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The phylogenetic trees of Florentino Ameghino and cladograms: a case for multiple discovery?

Los árboles filogenéticos de Florentino Ameghino y los cladogramas ¿un caso de descubrimiento múltiple?

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Abstract: The topology of the phylogenetic trees used by Florentino Ameghino in his works *Filogenia* and *Contribución al conocimiento de los mamíferos fósiles de la República Argentina,* is analysed. The similarities with the topology of the present day cladograms, branching orthogonal diagrams with dichotomies, are highlighted and discussed.

Resumen: Se analiza la topología de los árboles filogenéticos que Florentino Ameghino utilizó en sus obras *Filogenia* y *Contribución al conocimiento de los mamíferos fósiles de la República Argentina,* en comparación con la utilizada por otros autores, contemporáneos o posteriores, resaltando la semejanza con la de algunos tipos de cladogramas actuales en la utilización de diagramas ortogonales con dicotomías. Se discute las posibles razones de dicha semejanza.

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INTRODUCTION

The arboreal scheme has been a graphic representation of human knowledge for more than 800 years, in such a way that different scientific fields have appealed to this kind of representation as a form of diagrammatic synthesis (Lima, 2014). Whatever the field, this kind of figures has been used from two different points of view, namely, as a tool of classification or to show genealogy. Arboreal representation has been specially used in biology to evidence, for diverse porpoises, the relationships between living beings. Indeed, the utilization of that kind of figures is anterior to the evolutionary paradigm. Consequently, previously to the irruption of the evolutionary ideas, but even later, trees in biology have often had a classificatory purpose (Tassy, 1991).

The first biological arboreal representation that arrived to us was due to Agustin Augier (*Essai d'une nouvelle classification des végétaux*) (Spivak, 2006; Tassy, 2011) (Fig. 1). Published in 1801, it is thus previous to the first tree with an evolutionary meaning, that of Lamarck (1809) in *Philosophie zoologique* (Fig. 2). Leaving apart some outlines in Darwin's notebooks and also the only figure included in his *Origin of Species,* the first zoologist who used largely the arboreal diagrams, to show animal genealogy, was Ernst Haeckel, either in a baroque fashion, as in his very known tree of the three kingdoms in *Generelle Morphologie der Organismen* (Haeckel, 1866), or with a more schematic topology, as it is the case of *Natürliche Schöpfungsgeschichte* (Haeckel, 1868) (Fig. 3). This later kind of tree representation is very similar to that posteriorly used by the evolutionary taxonomy school, which arose with the synthetic theory, and it is still present mostly in textbooks, like, for example, Kardong (1998). They are called spindle or bubble diagrams and also romerograms, for the large use that Alfred Sherwood Romer made of this kind of representation. They show the diversity and relationships between taxa but also, by the thickness of branches, their quantitative importance through time (Hamilton, 2013).

Florentino Ameghino (1854–1911) is considered the father of the Argentinian vertebrate palaeontology. For years he described a huge quantity of fossils, for the most part mammals, product of the collecting

