SUPPRESSION AT THE FRONTIERS OF EVOLUTIONARY BIOLOGY: LÉON CROIZAT'S CASE.*

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ABSTRACT - Léon Croizat, a controversial figure in the history of the biological thought, was labeled by George Gaylord Simpson, as a member of the "lunatic fringe" as justification for ignoring development of a new research program called panbiogeography. In the 1950's Croizat proposed a revolutionary method of biogeographic analysis (Panbiogeography) based on geographic patterns of evolution and called for a profound revision of the prevailing ("orthodox") tenets upon which evolutionary theory was based. Although regarded with contempt by prominent evolutionists of the time, Croizat's major works represented the development of a long line of evolutionary thought originating in continental Europe. We argue in this paper that Croizat's contributions were eschewed because of sociological reasons (rather than lack of scientific value) resulting from the hegemony of the "modern synthesis" as the scientific orthodoxy. Recent developments in panbiogeography indicate the continued role of sociological factors with a resurgence of interest being generated from European, Latin American and South Pacific countries

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Suppression at the Frontiers of Evolutionary Biology: Léon Croizat's Case.

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> Anyone assuming that the literature of biogeography is necessarily scientific is in for a surprise, when learning that this literature is all too often subservient to strictly human foibles of conceit, obstinacy, illogical reasoning, etc. It is imperative that young students be informed of this because, if not, they will find impossible to judge correctly what the press and their surroundings offer for their attention.
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> [Croizat 1984b][1]

1. Introduction. It is not at all unusual in science that sociological factors often have more influence on the acceptance of new developments than objective evaluation of scientific merit. Within the social context of science there may be great resistance to relinquishing "pet" theories where they are linked to an individual's status in terms of career, power, and finance (public and private). This sociological inertia establishes a generally accepted theoretical and social framework that defines the 'serious' scientists vested with the authority of speaking and writing on behalf of the 'serious' or credible science. Thomas Kuhn illustrated this process in his *The Structure of Scientific Revolutions* (1970) in reference to a corpus of theories being organized into a "*paradigm*", or "*orthodoxy*", where dissenting voices are often dismissed as esoteric and mystical challenges that threaten to return science to the Dark Ages. This social construction of science leads to a procedural dilemma where science can only progress through the refutation of prevailing knowledge which itself is not possible without unorthodox challenges being recognized.

Unorthodox thinkers choosing to criticize orthodoxy face the real possibility of not only being ignored but also having their scientific credibility called into question by being labeled elements of the 'lunatic fringe'. The history of science is replete with examples, some of which will be presented elsewhere in this conference. In this paper we will examine how this sociological process affected the history of evolutionary biology and biogeography with respect to the science and career of Léon Croizat who was labeled a member of the lunatic fringe by George Gaylord Simpson (Nelson 1977), a prominent member of the New York school of evolutionary biology.

After a brief biography, we will outline Croizat's significant contributions, in the light of contemporary events and theoretical framework. Finally, we will analyze his complex academic fate: firstly being ignored by the scientific establishment, then being misunderstood and misused, and then finally recognized for his actual merits by primarily European, Latin American, and South Pacific biologists.

2. Léon Croizat. Léon Croizat was born in 1894 from well-to-do French parents in Italy, and died in Venezuela in 1982 at the age of 89. He was attracted to the study of the living world from a very early age. As a young man Croizat was often a guest of the herpetologist Count Mario Peracca, in whose greenhouse he was able to observe the collection of Galapagos tortoises and giant iguanas. There he no doubt met other naturalists and university professors, among them very likely was Daniele Rosa (1857-1944) who developed the first comprehensive modern theory of phylogenetic ('cladistic') classification (Rosa 1918). Here Croizat would have had the opportunity to be exposed to the problems of taxonomy, and of evolutionary theory, according to the views current in Europe at those times.

The First World War interrupted Croizat's studies. In his words he "was sucked for some six years into military service". In 1920 he obtained a law degree, taking advantage of special terms for war veterans. Fascism, which he opposed, obliged him to move to New

[1] All citations by Croizat are originally in English and have been translated into Italian by the Authors.

York in the United States. Even though years of hardship were to follow, he developed an interest in watercolor painting with some success. In 1936 D. E. Merril, Director of the Arnold Arboretum of Harvard University, offered him a job as technical assistant. Croizat soon started to take advantage of the facilities and his knowledge of several western European languages, publishing the results of his observations in a number of papers (173 from 1936 to 1946, according to the Bibliography of Croizat by Heads and Craw 1984). These contributions were sometimes considered controversial by the contemporary academic establishment, and Croizat writes explicitly of censorship during this period. Certainly he wrote what he believed; even though sometimes with a polemical wit that may have engendered some of the hostility against him. When Merril was removed from his position as director in 1946, Croizat was also dismissed in retaliation for earlier papers critical of the botanist I. W. Bailey. Croizat was unable to find another job in the United States, and moved to Venezuela, where he held a number of Academic positions from 1947 to 1952. In 1951 he was a botanist for the Universidad de los Andes, in the Franco-Venezuelan expedition to the Orinoco River.

