

# MrEnt: an editor for publication-quality phylogenetic tree illustrations

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## Abstract

We developed MrEnt, a Windows-based, user-friendly software that allows the production of complex, high-resolution, publication-quality phylogenetic trees in few steps, directly from the analysis output. The program recognizes the standard Nexus tree format and the annotated tree files produced by BEAST and MrBayes. MrEnt combines in a single software a large suite of tree manipulation functions (e.g. handling of multiple trees, tree rotation, character mapping, node collapsing, compression of large clades, handling of time scale and error bars for chronograms) with drawing tools typical of standard graphic editors, including handling of graphic elements and images. The tree illustration can be printed or exported in several standard formats suitable for journal publication, PowerPoint presentation or Web publication.

*Keywords:* graphic export, Nexus format, phylogenetic tree, tree editor

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## Introduction

Phylogenetic trees are a powerful means to convey information about the genealogical relationships between taxa or individuals. Most phylogenetic software provides at most a rough graphical output, and a number of dedicated software have been developed with the main or only purpose of generating a quality tree drawing (see Felsenstein's Web Server at <http://evolution.genetics.washington.edu/phylip/software.html> for an updated comprehensive list).

Some tree editors are mostly intended for screen visualization and allow only for limited tree manipulation (e.g. TreeView, Page 1996), while others offer various annotation functions that enhance the drawing, such as label editing, colouring and branch rotation (e.g. FigTree, Rambaut 2011; TreeGraph, Stöver & Müller 2010), or are optimized for the visualization of very large trees (HyperTree, Bingham & Sudarsanam 2000; Dendroscope, Huson *et al.* 2007). All these programs provide an export function for generating a graphic file that can be used as illustration. However, the illustrations so produced contain only the tree itself, and any additional graphic elements (e.g. arrows, brackets, text panels) must be added later with a graphic editor like PhotoShop or Illustrator.

To bridge the gap between the tree editors and the standard graphic editors, we developed MrEnt, a user-friendly software that allows the production of complex, high-resolution, publication-quality phylogenetic trees in few steps, directly from the analysis output. With its graphical user interface and an icon-based toolbar, the software is very intuitive even for new users.

## File input, file output

MrEnt recognizes and opens the standard tree files in the Nexus format (Maddison *et al.* 1997) as well the annotated tree files produced by BEAST (Drummond & Rambaut 2007) and MrBayes (Ronquist *et al.* 2012). Tree files in Newick format must be converted into a Nexus file, either by manual editing or using a software (e.g. with TreeView). If the tree file contains more than one tree, a prompt asks to select which tree should be displayed (Fig. 1).

The number of accepted terminals is virtually unlimited. Tests showed that trees up to 10000 terminals can be opened, browsed and manipulated on an average desktop computer (i.e. 4 GHz AMD Turion™ II P540 Dual-Core processor, 4 GB RAM).

MrEnt saves the tree drawing in an XML-based native file format with extension ENT. The file preserves the logical structure of the tree and any added or modified graphic feature, and it allows further tree editing.

