

## Symposium proceedings

### Challenges in identification and naming: *Salicaceae sensu stricto*

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#### Abstract

Challenges in the identification and naming of two genera, *Populus* L. and *Salix* L. (*Salicaceae sensu stricto*) are discussed and some suggestions and conclusions made about how to deal with them.

**Keywords:** challenges, identification, naming, *Populus*, *Salix*, *Salicaceae*

#### Introduction

Botanists and other researchers who, directly or indirectly, are involved with plants in their work should answer three main questions:

- (1) Which taxon does a plant belong to?
- (2) What is the correct name of this taxon?
- (3) What relationship does this taxon have with other taxa?

To answer these questions, one should understand the principles and basics of (1) taxonomy, (2) nomenclature and (3) systematics or phylogenetics, none of which can exist separately from each other. For example, while working on the taxonomy of weeping willows (Belyaeva *et al.*, 2018), I wondered if the weeping willow in Monet's pictures, the weeping willows growing on the streets in Paris and the weeping willow cultivated at the Royal Botanic Gardens, Kew are the same taxon (Fig. 1) and if these willows have the same scientific name. What are the challenges to be met and what steps should a scientist, professional or amateur, take in identifying and naming taxa of *Populus* L. (35–40 species worldwide) and *Salix* L. (350–400 species worldwide), two genera that belong to *Salicaceae sensu stricto*?

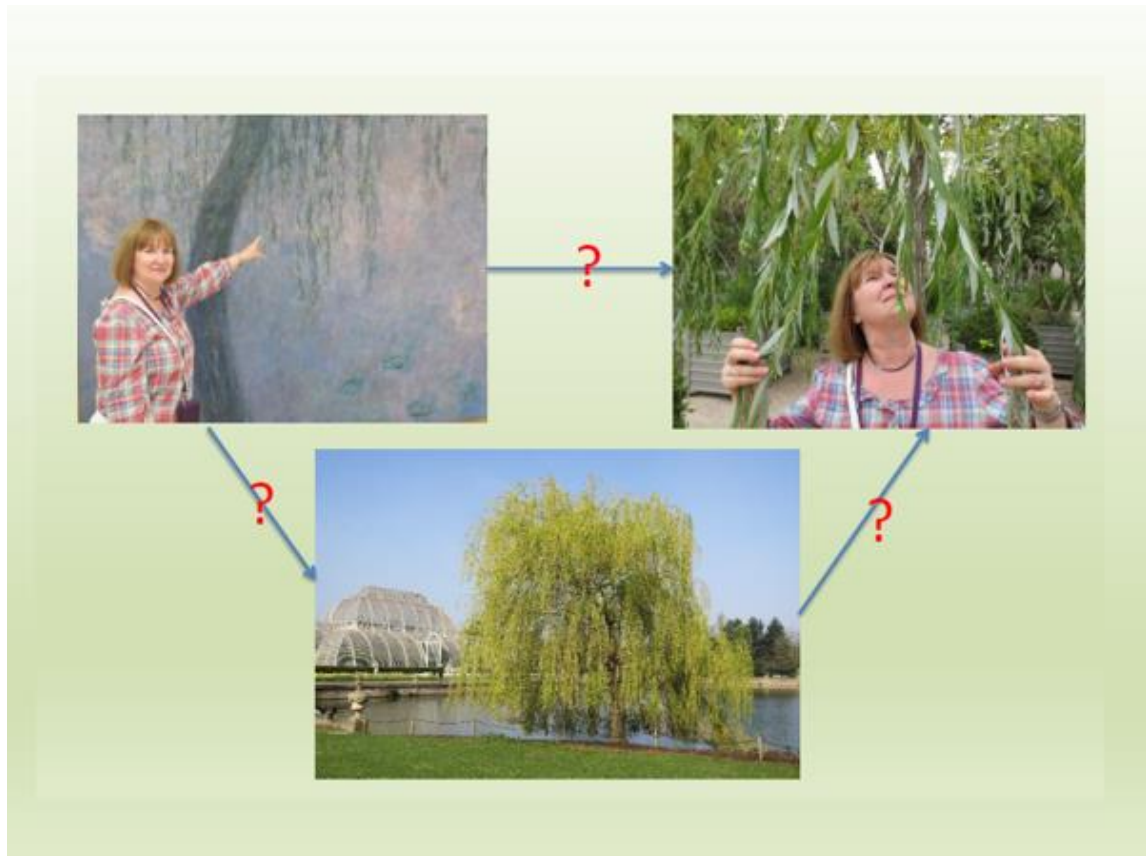


Figure 1. Are the weeping willows in Monet’s picture (top left), on a Parisian street (top right) and at the Royal Botanic Gardens, Kew (bottom) the same taxon? Pictures by Keith Chamberlain (top left and right) and Kevin McGinn (bottom), 2017.