In 1953 he divorced from his wife (he had married her while still in the Army, in Italy), and married again. His new wife, Catalina, in order to allow Croizat to work full time on his panbiogeography, decided to train as a landscape architect in the United States to provide them with sufficient income. Croizat gave up then all Academic positions to work full time on biological and biogeographic problems. By this time he had already published his *Manual of Phytogeography* (published by Junk, in The Hague in 1952), and further major books were published in the following years (*Panbiogeography*, 1958, *Principia Botanica,* 1961*, Space, Time, Form: The Biological Synthesis*, 1964). These were all published privately by Croizat in order to avoid the censorship that would be inevitably be imposed by science publishers.

It is interesting in this regard a note by Croizat on the very last page of *Space, Time, Form*:

> The almost universal attitude, so in the U.S.A. and Great Britain most particularly, is editorially to refuse acceptance to contributions that are "controversial", even only, may "invite discussion" in spite of their being "interesting". Since everything which is new thought is "controversial", it is hardly worth to deal with gentlemen action [acting][2] in that spirit. [Croizat 1964: 881

In 1974 he published a paper with Gareth Nelson and Donn E. Rosen in the prestigious Journal *Systematic Zoology* (now *Systematic Biology*). The manuscript Croizat sent to Nelson to be forwarded to the Journal editor for publication was heavily retouched by the other authors without Croizat's consent (he only consented to the addition of the names of Nelson and Rosen as junior authors), and Croizat therefore did not consider this paper to represent his views (Croizat 1982). More recently, and following a paper by Colacino (1997), Nelson[3] said Croizat's account was false and that Croizat was aware of all changes to the paper throughout all the stages of preparation although the supporting correspondence was destroyed upon his retirement.[4] The joint paper did provoke a wider recognition of Croizat's existence even though leading to a confusion of panbiogeography with vicariance cladistics as one and the same (e.g. Frankel 1984). We will return to this issue later (§4).

In 1976, at 82 years of age, Croizat and his wife became the first directors of *the "Jardin Botánico Xerófito*" in Coro, a Botanical Garden they initiated in 1970.[5] That same year he lost his right eye in an accident and further health problems characterized the following years until his death in 1982. He wrote his last paper around July-August of that year (and published posthumously in 1984 [Croizat 1984b]) in which he continued to

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[2] We thank Marco Mamone Capria for pointing out to us this possible typo in the original text.

[3] Personal communication to CC.

[4] *v.* also the comment by M. T. Ghiselin in Heads and Craw 1984.

[5] Now known as the "*Jardin Botánico Xerófito Léon Croizat*".

express the same lucidity of thought and vigor in fighting "academic authority and learned ignorance" throughout his career.[6] In a letter to Craw he wrote, in the year of his death:

> I have indeed lived and worked to my taste either in art or science. What more could a man desire? Knowledge has always been my goal. There is much that I shall leave behind undone ... but something at least I was privileged to leave for the world to use, if so intends... As the Latin poet said I will leave the table of the living like a guest who has eaten his fill. Yes, if I had another life to spend, I certainly would not waste it. But that cannot be so, so why complain? [cited in Craw 1984b]

3. Croizat's contribution. Croizat proposed in the 1950s a method of biogeographic analysis (Panbiogeography) whose results suggested the need for a profound revision of the tenets upon which evolutionary theory was based.[7] He was aware of his "unorthodoxy," and of its possible consequences:

> "Censorship is today as rampant as it ever was in the Middle Ages although its face is different, and its language no longer patterned after that of Divine Revelation as a whole." (Croizat 1964: 179).

Croizat produced one of the most fascinating critiques of Darwinism because he chose not to address directly the problem of biological form, but instead that of space (Craw 1984c). It is through time and space, in fact, that the forms of organisms change.

3.1. Croizat's Panbiogeography: its general contribution and relevance to evolutionary theory. The contributions of Croizat, and his biogeographic methodology, to evolutionary theory are insightful and profound. One point of importance is that his contribution derived from the application of a biogeographic method working with empirical data rather than the *aprioristic* abstract speculation characterizing much of biogeographic and evolutionary theory of his time.

Croizat considers the evolutionary process to be composed of three factors: *space*, *time*, *form*. Evolution in space and time results in the formation of distribution patterns that comprise the object of study for the science of biogeography. Biogeography was very important in the early development and formulation of evolutionary theory (*v.* Croizat 1964; Grehan 1988). Darwin's "Natural Selection", however, had the effect of stressing the notion of evolution as a temporal change in *form* (intending the term *form* to include morphology, genes, development, behavior, etc.), while biogeography (*space*) became of limited importance, if not redundant to the entire evolutionary enterprise (Grehan 1988).

Darwin seemed to be aware of the importance of constraints, or "laws of growth", he referred to them, for instance, in the several editions of his opus magnum *On the Origin of Species by means of natural selection* and in several of his published letters.[8] He admitted to have extended too far the action of natural selection. While recognizing that many morphological changes in plants could be "attributed to the laws of growth, independently of natural selection" (Darwin 1872: 175)[9], the Modern Synthesis stressed exclusively natural selection as the factor directing the course of evolutionary change.

