**Fig. 1(a).** Rainfall and atmospheric and water temperatures – Monthly variations at Achencoil river basin during June 2010 to May 2011.

**Fig. 1(b).** Rainfall and atmospheric and water temperatures – Seasonal variations at Achencoil river basin
Fig. 2(a). Atmospheric temperature - Monthly variation at the three sites

Fig. 2(b). Atmospheric temperature - Seasonal variations at the three sites
Fig. 3(a). Water temperature - Monthly variations at the three sites

Fig. 3(b). Water temperature - Seasonal variations at the three sites
Fig. 4(a). pH - Monthly variation at the three sites

Fig. 4(b). pH - Seasonal variations at the three sites
**Fig. 5(a).** DO - Monthly variation at the three sites

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**Fig. 5(b).** DO - Seasonal variations at the three sites

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Fig. 6(a). CO$_2$ - Monthly variation at the three sites

![CO$_2$ - Monthly variation at the three sites](image)

Fig. 6(b). CO$_2$ - Seasonal variations at the three sites

![CO$_2$ - Seasonal variations at the three sites](image)
Fig. 7(a). PO$_4$ - Monthly variation at the three sites

Fig. 7(b). PO$_4$ - Seasonal variations at the three sites
Fig. 8(a). NO$_3$ - Monthly variation at the three sites

Fig. 8(b). NO$_3$ - Seasonal variations at the three sites
Fig. 9 Abundance of ornamental fish species of Achencoil River
Fig. 10 Percentage composition of genera, species and individuals of ornamental fishes in Achencoil River
Fig. 11 Relative abundance of the 46 species of ornamental fishes in Achencoil River.
**Fig. 12** Rank-abundance curve of the ornamental fish community of Achencoil River (abundance of 3 most dominant species shown in boxes)

**Fig. 13** Preston graph (with superimposed log-abundance curve) for the ornamental fish community of Achencoil River

**Fig. 14** SHE analysis graph for the ornamental fish community of Achencoil River

*Fig. 12* shows the rank-abundance curve for the ornamental fish community of Achencoil River. The abundance of the three most dominant species is indicated: *Etroplus maculatus* = 94, *Barilius bakeri* = 92, and *Puntius filamentosus* = 83.

*Fig. 13* presents the Preston graph, which includes a superimposed log-abundance curve. It illustrates the distribution of species abundance categories.

*Fig. 14* depicts the SHE analysis graph, which visualizes the diversity (H, ln_S, ln_E) against the number of individuals for the ornamental fish community.
Fig. 15 Rank-abundance (based on proportion) of the ornamental fish community of Achencoil River

Fig. 16 Lorenz graph for the downstream ornamental fish assemblages of Achencoil river

Fig. 17 Diversity profile of the ornamental fish community of Achencoil River
**Fig. 18** Renyi’s diversity profile of the ornamental fish community of Achencoil river

**Fig. 19** Species accumulation curve (Individual rarefaction) (with 95% confidence interval) of the ornamental fish community of Achencoil River
**Fig. 20** Species accumulation curve (Sample rarefaction = Mao Tau) (with 95% confidence interval) of the ornamental fish community of Achencoil River

**Fig. 21** Singletons, doubletons, uniques and duplicates in the ornamental fish community of Achencoil River

**Fig. 22** Estimators of true species richness for the ornamental fish community of Achencoil River
Fig. 23 Michaelis-Menten (MM) estimator curves of true species richness for the ornamental fish community of Achencoil River

Fig. 24 Diversity indices for the ornamental fish community of Achencoil River
Fig. 25 Distribution and abundance of up-, mid- and downstream ornamental fish species of Achencoil River (Upstream, 26; Midstream, 30; Downstream, 24 species)
Fig. 26 Percentage composition of genera, species and individuals of upstream ornamental fish assemblage of Achencoil River

