

# Current Status and Future Prospects for Dalmatian toadflax\* Biological Control

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\*And yellow toadflax too!

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# Outline

- Biology and distribution of invasive toadflaxes in North America
- Taxonomy
- Current unintentionally and intentionally introduced biological control agents
- Status of research into additional biological controls
- Summary and Conclusions

# Invasive toadflaxes in North America

- Dalmatian and yellow toadflax were both intentionally introduced as ornamentals into the US in the 1800's.

# Invasive toadflaxes in North America

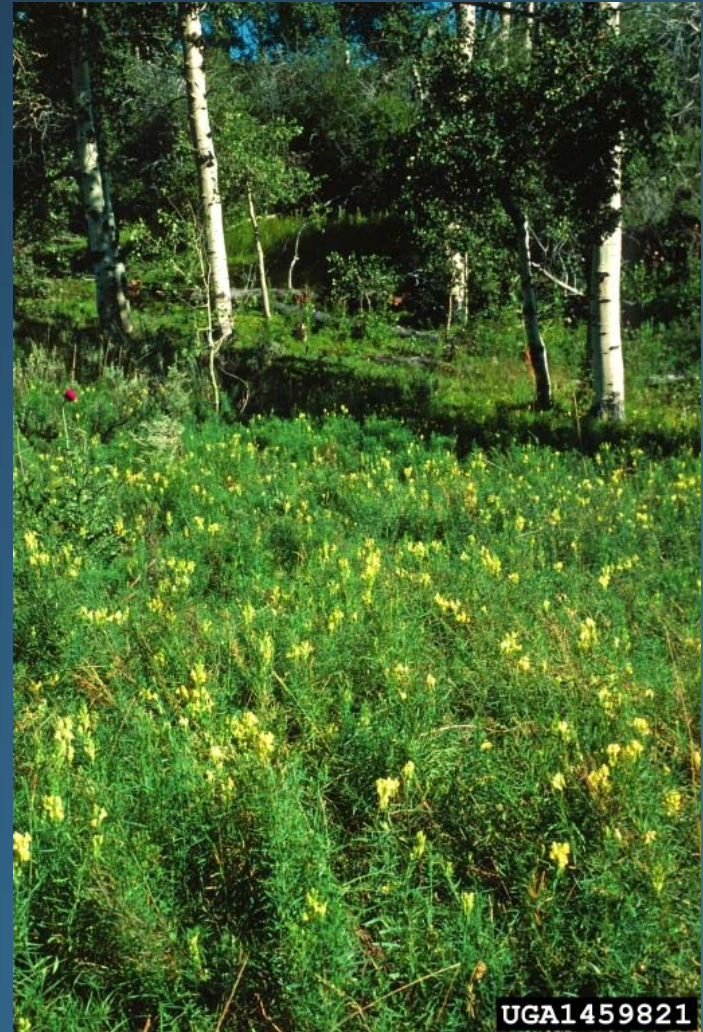
- Dalmatian toadflax prefers drier, coarse soils, more spring moisture and less summer water.
- Can invade “undisturbed” habitats but is more common in areas with fire or grazing disturbance.





# Invasive toadflaxes in North America

- Yellow toadflax prefers habitats with more summer moisture and deeper, more fertile soils.
- Invades undisturbed habitat, but can become **very** abundant in fire disturbed areas.
- In CO, found at higher elevations than DT.



Steve Dewy, Utah State University

# Taxonomy

- Confused, at present.
- “Dalmatian toadflax”:

*Linaria genistifolia*

*Linaria dalmatica*

*Linaria dalmatica* spp. *macedonica*

*Linaria genistifolia* spp. *dalmatica*

*Linaria dalmatica* spp. *dalmatica*

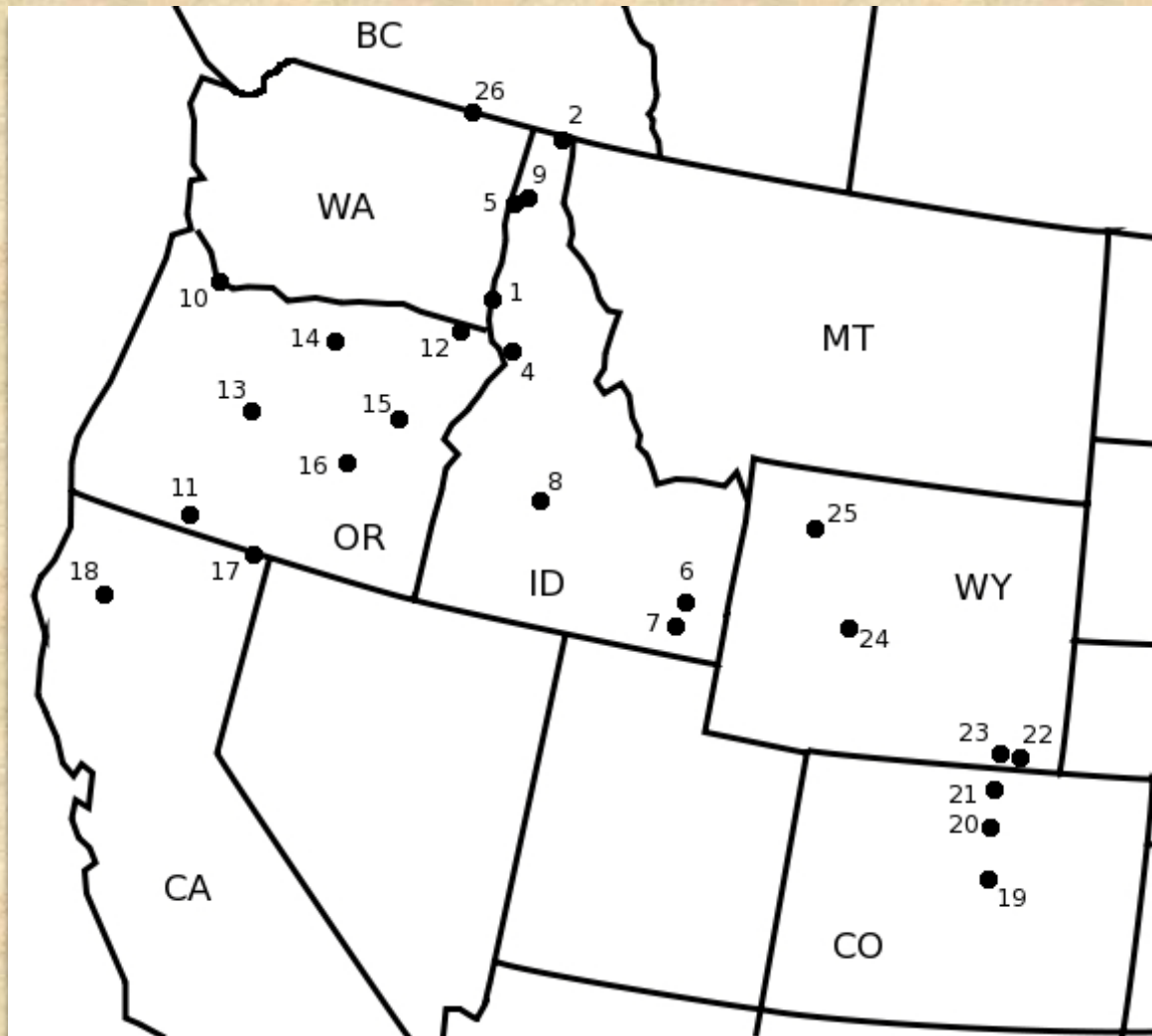
*Linaria genistifolia* x *Linaria grandiflora*

*Linaria grandiflora*

# Taxonomy

- Confused, at present.
- L. Brown, M. Schwarzlaender (U. ID) and J. Gaskin (MT-ARS):
- AFLP data from NA Dalmatian toadflax does not match EU source pops examined to date. Cannot resolve taxonomic status of NA DT toadflax.