This is reflected in one of the common definitions of evolution that equates evolution with *"any change in gene frequency"*.[10] This unfortunate event, according to Croizat (1964), retarded the progress of evolutionary thinking. Moreover, this neo-Darwinian theory of evolution, by explaining the natural pattern of classification as a

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[6] Biographic information from Craw, 1984b, Zunino 1992, Llorente *et al.* 2000, Morrone 2000, and from the short autobiographical notes at the end of Croizat 1982.

[7] Croizat 1952, 1958, 1961, 1964

[8] *v.* Craw 1984d for a compilation of relevant quotations.

[9] *v.* also Craw 1984c; Grehan 1984, Heads 1984

[10] *e.g.*, Wilson and Bossert 1971: 20.

pattern of descent (phylogeny) without actually predicting or prohibiting any pattern, is unable to generate additional understanding of macroevolutionary patterns.

Croizat's original approach to evolution was the use of the analysis of the present geographic distributions of organisms as the basis of an understanding of the process generating the evolution of form through space and time. He tested Darwin's aprioristic and conjectural concepts of speciation in "centers of origins", and subsequent "migration" from those centers by the use of "means of dispersal" by analyzing the degree of correspondence between the ability to disperse and spatial patterns of dispersal. He found that the dispersal patterns were not only repetitive (following main general "channels" or "tracks") but also that they were independent of the various "means of dispersal" of taxa.

To explain vicariant distributions (the occurrence of related taxa in different locations), he proposed they evolved from a broadly distributed ancestor that established its range during a former period of "mobilism" where its "means of survival" (mechanisms by which offspring are able to locate and establish themselves in locations resulting in continued survival) acting as means of dispersal (the range of available habitat expands). A period of "immobilism" follows in the course of which the ancestor will undergo active form-making around particular centers in consequence of different evolutionary trends taking place over its range (Croizat 1958, 1964, 1984a):

> "Form-making is an orderly process through time and over space. It takes place by the breaking down of an ancestral group (whatever its taxonomic rank) around essentially local centers of progressive differentiation." (Croizat 1958 [Vol. 2b]: 998).

As Grehan and Ainsworth explain [1985]: "[T]he descendants, therefore, evolve in different localities *as if* there had been actual migration between them". Disjunctions will occur through "extinctions" in the previously continuous range. Croizat, however, does not reject "dispersalism" as an impossible event:

> "...a biogeographer must be a vicarist in principle and a dispersalist in detail, case by case according to the merits of each case." (Croizat 1982).

Panbiogeography analyses biogeographic characters through the drawing of tracks, *and* the direct incorporation of information from *form* (to orient tracks with respect to particular geographic sectors of the earth). A track is a line connecting disjunct localities of a particular taxon. This track is interpreted as a graph of the geographic distribution of the taxon under consideration, and represents the "primary coordinates" in space of the taxon. Tracks are then oriented according to sea or ocean basins. This allows one to propose a hypothesis for the baseline (defining characteristic) for that track. The baseline represents a primary biogeographic homology (diagnostic character) for the taxon under study (Craw 1988). In the case of complex geographic distributions, information on the phylogenetic relationships of the group under study is needed to orient the track.

> ...the task of connecting the whole by 'tracks' proves exceedingly difficult unless the flow of the affinities in the group under study is perfectly known. [Croizat 1958, vol. 2: 688][11]

In any case, once determined, several individual tracks from different taxonomic groups with the same baseline constitute a *standard* or *generalized track*. A generalized track refers to the present day distribution of an ancestral biota of which the individual components are the relict fragments (Craw 1988). The generalized tracks for terrestrial life, as Croizat discovered in 1958, have no apparent spatial correlation with the distribution of continents today. Thus *parts* of continents/islands, are related one to another by tracks over sea and ocean basins, and not within the present day continental limits. They therefore do not constitute "biogeographic units equivalent to present day geographic areas" (Craw 1988).

