Botanical nomenclature and plant fossils

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Abstract The provisions in the Code for naming plant fossil taxa have changed substantially over the years. The history of these changes reflects the tension between palaeobotanists (including palynologists studying plant microfossils) who need a flexible set of regulations, and the tendency for the Code to include nomenclatural regulations that constrain taxonomic decisions. The current Vienna Code now provides for plant fossils to be named as fossil taxa, which is a flexible taxonomic concept that should suit the needs of most palaeobotanists. However, the Vienna Code also incorporates the more restrictive concept of morphotaxa and most palaeobotanists seem to be under the misapprehension that plant fossils can only be named as morphotaxa. In our view, the concept of morphotaxa is logically flawed and unnecessary in practice, and should be removed from the Code.

Keywords form-genera; fossil taxa; morphotaxa; organ-genera; palaeobotany; palynology; satellite taxa

INTRODUCTION

Since the publication of the Vienna Rules (Briquet, 1906) it has been accepted that taxonomic nomenclature of plant fossils should follow essentially the same procedures as used for living plants. However, it soon became evident that the fragmentation of plants prior to and during fossilisation, and the different types of information provided by different modes of preservation, made it impossible to name taxa of fossils in exactly the same way as taxa of living plants. Thus, various different nomenclatural measures have been proposed over the years for inclusion within the Code to accommodate fossils, the most recent being the introduction of “morphotaxa” in the St Louis Code (Greuter & al., 2000a) and of “fossil taxa” in the Vienna Code (McNeill & al., 2006).

Many palaeobotanists (including palynologists dealing with organic-walled plant and “algal” microfossils) remain uncertain about the current rules for palaeobotanical taxonomic nomenclature and their implications, and we agree that the position appears somewhat cryptic. However, the current Code does in fact meet the needs of palaeobotanists, and in our view there need only be a few fairly modest changes to the provisions covering plant fossils for the situation to become clear.

WHAT ARE WE NAMING?

This may seem self-evident, but in our view there has been some confusion. Palaeobotanists deal with two concepts: plant fossils and fossil plants. Plant fossils are the physical objects taken out of the ground that reveal evidence of long dead plants. These remains nearly always represent just fragments of the plants in which aspects of the original tissue have been at least partly lost through fossilisation. They are now biologically inert objects, but originated from living organisms.

Fossil plants, in contrast, were the plants from which these fossilised remains were derived. They were whole living organisms, which in principle could be treated in the same way as living plants. But there is the crucial difference that fossil plants no longer exist except in the minds of palaeobotanists, a view echoed by Bateman & Hilton (2009); nowhere can you today see a fossil plant other than as an illustration or model. It is of course true that the larger living plants are usually typified by herbarium specimens representing only parts of the organism, and these could be regarded as analogous to fossil fragments (Stafleu, 1967). Since the nomenclature of whole living plants is based around fragments preserved in herbaria, why can we not similarly name fossil plants based on our fragmentary plant fossils? The reason is, in our view, because there is a fundamental difference between the two situations. With living plants it is still usually possible to go to a whole living organism to check features that may not be shown by the type, a procedure that is impossible with long-extinct fossil plants. In some cases, reproductive organs and foliar organs have been found in apparent attachment, but except for the smaller fossil plants (e.g., Ash & Tidwell, 1986: fig. 2) whole articulated organisms are rare, and those that are available do not preserve the full range of their tissue and organs.

In the current Code (McNeill & al., 2006) the wording is somewhat ambiguous. In the footnote to Preamble 7, the implication is that the palaeobotanical provisions within the Code are dealing with fossil taxa (“… the term ‘fossil’ is applied to a taxon when its name is based on a fossil type …”) and the term “Fossil taxa” is explicitly used in Art. 1.2. This term can only be referring to taxa of [plant] fossils and not of reconstructed (“whole”) extinct plants. However, in most of
the rest of the Code where palaeobotanical nomenclature is dealt with (Arts. 8.5, 11.1, 13.1(f), 36.3, 38.1, 38.2; Rec. 8A.3) the term “fossil plants” is used; only Art. 7.9 mentions “plant fossils”. This has led to the strange concept of “morphotaxa of fossil plants” (Art. 11.1); if we had available an actual fossil plant, we would surely name it in the same way as we would a living plant rather than using morphotaxa. There can be no doubt that in most places in the Code where the term “fossil plants” is used, it really means “plant fossils”.