## Challenges

The challenges can be related to **identification**, namely those that are determined by (a) the subject of the research and (b) current taxonomy, or to **naming** (c) those that are determined by the nomenclature. Challenges in (a) and (c) are objective as they cannot be influenced by the researcher and should be accepted as such. However, current taxonomy (b) is always the opinion of a taxonomist, and different taxonomists could have different opinions about the same plant; thus, taxonomy is subjective. For example, *Salix arbutifolia* Pall. (Pallas, 1788: 79) is accepted by some authors (Belyaeva and Sennikov, 2008; Argus *et al.*, 2010; Chang *et al.*, 2014; Belyaeva and Skvortsov, 2019 and Belyaeva and Govaerts, 2020) whose opinions are based not only on morphological and geographical data but also on recent molecular research using different molecular markers to find phylogenetic relationships between taxa (Leskinen and Rappoport, 1999; Azuma *et al.*, 2000; Trybush *et al.*, 2008; Chen *et al.*, 2010; Hardig *et al.*, 2010; Abdollahzadeh *et al.*, 2011, Barkalov and Kozyrenko, 2014; Lauron-Moreau *et al.*, 2015).

Despite these recent data, there are other taxonomic opinions that the plant in question belongs to the genus *Chosenia* Nakai (1920: 67) and its name is *Chosenia arbutifolia* (Pall.) A.K.Skvortsov (Skvortsov, 1955; Bolshakov, 1982; Nedoluzhko, 1995; Fang *et al.*, 1999; Ohashi, 2001).

#### Challenges that are determined by the subject of research

As was noted by Linnaeus (1753) *Populus* and *Salix* are extremely difficult to identify, and there are a few reasons for this.

Firstly, the flowers of poplars and willows are simple and minute with the calyx reduced to a disk in *Populus* or nectar glands in *Salix*, subtended by a bract. The carpels are 2–4 valved, with many parietal ovules per valve (Fischer, 1928a, b; Nakai, 1930; Nagaraj, 1952; Hörandl *et al.*, 2002; Heywood *et al.*, 2007; Argus *et al.*, 2010; Valyagina-Malyutina, 2018). The flower formulas are ♂  $\text{Ca}^{0-x}\text{Co}^0\text{A}^{2-\infty}\text{G}^0$  and ♀  $\text{Ca}^{0-x}\text{Co}^0\text{A}^0\text{G}^{2-4}$ . Thus, flowers and fruits do not provide many morphological characteristics for identification.



Figure 2. *Salix magnifica* Hems. (a) Male catkin at Willow Mount, UK, 11 April 2020. (b) Female catkins, St Albans, UK, 24 May 2010. Photos by Irina V. Belyaeva

Secondly, it is well known that poplars and willows are dioecious plants which develop male (staminate) and female (pistillate) flowers (Fig. 2) on separate individuals (Fischer, 1928a, b; Hörandl *et al.*, 2002; Skvortsov, 1968; 1999; Argus, 1997; Heywood *et al.*, 2007; Alford and Belyaeva, 2010; Argus *et al.*, 2010; Cronk *et al.*, 2015; Valyagina-Malutina, 2018; Belyaeva and Skvortsov, 2019). Here we follow the terminology discussed by Dyachenko (2017) and use the

terms ‘male’ and ‘female’ for flowers, catkins and plants hereafter. The herbarium specimen with only female or male catkins is not always enough for correct identification.

Thirdly, in the identification keys of major taxonomic treatments or floras of different regions of the world the whole set of morphological, ecological and geographical characteristics is usually used (Komarov, 1934; 1936; Sokolov *et al.*, 1951; Skvortsov, 1968; 1999; 2006; 2007; 2010; Bugała, 1976; Chmelař and Meusel, 1976; Dorn, 1976; 2010; Tsaryov, 1979; Bolshakov, 1992; Meikle, 1984; Lautenschlager-Fleury and Lautenschlager, 1994; Nedoluzhko, 1995; Fang *et al.*, 1999; Koltzenburg, 1999; Ohashi, 2001; Fischer *et al.*, 2005; Belyaeva *et al.*, 2006; Argus, 2009; Argus *et al.*, 2010; Kostina and Schanzer, 2014; Kostina and Nasimovich, 2014; Belyaeva and Skvortsov, 2019). However, the characteristics of flowers, leaves and buds that are needed for identification cannot be observed at the same time (Fig. 3), and the herbarium material should be collected from the same individual at different times of the year. In this connection some authors produce separate identification keys for poplars and willows collected with flowers in spring, leaves in summer or without flowers and leaves in winter (Skvortsov, 1955; Lautenschlager, 1989; Hörandl, 1992; 1996; Hörandl *et al.*, 2002, Viereck and Little, 2007; Valyagina-Malyutina, 2001; 2004; 2018).



