera of the aplocheiloid family Aplocheilidae. The genus *Pachypanchax* includes seven species (Loiselle 2006).

Support: Morphological characteristics supporting the monophyly of *Pachypanchax* are given in Loiselle (2006). Our RAxML phylogeny includes two representatives of the genus and supports monophyly of *Pachypanchax* with BS 99.

First occurrence: Recent.

Diversity: 7 extant species (Froese & Pauly 2015).

Sampled species: *Pachypanchax playfairii* and *Pachypanchax omalonotus*.

Clade 261: Aplocheilus

Taxonomy: One out of two genera of the aplocheiloid family Aplocheilidae. The genus *Aplocheilus* includes seven species (Froese & Pauly 2015).

Support: Morphological characteristics described in Hertwig (2008) support the monophyly of *Aplocheilus*. The molecular phylogeny of Murphy & Collier (1998), as well as our RAxML phylogeny include two out of seven species of genus *Aplocheilus* and support their monophyly with BS 99.

First occurrence: Recent.

Diversity: 7 extant species (Froese & Pauly 2015).

Sampled species: *Aplocheilus panchax* and *Aplocheilus lineatus*.

Clade 262: Epiplatyinae

Taxonomy: Following Stiassny *et al.* (2007), we here recognize Epiplatyinae as one out of two subfamilies of Nothobranchiidae. As defined by Stiassny *et al.* (2007), Epiplatyinae combines the four genera *Epiplatys*, *Scriptaphyosemion*, *Callopanchax*, and *Archiaphyosemion*. Based on molecular data, Sonnenberg & Busch (2009) found *Archiaphyosemion* to be paraphyletic, and described a new genus, *Nimbapanchax*, for all species previously included in *Archiaphyosemion*, except the type species, *A. guineense*. Thus, Epiplatyinae include *Epiplatys*, *Scriptaphyosemion*, *Callopanchax*, *Archiaphyosemion*, and *Nimbapanchax*.

Support: Synapomorphies are given in Stiassny *et al.* (2007). The molecular phylogenies of Murphy & Collier (1998; BS 98) and Sonnenberg & Busch (2009) strongly support the monophyly of the subfamily. Epiplatyinae share a biogeographic distribution in Western Africa (Murphy & Collier 1998). Our RAxML phylogeny supports monophyly of Epiplatyinae with BS 100.

First occurrence: Recent.

Diversity: 55 extant species (Froese & Pauly 2015).

Sampled species: *Nimbapanchax leucopterygius*, *Nimbapanchax petersi*, *Archiaphyosemion guineense*, *Epiplatys roloffi*, *Epiplatys multifasciatus*, *Epiplatys sexfasciatus*, *Epiplatys chaperi*, *Callopanchax toddi*, *Callopanchax occidentalis*, *Callopanchax huwaldi*, *Scriptaphyosemion banforense*, *Scriptaphyosemion guignardi*, *Scriptaphyosemion geryi*, *Scriptaphyosemion roloffi*, *Scriptaphyosemion schmitti*, and *Scriptaphyosemion liberiense*.

Clade 263: Nothobranchiinae

Taxonomy: One out of two subfamilies of Nothobranchiidae (Stiassny *et al.* 2007), see clade 262 (Epiplatyinae). Nothobranchiinae combines the genera *Aphyosemion*, *Fenerbahce*, *Foerschichthys*, *Fundulopanchax*, *Nothobranchius*, and *Pronothobranchius*.

Support: Synapomorphies are given in Stiassny *et al.* (2007). The molecular phylogeny of Murphy & Collier (1998) strongly supports the monophyly of Nothobranchiinae. Species of subfamily Nothobranchiinae are predominantly found in Eastern Africa (Murphy & Collier 1998). Our RAxML phylogeny supports monophyly of Nothobranchiinae with BS 98.

First occurrence: Recent.

Diversity: 207 extant species (Froese & Pauly 2015).

Sampled species: *Aphyosemion cyanostictum*, *Aphyosemion louessense*, *Aphyosemion bualanum*, *Aphyosemion gabunense*, *Fenerbahce formosus*, *Nothobranchius thierryi*, *Pronothobranchius kiyawensis*, *Nothobranchius kuhntae*, *Nothobranchius furzeri*, *Nothobranchius kirki*, *Nothobranchius kafuensis*, *Fundulopanchax deltaensis*, *Fundulopanchax amieti*, *Fundulopanchax oeseri*, *Fundulopanchax scheeli*, *Fundulopanchax sjostedti*, *Fundulopanchax gardneri*, *Fundulopanchax mirabilis*, *Aphyosemion bivittatum*, *Aphyosemion calliurum*, *Aphyosemion australe*, *Foerschichthys flavipinnis*, *Aphyosemion exigoideum*, *Aphyosemion coeleste*, *Aphyosemion ocellatum*, *Aphyosemion wildekampi*, *Aphyosemion labarrei*, *Aphyosemion mimbon*, *Aphyosemion congium*, *Aphyosemion cognatum*, *Aphyosemion el-*

egans, *Aphyosemion christyi*, and *Aphyosemion rectogoense*.

Clade 264: Polycentridae

Taxonomy: One out of seven families that are considered *incertae sedis* in Ovalentariae. Polycentridae include four genera, *Afronandus*, *Polycentropsis*, *Monocirrhus*, and *Polycentrus*.

Support: Synapomorphies are given in Nelson (2006). The molecular phylogeny of Betancur-R *et al.* (2013) includes two out of four genera of Polycentridae, and strongly supports monophyly of Polycentridae (BS 100).

First occurrence: Recent.

Diversity: 4 extant species.

Sampled species: *Polycentropsis* sp.

Clade 265: Pholidichthyiformes

Taxonomy: One out of two orders of Cichlomorphae. Pholidichthyiformes include a single family, Pholidichthyidae, a single genus, *Pholidichthys*, and two species, *P. leucotaenia* and *P. anguis*.

Support: Synapomorphies are given in Springer & Larson (1996) and Wiley & Johnson (2010).

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: *Pholidichthys leucotaenia*.

Clade 266: Cichliformes

Taxonomy: One out of two orders of Cichlomorphae. Cichliformes include a single family, Cichlidae, and four subfamilies, Etroplinae, Ptychochrominae, Cichlinae, and Pseudocrenilabrinae.

Support: Monophyly of the family Cichlidae is strongly supported by morphological synapomorphies given in Stiassny (1980), Zihler (1981), Kaufman & Liem (1982), and Kullander (1998) (also see Takahashi & Nakaya 2002). Moreover, a large number of molecular phylogenies strongly supports monophyly of Cichlidae (e.g. Mabuchi *et al.* 2007, Azuma *et al.* 2008, Wainwright *et al.* 2012, Betancur-R *et al.* 2013).

First occurrence: †*Mahengechromis* spp. Murray, 2000 from Mahenge, Singida, Tanzania. See clades 283 (Cichlinae) and 384 (Hemichromini) for a discussion of the age of †*Gymnogeophagus eocenicus*, †*Plesioheros chauliodus*, and †*Mahengechromis* spp. The first occurrence of Cichliformes dates to 46.0-45.0 Ma.

Diversity: 2677 extant species.

Sampled species: All sampled species of clades 267 and 278.

Clade 267: Etroplinae

Taxonomy: One out of four subfamilies of Cichlidae (Sparks & Smith 2004a). Etroplinae include two genera, *Etroplus* and *Paretroplus*.

Support: Numerous synapomorphies are given in Sparks (2008). The molecular phylogeny of Sparks & Smith (2004a) includes nearly all species of both *Etroplus* and *Paretroplus* and strongly supports their monophyly (JRV 100). Further support for a sister group relationship of the two

genera is provided by the molecular phylogeny of Wainwright *et al.* (2012; BS 100). Our RAxML phylogeny also supports monophyly of Etroplinae with BS 100.

First occurrence: Recent.

Diversity: 16 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 268 and 273.

Clade 268: *Etroplus*

Taxonomy: One out of two genera of Etroplinae (Sparks & Smith 2004a). The genus *Etroplus* includes three species, *E. maculatus*, *E. suratensis*, and *E. canarensis*.

Support: Synapomorphies are given in Sparks (2008). The molecular phylogeny of Sparks & Smith (2004a) includes all species of genus *Etroplus* and strongly supports their monophyly (JRV 100). In addition, the three species of *Etroplus* are the only cichlids occurring on the Indian subcontinent, which supports their close relationship. Our RAxML phylogeny supports monophyly of *Etroplus* with BS 100.

First occurrence: Recent.

Diversity: 3 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 269 and 270.

Clade 269: *Etroplus maculatus*

Taxonomy: One out of three species of *Etroplus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Etroplus maculatus*.

Clade 270: *Etroplus suratensis*+*Etroplus canarensis*

Taxonomy: Combines two out of three species of *Etroplus*.

Support: Synapomorphies are given in Sparks (2008). The molecular phylogeny of Sparks & Smith (2004a) strongly supports a sister group relationship of *Etroplus suratensis* and *Etroplus canarensis*. Our RAxML phylogeny includes both *E. suratensis* and *E. canarensis* and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 2 extant species.

Sampled species: All sampled species of clades 290 and 291.

Clade 271: *Etroplus suratensis*

Taxonomy: One out of three species of *Etroplus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Etroplus suratensis*.

Clade 272: *Etroplus canarensis*

Taxonomy: One out of three species of *Etroplus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Etroplus canarensis*.

Clade 273: *Paretroplus*

Taxonomy: One out of two genera of the cichlid subfamily Etroplinae (Sparks & Smith 2004a). The genus *Paretroplus* includes 13 species.

Support: Synapomorphies are given in Sparks (2008). The phylogeny of Sparks (2008), based on morphological and molecular data, includes twelve out of 13 species of genus *Paretroplus* and strongly supports their monophyly (JRV 100). Our RAxML phylogeny supports monophyly of *Paretroplus* with BS 100.

First occurrence: Recent.

Diversity: 13 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 274, 275, 276, and 277.

Clade 274: “*Paretroplus damii* clade”

Taxonomy: Following Sparks (2008) and Sparks & Schelly (2011), we recognize a “*Paretroplus damii* clade” within the cichlid genus *Paretroplus*, which is composed of *P. damii*, *P. lamnabe*, *P. nourissati*, *P. tsimoly*, and *P. loisellei*.

Support: Synapomorphies are given in Sparks (2008) and Sparks & Schelly (2011). The phylogeny of Sparks (2008), based on morphological and molecular data, includes four out of five species of the “*Paretroplus damii* clade”, and strongly supports their monophyly (JRV 100). Our RAxML phylogeny includes two species of this clade and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 5 extant species (Sparks & Schelly 2011).

Sampled species: *Paretroplus nourissati* and *Paretroplus tsimoly*.

Clade 275: *Paretroplus polyactis*

Taxonomy: One out of 13 species of *Paretroplus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Paretroplus polyactis*.

Clade 276: “*Paretroplus kieneri* complex”

Taxonomy: Following Sparks (2008), we recognize a “*Paretroplus kieneri* complex”, that combines

two species of the cichlid genus *Paretroplus*, *P. gymnopreopercularis* and *P. kieneri*.

Support: Synapomorphies are given in Sparks (2008). The phylogeny of Sparks (2008), based on morphological and molecular data, includes both species of the “*Paretroplus kieneri* complex”, and strongly supports their monophyly (JRV 99).

First occurrence: Recent.

Diversity: 2 extant species (Sparks 2008).

Sampled species: *Paretroplus kieneri*.

Clade 277: “Deep-bodied western *Paretroplus*”

Taxonomy: Following Sparks (2008), we recognize the “Deep-bodied western *Paretroplus*”, which includes five species, *P. maculatus*, *P. dambabe*, *P. petit*, *P. menarambo*, and *P. maromandia*.

Support: Synapomorphies are given in Sparks (2008). The phylogeny of Sparks (2008), based on morphological and molecular data, includes all five species of the “Deep-bodied western *Paretroplus*”, and supports their monophyly (JRV 87). Our RAxML phylogeny supports monophyly of “Deep-bodied western *Paretroplus*” with BS 99.

First occurrence: Recent.

Diversity: 5 extant species (Sparks 2008).

Sampled species: *Paretroplus maculatus*, *Paretroplus dambabe*, *Paretroplus menarambo*, and *Paretroplus maromandia*.

Clade 278: Pseudocrenilabrinae+allies

Taxonomy: Combines three subfamilies of Cichlidae, Pseudocrenilabrinae, Cichlinae, and Ptychochrominae. Thus Pseudocrenilabrinae+allies includes all cichlid species except those of subfamily Etroplinae.

Support: No synapomorphies are known to unite Pseudocrenilabrinae+allies. However, the molecular phylogenies of Sparks & Smith (2004a; JRV 68), Azuma *et al.* (2008; BPP 1.0), Wainwright *et al.* (2012; BS 100), and Wagner *et al.* (2012; BS 87) strongly support the monophyly of Pseudocrenilabrinae+allies, as defined here. Our RAxML phylogeny supports monophyly of Pseudocrenilabrinae+allies with BS 93.

First occurrence: †*Mahengechromis* spp. Murray, 2000, from Mahenge, Singida, Tanzania. The first occurrence age of Pseudocrenilabrinae+allies dates to 46.0-45.0 Ma. See clades 283 (Cichlinae) and 384 (Hemichromini) for a discussion of the age of *Gymnogeophagus* †*ecenicus*, †*Plesioheros chauliodus*, and †*Mahengechromis* spp.

Diversity: 2661 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 279, and 282.

Clade 279: Ptychochrominae

Taxonomy: One out of four subfamilies of Cichlidae (Sparks & Smith 2004a). Ptychochrominae includes five genera: *Paratilapia*, *Ptychochromoides*, *Oxylapia*, *Katria*, and *Ptychochromis*.

Support: Synapomorphies are given in Sparks (2008). The molecular phylogeny of Sparks & Smith (2004a) includes four out of five genera of subfamily Ptychochrominae and strongly supports their

monophyly (JRV 100). Our RAxML phylogeny supports monophyly of Ptychochrominae with BS 100.

First occurrence: Recent.

Diversity: 16 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 280 and 281.

Clade 280: *Paratilapia*

Taxonomy: One out of five genera of the cichlid subfamily Ptychochrominae. *Paratilapia* includes two valid species, *P. pollenia* and *P. toddi*.

Support: Synapomorphies are given in Sparks (2008). The phylogenies of Sparks & Smith (2004a; JRV 100) and Sparks (2008; JRV 99), based on both morphological and molecular data, strongly support monophyly of genus *Paratilapia*.

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: *Paratilapia polleni*.

Clade 281: *Ptychochromis*+allies

Taxonomy: Combines four out of five genera of the cichlid subfamily Ptychochrominae, *Ptychochromoides*, *Oxylapia*, *Katria*, and *Ptychochromis*.

Support: Synapomorphies are given in Sparks (2008). The phylogenies of Sparks & Smith (2004a; JRV 97) and Sparks (2008; JRV 100), based on both morphological and molecular data, strongly support monophyly of *Ptychochromis*+allies, as it is defined here. Our RAxML phylogeny supports monophyly of *Ptychochromis*+allies with BS 100.

First occurrence: Recent.

Diversity: 14 extant species (Froese & Pauly 2015).

Sampled species: *Oxylapia polli*, *Ptychochromis grandidieri*, *Ptychochromis* sp. “Garaka”, *Ptychochromis oligacanthus*, *Katria katria*, *Ptychochromoides betsileanus*, and *Ptychochromoides vondrozo*.

Clade 282: Pseudocrenilabrinae+Cichlinae

Taxonomy: Combines two out of four subfamilies of Cichlidae, Pseudocrenilabrinae (all African cichlids, including lineages of the Middle East) and Cichlinae (all neotropical cichlids).

Support: Synapomorphies are given in Sparks (2008). The phylogenies of Farias *et al.* (2000), Sparks & Smith (2004a), Azuma *et al.* (2008), and Betancur-R *et al.* (2013), based on both morphological and molecular data, strongly support monophyly of a clade combining Pseudocrenilabrinae and Cichlinae (BS 100, BPP 1.0, JRV 97). Our RAxML phylogeny supports monophyly of Pseudocrenilabrinae+Cichlinae with BS 93.

First occurrence: †*Mahengechromis* spp. Murray, 2000, from Mahenge, Singida, Tanzania. The first occurrence of Pseudocrenilabrinae+Cichlinae dates to 46.0-45.0 Ma. See clades 283 (Cichlinae) and 384 (Hemichromini) for a discussion of the age of *Gymnogeophagus* †*eoenicus*, †*Plesioheros chauliodus*, and †*Mahengechromis* spp.

Diversity: 2643 extant species.

Sampled species: All sampled species of clades 283, 373, 374, 375, 383, 384, 385, 386, 387, 388, 389, 390, 391, 392, 393, 394, 395, 396, 397, 398, 399, 402, and 403.

Clade 283: Cichlinae

Taxonomy: One out of four subfamilies of Cichlidae (Sparks & Smith 2004a). Combines all neotropical cichlid fishes. Cichlinae include seven tribes (López-Fernández *et al.* 2010) and 56 genera (Froese & Pauly 2015).

Support: The molecular phylogenies of Sparks & Smith (2004a), López-Fernández *et al.* (2010), and Wainwright *et al.* (2012) strongly support monophyly of Cichlinae (BS 100, BPP 1.0, JRV 100). The biogeographic distribution of Cichlinae, occurring exclusively in the Neotropics, further supports monophyly of the subfamily. Our RAxML phylogeny supports monophyly of Cichlinae with BS 98.

First occurrence: *Gymnogeophagus* †*ecenicus* Malabarba, Malabarba, and del Papa, 2010, †*Plesioheros chauliodus* Alano Perez, Malabarba, and del Papa, 2010, and †*Proterocara argentina* Malabarba, Zuleta, and del Papa, 2006 from the Lumbrera Formation, Salta Province, Argentina. Cichlid fossils from the Lumbrera Formation have been associated with the Ypresian-Lutetian boundary, and the age of this boundary (48.6 Ma) has often been used to represent the age of these fossils without error (Alano Perez *et al.* 2010; Malabarba *et al.* 2010, 2014). However, this precise age is questionable for several reasons: First, according to the latest version of the International Chronostratigraphic Chart (International Commission on Stratigraphy; www.stratigraphy.org/index.php/ics-chart-timescale), the Ypresian-Lutetian boundary is no longer considered to be 48.6 Ma, but is now estimated at 47.8 Ma. Second, the association of the fossiliferous “Faja Verde” layers of the Lumbrera Formation with the Ypresian-Lutetian boundary remains vague (Benton *et al.* 2015). The Lumbrera Formation has traditionally been assigned to the Casamayoran South American Land Mammal Age (SALMA), based on the evolutionary grade of fossil mammals (del Papa *et al.* 2010), and it has been argued that the Lumbrera Formation could be as young as Mustersan (Deraco *et al.* 2008). The upper Lumbrera Formation has been dated directly using U/Pb zircon determination, resulting in an estimate of 39.9 Ma, that serves as a minimum age estimate, given that the fossiliferous “Faja Verde” layer lies below the dated tuff layer (del Papa *et al.* 2010). To support the putative close association of the “Faja Verde” layer with the Ypresian-Lutetian, Malabarba *et al.* (2014) cite “paleoclimatic inferences based on the study of alluvial paleosol horizons in the Lumbrera Formation, where a stratigraphic fluvial section correlative to the Faja Verde Lake has been preliminarily assigned to the Early Eocene Climatic Optimum (EECO; White *et al.* 2009)”. The reference given, “White *et al.* (2009)”, is a conference abstract, for a study with the title “Paleosol-based paleoclimate reconstruction of Late Paleocene through Middle Eocene Argentina”. While a study with this or a similar title has not been published since, del Papa (who is one of the authors of White *et al.* 2009) has published a study based on paleosol evidence in the following year (del Papa *et al.* 2010), in which the age of the Lumbrera Formation is discussed at length and considered to be Casamayoran in age, in agreement with earlier studies (Carbajal *et al.* 1977; Pascual 1980b,a; Pascual *et al.* 1981; Vucetich & Bond 1982; Bond & Vucetich 1983). An absolute

dating of SALMA stages (Vucetich *et al.* 2007) indicates a Mid Lutetian to Bartonian age of the Casamayoran, defined by polarities C20-C18. This is equivalent to 45.4-38.0 Ma. Given the absolute U/Pb zircon determination, this range can be reduced to 45.4-39.9 Ma. The morphology-based phylogenies of Alano Perez *et al.* (2010), Malabarba *et al.* (2010), and Smith *et al.* (2008) support placement of *Gymnogeophagus* †*eocenicus* in the Recent genus *Gymnogeophagus*, a position of †*Plesioheros chauliodus* among Recent Heroini, and a clade combining †*Proterocara argentina* with the Recent genera *Teleocichla* and *Crenicichla* within Geophagini. See clades 301 (*Gymnogeophagus*), 330 (Heroini), and 315 (*Teleocichla*+*Crenicichla*).

Diversity: 538 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 284 and 287.

Clade 284: Retroculini+Cichlini

Taxonomy: Combines two out of seven tribes of the cichlid subfamily Cichlinae, Retroculini and Cichlini.

Support: No synapomorphies are known to unite Retroculini and Cichlini, however, the phylogenies of López-Fernández *et al.* (2005) (BS 91) and López-Fernández *et al.* (2010) (BS 97, BPP 1.0), based on both morphological and molecular data, strongly support a sister group relationship of the two tribes. Our RAxML phylogeny supports monophyly of Retroculini+Cichlini with BS 98.

First occurrence: †*Palaeocichla longirostrum* (Bardack, 1961) from the La Yesera Creek, Salta Province, Argentina. The first occurrence of Retroculini+Cichlini dates to 23.03-5.332 Ma. See clade 286 (Cichlini).

Diversity: 18 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 285 and 286.

Clade 285: Retroculini

Taxonomy: One out of seven tribes of Cichlinae. Retroculini include a single genus, *Retroculus*, and three species.

Support: Synapomorphies are given in Smith *et al.* (2008). Our RAxML phylogeny includes two representatives of *Retroculus* and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 3 extant species (Froese & Pauly 2015).

Sampled species: *Retroculus lapidifer* and *Retroculus xinguensis*.

Clade 286: Cichlini

Taxonomy: One out of seven tribes of Cichlinae. Cichlini include a single genus, *Cichla*, and 15 species.

Support: Synapomorphies are given in Smith *et al.* (2008). Our RAxML phylogeny supports monophyly of Cichlini with BS 100.

First occurrence: †*Palaeocichla longirostrum* (Bardack, 1961) from the La Yesera Creek, Salta Province, Argentina. †*Palaeocichla longirostrum* was originally described as †*Acaronia longirostratum* (Bardack 1961). Unfortunately, the type specimen of †*Palaeocichla longirostrum* was lost, but

based on new specimens, Casciotta & Arratia (1993) were able to redescribe the species, place it in a new genus, *Palaeocichla*, and establish a sister group relationship between *Palaeocichla* and *Cichla* (Malabarba *et al.* 2006). As reported by Bardack (1961), fish fossils of the La Yesera Creek Formation occur in the “Terciario Subandino” stratigraphic unit, which was assumed to be Miocene or Pliocene at the time, and is considered Miocene by Murray (2001a) and Alano Perez *et al.* (2010). Thus, the first occurrence of Cichlini dates to 23.03-5.332 Ma.

Diversity: 15 extant species (Froese & Pauly 2015).

Sampled species: *Cichla temensis*, *Cichla intermedia*, *Cichla orinocensis*, *Cichla ocellaris*, and *Cichla monoculus*.

Clade 287: Heroini+allies

Taxonomy: Combines five out of seven tribes of the cichlid subfamily Cichlinae, Astronotini, Chaetobranchini, Heroini, Geophagini, and Cichlasomatini (López-Fernández *et al.* 2010).

Support: No synapomorphies are known to unite Astronotini, Chaetobranchini, Heroini, Geophagini, and Cichlasomatini. Molecular phylogenies, however, support the monophyly of Heroini+allies, as defined here (López-Fernández *et al.* 2010; BS 80, BPP 0.96). Our RAxML phylogeny supports monophyly of Heroini+allies with BS 98.

First occurrence: *Gymnogeophagus †eocenicus* Malabarba, Malabarba, and del Papa, 2010, *†Plesioheros chauliodus* Alano Perez, Malabarba, and del Papa, 2010, and *†Proterocara argentina* Malabarba, Zuleta, and del Papa, 2006, from the Lumbreira Formation, Salta Province, Argentina. The first occurrence of Heroini+allies dates to 45.4-39.9 Ma. See clades 283 (Cichlinae), 301 (*Gymnogeophagus*), 330 (Heroini), and 315 (*Teleocichla*+*Crenicichla*).

Diversity: 520 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 288, 289, 292, and 316.

Clade 288: Astronotini

Taxonomy: One out of seven tribes of Cichlinae. Astronotini include a single genus, *Astronotus*, and two valid species, *A. crassipinnis* and *A. ocellatus*.

Support: Synapomorphies are given in Smith *et al.* (2008).

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: *Astronotus ocellatus*.

Clade 289: Chaetobranchini

Taxonomy: One out of seven tribes of Cichlinae. Chaetobranchini include two genera, *Chaetobranchopsis* and *Chaetobranchius*.

Support: Morphological characteristics described in Regan (1906) and Smith *et al.* (2008). The molecular phylogeny of López-Fernández *et al.* (2010) strongly supports monophyly of Chaetobranchini (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Chaetobranchini with BS 100.

First occurrence: Recent.

Diversity: 4 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 290 and 291.

Clade 290: *Chaetobranchopsis*

Taxonomy: One out of two genera of Chaetobranchini. The genus *Chaetobranchopsis* includes two species, *C. bitaeniatus* and *C. australis* (Froese & Pauly 2015).

Support: Morphological characteristics described in Regan (1906).

First occurrence: Recent.

Diversity: 2 extant species Froese & Pauly (2015).

Sampled species: *Chaetobranchopsis bitaeniatus*.

Clade 291: *Chaetobranchus*

Taxonomy: One out of two genera of Chaetobranchini. The genus *Chaetobranchus* includes two species, *C. flavescens* and *C. semifasciatus* Froese & Pauly (2015).

Support: Morphological characteristics described in Regan (1906) support the monophyly of the genus.

First occurrence: Recent.

Diversity: 2 extant species Froese & Pauly (2015).

Sampled species: *Chaetobranchus flavescens*.

Clade 292: Geophagini

Taxonomy: One out of seven tribes of Cichlinae. Geophagini include 16 genera.

Support: Morphological characteristics given in Smith *et al.* (2008) support the monophyly of Geophagini. The molecular phylogeny of López-Fernández *et al.* (2010) includes all 16 genera of Geophagini and strongly supports their monophyly (BS 99, BPP 1.0). Our RAxML phylogeny supports monophyly of Geophagini with BS 98.

First occurrence: *Gymnogeophagus* †*eocenicus* Malabarba, Malabarba, and del Papa, 2010, and †*Proterocara argentina* Malabarba, Zuleta, and del Papa, 2006 from the Lumbrera Formation, Salta Province, Argentina. The first occurrence of Geophagini dates to 45.4-39.9 Ma. See clades 283 (Cichlinae), 301 (*Gymnogeophagus*), and 315 (*Teleocichla*+*Crenicichla*).

Diversity: 256 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 293, 294, 297, 298, 301, 302, 305, 310, 311, 312, 313, 314, and 315.

Clade 293: *Crenicara*

Taxonomy: One out of 16 genera of Geophagini. The genus *Crenicara* includes two species, *C. punctulatum* and *C. latruncularium* (Froese & Pauly 2015).

Support: Morphological characteristics given in Reis *et al.* (2003) support the monophyly of the genus.

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: *Crenicara punctulatum*.

Clade 294: *Biotodoma*

Taxonomy: One out of 16 genera of Geophagini. The genus *Biotodoma* includes two species, *B. cupido* and *B. wavrini* (Froese & Pauly 2015).

Support: Morphological characteristics given in Reis *et al.* (2003) support the monophyly of the genus. The phylogenies of López-Fernández *et al.* (2005; BS 68) and López-Fernández *et al.* (2010; BS 100, BPP 1.0), based on morphological and molecular data, further support monophyly of *Biotodoma*. Our RAxML phylogeny includes both representatives of genus *Biotodoma* and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 295 and 296.

Clade 295: *Biotodoma cupido*

Taxonomy: One out of two species of *Biotodoma*.

Support: This clade includes a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Biotodoma cupido*.

Clade 296: *Biotodoma wavrini*

Taxonomy: One out of two species of *Biotodoma*.

Support: This clade includes a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Biotodoma wavrini*.

Clade 297: “*Geophagus*” *brasiliensis*

Taxonomy: One out of two species of Geophagini that are without generic assignment. Following López-Fernández *et al.* (2005), we consider both “*Geophagus*” *brasiliensis* and “*Geophagus*” *steindachneri* as separate from genus *Geophagus*.

Support: This clade includes a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Geophagus*” *brasiliensis*.

Clade 298: *Mikrogeophagus*

Taxonomy: One out of 16 genera of Geophagini. The genus *Mikrogeophagus* includes two species, *M. ramirezi* and *M. altispinosus* (Froese & Pauly 2015).

Support: Morphological characteristics given in Reis *et al.* (2003) support the monophyly of the

genus. The molecular phylogeny of López-Fernández *et al.* (2010) includes both species of genus *Mikrogeophagus* and strongly supports their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports the sister group relationship of *M. ramirezi* and *M. altispinosus* with BS 99.

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 299 and 300.

Clade 299: *Mikrogeophagus ramirezi*

Taxonomy: One out of two species of *Mikrogeophagus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Mikrogeophagus ramirezi*.

Clade 300: *Mikrogeophagus altispinosus*

Taxonomy: One out of two species of *Mikrogeophagus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Mikrogeophagus altispinosus*.

Clade 301: *Gymnogeophagus*

Taxonomy: One out of 16 genera of Geophagini. The genus *Gymnogeophagus* includes eleven species (Froese & Pauly 2015).

Support: Morphological characteristics given in Kullander (1998). The molecular phylogeny of López-Fernández *et al.* (2010) includes three species of genus *Gymnogeophagus* and strongly supports their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of *Gymnogeophagus* with BS 100.

First occurrence: *Gymnogeophagus †eocenicus* Malabarba, Malabarba, and del Papa, 2010, from the Lumbrera Formation, Salta Province, Argentina. The phylogeny of Malabarba *et al.* (2010), based on the character matrix of López-Fernández *et al.* (2005) and with 48 out of 136 character states observed for *Gymnogeophagus †eocenicus*, supports its position among crown-group *Gymnogeophagus*. Specifically, the phylogeny includes two extant species of *Gymnogeophagus* (*G. balzanii* and *G. rhabdotus*) and recovers *Gymnogeophagus †eocenicus* as the sister lineage of *G. rhabdotus*, based on two synapomorphies. On the other hand, based on the number of caudal vertebrae, *Gymnogeophagus †eocenicus* could be more closely related to the “*G. gymnogenys* group” of Wimberger *et al.* (1998), which is composed of the Recent species *G. gymnogenys*, *G. lacustris*, *G. labiatus*, *G. balzanii*, as well as five undescribed species, and supported with BS values between 86 and 96 (Wimberger *et al.* 1998). Given the ambiguous relationship of *Gymnogeophagus †eocenicus* with either *G. rhabdotus*, or with the “*G. gymnogenys* group”, we follow Malabarba *et al.* (2010) in accepting *Gymnogeophagus †eocenicus* as a member of the *Gymnogeophagus*, but not necessarily

within the crown-group of the genus. As described for clade 283 (Cichlinae), we assume an age of 45.4-39.9 Ma for the fossiliferous layer of the Lumbreira Formation.

Diversity: 11 extant species (Froese & Pauly 2015).

Sampled species: *Gymnogeophagus rhabdotus*, *Gymnogeophagus setequedas*, *Gymnogeophagus balzanii*, and *Gymnogeophagus gymnogenys*.

Clade 302: *Geophagus*+“*Geophagus*” *steindachneri*

Taxonomy: Combines genus *Geophagus* and “*Geophagus*” *steindachneri*. Following López-Fernández *et al.* (2005), we consider “*Geophagus*” *steindachneri* as potentially separate from *Geophagus*.

Support: No synapomorphies are known that unite *Geophagus* and “*Geophagus*” *steindachneri*, but exclude “*Geophagus*” *brasiliensis*. However, the sister group relationship of *Geophagus* and “*Geophagus*” *steindachneri* is supported in the phylogenies of López-Fernández *et al.* (2005; BS 72) and López-Fernández *et al.* (2010; BS 98, BPP 1.0), based on morphological and molecular data. Our RAxML phylogeny supports monophyly of *Geophagus*+“*Geophagus*” *steindachneri* with BS 100.

First occurrence: Recent.

Diversity: 26 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 303 and 304.

Clade 303: “*Geophagus*” *steindachneri*

Taxonomy: One out of two species of Geophagini that are without generic assignment. Following López-Fernández *et al.* (2005), we consider “*Geophagus*” *steindachneri* as potentially separate from *Geophagus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Geophagus*” *steindachneri*.

Clade 304: *Geophagus*

Taxonomy: One out of 16 genera of Geophagini. The genus *Geophagus* includes 25 species.

Support: No synapomorphies are known to unite *Geophagus*, but exclude “*Geophagus*” *brasiliensis* and “*Geophagus*” *steindachneri*. However, the phylogenies of López-Fernández *et al.* (2005; BS 90) and López-Fernández *et al.* (2010; BS 100, BPP 1.0), based on morphological and molecular data, include five to six species of *Geophagus*, and strongly support monophyly of the genus. Our RAxML phylogeny supports monophyly of *Geophagus* with BS 100.

First occurrence: Recent.

Diversity: 25 extant species (Froese & Pauly 2015).

Sampled species: *Geophagus grammepareius*, *Geophagus taeniopareius*, *Geophagus harreri*, *Geophagus dicrozoster*, *Geophagus surinamensis*, and *Geophagus abalios*.

Clade 305: “Apistogrammines”

Taxonomy: Following López-Fernández *et al.* (2010), we recognize the clade “Apistogrammines”, which combines the four genera *Satanoperca*, *Apistogramma*, *Apistogrammoides*, and *Taeniacara*. Identical to the “*Satanoperca* clade” of López-Fernández *et al.* (2005).

Support: No synapomorphies are known to unite “Apistogrammines”, however, the molecular phylogenies of López-Fernández *et al.* (2005; BS 72) and López-Fernández *et al.* (2010; BS 100, BPP 1.0), based on morphological and molecular data, include three to four out of four genera of “Apistogrammines” and strongly support monophyly of “Apistogrammines”. Our RAxML phylogeny supports monophyly of “Apistogrammines” with BS 96.

First occurrence: Recent.

Diversity: 97 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 306 and 309.

Clade 306: *Apistogramma*+allies

Taxonomy: Combines three out of 16 genera of Geophagini, *Apistogramma*, *Apistogrammoides*, and *Taeniacara*.

Support: No synapomorphies are known to unite *Apistogramma*, *Apistogrammoides*, and *Taeniacara*, however, the molecular phylogeny of López-Fernández *et al.* (2010) includes representatives of all three genera, and strongly supports their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of *Apistogramma*+allies with BS 100.

First occurrence: Recent.

Diversity: 89 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of 326 and 327.