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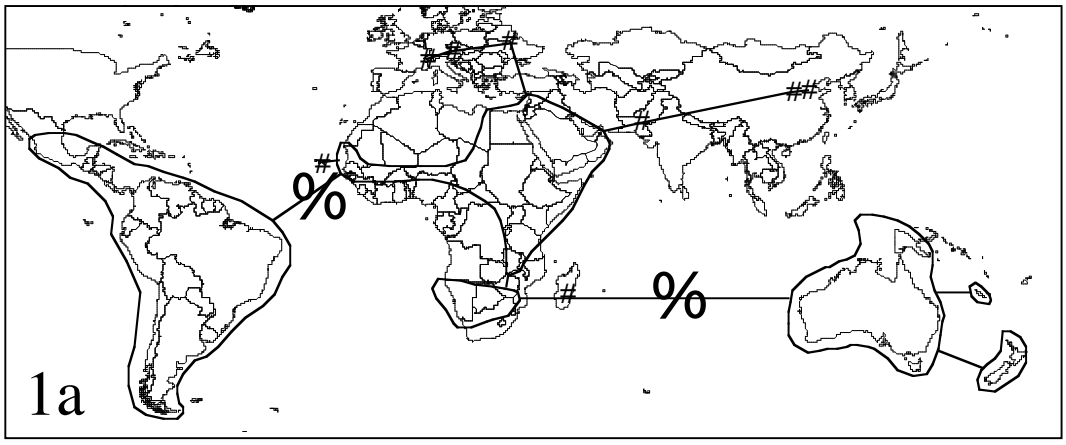
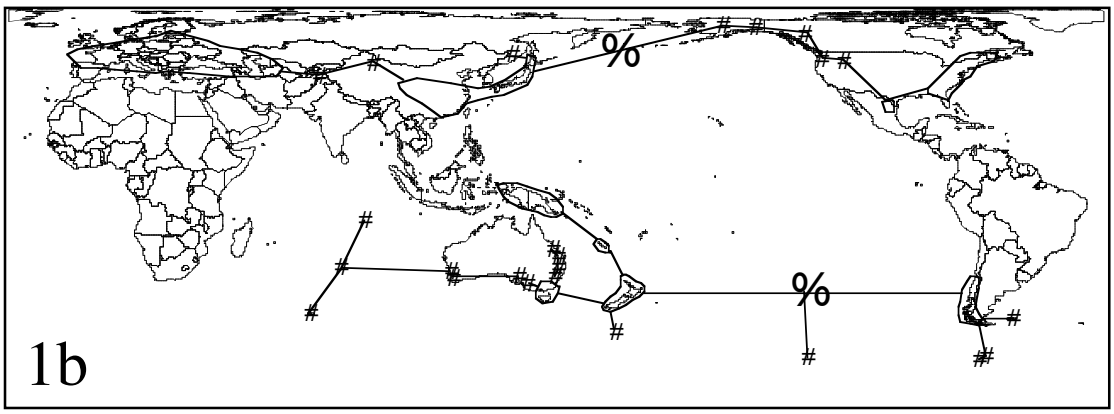
[11] *v.* also Craw 1983.

One of the revolutionary elements of Croizat's biogeography concerned the integration of biogeography and geology. Most biogeographers fail to integrate biogeography and geology, and simply attach stories about centers of origin and dispersal onto an accepted geological framework such as continental drift. Croizat's approach was quite different. He looked to the correlation of biogeographic patterns with tectonic features as the methodological foundation for predicting the historical association of earth history with the origin and evolution of distributions (Craw 1990). Croizat (1961, 1964) correlated the newly discovered tectonic spreading ridges with the spatial geometry of modern distribution patterns, and he also recognized the parallel historical implications of transform faults and distributional disjunctions (Croizat 1964). In these applications Croizat was actively making use of the new discoveries and models emerging from geological and geophysical studies of the seafloor that were revolutionizing the earth sciences at that time (cfr. Wood 1985). The technique of spatial correlations between biogeographic patterns with geological features generates predictions for the origin and evolution of taxa and their distributions (Heads 1990, 1998a) and liberates biogeography from the constraints of individual geological theories about past events (Craw 1989). Moreover, since this approach generates evolutionary predictions based only on the analysis of biogeographic evidence comprising biological relationships and geographic distribution it can, therefore, be used to actually test geological theories (Craw and Weston 1984).

3.2. An example: the distribution of Ratites and southern beeches. The contrasting method and results of panbiogeography are illustrated by a comparison of two classic biogeographic problems – the flightless ratite birds (*e.g.,* ostrich, emu, kiwi) and the southern beeches (genus *Nothofagus*) (Craw, 1985, Grehan, 1988b, Craw et al., 1999). Both groups are distributed mostly over fragments of the former Gondwana supercontinent although the beeches are absent from Africa and India. Both groups are widely viewed as poor dispersers and ancient lineages so with the acceptance of continental drift and plate tectonics it became popular to classify their current distributions as the result of continents moving apart with the fragmentation of Gondwana. The two group are biogeographic homologues with a common 'Gondwana' origin.





Panbiogeographic analysis identifies the distribution of ratites as having an Indian Ocean and Atlantic Ocean baseline, suggesting the history of these ocean basins is correlated with the origin of the ratite distribution (Fig. 1a). This spatial homology is congruent with fragmentation of a Gondwana distribution through formation of the Indian and Atlantic Ocean basins. The southern beeches, in contrast, are found mostly in and around the Pacific Ocean (Fig. 1b), suggesting the origin of this group is associated with the formation of the Pacific basin rather than the tectonic basins of Gondwana. The geographic overlap of modern beech and ratite distributions is not due to a common Gondwanic history, but through convergence of different geological regions (Gondwana and Pacific) as first predicted by Croizat (1958, 1961) and later corroborated by geologist (Craw, 1982, 1985). Only the ratites can be supported as having a 'Gondwanic' distribution while that of the southern beeches, along with many other plant and animal distributions, represents a non-Gondwanic Pacific basin distribution (see Craw et al., 1999).

3.3. Implications for evolutionary theory. The principal implication of Croizat's panbiogeography for evolutionary theory is its requirement for evolutionary processes causing a biological change in the ancestor over a wide area and not in some particular geographically restricted "center of origin" within the current geographic range. In this approach Croizat's panbiogeography shares important similarities with Rosa's theory of hologenesis. Both authors objected to ad hoc reasoning conventionally used to explain the origin and evolution of distributions, both were driven by methodological reasoning, and both developed a general model of widespread ancestral differentiation involving biological mechanisms of evolutionary change Croizat identified with the term "Orthogenesis" (Luzzato *et al.* 2000).