Fig. 27 Percentage composition of genera, species and individuals of midstream ornamental fish assemblage of Achencoil River
Fig. 28 Percentage composition of genera, species and individuals of downstream ornamental fish assemblage of Achencoil River
**Fig. 29** Relative abundance of upstream ornamental fish species of Achencoil River
Fig. 30 Relative abundance of midstream ornamental fish species of Achencoil River

Species

Abundance (%)
Fig. 31 Relative abundance of downstream ornamental fish species of Achencoil River
**Fig. 32** Log-abundance curves of the up-, mid- and downstream ornamental fish assemblages of Achencoil River

**Fig. 33** SHE analysis graph for the up-, mid- and downstream ornamental fish assemblages of Achencoil River
Fig. 34 Rank-abundance curves of up-, mid- and downstream ornamental fish assemblages of Achencoil River (abundance of 3 most dominant species at each site shown in boxes)

Fig. 35 Lorenz graph for the upstream ornamental fish assemblage of Achencoil River

Fig. 36 Lorenz graph for the midstream ornamental fish assemblage of Achencoil River
Fig. 37 Lorenz graph for the downstream ornamental fish assemblage of Achencoil River

Fig. 38 Diversity profiles of up-, mid- and down-stream ornamental fish assemblages of Achencoil River

Fig. 39 Renyi diversity profiles of up-, mid- and downstream ornamental fish assemblages of Achencoil River
**Fig. 40** Species accumulation curve (= Collector’s curve) (with 95% confidence interval) for up-, mid- and downstream ornamental fish assemblages of Achencoil River

**Fig. 41** Singletons, doubletons, uniques and duplicates in the upstream ornamental fish assemblage of Achencoil River

**Fig. 42** Singletons, doubletons, uniques and duplicates in the midstream ornamental fish assemblage of Achencoil River
**Fig. 43** Singletons, doubletons, uniques and duplicates in the downstream ornamental fish assemblage of Achencoil River

**Fig. 44** Estimators of true species richness for the upstream ornamental fish assemblage of Achencoil River

**Fig. 45** Estimators of true species richness for the midstream ornamental fish assemblage of Achencoil River
Fig. 46 Estimators of true species richness for the midstream ornamental fish assemblage of Achencoil River

Fig. 47 Michaelis-Menten (MM) estimator curves of true species richness for the upstream ornamental fish assemblage of Achencoil River

Fig. 48 Michaelis-Menten (MM) estimator curves of true species richness for the midstream ornamental fish assemblage of Achencoil River
**Fig. 49** Michaelis-Menten (MM) estimator curves of true species richness for the downstream ornamental fish assemblage of Achencoil River
Fig. 50 Hierarchical cluster analysis (single-linkage) - Dendrograms showing similarity among the up-, mid- and downstream ornamental fish assemblages of Achencoil River [based on Simpson Dominance (A), Spearman’s rank correlation (B) and Jaccard’s (C), Bray-Curtis’ (D) and Morisita’s (E) similarity indices]

A. Simpson Dominance
B. Spearman
C. Jaccard
D. Bray-Curtis

E. Morisita
Fig. 51 Dendrogram (by single-linkage hierarchical clustering) showing Euclidean distance of upstream, midstream and downstream ornamental fish assemblages of Achencoil River.
Fig. 52 Distribution and abundance of ornamental fish species during monsoon, postmonsoon and premonsoon in Achencoil River (Monsoon, 45; Postmonsoon, 46; Premonsoon, 45 species)
Fig. 53 Percentage composition of genera, species and individuals of the monsoon assemblage of ornamental fishes of Achencoil River

Fig. 54 Percentage composition of genera, species and individuals of postmonsoon assemblage of ornamental fishes of Achencoil River
Fig. 55 Percentage composition of genera, species and individuals of premonsoon assemblage of ornamental fishes of Achencoil River.
Fig. 56 Relative abundance of ornamental fish species of Achencoil River during monsoon
Fig. 57 Relative abundance of ornamental fish species of Achencoil River during postmonsoon
Fig. 58 Relative abundance of ornamental fish species of Achencoil River during premonsoon
Fig. 59 Log-abundance curves for the monsoon, postmonsoon and premonsoon assemblages of ornamental fishes of Achencoil River