Clade 307: *Taeniacara*

Taxonomy: One out of 16 genera of Geophagini. The genus *Taeniacara* includes a single species, *T. candidi* (Froese & Pauly 2015).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Taeniacara candidi*.

Clade 308: *Apistogramma*+*Apistogrammoides*

Taxonomy: Combines two out of 16 genera of Geophagini, *Apistogramma* and *Apistogrammoides*.

Support: Morphological characteristics supporting the monophyly of genus *Apistogramma* are given in Reis *et al.* (2003). The phylogenies of López-Fernández *et al.* (2005; BS 85) and López-Fernández *et al.* (2010; BS 100, BPP 1.0), based on morphological and molecular data, include representatives of both genera and strongly support their monophyly. Our RAxML phylogeny supports monophyly of *Apistogramma*+*Apistogrammoides* with BS 100.

First occurrence: Recent.

Diversity: 88 extant species (Froese & Pauly 2015).

Sampled species: *Apistogramma cacatuoides*, *Apistogramma hoignei*, *Apistogramma linkei*, and

Apistogrammoides pucallpaensis.

Clade 309: *Satanoperca*

Taxonomy: One out of 16 genera of Geophagini. The genus *Satanoperca* includes eight species (Froese & Pauly 2015).

Support: Morphological characteristics supporting the monophyly of *Satanoperca* are given in Reis *et al.* (2003). The phylogenies of López-Fernández *et al.* (2005; BS 78) and López-Fernández *et al.* (2010; BS 100, BPP 1.0), based on morphological and molecular data, include four to five species of *Satanoperca* and strongly support their monophyly.

First occurrence: Recent.

Diversity: 8 extant species (Froese & Pauly 2015).

Sampled species: *Satanoperca daemon*, *Satanoperca pappaterra*, *Satanoperca leucosticta*, *Satanoperca jurupari*, and *Satanoperca mapiritensis*.

Clade 310: *Mazarunia*

Taxonomy: One out of 16 genera of Geophagini. The genus *Mazarunia* includes three species (Froese & Pauly 2015), *M. charadrica*, *M. mazarunii*, and *M. pala*.

Support: Synapomorphies are given in López-Fernández *et al.* (2012). The molecular phylogeny of López-Fernández *et al.* (2010; BS 100, BPP 1.0) includes all three species of genus *Mazarunia*, and strongly supports their monophyly (see López-Fernández *et al.* 2012).

First occurrence: Recent.

Diversity: 3 extant species (López-Fernández *et al.* 2012).

Sampled species: *Mazarunia mazarunii*.

Clade 311: *Guianacara*

Taxonomy: One out of 16 genera of Geophagini. The genus *Guianacara* includes seven species (Arbour & López-Fernández 2011).

Support: Morphological characteristics for genus *Guianacara* are given in Reis *et al.* (2003). The molecular phylogeny of López-Fernández *et al.* (2010) includes four out of seven species of genus *Guianacara*, and strongly supports their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny includes two representatives of the genus and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 7 extant species (Arbour & López-Fernández 2011).

Sampled species: *Guianacara owroewefi*, and *Guianacara stergiosi*.

Clade 312: *Acarichthys*

Taxonomy: One out of 16 genera of Geophagini. The genus *Acarichthys* includes a single species, *A. heckelii* (Froese & Pauly 2015).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species (Froese & Pauly 2015).

Sampled species: *Acarichthys heckelii*.

Clade 313: *Biotoecus*

Taxonomy: One out of 16 genera of Geophagini. The genus *Biotoecus* includes two species, *B. dicentrarchus* and *B. opercularis* (Froese & Pauly 2015).

Support: Morphological characteristics for genus *Biotoecus* are given in Reis *et al.* (2003).

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: *Biotoecus dicentrarchus*.

Clade 314: *Dicrossus*

Taxonomy: One out of 16 genera of Geophagini. The genus *Dicrossus* includes five species, *D. filamentosus*, *D. foirni*, *D. gladicauda*, *D. maculatus*, and *D. warzeli* (Froese & Pauly 2015).

Support: Morphological characteristics for genus *Dicrossus* are given in Reis *et al.* (2003).

First occurrence: Recent.

Diversity: 5 extant species (Froese & Pauly 2015).

Sampled species: *Dicrossus filamentosus*.

Clade 315: *Teleocichla*+*Crenicichla*

Taxonomy: Combines two out of 16 genera of Geophagini, *Teleocichla* and *Crenicichla*.

Support: No synapomorphies are known to unite *Teleocichla* and *Crenicichla*, however, the molecular phylogeny of López-Fernández *et al.* (2010) strongly supports monophyly of a clade combining the two genera (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of *Teleocichla*+*Crenicichla* with BS 100.

First occurrence: †*Proterocara argentina* Malabarba, Zuleta, and del Papa, 2006, from the Lumbrera Formation, Salta Province, Argentina. Based on Kullander's (1998) matrix of 50 extant cichlid species and 91 characters (of which 17 could be coded for †*Proterocara argentina*), Malabarba *et al.* (2006) recover †*Proterocara argentina* as a sister group to a clade combining Geophagini and Cichlasomatini. The phylogeny of Smith *et al.* (2008), however, combines both molecular data of 90 species with an extension of Kullander's (1998) morphological character matrix (adding the character states for †*Proterocara argentina* as coded by Malabarba *et al.* (2006), and new data for *Mazarunia*), and supports a group combining †*Proterocara argentina* with *Crenicichla* and *Teleocichla*. After removing †*Proterocara argentina* from the data set, the sister group relationship of *Crenicichla* and *Teleocichla* is supported with JRV 100, but no support values are given for the clade combining the two extant genera with †*Proterocara argentina* in Smith *et al.* (2008). Regardless of the lack of a specified support value for this clade, the geophagine position of †*Proterocara argentina* is apparently accepted by Malabarba *et al.* (2010), and we therefore follow Smith *et al.* (2008) in assuming †*Proterocara argentina* to be part of the *Teleocichla*+*Crenicichla* clade. As described for clade 283 (Cichlinae), we assume an age of 45.4–39.9 Ma for the fossiliferous layer of the Lumbrera Formation. Thus, the first occurrence of *Teleocichla*+*Crenicichla* dates to 45.4–39.9 Ma.

Diversity: 97 extant species (Froese & Pauly 2015).

Sampled species: *Teleocichla monogramma*, *Teleocichla centrarchus*, *Crenicichla reticulata*, *Crenicichla geayi*, *Crenicichla regani*, *Crenicichla alta*, *Crenicichla sveni*, *Crenicichla multispinosa*, *Crenicichla lenticulata*, and *Crenicichla lugubris*.

Clade 316: Cichlasomatini+Heroini

Taxonomy: Combines two out of seven tribes of Cichlinae: Cichlasomatini and Heroini. Identical to the subfamily Cichlasomatinae of Kullander (1998).

Support: Synapomorphies are given in Kullander (1998) for his Cichlasomatinae. The molecular phylogeny of López-Fernández *et al.* (2010) strongly supports the monophyly of a clade combining Cichlasomatini and Heroini (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Cichlasomatini+Heroini with BS 98.

First occurrence: †*Plesioheros chauliodus* Alano Perez, Malabarba, and del Papa, 2010, from the Lumbrera Formation, Salta Province, Argentina. The first occurrence of Cichlasomatini+Heroini dates to 45.4–39.9 Ma. See clade 330 (Heroini).

Diversity: 259 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 317 and 330.

Clade 317: Cichlasomatini

Taxonomy: One out of seven tribes of Cichlinae. Following Musilová *et al.* (2009) and López-Fernández *et al.* (2010), we recognize ten genera as follows: *Acaronia*, *Aequidens*, *Andinoacara*, *Bujurquina*, *Cichlasoma*, *Cleithracara*, *Krobia*, *Laetacara*, *Nannacara*, and *Tahuantinsuyoa*. “*Aequidens*” *hoehnei* is included in Cichlasomatini without generic placement (Musilová *et al.* 2009; López-Fernández *et al.* 2010). Species composition of all genera except *Aequidens*, *Andinoacara*, *Cichlasoma*, and *Krobia* is as in Froese & Pauly (2015). Based on the morphological and molecular data of Musilová *et al.* (2009), we include the following species in genus *Aequidens*: *A. chimantanus*, *A. diadema*, *A. epae*, *A. gerciliae*, *A. mauesanus*, *A. metae*, *A. michaeli*, *A. pallidus*, *A. patricki*, *A. plagiozonatus*, *A. rondoni*, *A. tetramerus*, *A. tubicen*, and *A. viridis*. Genus *Andinoacara* is composed of *A. sapayensis*, *A. stalsbergi*, *A. biseriatus*, *A. coeruleopunctatus*, *A. latifrons*, *A. pulcher*, and *A. rivulatus*. Genus *Cichlasoma* combines *C. amazonarum*, *C. araguaiense*, *C. bimaculatum*, *C. boliviense*, *C. dimerus*, *C. orientale*, *C. orinocense*, *C. paranaense*, *C. portalegrense*, *C. pusillum*, *C. sanctifranciscense*, *C. taenia*, and *C. zarskei* (Ottoni 2011), and *Krobia* includes *K. paloemeuensis*, *K. potaroensis*, *K. guianensis*, *K. itanyi*, and *K. xinguensis*.

Support: Synapomorphies are given in Smith *et al.* (2008). The molecular phylogeny of López-Fernández *et al.* (2010) includes representatives of all ten genera of Cichlasomatini, and strongly supports their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Cichlasomatini with BS 98.

First occurrence: †*Tremembichthys garciae* Malabarba and Malabarba, 2008, from the Entre-Córregos Formation, Aiuruoca Tertiary Basin, Brazil. The phylogenetic analysis of Malabarba & Malabarba (2008) recovers †*Tremembichthys garciae*, and its congener †*Tremembichthys pauloensis* from the Tremembé Formation, Taubaté Basin, Brazil, as the sister group to a clade combining “*Aequidens*” *hoehnei*, *Laetacara*, *Cleithracara*, and *Nannacara* within Cichlasomatini, on the basis

of Kullander's (1998) character matrix including 91 character states for 50 extant taxa, with addition of the two fossil taxa, for which 29 characters could be coded. Inclusion of *Tremembichthys* to Cichlasomatini is supported by one observable character state in †*T. pauloensis*, and the sister group relationship with the clade combining “*Aequidens*” *hoehnei*, *Laetacara*, *Cleithracara*, and *Nannacara* is supported by a synapomorphy that can be verified in †*T. garciae* (Malabarba & Malabarba 2008). As molecular phylogenies, including our own, do not recover a clade including “*Aequidens*” *hoehnei*, *Laetacara*, *Cleithracara*, and *Nannacara*, but excluding *Cichlasoma*, *Krobia*, *Bujurquina*, *Andinoacara*, and *Tahuantinsuoya* (López-Fernández *et al.* 2010), we here accept †*Tremembichthys* as a member of Cichlasomatini, with unresolved relationships within the tribe. The Entre-Córregos Formation has been dated to 35.0-30.0 Ma (Garcia *et al.* 2000). Thus, the first occurrence of Cichlasomatini dates to 35.0-30.0 Ma.

Diversity: 74 extant species (see above).

Sampled species: All sampled species of clades 318, 321, and 324.

Clade 318: *Cleithracara*+*Nannacara*

Taxonomy: Combines two out of ten genera of Cichlasomatini, *Cleithracara* and *Nannacara*. Identical to “Nannacarines” of López-Fernández *et al.* (2010), and the “NIC Clade” of Musilová *et al.* (2009).

Support: Synapomorphies are given in Kullander (1998). The morphology-based and molecular phylogenies of Musilová *et al.* (2009; BS 72) and López-Fernández *et al.* (2010; BS 81, BPP 1.0) support a sister group relationship of the two genera. Our RAxML phylogeny supports monophyly of *Cleithracara*+*Nannacara* with BS 100.

First occurrence: Recent.

Diversity: 7 extant species (see clade 317)

Sampled species: All sampled species of clades 319 and 320.

Clade 319: *Cleithracara*

Taxonomy: One out of ten genera of Cichlasomatini. The genus *Cleithracara* includes a single species, *C. maronii*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Cleithracara maronii*.

Clade 320: *Nannacara*

Taxonomy: One out of ten genera of Cichlasomatini. The genus *Nannacara* includes six species (Froese & Pauly 2015; see clade 317), including *Nannacara adoketa* and *N. bimaculata*, which were previously included in genus *Ivanacara* (Musilová *et al.* 2009).

Support: Synapomorphies are given in Kullander (1998). The morphology-based and molecular phylogenies of Musilová *et al.* (2009) include five out of six species of genus *Nannacara* and support their monophyly (BS 86). Our RAxML phylogeny supports monophyly of *Nannacara* with BS 100.

First occurrence: Recent.

Diversity: 6 extant species (see clade 317).

Sampled species: *Nannacara adoketa*, *Nannacara taenia*, *Nannacara aureocephalus*, and *Nannacara anomala*.

Clade 321: “Cichlasomatines”

Taxonomy: Following López-Fernández *et al.* (2010), we assume monophyly of “Cichlasomatines”, combining three out of ten genera of Cichlasomatini, *Krobia*, *Aequidens*, and *Cichlasoma* (see clade 317).

Support: No synapomorphies are known to unite *Krobia*, *Aequidens*, and *Cichlasoma*, however, the molecular phylogeny of López-Fernández *et al.* (2010) strongly supports the monophyly of this clade (BS 88, BPP 1.0). Our RAxML phylogeny supports monophyly of “Cichlasomatines” with BS 97.

First occurrence: *Aequidens* †*saltensis* Bardack, 1961, from the La Yesera Creek, Salta Province, Argentina. The first occurrence of “Cichlasomatines” dates to 23.03–5.332 Ma. See clade 323 (*Aequidens*+*Cichlasoma*).

Diversity: 32 extant species (see clade 317).

Sampled species: All sampled species of clades 322 and 323.

Clade 322: *Krobia*

Taxonomy: One out of ten genera of Cichlasomatini. The genus *Krobia* includes five species, *Krobia paloemeuensis*, *K. potaroensis*, *K. guianensis*, *K. itanyi*, and *K. xinguensis* (see clade 317).

Support: Synapomorphies are given in Musilová *et al.* (2009). The morphology-based and molecular phylogenies of Musilová *et al.* (2009) include four out of five species included in genus *Krobia* and strongly support their monophyly (BS \geq 88).

First occurrence: Recent.

Diversity: 5 extant species (see clade 317).

Sampled species: *Krobia potaroensis* and *Krobia guianensis*.

Clade 323: *Aequidens*+*Cichlasoma*

Taxonomy: Combines two out of ten genera of Cichlasomatini, *Aequidens* and *Cichlasoma*.

Support: Synapomorphies are given in Musilová *et al.* (2009). The morphology-based and molecular phylogenies of Musilová *et al.* (2009; BS 69) and López-Fernández *et al.* (2010; BS 100, BPP 1.0) strongly support monophyly of a clade combining the two genera, even though *Aequidens* may be paraphyletic by inclusion of *Cichlasoma*. Our RAxML phylogeny supports monophyly of *Aequidens*+*Cichlasoma* with BS 100.

First occurrence: *Aequidens* †*saltensis* Bardack, 1961, from the La Yesera Creek, Salta Province, Argentina. Given the non-monophyly of *Aequidens*, as previously defined Musilová *et al.* (2009), the genus assignment of *Aequidens* †*saltensis* may be questioned. However, as described in Bardack (1961), *Aequidens* †*saltensis* “resembles the short-bodied members of the genus such as *A. tetramerus*”, which is part of clade *Aequidens*+*Cichlasoma*. Therefore, regardless of the non-

monophyly of *Aequidens*, we assume that *Aequidens* †*saltensis* represents the first known occurrence of *Aequidens*+*Cichlasoma*. Like †*Palaeocichla longirostrum*, *Aequidens* †*saltensis* is known from the “Terciario Subandino” stratigraphic unit of the La Yesera Creek Formation, which is considered Miocene by Murray (2001a) and Alano Perez *et al.* (2010). Thus, the first occurrence of *Aequidens*+*Cichlasoma* dates to 23.03–5.332 Ma.

Diversity: 27 extant species (see clade 317).

Sampled species: *Aequidens chimantanus*, *Aequidens tubicen*, *Aequidens diadema*, *Aequidens metae*, *Aequidens tetramerus*, *Cichlasoma araguaense*, *Cichlasoma pusillum*, *Cichlasoma dimerus*, *Cichlasoma orinocense*, *Cichlasoma amazonarum*, and *Cichlasoma bimaculatum*.

Clade 324: *Bujurquina*+allies

Taxonomy: Combines five out of ten genera of Cichlasomatini, *Laetacara*, *Acaronia*, *Andinoacara*, *Bujurquina*, and *Tahuantinsuyoa*.

Support: No synapomorphies are known to unite genera *Laetacara*, *Acaronia*, *Andinoacara*, *Bujurquina*, and *Tahuantinsuyoa*, however, the molecular phylogeny of López-Fernández *et al.* (2010) includes representatives of all genera and strongly supports their monophyly (BS 95, BPP 1.0). Our RAxML phylogeny supports monophyly of *Bujurquina*+allies with BS 98.

First occurrence: Recent.

Diversity: 28 extant species (see clade 317).

Sampled species: All sampled species of clades 325, 326, and 329.

Clade 325: *Laetacara*

Taxonomy: One out of ten genera of Cichlasomatini. The genus *Laetacara* includes six species (see clade 317).

Support: Synapomorphies are given in Musilová *et al.* (2009). The morphology-based and molecular phylogenies of Musilová *et al.* (2009; BS 64) and López-Fernández *et al.* (2010; BS 100, BPP 1.0) include two to three species of *Laetacara* and strongly support their monophyly. Our RAxML phylogeny supports monophyly of *Laetacara* with BS 100.

First occurrence: Recent.

Diversity: 6 extant species (see clade 317).

Sampled species: *Laetacara thayeri*, *Laetacara dorsigera*, and *Laetacara curviceps*.

Clade 326: *Acaronia*

Taxonomy: One out of ten genera Cichlasomatini. The genus *Acaronia* includes two species, *Acaronia nassa* and *A. vultuosa* (see clade 317).

Support: Synapomorphies are given in Kullander (1998). The molecular phylogenies of Musilová *et al.* (2009; BS 99) and López-Fernández *et al.* (2010; BS 100, BPP 1.0) include both species of *Acaronia* and strongly support their monophyly. Our RAxML phylogeny also includes both *A. nassa* and *A. vultuosa* and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (see clade 317).

Sampled species: All sampled species of clades 327 and 328.

Clade 327: *Acaronia nassa*

Taxonomy: One out of two species of *Acaronia*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Acaronia nassa*.

Clade 328: *Acaronia vultuosa*

Taxonomy: One out of two species of *Acaronia*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Acaronia vultuosa*.

Clade 329: “Andinoacarines”

Taxonomy: Combines three out of ten genera of Cichlasomatini, *Andinoacara*, *Bujurquina*, and *Tahuantinsuyoa* (López-Fernández *et al.* 2010; see clade 317).

Support: Synapomorphies are given in Musilová *et al.* (2009). The morphology-based and molecular phylogenies of Musilová *et al.* (2009; BS 90) and López-Fernández *et al.* (2010; BS 100, BPP 1.0) include representatives of all three genera and strongly support their monophyly.

First occurrence: Recent.

Diversity: 26 extant species (see clade 317).

Sampled species: *Andinoacara pulcher*, *Andinoacara coeruleopunctatus*, *Andinoacara biseriatus*, *Andinoacara rivulatus*, *Bujurquina zamorensis*, *Tahuantinsuyoa macantzatza*, *Bujurquina oenolaemus*, *Bujurquina vittata*, *Bujurquina syspilus*, *Bujurquina mariaae*, and *Bujurquina peregrinabunda*.

Clade 330: Heroini

Taxonomy: One out of seven tribes of Cichlinae. Heroini include 25 genera: *Amatitlania*, *Amphilophus*, *Archocentrus*, *Astatheros*, *Australoheros*, *Caquetaia*, *Cryptoheros*, *Herichthys*, *Heroina*, *Heros*, *Hoplarichus*, *Hypselecara*, *Hypsophrys*, *Mesonauta*, *Nandopsis*, *Parachromis*, *Paraneetroplus*, *Petenia*, *Pterophyllum*, *Symphysodon*, *Theraps*, *Thorichthys*, *Tomocichla*, and *Uaru*. These genera include a total of 148 species (Schmitter-Soto 2007a; López-Fernández *et al.* 2010; Hulsey *et al.* 2011; Froese & Pauly 2015). In addition, 24 species previously assigned to the cichlasomatine genus *Cichlasoma* are part of Heroini without currently being assigned to genera (Ottoni 2011) (see Supplementary Table S9). Following Říčan *et al.* (2008) and López-Fernández *et al.* (2010), we further recognize genus *Astatheros*, which includes 13 species: *Astatheros alfari*, *A. altifrons*, *A. bussingi*, *A. diquis*, *A. longimanus*, *A. macracanthus*, *A. margaritifer*, *A. rhytisma*, *A. robertsoni*, *A. rostratus*, as well as three species previously included in genus *Rocio* (Schmitter-Soto 2007a). Furthermore, we include “*Amphilophus*” *nourissati*, “*Cichlasoma*” *boucourti*, “*Cichlasoma*” *pear-*

sei, and “*Cichlasoma*” *ufermanni* in genus *Theraps* (McMahan *et al.* 2010), but exclude “*Theraps*” *wesseli* from it (López-Fernández *et al.* 2010). We also exclude “*Paraneetroplus*” *nebuliferus* from genus *Paraneetroplus*, following McMahan *et al.* (2010). Finally, we consider “*Amphilophus*” *lyonsi* and “*Amphilophus*” *calobrensis* as separate from genus *Amphilophus*, and “*Tomocichla sieboldii*” as separate from genus *Tomocichla* (Concheiro Pérez *et al.* 2007; López-Fernández *et al.* 2010; Hulsey *et al.* 2010).

Support: Synapomorphies are given in Kullander (1998) and Smith *et al.* (2008). The morphology-based and molecular phylogenies of Kullander (1998), Smith *et al.* (2008; JRV 100), and López-Fernández *et al.* (2010; BS 100, BPP 0.99) strongly support monophyly of Heroini. Our RAxML phylogeny supports monophyly of Heroini with BS 100.

First occurrence: †*Plesioheros chauliodus* Alano Perez, Malabarba, and del Papa, 2010, from the Lumbrera Formation, Salta Province, Argentina (Alano Perez *et al.* 2010). The phylogeny of Alano Perez *et al.* (2010), based on the character matrix of Kullander (1998), and with 32 characters coded for †*Plesioheros chauliodus*, recovers †*Plesioheros chauliodus* as the sister group to a clade combining *Australoheros*, *Heroina*, *Symphysodon*, *Pterophyllum*, *Mesonauta*, *Heros*, and *Uaru*, within Heroini. The clade formed by †*Plesioheros chauliodus* and the latter seven genera is supported by a single character, the presence of lingual cusps on the anterior teeth. Due to this weak support, and since a clade combining *Australoheros*, *Heroina*, *Symphysodon*, *Pterophyllum*, *Mesonauta*, *Heros*, and *Uaru*, but excluding *Caquetaia*, is not supported by molecular phylogenies (López-Fernández *et al.* 2010; this study), we consider the relationships of †*Plesioheros chauliodus* within Heroini as unresolved, but accept its position within Heroini based on two characters, including the presence of “anterior enlarged canines with a great size difference to the other teeth”, which “is not found in any other Neotropical cichlid and was pointed out by Kullander (1996) as a synapomorphy of Heroini” (Alano Perez *et al.* 2010). As described for clade 283 (Cichlinae), we assume an age of 45.4–39.9 Ma for the fossiliferous layer of the Lumbrera Formation. Thus, the first occurrence of Heroini dates to 45.4–39.9 Ma.

Diversity: 185 extant species (see above).

Sampled species: All sampled species of clades 331, 332, 337, and 344.

Clade 331: *Pterophyllum*

Taxonomy: One out of 25 genera of Heroini. The genus *Pterophyllum* includes three species, *P. scalare*, *P. altum*, and *P. leopoldi*.

Support: Morphological characteristics for genus *Pterophyllum* are given in Kullander (1998).

First occurrence: Recent.

Diversity: 3 extant species (Froese & Pauly 2015).

Sampled species: *Pterophyllum scalare*.

Clade 332: *Hoplarchus*+*Hypselecara*

Taxonomy: Combines two out of 25 genera of Heroini, *Hoplarchus* and *Hypselecara*.

Support: No synapomorphies are known to unite *Hoplarchus* and *Hypselecara*, however, the molecular phylogenies of Smith *et al.* (2008; JRV 74) and López-Fernández *et al.* (2010; BS 100, BPP

0.99) strongly support a sister group relationship of the two genera. Our RAxML phylogeny supports monophyly of *Hoplarchus*+*Hypselecara* with BS 100.

First occurrence: Recent.

Diversity: 3 extant species (see notes for clade 330).

Sampled species: All sampled species of clades 333 and 334.

Clade 333: *Hoplarchus*

Taxonomy: One out of 25 genera of Heroini. The genus *Hoplarchus* includes a single species, *H. psittacus*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species (see clade 330).

Sampled species: *Hoplarchus psittacus*.

Clade 334: *Hypselecara*

Taxonomy: One out of 25 genera of Heroini. The genus *Hypselecara* includes two species, *H. temporalis* and *H. coryphaenoides*.

Support: Synapomorphies are given in Kullander (1998). The molecular phylogeny of Ready *et al.* (2006; BS 82, BPP 1.0) and Concheiro Pérez *et al.* (2007; BPP 1.0) include both species of genus *Hypselecara* and strongly support their monophyly. Our RAxML phylogeny supports monophyly of *Hypselecara* with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (see clade 330).

Sampled species: All sampled species of clades 335 and 336.

Clade 335: *Hypselecara temporalis*

Taxonomy: One out of two species of *Hypselecara*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Hypselecara temporalis*.

Clade 336: *Hypselecara coryphaenoides*

Taxonomy: One out of two species of *Hypselecara*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Hypselecara coryphaenoides*.

Clade 337: “Mesonautines”

Taxonomy: Following López-Fernández *et al.* (2010), we recognize “Mesonautines” as a clade com-

prising four out of 25 genera of Heroini, *Mesonauta*, *Uaru*, *Symphysodon*, and *Heros*.

Support: While not explicitly given as a synapomorphy in López-Fernández *et al.* (2010), all their “Mesonautines” are characterized by a deep-bodied form. The molecular phylogeny of Ready *et al.* (2006; BPP 1.0) and López-Fernández *et al.* (2010; BS 100, BPP 1.0) include representatives of all four genera and strongly support their monophyly. Our RAxML phylogeny supports monophyly of “Mesonautines” with BS 100.

First occurrence: Recent.

Diversity: 15 extant species (see clade 330).

Sampled species: All sampled species of clades 338, 339, 342, and 343.

Clade 338: *Mesonauta*

Taxonomy: One out of four genera of “Mesonautines”. The genus *Mesonauta* includes six species.

Support: Synapomorphies are given in Kullander (1998). The molecular phylogeny of López-Fernández *et al.* (2010) includes two out of six species of *Mesonauta* and strongly supports their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny includes three representatives of genus *Mesonauta* and supports their monophyly with BS 100.

First occurrence: Recent.

Diversity: 6 extant species (see clade 330).

Sampled species: *Mesonauta egregius*, *Mesonauta festivus*, and *Mesonauta insignis*.

Clade 339: *Uaru*

Taxonomy: One out of four genera of “Mesonautines”. The genus *Uaru* includes two species, *U. fernandezyepezi* and *U. amphiacanthoides*.

Support: Synapomorphies are given in Kullander (1998). The molecular phylogenies of Concheiro Pérez *et al.* (2007) and López-Fernández *et al.* (2010) include both species of *Uaru* and strongly support their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of genus *Uaru* with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (see clade 330).

Sampled species: All sampled species of clades 340 and 341.

Clade 340: *Uaru fernandezyepezi*

Taxonomy: One out of two species of *Uaru*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Uaru fernandezyepezi*.

Clade 341: *Uaru amphiacanthoides*

Taxonomy: One out of two species of *Uaru*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Uaru amphiacanthoides*.

Clade 342: *Symphysodon*

Taxonomy: One out of four genera of “Mesonautines”. The genus *Symphysodon* includes three species, *S. aequifasciatus*, *S. discus*, and *S. tarzoo*.

Support: Synapomorphies are given in Bleher *et al.* (2007). The molecular phylogenies of Ready *et al.* (2006; BPP 1.0) and Bleher *et al.* (2007; BS 97) both include multiple specimens of all three species of *Symphysodon* and strongly support monophyly of the genus. Our RAxML phylogeny supports monophyly of *Symphysodon* with BS 100.

First occurrence: Recent.

Diversity: 3 extant species (see clade 330).

Sampled species: *Symphysodon discus* and *Symphysodon aequifasciatus*.

Clade 343: *Heros*

Taxonomy: One out of four genera of “Mesonautines”. The genus *Heros* includes four species, *H. efasciatus*, *H. notatus*, *H. severus*, and *H. spurius*.

Support: Synapomorphies are given in Bleher *et al.* (2007). The molecular phylogeny of López-Fernández *et al.* (2010) includes three out of four valid species of *Heros*, and strongly supports their monophyly (BS 100, BPP 1.0). In addition, the molecular phylogeny of Concheiro Pérez *et al.* (2007) supports the monophyly of two included species of *Heros* (BPP 1.0). Our RAxML phylogeny includes two representatives of genus *Heros* and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 4 extant species (see clade 330).

Sampled species: *Heros severus* and *Heros efasciatus*.

Clade 344: “SCAC” + “NCAC”

Taxonomy: Following López-Fernández *et al.* (2010), we here recognize the clade “SCAC” + “NCAC”, which combines all heroine cichlids of the “Southern Central American Clade” and the “Northern Central American Clade”. The clade thus includes all genera of the cichlid tribe Heroini except *Pterophyllum*, *Hoplarchus*, *Hypselecara*, *Mesonauta*, *Uaru*, *Symphysodon*, and *Heros*.

Support: No synapomorphies are known to unite all genera of “SCAC” + “NCAC”, however the molecular phylogenies of Concheiro Pérez *et al.* (2007) and López-Fernández *et al.* (2010) strongly support monophyly of this clade (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of “SCAC” + “NCAC” with BS 100.

First occurrence: *Nandopsis* †*woodringi* (Cockerell 1924) from Las Cahobas, Haiti. As described in Chakrabarty (2007b), several characters are shared between *Nandopsis* †*woodringi*, *Nandopsis haitiensis*, and *Nandopsis tetracanthus*, including lingual cusps on the oral teeth and four anal-fin spines, a character combination that is unique to *N. haitiensis* and *N. tetracanthus* among

extant cichlids. These morphological characteristics, as well as the fossil location on Haiti corroborate the placement of *Nandopsis* †*woodringi* in genus *Nandopsis*. The first occurrence of “SCAC”+“NCAC” dates to 11.608-5.332 Ma, however, due to the lack of morphological support for clade “SCAC”+“NCAC”, *Nandopsis* †*woodringi* is not used to constrain this age of this clade in our BEAST analysis. See clade 345 (*Nandopsis*).

Diversity: 164 extant species (see clade 330).

Sampled species: All sampled species of clades 345, 350, 351, 352, 353, 354, 357, 358, 359, 360, 361, 362, 363, 364, 365, 366, 367, 370, 371, and 372.

Clade 345: *Nandopsis*

Taxonomy: One out of 25 genera of the cichlid tribe Heroini. The genus *Nandopsis* includes three species, *N. haitiensis*, *N. tetracanthus*, and *N. ramsdeni*.

Support: Synapomorphies are given in Chakrabarty (2007a). The molecular phylogenies of Chakrabarty (2006; JRV 85), Concheiro Pérez *et al.* (2007; BPP 1.0), and Říčan *et al.* (2008; BS 95) include all three species included in *Nandopsis* and strongly support their monophyly. In addition, the biogeographic distribution of all species of *Nandopsis* on the Greater Antillean islands supports the monophyly of the genus. Our RAxML phylogeny supports monophyly of *Nandopsis* with BS 100.

First occurrence: *Nandopsis* †*woodringi* (Cockerell 1924) from Las Cahobas, Haiti. Based on morphological characteristics and biogeography (Chakrabarty 2007b), *Nandopsis* †*woodringi* is here accepted as the earliest record of the genus *Nandopsis*. Within *Nandopsis*, it may be argued that *Nandopsis* †*woodringi* is more closely related to *Nandopsis haitiensis* than to the Cuban endemic *Nandopsis tetramerus*, based on its “slender body shape” (Chakrabarty 2007a) and its occurrence on Hispaniola, however if cichlids dispersed to Hispaniola before they colonized Cuba, *Nandopsis* †*woodringi* might as well represent a stem lineage of the genus. Thus, we accept *Nandopsis* †*woodringi* as a member of the genus, but not necessarily as the sister to *Nandopsis haitiensis*. The age of fossils from Las Cahobas has been given as “?Pliocene” by Van Couvering (1982), Casciotta & Arratia (1993), and Murray (2001a), however, Chakrabarty (2007b) argues that there is “no justification for assigning this fossil to an age younger than Miocene”. Following Chakrabarty (2007b), we assume a Late Miocene age for *Nandopsis* †*woodringi*. Thus, the first occurrence of *Nandopsis* dates to 11.608-5.332 Ma.

Diversity: 3 extant species (see clade 330).

Sampled species: All sampled species of clades 346 and 347.

Clade 346: *Nandopsis haitiensis*

Taxonomy: One out of three species of *Nandopsis*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Nandopsis haitiensis*.

Clade 347: “Cuban *Nandopsis*”

Taxonomy: Combines two out of three species of *Nandopsis* (*Nandopsis tetracanthus* and *N. ramsdeni*), which both occur on Cuba.

Support: No synapomorphies are known to unite *Nandopsis tetracanthus* and *Nandopsis ramsdeni* excluding *Nandopsis haitiensis*, however the molecular phylogeny of Concheiro Pérez *et al.* (2007) includes multiple specimens of the three species and strongly supports a sister group relationship of *Nandopsis tetracanthus* and *Nandopsis ramsdeni* (BPP 1.0). The same topology is further supported by the molecular phylogeny of Chakrabarty (2006; BS 100). Moreover the biogeographic distribution of *Nandopsis tetracanthus* and *Nandopsis ramsdeni*, being the only two Cuban cichlid endemics, supports their monophyly. Our RAxML phylogeny supports the monophyly of “Cuban *Nandopsis*” with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (see clade 330).

Sampled species: All sampled species of clades 348 and 349.

Clade 348: *Nandopsis tetracanthus*

Taxonomy: One out two species of the “Cuban *Nandopsis*”.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Nandopsis tetracanthus*.

Clade 349: *Nandopsis ramsdeni*

Taxonomy: One out two species of the “Cuban *Nandopsis*”.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Nandopsis ramsdeni*.

Clade 350: “Caquetaines”

Taxonomy: Following López-Fernández *et al.* (2010), we here recognize “Caquetaines”, a clade combining two out of 25 genera of Heroini, *Caquetaia* and *Heroina* (see clade 330).