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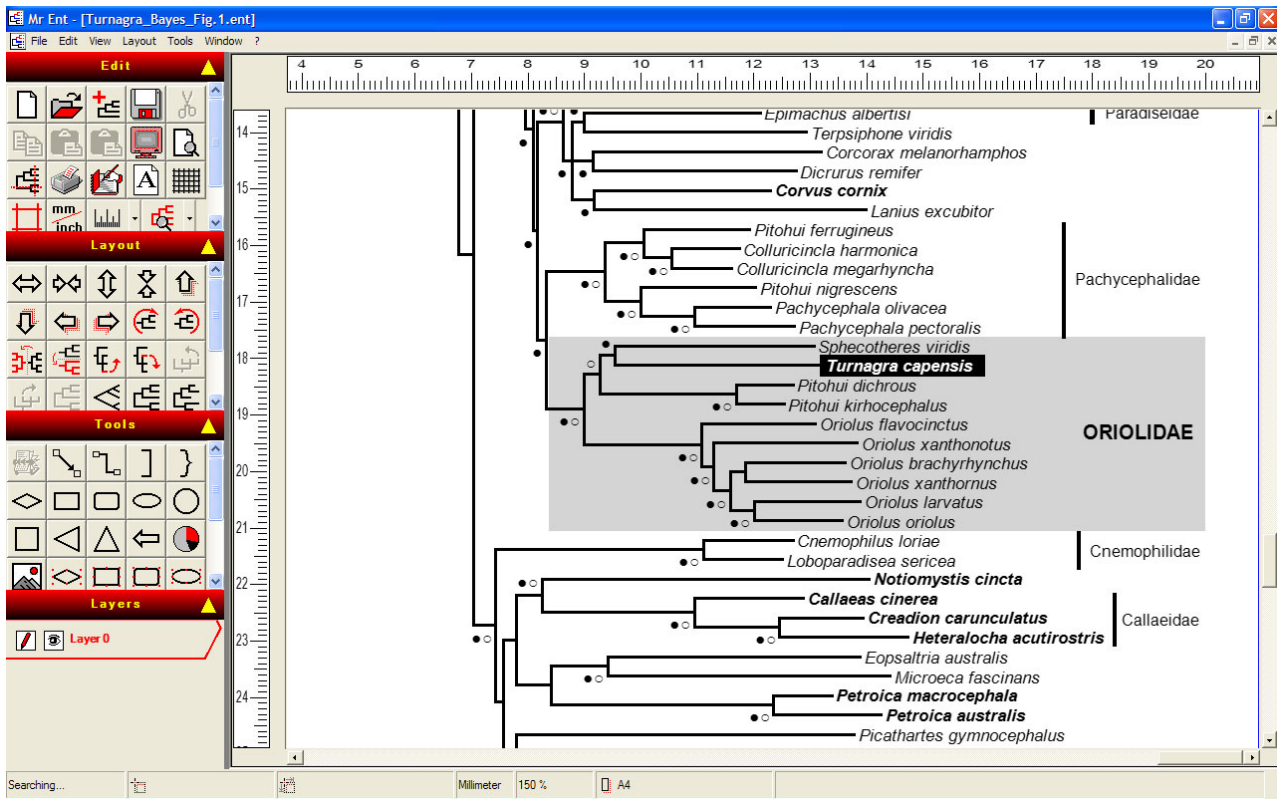


Fig. 1 View of MrEnt graphic user interface showing an example of phylogenetic tree with multiple feature annotations.

## Editing

MrEnt is structured as a graphic editor working with layers. A new tree drawing is created on a first layer. The opening of additional trees in the same drawing creates a corresponding number of new layers, one per tree. Each layer is a totally independent drawing, and it can also contain additional graphic elements associated with that specific tree. In case of multiple layers, the final illustration is simply generated by the sum of all layers (Fig. 2).

The tree can be displayed as rectangular cladogram, slanted cladogram or phylogram. The application offers great flexibility in the tree display with several basic tree manipulation tools such as rerooting, branch rotation and resizing. The style of each tree element (branches, taxon labels and support values) can be edited independently with respect to multiple parameters such as colour, line thickness and pattern, font, text orientation, background colour. Multiple selection and copy/paste style tools speed up the application of the same style to multiple elements on the same layer or across different layers or different files.