The process of evolution, according to Croizat (1958, 1964) involves a biological mechanism, called orthogenesis, responsible for a biased (rather than random) generation and establishment of new genetic mutations. Croizat did not exclude the possibility of local adaptations, but considers those of secondary importance for the evolutionary process):

> In evolution two moments are clearly discernible. One is primarily directional (orthogenetic!), that is, results from the deployment of structural premises that, once established, determine the course of subsequent form-making along lines of basically irreversible sequence in all essentials. The other moment involves adaptation and selection (mostly to the environment) in function of a primary directional stream. Theories of evolution which fail ... to discriminate these two moments ... cannot be satisfactory. "Orthoselection" is a patent misnomer confusing as one the two moments of evolution. ... Adaptation and selection are necessarily operative on a prior background furnished by orthogeny. [Croizat 1964: 709]

As we have said, Darwin seemed to be aware of the importance of "laws of growth", but he was not able to organically synthesize those laws in his theory. Neo-Darwinism and the so-called 'Modern Synthesis' completely ignored factors other than Natural Selection (including Darwin's laws of growth theory), considering natural selection both necessary and sufficient to explain all evolutionary change. More recently, some orthodox authors have acknowledged the possibility of biological factors playing an important role in evolutionary change.[12] That other factors may play a role in evolution is something well known in continental European literature on evolution from the last century and beginning of this one.[13]

Orthogenesis has often been incorrectly equated, especially by leading Anglo-American evolutionary theorists, with some kind of mystical belief, *e.g.,*

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[12] *e.g.*, Gould and Lewontin 1979; Maynard Smith *et al.* 1985; Reif *et al.* 1985.

[13] *e.g.*, Rosa, 1918, 1923, 1988; *v.* Grehan and Ainsworth 1985; Craw and Heads 1988 for a discussion on the history of orthogenesis.

> "...[orthogenesis] relies on some built-in tendency or drive toward perfection or progress. All these theories were finalistic: they postulated some form of cosmic teleology of purpose or program." (Mayr 1978);

or has been referred to in terms of linear series or trends toward a non-adaptive state (*e.g.*, Panchen 1992: 263). The main critique of orthogenesis is that, *e.g.*: "[It] must involve some form of unknown, and perhaps 'internal' mechanism. ... an appeal to mysticism." (Gould and Lewontin 1979). Orthogenesis is therefore rejected mainly because of lack of a known mechanism. Gould and Lewontin, however, do not give any "known" mechanism for "phyletic constraints" and "developmental constraints".[14]

Orthogenesis in the sense of Darwin, Croizat, Rosa (among others) has no teleological or mystical connotations. It simply refers to the fact that a variation in form is limited, constrained, by the initial state. "I use the term orthogeny in a purely mechanistic sense, not at all in a mystical one..." (Croizat 1964: 676). It does not imply any explanations in terms of *ends*, so common in adaptive "just-so" story-telling (and on this point, adaptive explanations appear to us to be far longer and teleological).

Croizat considered orthogenesis as the principal factor in evolutionary change. He considers evolution as consisting of two processes in interplay, *i.e.*, orthogenesis (type of organization, *Bauplan*) and adaptation (to different environments), with the first being the most important to explain (macro)evolutionary change. Recent developments in molecular genetics include concepts of 'molecular drive' and 'biased gene conversion' that require a coevolution of biological and environmentally mediated mechanisms of evolutionary change (Craw et al. 1999). These kinds of processes may correspond in whole or in part to the broad concept of Orthogenesis as proposed by Croizat.

4. Misrepresentations of Croizat's work: Real Misunderstanding or Ostracism? Many of the authors dealing in one way or another with Croizat's Panbiogeography have been misled by the improper association of Croizat's works with Vicariance Biogeography, a method considered by its supporters as an extension and improvement of the panbiogeographic method (*e.g.,* Patterson 1981; Humphries and Parenti 1999).

Vicariance biogeography only *assumes as possible* that life and earth may evolve together. This is an important point because it implies a conceptual difference between the two methods (cfr. Croizat 1982, 1984a; Heads and Craw 1984). Vicariance biogeography establishes relationships from *form* (*i.e.*, cladistics of structural, functional, behavioral aspects of organisms) without actually considering the *spatial* and *temporal* aspects of the organisms under study as an integral element of the method. The cladogram so obtained, therefore, does not contain any biogeographic information. The geographic distribution of the organisms (taxa) studied is then superimposed on the biological cladogram (Craw 1983).

Still today, after a series of works, and even a book on the subject have been published (e.g., Craw *et al.,* 1999) many biogeographers seem unable to grasp the difference between vicariance biogeography and Croizat's panbiogeography. In lecture outlines for a course in Biogeography from the University of Arizona, available until recently on the worldwide web (last update we have seen: 16 October 2000), for instance, Léon Croizat is presented as the "father of vicariance biogeography", and a "track" is defined as "a line circumscribing total range of a monophyletic taxon."