Many palaeobotanists seem to focus exclusively on these hypothetical “whole” plants, at least partly because they are considered necessary for incorporation in phylogenetic (“cladistic”) analyses. However, as they no longer exist as realities there are very real practical problems in formally naming extinct plants reconstructed from the fossil record, problems that remain unsolved: a problem noted by Chaloner (1986). Arguably the best practice is to not name fossil plants formally at all, but to refer to them by names such as the “Lepidodendron-tree” outside of a formally codified system of nomenclature. Plant fossils, in contrast, are physical objects that can be examined directly and thus more suitable to codified nomenclature.

INTRODUCTION OF FORM- AND ORGAN-GENERA

The Vienna Rules (Briquet, 1906) specifically stated in Art. 9 that it covered fossils but few provisions were devoted to them. The first serious attempt to address the issue came with a meeting of British palaeobotanists held in 1934 at the British Museum (Natural History), where a series of proposals to emend the Rules were drafted (Thomas, 1935). This draft was also seen by three palaeobotanists from continental Europe (Wilhelmus Jongmans, Thore Halle, Walter Gothan) who subsequently published a modified version of the same proposals (Jongmans & al., 1935). Both versions were in essential agreement about the key proposal that there should be separate taxonomic categories for naming plant fossils: fossils would normally be referred to organ-genera. However, there would be a subset of organ-genera that would be entirely artificial (“artificial genera” in the Thomas proposal, “form genera” in the Jongmans & al. proposal) being defined on strictly morphological criteria with no implications being made that they incorporated biologically related species.

Both versions of these proposals were presented at the 1935 Amsterdam International Botanical Congress (Sprague, 1935a), where they seem to have met with general approval (Sprague, 1935b). However, because two versions had been tabled, it proved difficult to agree on the exact words to be adopted. A committee of palaeobotanists was therefore created, with H. Hamshaw Thomas as secretary (Sprague, 1935b), to prepare a compromise set of proposals, which would form the basis of an Appendix to the Rules (M.L. Sprague & al., 1950: 10).

The outbreak of war in Europe in 1939 brought all progress on this to a halt. After the war, in 1948, a small meeting was held in Utrecht to try to initiate work again on revising the Rules (M.L. Sprague & al., 1950). However, the group included no palaeobotanists, and they had no draft proposals from the Thomas committee. Moreover, the American botanist H.W. Rickett stated that American palaeobotanists had not had an opportunity to consider the 1935 proposals (which contradicts the comments by Thomas 1935: 111 that the British proposals “have received the general approval of many American palaeobotanists”). Consequently, no palaeobotanical provisions were added to the published supplement to the Rules (T.A. Sprague, 1950), nor had any been included in the earlier “unofficial rules” published in America (Camp & al., 1947).

The taxonomic nomenclature of plant fossils was finally addressed properly in 1950 at the Stockholm Congress, where the International Association for Plant Taxonomy was established (Cowan & Stafleu, 1982; Stafleu, 1988), and the Rules became the International code of botanical nomenclature. At this meeting, H.H. Thomas tabled a report from the Special Committee for Palaeobotany (Lanjouw, 1953) that integrated the Thomas (1935) and Jongmans & al. (1935) proposals (the report was published as “Appendix III” in the proceedings of the Stockholm Congress – Lanjouw, 1953: 547). There is no record of the discussions that produced this compromise wording, nor were the proposals on form- and organ-genera discussed in detail at the Stockholm meeting itself. However, except for the proposed change to Article 20 (later 23) giving the starting date for palaeobotanical taxonomic nomenclature, the Thomas report was accepted “almost unanimously” by the Stockholm Congress (Lanjouw, 1953: 534), and became incorporated into the Code, initially as Appendix IV (Stockholm Code; Lanjouw & al., 1952) and then Appendix II (Paris Code; Lanjouw & al., 1956).

The original organ-genus definition was flexible: organ-genera were to reflect the different parts of the plant being preserved and modes of preservation, but nothing was said about the level to which they could be classified. The concept of form-genus was created with the clear aim of stabilising the use of a limited set of taxa, especially those introduced by Brongniart (1822) that, although being widely recognised as artificial, had a long history of use. Form-genera were regarded as a small subset of organ-genera: they were “organ genera which have been proved to contain species that are not generically related in the ordinary taxonomic sense” (Jongmans & al., 1935: 4). So, for most purposes, plant fossils were to be assigned to organ-genera unless one of the Brongniart taxa was to be used.