Support: No synapomorphies are known to unite “Caquetaines”, however, the molecular phylogenies of López-Fernández *et al.* (2010; BS 97, BPP 1.0) and Hulsey *et al.* (2010; BPP 0.99) include three out of five species of “Caquetaines” and strongly support their monophyly. Our RAxML phylogeny supports monophyly of “Caquetaines” with BS 100.

First occurrence: Recent.

Diversity: 5 extant species (see clade 330).

Sampled species: *Caquetaia umbrifera*, *Caquetaia kraussii*, *Caquetaia myersi*, and *Heroina isonycterina*.

Clade 351: *Australoheros*

Taxonomy: One out of 25 genera of Heroini. The genus *Australoheros* includes 27 species (Ottoni 2012).

Support: Synapomorphies are given in Ottoni & Costa (2008).

First occurrence: Recent.

Diversity: 27 extant species (Ottoni 2012).

Sampled species: *Australoheros facetus*.

Clade 352: *Petenia*

Taxonomy: One out of 25 genera of Heroini. *Petenia* includes a single species, *P. splendida*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Petenia splendida*.

Clade 353: “*Cichlasoma*” *urophthalmum*

Taxonomy: One out of 24 species that were previously assigned to genus *Cichlasoma*, of the cichlid tribe Cichlasomatini, but are part of Heroini instead (Ottoni 2011; Froese & Pauly 2015). Chakrabarty (2007a) recovers “*Cichlasoma*” *urophthalmum* as closely related to “*Cichlasoma*” *trimaculatum* in her morphology-based phylogeny, whereas the molecular data of Concheiro Pérez *et al.* (2007) and López-Fernández *et al.* (2010) support a sister group relationship with *Petenia* (BS 100, BPP 1.0).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Cichlasoma*” *urophthalmum*.

Clade 354: *Hypsophrys*

Taxonomy: One out of 25 genera of Heroini. The genus *Hypsophrys* includes two species, *H. nematopus* and *H. nicaraguensis*.

Support: Synapomorphies are given in Schmitter-Soto (2007b). The molecular phylogeny of López-Fernández *et al.* (2010) includes both species of *Hypsophrys* and strongly supports their monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of *Hypsophrys* with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (see clade 330).

Sampled species: All sampled species of clades 355 and 356.

Clade 355: *Hypsophrys nematopus*

Taxonomy: One out of two species of *Hypsophrys*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Hypsophrys nematopus*.

Clade 356: *Hypsophrys nicaraguensis*

Taxonomy: One out of two species of *Hypsophrys*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Hypsophrys nicaraguensis*.

Clade 357: *Cryptoheros* (*Cryptoheros*)

Taxonomy: One out of three subgenera of genus *Cryptoheros*. Non-monophyly of genus *Cryptoheros* has been suggested by the molecular phylogenies of López-Fernández *et al.* (2010) and Hulsey *et al.* (2010). Subdivision of genus *Cryptoheros* into subgenera follows Schmitter-Soto (2007a). The affinities of all members of the remaining two subgenera of *Cryptoheros* are unresolved, but may lie with *Parachromis*, *Amatitlania*, *Archocentrus*, *Amphilophus*, “*Cichlasoma*” *istlanum*, “*Cichlasoma*” *trimaculatum*, or *Hypsophrys* (López-Fernández *et al.* 2010; Hulsey *et al.* 2010) (see Supplementary Table S9). *Cryptoheros* (*Cryptoheros*) includes three species, *Cryptoheros* (*Cryptoheros*) *cutteri*, *C. (C.) chetumalensis*, and *C. (C.) spilurus*.

Support: Synapomorphies are given in Schmitter-Soto (2007a). The molecular phylogeny of Hulsey *et al.* (2010) includes all three species included in *Cryptoheros* (*Cryptoheros*) and strongly supports their monophyly (BPP 0.99). Our RAxML phylogeny supports monophyly of *Cryptoheros* (*Cryptoheros*) with BS 100.

First occurrence: Recent.

Diversity: 3 extant species.

Sampled species: *Cryptoheros cutteri* and *Cryptoheros chetumalensis*.

Clade 358: *Parachromis*

Taxonomy: One out of 25 genera of Heroini. The genus *Parachromis* includes five species, *P. dovii*, *P. friedrichsthalii*, *P. loisellei*, *P. managuensis*, and *P. motaguensis* (Froese & Pauly 2015).

Support: Synapomorphies are given in Schmitter-Soto (2007b). Whereas the morphology-based phylogeny of Chakrabarty (2007a) resolves *Parachromis* as non-monophyletic, the molecular phylogeny of López-Fernández *et al.* (2010) includes four out of five species assigned to genus *Parachromis* and strongly supports their monophyly (BS 85, BPP 1.0). In addition, the single species of *Parachromis* missing in the data set of López-Fernández *et al.* (2010), *P. motaguensis*, is recovered as the sister group of *P. loisellei* with strong support in Hulsey *et al.* (2010) (BPP 1.0), thus supporting monophyly of the genus. In Hulsey *et al.* (2010), *Parachromis* appears paraphyletic, because *P. managuensis* and *P. dovii* are resolved as more closely related to *Cryptoheros* (*Bussingius*) *sajica* than to the remaining species of *Parachromis*, albeit with lower support for the clade combining *P. managuensis*, *P. dovii*, and *C. (B.) sajica* (BPP 0.76). We here assume monophyly of *Parachromis*, based on the relatively stronger support for monophyly in López-Fernández *et al.* (2010), than for

paraphyly in Hulsey *et al.* (2010), and based on the strong support for monophyly resulting from our own molecular data set. Our RAxML phylogeny supports monophyly of *Parachromis* with BS 100.

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Parachromis loisellei*, *Parachromis friedrichsthalii*, *Parachromis dovii*, and *Parachromis managuensis*.

Clade 359: “*Theraps*” *wesseli*

Taxonomy: Following López-Fernández *et al.* (2010), we assume “*Theraps*” *wesseli* to be separate from genus *Theraps*. See clade 330 (Heroini).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Theraps*” *wesseli*.

Clade 360: *Amatitlania*+*Cryptoheros* (*Bussingius*) *myrnae*

Taxonomy: Combines genus *Amatitlania* with *Cryptoheros* (*Bussingius*) *myrnae*. *Amatitlania* is one out of 25 genera of the cichlid tribe Heroini and includes four species, *Amatitlania coatepeque*, *A. kanna*, *A. nigrofasciata*, and *A. siquia* (Schmitter-Soto 2007a).

Support: Synapomorphies for *Amatitlania* are given in (Schmitter-Soto 2007a). The molecular phylogenies of Concheiro Pérez *et al.* (2007; BPP 1.0) and Hulsey *et al.* (2010; BPP 0.99) strongly support a position of *Cryptoheros* (*Bussingius*) *myrnae* within *Amatitlania*, and monophyly of a clade combining *Amatitlania* and *Cryptoheros* (*Bussingius*) *myrnae*.

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Amatitlania nigrofasciata*.

Clade 361: “*Cichlasoma*” *istlanum*+“*Cichlasoma*” *beani*

Taxonomy: Combines two out of 24 species that were previously assigned to genus *Cichlasoma*, “*Cichlasoma*” *istlanum*+“*Cichlasoma*” *beani* (see above).

Support: No synapomorphies are known to unite “*Cichlasoma*” *istlanum* and “*Cichlasoma*” *beani*, however both the phylogenies of Říčan *et al.* (2008) and Hulsey *et al.* (2010) strongly support a sister group relationship of the two species (BS 100, BPP 1.0).

First occurrence: Recent.

Diversity: 2 extant species.

Sampled species: “*Cichlasoma*” *istlanum*.

Clade 362: “*Cichlasoma*” *trimaculatum*+“*Amphilophus*” *lyonsi*

Taxonomy: Combines “*Cichlasoma*” *trimaculatum*, one out of 24 species that were previously assigned to genus *Cichlasoma*, with “*Amphilophus*” *lyonsi*. See notes for clade 361 (“*Cichlasoma*”

istlanum+“*Cichlasoma*” *beani*).

Support: No synapomorphies are known to unite “*Cichlasoma*” *trimaculatum* and “*Amphilophus*” *lyonsi*, however the molecular phylogenies of Concheiro Pérez *et al.* (2007), López-Fernández *et al.* (2010) and Hulsey *et al.* (2010) strongly support a sister group relationship of the two species (BS 100, BPP 1.0).

First occurrence: Recent.

Diversity: 2 extant species.

Sampled species: “*Cichlasoma*” *trimaculatum*.

Clade 363: *Archocentrus centrarchus*

Taxonomy: One out of three species of genus *Archocentrus* (Schmitter-Soto 2007a). Non-monophyly of the three species included in *Archocentrus* (*A. centrarchus*, *A. multispinosus*, and *A. spinosissimus*) is suggested by the molecular data of Hulsey *et al.* (2010) (see Supplementary Table S9).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Archocentrus centrarchus*.

Clade 364: *Amphilophus*

Taxonomy: One out of 25 genera of the cichlid tribe Heroini. We here consider genus *Amphilophus* to include all species of the *Amphilophus citrinellus* species complex, these are *A. citrinellus*, *A. amarillo*, *A. labiatus*, *A. sagittae*, *A. xiloaensis*, *A. zaliosus*, *A. chanco*, *A. flaveolus*, *A. astorquii*, *A. superciliosus*, and *A. globosus* (Stauffer *et al.* 2008; Geiger *et al.* 2010). In addition, we include *A. hogaboomorum*, based on the molecular phylogenies of Concheiro Pérez *et al.* (2007) and Hulsey *et al.* (2010), which strongly support a close relationship between *A. hogaboomorum* and the two included species of the *Amphilophus citrinellus* species complex (*A. citrinellus* and *A. labiatus*; BPP 1.0). *Amphilophus*, as defined here, includes twelve species. “*Amphilophus*” *lyonsi* and “*Amphilophus*” *calobrensis* are excluded, based on the molecular data of Concheiro Pérez *et al.* (2007), López-Fernández *et al.* (2010) and Hulsey *et al.* (2010), which supports a close relationship between “*Amphilophus*” *lyonsi* and “*Cichlasoma*” *trimaculatum*, and between “*Amphilophus*” *calobrensis* and a clade combining *Petenia splendida* and “*Cichlasoma*” *urophthalmus*.

Support: No synapomorphies are known to unite *Amphilophus* excluding “*Amphilophus*” *lyonsi* and “*Amphilophus*” *calobrensis*, however the molecular phylogenies of Concheiro Pérez *et al.* (2007), López-Fernández *et al.* (2010) and Hulsey *et al.* (2010) all include *A. hogaboomorum* together with multiple species of the *Amphilophus citrinellus* species complex, and strongly support their monophyly (BS 100, BPP 1.0). In addition the monophyly of the *Amphilophus citrinellus* species complex (without *A. hogaboomorum*) is strongly supported by their biogeographic distribution that is, with exception of *A. labiatus* and *A. citrinellus*, limited to the Nicaraguan Lakes Apoyo and Xiloa (Stauffer *et al.* 2008; Geiger *et al.* 2010). Our RAXML phylogeny supports monophyly of *Amphilophus* with BS 100.

First occurrence: Recent.

Diversity: 12 extant species (see above).

Sampled species: *Amphilophus labiatus*, *Amphilophus astorquii*, *Amphilophus zaliosus*, *Amphilophus citrinellus*, and *Amphilophus hogaboomorum*.

Clade 365: *Astatheros*

Taxonomy: The genus *Astatheros* includes ten species previously placed in genus *Amphilophus*, and all three species of genus *Rocio* (López-Fernández *et al.* 2010).

Support: No synapomorphies are known to unite *Astatheros* including *Rocio*, however, the molecular phylogeny of López-Fernández *et al.* (2010) strongly supports monophyly of this clade (BS 79, BPP 1.0). Our RAxML phylogeny supports monophyly of *Astatheros* with BS 97.

First occurrence: Recent.

Diversity: 13 extant species (López-Fernández *et al.* 2010; Froese & Pauly 2015).

Sampled species: *Astatheros macracanthus*, *Astatheros octofasciata*, *Astatheros robertsoni*, *Astatheros diquis*, *Astatheros longimanus*, and *Astatheros rostratus*.

Clade 366: *Archocentrus multispinosus*

Taxonomy: One out of three species of *Archocentrus* (Schmitter-Soto 2007a). Non-monophyly of the three species included in *Archocentrus* is suggested by the molecular data of Hulsey *et al.* (2010).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Archocentrus multispinosus*.

Clade 367: *Tomocichla*

Taxonomy: One out of 25 genera of Heroini. Following Concheiro Pérez *et al.* (2007), López-Fernández *et al.* (2010) and Hulsey *et al.* (2010), we exclude “*Tomocichla*” *sieboldii* from genus *Tomocichla*. *Tomocichla* thus includes two species, *T. asfraci* and *T. tuba*.

Support: No synapomorphies are known to unite *Tomocichla* without “*Tomocichla*” *sieboldii*, however the molecular phylogenies of Concheiro Pérez *et al.* (2007), and López-Fernández *et al.* (2010) strongly support a sister group relationship of *T. asfraci* and *T. tuba* (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of *Tomocichla* with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (see above).

Sampled species: All sampled species of clades 368 and 369.

Clade 368: *Tomocichla asfraci*

Taxonomy: One out of two species of *Tomocichla*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Tomocichla asfraci*.

Clade 369: *Tomocichla tuba*

Taxonomy: One out of two species of *Tomocichla*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Tomocichla tuba*.

Clade 370: “*Cichlasoma*” *salvini*

Taxonomy: One out of 24 species that were previously assigned to genus *Cichlasoma*. The molecular data of Concheiro Pérez *et al.* (2007) supports a close relationship of “*Cichlasoma*” *salvini* (their “*Heros*” *salvini*) with genus *Thorichthys*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Cichlasoma*” *salvini*.

Clade 371: *Thorichthys*

Taxonomy: One out of 25 genera of Heroini. The genus *Thorichthys* includes eight species (Froese & Pauly 2015).

Support: Synapomorphies are given in Chakrabarty (2007a). The molecular phylogenies of Concheiro Pérez *et al.* (2007; BPP 1.0), López-Fernández *et al.* (2010; BS 100, BPP 1.0) and Hulsey *et al.* (2010; BPP 0.99) include 5-8 species of genus *Thorichthys* and strongly support their monophyly. Our RAxML phylogeny supports monophyly of *Thorichthys* with BS 100.

First occurrence: Recent.

Diversity: 8 extant species (Froese & Pauly 2015).

Sampled species: *Thorichthys aureus*, *Thorichthys ellioti*, *Thorichthys helleri*, *Thorichthys pasionis*, *Thorichthys meeki*, and *Thorichthys affinis*.

Clade 372: *Herichthys*+allies

Taxonomy: Combines three out of 25 genera of the cichlid tribe Heroini, *Herichthys*, *Paraneetroplus*, and *Theraps* (see clade 330).

Support: No synapomorphies are known to unite genera *Herichthys*, *Paraneetroplus*, and *Theraps*, however, the molecular phylogenies of Concheiro Pérez *et al.* (2007; BPP 1.0), López-Fernández *et al.* (2010; BS 100, BPP 1.0), McMahan *et al.* (2010; BS 83, BPP 1.0) and Hulsey *et al.* (2010; BPP 0.98) all include multiple representatives of all three genera and strongly support their monophyly. Our RAxML phylogeny supports monophyly of *Herichthys*+allies with BS 100.

First occurrence: Recent.

Diversity: 33 extant species (see clade 330).

Sampled species: *Herichthys cyanoguttatus*, *Herichthys carpintis*, *Herichthys tamasopoensis*, *Herichthys*

bartoni, *Herichthys labridens*, *Herichthys steindachneri*, *Herichthys pantostictus*, *Theraps nourissati*, *Theraps irregularis*, *Theraps pearsei*, *Theraps intermedius*, *Theraps godmanni*, *Paraneetroplus bulleri*, *Paraneetroplus maculicauda*, *Paraneetroplus synspilus*, *Paraneetroplus melanurus*, *Paraneetroplus guttulatus*, *Paraneetroplus hartwegi*, and *Paraneetroplus bifasciatus*.

Clade 373: Heterochromini

Taxonomy: Following Murray (2000b), Sparks & Smith (2004a), and Schwarzer *et al.* (2009), we here recognize Heterochromini as a tribe of Pseudocrenilabrinae. It includes a single genus, *Heterochromis*, and a single species *H. multidens*.

Support: This clade include a single extant species.

First occurrence: ?*Heterochromis* fossil from the Baid Formation, Ad Darb locality, Tihamat Asir, Saudi Arabia. Based on predorsal bone count and scale structure, three fossil specimens (LNK.te17, LNK.Gi2, and LNK.Gi6 of the Staatliches Museum für Naturkunde, Karlsruhe, Germany) are considered most closely related to *Heterochromis* (Lippitsch & Micklich 1998), albeit the authors hesitate to include the fossil specimens in the genus. The Baid Formation is assigned to an Oligocene age by Lippitsch & Micklich (1998), but considered Early Miocene by Brown *et al.* (1989), thus we here accept an Oligocene-Early Miocene age of the Saudi-Arabian ?*Heterochromis* remains. Thus, the first occurrence of Heterochromini dates to 33.9-15.97 Ma.

Diversity: 1 extant species.

Sampled species: *Heterochromis multidens*.

Clade 374: Tylochromini

Taxonomy: Following Murray (2000b) and Takahashi (2003), we here recognize Tylochromini as a tribe of Pseudocrenilabrinae. It include a single genus, *Tylochromis*, and 18 species (Froese & Pauly 2015).

Support: Synapomorphies are given in Takahashi (2003). The morphology-based phylogeny of Takahashi (2003) includes five out of 18 species of Tylochromini, and supports their monophyly. In addition, the molecular phylogeny of Wagner *et al.* (2012) includes eight species of genus *Tylochromis*, and strongly supports their monophyly (BS 99). Our RAxML phylogeny supports monophyly of Tylochromini with BS 100.

First occurrence: ?*Tylochromis* fossil from the Jebel Qatrani Formation, Egypt. The ?*Tylochromis* fossil specimen (DPC 4973, Duke Primate Center, Duke University, North Carolina) is a lower pharyngeal jaw with hypertrophied median teeth similar to those observed in extant *Tylochromis* (Murray 2002). On the basis of this similarity, the “fossil cichlid remains from the Jebel Qatrani probably belonged to a species of *Tylochromis*” (Murray 2004). The age of the Jebel Qatrani Formation is 35.12-33.77 Ma, according to paleomagnetic data (Murray 2002). Thus, the first occurrence of Tylochromini dates to 35.12-33.77 Ma.

Diversity: 18 extant species (Froese & Pauly 2015).

Sampled species: *Tylochromis leonensis*, *Tylochromis pulcher*, *Tylochromis lateralis*, *Tylochromis polylepis*, and *Tylochromis* cf. *variabilis*.

Clade 375: Chromidotilapiini

Taxonomy: Following (Murray 2000b), we here consider Chromidotilapiini as a tribe of Pseudocrenilabrinae. (Murray 2000b) includes six genera in Chromidotilapiini, *Chromidotilapia*, *Limbochromis*, *Nanochromis*, *Parananochromis*, *Pelvicachromis*, and *Thysochromis*. In subsequent work, Lamboj & Snoeks (2000) described the monotypic genus *Divandu*, for *D. albimarginatus*, which is considered part of Chromidotilapiini (Stiassny *et al.* 2007). Genus *Benitochromis* was described by Lamboj (2001) for three new species, as well as “*Chromidotilapia*” *batesii*, “*Chromidotilapia*” *finleyi*, and “*Nanochromis*” *riomuniensis*. Genus *Congochromis* was described by Stiassny & Schliewen (2007) for four species, three of which had previously been included in genus *Nanochromis*, thus *Congochromis* is also considered part of Chromidotilapiini. Finally, genus *Enigmatochromis* was described for *E. lucanusi*, that is considered a chromidotilapiine (Lamboj 2009) (see Supplementary Table S9). The position of genus *Teleogramma* has long been considered uncertain, and even its inclusion in Cichlidae has previously been questioned (Takahashi & Nakaya 2002). Murray (2000b) includes *Teleogramma* in Lamprologini, however, we here follow Lamboj (2012) in considering *Teleogramma* as part of the Chromidotilapiini.

Support: No synapomorphies are known to unite Chromidotilapiini including *Teleogramma*, however, a number of morphological characters is shared between the two groups, as described in Takahashi & Nakaya (2002). Our RAxML phylogeny supports monophyly of Chromidotilapiini with BS 99.

First occurrence: Recent.

Diversity: 55 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 376, 377, 378, 379, 380, 381, and 382.

Clade 376: *Teleogramma*

Taxonomy: Genus *Teleogramma* was previously included in the cichlid tribe Lamprologini (Takahashi 2002), but is here considered as one out of eleven genera of Chromidotilapiini. The genus *Teleogramma* includes four species, *T. brichardi*, *T. depressa*, *T. gracile*, and *T. monogramma*.

Support: Synapomorphies are given in Takahashi & Nakaya (2002). Our RAxML phylogeny supports monophyly of *Teleogramma* with BS 100.

First occurrence: Recent.

Diversity: 5 extant species (Froese & Pauly 2015).

Sampled species: *Teleogramma depressa* and *Teleogramma gracile*.

Clade 377: *Thysochromis*

Taxonomy: One out of eleven genera of Chromidotilapiini. The genus *Thysochromis* includes two species, *T. annectens* and *T. ansorgii* (Froese & Pauly 2015).

Support: Synapomorphies are given in Stiassny *et al.* (2007).

First occurrence: Recent.

Diversity: 2 extant species (Stiassny *et al.* 2007).

Sampled species: *Thysochromis ansorgii*.

Clade 378: *Chromidotilapia*

Taxonomy: One out of eleven genera of the cichlid tribe Chromidotilapiini. The genus *Chromidotilapia* includes eleven species (Froese & Pauly 2015), however, based on its disjunct distribution, we here exclude the “enigmatic eastern Congolese” (Stiassny & Schliewen 2007) “*Chromidotilapia*” *schoutedeni*, thus limiting *Chromidotilapia*, as recognized here to ten species that occur between Liberia and Congo, *C. cavalliensis*, *C. elongata*, *C. guntheri*, *C. kingsleyae*, *C. linkei*, *C. mamonekenei*, *C. melaniae*, *C. mrac*, *C. nana*, and *C. regani*. Based on information given in Stiassny & Schliewen (2007), we consider “*Chromidotilapia*” *schoutedeni* to be most closely related to either *Chromidotilapia*, *Congochromis*, or *Nanochromis* (see Supplementary Table S9).

Support: Synapomorphies are given in Stiassny *et al.* (2007).

First occurrence: Recent.

Diversity: 10 extant species (see above).

Sampled species: *Chromidotilapia guntheri*.

Clade 379: *Benitochromis*

Taxonomy: One out of eleven genera of Chromidotilapiini. The genus *Benitochromis* includes six species (Froese & Pauly 2015).

Support: Synapomorphies are given in Stiassny *et al.* (2007).

First occurrence: Recent.

Diversity: 6 extant species (Froese & Pauly 2015).

Sampled species: *Benitochromis nigrodorsalis*.

Clade 380: *Pelvicachromis*

Taxonomy: One out of eleven genera of Chromidotilapiini. The genus *Pelvicachromis* includes eight species (Froese & Pauly 2015).

Support: Synapomorphies are given in Stiassny *et al.* (2007). The molecular phylogeny of Wagner *et al.* (2012) includes two out of seven species of genus *Pelvicachromis* and supports their monophyly (BS < 50).

First occurrence: Recent.

Diversity: 8 extant species (Froese & Pauly 2015).

Sampled species: *Pelvicachromis pulcher*.

Clade 381: *Congochromis*

Taxonomy: One out of eleven genera of Chromidotilapiini. The genus *Congochromis* includes five species (Froese & Pauly 2015).

Support: Synapomorphies are given in Stiassny & Schliewen (2007). The molecular phylogeny of Schwarzer *et al.* (2011a) includes three out of five species of genus *Congochromis* and supports their monophyly (no support values given).

First occurrence: Recent.

Diversity: 5 extant species (Froese & Pauly 2015).

Sampled species: *Congochromis* cf. *sabinae*.

Clade 382: *Nanochromis*

Taxonomy: One out of eleven genera of Chromidotilapiini. The genus *Nanochromis* includes eight species (Froese & Pauly 2015).

Support: Synapomorphies are given in Stiassny & Schliewen (2007). The molecular phylogeny of Schwarzer *et al.* (2011a) includes all species of genus *Nanochromis* and supports their monophyly (no support values given). Our RAxML phylogeny supports monophyly of *Nanochromis* with BS 100.

First occurrence: Recent.

Diversity: 8 extant species (Froese & Pauly 2015).

Sampled species: *Nanochromis minor*, *Nanochromis wickleri*, *Nanochromis transvestitus*, *Nanochromis consortus*, *Nanochromis splendens*, *Nanochromis nudiceps*, *Nanochromis parilus*, and *Nanochromis teugelsi*.

Clade 383: *Pelmatochromini*

Taxonomy: Following Schwarzer *et al.* (2009) and Lamboj (2012), we recognize Pelmatochromini as a tribe of Pseudocrenilabrinae. Pelmatochromini include two genera, *Pelmatochromis* and *Pterochromis*. Molecular evidence suggests that *Pelmatochromis* is paraphyletic, and includes the monotypic *Pterochromis* (Schwarzer *et al.* 2009).

Support: Shared morphological characteristics are given in Greenwood (1987). The molecular phylogeny of Schwarzer *et al.* (2009) includes two species of genus *Pelmatochromis* and *Pterochromis congicus*, and strongly supports the monophyly of a clade combining both genera (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Pelmatochromini with BS 100.

First occurrence: ?*Pelmatochromis* spp. Van Couvering, 1982, from the “Lamitima Beds” east of Bukwa, Uganda. The ?*Pelmatochromis* remains consist of isolated elements representing two or more species (Van Couvering 1982; Murray 2001a). An Early Miocene age is assigned to the “Lamitima Beds” (Murray 2001a). Thus, the first occurrence of Pelmatochromini dates to 23.03–15.97 Ma.

Diversity: 4 extant species (Froese & Pauly 2015).

Sampled species: *Pelmatochromis buettikoferi*, *Pterochromis congicus*, and *Pelmatochromis nigrofasciatus*.

Clade 384: *Hemichromini*

Taxonomy: Following Schwarzer *et al.* (2009) and Lamboj (2012), we recognize Hemichromini as a tribe of Pseudocrenilabrinae. Hemichromini include two genera, *Hemichromis* and *Anomalochromis*.

Support: The sister group relationship of the genera *Hemichromis* and *Anomalochromis* is supported by shared morphological and behavioural traits, as described in Greenwood (1985). Our RAxML phylogeny supports monophyly of Hemichromini with BS 100.

First occurrence: †*Mahengechromis* spp. Murray, 2000, from Mahenge, Singida, Tanzania. The single predorsal bone of †*Mahengechromis* supports its position among a clade combining all African

cichlids except *Heterochromis* and *Tylochromis* (Murray 2000b, 2001b). Using a matrix of 37 osteological characters, scored for representatives of all major cichlid groups, Murray (2000b) superimposed character evolution on a composite tree that reflected known cichlid relationships at the time, and found the most parsimonious placement of †*Mahengechromis* as the sister of *Hemichromis*. The close relationship between †*Mahengechromis* and *Hemichromis* is further supported by similarities in the shape of the dorsal edge of opercle above the level of the hyomandibular facet, and the total number of vertebrae (Murray 2000b). Given that Murray's (2000b) composite tree is mostly congruent with more recent molecular phylogenies (e.g. recovering *Heterochromis* and *Tylochromis* as basal to a clade combining Hemichromini, Chromidotilapini, Tilapini, and Haplochromini), and following the recommendation of Alison Murray (personal communication), we here accept †*Mahengechromis* as the first occurrence of Hemichromini. Based on U-Pb isotopic analyses of Mahenge zircon, the Mahenge paleolake formed 45.83±/-0.17 Ma (Harrison *et al.* 2001). Assuming that the crater lake filled with sediment within 0.2-1.0 Myr (Harrison *et al.* 2001), we here accept the age of †*Mahengechromis* spp. to be 46.0-45.0 Ma. Thus, the first occurrence of Hemichromini dates to 46.0-45.0 Ma.

Diversity: 12 extant species (Froese & Pauly 2015).

Sampled species: *Anomalochromis thomasi*, *Hemichromis elongatus*, *Hemichromis fasciatus*, *Hemichromis letourneuxi*, *Hemichromis guttatus*, and *Hemichromis lifalili*.

Clade 385: Etiini

Taxonomy: A tribe of Pseudocrenilabrinae (Dunz & Schliewen 2013). Etiini include a single genus, *Etia*, and a single species: *E. nguti*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Etia nguti*.

Clade 386: Oreochromini

Taxonomy: A tribe of Pseudocrenilabrinae (Dunz & Schliewen 2013). Oreochromini include all valid species of the genera *Oreochromis*, *Sarotherodon*, *Alcolapia*, *Iranocichla*, *Tristramella*, *Danakilia*, *Stomatepia*, *Myaka*, *Pungu*, and *Konia*.

Support: No synapomorphies are known to unite all genera included in Oreochromines, however, the molecular phylogeny of Schwarzer *et al.* (2009) includes representatives of *Oreochromis*, *Sarotherodon*, *Alcolapia*, *Tristramella*, *Iranocichla* and *Stomatepia*, and strongly supports their monophyly (BS 100, BPP 1.0). In addition, the molecular phylogeny of Wagner *et al.* (2012) includes the multiple species of the genera *Oreochromis*, *Sarotherodon*, *Alcolapia*, *Stomatepia*, and *Konia*, as well as *Tristramella simonis*, *Iranocichla hormuzensis*, *Pungu maclareni*, and *Myaka myaka* (the latter three being the only valid species of their respective genera), and strongly support their monophyly of (BS 100, BPP 1.0). Genus *Danakilia* has never been included in a molecular data set, but is considered closely related to *Iranocichla* and *Tristramella*, and is therefore included in Oreochromini (Schwarzer *et al.* 2009). Our RAxML phylogeny supports monophyly of Oreochro-

mini with BS 98.

First occurrence: *Oreochromis* †*martyini* (Van Couvering, 1982) from the Ngorora Formation, Kenya. *Oreochromis* †*lorenzoii* Carnevale, Sorbini, and Landini, 2003 from the Gessoso-Solfifera Formation, Italy, is frequently considered the oldest member of the genus *Oreochromis* (Genner *et al.* 2007), however there is no reason to ignore *Oreochromis* †*martyini*, that has originally been described as *Sarotherodon* †*martyini*, but reassigned to the genus *Oreochromis*, and is older than *Oreochromis* †*lorenzoii* (Murray & Stewart 1999). Even if *Oreochromis* †*martyini* should not be part of genus *Oreochromis*, its inclusion in Oreochromines is not questioned. The earliest record of *Oreochromis* †*martyini* is between layers of the Ngorora Formation that were dated at 9.3 and 12.0 Ma (Van Couvering 1982; Murray & Stewart 1999). Thus, the first occurrence of Oreochromines dates to 12.0-9.3 Ma.

Diversity: 63 extant species Froese & Pauly (2015).

Sampled species: *Alcolapia alcalica*, *Iranocichla hormuzensis*, *Konia dikume*, *Konia eisenbrauti*, *Myaka myaka*, *Oreochromis aureus*, *Oreochromis leucostictus*, *Oreochromis esculentus*, *Oreochromis urolepis*, *Oreochromis mweruensis*, *Oreochromis macrochir*, *Oreochromis andersonii*, *Oreochromis mossambicus*, *Oreochromis tanganicae*, *Oreochromis schwebischi*, *Oreochromis amphimelas*, *Oreochromis variabilis*, *Oreochromis karongae*, *Oreochromis niloticus*, *Pungu maclareni*, *Sarotherodon caudomarginatus*, *Sarotherodon melanotheron*, *Sarotherodon nigripinnis*, *Sarotherodon occidentalis*, *Sarotherodon galilaeus*, *Sarotherodon lohbergeri*, *Sarotherodon mvogoi*, *Stomatepia mariae*, and *Tristramella simonis*.

Clade 387: *Chilochromis*

Taxonomy: One out of three genera of Tilapiini (Dunz & Schlieven 2013). The genus *Chilochromis* includes a single species, *C. duponti*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Chilochromis duponti*.

Clade 388: *Congolapia*

Taxonomy: One out of three genera of Tilapiini (Dunz & Schlieven 2013). The genus *Congolapia* includes three species, *C. bilineata*, *C. crassa*, and *C. louna*.

Support: Monophyly of the genus *Congolapia* is supported by morphological characteristics as described in Dunz *et al.* (2012). The molecular phylogeny of Dunz & Schlieven (2013) includes *Congolapia bilineata* and *C. crassa*, and strongly supports their sister group relationship (BS 100).

First occurrence: Recent.

Diversity: 3 extant species.

Sampled species: *Congolapia bilineata*.

Clade 389: *Tilapia ruweti*

Taxonomy: One out of four species remaining in the revised genus *Tilapia* (Dunz & Schlieven

2013). Besides *Tilapia ruweti*, the three other species included in the genus are *T. sparrmanii* (type species), *T. baloni*, and *T. guinasana*. Of these, *T. baloni* is described in Trewavas & Stewart (1975) and considered very closely related to *T. sparrmani*, possibly even at subspecies level. The molecular phylogenies of Schwarzer *et al.* (2009; BS 53) and Dunz & Schliewen (2013; BS 74) include three out of four species of the genus *Tilapia*, *T. ruweti*, *T. sparrmani*, and *T. guinasana*, and support their monophyly. The same phylogenies provide much higher support for a sister group relationship of *T. sparrmani* and *T. guinasana* (BS 100, BPP 1.0). Given the weak support for genus *Tilapia* in our RAxML phylogeny (BS 82), we consider monophyly of subgenus *Tilapia* likely, but do not constrain all four species to form a monophyletic group in our analyses. Instead we consider *T. ruweti* as separate from a monophyletic clade combining the three species *T. sparrmani*, *T. guinasana*, and *T. baloni*. “*Tilapia*” *jallae* can not be reliably assigned to a taxon of the former genus *Tilapia* (prior to the revision of Dunz & Schliewen 2013) (see Supplementary Table S9).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Tilapia ruweti*.

Clade 390: *Tilapia sparrmanii*+allies

Taxonomy: Combines three out of four species remaining in the revised genus *Tilapia* (Dunz & Schliewen 2013), *Tilapia sparrmani*, *T. guinasana*, and *T. baloni*. See comments for clade 389 (*Tilapia ruweti*).

Support: No synapomorphies are known to unite *Tilapia sparrmani*, *T. guinasana*, and *T. baloni* without *T. ruweti*. However, the molecular phylogenies of Schwarzer *et al.* (2009) and Dunz & Schliewen (2013) include *T. sparrmani* and *T. guinasana*, and strongly support a sister group relationship of the two species (BS 100, BPP 1.0). In addition, *T. baloni* is morphologically highly similar to *T. sparrmani*, and is found in the same geographic region, therefore, we include *T. baloni* in *Tilapia sparrmanii*+allies (see clade 389). Our RAxML phylogeny includes *T. sparrmani* and *T. guinasana* and supports their sister group relationship with BS 100.

