Auchenorrhyncha PEET Workshop
9-11 March 2007
Cicadoidea Part I: Overview of Phylogeny

A. Overview of Taxonomy of Cicadoidea (Max Moulds and Kathy Hill)

B. Molecular Phylogeny of Cicadettini (Vanderpool, Marshall, Hill, Moulds, Simon)

Acknowledgments

Simon Lab people contributing (not including co-authors): Peter Arensburger, John Cooley, Michael Cordiero


Moulds 2005, Fig 1. Historical family (caps) and subfamily concepts Timbal covers vs. none

Moulds 2005
Basal nodes and character transformations shown are the same for all 161 MP trees.
Family Cicadidae
- Estimated 3000 spp. worldwide
- All temperate continents
- Mesozoic origins

Tibicen linnei, K. Hill, Delaware

Moulds’ 2005, New Cicada Subfamilies (Fig 53)
“Tettigadinae”
Moulds 2005

Tettigadinae

K. Hill & D. Marshall

Worldwide Tettigadinae distribution

Approximately 200? extant species

Moulds’ 2005
New Cicada Subfamilies (Fig 53)

Cicadinae

Cicadinae

Cicadinae

Tettigadinae

Cicadettinae

Zammara

Tacua

Cyclochila

Tibicen

Thopha
Platypleurini, Ugada limbata, Ghana
Pinned from alcohol, photo K. Hill

Worldwide Cicadinae distribution

Perhaps 1000 extant species

Cicadettinae formerly Tibicininae (part)

Moulds’ 2005
New Cicada Subfamilies (Fig 53)

Cicadettinae

M.S. Moulds, 2005, Subfamily Scheme

Cicadinae

Tettigadinae

CICADIDAE

TETTIGARCTIDAE

OUTGROUP - CERCOPIDAE

Cicadettinae

Worldwide Cicadettinae distribution

Amphipsalta cingulata

Maoricicada campbelli

Anyhipsalta cinquicauda
Sister Tribes of Cicadettini

<table>
<thead>
<tr>
<th>Tribe</th>
<th>Description</th>
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<tbody>
<tr>
<td>Parnisini</td>
<td></td>
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<tr>
<td>Prasini</td>
<td></td>
</tr>
<tr>
<td>Taphurini</td>
<td><em>Magicicada moved to Taphurini</em></td>
</tr>
<tr>
<td>Carinetini*</td>
<td>Moulds (pers. com.) These other Cicadettinae tribes may fall within the above monophyletic group but unknown.</td>
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<tr>
<td>Dazini</td>
<td></td>
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<tr>
<td>Hemidictyini*</td>
<td></td>
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<tr>
<td>Huechysini</td>
<td>Huechysini probably fall within the Cicadettini.</td>
</tr>
<tr>
<td>Lamotialnini</td>
<td></td>
</tr>
<tr>
<td>Tettigomylina</td>
<td></td>
</tr>
<tr>
<td>Ydiiellini*</td>
<td>*Tribes with highly divergent attributes e.g., Carinetini, Hemidictyini and Ydiiellini probably require resolution with DNA.</td>
</tr>
</tbody>
</table>

Magicicada now in Tribe Taphurini (also suggested by Maxine Heath)

Moulds 2005

Okanagana rimosa

Magicicada septendecim

http://hydrodictyon.eeb.uconn.edu/projects/cicada/sp_pages/NA_species/
Tribe Cicadettini
- Estimated 1000 spp. worldwide
- 1/3rd of world cicada diversity
- 500+ Australia
- All temperate continents except South America
- Many species undescribed...

Tribe Cicadettini
- Very small to medium-sized
- Songs usually high-pitched and complex
- Rare in tropics
- Prefer bush edge, shrub/scrub, and grass habitats
- “Duetting” pairs

Molecular Phylogeny of Cicadettini
Dan Vanderpool¹, David Marshall¹, Kathy Hill¹, Max Moulds², & Chris Simon¹,³
University of Connecticut
The Australian Museum
Victoria University of Wellington

Magicicada relationships previously unknown, now Taphurini

Marobduus gillioni, Ghana
Ydiellini [related to Taphurini?]