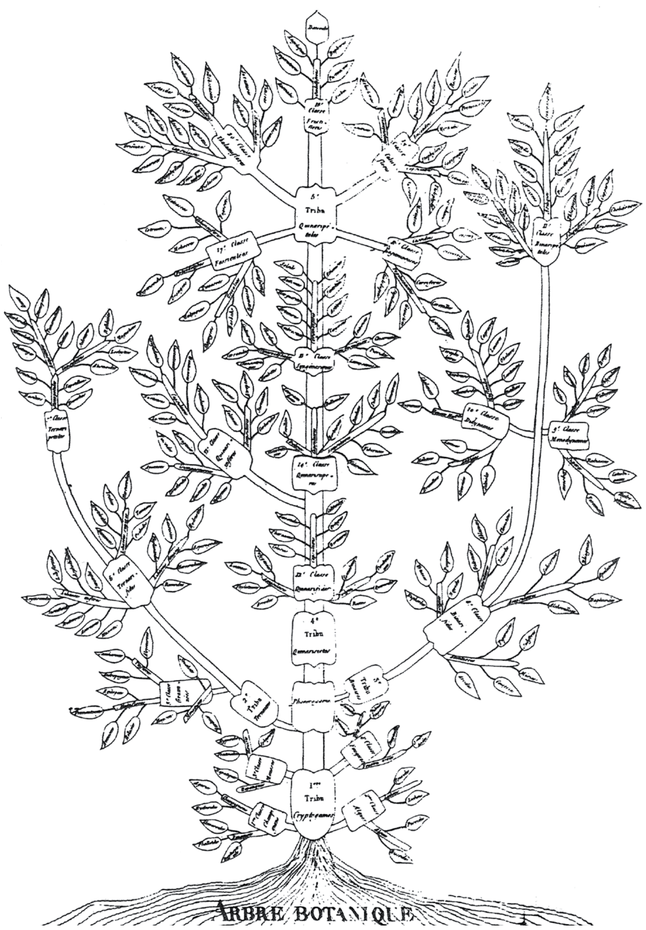

Figure 1. Agustin Augier's tree (*Essai d'une nouvelle classification des végétaux*). From Tassy (1991).

campaigns that his brother Carlos carried out in the Patagonian outcrops. Moreover, Carlos established their stratigraphic sequences with a surprising meticulousness.

Unfortunately, Florentino Ameghino never took into account the chronology established by other palaeontologists using fossils from other groups of vertebrates or invertebrates from the same localities. He dated only with the mammalian faunas he studied. Moreover, he distinguished, in a rather arbitrary way, between characters supposedly primitive or advanced. His arguments were thus completely circular and as a result Florentino Ameghino dated erroneously the formations studied, considering them very much older than they actually were (Casinos, 2012).

However, it can be not denied that from the beginning Ameghino focused all his work from an evolutionary perspective, although sometimes his approach was very naïve. An important result of his evolutionary interest was *Filogenia* (Ameghino, 1884) the first book published anywhere, and in any language, using as title, in its Spanish form, the neologism "Phylogenie" devised by Ernst Haeckel only some years ago (Haeckel, 1866). A fact that is mostly ignored. *Filogenia* is a synthesis of the morphological and taxonomical assumptions that inspired his work (Casinos, 2012).

In *Filogenia* Florentino Ameghino started to use arboreal schemes in order to show the relationships ancestor-descendant that he established between taxa, either described for himself or previously. But it is in a posterior work, *Contribución al conocimiento de los mamíferos fósiles de la República Argentina* (Ameghino, 1889), where he used in an exhaustive way trees with a phylogenetic meaning.

The aim of this paper is to review the topology of the phylogenetic trees used by Ameghino in his two quoted books, *Filogenia* and *Contribución al conocimiento de los mamíferos fósiles de la República Argentina.* His phylogenetic trees and the corresponding topology have absolutely been ignored in the up to date published reviews on the history and development of phylogenetic diagrams (Spivak, 2006; Tassy, 2011).

In the present context, topology is normally understood as the branching structure of a phylogenetic tree, showing the relatedness between the taxa included in the tree.