First occurrence: Recent.

Diversity: 3 extant species.

Sampled species: *Tilapia sparrmanii* and *Tilapia guinasana*.

Clade 391: Steatocranini

Taxonomy: Following Dunz & Schliewen (2013), we recognize Steatocranini as a tribe of Pseudocrenilabrinae, including a single genus, *Steatocranus*. We exclude “*Steatocranus*” *irvinei* from genus *Steatocranus* and Steatocranini, in which then ten species remain (Schwarzer *et al.* 2011b).

Support: Synapomorphies are given in Dunz & Schliewen (2013). Furthermore, the disjunct geographic distribution of “*Steatocranus*” *irvinei* and all other species of genus *Steatocranus* supports separation of “*Steatocranus*” *irvinei* from the genus. In addition, the molecular phylogenies of Schwarzer *et al.* (2009, 2011a) include all species of *Steatocranus*, and strongly support their monophyly after exclusion of “*Steatocranus*” *irvinei* (BS 100, BPP 1.0). Our RAxML phylogeny supports

monophyly of Steatocranini with BS 100.

First occurrence: Recent.

Diversity: 10 extant species (Schwarzer *et al.* 2011b).

Sampled species: *Steatocranus tinanti*, *Steatocranus glaber*, *Steatocranus gibbiceps*, *Steatocranus bleheri*, *Steatocranus casuarius*, *Steatocranus ubanguiensis*.

Clade 392: *Pelmatolapia cabrae*

Taxonomy: One out of two species included in genus *Pelmatolapia* (Dunz & Schliewen 2013).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Pelmatolapia cabrae*.

Clade 393: *Pelmatolapia mariae*

Taxonomy: One out of two species included in genus *Pelmatolapia* (Dunz & Schliewen 2013).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Pelmatolapia mariae*.

Clade 394: “*Tilapia*” *brevimanus*

Taxonomy: One out of six species included in tribe Gobiocichlini, together with *Gobiocichla wonderi*, *Gobiocichla ethelwynnae*, “*Steatocranus*” *irvinei*, “*Tilapia*” *busumama*, “*Tilapia*” *brevimanus*, and “*Tilapia*” *pra* (Dunz & Schliewen 2013).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Tilapia*” *brevimanus*.

Clade 395: *Gobiocichla*

Taxonomy: Genus *Gobiocichla* includes two species, *Gobiocichla wonderi* and *G. ethelwynnae*, and is included in tribe Gobiocichlini, together with “*Steatocranus*” *irvinei*, “*Tilapia*” *busumama*, “*Tilapia*” *brevimanus*, and “*Tilapia*” *pra* (Dunz & Schliewen 2013).

Support: Monophyly of *Gobiocichla* is supported by “a suite of derived features” (Stiassny *et al.* 2007). In contrast, molecular phylogenies (Wagner *et al.* 2012; Dunz & Schliewen 2013) have so far failed to corroborate the monophyly of the genus.

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: *Gobiocichla wonderi*.

Clade 396: “*Steatocranus*” *irvinei*

Taxonomy: Following Schwarzer *et al.* (2009) and Dunz & Schliewen (2013), we here exclude “*Steatocranus*” *irvinei* from genus *Steatocranus*, based on the molecular phylogenies of Schwarzer *et al.* (2009), Wagner *et al.* (2012), and Dunz & Schliewen (2013), which strongly support non-monophyly of *Steatocranus* including “*Steatocranus*” *irvinei*, and monophyly of all remaining species of *Steatocranus* (BS 100, BPP 1.0). Moreover, the disjunct biogeography of “*Steatocranus*” *irvinei* supports its separation from the genus.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Steatocranus*” *irvinei*.

Clade 397: “*Tilapia*” *busumana*+“*Tilapia*” *pra*

Taxonomy: Combines two out of six species of tribe Gobiocichlini (Dunz & Schliewen 2013), “*Tilapia*” *busumana* and “*Tilapia*” *pra* (Dunz & Schliewen 2010b).

Support: As described in Dunz & Schliewen (2010b), “*Tilapia*” *busumana* and “*Tilapia*” *pra* have an overlapping distribution and can only be distinguished on the basis of ground coloration, which supports a sister group relationship of the two species. The molecular phylogeny of Dunz & Schliewen (2013) further corroborates the monophyly of the two species (BS 100).

First occurrence: Recent.

Diversity: 2 extant species (Dunz & Schliewen 2010b).

Sampled species: *Tilapia busumana*.

Clade 398: Coelotilapiini

Taxonomy: Following Dunz & Schliewen (2013), we here recognize Coelotilapiini as a tribe of Pseudocrenilabrinae. Coelotilapiini include a single genus, *Coelotilapia*, and a single species, *Coelotilapia joka*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Tilapia joka*.

Clade 399: Heterotilapiini

Taxonomy: Following Dunz & Schliewen (2013), we here recognize Heterotilapiini as a tribe of Pseudocrenilabrinae. Heterotilapiini includes a single genus, *Heterotilapia*, and two species, *Heterotilapia cessiana* and *H. buttikoferi* (Dunz & Schliewen 2013).

Support: Synapomorphies are given in Dunz & Schliewen (2013). The molecular phylogeny of Wagner *et al.* (2012) strongly supports a sister group relationship of *Heterotilapia cessiana* and *H. buttikoferi* (BS 98). Our RAxML phylogeny supports monophyly of Heterotilapiini with BS 100.

First occurrence: Recent.

Diversity: 2 extant species.

Sampled species: All sampled species of clades 400 and 401.

Clade 400: *Heterotilapia cessiana*

Taxonomy: One out of two species of *Heterotilapia* (Dunz & Schliewen 2013).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Heterotilapia cessiana*.

Clade 401: *Heterotilapia buttikoferi*

Taxonomy: One out of two species of *Heterotilapia* (Dunz & Schliewen 2013).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Heterotilapia buttikoferi*.

Clade 402: Coptodiini

Taxonomy: Following Dunz & Schliewen (2013), we here recognize Coptodiini as a tribe of Pseudocrenilabrinae. Coptodiini include a single genus, *Coptodon*, which combines all species of the previous subgenera *Tilapia* (*Coptodon*) and *Tilapia* (*Dageti*), as well as three undescribed species (Dunz & Schliewen 2013).

Support: Monophyly of genus *Coptodon* is supported by a number of synapomorphies (Dunz & Schliewen 2010a), as well as by the molecular phylogenies of Schwarzer *et al.* (2009), Wagner *et al.* (2012), and Dunz & Schliewen (2013) (BS 100). The fact that *Coptodon discolor* appears outside of genus *Coptodon* as the sister to “*Tilapia*” *busumana* in Klett & Meyer (2002; BS 72) and in our RAxML phylogeny (BS 100), or to a clade combining “*Tilapia*” *busumana* and *Gobiocichla ethelwynna* in Wagner *et al.* (2012; BS 73), but deeply nested within genus *Coptodon* in all phylogenies that did not include the ND2 sequence of Klett & Meyer (2002) (Nagl *et al.* 2001, Schwarzer *et al.* 2009; BS 100, BPP 1.0), suggests that the discrepancy is due to either misidentification or mitochondrial introgression from the sympatrically occurring “*Tilapia*” *busumana* (Schwarzer *et al.* 2009, Additional file 3). We therefore exclude *C. discolor* from our data set for all analyses subsequent to the ML phylogenetic inference with RAxML, and assume that *C. discolor* is part of a well supported genus *Coptodon*.

First occurrence: Cichlidae fossils from Jordan Valley, Israel. Cichlid fossils from the Jordan Valley, Israel, are reported to be similar to *Coptodon zillii* (Avnimelech & Steinitz 1951; Murray 2001a), and are therefore here considered to represent the first occurrence of genus *Coptodon*. The age of these fossils is given as Murray (2001a). Thus, the first occurrence of genus *Coptodon* dates to 5.332-2.588 Ma.

Diversity: 34 extant species (see above).

Sampled species: *Coptodon dageti*, *Coptodon tholloni*, *Coptodon guineensis*, *Coptodon louka*, *Coptodon* aff. *rheophila*, *Coptodon bemini*, *Coptodon snyderae*, *Coptodon rendalli*, *Coptodon walteri*, *Coptodon zillii*, *Coptodon coffea*, and *Coptodon discolor* (excluded from BEAST analyses, see

above).

Clade 403: “East African radiation”

Taxonomy: The “East African radiation” includes all cichlids endemic to Lake Tanganyika with the exception of Tylochromini, plus the riverine lineages *Astatoreochromis*, *Pseudocrenilabrus*, *Orthochromis*, *Ctenochromis*, *Schwetzoichromis*, *Cyclopharynx*, *Thoracochromis*, *Serranochromis*, *Chetia*, *Sargochromis*, *Pharyngochromis*, as well as all “modern haplochromines” of Salzburger *et al.* (2005). This clade is identical to the clade named “Austrotilapiini AI (EAR)” in Schwarzer *et al.* (2009).

Support: Its biogeographic distribution (see Salzburger *et al.* 2005), as well as the molecular phylogenies of Schwarzer *et al.* (2009; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS 96) strongly support monophyly of the “East African radiation” clade. Our RAxML phylogeny supports monophyly of this clade with BS 92.

First occurrence: Recent fossils from the Baid Formation, Ad Darb locality, Tihamat Asir, Saudi Arabia, were tentatively assigned to genus *Astatotilapia* by Micklich & Roscher (1990) on the basis of ctenoid scale morphology. However, as demonstrated by Murray (2000b), ctenoid scale morphology is a highly variable character among cichlid fishes. Moreover, genus *Astatotilapia* has been shown to be non-monophyletic (Salzburger *et al.* 2005; Wagner *et al.* 2012), therefore the genus assignment of Micklich & Roscher (1990) can not be upheld (Lippitsch & Micklich 1998). For these reasons, we do not assume fossils from the Baid Formation to represent the first occurrence of the “East African radiation”.

Diversity: 1886 extant species.

Sampled species: All sampled species of clades 404, 405, 415, 416, 417, 426, 427, 428, 429, 430, 433, 434, 435, 436, 441, 442, 443, 444, 445, 446, 447, 448, 449, 450, 451, 452, 453, 454, and 455.

Clade 404: Boulengerochromini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Boulengerochromini include a single genus, *Boulengerochromis*, and a single species, *B. microlepis*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Boulengerochromis microlepis*.

Clade 405: Bathybatini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Bathybatini include three genera, *Trematocara*, *Hemibates*, and *Bathybates*.

Support: Synapomorphies are given in Takahashi (2003). The molecular phylogenies of Day *et al.* (2008; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS 99) include representatives of all three genera and strongly support their monophyly. Our RAxML phylogeny supports monophyly of Bathybatini with BS 100.

First occurrence: Recent.

Diversity: 17 extant species.

Sampled species: All sampled species of clades 406, 407, 408, 409, 410, 411, 412, 413, and 414.

Clade 406: *Trematocara*

Taxonomy: One out of three genera of Bathybatini (Takahashi 2003; Kirchberger *et al.* 2012). Has previously been considered a tribe on its own, Trematocarini (Poll 1986). The genus *Trematocara* includes nine species (Froese & Pauly 2015).

Support: Synapomorphies are given in Takahashi (2002). The molecular phylogeny of Koblmüller *et al.* (2005; BS 96) and Kirchberger *et al.* (2012; BS 100, BPP 1.0) include two out of nine species of *Trematocara* and strongly support their monophyly. Our RAxML phylogeny supports monophyly of *Trematocara* with BS 100.

First occurrence: Recent.

Diversity: 9 extant species (Froese & Pauly 2015).

Sampled species: *Trematocara unimaculatum*, *Trematocara marginatum*, and *Trematocara nigrifrons*.

Clade 407: *Hemibates*

Taxonomy: One out of three genera of Bathybatini (Takahashi 2003; Kirchberger *et al.* 2012). The genus *Hemibates* includes a single species, *H. stenosoma*.

Support: This clade includes a single species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Hemibates stenosoma*.

Clade 408: *Bathybates minor*

Taxonomy: One out of seven species of *Bathybates*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Bathybates minor*.

Clade 409: *Bathybates graueri*

Taxonomy: One out of seven species of *Bathybates*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Bathybates graueri*.

Clade 410: *Bathybates hornii*

Taxonomy: One out of seven species of *Bathybates*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Bathybates hornii*.

Clade 411: *Bathybates fasciatus*

Taxonomy: One out of seven species of *Bathybates*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Bathybates fasciatus*.

Clade 412: *Bathybates ferox*

Taxonomy: One out of seven species of *Bathybates*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Bathybates ferox*.

Clade 413: *Bathybates vittatus*

Taxonomy: One out of seven species of *Bathybates*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Bathybates vittatus*.

Clade 414: *Bathybates leo*

Taxonomy: One out of seven species of *Bathybates*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Bathybates leo*.

Clade 415: Eretmodini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Eretmodini include three genera, *Eretmodus*, *Spathodus*, and *Tanganicodus*.

Support: Synapomorphies are given in Takahashi (2003). The molecular phylogenies of Salzburger *et al.* (2005; BS 100, BPP 1.0), Day *et al.* (2008; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS 92) include representatives of all three genera and strongly support their monophyly. Our RAxML phylogeny supports monophyly of Eretmodini with BS 100.

First occurrence: Recent.

Diversity: 5 extant species.

Sampled species: *Eretmodus cyanostictus*, *Spathodus erythrodon*, *Spathodus marlieri*, and *Tanganicodus irsacae*.

Clade 416: Lamprologini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Lamprologini include eight genera, *Altolamprologus*, *Chalinochromis*, *Julidochromis*, *Lamprologus*, *Lepidiolamprologus*, *Neolamprologus*, *Telmatochromis*, and *Variabilichromis*. Molecular evidence suggests that all genera except *Altolamprologus* and *Variabilichromis* are nonmonophyletic, but does not question monophyly of Lamprologini as a whole (Day *et al.* 2008).

Support: Synapomorphies are given in Takahashi (2003). Lamprologini are further characterized by shell-brooding behaviour, whereas most other cichlids of the “East African radiation” are mouth-brooders (Takahashi 2003). The molecular phylogenies of Salzburger *et al.* (2005; BS 100, BPP 1.0), Day *et al.* (2008; BS 100, BPP 1.0), and Wagner *et al.* (2012; BS 99) include up to 82 out of 91 species of Lamprologini and strongly support their monophyly. Our RAXML phylogeny supports monophyly of Lamprologini with BS 99.

First occurrence: Recent.

Diversity: 91 extant species (Froese & Pauly 2015).

Sampled species: *Altolamprologus calvus*, *Altolamprologus compressiceps*, *Chalinochromis brichardi*, *Chalinochromis popelini*, *Julidochromis dickfeldi*, *Julidochromis marlieri*, *Julidochromis ornatus*, *Julidochromis regani*, *Julidochromis transcriptus*, *Lamprologus callipterus*, *Lamprologus congoensis*, *Lamprologus kungweensis*, *Lamprologus laparogramma*, *Lamprologus lemairii*, *Lamprologus melea-gris*, *Lamprologus mocquardi*, *Lamprologus ocellatus*, *Lamprologus ornatipinnis*, *Lamprologus signatus*, *Lamprologus speciosus*, *Lamprologus teugelsi*, *Lamprologus tigripictilis*, *Lamprologus werneri*, *Lepidiolamprologus attenuatus*, *Lepidiolamprologus cunningtoni*, *Lepidiolamprologus elongatus*, *Lepidiolamprologus kendalli*, *Lepidiolamprologus nkambae*, *Lepidiolamprologus profundicola*, *Neolamprologus bifasciatus*, *Neolamprologus brevis*, *Neolamprologus brichardi*, *Neolamprologus buescheri*, *Neolamprologus caudopunctatus*, *Neolamprologus christyi*, *Neolamprologus cylindricus*, *Neolamprologus falcicula*, *Neolamprologus fasciatus*, *Neolamprologus furcifer*, *Neolamprologus helianthus*, *Neolamprologus leloupi*, *Neolamprologus marunguensis*, *Neolamprologus modestus*, *Neolamprologus mondabu*, *Neolamprologus multifasciatus*, *Neolamprologus mustax*, *Neolamprologus nigriventris*, *Neolamprologus olivaceous*, *Neolamprologus pectoralis*, *Neolamprologus prochilus*, *Neolamprologus pulcher*, *Neolamprologus savoryi*, *Neolamprologus sexfasciatus*, *Neolamprologus similis*, *Neolamprologus tetracanthus*, *Neolamprologus toae*, *Neolamprologus tretocephalus*, *Neolamprologus ventralis*, *Telmatochromis bifrenatus*, *Telmatochromis brichardi*, *Telmatochromis dhonti*, *Telmatochromis vittatus*, and *Variabilichromis moorii*.

Clade 417: “Proto-Malagarasi River system *Orthochromis*”

Taxonomy: Non-monophyly of the riverine cichlid genus *Orthochromis* is strongly supported by the molecular phylogenies of Salzburger *et al.* (2005), Koblmüller *et al.* (2008), Wagner *et al.* (2012), and Schwarzer *et al.* (2012). However, molecular phylogenies have so far included 13 out of 14 valid species of genus *Orthochromis* and consistently recover four monophyletic groups that coincide with

their biogeographic distribution: (i) All *Orthochromis* of the Western Tanzania/Burundi river systems Malagarasi, Rugufu, and Luiche that drain into north-western Lake Tanganyika no more than 30 km from each other and have previously been connected in the “Proto-Malagarasi River system” (De Vos & Seegers 1998; Thieme *et al.* 2005), this group includes *O. kasuluensis*, *O. luichensis*, *O. malagaraziensis*, *O. mazimeroensis*, *O. mosoensis*, *O. rubrolabialis*, *O. rugufuensis*, and *O. uvinzae*; (ii) *O. stormsi* and *O. polyacanthus*, that both occur in the upper Congo River basin; (iii) *O. torrenticola*, which also occurs in the upper Congo River basin, but seems to be phylogenetically separated from *O. stormsi* and *O. polyacanthus* (Schwarzer *et al.* 2012); (iv) *O. machadoi*, with a distribution limited to the Cunene River in Angola and Namibia. The relationships of the two remaining species of genus *Orthochromis* (*O. kalungwishiensis* and *O. luongoensis*) remain uncertain. The molecular phylogeny of Schwarzer *et al.* (2012) includes *Orthochromis* sp. aff. *kalungwishiensis*, which appears closely related to either *Pseudocrenilabrus* (on the basis of mtDNA; BS 95) or *O. stormsi* and *O. polyacanthus* (based on nuclear DNA; BS 94). *O. luongoensis* has never been included in a molecular phylogeny, but is suspected to be closely related to *O. kalungwishiensis* (Cotterill 2006).

Support: No synapomorphies are known to unite the eight species included in “Proto-Malagarasi River system *Orthochromis*”, however the molecular phylogenies of Salzburger *et al.* (2005) and Wagner *et al.* (2012) include all eight species of this clade, and strongly support its monophyly (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of “Proto-Malagarasi River system *Orthochromis*” with BS 100.

First occurrence: Recent.

Diversity: 8 extant species (see above).

Sampled species: All sampled species of clades 418, 419, 420, 421, 422, 423, 424, and 425.

Clade 418: *Orthochromis luichensis*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”. See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis luichensis*.

Clade 419: *Orthochromis uvinzae*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”. See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis uvinzae*.

Clade 420: *Orthochromis rugufuensis*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”.

See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis rugufuensis*.

Clade 421: *Orthochromis rubrolabialis*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”.

See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis rubrolabialis*.

Clade 422: *Orthochromis kasuluensis*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”.

See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis kasuluensis*.

Clade 423: *Orthochromis mosoensis*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”.

See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis mosoensis*.

Clade 424: *Orthochromis mazimeroensis*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”.

See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis mazimeroensis*.

Clade 425: *Orthochromis malagaziensis*

Taxonomy: One out of eight species included in “Proto-Malagarasi River system *Orthochromis*”.

See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Orthochromis malagaraziensis*.

Clade 426: Cyphotilapiini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Cyphotilapiini include a single genus, *Cyphotilapia*, and two species, *Cyphotilapia frontosa* and *C. gibberosa* (Froese & Pauly 2015).

Support: Synapomorphies are given in Takahashi (2003) and Takahashi & Nakaya (2003).

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: *Cyphotilapia frontosa*.

Clade 427: “*Ctenochromis*” *benthicola*

Taxonomy: Nonmonophyly of the genus *Ctenochromis* is supported by morphological (Takahashi 2003) and molecular phylogenies (Muschick *et al.* 2012). We follow Stiassny *et al.* (2011) in assuming that *Ctenochromis luluae* (= *Haplochromis luluae*) may be a synonym of *Haplochromis stigmatogenys* (= *Thoracochromis stigmatogenys*). The remaining five species included in genus *Ctenochromis* according to Froese & Pauly (2015) are *C. benthicola*, *C. horei*, *C. pectoralis*, *C. oligacanthus*, and *C. polli*, which are all included in our RAxML phylogeny, and here considered individual lineages.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: “*Ctenochromis*” *benthicola*.

Clade 428: *Triglachromis*

Taxonomy: One out of six genera of Limnochromini according to Takahashi (2003). Limnochromini, as recognized by Takahashi (2003), exclude the genus *Greenwoodochromis*, however, molecular evidence supports monophyly of Limnochromini only when *Greenwoodochromis* is included (Day *et al.* 2008; Wagner *et al.* 2012). Genus *Triglachromis* includes a single species, *Triglachromis otostigma*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Triglachromis otostigma*.

Clade 429: *Limnochromis abeelei*

Taxonomy: Genus *Limnochromis* includes three species, *Limnochromis abeelei*, *L. staneri*, and *L. auritus*, but is nonmonophyletic according to the molecular phylogenies of Day *et al.* (2008) and

Wagner *et al.* (2012). All three species are included in our molecular data set.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Limnochromis abeelei*.

Clade 430: *Greenwoodochromis*

Taxonomy: Genus *Greenwoodochromis* is included in Limnochromini in Poll (1986), but is placed in its own tribe, Greenwoodochromini, in Takahashi (2003). The genus includes two species, *Greenwoodochromis bellcrossi* and *G. christyi* (Froese & Pauly 2015).

Support: Synapomorphies are given in Takahashi (2003) for tribe Greenwoodochromini. The molecular phylogenies of Day *et al.* (2008; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS < 50) strongly support a sister group relationship of *Greenwoodochromis bellcrossi* and *G. christyi*. Our RAxML phylogeny supports monophyly of *Greenwoodochromis* with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 431 and 432.

Clade 431: *Greenwoodochromis bellcrossi*

Taxonomy: One out of two species included in *Greenwoodochromis*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Greenwoodochromis bellcrossi*.

Clade 432: *Greenwoodochromis christyi*

Taxonomy: One out of two species included in *Greenwoodochromis*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Greenwoodochromis christyi*.

Clade 433: *Limnochromis staneri*

Taxonomy: One out of three species included in *Limnochromis*, which is strongly supported to be nonmonophyletic. See clade 429 (*Limnochromis abeelei*).

Support: This clade includes a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Limnochromis staneri*.

Clade 434: *Limnochromis auritus*+allies

Taxonomy: Combines the three monotypic genera *Baileychromis*, *Reganochromis*, and *Tangachromis* with the individual species *Limnochromis auritus* and *Gnathochromis permaxillaris*. This group is identical to tribe Limnochromini of Takahashi (2003) with the exception that *Triglachromis* is included in Takahashi's (2003) Limnochromini. However, Takahashi (2003) did not include *Limnochromis abeelei* and *Limnochromis staneri* in his data set and may have assumed monophyly of the genus *Limnochromis*. Non-monophyly of genus *Gnathochromis* is supported by morphological and molecular data (Takahashi 2003; Wagner *et al.* 2012; Muschick *et al.* 2012).

Support: No synapomorphies are known to unite *Limnochromis auritus*+allies, however the molecular phylogenies of Day *et al.* (2008; BS 98, BPP 1.0) and Wagner *et al.* (BS < 50) include all species of *Limnochromis auritus*+allies except *Tangachromis*, and strongly support their monophyly.

First occurrence: Recent.

Diversity: 5 extant species (Froese & Pauly 2015).

Sampled species: *Gnathochromis permaxillaris*, *Limnochromis auritus*, *Baileychromis centropomoides*, and *Reganochromis calliurus*.

Clade 435: Benthochromini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Benthochromini include a single genus, *Benthochromis*, and three species, *B. horii*, *B. melanoides*, and *B. tricoti* (Froese & Pauly 2015).

Support: Synapomorphies are given in Takahashi (2003). The molecular phylogeny of Day *et al.* (2008) and Wagner *et al.* (2012) include two out of three species of Benthochromini, and strongly support their sister group relationship (BS 100, BPP 1.0). Our RAxML phylogeny supports monophyly of Benthochromini with BS 100.

First occurrence: Recent.

Diversity: 3 extant species (Froese & Pauly 2015).

Sampled species: *Benthochromis melanoides* and *Benthochromis tricoti*.

Clade 436: Cyprichromini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Cyprichromini include two genera, *Cyprichromis* and *Paracyprichromis*.

Support: Synapomorphies are given in Takahashi (2003). The molecular phylogenies of Day *et al.* (2008; BS 96, BPP 1.0) and Muschick *et al.* (2012; BPP 1.0) include representatives of both genera of Cyprichromini and strongly support their sister group relationship. Our RAxML phylogeny supports monophyly of Cyprichromini with BS 99.

First occurrence: Recent.

Diversity: 7 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 437 and 440.

Clade 437: *Paracyprichromis*

Taxonomy: One out of two genera of Cyprichromini. The genus *Paracyprichromis* includes two

species, *P. brieni* and *P. nigripinnis* (Froese & Pauly 2015).

Support: Synapomorphies are given in Takahashi (2004). The molecular phylogenies of Day *et al.* (2008; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS < 50) include both species of genus *Paracyprichromis* and strongly support their sister group relationship. Our RAxML phylogeny supports monophyly of *Paracyprichromis* with BS 100.

First occurrence: Recent.

Diversity: 2 extant species (Froese & Pauly 2015).

Sampled species: All sampled species of clades 438 and 439.

Clade 438: *Paracyprichromis brieni*

Taxonomy: One out of two species of *Paracyprichromis*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Paracyprichromis brieni*.

Clade 439: *Paracyprichromis nigripinnis*

Taxonomy: One out of two species of *Paracyprichromis*.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Paracyprichromis nigripinnis*.

Clade 440: *Cyprichromis*

Taxonomy: One out of two genera of Cyprichromini. The genus *Cyprichromis* includes five species, *C. coloratus*, *C. leptosoma*, *C. microlepidotus*, *C. pavo*, and *C. zonatus* (Froese & Pauly 2015).

Support: Synapomorphies are given in Takahashi (2004). The molecular phylogenies of Day *et al.* (2008; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS < 50) include four out of five species of genus *Cyprichromis* and strongly support their monophyly. Our RAxML phylogeny supports monophyly of *Cyprichromis* with BS 100.

First occurrence: Recent.

Diversity: 5 extant species (Froese & Pauly 2015).

Sampled species: *Cyprichromis pavo*, *Cyprichromis zonatus*, *Cyprichromis leptosoma*, and *Cyprichromis microlepidotus*.

Clade 441: Perissodini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Perissodini include four genera, *Haplotaxodon*, *Perissodus*, *Plecodus*, *Xenochromis*. Molecular phylogenies suggest that all genera except the monotypic *Xenochromis* may be nonmonophyletic (Wagner *et al.* 2012; Muschick *et al.* 2012), but do not question the monophyly of Perissodini as a whole.

Support: Synapomorphies are given in Takahashi (2003). The molecular phylogenies of Day *et al.*

(2008; BS 100, BPP 1.0), Wagner *et al.* (2012; BS 100) and Muschick *et al.* (2012; BPP 1.0) include at least three out of four genera of tribe Perissodini and strongly support their monophyly. Our RAxML phylogeny supports monophyly of Perissodini with BS 100.

First occurrence: Recent.

Diversity: 9 extant species (Froese & Pauly 2015).

Sampled species: *Xenochromis hecqui*, *Plecodus multidentatus*, *Perissodus eccentricus*, *Plecodus straeleni*, *Perissodus microlepis*, *Haplotaxodon trifasciatus*, *Haplotaxodon microlepis*, and *Plecodus paradoxus*.

Clade 442: Ectodini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Ectodini include ten genera, *Aulonocranus*, *Callochromis*, *Cardiopharynx*, *Cunningtonia*, *Cyathopharynx*, *Ectodus*, *Grammatotria*, *Lestradea*, *Ophthalmotilapia*, and *Xenotilapia*. Molecular evidence suggests that at least some of the genera included in Ectodini are nonmonophyletic (Day *et al.* 2008; Wagner *et al.* 2012; Muschick *et al.* 2012).

Support: Synapomorphies are given in Takahashi (2003). The molecular phylogenies of Day *et al.* (2008; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS < 50) include all genera of tribe Ectodini, and strongly support their monophyly. Our RAxML phylogeny supports monophyly of Ectodini with BS 97.

First occurrence: Recent.

Diversity: 33 extant species (Froese & Pauly 2015).

Sampled species: *Aulonocranus dewindti*, *Callochromis macrops*, *Callochromis pleurospilus*, *Cardiopharynx schoutedeni*, *Cunningtonia longiventralis*, *Cyathopharynx furcifer*, *Ectodus descampsii*, *Grammatotria lemairii*, *Lestradea perspicax*, *Lestradea stappersii*, *Ophthalmotilapia boops*, *Ophthalmotilapia nasuta*, *Ophthalmotilapia ventralis*, *Xenotilapia bathyphila*, *Xenotilapia boulengeri*, *Xenotilapia caudafasciata*, *Xenotilapia flavipinnis*, *Xenotilapia leptura*, *Xenotilapia melanogenys*, *Xenotilapia ochrogenys*, *Xenotilapia rotundiventralis*, *Xenotilapia sima*, *Xenotilapia spiloptera*, and *Xenotilapia tenuidentata*.

Clade 443: *Ctenochromis pectoralis*

Taxonomy: One out of five species of the nonmonophyletic genus *Ctenochromis*. See clade 427 ("*Ctenochromis*" *benthicola*).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Ctenochromis pectoralis*.

Clade 444: "Serranochromines"

Taxonomy: Combines all species of the riverine genera *Schwetzochromis*, *Cyclopharynx*, *Serranochromis*, *Chetia*, *Sargochromis*, and *Pharyngochromis* with eight out of twelve species currently included in *Thoracochromis* (Froese & Pauly 2015). Specifically, we exclude *Thoracochromis moeru-*

ensis, which is more closely related to *Pseudocrenilabrus* (Wagner *et al.* 2012) and *Thoracochromis wingatii*, which is nested within the “Lake Victoria region superflock”, based on molecular evidence and its geographic distribution (Wagner *et al.* 2012). The placement of two more species of *Thoracochromis* (*T. lucullae* and *T. schwetzi*) is uncertain and assumed to lie either with “Serranochromines” or with *Pseudocrenilabrus*, based on their geographic distribution in Angola. Inclusion of the remaining eight species of *Thoracochromis* (*T. albolabris*, *T. bakongo*, *T. brauschi*, *T. buysi*, *T. callichromus*, *T. demeusii*, *T. fasciatus*, and *T. stigmatogenys*) is supported by molecular data of Koblmüller *et al.* (2008), Wagner *et al.* (2012), and Schwarzer *et al.* (2012). Based on molecular evidence of Salzburger *et al.* (2005; BS 62, BPP 1.0), Koblmüller *et al.* (2008; BS 100, BPP 1.0), Wagner *et al.* (2012; BS 87) and Schwarzer *et al.* (2012; BS 100, BPP 1.0), we further include *Orthochromis stormsi*, *Orthochromis polyacanthus*, *Orthochromis torrenticola*, and the two closely related *Ctenochromis polli* and *Ctenochromis oligacanthus*. It remains unclear whether *Orthochromis kalungwishiensis* and the closely related (Cotterill 2006) *Orthochromis luongoensis* should also be included in “Serranochromines”, as Schwarzer *et al.* (2012) find support for a clade combining *Orthochromis* sp. aff. *kalungwishiensis* and *Pseudocrenilabrus* on the basis of mtDNA (BS 95), but for a clade combining *Orthochromis* sp. aff. *kalungwishiensis*, *Orthochromis stormsi*, and *Orthochromis polyacanthus* on the basis of nuclear AFLP data (BS 94). We also consider *Haplochromis snoeksi*, *Haplochromis bakongo*, and *Haplochromis fasciatus* as part of “Serranochromines”, based on their distribution and the molecular data of Schwarzer *et al.* (2012), which strongly supports inclusion of the three species (BS 93, BPP 1.0 for *H. snoeksi* and *H. bakongo* based on mtDNA, and BS 100, BPP 1.0 for *H. fasciatus* based on nuclear DNA). Finally, we assume the inclusion of four rare species still listed as *Haplochromis* in Froese & Pauly (2015), based on their mostly riverine distribution in Congo, Angola, and Botswana: *H. humilis*, *H. multiocellatus*, *H. placodus*, and *H. smithii*. Thus, “Serranochromines”, as defined here, comprise at least 50 species.

Support: No synapomorphies are known to unite “Serranochromines”, as defined here. However, the molecular phylogenies of Salzburger *et al.* (2005; BS 67, BPP 1.0), Koblmüller *et al.* (2008; BS 77, BPP 1.0), Wagner *et al.* (2012; BS 87), and Schwarzer *et al.* (2012; BS 93, BPP 1.0; based on mtDNA) strongly support monophyly of “Serranochromines”. Our RAxML phylogeny supports monophyly of “Serranochromines” with BS 93.

First occurrence: Recent.

Diversity: 50 extant species (see above).

Sampled species: *Chetia brevicauda*, *Chetia brevis*, *Chetia flaviventris*, *Ctenochromis oligacanthus*, *Ctenochromis polli*, *Cyclopharynx fuae*, *Pharyngochromis acuticeps*, *Sargochromis carlottae*, *Sargochromis codringtonii*, *Sargochromis coulteri*, *Sargochromis giardi*, *Sargochromis mellandi*, *Schwetochromis neodon*, *Serranochromis altus*, *Serranochromis angusticeps*, *Serranochromis macrocephalus*, *Serranochromis stappersi*, *Serranochromis thumbergi*, *Thoracochromis albolabris*, *Thoracochromis brauschi*, and *Thoracochromis buysi*.

Clade 445: *Astatoreochromis*

Taxonomy: The riverine genus *Astatoreochromis* is recovered as the sister lineage to the “modern haplochromines” in Salzburger *et al.* (2005). *Astatoreochromis* includes three species: *A. alluaudi*,

A. straeleni, and *A. vanderhorsti*.

Support: Morphological characteristics described in Greenwood (1979).

First occurrence: Recent.

Diversity: 3 extant species (Greenwood 1979; Froese & Pauly 2015).

Sampled species: *Astatoreochromis alluaudi*.

Clade 446: *Pseudocrenilabrus*+allies

Taxonomy: Combines the genus *Pseudocrenilabrus* with *Orthochromis machadoi* and *Thoracochromis moeruensis*. See clade 417 (“Proto-Malagarasi River system *Orthochromis*”).