Figure 3. Flowers (top left), buds (top right) and leaves (bottom) cannot be observed at the same time. Willows from National Willow Collection, cultivated at Rothamsted Research, Harpenden, UK, 2005. Photos by Irina V. Belyaeva.



Figure 4. Variability of one-year shoots on different individual of the same species, *Salix phlycifolia* L., cultivated at Rothamsted Research, Harpenden, UK, 2005. Photos by Irina V. Belyaeva.

The fourth reason for difficulties in the identification of taxa in Salicaceae *sensu stricto* is the high level of infraspecific variability of their characteristics illustrated in Figure 4 (Heribert-Nilsson, 1918; Critchfield, 1960; Skvortsov, 1968; 1999; Shaburov, 1970; Curtis and Lersten, 1974; Bugała, 1976; Belyaeva, 1988; Belyaeva, 2020). For this reason, none of the individual characteristics should be used for the identification separately from the others. However, there still could be found a unique combination of characters for the identification of taxa.

The fifth reason that could cause some difficulties with identification is that one plant can form different types of branchlets (Belyaeva, 1988) and it is important to collect all types of shoots from the crown (Fig. 5).



Figure 5. Different types of branchlets of *Salix purpurea* f. *gracilis* Wimm., Willow Mount, UK, 27 September 2020. Photo by Irina V. Belyaeva.

The sixth reason that makes plants of Salicaceae *sensu stricto* difficult to identify is the great morphological similarity of different taxa growing in well separated geographical regions. For example, within each of the following pairs the taxa are very similar morphologically and would be very difficult to identify without knowing their origin: *Salix viminalis* L., [E00096532!](#), Figure 6a (Europe, West Siberia) and *S. schwerinii* E.L.Wolf, VBG195828!, Figure 6b (East Siberia, Far East); *S. amplexicaulis* Bory & Chaub. [E00371227!](#) (Europe) and *S. integra* Thunb. [P04703570!](#) (Siberia, Far East, Japan); *S. xanthicola* K.I.Chr. [C10018522!](#) (Europe) and *S. gracilistyla* Miq. [L0103712!](#) (Far East, China). My colleague and friend, George W. Argus (pers. comm.), said that the origin is a highly important characteristic for identification and, because of this, compiling separate taxonomic keys for different geographic regions of the New World (Argus, 1957; 1967; 1973; 1986; 1991; 1992; 1993a, b; 1995; 2003; 2004; 2005; 2006a, b) was for him much easier than the compilation of a taxonomic key for Flora of North America (Argus *et al.*, 2010). Without knowing the origin, the chances of identification of a plant from Salicaceae *sensu stricto* are close to zero. It is important to remember this matter, especially when working with cultivated plants (Trybush *et al.*, 2008; Kuzovkina *et al.*, 2008; Kuzovkina and Vietto, 2014; Kuzovkina, 2015; Kuzovkina *et al.*, 2016a, b; Belyaeva *et al.*, 2018).

The seventh reason why taxonomists have a real struggle with the identification of representatives from Salicaceae *sensu stricto* is their frequent natural interspecific hybridisation which can be a natural background of reticulate evolution and a cause of complex phylogenetic relationships in this family (Wu *et al.*, 2015; Gramlich and Hörandl, 2016; Gramlich *et al.*, 2016; 2018; Wagner *et al.*, 2018; Wagner *et al.*, 2020; He *et al.*, 2020). The combination of characteristics of two or more parents and the appearance of some new characteristics in hybrids makes their correct identification nearly impossible. My teacher and dear friend, Alexey K. Skvortsov, once mentioned (pers. comm.) that the identification label for a hybrid should always have been annotated with a question mark and I cannot agree more. Often hybrids are not fertile and have monstrous flowers and catkins (Belyaeva *et al.*, 1995; Belyaeva, 1998; Belyaeva *et al.*, 2018: 47, fig. 4). However, some produce viable seeds (Fig. 7) and thus a number of variable plants (Chmelař, 1961; Eckenwalder, 1984a, b; Belyaeva, 2009; Efimova *et al.*, 2009; 2019; Van Puyvelde, 2013; Stace *et al.*, 2015; Zhang *et al.*, 2018).

