SYMPOSIUM - PHYLOGENY AND EVOLUTION OF AUCHENORRHYNCHA

Re-Examining the Phylogeny of Auchenorrhyncha (Insecta: Hemiptera)

Jason Cryan, New York State Museum, 3140 Cultural Education Center, Empire State Plaza, Albany, NY 12230; jcryan@mail.nysed.gov

The phylogeny of Auchenorrhyncha and its included lineages, has been the subject of some controversy in the systematic literature. Traditionally treated as monophyletic, Auchenorrhyncha includes the lineages Fulgoromorpha (planthoppers) and Cicadomorpha (cicadas, leafhoppers, treehoppers, froghoppers, and spittlebugs). In 1995, however, the monophyly of Auchenorrhyncha was debated in a series of publications based on phylogenetic analyses of partial 18S rDNA nucleotide sequences (von Dohlen & Moran, 1995; Campbell et al., 1995; Sorensen et al., 1995); it seemed that molecular evidence showed Auchenorrhyncha to be paraphyletic (Fig. 1). Although new morphological evidence (primarily, features of the forewing) supporting the monophyly of Auchenorrhyncha has been discovered recently (Yoshizawa & Saigusa, 2001; D'Urso, 2002), no new molecular evidence has been generated to examine this question.

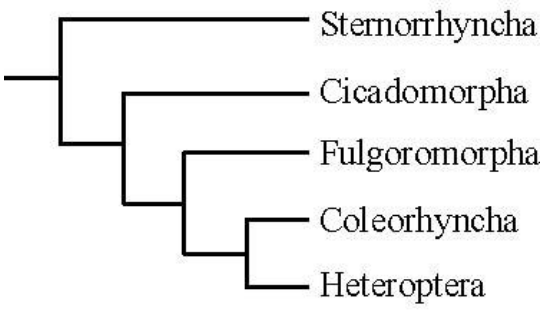

Fig. 1: Phylogeny of Heniptera showing Auchenorrhyncha as paraphyletic

Cicadomorpha, one of the major auchenorrhynchan lineages, comprises the superfamilies Cicadoidea (cicadas), Cercopoidea (spittlebugs and froghoppers), and Membracoidea (leafhoppers and treehoppers). Figure 2 illustrates alternative phylogenetic hypotheses that have been proposed for relationships within Cicadomorpha, whether Cicadoidea is sister to Cercopoidea + Membracoidea (Fig. 2A; Hamilton, 1981; Sorensen *et al*., 1995; von Dohlen & Moran, 1995), Membracoidea is sister to Cicadoidea + Cercopoidea (Fig. 2B; Boulard, 1988; Campbell *et al*., 1995; Ouvrard *et al*., 2000; Bourgoin & Campbell, 2002; Dietrich, 2002), or Cercopoidea is sister to Cicadoidea + Membracoidea (Fig. 2C; Evans, 1963; Hamilton 1996, 1999). Earlier attempts to reconstruct relationships among these three monophyletic lineages using either morphological or molecular data suffered from insufficient sampling (taxonomic and data) and problematic tree rooting, leading to the discordant results depicted in Fig. 2. To address this controversy, I recently published the results of a phylogenetic analysis of Cicadomorpha based on DNA nucleotide sequence data from three genetic loci (Cryan, 2005); analyses of the combination of data sets support the major relationships within Cicadomorpha as (Membracoidea, (Cicadoidea, Cercopoidea)). Internal relationships recovered within each superfamily shows evidence for: 1) the placement of Myerslopiidae as the sister group of the remaining Membracoidea; 2) the paraphyly of Cicadellidae; 3) the sister group relationship between Machaerotidae and Clastopteridae; 4) the monophyly of Cercopidae; 5) the diversification of Epipygidae from within the possibly paraphyletic Aphrophoridae.