CHANGES TO FORM- AND ORGAN-GENERA

The Montreal Code (Lanjouw & al., 1961) saw the removal of the Appendix for fossil plants and the incorporation of its regulations within the main body of the Code. More significantly, the definitions of the concepts of form- and organ-genera were substantially changed. Instead of having an essentially flexible concept of organ-genera to which all plant fossils could be assigned, but which included a relatively small subset of artificial form-genera for certain mainly foliage fossils, there were now two rigidly defined and mutually exclusive concepts: an organ-genus was for fossils that could be assigned
to a family, but fossils that could not be assigned to a family had to be placed in a form-genus.

The revised definition had the merit of clarity (Schopf, 1963) but its rigidity caused difficulties for many palaeobotanists (Faegri, 1963), especially as it resulted in nomenclatural procedure impinging unnecessarily on purely taxonomic matters. Faegri (1963) proposed to make these taxonomic categories once again more flexible but this was rejected (Mamay, 1964). Over the following years, various other proposals were made to try to improve the situation (Potonie, 1964; Krassilov, 1968; Jansonius, 1974; Meyen, 1975; see also the informal suggestions by Stafileu, 1967) but again none were accepted (Traverse, 1975). Eventually, a re-definition of form-genus was proposed by the Committee for Fossil Plants (as reported by Voss, 1976) that provided a flexible nomenclatural tool: a form-genus may or may not be assignable to a family, and so there was no need for organ-genera. Unfortunately, however, the Editorial Committee “improved” the wording that was eventually included in the Leningrad Code (Stafileu & al., 1978) so that now a form-genus could not be assigned to a family under any circumstance (see comments by Meyen & Traverse, 1979). The result was that palaeobotanists were left with a rigidly and narrowly defined form-genus concept for the less well-understood fossils, and nowhere to place the better-understood fossils – arguably the worst of both worlds.

Meyen & Traverse (1979: 597) attempted to resolve the problem by proposing that the whole concept of form- and organ-genera should be removed from the Code, and that the genera used for fossils should be treated nomenclaturally in the same way as genera of living plants, but an unattributed “official opinion” given to the Committee for Fossil Plants was that this approach was too simplistic and it was rejected (Traverse, 1981). Boulter (1979) argued in essence for a modified version of the proposal reported by Voss (1976) but with a clearer wording, and the suggestion that “form-genera” should be replaced by “fossil-genera”. Again, however, the proposal did not meet favour with the unnamed “official referee” and it was also rejected (Traverse, 1981). Thereafter, discussions on the issue ceased for a while; the impression is given that palaeobotanists found the problem to be intractable. Many palaeobotanists either simply ignored the Code, or pragmatically bent or even broke the regulations as necessity required: for example, Meyen (1982) described a new family of Palaeozoic seed-plants, the Rufioraceae, with a basionym of the foliar form-genus Ruforia Meyen; and Watson (1988) included the pollen form-genus Classopolis Pflug, and the foliar form-genus Geintzia Endlicher within the Mesozoic conifer family Chieirolepidaeae Hirmer & Hörhammer.

For a further discussion of the history of the taxonomic (rather than nomenclatural) concepts behind form- and organ-genera, see Bateman & Hilton (2009).

■ SATELLITE TAXA

When attempting to group both living and fossil lycopsids into families, Thomas & Brack-Hanes (1984) encountered the absurd but legislated problem that fossils as form-genera could not be assigned to a family. In order to circumvent the problem they followed Meyen (1978) in using the term “satellite taxa” for genera that could be conditionally included in suprageneric taxa for storage. They suggested that such an approach to family organisation could solve the problem of fitting isolated plant organs of uncertain affinities into a taxonomic scheme under nomenclatural legislation that no longer recognised organ-genera and had form-genera unassignable to families. Their suggestion was that satellite taxa might be interpreted as genera tentatively being considered for assignment to families, but awaiting conclusive data. They also suggested that satellite taxon status could also be used at order level to include all the plant parts that cannot, with some degree of confidence, be assigned to a family. To their approach to using satellite taxa in the lycophytes, they suggested that reproductive organs be used as the basis for defining families. Bateman & Hilton (2009) have broadly agreed with the potential value of the satellite taxa concept, although they have argued that a more flexible approach was needed to decide what plant organs should be used to determine whether a taxon belonged to a family or was a satellite of a higher-ranked taxon.