Fig. 60 SHE analysis graph for the monsoon, postmonsoon and premonsoon assemblages of ornamental fishes Achencoil River
Fig. 61 Rank-abundance curves for the monsoon, postmonsoon and premonsoon assemblages of ornamental fishes of Achencoil River (abundance of 3 most dominant species in each season shown in boxes)

Fig. 62 Lorenz graph for the monsoon ornamental fish assemblage of Achencoil River

Fig. 63 Lorenz graph for the postmonsoon ornamental fish assemblage of Achencoil River
**Fig. 64** Lorenz graph for the premonsoon ornamental fish assemblages of Achencoil River

**Fig. 65** Diversity profiles for the monsoon, postmonsoon and premonsoon assemblages of ornamental fishes of Achencoil River
**Fig. 66** Renyi diversity profiles of the monsoon, postmonsoon and premonsoon assemblages of ornamental fishes of Achencoil River

![Graph showing Renyi diversity profiles for different seasons.](image)

**Fig. 67** Species accumulation curve (= Collector’s curve) (with 95% confidence interval) for the monsoon, postmonsoon and premonsoon assemblages of ornamental fishes of Achencoil River

![Graph showing species accumulation curve for different seasons.](image)

**Fig. 68** Singletons, doubletons, uniques and duplicates of the monsoon assemblage of ornamental fishes of Achencoil River

![Graph showing singletons, doubletons, uniques, and duplicates.](image)
Fig. 69 Singletons, doubletons, uniques and duplicates in the postmonsoon assemblage of ornamental fishes of Achencoil River

Fig. 70 Singletons, doubletons, uniques and duplicates in the premonsoon assemblage of ornamental fishes of Achencoil River
**Fig. 71** Estimators of true species richness for the monsoon assemblage of ornamental fishes of Achencoil River

**Fig. 72** Estimators of true species richness for the postmonsoon assemblage of ornamental fishes of Achencoil River
Fig. 73 Estimators of true species richness for the premonsoon assemblage of ornamental fishes of Achencoil River

Fig. 74 Michaelis-Menten (MM) estimator curves of true species richness for the monsoon assemblage of ornamental fishes of Achencoil River
**Fig. 75** Michaelis-Menten (MM) estimator curves of true species richness for the postmonsoon assemblage of ornamental fishes of Achencoil River

![Graph of postmonsoon species richness](image1)

**Fig. 76** Michaelis-Menten (MM) estimator curves of true species richness for the premonsoon assemblage of ornamental fishes of Achencoil River

![Graph of premonsoon species richness](image2)
**Fig. 77** Hierarchical cluster analysis (single-linkage) - Dendrograms showing similarity among the monsoon (Mon), postmonsoon (Pom) and premonsoon (Prm) assemblages of ornamental fishes of Achencoil River based on Simpson *Dominance* (A), Spearman’s rank correlation (B) and Jaccard’s (C), Bray-Curtis’ (D) and Morisita’s (E) similarity indices.
D. Bray-Curtis

E. Morisita
**Fig. 78** Dendrogram (by single-linkage hierarchical clustering) showing Euclidean distance of monsoon, postmonsoon and premonsoon assemblages of ornamental fishes of Achencoil River

![Dendrogram](image)

**Fig. 79** Species composition of the up-, mid- and downstream ornamental fish assemblages of Achancoil river

![Species Composition](image)

*Own species* = Species present exclusively in a given site, which not shared with the other two sites

*Common species* = Species common to all three sites/common to a site pair

*Up* = Upstream; *Mid* = Midstream; *Down* = Downstream
Fig. 80 Seriation diagram of the ornamental fish assemblages of River Achencoil
(Grey-shaded cells denote presence and blank cells absence of a given species)

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U = Upstream; M = Midstream; D = Downstream
A = Monsoon; B = Postmonsoon; C = Premonsoon
Observed number of species within brackets at right extreme
Fig. 81 Percentages of matching/mismatching \((a', b', c')\) components in the three site pairs of Achancoil river

Fig. 82 Ternary plot of \(a', b',\) and \(c'\) components of the three site pairs of River Achancoil showing their \(\beta\)-diversity profiles
Fig. 83 Matching/mismatching components and the different measures thereof generating β-diversity patterns in the three site pairs of Achencoil river.