Support: No synapomorphies are known to unite all species of *Pseudocrenilabrus* with *Orthochromis machadoi* and *Thoracochromis moeruensis*, however, the molecular phylogenies of Koblmüller *et al.* (2008) and Wagner *et al.* (2012) strongly support a position of *Orthochromis machadoi* within the genus *Pseudocrenilabrus* (BS 100, BPP 1.0). The molecular phylogeny of Wagner *et al.* (2012) further supports inclusion of *Thoracochromis moeruensis* in *Pseudocrenilabrus* (BS 99) (the species is not included in the molecular data set of Koblmüller *et al.* 2008). Our RAXML phylogeny supports monophyly of *Pseudocrenilabrus*+allies with BS 100.

First occurrence: Recent.

Diversity: 5 extant species (Froese & Pauly 2015).

Sampled species: *Orthochromis machadoi*, *Pseudocrenilabrus multicolor*, *Pseudocrenilabrus nicholsi*, and *Pseudocrenilabrus philander*.

Clade 447: Tropheini

Taxonomy: One out of 16 tribes of Lake Tanganyika cichlids according to Takahashi (2003). Combines the genera *Interochromis*, *Limnotilapia*, *Lobochilotes*, *Petrochromis*, *Pseudosimochromis*, *Simochromis*, and *Tropheus* with “*Ctenochromis*” *horei* and “*Gnathochromis*” *pfefferi*. The molecular phylogenies of Salzburger *et al.* (2005), Day *et al.* (2008), Koblmüller *et al.* (2010), Wagner *et al.* (2012), and Muschick *et al.* (2012) suggest nonmonophyly of the genera *Petrochromis*, *Simochromis*, and *Tropheus*, but do not question the monophyly of Tropheini as a whole.

Support: Synapomorphies are given in Takahashi (2003). The molecular phylogenies of Day *et al.* (2008; BS 76, BPP 1.0), Koblmüller *et al.* (2010; BS 100), Wagner *et al.* (2012; BS 88), and Muschick *et al.* (2012; BPP 1.0) include representatives of all genera of Tropheini and strongly support their monophyly.

First occurrence: Recent.

Diversity: 25 extant species (Froese & Pauly 2015).

Sampled species: “*Ctenochromis*” *horei*, “*Gnathochromis*” *pfefferi*, *Interochromis loocki*, *Limnotilapia dardennii*, *Lobochilotes labiatus*, *Petrochromis famula*, *Petrochromis fasciolatus*, *Petrochromis macrognathus*, *Petrochromis orthognathus*, *Petrochromis polyodon*, *Petrochromis trewavasae*, *Pseudosimochromis curvifrons*, *Simochromis babaulti*, *Simochromis diagramma*, *Simochromis marginatus*, *Tropheus brichardi*, *Tropheus duboisi*, *Tropheus moorii*, and *Tropheus polli*.

Clade 448: *Astatotilapia desfontainii*

Taxonomy: One out of eight species currently assigned to *Astatotilapia* in Froese & Pauly (2015). The genus is clearly nonmonophyletic (van Oijen 1996; Wagner *et al.* 2012). *Astatotilapia swynner-toni*, the only species of *Astatotilapia* missing in our data set, is assumed to be the sister lineage to *Astatotilapia calliptera*, and thus nested in the “Lake Malawi radiation” according to the molecular phylogeny of Joyce *et al.* (2011).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Astatotilapia desfontainii*.

Clade 449: *Astatotilapia bloyeti*

Taxonomy: One out of eight species currently assigned to *Astatotilapia* in Froese & Pauly (2015). See clade 448 (*Astatotilapia desfontainii*).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Astatotilapia bloyeti*.

Clade 450: *Astatotilapia burtoni*

Taxonomy: One out of eight species currently assigned to *Astatotilapia* in Froese & Pauly (2015). See clade 448 (*Astatotilapia desfontainii*).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Astatotilapia burtoni*.

Clade 451: *Haplochromis gracilior*

Taxonomy: One out of 229 species currently assigned to genus *Haplochromis* by Froese & Pauly (2015), following van Oijen (1996). Almost all *Haplochromis* of Froese & Pauly (2015) are part of the “Lake Victoria region superflock”, with the following exceptions: *H. snoeksi*, *H. bakongo*, *H. fasciatus*, *H. humilis*, *H. multiocellatus*, *H. placodus*, and *H. smithii* are here assumed to be part of “Serranochromines” (see clade 444), and *H. gracilior* and *H. paludinosus* are considered individual lineages.

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Haplochromis gracilior*.

Clade 452: *Astatotilapia flaviijosephi*

Taxonomy: One out of eight species currently assigned to genus *Astatotilapia* in Froese & Pauly (2015). See clade 448 (*Astatotilapia desfontainii*).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Astatotilapia flavijosephi*.

Clade 453: *Haplochromis paludinosus*

Taxonomy: One out of 229 species currently assigned to genus *Haplochromis* in Froese & Pauly (2015). See clade 451 (*Haplochromis gracilior*).

Support: This clade include a single extant species.

First occurrence: Recent.

Diversity: 1 extant species.

Sampled species: *Haplochromis paludinosus*.

Clade 454: “Lake Victoria region superflock”

Taxonomy: The “Lake Victoria region superflock” combines all haplochromine cichlids of Lake Victoria (700), Lake Kivu (18), Lake Albert (9), Lakes Edward and George (60), Lake Kyoga (100), Lake Turkana (7), Lake Rukwa (5), and Lake Nabugabo (5) (numbers of endemic haplochromine species in parentheses, according to Turner *et al.* 2001), with the exception of *Astatoreochromis* and *Haplochromis gracilior* (see clades 445 and 451), but including *Astatotilapia stappersi*, which is so far the only species of the “Lake Victoria region superflock” known to reinvade Lake Tanganyika (Wagner *et al.* 2012; Meyer *et al.* 2015). In total, we assume the “Lake Victoria region superflock” to include 905 species.

Support: No morphological synapomorphies are known to unite all haplochromines of the “Lake Victoria region superflock”. We here consider this group to be monophyletic, based on its very small genetic divergence, distribution pattern, and the molecular phylogenies of Salzburger *et al.* (2005; BS 99, BPP 1.0) and Wagner *et al.* (2012; BS 100), that include as many as 67 different species of the “Lake Victoria region superflock” and strongly support their monophyly. Our RAxML phylogeny supports monophyly of the “Lake Victoria region superflock” with BS 72.

First occurrence: Recent.

Diversity: 905 extant species (see above).

Sampled species: *Astatotilapia stappersi*, *Haplochromis aeneocolor*, *Haplochromis astatodon*, *Haplochromis chilotes*, *Haplochromis cinctus*, *Haplochromis crebridens*, *Haplochromis elegans*, *Haplochromis graueri*, *Haplochromis insidiae*, *Haplochromis laparogramma*, *Haplochromis lividus*, *Haplochromis macropoides*, *Haplochromis microchrysomelas*, *Haplochromis nigroides*, *Haplochromis nubilus*, *Haplochromis obesus*, *Haplochromis obliquidens*, *Haplochromis occultidens*, *Haplochromis phytophagus*, *Haplochromis piceatus*, *Haplochromis pyrrhocephalus*, *Haplochromis rubescens*, *Haplochromis rudolfianus*, *Haplochromis sauvagei*, *Haplochromis scheffersi*, *Haplochromis* sp. “rock kribensis”, *Haplochromis squamipinnis*, *Haplochromis velifer*, *Haplochromis venator*, *Haplochromis vittatus*, *Haplochromis xenognathus*, *Harpagochromis guiarti*, *Neochromis nigricans*, *Platytaeniodus degeni*, and *Pundamilia nyererei*.

Clade 455: “Lake Malawi radiation”

Taxonomy: Combines all haplochromine cichlids endemic to Lake Malawi (700 species; Turner *et al.* 2001), as well as *Astatotilapia tweddlei*, *A. calliptera*, and *A. swynnertoni* from Lakes Chilwa and Chilingali and the Buzi River, and an undescribed species of *Astatotilapia* from the Rovuma River (Joyce *et al.* 2011). We thus assume the “Lake Malawi radiation” to encompass 704 species.

Support: No synapomorphies are known to unite all haplochromines of the “Lake Malawi radiation”, however, the biogeographic distribution that is almost entirely limited to Lake Malawi, and the molecular phylogenies of Salzburger *et al.* (2005; BS 100, BPP 1.0) and Wagner *et al.* (2012; BS 84) include up to 134 species of the “Lake Malawi radiation” and strongly support their monophyly. Our RAxML phylogeny supports monophyly of the “Lake Malawi radiation” with BS 97.

First occurrence: Recent.

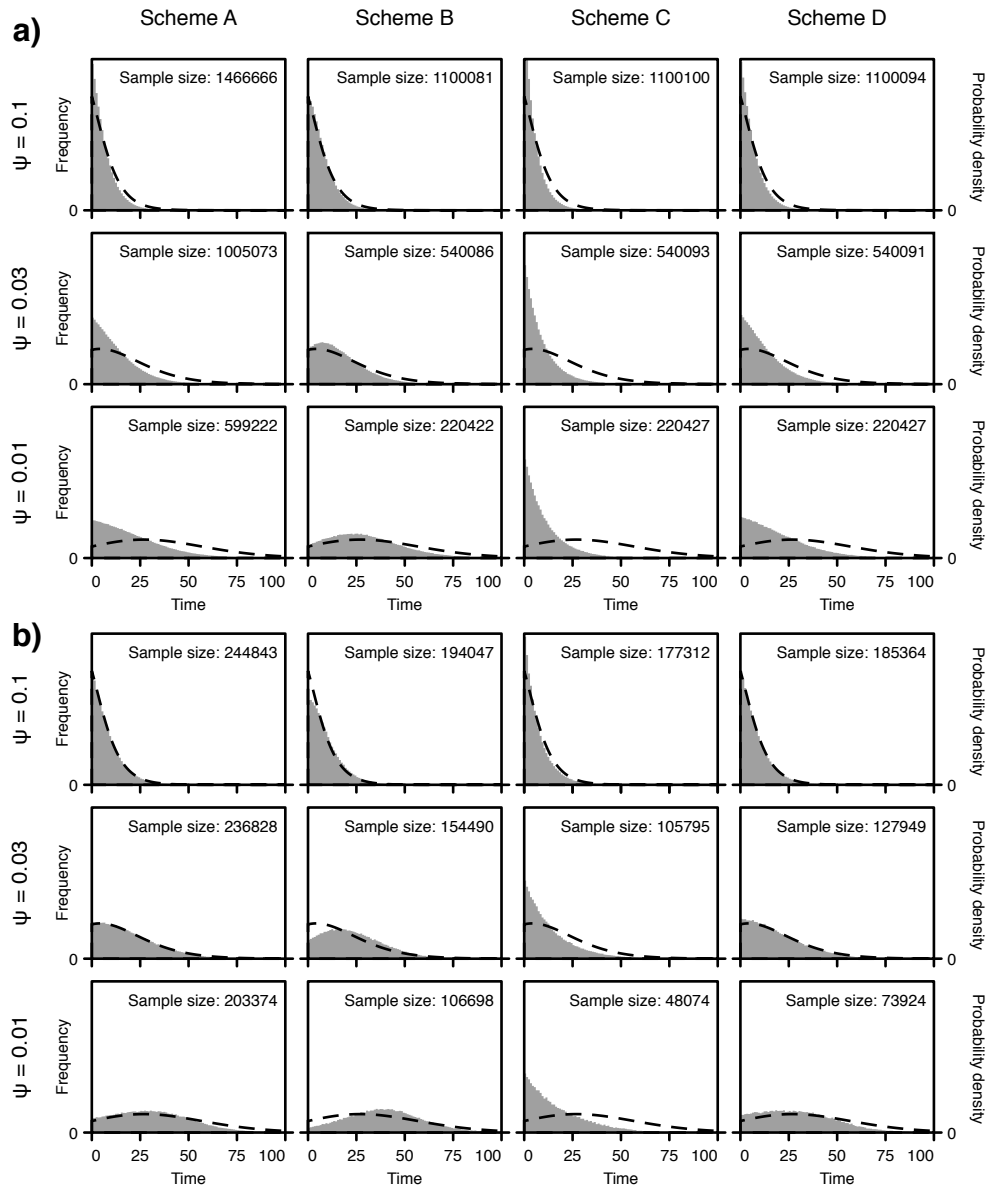
Diversity: 704 extant species (see above).

Sampled species: *Alticorpus peterdaviesi*, *Aristochromis christyi*, *Astatotilapia calliptera*, *Aulonocara hansbaenschi*, *Aulonocara stuartgranti*, *Buccochromis heterotaenia*, *Buccochromis lepturus*, *Champsochromis spilorhynchus*, *Cheilochromis euchilus*, *Chilotilapia rhoadesii*, *Copadichromis borleyi*, *Copadichromis mbenjii*, *Copadichromis virginalis*, *Ctenopharynx pictus*, *Cyathochromis obliquidens*, *Cynotilapia afra*, *Cyrtocara moorii*, *Dimidiochromis compressiceps*, *Diplotaxodon greenwoodi*, *Diplotaxodon limnothrissa*, *Docimodus evelynae*, *Exochochromis anagenys*, *Fossorochromis rostratus*, *Genyochromis mento*, *Haplochromis tweddlei*, *Hemitilapia oxyrhyncha*, *Labeotropheus fuelleborni*, *Labeotropheus trewavasae*, *Labidochromis caeruleus*, *Labidochromis gigas*, *Lethrinops auritus*, *Lethrinops furcifer*, *Lethrinops gossei*, *Lethrinops longipinnis*, *Lethrinops microdon*, *Maylandia callainos*, *Maylandia livingstonii*, *Maylandia zebra*, *Mchenga conophoros*, *Mchenga eucinostomus*, *Melanochromis auratus*, *Melanochromis lorae*, *Melanochromis vermivorus*, *Mylochromis anaphyrmus*, *Mylochromis incola*, *Mylochromis mola*, *Nimbochromis fuscotaeniatus*, *Nimbochromis linni*, *Nimbochromis livingstonii*, *Nimbochromis polystigma*, *Nimbochromis venustus*, *Nyassachromis prostoma*, *Otopharynx brooksi*, *Otopharynx speciosus*, *Pallidochromis tokolosh*, *Petrotilapia nigra*, *Placidochromis johnstoni*, *Placidochromis milomo*, *Protomelas annectens*, *Protomelas fenestratus*, *Protomelas similis*, *Pseudotropheus crabro*, *Pseudotropheus sp. acei*, *Rhamphochromis esox*, *Rhamphochromis macrophthalmus*, *Sciaenochromis benthicola*, *Sciaenochromis psammophilus*, *Stigmatichromis woodi*, *Taeniolethrinops furcicauda*, *Taeniolethrinops laticeps*, *Taeniolethrinops praeorbitalis*, *Tramitichromis brevis*, *Tramitichromis intermedius*, *Tramitichromis variabilis*, *Tropheops microstoma*, *Tropheops tropheops*, *Tyrannochromis macrostoma*, *Tyrannochromis maculiceps*, and *Tyrannochromis nigriventer*.

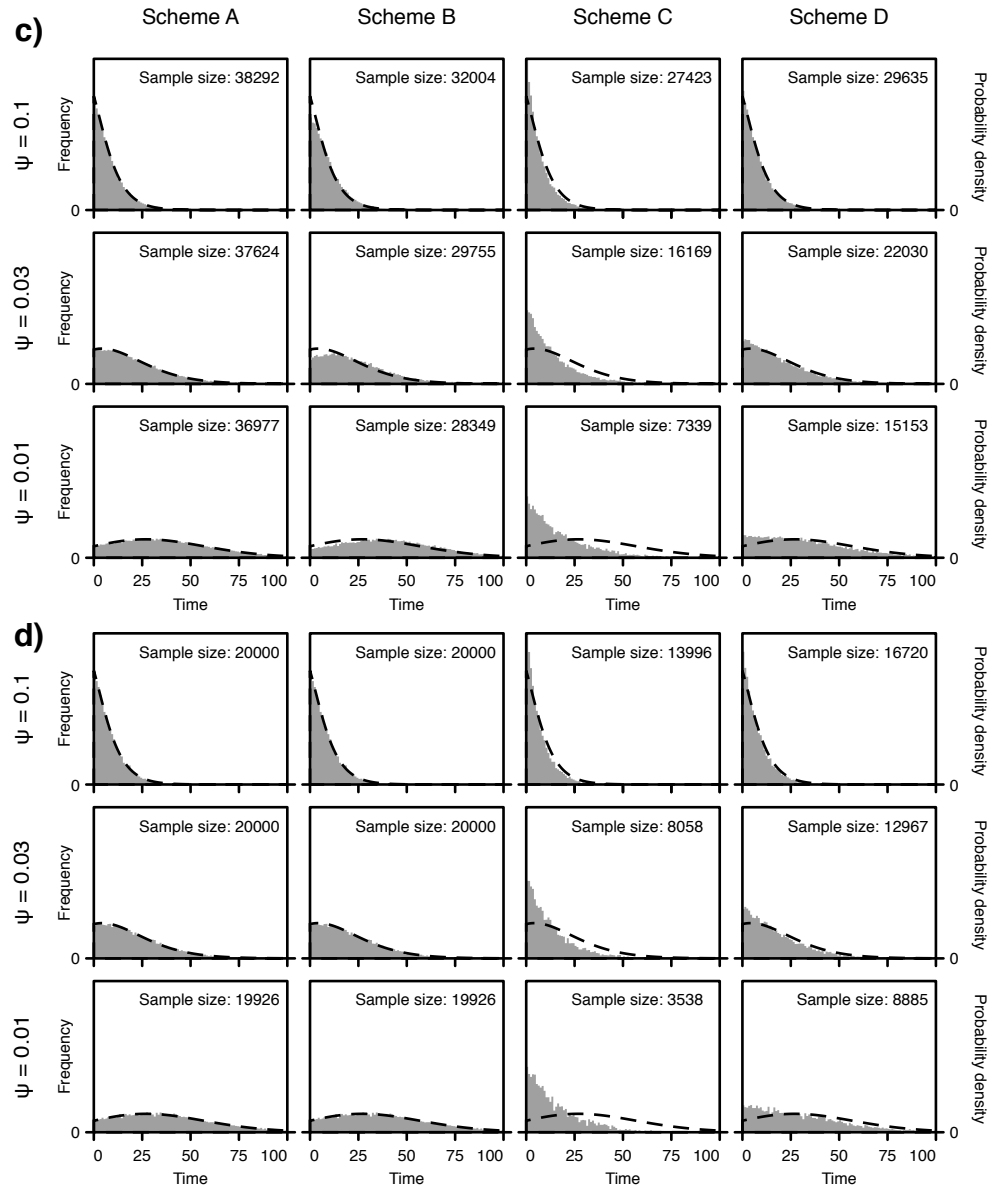
2 Supplementary Figures

Supplementary Figure S1: Comparison of waiting time frequency distributions with CladeAge calibration densities.

Waiting times between clade origin and the age of its oldest fossil were calculated for clades in 10 000 simulated phylogenies, according to sampling schemes A to D, and with different thresholds for the true clade age. Simulations were based on a pure Yule model with speciation rate $\lambda = 0.04$ and were repeated with three different sampling rates $\psi = 0.1, 0.03, 0.01$. Waiting times frequency distributions are shown in gray, and scaled distributions of CladeAge calibration densities are indicated with dashed black lines. Applied clade age thresholds are $t_o \geq 0$ in a), $t_o \geq 0.5 \times t_{root}$ in b), $t_o \geq 0.9 \times t_{root}$ in c), and $t_o = t_{root}$ in d).

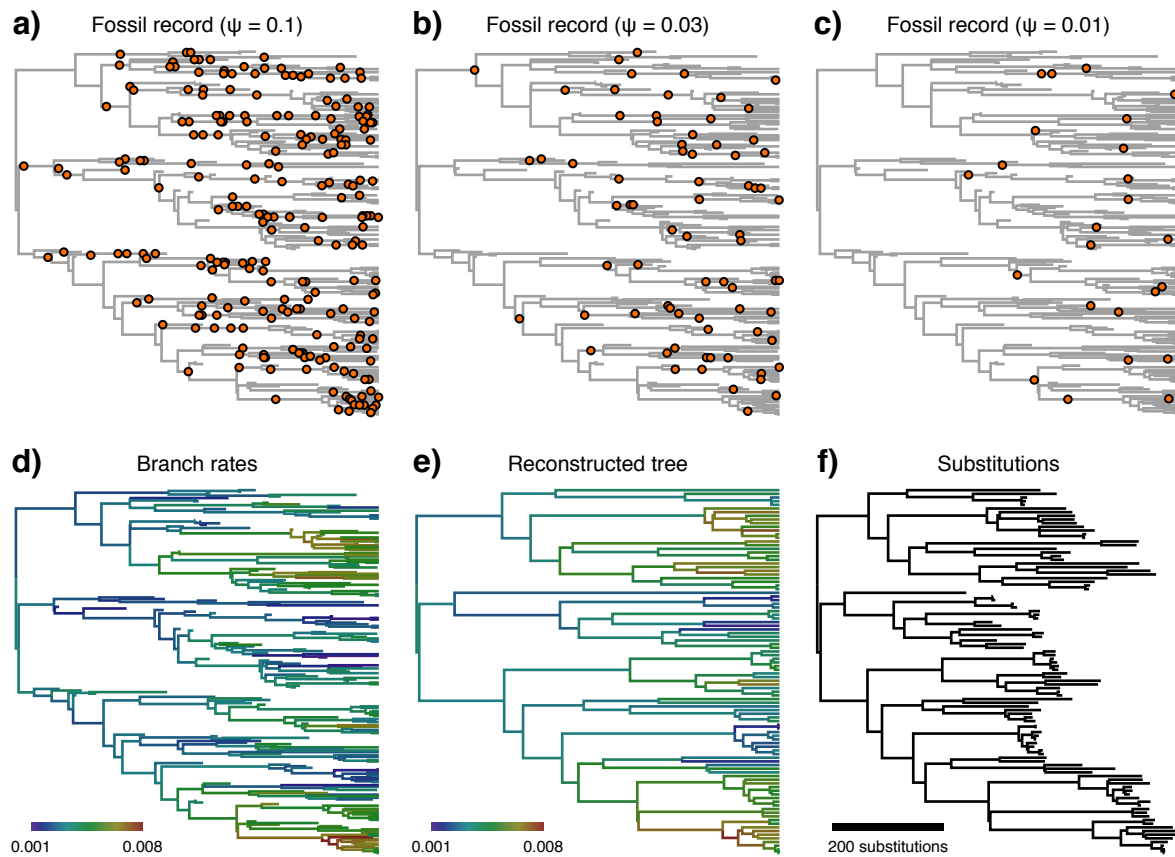


Supplementary Figure S1 (continued): Comparison of waiting time frequency distributions with CladeAge calibration densities.



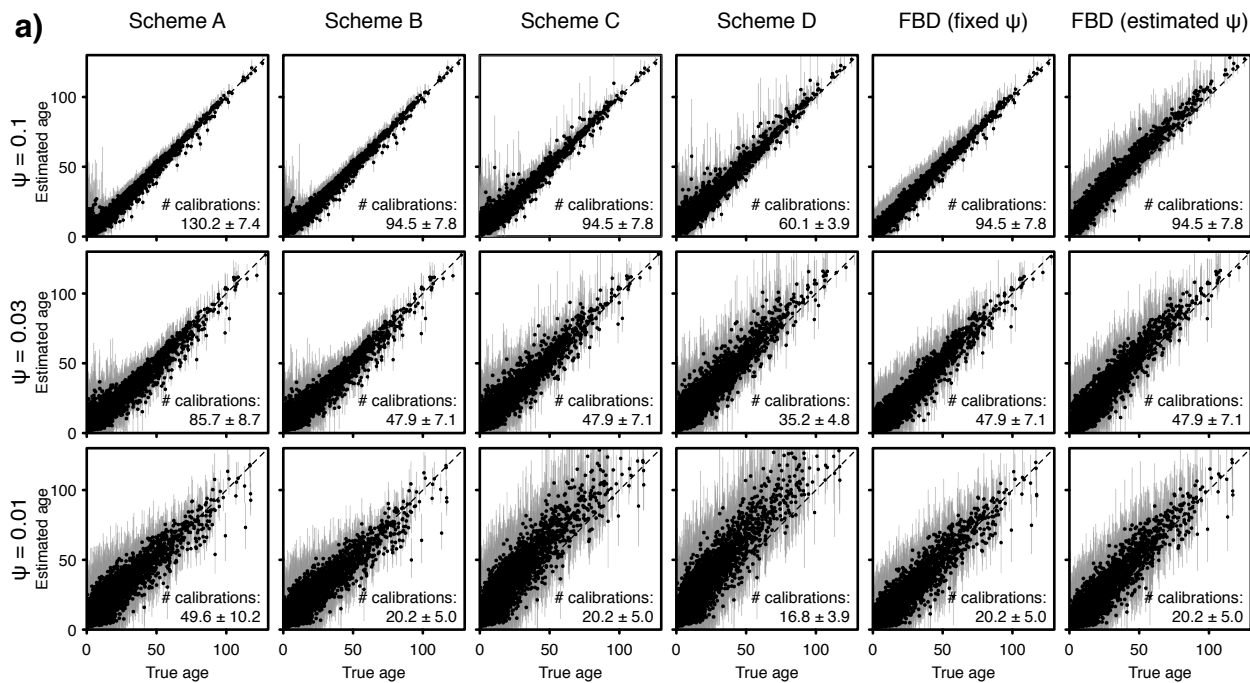
Supplementary Figure S2: Exemplary simulated data set of phylogenetic tree, fossil record, and substitution branch rates.

a)-c) Simulated phylogenetic tree with fossil records according to sampling rates of $\psi = 0.1$, 0.03, 0.01. Fossils are indicated with orange circles. d) Substitution rates assigned to branches based on the CIR process. e) Substitution branch rates after tree reconstruction. f) Branch lengths indicate the number of substitutions on each branch, for a sequence of 3000 bp.



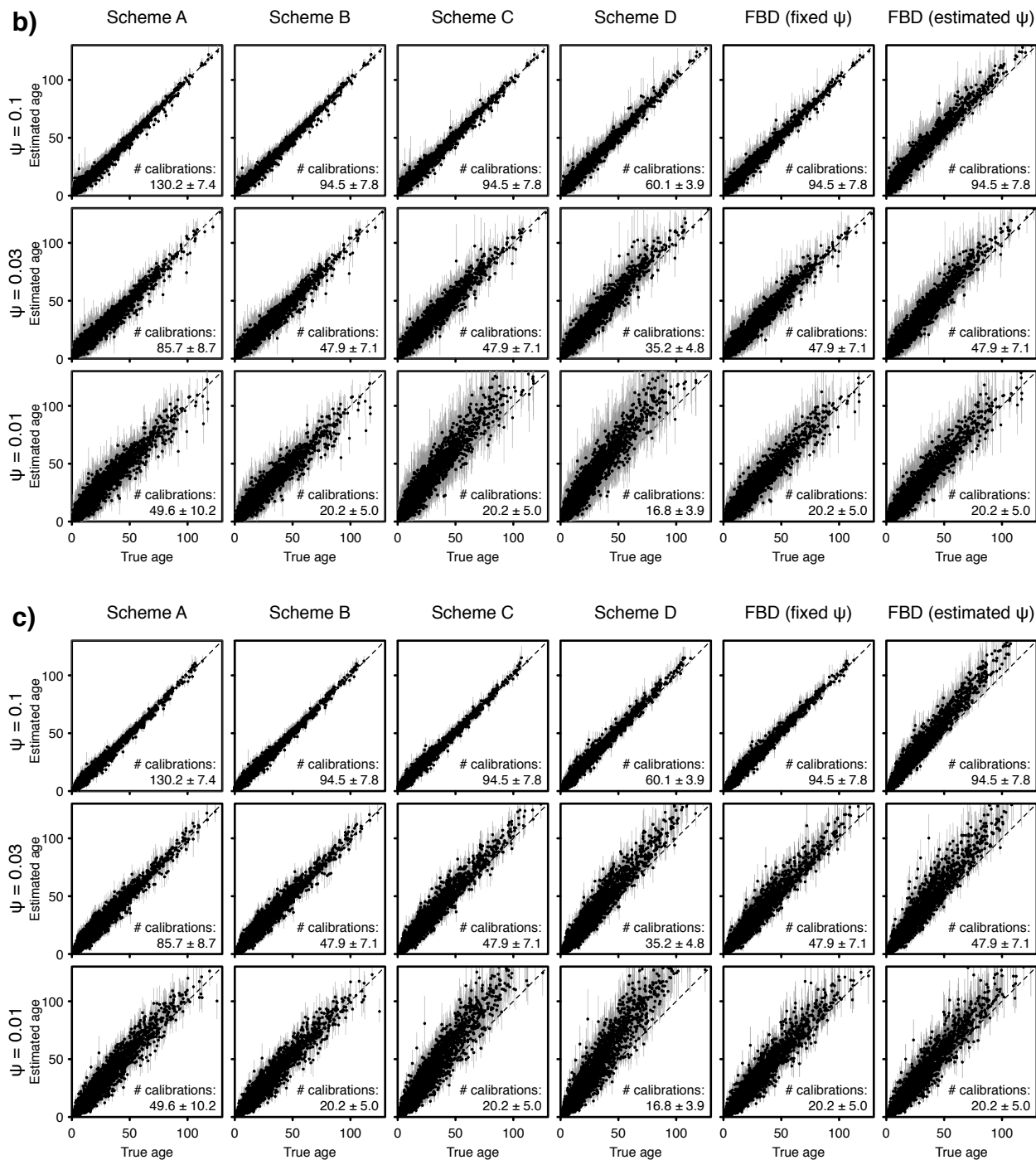
Supplementary Figure S3: Comparison of true and estimated node ages.

For each of 50 replicate data sets based on three sampling rates $\psi = 0.1, 0.03, 0.01$ and two models of branch rate variation, node ages were estimated with BEAST, using CladeAge calibration densities according to calibration schemes A to D, or the FBD process. CladeAge calibration densities were based on the true values for diversification and sampling rates. Diversification rates were also fixed to their true values in all analyses using the FBD process, but the sampling rate ψ was both fixed and estimated in separate analyses. The plots show true and estimated age for each node in the 50 simulated phylogenies. Mean age estimates are indicated with black dots, and 95% highest posterior density (HPD) intervals are shown as gray bars. Numbers given within each plot specify the mean and the standard deviation of the number of fossils used for time calibration in the respective calibration scheme. These numbers may differ between analyses using different schemes, since some fossils can be used multiple times while others may not be used at all depending on the calibration scheme (see Figure 2 of the main text). a) Results are given for analyses sampling from the prior only.



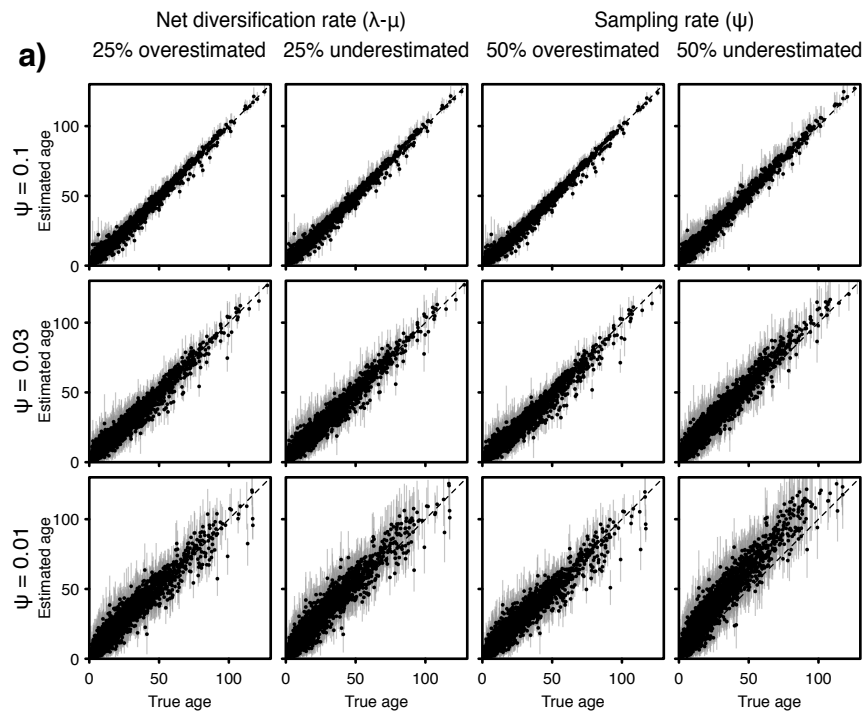
Supplementary Figure S3 (continued): Comparison of true and estimated node ages.

Results are shown for analyses sampling from the posterior, with sequence data sets simulated with uncorrelated branch rates (b), or with autocorrelated branch rates (c).



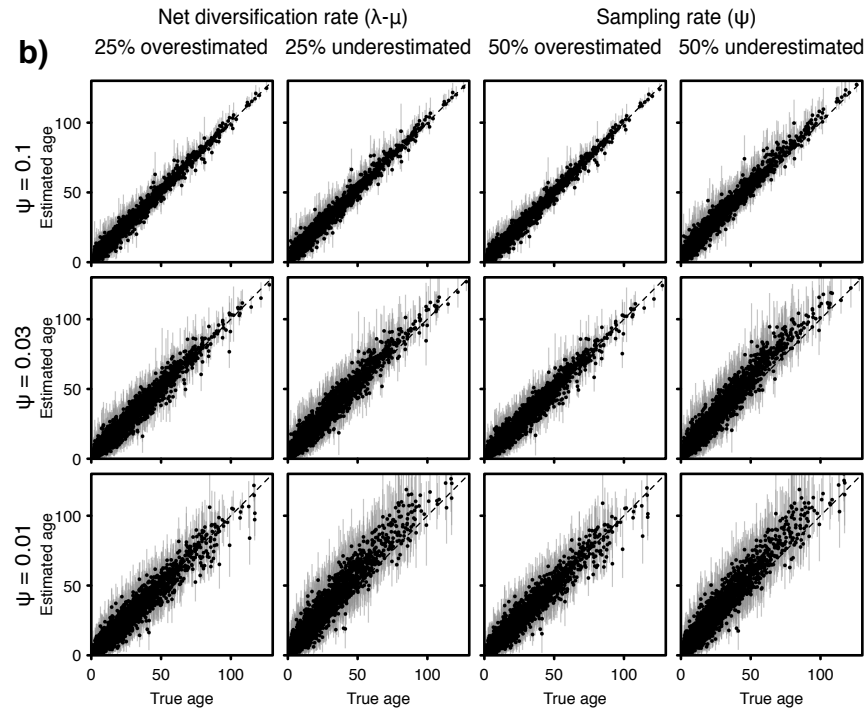
Supplementary Figure S4: Comparison of true and estimated node ages when rates are misspecified.

Results are shown for analyses with CladeAge calibration densities and calibration scheme A (a) and for analyses with the FBD process and fixed parameter values (b; see next page). In both cases, parameters assumed for inference differed from those used for data set generation: the net diversification rate was either over- or underestimated by 25%, or the sampling rate was either over- or underestimated by 50%. All analyses used sampling from the posterior, and sequence data sets were simulated with uncorrelated branch rates.