In one of the few (otherwise good) textbooks of biogeography citing Croizat we find it misrepresents his ideas stating, for instance, that "Croizat categorically denounced Wegenerism" (Brown and Gibson 1983: p.267), without saying that Croizat did not oppose continental drift because he thought it was false (as, for example, Simpson and Mayr maintained), but because the reconstruction of the continents into one supercontinent (Pangaea) conflicted with his results, especially in the Pacific area (so he did not oppose, in

[14] *v.* Colacino 1997, for a brief discussion.

principle, the idea of "floating continents"). Even though the authors pretend to represent fairly Croizat's ideas in a couple of pages (p. 350-352) of the new edition (Brown and Lomolino, 1998) we are informed that:

- it was Croizat who arrogantly dismissed alternative views;
- nowadays "except for a few zealous disciples of panbiogeography [...] most biogeographers recognize Croizat's approach as being flawed"; and, again,
- Croizat "in his earlier writings, denounced Wegenerism".

Of course Brown and Lomolino did not treat the opposition of Simpson and Mayr to continental drift (cf. Nelson 1977) with the same determined critique. To the contrary, when they cite Simpson's opposition to Wegenerism they stress the problems associated with the early shortcomings of that theory. Reality is that Wegener's ideas were generally rejected during the thirties, forties, and early fifties:

> "arguments which denied continental dispersion passed without scrutiny or test. They were correct a priori because everybody knew that continental drift was wrong." (Carey 1976, cited by Craw 1984a).

And yet it was Croizat (1958, 1961) who appears to be the first evolutionist and biogeographer to apply the new geological data on sea-floor spreading and plate tectonics (Craw 1990, Grehan 2001).

The most curious critique is that that "Croizat lacked a solid systematic and phylogenetic foundation" (Brown, Lomolino 1998). It is evident that an accurate biogeographic analysis depends on the systematic information available, and that, most of the time, the quality of that information does not depend on the biogeographer himself who uses information gathered by other scientists. Phylogeny, moreover, is not independent of space and time, and indeed one of the tenets of Croizat's panbiogeography is exactly that of using the spatiotemporal coordinates of taxa in elucidating phylogenetic relationships and assist in reconstructing phylogeny (e.g. Croizat 1958, 1964; Craw *et al.,* 1999). We believe this critique is valid in general terms for any biogeographic work and represents a selective dismissal of an alternative biogeographic method threatening the hegemony of traditional biogeography and evolution.

We want to stress here that many reviewers have held that phylogenetic considerations had no role in Croizat's biogeography.[15] Many authors probably confused by Croizat's many negative comments on Hennigian systematics (cladistics) assumed he lacked an understanding of phylogenetic relationships. This is false as Croizat was well aware of the importance of phylogeny (Craw 1982), and he included in his analyses concepts of ancestor-descendent and common ancestry (*e.g., v.* Croizat 1958[1]: 726; Croizat 1979). As an aside, we will add that Croizat was, however, very critical of Hennig's "Phylogenetic Systematics". Croizat did not consider Hennig's approach to be original, but conceptually a compilation of the previous work of Rosa (1918, 1923), and in particular on his *Theory of Hologenesis* (Croizat 1979, Luzzatto et al. 1997, 2000).

Many previous workers may also have been put off by his unorthodox, and repetitive way of presenting his ideas (*v.* Croizat 1964: xvii-xviii, for a comment by Croizat), and misinterpretation and misrepresentation of Croizat's views has been the most common result.[16] At the same time, some other authors preferred just to ignore Croizat's contributions *tout court.* In particular, Simpson, as we have said, was convinced that Croizat "is a member of the lunatic fringe," while Mayr considered Croizat as having a "totally unscientific style and methodology" and adding that "time is too short to argue with such authors", so dismissing Croizat's works as a whole unscrupulously (*v.* Nelson

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[15] *e.g.*, Ball 1976; Cracraft 1975; McDowall 1978; Patterson 1981.

[16] *e.g.*, Ball 1976; Brundin 1972; Cracraft 1975; Croizat, Nelson and Rosen 1974; Mayr 1982b; Nelson and Platnick 1980; Nelson 1974; Rosen 1978.

1977 *fn.* 3)[17]. Mayr avoids a direct mention of Croizat in his 1982's opus magnum, *The Growth of Biological Thought* (Mayr 1982a), while, at the same time misrepresents Croizat's method, presented as:

> A somewhat eccentric biogeographic theory was proposed in the late 1950s, 'vicariance biogeography', [...][18]

Mayr, that same year, though, finally mentions Croizat in a book review (Mayr 1982b).

It is interesting to note that among the scientists who largely ignored Croizat in public, some corresponded with him in private, and in some cases for a long time. Among them: Stephen J. Gould (from 1978 to 1982), Soren Løvtrup (1978-80), Daniel Janzen (1974), Peter Raven (1978), Armen Takhtajan (1961-70), and George Gaylord Simpson (1959). Stephen Jay Gould, for instance, informed Croizat he read *Panbiogeography* in graduate school, but never mentioned Croizat in his historical or evolutionary publications while focusing on many obscure figures in biology.

