The man and the reeds: a taxonomic tale on the genus *Arundo* L. (Poaceae)

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**Arundo** L. (Poaceae)

Historically, the genus of reeds (c. 200 taxa and synonyms)

- *A. donax* L., subtropical Eurasian, useful but invasive
- *A. formosana* Hack., Taiwanese endemic
- *A. plinii* Turra, Mediterranean, protected in SE France
Taxonomy of *A. plinii* before the 21st Century

*Arundo plinii* Turra, Farsetia, 1765

*Locus classicus*: Reno river, Bologna (N Italy)

…and several taxa put in synonymy for decades

= *Arundo collina* Ten., Flora Napolitana, 1811. *Locus classicus*: Napoli

= *Arundo mauritanica* Desf., Flora Atlantica, 1798. *Locus classicus*: Algeria

NOMEN ILLEGITIMUM ≠ *A. mauritanica* Poir. ≔ *Ampelodesmos mauritanicus* (Poir.) T. Durand & Schinz

Preliminary revision of *Arundo plinii* by Pr. A. Danin

2002, trip in Greece: description of a small *Arundo*

- *Arundo hellenica* Danin *et al.*, Willdenowia, 2002

- *Arundo plinii* s.str.

2004, trip in Italy: same small *Arundo* in Italy

- *A. collina* Ten. = *A. hellenica* Danin *et al.*

- *A. mediterranea* Danin, Willdenowia, 2004

= *A. micrantha* Lam. (Hardion *et al.* 2012. *Candollea*)

a taller and branched *Arundo*

- *Arundo plinii* s.str.
Original context: conservation of *A. plinii* in Fréjus

- Population genetics (AFLPs): only one clone
- Cytogenetic analysis: $2n = 108$ vs. $2n = 72$ for other localities
- Morphometric difference with the *locus classicus*
  contrasting with observations of A. Danin

Need for deeper investigations based on:
- a Mediterranean-wide sampling and *in situ* measurements
- Standard morphometric, phylogenetic en cytogenetic approaches
Taxonomic revision of *A. plinii*

A Mediterranean-wide sampling

13 trips, 80 sampled localities

\( \approx 11,000 \text{ km} \)

Rhizomes & herbarium specimens

**Phylogenetics**

Amplified Fragment Length Polymorphism:

multilocus genotype markers, fine resolution

**Morphometry**

14 quantitative variables

c. 1000 samples

Including the help of many Mediterranean botanists. Thanks!
Taxonomic revision of *A. plinii*

**Phylogenetics** (AFLPs)

*A. plinii* = three clusters

Fréjus = one cluster, close to the Italo-Balkan cluster

**Morphometry** (14 quantitative traits)

*A. plinii* = three clusters

1st plan of a discriminant analysis on locality means

1st plan of a DAPC, 95 samples, 1046 markers
Taxonomic revision of *A. plinii*

Rehabilitation of two species placed under synonymy of *A. plinii sensu lato*

!!! Not any genetic variation for *A. donaciformis*, *A. micrantha*, *A. donax* in the Mediterranean

Hardion *et al.* 2012. *TAXON* 61, 1217-1226
Origin of *A. donaciformis* and phylogeography of *A. plinii*

*A. donaciformis* = one clone relative to *A. plinii*

Geographical and polyploid distinction

Hypothesis: speciation by marginal polyploidisation
→ sexual and geographical isolation

**Methods**

- Five non-coding cpDNA regions (c. 5 kb) including hypervariable sites (mini- & microsatellites)
- Amplified Fragments Length Polymorphism
- Chromosome counts
Origin of *A. donaciformis* and phylogeography of *A. plinii*

**Cytogenetics**

- Several high polyploids (2n ~ 108) in *A. plinii s.str.*

- Mainly located on margins of the distribution of *A. plinii*

- Polyploidy *per se ≠ speciation*
Origin of *A. donaciformis* and phylogeography of *A. plinii*

- *A. donaciformis* including in the evolutionary history of *A. plinii*, but related to Ostia locality (Centre Italy)

![cpDNA haplotype network (TCS)](image)

![AFLPs NeighborNet diagram (SplitsTree)](image)
Origin of *A. donaciformis* and phylogeography of *A. plinii*

**Conclusion: Two competitive hypotheses**

- **H0**: post-glacial recolonization northward, and speciation by marginal polyploidisation and glacial isolation in Liguria

- **H1**: Human selection and dispersal between roman ports of a robust polyploid clone for weapons (arrows), farming, building...