Fig. 84 β-diversity patterns (β_{cc}) of the three site pairs of Achencoil river disentangled into replacement (β_{-3}) and species richness difference (β_{rich}) (Carvalho’s).

Fig. 85 β-diversity patterns (β_{cc}) of the three site pairs of Achencoil river disentangled into replacement (β_{sim}) and species richness difference (β_{nes}) (Baselga’s).
**Fig. 86** Compositional differences (%) in β-diversity patterns of the three site pairs of Achencoil river accountable to replacement (β_{3/σc}) and species richness (β_{rich/σc}).

**Fig. 87** Compositional differences (%) in β-diversity patterns of the three site pairs of Achencoil river accountable to replacement (β_{sim/σor}) and species richness (β_{nes/σor}).
Fig. 88 Ternary plot of $a'$, $b'$ and $c'$ components of the three season pairs of ornamental fish assemblages in Achencoil River showing their $\beta$-diversity profiles.
Table: 89 (a). TAXONOMIC TREE OF OBSERVED ASSEMBLAGES OF ORNAMENTAL FISHES IN RIVER ACHENCOIL.
Table 89 (b). TAXONOMIC TREE OF OBSERVED ASSEMBLAGES OF ORNAMENTAL FISHES IN RIVER ACHENCOIL (contd.....)
Table: 90 (a). TAXONOMIC TREE OF REPORTED ASSEMBLAGES OF ORNAMENTAL FISHES FROM RIVER ACHENCOIL
Table: 90 (b). TAXONOMIC TREE OF REPORTED ASSEMBLAGES OF ORNAMENTAL FISHES IN RIVER ACHENCOIL (cont.....)

- **Acanthopterygii**
  - **Perciformes**
    - **Beloniformes**
      - **Adrianichthyidae**
        - *Adrianichthys*
      - **Hemiramphidae**
        - *Hemiramphus*
      - **Beloniformes**
        - *Belone*
      - **Cyprinodontiformes**
        - **Aplocheilidae**
          - *Aplocheilus*
        - **Poeciliidae**
          - *Poecilia*
      - **Hemiramphidae**
        - *Hyporhamphus*
      - **Cyprinodontiformes**
        - **Ambassidae**
          - *Ambassis*
        - **Poeciliidae**
          - *Poecilia*
      - **Cyprinodontiformes**
        - **Pseudosphronemus**
          - *Pseudosphronemus cupanus*
      - **Cyprinodontiformes**
        - **Pterolepididae**
          - *Pristolepis*
        - **Ambassidae**
          - *Ambassis*
        - **Cyprinodontiformes**
          - **Anabantidae**
            - *Anabas*
          - **Cichlidae**
            - *Etroplus*
          - **Gobiidae**
            - *Glossogobius*
          - **Nandidae**
            - *Nandus*
          - **Osphronemidae**
            - *Pseudosphronemus*
          - **Pristolepididae**
            - *Pristolepis*
        - **Perciformes**
          - *Pterolepis*
      - **Cyprinodontiformes**
        - **Nandidae**
          - *Nandus*
        - **Osphronemidae**
          - *Pseudosphronemus*
        - **Cichlidae**
          - *Etroplus*
        - **Gobiidae**
          - *Glossogobius*
        - **Nandidae**
          - *Nandus*
        - **Osphronemidae**
          - *Pseudosphronemus*
        - **Cichlidae**
          - *Etroplus*
        - **Gobiidae**
          - *Glossogobius*
        - **Nandidae**
          - *Nandus*
        - **Osphronemidae**
          - *Pseudosphronemus*
        - **Cichlidae**
          - *Etroplus*
        - **Gobiidae**
          - *Glossogobius*
        - **Nandidae**
          - *Nandus*
        - **Osphronemidae**
          - *Pseudosphronemus*
Fig. 91 Taxonomic tree ornamental fishes from Upstream of Achancoil river
Figure 92: Taxonomic tree of ornamental fishes from the Midstream of Achencoil river.
Figure.93  Taxonomic tree ornamental fishes from Downstream of Achencoil river