■ INTRODUCTION OF MORPHOTAXA

The situation resulting from the 1978 Leningrad Code remained virtually unaltered for nearly two decades and is usefully summarised by Chaloner (1999). The next significant development was through the proposals by Fensome & Skog (1997). Following Meyen & Traverse (1979) and Boulter (1979), they recognised the need for flexibility in the definition of the taxonomic concepts to be used for plant fossils, and proposed a revised definition for form-genera: “Because fossil specimens may represent dispersed parts of an organism or a single stage in a life cycle .... they can be assigned to form-genera. It may also be necessary to define form-genera on the basis of different preservational modes” (Fensome & Skog, 1997: 557). This has much in common with the spirit of the original proposals of Thomas (1935), Jongmans & al. (1935) and Boulter (1979), as well as those reported by Voss (1976), where no restrictions are placed on the level to which a form-genus could be classified or of the extent of its circumscription.

Chaloner & al. (1998) recognised the great merit of the Fensome & Skog proposals, but went further and argued that such “fossil taxa” should not be limited to the generic rank – that it should be possible to have “fossil taxa” at any rank, specifically mentioning species and families. They were unhappy with the term form-taxon, partly because form-genera had been used previously with such a wide range of meanings, and so proposed adopting a possible alternative, “paratax” (a term that had been first introduced by Hawksworth & al., 1994). The latter was also unacceptable to the Committee for Fossil Plants (Skog, 1999) and was ultimately replaced by “morphotaxa”. The origin of this term has not been recorded in the literature, but according to J. Skog (pers. comm., 2008) it was based on a suggestion by Knut Faegri.
Chaloner & al. (1998) emphasised that their proposals had the merit of flexibility, and allowed the practicing palaeobotanist to determine the limits of parataxa (later morphotaxa) on a case by case basis. However, they then proceeded to shackle that freedom by introducing a new limit to the definition of morphotaxa, whereby they can only be used for fossils that represent “those parts, life-history stages, or preservation states of organisms that are represented by the corresponding types” (Chaloner & al., 1998: 909). It was not stated in the proposal why this limitation was introduced, but it may have originated from views expressed earlier by two of the authors in their preamble to the Draft BioCode (Greuter & Nicolson, 1996: 348): “Palaeobotanists may find it desirable to prevent the use of names of organ taxa … for different fossil organs, once the link is established. We doubt that palaeobotanists would want to take up, say, a name typified by pollen organs for a fossil leaf or wood sample when both pertain to the same organism.” The authority on which this perceived opinion of palaeobotanists was based was not given. The quoted example is, of course, an extreme situation, and it is difficult to imagine any scenario where palaeobotanists would want to unite taxa of pollen and leaves in this way. However, if the wording of the example is changed slightly, the situation is less clear-cut: “We doubt that palaeobotanists would want to take up, say, a name typified by stems for a fossil leaf when both pertain to the same organism.” Surely, if the evidence pointed beyond reasonable doubt to all stems of a particular form having borne leaves of a particular form, and that those leaves were only found on that form of stem, what would be the point of having separate names?

Another difficulty is that Chaloner & al. (1998) did not specify what they meant by “plant parts”. For a Palaeozoic pteridosperm frond, for instance, is the “plant part” an individual pinnule, a pinna or the whole frond? All three have at different times been used as the basis for the generic classification of such foliage (Brongniart, 1822; Gothan, 1941; Cleal & al., 1990). Bateman & Hilton (2009) have argued that how the plant disarticulates should help determine what plant parts (in their terminology “organs”) should determine the circumscription of such taxa. This very practical approach certainly has merit but it still does not overcome all of the difficulties encountered by the palaeobotanist. In the Mississippian (early Carboniferous) pteridosperm ovulate structures, for instance, is the “plant part” the individual ovule, or the groups of ovules in their original cupulate structures? We know that both appear to have been abscised from the plant and are often found as fossils (e.g., Rothwell & Wight, 1989). Similar problems exist with the term “mode of preservation”. For instance fossils preserved as depressions give different levels of information to those preserved as impressions, and could arguably be classified in different ways. However, it is common for macrofloras and sometimes even individual fossils to show both types of preservation, hence the introduction of the term “adpression” by Shute & Cleal (1986). Where are the dividing lines between compressions, adpressions and impressions that we would need to know to interpret the circumscription of morphotaxa on such fossils? And what about specimens such as those described by Edwards & Kenrick (1986) as the Early Devonian zosterophyll *Tarella* that are preserved partly as depressions showing morphology and partly as pyrite petrifications showing internal anatomy? Plant fossils preserved as authigenic mineralisations in sideritic nodules can show features of morphology and are named as taxa typified by adpression fossils (e.g., Wittry, 2006) but also reveal evidence of anatomy and have been named as taxa with petrification types (e.g., Jennings & Millay, 1978). Which is correct? Or should there be a third set of morphotaxa just for use with authigenic mineralisations?

