Taxonomic Concept Alignment in TaxonWorks

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Names vs. Taxonomic concepts

• Perennial issue in biology

• A name is a point in variation space, tied to a single type specimen

• The taxonomic concept in the mind of a human is a region in variation space, circumscribed by descriptions or specimen lists

• Problem: over time a name may remain the same, but the concepts that use it may vary greatly

• To refer to a specific concept we must specify a usage: \{Name ‘sec.’ (or ‘sensu’) Publication\}
  
  E.g., Ephedra torreyana Watson sec. Wendt 1993
Taxonomic concept alignment

• Because they are regions/clouds/sets, taxonomic concepts can be aligned, or ‘mapped’ using five simple set relationships: **congruent with, includes, is included in, partially overlaps, disjunct with** (RCC-5)

(from Franz et al., 2008)
Example: Alan Weakley’s Flora of the Southeast

Andropogon virginicus Linnaeus var. virginicus; Old-field Broomstraw, Broomsedge, "Sedge Grass", "Sage Grass". Old fields, roadbanks, disturbed sites. Sep-Oct. MA west to MI and e. KA, south to FL and e. TX, and in the Caribbean and Central America. Campbell (1983) recognized 3 "variants" within A. virginicus var. virginicus; the "deceptive variant" he later (1986) described formally as var. decipiens (see above). The "old-field variant" is the common "variant" in our area, occurring abundantly throughout the state. It has green stem internodes and the leaves usually pubescent, at least on the margins near the collar. The "smooth variant" is known only from the Coastal Plain and is apparently rare in our area. [< A. virginicus var. virginicus – FNA, K, WH3, Va, Z; < A. virginicus – Pa, RAB, S, W; < A. virginicus var. virginicus – C, WV; < A. virginicus var. virginicus – G, HC; >> A. virginicus var. virginicus – F; >> A. virginicus var. tetrastachyus (Elliott) Hackel – F]

https://fsus.ncbg.unc.edu/; see this taxon
Synonymy and T.C. alignments

• The relationship between concepts is often implicitly inferred from traditional, nomenclatural synonymy:
  – “A is a (homotypic/heterotypic) synonym of B” suggests either $A == B$ or $A < B$ (where $A$ means the taxonomic concept of name $A$ by author of $A$)
  – “A is a pro parte synonym of B” suggests $A > B$ (see Turland et al., 2018, 52.2.Ex.5)

• But such inferences may be incorrect. Making explicit set statements about taxonomic concepts is far more informative.
T.C. alignment for the Alaska flora

- Example: the *Papaver* (poppy) graph among related uses of each name in 5 publications (thanks to Kimberly Cook)
Managing T.C. alignment data

- **TaxLink** ([Gradstein et al., 2001](#)) (MS windows) based on the Berlin Model ([Berendsohn and al., 2003](#))
- **ConceptMapper** ([Liu et al., 2007](#)) (Java) from NCEAS
- Since 2020, **Arctos** (Thanks Dusty!)
- **TCM**: web app for publications, names, concepts, and relationships ([Webb et al., 2021](#))
- **TaxonWorks**: only system with comprehensive taxonomy model
Steffi’s work on Ephedra

Gymnosperm shrubs, c. 60 species, worldwide, desert regions.
Testing TaxonWorks as platform for a monograph
An Ephedra T.C. example

Ephedra americana sec. Hunziker 1949

Ephedra breana sec. Hunziker 1949

Ephedra americana var. humboldtii sec. Stapf 1889

Two cases of a partially overlapping relationship
TCM app: names and concepts

Name

<table>
<thead>
<tr>
<th>Code</th>
<th>Genus</th>
<th>Species</th>
<th>Rank</th>
<th>Infrasp</th>
<th>Author</th>
<th>Orig. Publ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephedra americana Humb. &amp; Bonpl. ex Willdenow</td>
<td>Ephedra americana</td>
<td></td>
<td></td>
<td>Humb. &amp; Bonpl. ex Wil...</td>
<td>Willdenow 1805</td>
<td>V E D [tc]</td>
</tr>
<tr>
<td>Ephedra americana var. humboldtii Stapf</td>
<td>Ephedra americana var. humboldtii</td>
<td></td>
<td></td>
<td>Stapf</td>
<td>Stapf 1889</td>
<td>V E D [tc]</td>
</tr>
<tr>
<td>Ephedra breana Philippi</td>
<td>Ephedra breana</td>
<td></td>
<td></td>
<td>Philippi</td>
<td>Philippi 1895b</td>
<td>V E D [tc]</td>
</tr>
</tbody>
</table>

Add | Search (Searches on primary sort field; use '%' as wildcard)