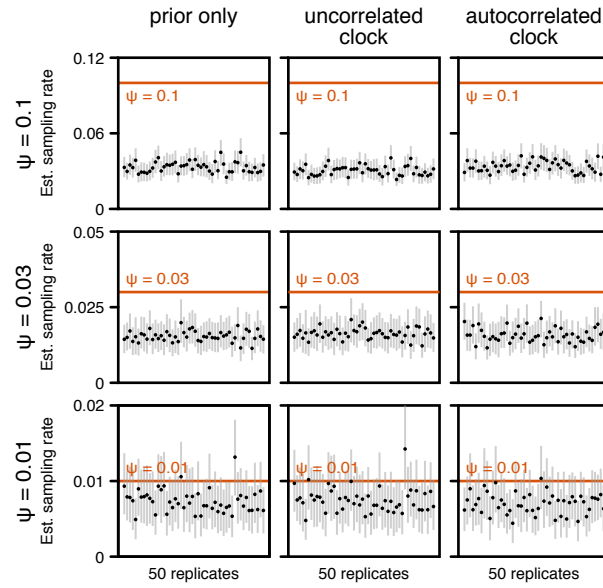
Supplementary Figure S4 (continued): Comparison of true and estimated node ages when rates are misspecified.

Results are shown for analyses with the FBD process and fixed parameter values (b).



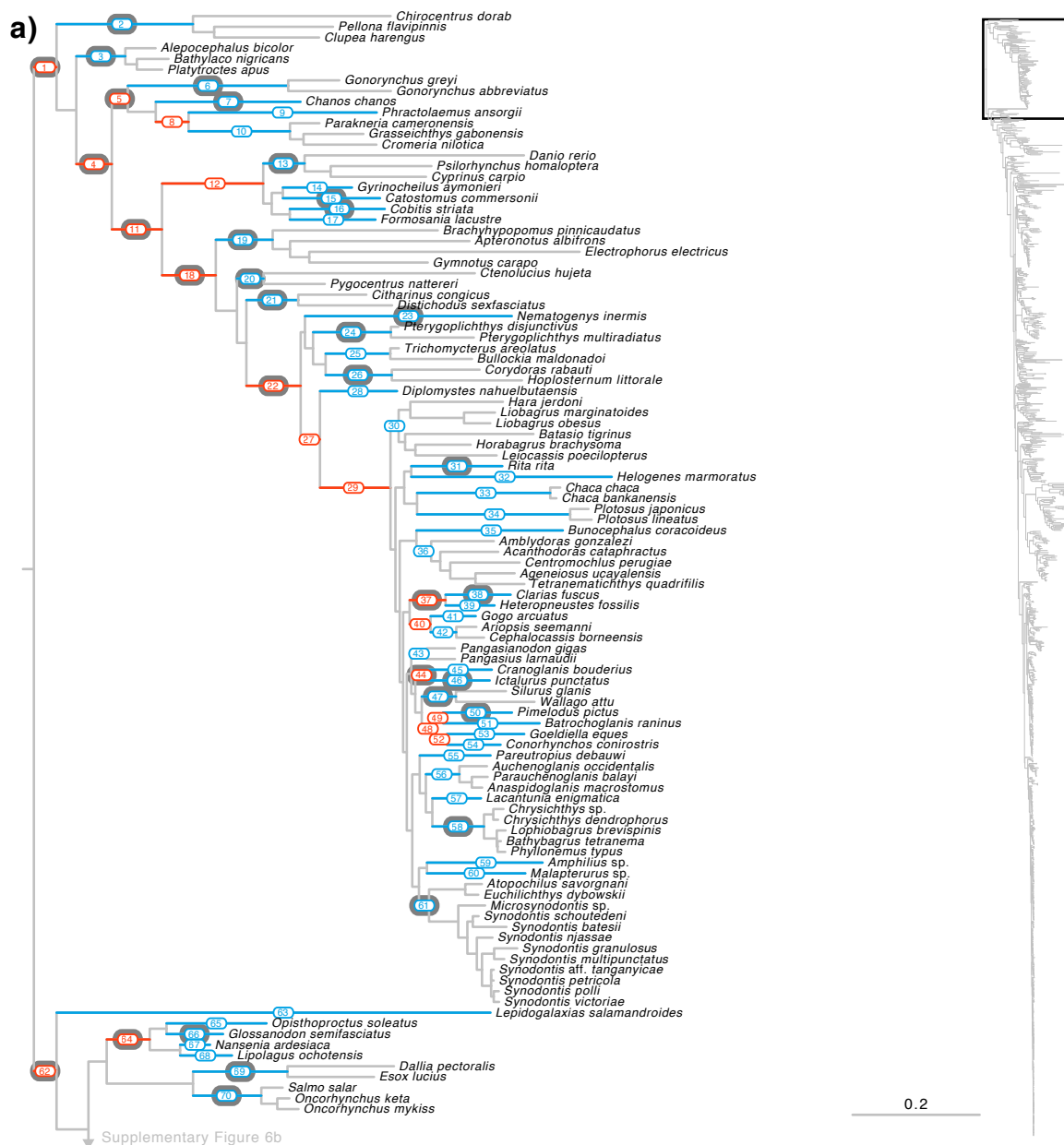
Supplementary Figure S5: Comparison of true sampling rates and sampling rate estimates resulting from FBD analyses.

For each of 50 replicates of FBD analyses of datasets generated with three different sampling rates $\psi = 0.1, 0.03, 0.01$ and two models of branch rate variation (the uncorrelated and autocorrelated clock models), the resulting sampling rate estimates are compared to the true sampling rate used for simulations (marked in red). As only the fossil sampling proportion s is directly estimated in FBD analyses, estimates for this proportion were used to calculate sampling rate estimates using equation 8 of Gavryushkina *et al.* (2014) and the true extinction rate $\mu = 0.04$, which was used for the generation of all datasets. Per replicate, the mean estimate is indicated by a black dot, and gray bars indicate 95% HPD intervals.



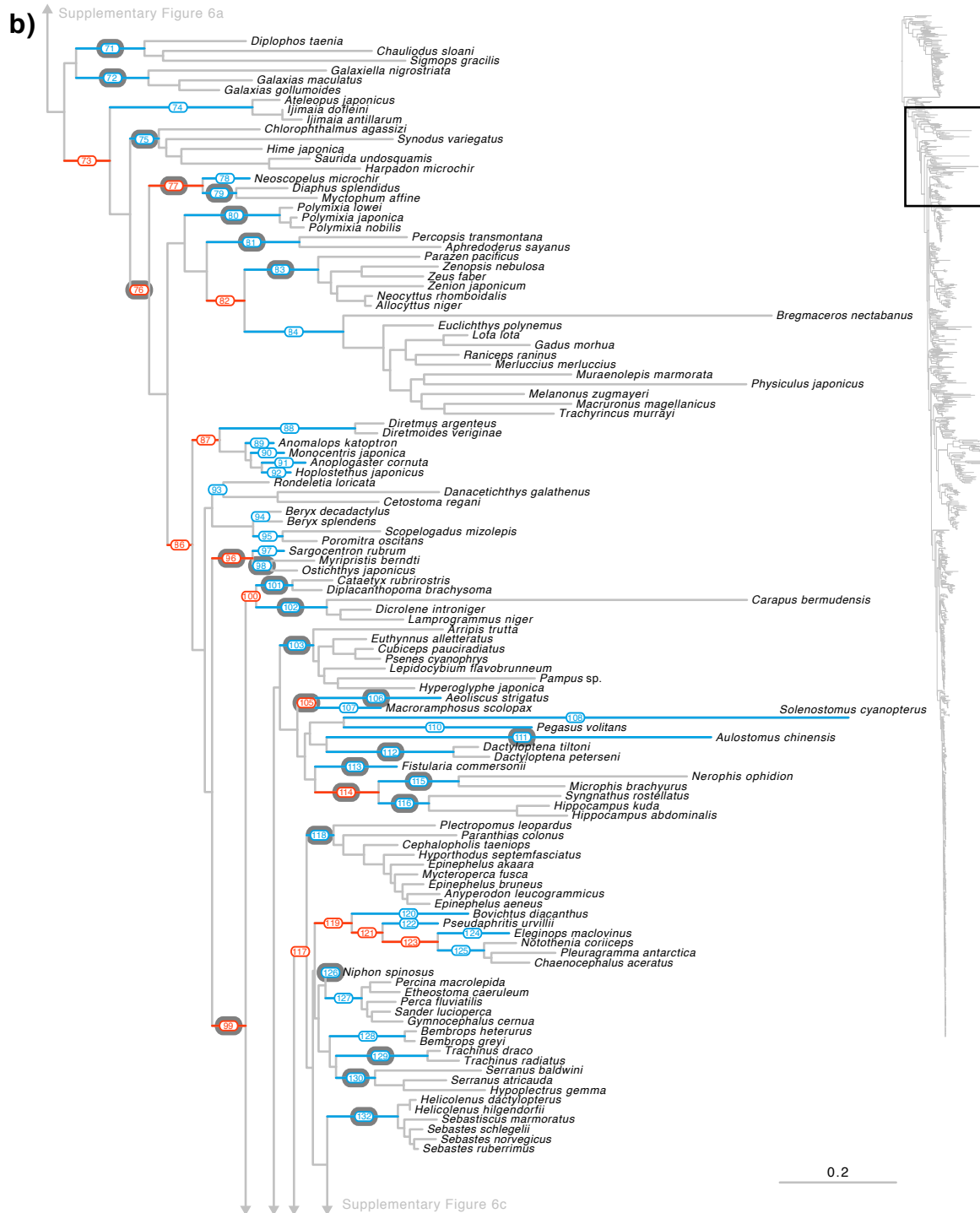
Supplementary Figure S6: RAxML maximum-likelihood phylogeny.

Phylogenetic relationships of 1192 fish species of the Supercohort Clupeocephala (Betancur-R *et al.* 2013), inferred with RAxML on the basis of 40 molecular sequence markers listed in Supplementary Table S4. Colored branches mark strongly supported clades and numbers on branches refer to clade IDs in Supplementary Text S2. Support for the monophyly of these clades is listed in Supplementary Text S2. Blue branches indicate mutually exclusive clades used as tips in the BEAST analysis, and clades used for time calibration are marked with gray strokes around clade numbers. a) Otomorpha (clade 1), Lepidogalaxii (63), Argentiniformes (64), Esociformes (69), and Salmoniformes (70).



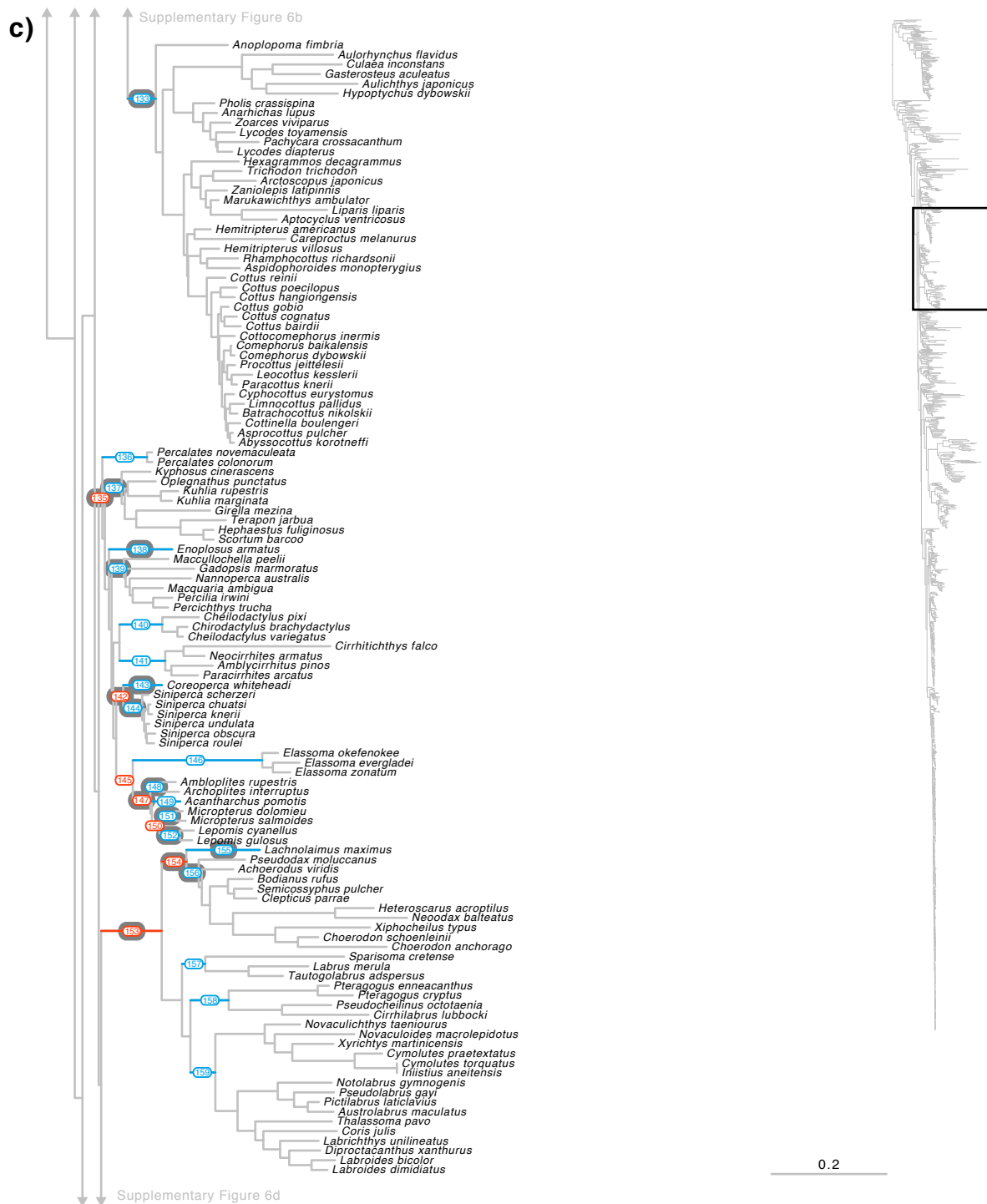
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

b) Stomiati (clade 71), Galaxiiformes (72), Ateleopodia (74), Aulopa (75), Myctophata (77), Paracanthopterygii (80-82), and early-branching lineages of Percomorphaceae (99).



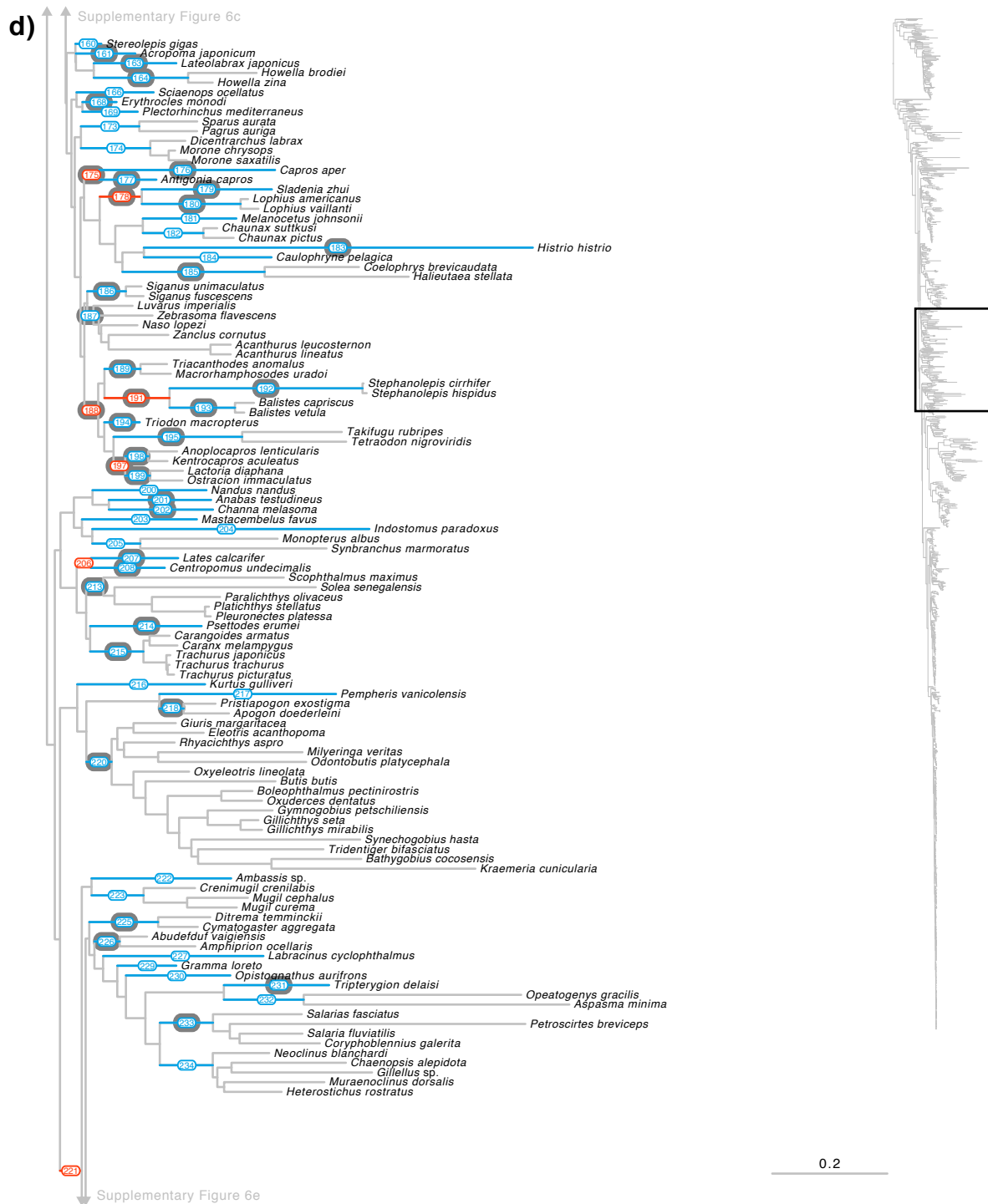
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

c) Cottioidei (clade 133), Centrarchiformes+allies (135), and Labriformes (153).



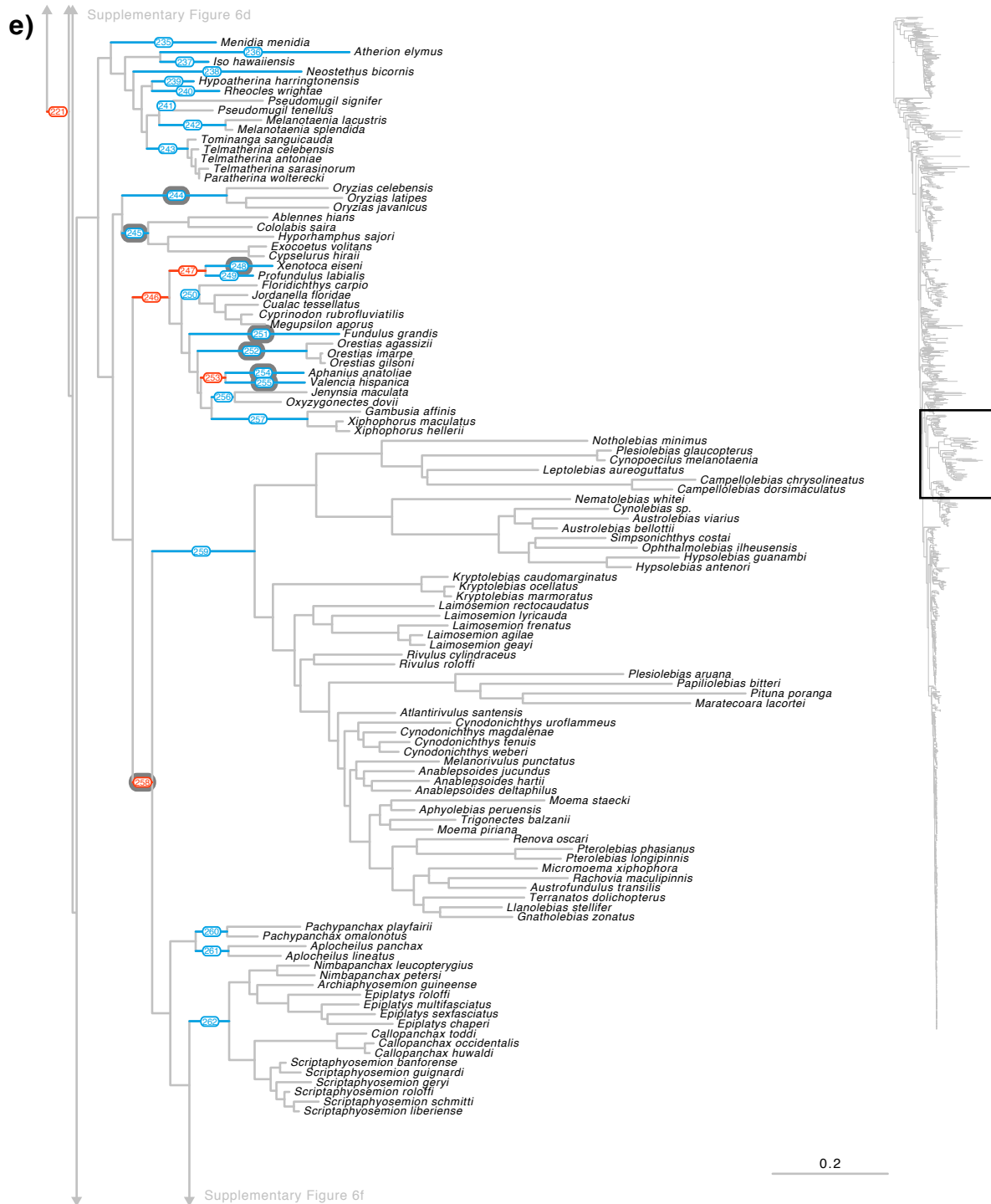
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

d) Lophiiformes (178-185), Acanthuriformes (187), Tetraodontiformes (188), Pleuronectiformes (213,214), Kurtiformes (216,218), Pempheriformes (217), Gobiiformes (220), various percomorph families (160-175,186,200-206,215), and early-branching lineages of Ovalentariae (221).



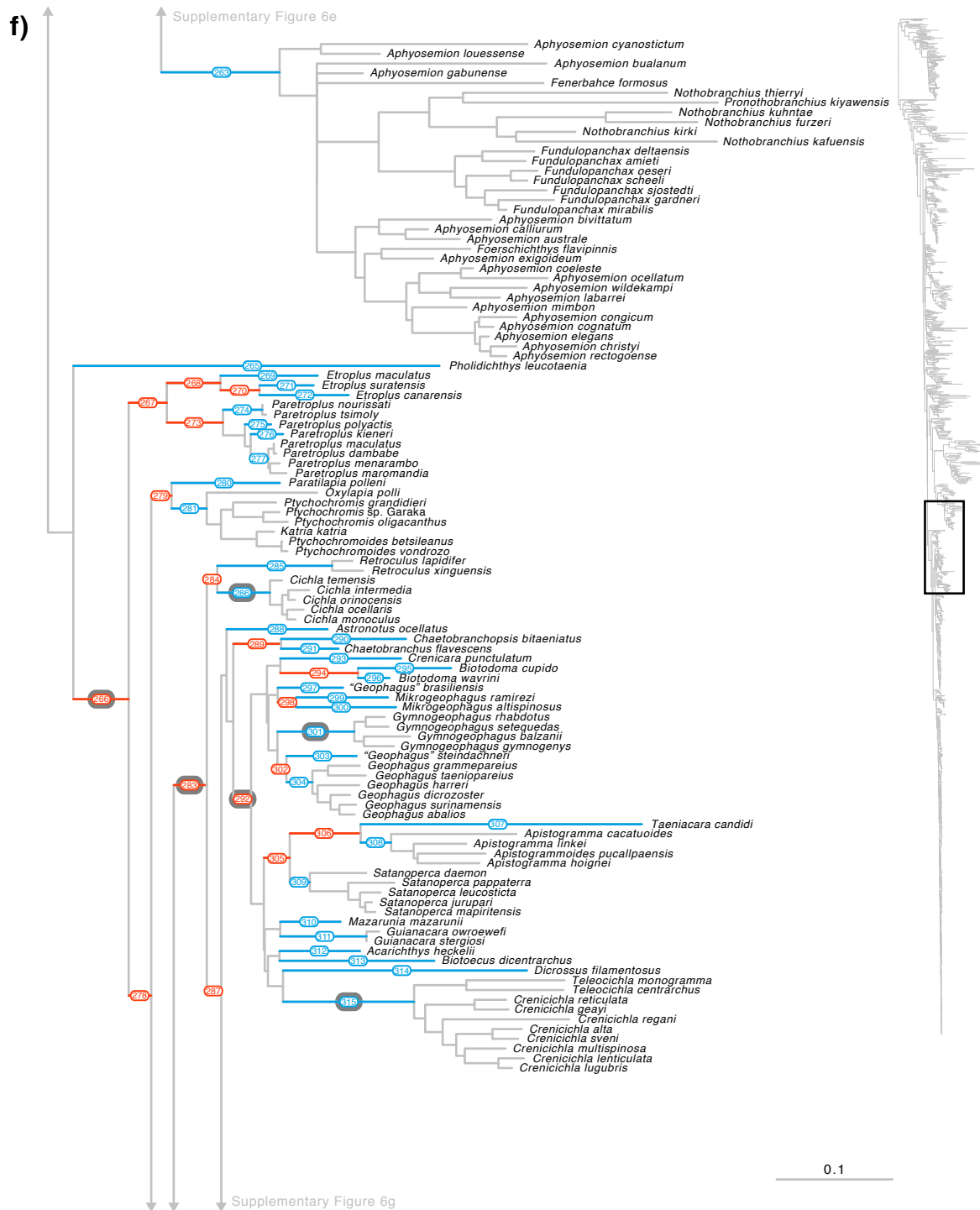
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

e) Atheriniformes (clades 235-243), Beloniformes (244,245), and Cyprinodontiformes (excluding Nothobranchiinae, see Supplementary Figure S6f) (246,258).

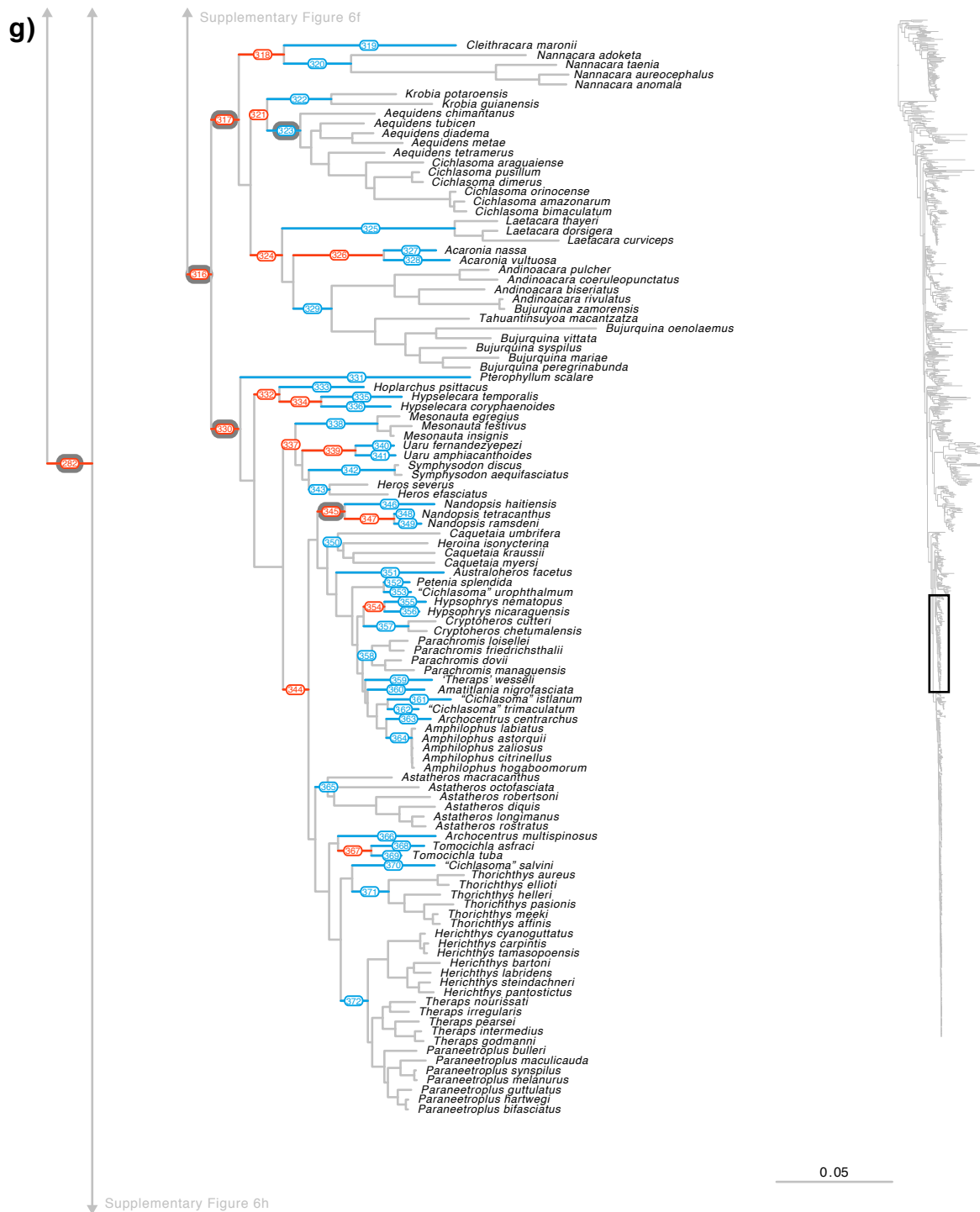


Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

f) Nothobranchiinae (clade 263), Pholidichthyiformes (265), Etroplinae (267), Ptychochrominae (279), Retroculini (285), Cichlini (286), Astronotini (288), Chaetobranchini (289), and Geophagini (292).

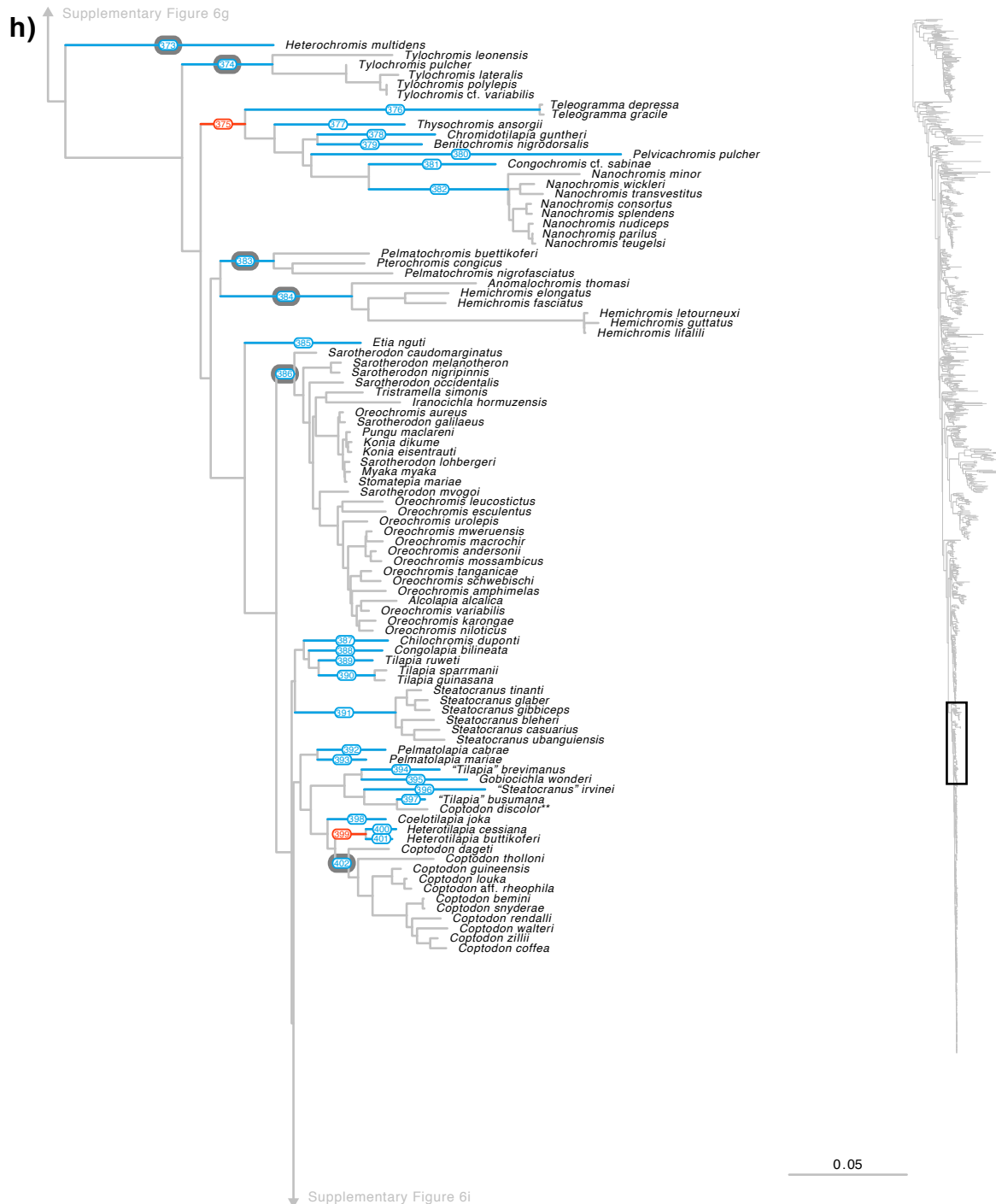


Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.
g) Cichlasomatini (clade 317) and Heroini (330).