It was George Gaylord Simpson who first attempted to exile the work of Croizat by defining him a member of the lunatic fringe. Simpson was one of the most vocal (and powerful) representatives of the contemporary orthodoxy that was strictly Neo-Darwinist, and at vehement variance with Croizat's views, especially in reference to dispersal. Croizat pointed out in his works several inconsistencies in Simpson's views. Simpson, however, chose to completely ignore Croizat even though his position apparently did move toward an acceptance (never declared) of some of Croizat's ideas (*v. e.g.,* Croizat 1982). Simpson, however, continued to condemn Croizat's view anyway, a "cognitive dissidence" which he apparently shares with other, more recent, reviewers of the panbiogeographic method.[19]

It is also interesting to note a comment made by Craw (1984a) dealing with a historical interpretation of Simpson by Frankel (1981). It is apparent that the ostracism Croizat suffered resulted in lasting damage to the science of biogeography. Frankel's comments, in fact, completely ignore some of the most relevant objections to Simpson's zoogeography, those of Croizat:

> What is clear is the remarkable parallelism between Frankel's approach, and Simpson's (one of the chief protagonists in the debate) recent attempts to rationalize his previous oppositions to the drift solution as an attempt to evade falsification of his inductivist-dispersalist 'theory' of zoogeography. The widespread acceptance of plate tectonics in the 1960's and early 1970's corroborates both Wegener's and, in part, Croizat's biogeographic hypotheses. That Simpson has attempted, and continues to attempt to discredit one (Wegener) and ignore the other (Croizat) is testament to his desire to evade falsification of his own approach to zoogeography.
>
> Frankel has chosen to locate himself within the inductivist-dispersalist Matthew/Simpson tradition and he has written his history in accordance with that

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[17] Footnote 3's complete text from Nelson 1977: "Because Simpson has never publicly commented on Croizat, and to judge from his recent writings never will, his (1973 in litt.) evaluation may be recorded here: "Study of Croizat's voluminous work has convinced me that he is a member of the lunatic fringe." Croizat contributes some information about the basis of Simpson's judgment: "Simpson tuvo en sus manos mi *Panbiogeography* tan pronto como estuve a la venta (1958), ya que me escribió personalmente sus comentarios al respecto …" (p. 106). [it refers to a page from Croizat-Chaley, 1979]. Because Mayr has never publicly commented on Croizat, his (1974, in litt.) evaluation may also be recorded here: "Neither Simpson nor anyone else has affected my treatment of Croizat, but only his totally unscientific style and methodology. Time is too short to argue with such authors and one cannot simply refer to Croizat without a detailed analysis. I am prepared to be criticized for this, but any scientist has to make the decision where to draw the line." With respect to the reception of his own work, Croizat from time to time has mentioned a "conspiracy of silence", exemplified by the American Museum-Harvard University school of Dispersalists /Simpson, Darlington, Mayr, and their many students). In this matter I think Croizat appropriately resurrects Thomas Huxley's arresting phrase, used by him to describe the reception given Darwin by the academic establishment of that time. And I think Croizat's comments bring into focus the same lassitude in our own institutions, or at least in two of them and their acolytic offspring."

[18] *v.* Croizat 1984b for Croizat's comments.

[19] Cfr. Cox (1998), and Cracraft's (2000) reviews of *Panbiogeography* by Craw *et al.* (1999).

> tradition. In so doing he has failed to appreciate the hypothetico-deductive nature of Wegener's biogeography and the inductivist nature of Simpson's permanent critique.
> The recent history of geology and biogeography contains much of interest to the philosopher, historian and sociologist of science. That this is a fruitful area of research should be apparent from the above comments. In his neglect of pertinent literature, as well as recent comment at variance with his own interpretation, Frankel has failed to take a critical and insightful approach. He has failed to respond to the challenge that his subject presents (Craw 1984a).

Perhaps not surprisingly, Frankel (1984) maintained his views and claimed the relegation of Croizat to the "lunatic fringe" by many is "quite understandable." Frankel (1984) pointed to:

- Croizat's lack of an "extended teaching position" in which he could "promulgate [=indoctrinate?] his panbiogeography among future biogeographers";
- Croizat's insistence that biogeography stands on its own merits rather than that of geology;
- Croizat's opposition to other popular views such as the emphasis on natural selection in evolution and the use of cladistic analysis in systematics; and
- Croizat's "difficult" and "voluminous" writing.

In drawing attention to these issues Frankel (1984) attempts to maintain a fiction that it was Croizat who was unreasonable while his opponents in biogeography who failed to anticipate the geological revolution of plate tectonics could hardly be blamed for doing so.

5. Path to the future. The conference *Scienza e Democrazia – Science and Democracy* recognizes the critical problem of democratic control over scientific research and the role of internal politics within scientific communities. The ambition for scientific knowledge to be free of political and ideological bias is confounded by the fact that science is a profoundly 'social' construction produced by hierarchically organized groups that evaluate, award, and punish their own members, and exert control over what opinions can be held or even just discussed in a public setting (Hull 1988; cfr. "Introduzione" in this volume).