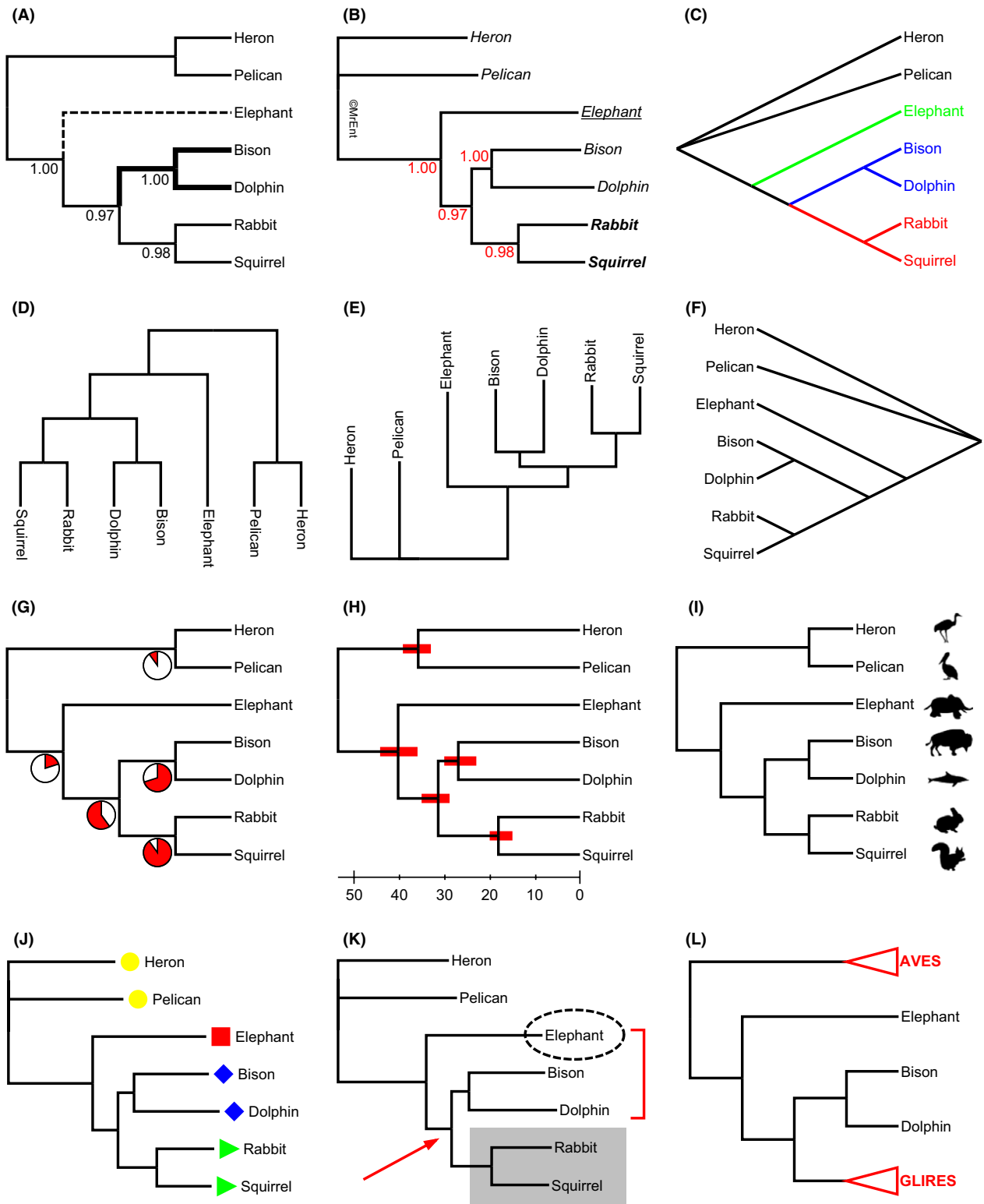
Several advanced tree editing options further extend the software flexibility covering a wide range of features:

- 1 tree rotation;

- 2 possibility to display a symbol in front of the taxon name for character mapping onto the tree;
- 3 addition of comments after the taxon name;
- 4 collapse of nodes with support values below a given threshold;
- 5 compression of large clades into triangular shapes;
- 6 addition of pie charts for mapping of ancestral states;
- 7 automatic generation of a time scale for chronograms based on a calibration node;
- 8 addition of a scale bar for phylogram.

MrEnt provides a function for adding error bars in chronograms, either manually to few selected nodes, one node at a time, or to all nodes together by filling an interactive table. The software is also able to recognize the annotated Nexus files generated by BEAST (Drummond & Rambaut 2007), import the range values for each node and create automatically the associated error bars.

MrEnt integrates some functions typical of standard graphic editors that are not supplied by any other tree editor. The tree drawing can be enriched with simple graphic elements, such as geometric shapes, brackets, lines and arrows, each of them fully editable in size, colour and line thickness. All geometric shapes are



1.0

**Fig. 2** (A) quick overview of features and options available for creating tree illustrations with MrEnt. (A–C) basic display (rectangular cladogram, phylogram, slanted cladogram) with different branch and label styles; (D–F) different tree orientation; (G) pie charts; (H) error bars and time ruler; (I) additional images; (J) taxon symbols for character mapping and scale bar; (K) additional graphic elements; (L) clade compression.

potentially also text boxes, providing a simple tool for adding labels or text panels.

The illustration can be further enhanced with images. MrEnt can integrate in the drawing images supplied in BMP, JPG, PNG, GIF, TIF, WMF or EMF format.