Ostariophysi

Cypriniformes

Cyprinidae

Amblypharyngodon
Barilius
Danio
Puntius
Rasbora
Salmophasis
Batasio
Mystus

Siluriformes

Bagridae

Batasio
travancoria

Barilius
bakeri
canarensis
aequipinnatus
amphibiкус
chola
filamentosus
mahecola
vittatus
daniconius
boopis

Melittinius
microlepis

Cyprinodontiformes

Aplocheilidae

Aplocheilus
lineatus

Acanthopterygii

Beloniformes

Hemiramphidae

Hyporhamphus
xantheropterus

Cyprinodontiformes

Aplocheilidae

Aplocheilus
lineatus

Acanthopterygii

Ambassidae

Chanda
nama

Parambassis
thomassi

Anabantidae

Anabas
testudineus

Cichlide

Etroplus
maculatus

Gobiidae

Glossogobius
giuris

Nandidae

Nandus
nandus

Pristolepididae

Pristolepis
marginata

Tetraodontiformes

Tetraodontidae

Carinotetraodon
travancoricus
Fig. 94 Taxonomic tree of indigenous, freshwater ornamental fishes of Kerala (Regional Master List compiled from existing information)

<table>
<thead>
<tr>
<th>Superorder (5)</th>
<th>Order (14)</th>
<th>Family (39)</th>
<th>Genus (83)</th>
<th>Species * (187)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ostrognathoorpha</td>
<td>Ostrognathorpha</td>
<td>Notoperiderae</td>
<td>Notoperus (1)</td>
<td></td>
</tr>
<tr>
<td>Chupromorpha</td>
<td>Chupromorphidae</td>
<td>Angiulidae</td>
<td>Angiulus (2)</td>
<td></td>
</tr>
<tr>
<td>Elopomorpha</td>
<td>Angiulinae</td>
<td>Ophichthidae</td>
<td>Ophichthys (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cypriniformes</td>
<td>Cyprinidae</td>
<td>Cyprinidae</td>
<td>Cyprinus (2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Latirostrida</td>
<td>Latirostridae</td>
<td>Latirostridae</td>
<td>Latirostrus (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Ctenopoma</td>
<td>Ctenopomatidae</td>
<td>Ctenopoma</td>
<td>Ctenopoma (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acanthopterygii</td>
<td>Acanthopterygii</td>
<td>Acanthopterygii</td>
<td>Acanthopteryx (1)</td>
<td></td>
</tr>
</tbody>
</table>

*Number of species reported in each genus given within parentheses.*
Fig. 95  Taxonomic composition of the reported and observed ornamental fish assemblages of Achencol river and of the compiled regional master list of ornamental fishes of Kerala

Fig. 96  Taxonomic composition of up-, mid- and downstream ornamental fish assemblages compared with that of the observed assemblage of Achencol river
Fig. 97 Taxonomic composition of monsoon, postmonsoon and premonsoon ornamental fish assemblages compared with the observed assemblage of Achencoil river.

Fig. 98 Cluster dendrogram (by hierarchical complete linkage) of the taxonomic distance structure among species of the observed ornamental fish assemblage of Achencoil river.
Fig. 99 95% probability funnel (red line) and theoretical mean for random selections from regional master list (blue line) for $\Delta^+$ and the observed $\Delta^+$ for the ornamental fish assemblage of River Achencoil.