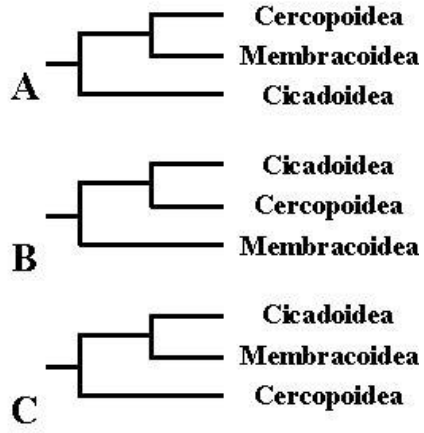

Fig. 2: Alternative phylogenies for Cicadomorpha

Fulgoromorpha, the other major lineage within Auchenorrhyncha, comprises approximately 20 planthopper families. Julie Urban will discuss the contentious phylogeny of this group in her presentation at this symposium.

The first goal of this presentation is to address the topic of auchenorrhynchan monophyly using evidence from both morphological data and DNA nucleotide sequence data. I will discuss the results from analyses of a preliminary data set comprising nearly complete sequences of 18S rDNA generated from exemplar taxa representing the major lineages of Hemiptera. These results demonstrate molecular evidence, from the same gene used in the 1995 papers, supporting the monophyly of Auchenorrhyncha. The second goal of this presentation is to discuss the phylogeny of Cicadomorpha and included superfamilies.

References

Boulard, M. 1988. Taxonomie et nomenclature supérieures des Cicadoidea. Histoire, Problèmes et solutions. (2nd edition), *Travaux du Laboratoire Biologie et Evolution des insects Hemipteroidea* 1, 89pp.

Bourgoin, T., and B.C. Campbell. 2002. Inferring a phylogeny for Hemiptera: falling into the 'autapomorphic trap'. *Denisia* 4: 67-82.

Campbell, B.C., J.D. Steffen-Campbell, J.T. Sorensen, and R.J. Gill. 1995. Paraphyly of Homoptera and Auchenorrhyncha inferred from 18S rDNA nucleotide sequences. *Systematic Entomology* 20: 175-194.

Cryan, J.R. 2005. Molecular Phylogeny of Cicadomorpha (Insecta: Hemiptera: Cicadoidea, Cercopoidea, and Membracoidea): Adding Evidence to the Controversy. *Systematic Entomology*, in press.

Dietrich, C.H. 2002. Evolution of Cicadomorpha (Insecta, Hemiptera). *Denisia* 4: 155-170.

D'Urso, V. 2002. The wing-coupling apparatus of Hemiptera Auchenorrhyncha: structure, function, and systematic value. *Denisia* 4: 401-410.

Evans, J.W. 1963. The phylogeny of the Homoptera. *Annual Review of Entomology* 8: 77-94.

Hamilton, K.G.A. 1981. Morphology and evolution of the rhynchotan head (Insecta: Hemiptera, Homoptera). *The Canadian Entomologist* 113: 953-974.

Hamilton, K.G.A. 1996. Cretaceous Homoptera from Brazil: Implications for classification. *Studies on Hemipteran Phylogeny* (ed. by C.W. Schaefer), pp. 89-110. Proceedings, Thomas Say Publications in Entomology, **Entomological Society of America, Lanham.**

Hamilton, K.G.A. 1999. The ground-dwelling leafhoppers Myerslopiidae, new family, and Sagmatiini, new tribe (Homoptera: Membracoidea). *Invertebrate Taxonomy* 13: 207-235.

Ouvrard, D., B.C. Campbell, T. Bourgoin, and K.L. Chan. 2000. 18S rRNA secondary structure and phylogenetic position of Peloridiidae (Insecta, Hemiptera). *Molecular Phylogenetics and Evolution* 16: 403-417.

Sorensen, J.T., B.C. Campbell, R.J. Gill, and J.D. Steffen-Campbell. 1995. Non-monophyly of Auchenorrhyncha ("Homoptera"), based upon 18S rDNA phylogeny: eco-evolutionary and cladistic implications within pre-Heteropterodea Hemiptera (s.l.) and a proposal for new monophyletic suborders. *Pan-Pacific Entomologist* 71: **31-60.**

von Dohlen, C.D., and N.A. Moran. 1995. Molecular phylogeny of the Homoptera: a paraphyletic taxon. *Journal of Molecular Evolution* 41: 211-223.

Yoshizawa, K., and T. Saigusa. 2001. Phylogenetic analysis of paraneopteran orders (Insecta: Neoptera) based on forewing base structure, with comments on monophyly of Auchenorrhyncha (Hemiptera). *Systematic Entomology* 26: 1-13.