Users can customize the default settings for almost any editable parameter. All changes applied to the tree are reversible, and all added features can be deleted at any time. During the tree editing, the command calls are retained in memory and the undo-redo function allows to reverse-restore a sequence of up to 32 commands.

### Printing and graphic file export

The illustration can be printed or exported in several standard formats (BMP, PNG, EMF, EPS, PDF) suitable for journal publication, PowerPoint presentation or Web publication. BMP, PNG and EMF have a resolution of 92 dpi. The export to the postscript and PDF formats is mediated by the PDFCreator library (<http://sourceforge.net/projects/pdfcreator/>).

The page size on which the tree drawing is made can be selected from a preset list of standard formats (e.g.

**Table 1** Comparison of editing options and graphic export formats for a selection of widely used tree editors. X: present; (X): present with restrictions

Software (version)	MrEnt 2.5	Archaeopteryx (ATV) (0.9813)	Dendroscope 3	FigTree (1.4)	Tree editor, MEGA 6	Mesquite (2.75, build 564)	TreeDyn (198.3)	TreeGraph 2 (2.0.50 beta)	TreeView (1.6.6)
<b>Editing functions</b>									
Rerooting	X	X	X	X	X	X	X	X	X
Ladderizing	X	X	X	X		X	X	X	X
Tree rotation	X		X			X			
Copy-paste elements	X	X						X	
Copy-paste style	X								
Advanced selection options	X		X					X	
Text style (font, size, colour)	X	(X)	X	(X)	X	(X)	X	X	(X)
Line style (thickness, colour, pattern)	X	(X)	X	(X)	X	X	X	X	
Undo-Redo function	X					X		X	X
Collapsing nodes	X					X	X	X	X
Compressing clades	X		X	X	X	X	X		
Pie charts	X								
Time scale	X			X	X			X	
Character mapping	X					X	X		
Additional graphic elements	X						X		
Embedding images	X	X							
Multiple trees	X		X			X	X		(X)
<b>Graphic format export</b>									
BMP	X	X	X				X		
EMF	X				X			X	X
EPS	X		X				X		
PDF	X	X	X	X	X	X	X	X	
PNG	X	X	X		X		X	X	

A4, Letter, US Folio) or the user can define a custom page. Rulers surrounding the page, a grid and the margin lines help the user to draw the tree according to the size and the position that it should assume in the exported graphic file and eventually in print.

If the drawing is made over an area larger than the printer paper, when printing or when creating a PDF, MrEnt subdivides the image over the appropriate number of pages, respecting the not printable page margins, in a way fully comparable with Microsoft Excel printing a large worksheet.

### Comparison with other programs

Most popular programs for visualizing phylogenetic trees allow only a limited manipulation of the tree (e.g. ATV (Zmasek *et al.* 2001), Dendroscope (Huson *et al.* 2007), FigTree (Rambaut 2011), Mesquite (Maddison & Maddison 2011), PhyloWidget (Jordan & Piel 2008), TreeView (Page 1996), see Table 1). Only TreeDyn and TreeGraph provide also functions for annotating the tree nodes, but the editing is limited to the tree itself.

In addition to offering extensive options for formatting and editing the tree, MrEnt is to our knowledge the only software that supports a suite of graphic tools for enriching the tree drawing with complementary graphic elements. The entire process of creating a complex tree illustration suitable for publication becomes feasible within the tree editor, without making use of any other software.

All programs to date offer export functions for saving the tree in various graphic formats. However, they offer limited or no control over the size and positioning of the tree in the drawing or on the printed page. Together with TreeGraph, MrEnt is the only tree editor where the image layout and print options can be set by the user to precisely determine the final layout. However, contrary to MrEnt, TreeGraph does not allow the user to define the page size.

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A.Z. and D.Z. conceived the software and tested the program, A.Z. wrote the code, D.Z. drafted the software manual and the manuscript. Both authors read and approved the final manuscript.

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### Data Accessibility

MrEnt is freely available with its user manual at <http://www.mrent.org>. The software, written in Microsoft C Sharp, is currently available for the Windows operating systems. It requires the freely available Framework 2.0 library (usually already preinstalled in all recent Windows operating systems or available from the Microsoft web site).