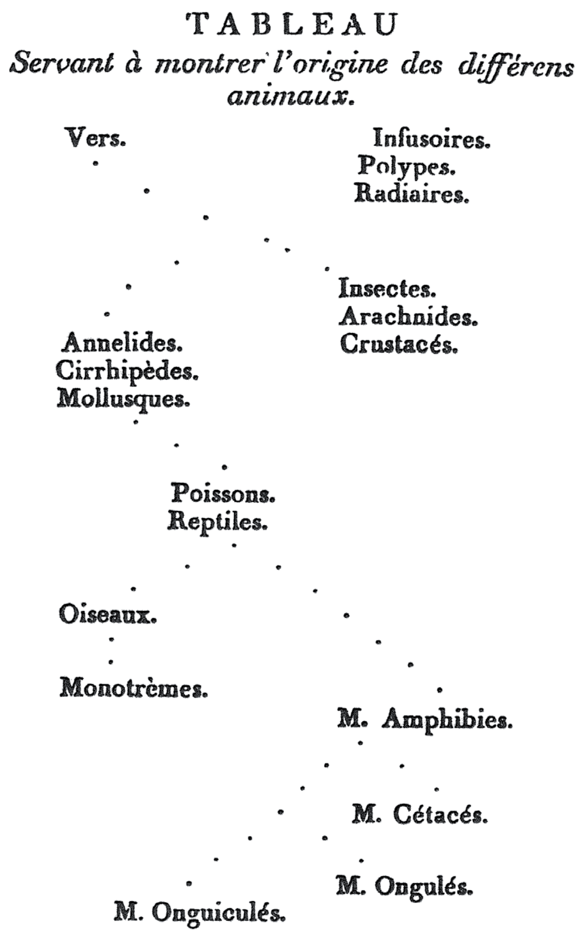

Figure 2. Lamarck's tree (*Philosophie zoologique*). From Tassy (1991).

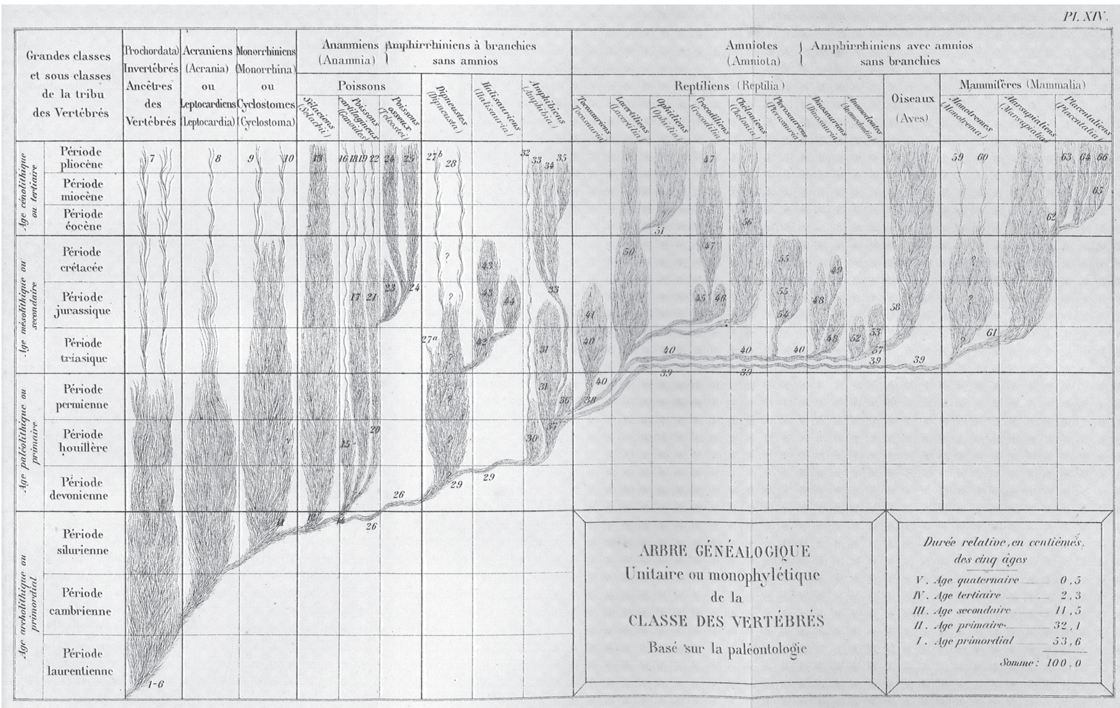

Figure 3. Haeckel's tree. *Natürliche Schöpfungsgeschichte.* From Haeckel (1874).