#### Challenges determined by current taxonomy or which taxonomic opinion to follow?

As already mentioned above, taxonomic opinion is subjective as there could be as many different taxonomic opinions as there are taxonomists. The important thing is to choose an opinion which, one believes, is supported by most of the data from different fields of biological



Figure 6a. Herbarium specimen E00096532 of *Salix viminalis* L., downloaded from <https://data.rbge.org.uk/search/herbarium/>



Figure 6b. Herbarium specimen VBG195828 of *Salix schwerinii* E.L.Wolf., downloaded from <http://botsad.ru/herbarium/>



research such as morphology, anatomy, cytology, physiology, biochemistry, molecular genetics, ecology, biogeography etc. and which is accepted in most major taxonomic treatments. It is important to make a clear and correct reference to whichever taxonomic opinion one follows. For example, there are two different taxonomic opinions on which rank to treat the same plant – as a species, *Salix atrocinerea* Brot., as it was described (Brotero, [1804: 31](#)) and accepted in the majority of taxonomic research (Rechinger, 1964; 1981; Rechinger and Akeroyd, 1993; Skvortsov, 1968; 1999; Jalas and Suominen, 1976; Neumann, 1981; Lautenschlager-Fleury and Lautenschlager, 1994; Newsholm, 1992; Blanco, 1993; Hörandl *et al.*, 2002; Fischer *et al.*, 2005, Zinovjev and Kadis, 2009; Argus *et al.*, 2010; Uotila, 2011; Dickman and Kuzovkina, 2014 ; Belyaeva and Govaerts, 2020) or as a taxon that is conspecific to another closely related species, *S. cinerea* L., at the rank of subspecies, *S. cinerea* L. subsp. *oleifolia* Macreight (Meikle, 1984; Zwanaepoel, 2006; 2020). As shown, both opinions could co-exist even in the same volume of a journal (Ronse *et al.*, 2020; Zwaenepoel, 2020).