The Fensome & Skog (1997) and Chaloner & al. (1998) proposals were referred to the Committee for Fossil Plants (Greuter & Hawksworth, 1999) who accepted the former and rejected the latter (Skog, 1999). The subject was further discussed during the nomenclature sessions at the St Louis Congress, where the potential problem of priority of competing names for different plant parts was again raised (Greuter & al., 2000b: 45–51). During these sessions, there was an *ad hoc* meeting of the members of the Committee for Fossil Plants that were present, which resulted in a compromise that appeared to combine the Fensome & Skog (1997) and Chaloner & al. (1998) proposals. It was not a real compromise, however, as the resulting new Article 1.2 that appeared in the *St Louis Code* (Greuter & al., 2000a) was based almost exclusively on the Chaloner & al. (1998) proposals and the more flexible approach advocated by Fensome & Skog (1997) was largely abandoned.

### INTRODUCTION OF FOSSIL TAXA

In an attempt to clarify the conceptual confusion surrounding morphotaxa, Chaloner (2004) proposed that the *Code* should include two examples showing how such taxa should be used. This proposal generated “strong opposing opinions” among the Committee for Fossil Plants (Skog, 2005) and, after some discussion, the Committee formulated an alternative proposal: a Note should be added to Article 1.2: “Any fossil taxon that is described as including more than one part, life-history stage, or preservational state is not a morphotaxon” (McNeill & al., 2005). The Committee’s secretary (J.E. Skog) presented this proposal to the Nomenclatural Section during the 2005 Vienna International Botanical Congress and despite it having not been announced before the Congress (the proposal was only reported-on after the meeting – McNeill & al., 2005: 1063) it was incorporated into the *Vienna Code* (McNeill & al., 2006). This would seem to leave us in the position that a fossil taxon that is not a morphotaxon because it includes more than one part, life-history stage or preservational state, is still a fossil taxon.

But what is a fossil taxon? The expression was explicitly used for the first time in the *St Louis Code* (Greuter & al., 2000a) in Art. 1.2. However, it seems to have been used here as a simple adjective-noun couplet, analogous to “plant taxon”, rather than a defined taxonomic concept, analogous to form-genus in the earlier *Codes*. The nearest we can find to a definition in the *St Louis Code* is the footnote to Preamble point 7, which states that “the term ‘fossil’ is applied to a taxon when
its name is based on a fossil type” (this footnote in fact dates back to the Sydney Code [Voss & al., 1983] although the phrase “fossil taxon” itself is not explicitly used there).

In the context of the St Louis Code, the issue is somewhat academic as all fossil taxa were to be regarded as morphotaxa (McNeill & al., 2006: xi). However, the changes introduced in the Vienna Code effectively permitted the existence of a non-morphotaxon fossil taxon. The newly-introduced Glossary at the end of the Vienna Code defines fossil taxa by in effect reiterating the footnote in the Preamble (there had been an earlier Glossary, published separately from the Code, but this did not refer to the term “fossil taxa” – McVaugh & al., 1968).

So, we can only conclude that all taxa that are based on a fossil type are to be regarded as fossil taxa and their nomenclature presumably has to follow the same rules as for other plant taxa unless the Code states otherwise.

### SO DO WE NEED MORPHOTAXA?

It is quite clear from Art. 1.2 of the Vienna Code that morphotaxa are a subset of fossil taxa (“Fossil taxa … may be treated as morphotaxa” – emphasis by the present authors). It is also quite clearly stated in Art. 1.2 that a particular morphotaxon can only comprise “…the one part, life-history stage, or preservational state represented by the corresponding nomenclatural type.” However, although Art. 1.2 explains how you define a taxon such as Sphenopteris (Brongn.) Brongn., if it is to be accepted as a morphotaxon, nowhere does the Code explain what makes it a morphotaxon in the first place.