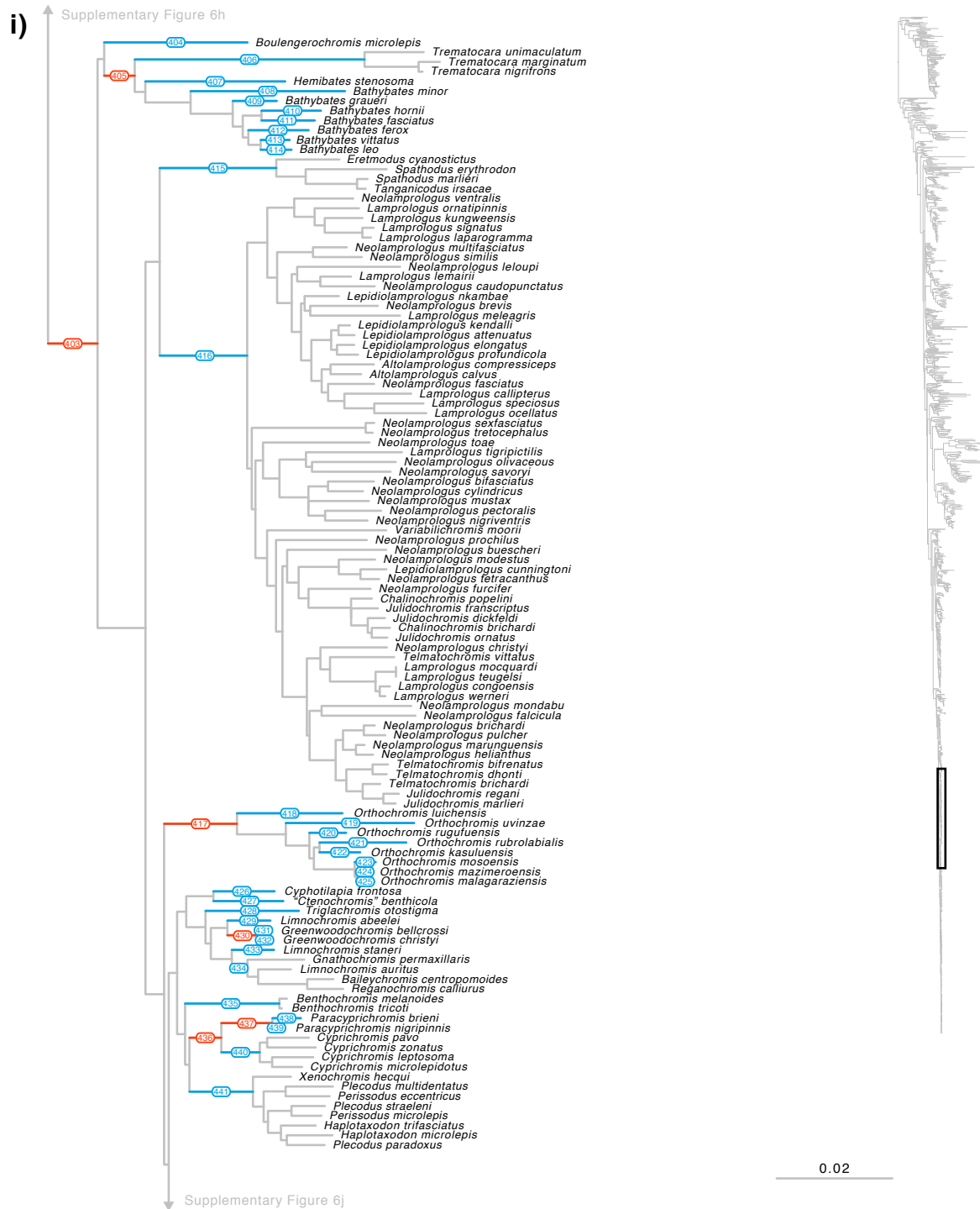
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

h) Heterochromini (clade 373), Tylochromini (374), Chromidotilapiini (375), Pelmatochromini (383), Hemichromini (384), Etiini (385), Oreochromini (386), Tilapiini (387-390), Steatocranini (391), Pelmatolapiini (392,393), Gobiocichlini (394-397), Coelotilapiini (398), Heterotilapiini (399), and Coptodiini (402).



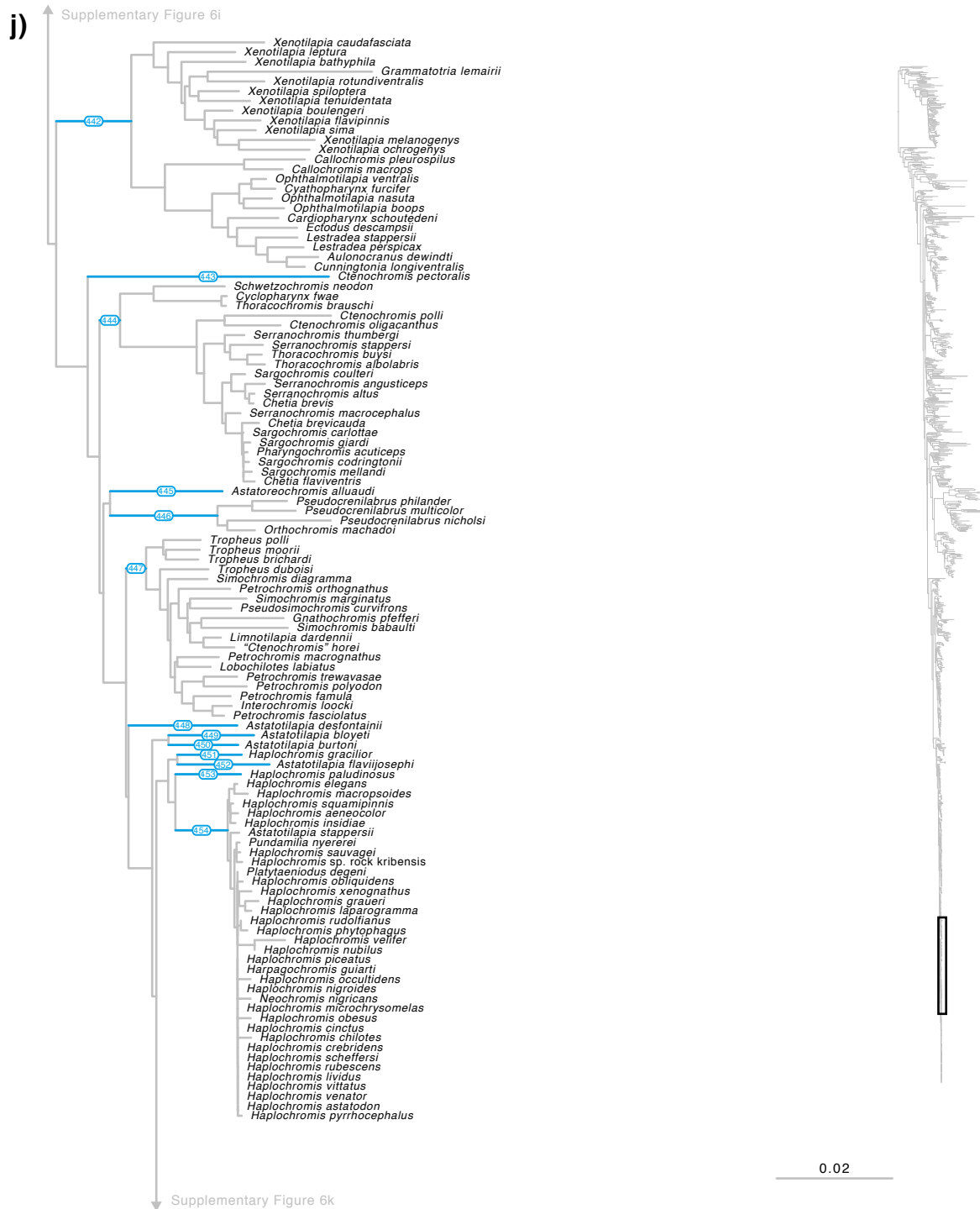
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

I) Boulengerochromini (clade 404), Bathybatini (405), Eretmodini (415), Lamprologini (416), “Proto-Malagarasi River system Orthochromis” (417), Cyphotilapiini (426), Limnochromini (427-434), Benthochromini (435), Cyprichromini (436), and Perissodini (441).



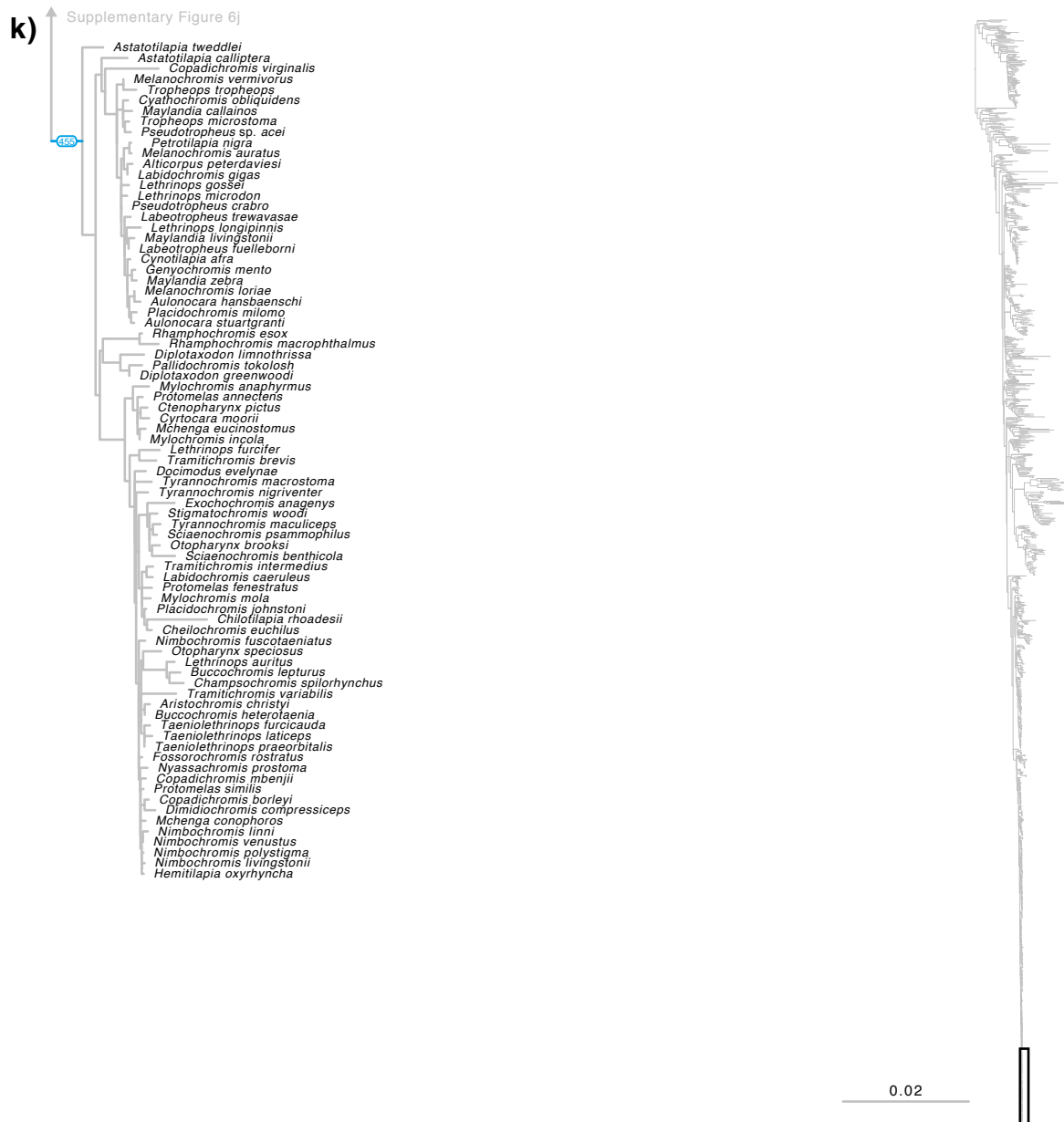
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

j) Ectodini (clade 442), *Ctenochromis pectoralis* (443), “Serranochromines” (444), *Astatoreochromis* (445), *Pseudocrenilabrus*+allies (446), Tropheini (447), various lineages assigned to *Astatotilapia* and *Haplochromis*, and the “Lake Victoria region superflock” (454).



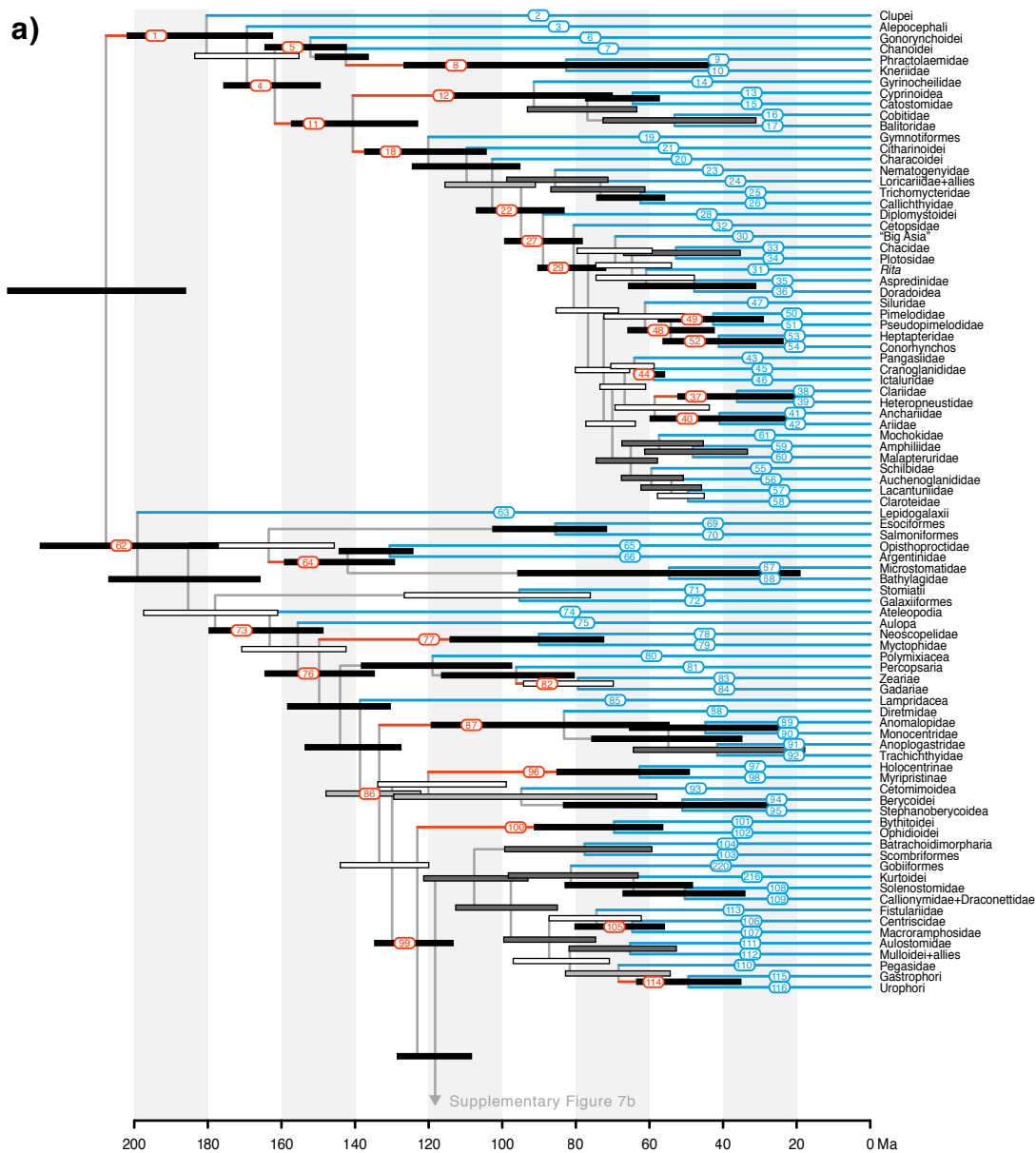
Supplementary Figure S6 (continued): RAxML maximum-likelihood phylogeny.

k) The “Lake Malawi radiation” (clade 455).



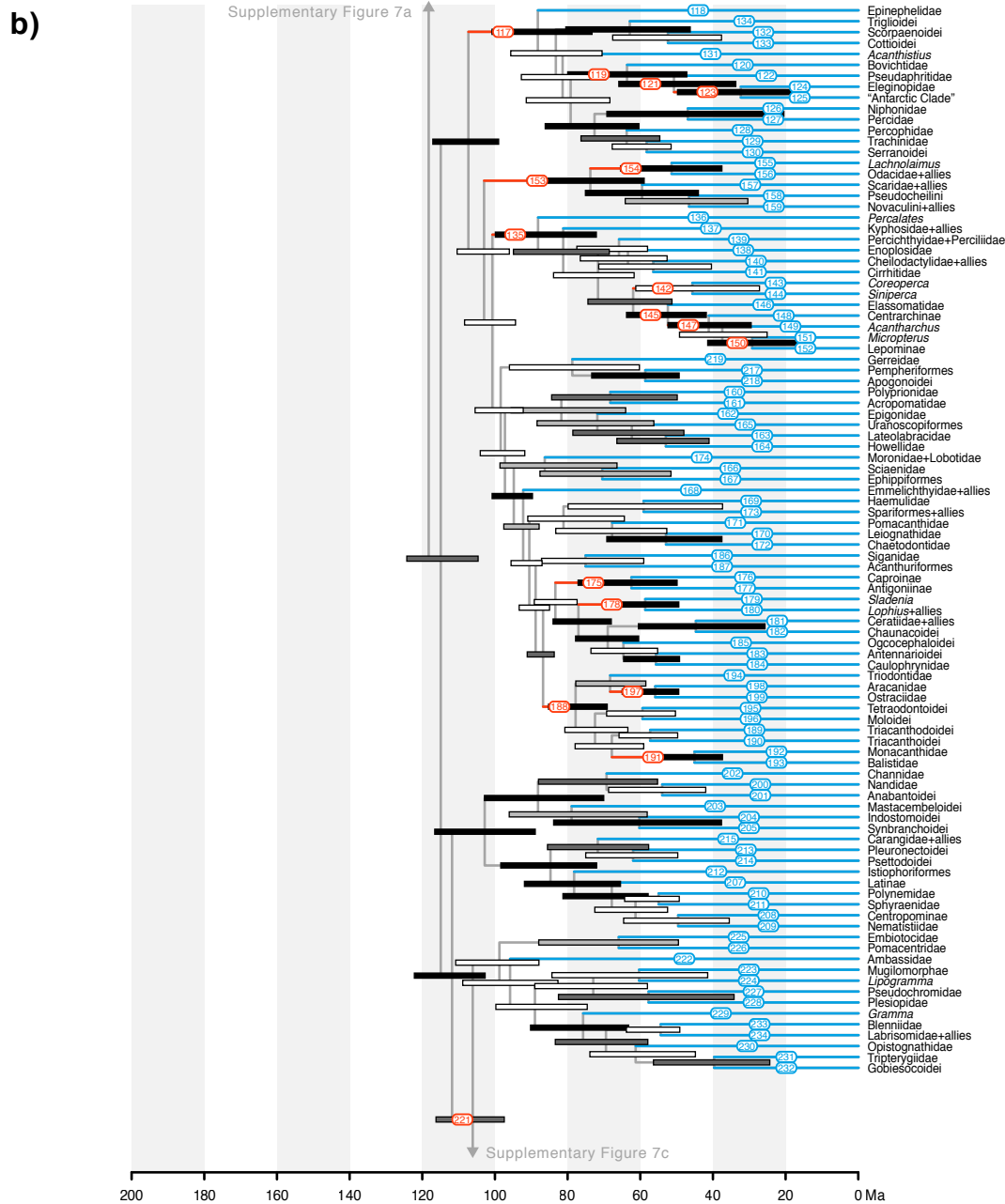
Supplementary Figure S7: BEAST phylogeny.

Time-calibrated phylogeny of 362 mutually exclusive clades within the Supercohort Clupeocephala (Betancur-R *et al.* 2013), inferred with BEAST on the basis of 32 molecular sequence markers (see Supplementary Table S4) and 147 fossil constraints (see Supplementary Text S2). Colored branches mark clades listed in Supplementary Text S2. Node bars indicate 95% HPD intervals of divergence events, and bars are colored according to topological node support (black: BPP 1.0; dark gray: BPP 0.9-0.99; light gray: BPP 0.75-0.89; white: BPP < 0.75). a) Otomorpha (clade 1), Lepidogalaxii (63), Argentiniformes (64), Esociformes (69), Salmoniformes (70), Stomiati (71), Galaxiiformes (72), and early-diverging lineages of Neoteleostei (73).



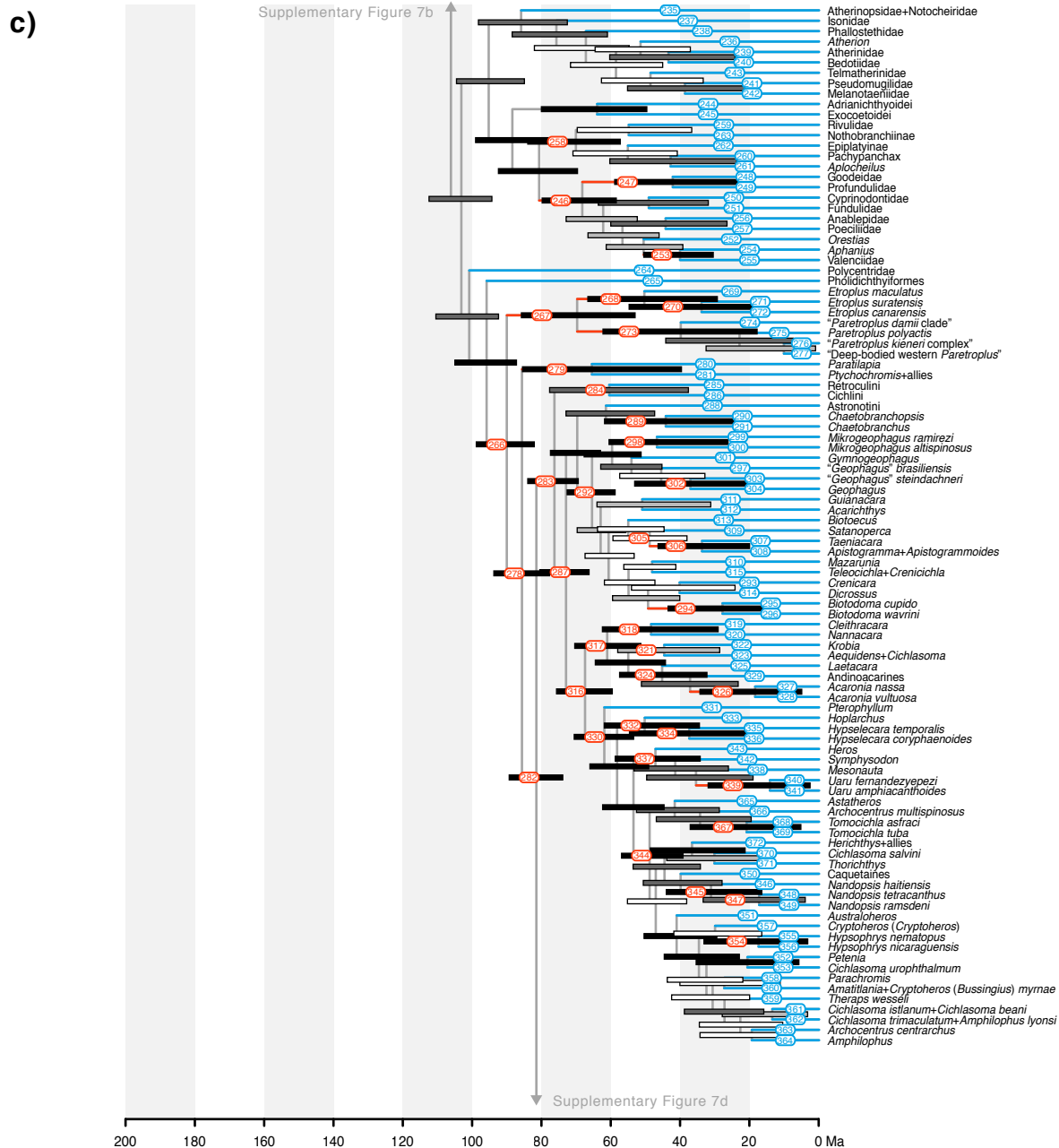
Supplementary Figure S7 (continued): BEAST phylogeny.

b) Perciformes (clade 117), Labridae (153), Centrarchiformes+allies (135), Pempheriformes (217), Uranoscopiformes (165), Ephippiformes (167), Spariformes+allies (173), Acanthuriformes (187), various percomorph families (160-177,186,187,217-219), Lophiiformes (178-185), Tetraodontiformes (188), Anabantiformes (200-202), Synbranchiformes (203-205), Carangimorphariae (207-214), and early-diverging lineages of Ovalentariae (221).



Supplementary Figure S7 (continued): BEAST phylogeny.

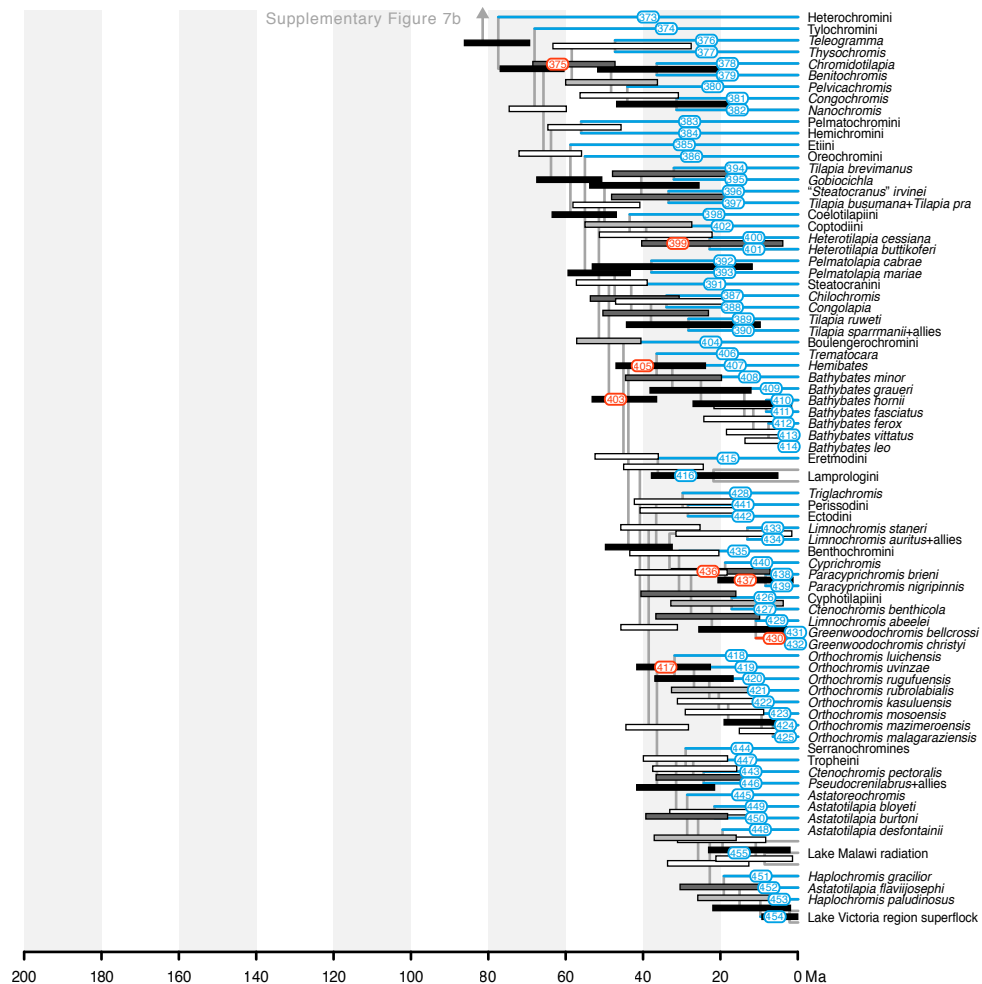
c) Atheriniformes (clades 235-243), Beloniformes (244,245), Cyprinodontiformes (246,258), Polycentridae (264), Pholidichthyiformes (265), Etroplinae (267), Ptychochrominae (279), and Cichlinae (283).



Supplementary Figure S7 (continued): BEAST phylogeny.

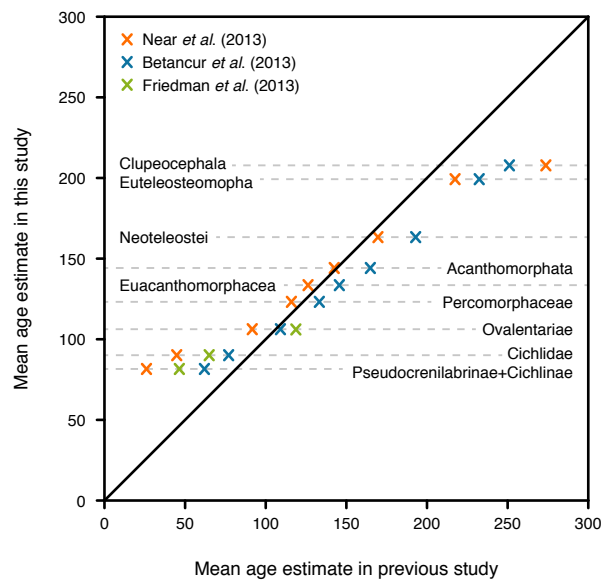
d) Pseudocrenilabrinae (clades 373-454).

d)



Supplementary Figure S8: Comparison of age estimates with previous studies.

Mean age estimates of nine selected clades, resulting from the BEAST analysis in this study, compared to those obtained previously by Near *et al.* (2013), Betancur-R *et al.* (2013), and Friedman *et al.* (2013). Estimates based on CladeAge calibration densities appear generally older for more recent clades, and younger for deep phylogenetic splits, than the estimates obtained by the three studies.



3 Supplementary Tables

Supplementary Table S1: Species-level sampling rate estimates for 23 animal clades.

Where necessary, genus-level sampling probabilities were translated to species-level rates (per lineage and million year; $L^{-1}myr^{-1}$) as described in the main text. Δt : Mean duration of geologic time intervals (in million years) used for calculation (see Foote & Sepkoski 1999).

Clade	Sampling probability	Δt	Sampling rate ($L^{-1}myr^{-1}$)	Reference
Anthozoa	0.4-0.5	5.3-5.5	0.031-0.048	Foote & Sepkoski (1999)
Asterozoa	0.25	5.3-5.5	0.014	Foote & Sepkoski (1999)
Bivalvia	0.45-0.5	5.3-5.5	0.032-0.040	Foote & Sepkoski (1999)
Brachiopoda	0.9	5.3-5.5	0.30	Foote & Sepkoski (1999)
Bryozoa	0.7-0.75	5.3-5.5	0.11-0.14	Foote & Sepkoski (1999)
Cephalopoda	0.8-0.9	5.3-5.5	0.20-0.32	Foote & Sepkoski (1999)
Chiroptera	0.04	5.07	0.002	Eiting & Gunnell (2009)
Chondrichthyes	0.1-0.15	5.3-5.5	0.004-0.006	Foote & Sepkoski (1999)
Echinoidea	0.55-0.65	5.3-5.5	0.058-0.088	Foote & Sepkoski (1999)
Gastropoda	0.4-0.55	5.3-5.5	0.024-0.048	Foote & Sepkoski (1999)
Malacostraca	0.2-0.35	5.3-5.5	0.011-0.026	Foote & Sepkoski (1999)
Mammalia	-	-	0.03-0.06 ¹	Foote <i>et al.</i> (1999)
Iberian mammals	0.66 ²	1.39	0.78	Alba <i>et al.</i> (2001)
†Ornithischia	-	-	0.172 0.355 ¹	Starrfelt & Liow (2016)
Osteichthyes	0.15-0.3	5.3-5.5	0.007-0.018	Foote & Sepkoski (1999)
Ostracoda	0.5	5.3-5.5	0.052	Foote & Sepkoski (1999)
Polychaeta	0.05	5.3-5.5	0.002	Foote & Sepkoski (1999)
Porifera	0.4-0.45	5.3-5.5	0.019-0.024	Foote & Sepkoski (1999)
Rhinocerotidae	-	-	5.701 ¹	Silvestro <i>et al.</i> (2014)
†Sauropodomorpha	-	-	0.084 0.304 ¹	Starrfelt & Liow (2016)
Spheniscidae	-	-	0.094 ^{1,3}	Gavryushkina <i>et al.</i> (2015)
Theropoda	-	-	0.104 0.243 ¹	Starrfelt & Liow (2016)
Ursidae	-	-	0.094 ^{1,4}	Gavryushkina <i>et al.</i> (2014)

¹: Species-level rate given in reference.

²: Species-level probability given per time interval.

³: Mean estimate, based on reported mean estimates of sampling proportion, net diversification, and turnover.

⁴: Median estimate, based on reported median estimates of sampling proportion, net diversification, and turnover.

Supplementary Table S2: Sequence accession numbers.

Species names are according to FishBase (Froese & Pauly 2015), except for taxa listed in Supplementary Table S3. Marker names, including synonyms used in the phylogenetic literature and ENSEMBL gene tree IDs are given in Supplementary Table S4. Sequences KX347580-KX347886, KR150861-KR150878, KR233974-KR233978, KU531434-KU531436, and KX397358-KX397359 were produced for this study, including 26 mitochondrial genomes of cichlid fishes listed in Supplementary Table S6. See Supplementary Text S1 for sequencing protocols. Sequences listed as “ENSEMBL” were obtained from ENSEMBL, and corresponding accession numbers are listed in Supplementary Table S6. Sequences compiled from genomic data sets, such as short read archives, are labelled as “Genomic” and listed in Supplementary Table S7. Five sequences of mt-co1 were obtained from the Barcode of Life Data System (BOLD; Ratnasingham & Hebert 2007): *Nanochromis splendens* (AMNHI035-09), *Pelmatochromis nigrofasciatus* (AMNHI706-12), *Steatocranus casuarius* (AMNHI015-09), *Steatocranus gibbiceps* (AMNHI010-09), and *Tylochromis lateralis* (AMNHI039-09). For all other sequences, accession numbers of the NCBI nucleotide database (www.ncbi.nlm.nih.gov/nucleotide) are given.

* Sequence added subsequent to maximum-likelihood phylogenetic inferences, as additional data became publicly available.

See separate file `accessions.xlsx`.

Supplementary Table S3: Species names not following FishBase.

The following species names differ between Supplementary Table S2 and FishBase.

Species	FishBase name	Reference
<i>Percalates colonorum</i>	<i>Macquaria colonorum</i>	Near <i>et al.</i> (2012c)
<i>Percalates novemaculeata</i>	<i>Macquaria novemaculeata</i>	Near <i>et al.</i> (2012c)
<i>Krobia potaroensis</i>	<i>Aequidens potaroensis</i>	Musilová <i>et al.</i> (2009)
<i>Astatheros diquis</i>	<i>Amphilophus diquis</i>	Říčan <i>et al.</i> (2008)
<i>Astatheros longimanus</i>	<i>Amphilophus longimanus</i>	Říčan <i>et al.</i> (2008)
<i>Astatheros macracanthus</i>	<i>Amphilophus macracanthus</i>	Říčan <i>et al.</i> (2008)
<i>Astatheros robertsoni</i>	<i>Amphilophus robertsoni</i>	Říčan <i>et al.</i> (2008)
<i>Lepidolamprologus nkambae</i>	<i>Lepidolamprologus kendalli</i>	Schelly <i>et al.</i> (2006)
<i>Haplogochromis guiarthi</i>	<i>Haplochromis guiarthi</i>	van Oijen (1996)
<i>Neochromis nigricans</i>	<i>Haplochromis nigricans</i>	van Oijen (1996)
<i>Platytaeniodus degeni</i>	<i>Haplochromis degeni</i>	van Oijen (1996)
<i>Pundamilia nyererei</i>	<i>Haplochromis nyererei</i>	Seehausen <i>et al.</i> (1998)

Supplementary Table S4: Molecular sequence markers used for phylogenetic analyses.

In order to reduce the potential for homoplasious substitutions, sequences of two rapidly evolving markers, the non-coding D-loop and the first intron of rps7, were used only for cichlid fishes. For the same reason, mitochondrial third codon positions were replaced with gaps in all non-cichlid taxa.