Fig. 100 95% probability funnel (red line) and theoretical mean for random selections from regional master list (blue line) for $\Lambda^+$ and the observed $\Lambda^+$ for the ornamental fish assemblage of River Achencoil.
Fig. 101 95% probability funnel (red line) and theoretical mean for random selections from regional master list (blue line) for $\Delta^+$ and the observed $\Delta^+$ for the up-, mid- and downstream ornamental fish assemblages of River Achencoil.

Fig. 102 95% probability funnel (red line) and theoretical mean for random selections from regional master list (blue line) for $\Lambda^+$ and the observed $\Lambda^+$ for the up-, mid- and downstream ornamental fish assemblages of River Achencoil.
**Fig. 103** 95% probability funnel (red line) and theoretical mean for random selections from regional master list (blue line) for $\Delta^+$ and the observed $\Delta^+$ for the seasonal ornamental fish assemblages of River Achencoil

![Graph showing 95% probability funnel and theoretical mean for random selections from regional master list for $\Delta^+$ and observed $\Delta^+$ for River Achencoil.]

**Fig. 104** 95% probability funnel (red line) and theoretical mean for random selections from regional master list (blue line) for $\Lambda^+$ and the observed $\Lambda^+$ for the seasonal ornamental fish assemblages of River Achencoil

![Graph showing 95% probability funnel and theoretical mean for random selections from regional master list for $\Lambda^+$ and observed $\Lambda^+$ for River Achencoil.]

Fig. 105 95% probability contours of joint $(\Delta^+, \Lambda^+)$ distribution from 1000 simulations for the observed ornamental fish assemblage of River Achencoil (random subsets of sample sizes $= m = 20, 30, 40$ and 50 simulated; observed number of species given within brackets)

Fig. 106 95% probability contours of joint $(\Delta^+, \Lambda^+)$ distribution from 1000 simulations for the observed up-, mid- and downstream ornamental fish assemblages of River Achencoil (random subsets of sample sizes $= m = 20, 30, 40$ and 50 simulated; observed number of species given within brackets)
Fig. 107  95% probability contours of joint ($\Delta^+$, $\Lambda^+$) distribution from 1000 simulations for the observed seasonal ornamental fish assemblages of River Achencoil (random subsets of sample sizes $= m = 20, 30, 40$ and $50$ simulated; observed number of species given within brackets)
Fig. 108 Percentage Composition of Different Food Items in *Rasbora daniconius* from Achencoil River during June 2010 to May 2011

- Filamentous algae
- Plant matter
- Crustaceans
- Insect remains
- Insect larva
- Colepterans
- Odonates
- Dipterans
- Hymenopterans
- Worms
- Fish eggs
- Detritis
Fig. 109  Percentage Composition of Different Food Items in *Danio aequipinuatus*
from Achencoil River during June 2010 to May 2011
Fig. 110 Feeding Intensity of *Rasbora daniconius* from Achencoil River during June 2010 to May 2011
Fig. 111   Feeding Intensity of Danio aequipinnatus from Achencol River during June 2010 to May 2011
PLATES 3–7: Ornamental Fishes Collected From River Achencoil during June 2010 to May 2011
Ambassis gymnocephalus

Amblypharyngodon microlepis

Amblypharyngodon melittinius

Anabas testudineus

Aplocheilus lineatus

Balitora brucei

Barilius canarensis

Barilius gatensis

Barilius bakeri

Batasio travancoria
Bhavania australis

Chanda nama

Carinotetraodon travancoricus

Danio aequipinnatus

Danio malabaricus

Dravidia fasciata

Esomus danricus

Etroplus maculatus

Garra mullya

Garra surendranathani
Glossogobius giuris

Glyptothorax anamalaiensis

Hyporhamphus xanthopterus

Hypselobarbus jerdoni

Lepidocephalus thermalis

Laubuca fasciata

Nandus nandus

Mystus oculatus

Nemacheilus triangularis

Nemacheilus guentheri
Osteobrama bakeri

Parambassis dayi

Parambassis thomassi

Pethia ticto

Poecilia reticulata

Pristolepis marginata

Puntius amphibius

Puntius bimaculatus