It has been suggested that if any fossil taxon is based on a type consisting of just one plant part in a particular phase of its life-history, and preserved in one mode, then it is by definition a morphotaxon. Chaloner (2004) for instance argued that the fossil genus Lyginopteris Potonié was a morphogenus simply because its type was an anatomically-preserved stem. However, this is not what Art. 1.2 or any other part of the Code says (the interpretation is, in technical logic, a fallacy of the undistributed middle – see Damer, 2006): nowhere does it stipulate that a taxon based on one plant part must be regarded as a morphotaxon, only that it may be. Perhaps, therefore, clarification would be achieved by emending Art. 1.2 to say “must” instead of “may”? However, such a change would not in fact achieve any useful result, unless we also introduce some restriction whereby the circumscription of a morphotaxon cannot subsequently be emended. A morphotaxon would have to be “fixed in stone” as a morphotaxon as soon as it was erected, or else a subsequent author could simply emend its diagnosis, changing its circumscription so that it could include more than one plant part, life-history stage or preservation state, and so was no longer a morphotaxon. If morphotaxa could be emended in this way, it would make meaningless the distinction between fossil taxa that were and were not morphotaxa. And what about the older nomenclatural names, such as those introduced by Brongniart (1822) and Sternberg (1820–1838) that are still widely used by palaeobotanists? Would there be a definitive list of fossil taxa that would have to remain morphotaxa in perpetuity, perhaps compiled by a committee of eminent palaeobotanists? This is surely where nomenclature is again imposing on purely taxonomic matters.

In the above example, for instance, if we accept Lyginopteris as a morphotaxon simply because its type is an anatomically preserved stem, then we need a separate generic name for the foliage (assuming we did not merely subsume it into the highly “artificial” and systematically meaningless Sphenopteris, as suggested by Chaloner, 2004). However, there is nothing in the Code that prevents us accepting the emendation of the diagnosis of Lyginopteris made by Gothan (1931) whereby he also incorporated the distinctive range of frond apressions believed to represent the foliage borne by the same plants as these stems, thereby transforming Lyginopteris into a non-morphogenus fossil genus. Another example is Sigillaria Brongn., which is quoted in Ex. 28 of the Code as an example of a morphogenus. Its type is an adpression of stem “bark” of a Carboniferous lycopsid, but many palaeobotanists use this generic name also for anatomically preserved fossils of the whole stem (e.g., Brongniart, 1839; Phillips & DiMichele, 1992). All of these stems produced similar “bark”, and this type of “bark” is only known to have been produced by stems with this type of anatomy. It makes little sense to maintain Sigillaria as a morphogenus in the latter’s current rigid definition, as it would merely require another generic name to be created for the stem petrifactions.

### THE USE OF FOSSIL TAXA

In our view, the best solution is the simplest and most flexible one. We should remove the concept of morphotaxa from the Code – all taxa that are based on a fossil type are just fossil taxa. As with all other taxa dealt with in the Code, how widely or narrowly a fossil taxon is circumscribed is set out in its diagnosis. A fossil taxon could be defined on very narrow morphological criteria, such as Sphenopteris, whose original diagnosis only mentioned details of pinnule shape and venation (Brongniart, 1822) and is widely accepted as a highly “artificial” but still useful taxon. Alternatively, a fossil taxon could be defined on wider criteria, such as Lyginopteris, which now includes stems and fronds that are preserved either as adpressions or petrifactions, and which belongs to a distinct family, the Lyginopteridaceae Potonié (Gothan, 1931). A fossil taxon could even represent the remains of an almost complete plant, albeit with some of its internal tissue structure lost through fossilisation, such as the zygopteridalean fern Nemejopteris Barthel (1968). The diagnosis and thus circumscription of a fossil taxon can of course be emended by subsequent authors. If there is a good taxonomic case for emending a taxon so that it can include additional plant parts or preservation states to those given in the original diagnosis, the Code does not and should not prevent this. As far as we can see, there is no useful role for the concept of morphotaxa as a formally demarcated subset of fossil taxa.