Carineta sp., Peru
Males can be attracted by imitating female species specific wing flick.

**Worldwide Distribution of Described Cicadettini Genera**

![Worldwide Distribution of Described Cicadettini Genera](image)

*....a worldwide tribe, but poorly represented in the tropics*

**Sister Groups of Cicadettini:**
- Parnisini
- Taphurini
- Chlorocystini
- Prasiini

**Phylogenetic Questions**

Is the tribe Cicadettini monophyletic?

Is the tribe composed of well-defined sub-clades?

Did they originate in Australasia, & spread to other continents?

Did Cicadettini radiate in concert with the aridification of Australia?

Are Cicadettini post-Gondwanan?
**Taxon sampling**

- 129 Cicadettini species
- 10 outgroup taxa (3 Chlorocystini, 6 Taphurini)...more to come.
- Cicadinae outgroup (Tamaša)
- All continents
- Emphasis on distinctive forms, earlier branching lineages (e.g., type species of all genera).

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**Tribe Cicadettini**

- Cicadetta n. sp. "Escarpment Tick-tock" (Cicadettini)
- Wing vein variation in *M. phaeoptera*
- Moulds: New tribal definition based on 4 derived characters; more taxa

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**Testing the monophyly of the new tribal definition (Moulds 2005)**

**Genetic Dataset**

- ca. 1500 bp mtDNA cytochrome oxidase I and II
- ca. 3000 bp nuclear EF-1α, introns and exons (Some nuclear data still missing)
- All data aligned by eye, gaps treated as missing data.
- Combined data analyses only (this talk)

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**Phylogenetic Methods**

  - Garli v0.95 (Genetic Algorithm, D. Zwickl), single partition mtDNA+nuclear, GTR + 8 category gamma
  - RAxML v2.2.1 (A. Stamatakis, SFIT), two partitions, separate model parameters, GTR+CAT, 25 rates.
- Bayesian (80-taxon dataset only – DV)
  - MrBayes 3.0b4, complex six-partition model, separate parameters, GTR+gamma
Phylogeny of the Tribe Cicadettini

- Monophyletic Cicadettini, Moulds’ new assignments
- Solid support at key positions along tree backbone
- Major groups well-supported (ML, BY)

129 ingroup
10 outgroup
Bayes & ML
Cicadettini

World Geography Tribe Cicadettini

Australian/Australasian center of origin
First appearance of non-Australasian lineages
Nearest non-Cicadettini lineage also Australian

Clade 1
Australian
European
North America

Clade 2
South Africa
Australian
Taiwan

New Zealand
Australian

New Caledonia

Mostly Australian Paraphyletic Mess

Australian Pauropsalita and relatives

World Geography
Tribe Cicadettini

Long branch broken with lucky outgroup find....

Cicadettini’s Outgroups

Molecular Dating – Methods

- Bayesian relaxed-clock, MULTIDIVTIME (Thorne et al. 1998)
- Tree from partitioned ML (RAxML) analysis, with smaller, representative taxon sample.
- Diffuse priors (stdev = mean)
- Fossil and Geological calibrations
Molecular Dating – 2 Calibrations

Age of large New Zealand cicada radiation (KMR)
- NZ/NC ancestor 7-14 Ma molecular clock and local geological calibrations (Norfolk Island emergence; Arensburger et al. 2004)

Age of Paracicadetta fossil lineage (France)
- European presence in late Oligocene (ca. 24 my) (Boulard and Nel 1990)

In Summary

- Out of Australia hypothesis strongly suggested
- If true, Cicadettini have colonized the remaining temperate continents during two separate invasions from Australia.
- Diversification began after breakup of Gondwana, probably Oligocene or Miocene.
- Most species have formed during and after the Miocene-era aridification of Australia and other southern continents.
- Narrow tropical “waist” of Central America may help explain absence of tribe from S. America.

Future Work

- Better outgroup sampling and additional fossil calibrations (e.g., Prasiini)
- Biogeographic reconstructions to test the “Out of Australia” Hypothesis
- In-depth phylogenetic analysis of widespread, speciose Australian genera

The End