ANALYSIS

When reviewing globally the phylogenetic trees used by Florentino Ameghino, the first thing that draw attention is the originality of the topology. Indeed, if we compare with any of the phylogenetic representations of Haeckel, quoted above, who was at that historical moment the reference author on the subject, especially for the Argentinian palaeontologist himself (Casinos, 2012), differences are absolutely huge. Moreover, Ameghino's topology is, for example, even innovative compared with that of another contemporary palaeontologist, Gaudry (1866) (see Tassy, 2011), with whom Ameghino maintained an important relationship (Casinos, 2012). The differences between the topologies used by both contemporary palaeontologists are especially important, since Gaudry's phylogenetic representations were already completely genealogical (Tassy, 2011), establishing a relationship ancestor-descendant with or without dichotomies.

Regarding the topologies of phylogenetic trees used in both quoted Ameghino books, although similarities exist, important differences are also present.

In *Filogenia* the arboreal representations are mostly lineal (Fig. 4), reduced to sequences ancestor-descendant. In very few cases there are dichotomies. However, dichotomies are much more common than lineal relationships in *Contribución al conocimiento de los mamíferos fósiles de la República Argentina.* Moreover, in this late work not only genealogies of high taxa appear, like in Haeckel work, but Ameghino shows mostly phylogenetic trees of low taxa, even at genus level (Fig. 5).

But the most surprising feature in the topology used by Ameghino in *Contribución* is its similarity with the current one of the cladistics school (see below), although obviously variations also exist. Nevertheless, some of these variations do not matter. For example, Ameghino used mainly vertical representations (Fig. 5A). When opting by a horizontal representation, the ancestor can be placed either on the left or on the right side (Fig. 5B). As quoted above, dichotomies are most employed in all the showed representations, particularly in the cases that he seems to consider that the "sister" groups share characters. Trichotomies are also present (Fig. 5A). Some dichotomies appear without a taxon in one of the branches (Fig. 5), perhaps indicating that the

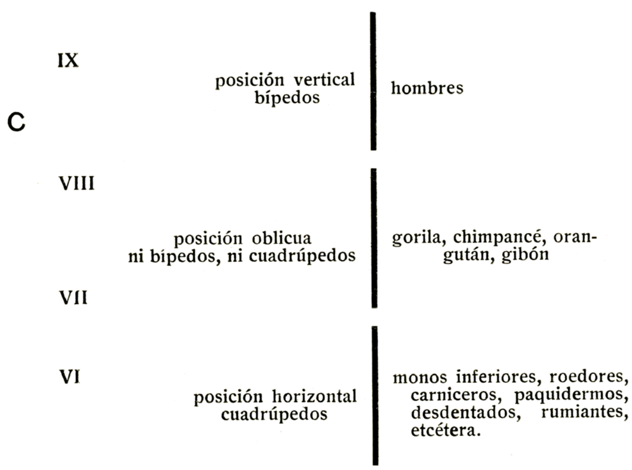

Figure 4. An example of the genealogical diagrams used in *Filogenia* (Ameghino, 1884).