Taxon Concept

<table>
<thead>
<tr>
<th>Code</th>
<th>Name</th>
<th>Publication</th>
<th>BHL pg1 ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephedra americana Humb. &amp; Bonpl. ex Willdenow</td>
<td>Ephedra americana Humb. &amp; Bonpl. ex Willdenow</td>
<td>Hunziker 1949</td>
<td>V E D [tc] [tc]</td>
</tr>
<tr>
<td>Ephedra americana var. humboldtii Stapf</td>
<td>Ephedra americana var. humboldtii Stapf</td>
<td>Stapf 1889</td>
<td>V E D [tc] [tc]</td>
</tr>
<tr>
<td>Ephedra breana Philippi</td>
<td>Ephedra breana Philippi</td>
<td>Hunziker 1949</td>
<td>V E D [tc] [tc]</td>
</tr>
</tbody>
</table>

Make congruent TCMs for checked TCs

Add | Search (Searches on primary sort field; use '%' as wildcard)
TCM app: TC relationships

TC Relationships

<table>
<thead>
<tr>
<th>TC1 newer</th>
<th>Relation</th>
<th>Synonymy</th>
<th>TC2 older</th>
<th>Publication</th>
<th>Graph</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephedra americana sec. Hunziker 1949</td>
<td>overlaps</td>
<td>Ephedra americana var. humboldtii sec. Stapf 1889</td>
<td>inferred by Ickert-Bond 2023</td>
<td>1</td>
<td>V E D</td>
</tr>
<tr>
<td>Ephedra breana sec. Hunziker 1949</td>
<td>overlaps</td>
<td>Ephedra americana var. humboldtii sec. Stapf 1889</td>
<td>inferred by Ickert-Bond 2023</td>
<td>1</td>
<td>V E D</td>
</tr>
</tbody>
</table>

Add | Search (Searches on primary sort field; use "%" as wildcard)

TCM graph

- **Ephedra americana sec. Hunziker 1949**
- **Ephedra breana sec. Hunziker 1949**
- **Ephedra americana var. humboldtii sec. Stapf 1889**

Nodes and edges are clickable. Hover over edges that are marked with * to see notes.

Edge style key:
- Solid black: congruent with (−)
- Dashed black: overlaps (>−)
- Dotted black: intersects (।)
- Dashed black with arrow: <arrow from> is included in <arrow to> (>−)
- Solid red: is disjunct from ([])

Home | Publication (+) | Name (+) | Taxon Concept (+) | TC Relationships (+) | Graph
TaxonWorks OTUs

• TaxonWorks is *preadapted* for handling taxonomic concepts and taxonomic concept relationships because of the foundational use of Operational Taxonomic Units (OTUs): “regions, not points”

• What we mean by an OTU is almost exactly the same as what we mean by a Taxonomic Concept

• In TaxonWorks, one name may have many OTUs
Sources → Names → OTUs

We name the OTUs: **Name sec. Publication**

<table>
<thead>
<tr>
<th>Name</th>
<th>Taxon name</th>
<th>Updated by</th>
<th>Last updated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ephedra americana sec. Hunziker 1949</td>
<td><em>Ephedra americana</em></td>
<td>Stefanie Ickert-Bond</td>
<td>6 days</td>
</tr>
<tr>
<td>Ephedra americana var. humboldtii sec. Stapf 1889</td>
<td><em>Ephedra americana var. humboldtii</em></td>
<td>Stefanie Ickert-Bond</td>
<td>6 days</td>
</tr>
<tr>
<td>Ephedra antisypilitica sec. Meyer 1849</td>
<td><em>Ephedra antisypilitica</em></td>
<td>Campbell Webb</td>
<td>8 months</td>
</tr>
<tr>
<td>Ephedra antisypilitica sec. Cutler 1939</td>
<td><em>Ephedra antisypilitica</em></td>
<td>Campbell Webb</td>
<td>8 months</td>
</tr>
<tr>
<td>Ephedra aspera sec. Cutler 1939</td>
<td><em>Ephedra aspera</em></td>
<td>Stefanie Ickert-Bond</td>
<td>6 months</td>
</tr>
<tr>
<td>Ephedra aspera sec. Watson 1889</td>
<td><em>Ephedra aspera</em></td>
<td>Stefanie Ickert-Bond</td>
<td>about 1 month</td>
</tr>
</tbody>
</table>
An annotations can be added to the OTU relationships for the “according to”
TW: taxon concept alignments

• Possible relationships (RCC5) in TaxonWorks:

  A is disjoint with B (\(|\)\)
  OtuRelationship::Disjoint

  A congruent with B (\(==\))
  OtuRelationship::Equal

  A includes B (\(\rangle\))
  OtuRelationship::ProperPartInverse

  A is included in B (\(\langle\))
  OtuRelationship::ProperPart

  A overlaps with B (\(\rangle\langle\))
  OtuRelationship::PartiallyOverlapping

  (A intersects with B
  OtuRelationship::Intersecting)
Taxonomic concept alignment is easy to implement in TaxonWorks. Yay! Thanks

Wishlist:

- Taxonomic concept alignment visualization within TaxonWorks *(hinted at by Matt on Tuesday!)*
- Taxonomic concept panels, with alignment visualization, in TaxonPages
- Export concepts and alignments using TCS2 (an emerging TDWG standard)
Thanks to...

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• **FOSS**: Linux, Apache, MySQL/MariaDB, Gawk, Graphviz, \LaTeX, Arctos, TaxonWorks...
References