The history of Croizat's ideas and research program represent the development of a long line of evolutionary thought that has its foundation in the philosophy and culture of continental Europe. His panbiogeographic method (not to be confused with vicariance biogeography) is an original and fruitful method of investigation worthy of consideration, as demonstrated by its recent application and development by New Zealand and Latin American scientists.[20] Its uncritical dismissal from the scientific establishment of the 'Modern Synthesis' is, from a scientific point of view, unjustifiable.

It is apparent that the acknowledgment of Croizat's contributions in 1950s and 1960s (and later) was eschewed because of sociological reasons (and not lack of scientific value), when the "modern synthesis" became established as the scientific orthodoxy. The heavy hand of hierarchical organization and political control of science was no less apparent when panbiogeography resurfaced as a contender for scientific debate in New Zealand. Virtually exiled from the New Zealand scientific literature, the initial development and articulation of the panbiogeographic method and synthesis was made possible overseas, particularly through the journal Systematic Zoology (now Systematic Biology) as one of the rare publications where scientific debate and discord was tolerated, if not promoted as the necessary companion to scientific progress.

In contrast, panbiogeography was virtually banned from New Zealand scientific journals such as the Journal of the Royal Society of New Zealand and there remains to this

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[20] *e.g.*, Craw 1982, 1983, 1988; Craw *et al.,* 1999; Craw and Heads 1988; Craw and Weston 1984; Grehan and Ainsworth 1985; Heads 1985, 1990; Morrone and Crisci, 1995; Morrone *et al.* 1996; Page 1987, Zunino 2000.

day a blackout on panbiogeography in the popular natural history media. A preliminary discussion of Croizat's panbiogeography and his botanical work (*Principia Botanica*) in the Victoria University of Wellington biology journal *Tuatara* (Craw and Gibbs 1984) was made possible through the support of the zoology editor (G. W. Gibbs) in the face of a withdrawal of involvement by the botanical editor (B. Sampson). A further special issue on panbiogeography was published in the Italian journal *Rivista di Biologia – Biology Forum* through the active interest and support of the editor Giuseppe Sermonti (Craw and Sermonti 1988). In the following year the first panbiogeography conference was successfully held at the Museum of New Zealand in Wellington. With over 70 people in attendance the conference generated a diverse range of papers published as a special issue of the New Zealand Journal of Zoology (Matthews 1990) with the financial support from the publication budget of the Museum of New Zealand curator of Mollusks, Frank Climo.

With the successful conclusion of the conference and publication of the proceedings the future of panbiogeography in New Zealand looked promising, but the impact of 'democratic' and social control became even more critical when New Zealand science policy moved towards 'competitive' funding as the primary support for scientific research through the new Foundation for Research and Technology. Through this organization opponents of panbiogeography were given the opportunity, in their capacity as reviewers, to eliminate any opportunity for funding. By ascribing impossible standards of verification for the science of panbiogeography, it became all too easy to eliminate panbiogeography as a serious contender while orthodox Darwinian models of evolutionary research were supported.

Ironically, it was this competitive approach that the Minister of Science, Simon Upton, thought would provide opportunities for the development of panbiogeography, yet in the light of institutional opposition, he finally acknowledged (ministerial communication to JRG) the science environment of New Zealand lacked the necessary diversity for panbiogeography to thrive. In contrast, panbiogeography has internationally emerged from the obscurity imposed by Simpson, Mayr, and other contemporary proponents of Darwinian evolution and biogeography. Recent applications include analysis of the the Proteaceae (Weston and Crisp, 1996), argentine scorpions (Mattoni and Acosta, 1997), *Cecropia* trees (Franco-Rosselli and Berg, 1997), reduvid bugs (Coscaron 1997, Coscaron and Morrone, 1995), clerid beetles (Kolibáč, 1998), Columbian flora (Cortes and Franco, 1997), freshwater Crustacea (Lopretto and Morrone, 1998), divaricating tree daisies (Heads 1998b), marine desmosponges (Hajdu, 1998), keroplatid and mycetophilid flies (Matile, 1998, 1999), middle America herpetofauna (Wilson and McCranie, 1998), scorpions (Lourenço,1998), *Abrotanella* daisies (Heads, 1999), the Andean biota (Katinas *et al.* 1999), centipedes (Morrone and Pereira 1999), Cycadales and Coniferales (Contreras-Mendina *et al.,* 1999), aeshnoid dragonflies (DeMarmels, 2000), copepods (Menu-Marque *et al.,* 2000), cloud forest conservation (Luna et al. 2000), and genera of the tea family Theaceae (Luna and Contreras, 2000)

Panbiogeography is now internationally recognized as one of the principal biogeographic methods in evolutionary biology (Brown and Lomolino, 1998; Craw *et al.,* 1999; Humphries and Parenti 1999, Bueno and Llorente 2000; Cox and Moore, 2000; Morrone 2000). Brown and Lomolino (1998) identified Croizat as one of the great scientists to contribute to the development of biogeography, and the XXVIII meeting of the Società Italiana di Biogeografia honored Croizat work with a commemorative medal (Zunino, 1992). Sociological factors appear to still be significant in the emerging panbiogeographic interest with much of the activity being expressed in Latin American, and South Pacific countries (Espinosa and Llorente, 1993; Llorente et al., 2000), and Europe (Zunino 1992, Colacino 1997, Monge-Nájera, 1999).

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