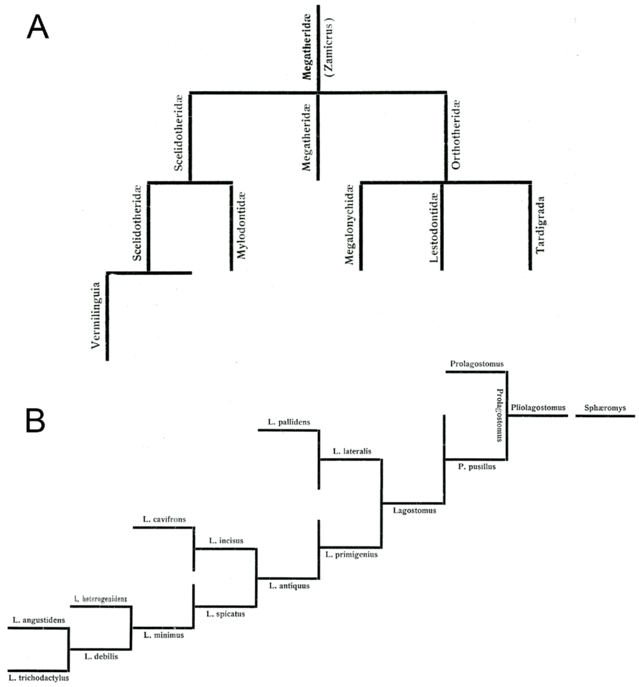

Figure 5. Two different examples of Florentino Ameghino's phylogenetic trees. **A,** Megatheridae; **B,** *Lagostomus*. From *Contribución al conocimiento de los mamíferos fósiles de la República Argentina* (Ameghino, 1889).

lacking taxa is for the moment unknown. An important difference with the present day cladograms is that, according to Ameghino representations, the ancestor is always known. In this way, relationships ancestor-descendant are established even between extinct and extant groups (Fig. 5B), or either between only extinct or extant taxa. Setting aside the quoted assumption of the possibility of fixing an ancestor, an assumption largely accepted in the time Ameghino published his work, and even later, it does seem that the topology he used responded to a theoretical coherent basis.

DISCUSSION

It is known that in cladistics three types of arboreal representations are currently used, all of them generically known as cladograms. In two types, branches are designed in orthogonal way, either in horizontal or vertical sequence. In the third type, branches of the tree are diagonally placed. In his seminal book Willi Hennig (Hennig, 1968) always used that third type of representation, which is known as "Hennig's comb".

It seems clear that the practitioners of the phenetic school (also known as numerical taxonomy school) were the first ones to adopt the orthogonal topology to represent genealogical trees. A good example of that is Sokal and Sneath (1963), the book that can be considered seminal for the school. Orthogonal topology with vertical orientation is preferably used by that school, although there are also trees drawn in horizontal. Probably cladistics adopted orthogonal trees under the influence of phenetics.

Given the common use of orthogonal topology both in Ameghino work and in the present-day phylogenetic schools, the question arises whether Ameghino representations were known by the founders of phenetics. Nevertheless, as far as I know, no mention on the phylogenetic representations used by Ameghino exists in textbooks on phylogenetic analysis of this school, and not even in cladistics textbooks. Alternatively, if actually Ameghino work was not known for either phenetic or cladistic authors, we were before a case of what is called in philosophy of science multiple discovery.

Multiple discovery can involve not only a coincident expression of the same theory, but also the similar design of instruments (Lamb & Easton, 1984). In the case here reviewed, topology may be considered an instrument of phylogenetic analysis.

Multiple discoveries can be synchronic or diachronic. When multiple discoveries are synchronic, the traditional explanation is the so called *zeitgeist* theory of discovery (Simonton, 1979). Briefly, the accumulation of scientific knowledge would be, in last term, the cause of a simultaneous formulation, like that of natural selection by Darwin and Wallace. But independent contributions can be diachronic, separated by a more or less long-time span, originating facts that are known as "rediscoveries". Mendel's inheritance laws are a classical example.

From my point of view, the similarity between Ameghino phylogenetic trees and cladograms is not even a rediscovery, unless any of the authors of the phenetic school that firstly used orthogonal topology knew Ameghino preceding and he (or she) did not quote it. Otherwise, we would have to accept the possibility of another of the two explanations that Simonton (1979) suggest for a multiple discovery, genius, and chance. Genius theory of creativity assumes that scientific discoveries are produced by people with special abilities or backgrounds, not frequent among their contemporary colleagues. Independent contributions can be separated by long time spans.

Simonton (1979) analysed a large sample of multiple discoveries, scientists, and inventors. The analysis supported in first place the chance theory as the most probable, followed by the *zeitgeist* theory. Chance theory seems to me a good explanation by facts as that here reviewed, concerning not a new scientific paradigm, but a similar design of an instrument, in the present case, the orthogonal topology, that can be compatible with alternative methodologies and theoretical assumptions, as it happens in Ameghino's work, phenetics, or cladistics.

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