GETTING TO KNOW YOUR ENEMY – how a scientific approach can assist the fight against Japanese Knotweed

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Scientific progress so far…

• Controlled herbicide trials
• Implementation of a Bio-control programme
• Correct identification of taxa
• Genetic diversity of UK population
• Origin of the UK population
• What is the spectrum of variation in native area
• How is Japanese Knotweed spread
• Extent and implications of hybridisation
Japanese Knotweed (*Fallopia japonica*) at home in Wales
F. japonica var. compacta

Whilst this plant is seldom found naturalised, it has played an important role in F. x bohemica in the UK at least.
Arrived some twenty years later than *F. japonica* and quickly hybridised with it. The plant can be more than 4 metres tall in suitable conditions.
Correct identification of taxa

In the early 1980s when I began my research - received wisdom stated there were three different dioecious Knotweed taxa in the UK.

**Japanese Knotweed** (*Fallopia japonica* var. *japonica*) - mostly female with rare males.

**Fallopia japonica** var. **compacta** - dwarf garden form rarely naturalised - both sexes.

**Giant Knotweed** (*Fallopia sachalinensis*) - much less common than Japanese Knotweed, both sexes more females.
The application of chromosome data caused us to revise our identifications

*F. sachalinensis* - all plants had 44 chromosomes

*F. japonica* var. compacta - 44 chromosomes

*F. japonica* var. *japonica* female - 88 chromosomes

*F. japonica* var. *japonica* male - 44 or 66 chromosomes

This was the first evidence of hybridisation
Cytological background of *F. x bohemica*

These were all confirmed by artificial hybridisations at Leicester in the 1980s.
Morphology & Anatomy
All the true Japanese Knotweed in the UK was female and two different hybrids of *F. x bohemica* also existed - this had important implications

- Japanese Knotweed could not reproduce itself by seed in the UK
- Could all our Japanese Knotweed be a single clone?
- Would *F. x bohemica* be easier or more difficult to eradicate?
- What was the extent of hybridisation?
Where does it come from?

The plant was on sale at Von Siebold’s nursery in Leiden in the late 1840’s. In 1848 500 francs would buy 1 mother plant and 25 strong plants.

2) Cette Renouée est une de nos introductions les plus importantes du Japon, une plante d’ornement vivace, inextirpable, d’un feuillage luisant et des fleurs en grappe très gracieuses, par laquelle on peut improviser des bosquets, abriter les jeunes plantations et fortifier les collines sablonueuses et les dunes. L’herbe qu’on peut faucher en printemps à plusieurs reprises fournit un fourrage excellant pour l’engraissement des bestiaux qui la mangent de préférence; les fleurs, qui paraissent en automne, sont très milleuses et donnent aux abeilles leur provision d’hiver; la racine amère et tonique est un médicament réputé chez les Chinois et les Japonais; enfin les tiges même qui meurent en hiver sont bonnes à bruler et pour en faire des allumettes.
Contemporary engraving by De Vriese of Von Siebold’s plant – showing all the features of the British Japanese Knotweed

This was the starting point for the research at Leicester which showed that we were dealing with a single female clone.
Entry from the 1848-1858 Kew Inwards book for August 9th 1850

31. Spiraea thunbergii, Hassk.
32. Stephanocyparis japonica (Cleypus japonica)
33. Saonia montana, K. Junaria 8.
34. Polygonum tobolesi, Rhein.
35. Raphis aspera, L. sub. (Lith. Sieboldi)
Genetic fingerprinting using RAPDs showed that all UK plants of *F. japonica* belonged to a single female clone imported from Holland in the 1850s – the impressive spread was all clonal.
The fact that all UK Japanese Knotweed is a single clone means that it would have no resistance to a suitable bacterial or fungal disease.

One of the principal tenets of Biological Control is to seek potential bio-control agents in the area where the invasive alien evolved.

Historical evidence pointed to a Japanese origin - but JK is also widespread in China. Further, Japan is split into a number of islands with very different habitats spread over a wide degree of longitude.
Live rhizomes, DNA samples and herbarium specimens were collected from a wide area of Japan and posted home under quarantine regulations.

Results

There was a broader spectrum of variation than in the UK.

Dwarf montane variety - mountains & volcanoes
2n=44 - which we call var. compacta in Europe

Giant lowland variety - 2n=44 - not found in Europe

Giant lowland variety - 2n=88 less common than the 44 variety
Dwarf Japanese Knotweed on volcanic ash Mt Aso
Japanese Knotweed – but not as we know it!
Mutations in certain non-coding parts of the chloroplast genome were discovered that were capable of distinguishing the 4 different types of Knotweed in Britain. This enabled us to produce a chloroplast haplotype which we could use to match the haplotype of the UK plant with the Japanese samples.
Hinf I RFLP fingerprint of chloroplast trnC-D region

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KEY:
A: British F. japonica var. compacta
B: British F. sachalinensis
C: Chinese F. japonica var. japonica
D: British F. japonica var. japonica
How is Knotweed spread

Rhizome?  
Stem?  
Seed?
Japanese Knotweed seed set

Although JK cannot reproduce itself by seed it can be pollinated by related taxa such as $F. \times bohemica$ to produce viable backcrosses

Such back-crosses could if they became established, increase the genetic diversity of Japanese Knotweed and conceivably lead to the production of even more problematic taxa
Seedlings are inconspicuous and rarely found
Japanese Knotweed does not just hybridize with closely related taxa

Most seed on JK in the UK has been pollinated by the common garden plant Russian vine (*F. baldschuanica*) - now named as *Fallopia x conollyana*

Fortunately it does not combine the vigour of both its parents!
An unlikely marriage!

Fallopia japonica
Octoploid
Base number 11
Herbaceous
Reserves in rhizome
Japan and China

F. baldschuanica
Diploid
Base number 10
Woody, deciduous
Reserves in woody stem
Baldschuan & N. China
HUGE UNINTENDED BREEDING EXPERIMENT

With hundreds of hectares of female *F. japonica* in Europe - anything that could pollinate it did;

- Hybridisation with the dwarf variant var. *compacta*

- Hybridisation with the related Asiatic alien *F. sachalinensis* to give *F. x bohemica*

- Hybridisation with the common garden plant Russian Vine or Mile a Minute plant (*F. baldschuanica*) to produce *F. x conollyana*
OUTCOMES OF HYBRIDISATION?

The hybrid $F. \times bohemica$ is a more serious pest than its parents and is also more genetically diverse.

Backcrossing between $F. \times bohemica$ and its parents could possibly lead to genotypes better suited to Europe.

Highly sterile wide hybrids produced around the globe - better adapted to adventive range - threat of allopolyploid speciation.
Meanwhile on the other side of the world, open pollinated seed was collected from *F. japonica* and sent to Leicester by Tim Senior.
Muehlenbeckia australis - Russian Vine of the Southern Hemisphere – the male parent
A much better match!

**Fallopia japonica**
- Octoploid
- Base number 11
- Herbaceous
- Reserves in rhizome
- Japan and China

**Muehlenbeckia australis**
- Diploid
- Base number 10
- Evergreen and stoloniferous
- Reserves in woody stems & leaves
- New Zealand & Australia
Future research areas

• Further research into abiotic and biotic controls
• Establishment of reliable viability test for Japanese Knotweed rhizome
• Controlled trials of actual regeneration rates of rhizome and cut stems in the field
• Further competition experiments between *F. x bohemica* and Japanese Knotweed
• Evolution at the epigenetic level?