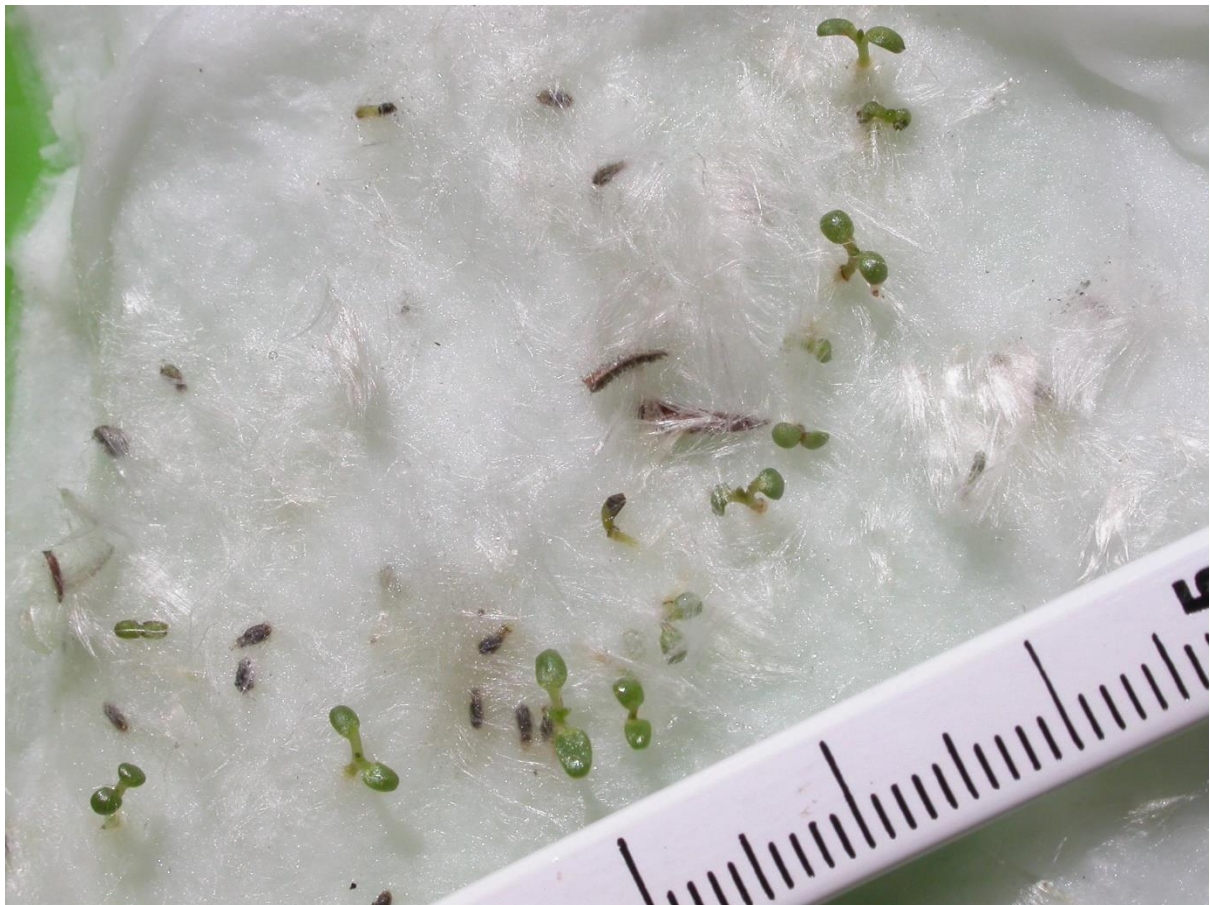


Figure 7. Seedlings of *Salix x fragilis* L. (*S. alba* L.  $\times$  *S. euxina* I.V.Belyaeva), St Albans, UK, May 2010. Photo by Irina V. Belyaeva

There are different online taxonomic databases that can help to decide which opinion to follow, i.e. *Catalogue of Life* (CoL, 2020), *World Checklist of Vascular Plants* (WCVP, Govaerts, 2020), *Plants of the World Online* (POWO, 2020) and *Tropicos* (2020) where taxonomic opinions on accepted names and synonyms are given. These taxonomic resources are based on the names from the nomenclatural database, *International Plant Names Index* (IPNI, 2020) where all nomenclatural data on the recorded names are provided. WCVP and POWO have hyperlinks to IPNI-identifiers. Using IPNI IDs one can easily find further useful information, such as available protologues from *Biodiversity Heritage Library* (BHL, 2020), linked digitized specimens from the virtual Kew Herbarium (K) and geographical distribution (POWO, 2020).

The biggest problem for users who are not professional taxonomists is to understand the difference between the nomenclatural and taxonomic aspects of each taxon and their relationship as taxonomic opinion changes with time. The nomenclatural component of these relationships follows the rules written in the latest *International Code of Nomenclature for Algae, Fungi, and Plants* (ICN, Turland *et al.*, 2018) and is based on the type concept. If the name is published according to the rules, the nomenclatural status of this name cannot be changed from ‘validly published’ to ‘invalidly published’ just because someone does not accept this name. However, the taxonomic component or taxonomic opinion could change over time as it is based on the species concept and relates to new scientific findings and evidence from different scientific fields, and it is not always clear where to draw the boundaries between certain taxa. New methods of research mean that this concept is changing very rapidly and sometimes is difficult to keep up. This process of concept change is very well illustrated by Humphreys and Linder (2009: 1055). Additional challenges: cultivated plants.

Transferring plants from one region to another during their cultivation have not only positive effects on mankind but also some negative consequences. The cultivation of willows and poplars and their identification are not exceptions. Seeds or particles of cultivated plants can escape from gardens and can also hybridise with native species and make unexpected hybrid combination that one could not even dream of. Knowing the local flora can help only partly because the process of pollination is not predictable, and one native female individual could be pollinated by several male cultivated plants and vice versa. As a result, we get new hybrid plants that are difficult to identify unless their parents have very distinctive characteristics. It is shown in multiple research, that willows and poplars can produce double, triple and quadruple artificial hybrids not only between native species but also between native and cultivated species (Henry,

1914; 1830; Wichura, 1854; 1865; Heribert-Nilsson, 1930; 1937; 1954; Ikeno, 1918; 1922; Sukachev, 1934; 1939; Van Broekhuizen, 1964; 1972; Starova, 1980; Tsaryov, 1985; Belyaeva *et al.*, 1998; 1999; 2000; Lageström and Uronen, 2005) and there are reports of such hybrids that have spontaneously occurred between native and cultivated species of *Populus* and *Salix* in the USA, Russia and Belgium (Eckenwalder, 1984a, b; Kostina *et al.*, 2017; Meert, 2020). The era of new hybrid willows has already begun in highly populated regions of our planet, and the worst-case scenario is that in the future native species of Salicaceae will only be identified via fingerprinted collections of clones of the native plants growing as artificial populations in cultivation (Belyaeva *et al.*, 2020, in preparation).

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