ZFIN name	Synonyms	ENSEMBL gene tree	Alignment length (bp)	Missing sequences	Used in BI
-	12S rRNA	-	623	50.80%	yes
-	16S rRNA	-	885	32.35%	yes
mt-atp6	ATPase6	ENSGT00390000005568	681	68.41%	yes
mt-atp8	ATPase8	ENSGT00400000025179	165	68.66%	yes
mt-co1	CO1	ENSGT00390000001518	1539	45.83%	yes
mt-co2	CO2	ENSGT00390000017410	687	72.96%	yes
mt-co3	CO3	ENSGT00390000013064	783	73.21%	yes
mt-cyb	CytB	ENSGT00390000017948	1131	23.93%	yes
mt-nd1	NADH1	ENSGT00390000006621	969	71.44%	yes
mt-nd2	NADH2	ENSGT00730000111348	1023	32.35%	yes
mt-nd3	NADH3	ENSGT00390000011605	348	72.45%	yes
mt-nd4	NADH4	ENSGT00730000111316	1380	57.29%	yes
mt-nd4l	NADH4L	ENSGT00390000004755	291	72.96%	yes
mt-nd5	NADH5	ENSGT00730000111303	1818	72.54%	yes
-	D-loop	-	403	69.92%	no
rag1	-	ENSGT00390000008679	1491	66.39%	yes
rag2	-	ENSGT00390000012559	930	79.53%	yes
rho	Rhod, RH1	ENSGT00710000106574	1065	80.37%	yes
ttna	Tmo4c4	ENSGT00690000101977	510	77.76%	yes
zic1	-	ENSGT00650000092933	849	84.33%	yes
myh6	-	ENSGT00720000108683	753	79.78%	yes
ptchd4	ptr	ENSGT00680000099845	702	79.02%	yes
enc1	-	ENSGT00740000115131	810	78.43%	yes
tbr1b	tbr1	ENSGT00740000115029	687	84.84%	yes
snx33	sh3px3	ENSGT00510000046469	705	86.77%	yes
plagl2	-	ENSGT00390000013640	672	85.68%	yes
gpr85	sreb2	ENSGT00750000117696	987	87.45%	yes
BEGAIN	si:dkey	ENSGT00530000063778	1080	93.85%	yes
slc10a3	-	ENSGT00550000074505	729	94.36%	yes
ube3a	-	ENSGT00750000117423	693	94.19%	yes
-	UBE-like	ENSGT00750000117423	633	94.86%	yes
znf503	-	ENSGT00390000014618	1263	93.93%	yes
opn1sw1	SWS1	ENSGT00710000106574	1417	95.96%	yes
dlx2a	dlx2	ENSGT00720000108450	684	93.26%	no
mitfb	-	ENSGT00390000004402	251	93.60%	no
rps7	-	ENSGT00390000014122	571	77.42%	no
edn1	-	ENSGT00530000063310	2414	96.80%	no
edn3b	-	ENSGT00530000063310	494	96.97%	no
ednraa	-	ENSGT00690000101856	927	96.63%	no
ednrb1a	-	ENSGT00690000101856	1772	91.83%	no
Total			35815	76.73%	32

Supplementary Table S5: Accession numbers for 26 mitochondrial genomes sequenced for this study.

Name	NCBI accession number
<i>Retroculus lapidifer</i>	KR150871
<i>Cichla ocellaris</i>	KR150863
<i>Chaetobranchopsis bitaeniatus</i>	KR150861
<i>Geophagus brasiliensis</i>	KU531434
<i>Mikrogeophagus ramirezi</i>	KR233976
<i>Gymnogeophagus balzanii</i>	KR150864
<i>Geophagus steindachneri</i>	KR150866
<i>Taeniacara candidi</i>	KR150873
<i>Apistogramma cactuoides</i>	KR150874
<i>Dicrossus filamentosus</i>	KR233975
<i>Crenicichla regani</i>	KR233977
<i>Nannacara anomala</i>	KU531436
<i>Krobia guianensis</i>	KR233978
<i>Aequidens metae</i>	KR150865
<i>Cichlasoma dimerus</i>	KR150876
<i>Laetacara thayeri</i>	KR233974
<i>Andinoacara biserialatus</i>	KX397359
<i>Andinoacara pulcher</i>	KR150868
<i>Bujurquina mariae</i>	KR150862
<i>Bujurquina oenolaemus</i>	KX397358
<i>Pterophyllum scalare</i>	KR150869
<i>Uaru amphiacanthoides</i>	KR150875
<i>Cryptoheros cutteri</i>	KR150878
<i>Rocio octofasciata</i>	KR150870
<i>Thorichthys aureus</i>	KU531435
<i>Herichthys cyanoguttatus</i>	KR150867

Supplementary Table S6: ENSEMBL accession numbers.

Accession numbers for sequences listed as “ENSEMBL” in Supplementary Table S2.

Marker	<i>Danio rerio</i>	<i>Gadus morhua</i>	<i>Gasterosteus aculeatus</i>
rho	ENSDARG00000002193		
ttna	ENSDARG00000028213	ENSGMOG00000010782	ENSGACG00000000274
zic1	ENSDARG00000015567		
plagl2	ENSDARG00000076657		
BEGAIN	ENSDARG00000043673	ENSGMOG00000008650	ENSGACG00000008363
slc10a3	ENSDARG00000095660	ENSGMOG00000003622	ENSGACG00000002112
ube3a		ENSGMOG00000018993	ENSGACG00000015321
UBE-like		ENSGMOG00000004287	ENSGACG00000013744
znf503	ENSDARG00000018492	ENSGMOG00000012626	ENSGACG00000008890
opn1sw1	ENSDARG00000045677		ENSGACG00000000716
dlx2a		ENSGMOG00000002233	ENSGACG00000004914
mitfb		ENSGMOG00000010175	ENSGACG00000003425
edn1		ENSGMOG00000011415	
edn3b	ENSDARG00000086669		
ednraa	ENSDARG00000011876	ENSGMOG00000002010	ENSGACG00000017219
ednrb1a	ENSDARG00000089334	ENSGMOG00000013737	ENSGACG00000012901

Marker	<i>Takifugu rubripes</i>	<i>Tetraodon nigroviridis</i>	<i>Oryzias latipes</i>
rag1	ENSTRUG00000001340	ENSTNIG00000012168	
rag2		ENSTNIG00000012169	
ttnaa		ENSTNIG00000019381	ENSORLG00000018144
zic1	ENSTRUG00000017760	ENSTNIG00000012758	
myh6	ENSTRUG00000005019		
enc1	ENSTRUG00000018509		
tbr1b	ENSTRUG00000005183	ENSTNIG00000016497	
plagl2	ENSTRUG00000002593	ENSTNIG00000004990	
BEGAIN	ENSTRUG00000004803	ENSTNIG00000012233	ENSORLG00000011506
slc10a3	ENSTRUG00000004776	ENSTNIG00000001402	ENSORLG00000015265
ube3a	ENSTRUG00000006347	ENSTNIG00000014475	ENSORLG00000020667
UBE-like	ENSTRUG00000006748	ENSTNIG00000013784	ENSORLG00000015759
znf503	ENSTRUG00000003530	ENSTNIG00000008627	ENSORLG00000006570
dlx2a	ENSTRUG00000017732	ENSTNIG00000016939	ENSORLG00000017372
mitfb	ENSTRUG00000012080	ENSTNIG00000012564	ENSORLG00000013461
edn1			ENSORLG00000009276
ednraa	ENSTRUG00000014468	ENSTNIG00000017728	ENSORLG00000007423
ednrb1a	ENSTRUG00000008869	ENSTNIG00000007897	ENSORLG00000011054

Marker	<i>Oreochromis niloticus</i>	Marker	<i>Oreochromis niloticus</i>
rag1	ENSTRUG00000001340	dlx2a	ENSONIG00000008722
BEGAIN	ENSONIG00000005885	mitfb	ENSONIG00000016952
slc10a3	ENSONIG00000010948	edn1	ENSONIG00000013695
ube3a	ENSONIG00000003746	edn3b	ENSONIG00000002242
UBE-like	ENSONIG00000019346	ednraa	ENSONIG00000010008
znf503	ENSONIG00000018528	ednrb1a	ENSONIG00000018701

Supplementary Table S7: Sequences identified from other genomic resources.

Access information for sequences listed as “Genomic” in Supplementary Table S2. All sequences were identified through BLAST search against combined resources, using related sequences as queries. For each identified sequence, orthology was confirmed with single-gene phylogenies. Traces listed are publicly available through NCBI’s taxonomy browser website. ABC: Agencourt Bioscience Corporation; BROAD: Broad Institute; EST: Expressed sequence tags; GSS: Genome survey sequences; NISC: NIH Intramural Sequencing Center; WGS: Whole genome sequencing.

Species	Number of markers	Resources
<i>Cyprinus carpio</i>	7	NCBI GSS + EST + SRX007427
<i>Danio rerio</i>	1	ENSEMBL Zv9
<i>Ictalurus punctatus</i>	4	NCBI GSS + EST + 27 700 NISC shotgun traces
<i>Oncorhynchus mykiss</i>	7	NCBI GSS + EST + DRX000493 + SRX007396
<i>Salmo salar</i>	11	NCBI GSS + EST + 15 506 038 ABC WGS traces + 28,899 NISC shotgun traces
<i>Gadus morhua</i>	2	ENSEMBL gadMor1
<i>Chaenocephalus aceratus</i>	3	NCBI SRX089048 + SRX089049
<i>Notothenia coriiceps</i>	2	NCBI SRX089044 + SRX089045
<i>Pleuragramma antarctica</i>	3	NCBI SRX089046 + SRX089047
<i>Anoplopoma fimbria</i>	12	NCBI PRJNA71237
<i>Zoarces viviparus</i>	13	NCBI SRX002161
<i>Gasterosteus aculeatus</i>	3	ENSEMBL BROADS1
<i>Sparus aurata</i>	9	NCBI GSS + EST + PRJEB2658
<i>Dicentrarchus labrax</i>	12	NCBI EST + CABK00000000
<i>Morone saxatilis</i>	1	NCBI SRX007394
<i>Takifugu rubripes</i>	7	ENSEMBL FUGU4
<i>Tetraodon nigroviridis</i>	7	ENSEMBL TETRAODON8
<i>Paralichthys olivaceus</i>	4	NCBI EST + SRX012829 + SRX036580
<i>Scophthalmus maximus</i>	1	NCBI + SRX098093
<i>Oryzias latipes</i>	2	ENSEMBL MEDAKA1
<i>Xiphophorus maculatus</i>	21	NCBI GCF_000241075.1
<i>Nothobranchius furzeri</i>	9	NCBI ACCZ000000000.1 + ABLO000000000.1 + SRX000346
<i>Nothobranchius kuhntae</i>	7	NCBI ACDA000000000.1
<i>Amphilophus astorquii</i>	14	NCBI SRX012375
<i>Amphilophus zaliosus</i>	14	NCBI SRX010970
<i>Oreochromis niloticus</i>	1	ENSEMBL Orenil1.0
<i>Neolamprologus brichardi</i>	21	BROAD NeoBri1.0
<i>Ophthalmotilapia ventralis</i>	15	NCBI PRJNA66843
<i>Astatotilapia burtoni</i>	13	NCBI EST + PRJNA66841 + BROAD HapBur1.0
<i>Pundamilia nyererei</i>	21	NCBI SRX033962 + BROAD PunNye1.0
<i>Labeotropheus fuelleborni</i>	18	NCBI ABPK000000000.1
<i>Maylandia zebra</i>	10	BROAD MayZeb1.0
<i>Melanochromis auratus</i>	13	NCBI ABPL000000000.1
<i>Mchenga conophoros</i>	15	NCBI ABPJ000000000.1
<i>Rhamphochromis esox</i>	16	NCBI ABPN000000000.1

Supplementary Table S8: Best-fitting partitioning scheme for maximum-likelihood phylogenetic analyses.

Partitioning scheme identified with PartitionFinder, based on BIC. Subscripts 1, 2, 3, and n denote the first, second, and third codon positions, and non-coding sites, respectively.

Subset	Sites	Primary data blocks
1	623	12S _n
2	885	16S _n
3	1229	mt-atp6 ₁ , mt-atp8 ₁ , mt-nd2 ₁ , mt-nd5 ₁
4	1293	mt-atp6 ₂ , mt-nd4 ₂ , mt-nd5 ₂
5	1413	mt-atp6 ₃ , mt-co1 ₃ , mt-nd3 ₃ , mt-nd4 ₃ , mt-nd4l ₃
6	1212	mt-atp8 ₂ , mt-cyb ₂ , mt-nd1 ₂ , mt-nd2 ₂ , mt-nd3 ₂
7	1474	mt-atp8 ₃ , mt-co2 ₃ , mt-co3 ₃ , mt-nd1 ₃ , mt-nd5 ₃
8	743	mt-co1 ₁ , mt-co2 ₁
9	1583	mt-co1 ₂ , mt-co2 ₂ , mt-co3 ₂ , opn1sw1 ₂ , slc10a3 ₂
10	358	mt-co3 ₁ , mt-nd4l ₁
11	816	mt-cyb ₁ , mt-nd1 ₁ , mt-nd3 ₁
12	718	mt-cyb ₃ , mt-nd2 ₃
13	403	mt-dloop _n
14	460	mt-nd4 ₁
15	97	mt-nd4l ₂
16	2795	dlx2a ₁ , edn1 ₂ , edn3b ₁ , ednraa ₁ , gpr85 ₁ , plagl2 ₁ , ptchd4 ₁ , rag1 ₁ , slc10a3 ₁ , ttna ₁ , ube3a ₁ , znf503 ₁
17	1643	dlx2a ₂ , enc1 ₂ , edn3b ₂ , mitfb ₂ , plagl2 ₂ , tbr1b ₂ , zic1 ₂ , znf503 ₂
18	1802	dlx2a ₃ , edn1 ₃ , edn3b ₃ , ednrb1a ₃ , enc1 ₃ , mitfb ₃ , myh6 ₃ , rag1 ₃ , UBE-like ₃
19	5148	dlx2a _n , edn1 _n , edn3b _n , ednraa _n , ednrb1a _n , mitfb _n , rps7 _n
20	1111	BEGAIN ₁ , BEGAIN ₂ , edn1 ₁ , UBE-like ₁
21	1414	ednraa ₂ , myh6 ₂ , ptchd4 ₂ , snx33 ₂ , ttna ₂ , UBE-like ₂ , ube3a ₂
22	2066	BEGAIN ₃ , ednraa ₃ , opn1sw1 ₃ , rho ₃ , tbr1b ₃ , zic1 ₃ , znf503 ₃
23	730	ednrb1a ₁ , enc1 ₁ , mitfb ₁ , myh6 ₁
24	861	ednrb1a ₂ , gpr85 ₂ , rho ₂
25	1496	gpr85 ₃ , plagl2 ₃ , ptchd4 ₃ , slc10a3 ₃ , snx33 ₃ , ube3a ₃
26	1216	opn1sw1 _n , rag1 ₂ , rag2 ₂
27	310	rag2 ₁
28	310	rag2 ₃
29	1438	opn1sw1 ₁ , rho ₁ , snx33 ₁ , tbr1b ₁ , zic1 ₁
30	170	ttna ₃

Supplementary Table S9: Missing diversity.

Groups that are part of Supercohort Clupeocephala (Froese & Pauly 2015; Betancur-R *et al.* 2013), but are not represented by any of the 362 mutually exclusive clades listed in Supplementary Text S2.

Name	Extant species richness	Higher-level clade
Banjosidae	1	99
Bathyclupeidae	7	99
Centrogeniidae	1	99
Dichistiidae	2	99
Dinolestidae	1	99
Dinopercidae	2	99
Lactariidae	1	99
Leptobramidae	1	99
Menidae	1	99
Monodactylidae	5	99
Ostracoberycidae	4	99
Pentacerotidae	12	99
Scatophagidae	4	99
Scombropidae	3	99
Symphysanodontidae	6	99
Toxotidae	6	99
Champsodontidae	13	117
Hoplichthyidae	10	117
<i>Bostockia</i>	2	135
Dentatherinidae	1	221
Notograptidae	2	221
" <i>Tilapia</i> " <i>jallae</i>	1	282
" <i>Amphilophus</i> " <i>calobrensis</i>	1	344
<i>Archocentrus spinosissimus</i>	1	344
<i>Cryptoheros (Bussingius) altoflavus</i>	1	344
<i>Cryptoheros (Bussingius) nanoluteus</i>	1	344
<i>Cryptoheros (Bussingius) sajica</i>	1	344
<i>Cryptoheros (Bussingius) septemfasciatus</i>	1	344
<i>Cryptoheros (Panamius) panamensis</i>	1	344
" <i>Cichlasoma</i> " <i>aguadae</i>	1	344
" <i>Cichlasoma</i> " <i>alborum</i>	1	344
" <i>Cichlasoma</i> " <i>amarum</i>	1	344
" <i>Cichlasoma</i> " <i>atromaculatum</i>	1	344
" <i>Cichlasoma</i> " <i>cienagae</i>	1	344
" <i>Cichlasoma</i> " <i>conchitae</i>	1	344
" <i>Cichlasoma</i> " <i>ericymba</i>	1	344
" <i>Cichlasoma</i> " <i>festae</i>	1	344
" <i>Cichlasoma</i> " <i>geddesi</i>	1	344
" <i>Cichlasoma</i> " <i>gephyrum</i>	1	344
" <i>Cichlasoma</i> " <i>grammodes</i>	1	344
" <i>Cichlasoma</i> " <i>mayorum</i>	1	344
" <i>Cichlasoma</i> " <i>microlepis</i>	1	344
" <i>Cichlasoma</i> " <i>ornatum</i>	1	344
" <i>Cichlasoma</i> " <i>stenozonum</i>	1	344

Supplementary Table S9 (continued): Missing diversity.

Name	Extant species richness	Higher-level clade
" <i>Cichlasoma</i> " <i>troschelii</i>	1	344
" <i>Cichlasoma</i> " <i>tuyrense</i>	1	344
" <i>Cichlasoma</i> " <i>zebra</i>	1	344
" <i>Paraneetroplus</i> " <i>nebuliferus</i>	1	344
" <i>Chromidotilapia</i> " <i>schoutedeni</i>	1	375
<i>Divandu</i>	1	375
<i>Enigmatochromis</i>	1	375
<i>Limbochromis</i>	1	375
<i>Parananochromis</i>	6	375
<i>Orthochromis kalungwishiensis</i>	1	403
<i>Orthochromis luongoensis</i>	1	403
<i>Thoracochromis lucullae</i>	1	403
<i>Thoracochromis schwetzi</i>	1	403
Sum	126	

Supplementary Table S10: Mean 95% HPD width of node age estimates, and the percentage of HPD intervals that contain the true node age, in 50 replicate analyses of data sets simulated with sampling rates $\psi = 0.1, 0.03, 0.01$. Results are given for analyses sampling from the prior only. Schemes refer to CladeAge calibration schemes (see Figure 2).

Mean 95% HPD width:							
ψ	True node age	Scheme A	Scheme B	Scheme C	Scheme D	FBD (fixed ψ)	FBD (estimated ψ)
0.1	0-20	9.86	10.93	11.92	13.86	11.37	18.49
0.1	20-40	8.06	8.76	10.73	14.35	13.11	23.99
0.1	40-60	7.93	8.56	9.98	14.43	13.32	24.17
0.1	60-80	8.05	8.50	10.92	15.56	13.06	23.46
0.1	80-100	8.21	8.72	12.15	17.52	11.36	21.36
0.1	All	9.34	10.30	11.55	14.07	11.84	20.01
0.03	0-20	17.58	18.73	21.14	22.65	16.29	19.63
0.03	20-40	17.79	18.82	23.95	27.71	22.71	28.42
0.03	40-60	15.54	15.98	22.78	28.37	22.58	29.40
0.03	60-80	16.56	16.45	24.18	30.93	24.14	31.77
0.03	80-100	15.30	15.15	20.74	29.07	20.12	28.81
0.03	All	17.42	18.50	21.84	24.27	18.11	22.30
0.01	0-20	23.69	22.67	29.07	30.61	18.37	19.51
0.01	20-40	29.84	28.93	42.11	45.56	29.40	31.81
0.01	40-60	27.89	26.08	44.59	50.90	33.14	36.23
0.01	60-80	27.76	24.71	47.74	55.02	34.70	39.13
0.01	80-100	27.06	22.95	48.09	57.79	34.09	38.52
0.01	All	25.28	24.13	33.26	35.72	22.03	23.66

Percentage of 95% HPD intervals containing the true node age:							
ψ	True node age	Scheme A	Scheme B	Scheme C	Scheme D	FBD (fixed ψ)	FBD (estimated ψ)
0.1	0-20	96.9	97.3	96.2	95.5	98.2	95.1
0.1	20-40	91.6	95.7	95.9	95.2	98.3	85.7
0.1	40-60	90.5	94.9	95.9	97.8	98.1	88.2
0.1	60-80	87.8	91.2	92.6	95.9	99.1	95.3
0.1	80-100	93.8	95.8	100.0	95.8	96.1	97.9
0.1	All	95.2	96.7	96.1	95.6	98.2	93.0
0.03	0-20	95.4	94.6	93.1	92.2	97.5	97.2
0.03	20-40	94.8	95.3	92.9	88.9	95.0	93.4
0.03	40-60	92.4	93.9	94.4	89.0	96.8	91.6
0.03	60-80	85.7	87.4	94.1	93.3	98.3	95.0
0.03	80-100	92.9	89.3	92.9	98.2	94.6	98.2
0.03	All	94.8	94.4	93.2	91.5	97.0	96.1
0.01	0-20	93.8	95.7	93.0	92.5	97.3	97.4
0.01	20-40	89.4	92.2	81.5	80.0	92.6	93.7
0.01	40-60	92.8	94.5	79.2	74.9	95.4	96.1
0.01	60-80	89.6	82.1	77.6	76.9	93.3	96.3
0.01	80-100	90.0	82.0	94.0	84.0	96.0	96.0
0.01	All	92.6	94.3	89.5	88.5	96.1	96.5

Supplementary Table S11: Mean 95% HPD width of node age estimates, and the percentage of HPD intervals that contain the true node age, in 50 replicate analyses of data sets simulated with sampling rates $\psi = 0.1, 0.03, 0.01$. Results are given for analyses sampling from the posterior, with sequence data sets simulated with uncorrelated branch rates. Schemes refer to CladeAge calibration schemes (see Figure 2).

Mean 95% HPD width:

ψ	True node age	Scheme A	Scheme B	Scheme C	Scheme D	FBD (fixed ψ)	FBD (estimated ψ)
0.1	0-20	6.11	6.59	7.04	7.89	7.19	10.23
0.1	20-40	7.08	7.71	8.71	11.35	10.66	17.80
0.1	40-60	7.00	7.61	8.88	12.03	11.03	20.30
0.1	60-80	7.77	8.19	10.09	13.93	11.98	22.88
0.1	80-100	8.08	8.40	9.35	14.04	10.52	22.91
0.1	All	6.41	6.91	7.55	9.00	8.20	12.68
0.03	0-20	9.31	9.70	10.68	11.35	9.48	10.94
0.03	20-40	13.84	14.51	17.75	20.12	17.00	20.96
0.03	40-60	13.31	13.75	18.42	22.25	18.58	24.53
0.03	60-80	15.05	15.00	21.61	27.20	21.00	28.98
0.03	80-100	15.95	15.52	23.42	30.13	21.19	31.78
0.03	All	10.63	11.06	12.91	14.30	11.90	14.39
0.01	0-20	11.22	10.56	13.64	14.28	10.11	10.69
0.01	20-40	20.84	19.73	28.75	30.92	21.00	22.77
0.01	40-60	22.36	20.84	35.54	39.26	25.67	28.61
0.01	60-80	24.96	21.99	42.25	48.47	30.82	34.54
0.01	80-100	28.16	23.73	51.92	59.21	34.88	40.60
0.01	All	14.08	13.19	18.67	19.99	13.71	14.77

Percentage of 95% HPD intervals containing the true node age:

ψ	True node age	Scheme A	Scheme B	Scheme C	Scheme D	FBD (fixed ψ)	FBD (estimated ψ)
0.1	0-20	95.6	95.6	95.4	93.9	95.7	88.7
0.1	20-40	93.7	94.9	94.7	93.0	95.2	68.7
0.1	40-60	91.4	96.0	95.1	92.9	96.9	67.9
0.1	60-80	91.3	93.0	95.7	94.8	98.3	78.3
0.1	80-100	92.2	92.2	96.1	98.0	94.1	90.2
0.1	All	94.9	95.4	95.3	93.8	95.8	83.7
0.03	0-20	94.0	93.3	91.8	90.9	95.0	93.4
0.03	20-40	94.2	93.1	87.4	80.9	93.3	86.0
0.03	40-60	89.3	92.8	89.3	82.6	94.2	82.1
0.03	60-80	94.4	93.6	91.2	81.6	96.8	88.0
0.03	80-100	90.0	90.0	93.3	93.3	96.7	96.7
0.03	All	93.7	93.2	90.9	88.3	94.7	91.1
0.01	0-20	92.1	93.4	88.4	87.5	94.3	94.6
0.01	20-40	85.4	90.6	72.9	70.3	93.4	92.3
0.01	40-60	87.5	92.4	66.7	57.8	93.4	92.7
0.01	60-80	90.8	84.4	67.0	63.3	95.4	91.7
0.01	80-100	83.3	76.2	81.0	69.0	92.9	97.6
0.01	All	90.5	92.4	83.9	82.0	94.1	94.0

Supplementary Table S12: Mean 95% HPD width of node age estimates, and the percentage of HPD intervals that contain the true node age, in 50 replicate analyses of data sets simulated with sampling rates $\psi = 0.1, 0.03, 0.01$. Results are given for analyses sampling from the posterior, with sequence data sets simulated with autocorrelated branch rates. Schemes refer to CladeAge calibration schemes (see Figure 2).

Mean 95% HPD width:

ψ	True node age	Scheme A	Scheme B	Scheme C	Scheme D	FBD (fixed ψ)	FBD (estimated ψ)
0.1	0-20	3.97	4.17	4.33	4.74	4.60	5.98
0.1	20-40	5.79	6.19	6.67	8.28	7.95	12.50
0.1	40-60	6.15	6.59	7.21	10.03	9.35	17.59
0.1	60-80	6.70	7.18	7.88	11.75	10.49	22.36
0.1	80-100	7.15	7.75	8.56	13.11	10.81	27.61
0.1	All	4.56	4.82	5.10	6.03	5.75	8.66
0.03	0-20	5.17	5.23	5.62	5.94	5.47	6.20
0.03	20-40	10.00	10.32	11.82	13.30	11.90	14.48
0.03	40-60	10.89	11.19	14.16	17.15	14.51	19.20
0.03	60-80	13.52	13.62	17.73	22.00	19.30	26.00
0.03	80-100	14.32	14.69	19.54	26.00	21.80	31.18
0.03	All	6.77	6.92	7.83	8.73	7.84	9.44
0.01	0-20	5.75	5.48	7.01	7.59	5.67	6.04
0.01	20-40	13.33	12.58	18.31	20.39	13.55	14.92
0.01	40-60	16.86	15.78	25.62	29.27	18.68	21.16
0.01	60-80	19.65	17.82	32.01	36.39	23.18	26.99
0.01	80-100	22.93	19.62	37.32	44.40	27.88	32.56
0.01	All	8.49	8.00	11.39	12.63	8.76	9.61

Percentage of 95% HPD intervals containing the true node age:

ψ	True node age	Scheme A	Scheme B	Scheme C	Scheme D	FBD (fixed ψ)	FBD (estimated ψ)
0.1	0-20	87.2	85.8	84.7	81.0	83.4	70.1
0.1	20-40	88.3	89.4	87.7	82.5	83.5	55.2
0.1	40-60	89.8	93.6	93.9	85.0	88.9	36.0
0.1	60-80	91.9	94.6	96.6	92.6	96.6	26.4
0.1	80-100	100.0	100.0	97.9	87.5	100.0	27.1
0.1	All	87.9	87.3	86.4	81.9	84.4	63.5
0.03	0-20	76.3	75.3	71.5	67.6	74.1	69.2
0.03	20-40	75.2	74.1	63.8	54.6	66.6	53.8
0.03	40-60	77.3	74.4	59.0	43.6	64.5	45.6
0.03	60-80	92.4	89.9	68.9	47.1	76.5	43.7
0.03	80-100	94.6	94.6	75.0	44.6	71.4	37.5
0.03	All	76.8	75.7	69.3	62.7	72.2	63.8
0.01	0-20	69.7	71.5	63.4	61.9	72.5	71.3
0.01	20-40	56.7	65.3	45.0	40.0	65.0	60.6
0.01	40-60	54.4	65.5	34.2	29.0	60.9	52.4
0.01	60-80	62.7	76.9	32.8	28.4	69.4	59.0
0.01	80-100	80.0	92.0	36.0	14.0	74.0	68.0
0.01	All	66.2	70.3	57.0	54.3	70.3	67.7

Supplementary Table S13 (next page): Performance of CladeAge calibration densities when model parameters are misspecified. Given are the mean 95% HPD width of node age estimates, and the percentage of HPD intervals that contain the true node age, in 50 replicate analyses with CladeAge calibration scheme A of data sets simulated with sampling rates $\psi = 0.1, 0.03, 0.01$. Results are for analyses sampling from the posterior, with sequence data sets simulated with uncorrelated branch rates.

Supplementary Table S13: Performance of CladeAge calibration densities when model parameters are misspecified.**Mean 95% HPD width:**

ψ	True node age	Assumed net diversification ($\lambda - \mu$)		Assumed sampling rate (ψ)	
		25% overestimated	25% underestimated	50% overestimated	50% underestimated
0.1	0-20	6.03	6.22	5.31	7.78
0.1	20-40	6.94	7.42	5.69	10.39
0.1	40-60	6.92	7.49	5.64	10.75
0.1	60-80	7.71	8.38	6.20	12.22
0.1	80-100	7.77	8.50	6.23	12.49
0.1	All	6.31	6.60	5.43	8.60
0.03	0-20	9.10	9.40	8.31	11.41
0.03	20-40	13.30	14.45	11.82	18.35
0.03	40-60	12.94	14.40	11.26	19.16
0.03	60-80	14.64	16.37	12.28	22.17
0.03	80-100	15.62	17.79	13.19	25.25
0.03	All	10.34	10.94	9.31	13.63
0.01	0-20	11.99	11.64	10.06	14.39
0.01	20-40	19.67	22.12	18.04	26.67
0.01	40-60	20.73	24.76	19.17	29.23
0.01	60-80	23.37	28.84	21.22	33.62
0.01	80-100	26.08	32.63	23.22	38.96
0.01	All	13.55	14.90	12.41	18.17

Percentage of 95% HPD intervals containing the true node age:

ψ	True node age	Assumed net diversification ($\lambda - \mu$)		Assumed sampling rate (ψ)	
		25% overestimated	25% underestimated	50% overestimated	50% underestimated
0.1	0-20	95.6	96.1	93.9	93.6
0.1	20-40	93.0	94.4	86.7	93.3
0.1	40-60	92.3	94.1	81.2	96.0
0.1	60-80	90.4	93.9	85.2	97.4
0.1	80-100	92.2	92.2	88.2	96.1
0.1	All	94.8	95.6	91.6	93.8
0.03	0-20	94.2	94.2	94.6	87.8
0.03	20-40	94.4	94.1	90.1	77.4
0.03	40-60	89.0	92.0	77.4	81.8
0.03	60-80	92.8	93.6	80.0	84.0
0.03	80-100	93.3	93.3	76.7	100.0
0.03	All	93.9	94.0	92.1	85.5
0.01	0-20	92.0	91.1	93.6	81.1
0.01	20-40	87.0	83.3	92.4	54.0
0.01	40-60	88.1	83.2	89.1	43.9
0.01	60-80	89.9	89.9	86.2	48.6
0.01	80-100	78.6	85.7	73.8	64.3
0.01	All	90.7	89.2	92.8	73.3

Supplementary Table S14 (next page): Performance of the FBD process when model parameters are fixed but misspecified. Given are the mean 95% HPD width of node age estimates, and the percentage of HPD intervals that contain the true node age, in 50 replicate analyses of data sets simulated with sampling rates $\psi = 0.1, 0.03, 0.01$. Results are given for analyses sampling from the posterior, with sequence data sets simulated with uncorrelated branch rates.

Supplementary Table S14: Performance of the FBD process when model parameters are fixed but misspecified.

Mean 95% HPD width:						
ψ	True node age	Assumed net diversification ($\lambda - \mu$)		Assumed sampling rate (ψ)		
		25% overestimated	25% underestimated	50% overestimated	50% underestimated	
0.1	0-20	6.85	7.61	6.20	8.97	
0.1	20-40	10.03	11.44	8.70	14.76	
0.1	40-60	10.32	11.88	8.86	15.97	
0.1	60-80	11.16	12.94	9.37	17.48	
0.1	80-100	9.66	11.63	8.07	15.95	
0.1	All	7.77	8.74	6.91	10.73	
0.03	0-20	8.83	10.27	8.55	10.96	
0.03	20-40	15.53	18.76	14.68	20.86	
0.03	40-60	16.77	21.09	15.43	24.31	
0.03	60-80	18.80	24.78	17.17	28.74	
0.03	80-100	18.47	26.03	16.65	31.59	
0.03	All	10.96	13.11	10.45	14.36	
0.01	0-20	9.08	11.72	9.39	11.17	
0.01	20-40	18.69	24.56	19.15	23.94	
0.01	40-60	22.13	30.91	22.86	30.21	
0.01	60-80	25.80	37.54	26.80	36.82	
0.01	80-100	28.46	44.02	29.21	43.00	
0.01	All	12.15	16.08	12.53	15.50	

Percentage of 95% HPD intervals containing the true node age:						
ψ	True node age	Assumed net diversification ($\lambda - \mu$)		Assumed sampling rate (ψ)		
		25% overestimated	25% underestimated	50% overestimated	50% underestimated	
0.1	0-20	96.1	95.0	95.6	92.3	
0.1	20-40	96.1	93.0	96.3	83.5	
0.1	40-60	95.4	95.4	95.7	85.8	
0.1	60-80	97.4	98.3	94.8	92.2	
0.1	80-100	94.1	98.0	92.2	96.1	
0.1	All	96.1	94.8	95.7	90.4	
0.03	0-20	95.1	93.4	94.9	92.2	
0.03	20-40	93.9	89.1	93.8	83.6	
0.03	40-60	93.1	88.7	92.3	78.5	
0.03	60-80	95.2	92.8	92.0	84.8	
0.03	80-100	96.7	96.7	90.0	96.7	
0.03	All	94.7	92.3	94.4	89.5	
0.01	0-20	94.6	91.9	94.6	94.0	
0.01	20-40	93.6	83.6	94.3	88.0	
0.01	40-60	94.4	81.2	95.0	86.1	
0.01	60-80	94.5	82.6	95.4	83.5	
0.01	80-100	85.7	92.9	83.3	92.9	
0.01	All	94.3	89.6	94.5	92.2	

4 Supplementary Data

Supplementary Data S1: XML input files for BEAST analyses.

XML input files for analyses with simulated datasets are provided as a compressed directory. **See separate file `xmls.tgz`.**

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