Fossil taxa are often diagnosed so that their mutual hierarchical relationships reflect the assumed biological relationships...
of the parent fossil plants (e.g., Cleal & Shute, 2003). Fossil taxa can also have a role, however, in naming fossils of uncertain systematic position. Such “artificial” fossil taxa should continue to be used if they provide a useful means of classifying certain fossils, such as Sphenopteris. They need not be assignable to the full hierarchy of higher ranked taxa as would a taxon of living plants, but can be regarded as satellite taxa. However, there need not be a sharp delineation between such “artificial” fossil taxa and fossil taxa that more closely reflect the taxonomy of the parent fossils; a fossil taxon might not be assignable to a family, but perhaps be regarded as a satellite taxon (sensu Meyen, 1978; Thomas & Brack-Hanes, 1984) of a class or even an order. Moreover, it should be possible for the diagnosis of a fossil taxon to be emended so that the level of its “artificiality” changes to reflect improved palaeobotanical knowledge or the practical needs of palaeobotanists; such an emendation would be a taxonomic matter and should not be constrained by the rules in the Code.

The nomenclatural rules for fossil taxa given in the current Code do not differ substantially from those for non-fossil taxa. Other than differences in the starting point for their nomenclature (Art. 13.1), the selection of types (Art. 9.13), the language that is allowed for diagnoses (Art. 36.3) and the role of illustrations in protologues (Art. 38), the only substantive difference from taxonomic nomenclature of extant plants is that names of fossil taxa are allowed to represent remains of isolated parts of plants in different stages of their life histories, and preserved in different ways. For instance, it is possible to have independent fossil taxa for leaves preserved as adpressions, stems preserved as casts, and anatomically-preserved reproductive organs that were all produced by the same taxon of parent plant. Moreover, a fossil taxon might represent just leaves, or perhaps leaves and stems connected together as leafy shoots. What plant parts, life-history stages and preservation states a fossil taxon represents is part of that taxon’s circumscription and is thus defined in its diagnosis. Since there is nothing in the Code to prevent subsequent emendation of this part of a fossil taxon’s diagnosis provided it does not cause the exclusion of the type (unless by formal conservation of the name with a different type) fossil taxa represent a flexible nomenclatural context within which palaeobotanists can name and classify their fossils according to purely taxonomic criteria.

### CONCLUSIONS

Most palaeobotanists have been aware of the weaknesses in the previous Codes in dealing with the naming of plant fossils, and have either ignored them altogether in their work, or bent the rules to suit their immediate purposes. Bateman & Hilton (2009) have recently suggested that these problems could be overcome by reverting to some of the traditional concepts of form- and organ-taxa, as well as introducing a concept of autapo-species for organ-species that have at least one unique character-state. In our view, however, this increase in the diversity of palaeobotanical taxonomic concepts should not result in an increase in the complexity of the nomenclatural provisions for naming them. Giving rigid nomenclatural definitions as to what are or are not form-, organ- or autapo-taxa merely introduces artificial barriers between taxa, which could hinder what should be purely taxonomic decisions. Surely it is better to continue with the current Vienna Code, which now allows any plant fossil to be named as a fossil taxon, whose circumscription in terms of plant parts, life history stages and preservation states that can be included is defined by its diagnosis. These can include fossil species, fossil genera, fossil families and even fossil orders (a fossil order of dinoflagellate cysts already exists; R. Fensome, pers. comm., 2009); these
are not to be confused with orders of whole fossil organisms, the basionym of whose names may be a fossil genus, such as the Archaeopteridales. Their circumscription can be changed as new information and ideas become available, and so fossil taxa provide the flexible nomenclatural tool for which palaeobotanists have been seeking for decades. Fossil taxa can be regarded as the successors of organ-genera in their original concept introduced by Thomas (1935) and Jongmans & al. (1935), and form-genera as in the proposals reported by Voss (1976) and made by Fensome & Skog (1997) (the latter renamed as morphotaxa), but not as those taxonomic concepts became reinterpreted within the various editions of the Code.

In our view the concept of morphotaxa for naming plant fossils is flawed logically and unnecessary in practice; it has tended to confuse palaeobotanists and to obscure the concept of fossil taxa that can be more meaningfully used to name plant fossils. Moreover, it runs counter to one of the main principles of botanical nomenclature, that it should not significantly influence taxonomic decisions (McNeill, 2000). We will, therefore, be making formal proposals to remove morphotaxa from the Code and to make the meaning of fossil taxa in that context clearer.

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LITERATURE CITED

Bottanical nomenclature and plant fossils