→ **Need for palaeo- or archaeological supports**

Preliminary results (Verlaque): Identification of *Arundo* attesting to the use of ≠ reeds by Romans

What about the other clone species?

*A. donax* and *A. micrantha* exhibit only one sterile genotype all around the Mediterranean

A unique case for a widespread native species... but similar cases for invasive taxa...

*A. donax* is invasive in Americas, Australia... but known for ages in the Mediterranean...

→ The archaeophyte hypothesis (Pysek et al. 2005)

✔ larger distribution than neophyte  ✔ anthropogenic distribution  ? lower genetic diversity than in native area

Plant sampling from Herbaria (B, BM, E, G, K, MARS, P, W)

**Study aims:**  - to localize the invasive clone in Asia  - to find genetic diversity for *A. donax* in Asia

**Three methods:**  - Phylogeography (cpDNA)  - Morphometry  - Ecological (bioclimatic niche modelling)
Origin of *A. donax*

**Morphometry and fertility**

126 herbarium samples, 15 variables on flowers and epidermis

Two morphotypes in *A. donax*:
- ○ a sterile, robust, invasive morphotype: Mediterranean, Iran, Indus Valley
- ○ a smaller Asian morphotype, fertile in S. Iran, Indus Valley, S. Hymalaya
Origin of *A. donax*

Phylogeography

- Five non-coding cpDNA regions (c. 5 kb) with hypervariable sites, only 57 specimens
- **Genetic diversity in Asia!** - The Mediterranean clone closely related to Indus populations

Without mini-microsatellites
Origin of \textit{A. donax}

Ecological niche modelling (SDMs)

Using Mediterranean distribution of \textit{A. donax} and bioclimatic data (www.worldclim.org):

- to calibrate a model on its ecological niche
- to find suitable bioclimatic conditions in Asia

\textbf{\textit{A. donax} distribution} : 3429 occurrences from Mediterranean databases (France, Spain, Croatia, Greece, Israel)

Most suitable Asian regions for the invasive clone:

- North and South Iran
- Indus Valley
Origin of *A. donax*


**Morphometry**

- *A. donax* T2
- *A. formosana*
- *A. donax* T1

**Phylogenetics**

**Ecological modelling**

* : seed occurrence
**Origin of A. *donax***

**Conclusion: A. *donax*, an invasive archaeophyte in the Mediterranean**

One robust and sterile clone originated from the Middle East (Indus Valley)

Human dispersal from the Middle to the Near East, then to the Mediterranean

Numerous uses of reeds by Mesopotamian civilisations

Perspectives: find archaeological support for the use of reeds by humans
The systematics of Taiwanese *Arundo*

Taiwan = hotspot of taxonomic description for *Arundo*, including the endemic *A. formosana* Hack.: 

1. var. *formosana*  
2. var. *gracilis* Hack.  
3. var. *robusta* Conert

→ largely neglected by recent floras

→ Two phylogenetic lineages supported by morphology, and one subunit with genetic and morphological support
Taiwan = hotspot of taxonomic description for *Arundo*, including the endemic *A. formosana* Hack.:

- **A. formosana**
  - subsp. *formosana*
    - var. *robusta*
  - subsp. *gracilis*
  - var. *formosana*

*A. formosana subsp. gracilis*  
*A. formosana var. robusta*
The systematics of Taiwanese *Arundo*

Taiwan = hotspot of taxonomic description for *Arundo*, including the endemic *A. formosana* Hack.:
The systematics of *Arundo*

**Conclusion & perspectives**

- Origin of *A. micrantha*?
- *A. donax* = a paraphyletic species?
- Two species or subspecies in Asia? *A. donax* & *A. bifaria*
- Standardisation of taxonomic ranks according to level of genetic-morphological differentiation

Phylogeny of the genus *Arundo* based on cpDNA sequences (c. 5kb)
Thank you for your attention