# Dalmatian toadflax sampling



- 26 sites in the United States
- Ranged from 10 – 2,381 m in elevation

L. Brown, M.  
Schwarzlaender, J.  
Gaskin.

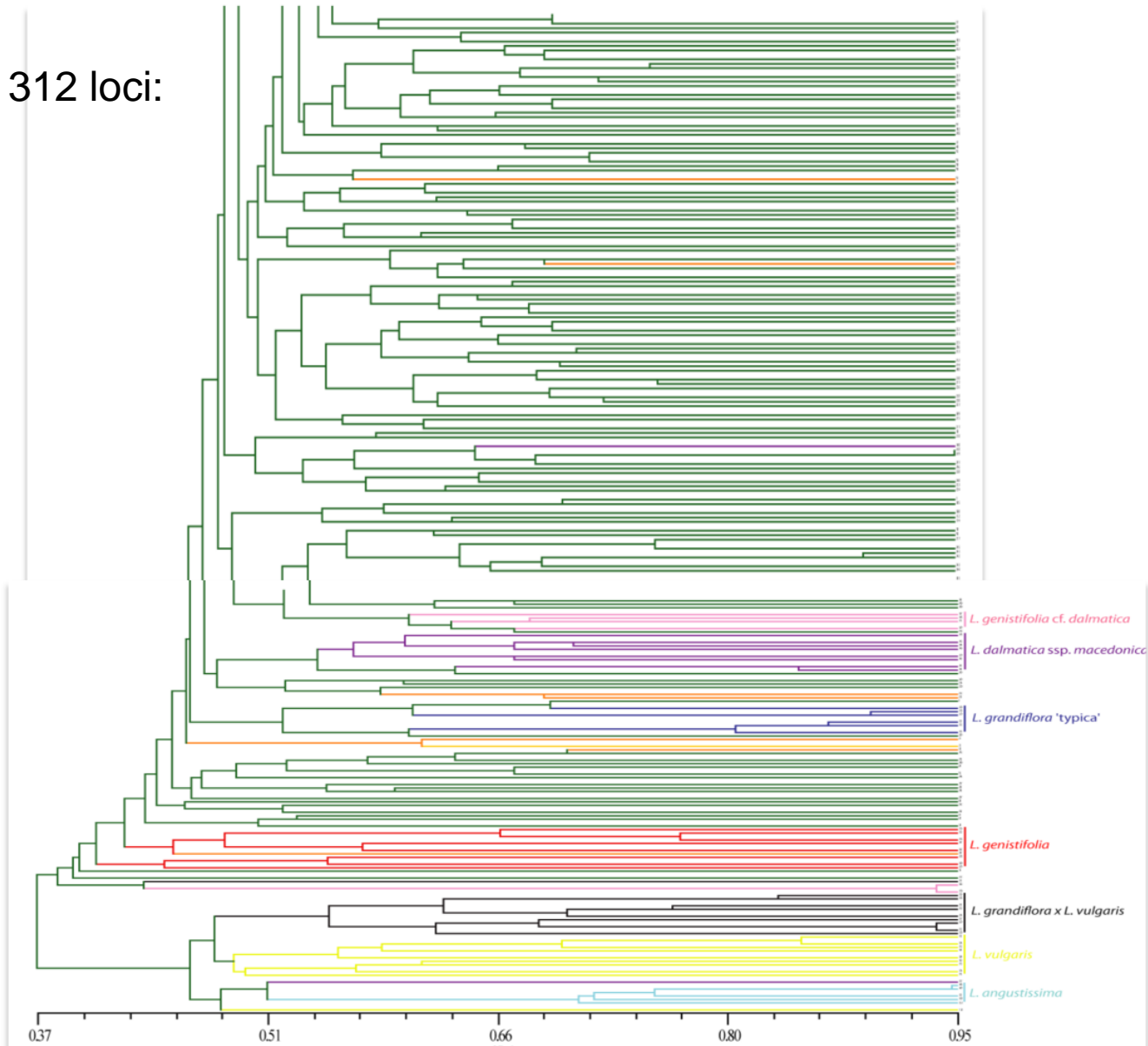


# Dalmatian toadflax sampling



- 17 sites in Europe
- 78 - 899 m in elevation

AFLP data, 312 loci:



# Taxonomy

- Confused, at present.
- Dalmatian and yellow toadflax can hybridize in the field, and laboratory hybrids are readily generated (S. Ward (CoSU) and S. Sing (MtSU)).
- High degree of genetic variation within and between YT populations (S. Ward et al.).
- Multiple introductions, or hybrids?

# Taxonomy

- Both species are genetically very variable in NA.
- N.A. “Dalmatian toadflax” is not assignable to any of the EU populations sampled so far.
- DT and YT can hybridize, though how common this is is not known.

# Current Biological Control Agents for toadflaxes

- The emphasis has been on agents for Dalmatian toadflax, until recently little research devoted specifically to yellow toadflax.



# Current Biological Control Agents for toadflaxes

- 1) *Rhinusa (Gymnetron) antirrhini*.
- Common on yellow toadflax, also found on Dalmatian toadflax.
- Feeds on developing seeds.
- Unintentionally introduced.



UGA0024013

Eric Coombs, Oregon Department of Agriculture, Bugwood.org

# Current Biological Control Agents for toadflaxes

- 2) *Brachypterolus pulicarius*.
- Common on yellow toadflax, also found on Dalmatian.
- Feed on developing seeds.
- Unintentionally introduced.



Susan Turner, British Columbia  
Ministry of Forests, Bugwood.org

# Current Biological Control Agents for toadflaxes

- Both flower feeding beetles prefer yellow toadflax, but are also found on Dalmatian.
- In cage studies, both species can damage the plants and reduce seed set, but this probably has no effect on plant population growth.
- Both species are common on toadflax, and further releases are not warranted.

# Current Biological Control Agents for toadflaxes

- 3) *Calophasia lunula*.
- Intentionally introduced in the 1960s.
- Defoliates Dalmatian and yellow toadflax, also feeds on some other plants in the *Antirhinni* (some natives).
- Common, but rarely reaches densities high enough to have substantial impact.



Bob Richard, USDA APHIS PPQ,  
Bugwood.org



# Current Biological Control Agents for toadflaxes

- 4) *Mecinus janthinus*
- Stem-boring weevil first introduced in 1995.
- Feeds on Dalmatian toadflax, can feed on some native *Antirrhini* (but not observed to do so in the field). NOT approved for release into CA.
- Has had substantial and dramatic impacts on Dalmatian toadflax populations.







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Sharlene Sing, MTSU

# Current Biological Control Agents for toadflaxes

- 4) *Mecinus janthinus*
- This weevil has been established in many western states (WA, OR, ID, MT, WY, CO, UT), and has dramatically reduced DT populations in many areas.
- In CO, has established at all release sites visited and has reduced DT populations 4 – 5 years following release.



# Current Biological Control Agents for toadflaxes

- 4) *Mecinus janthinus*
- No Impact on yellow toadflax in US.





# Current Biological Control Agents for toadflaxes

- 4) *Mecinus janthinus*
- Limitations –
- Overwintering mortality
- Browsers



# Future prospects

- 1) *Rhinusa linariae*
- Root galling weevil.
- Originally introduced in 1995, established on yellow toadflax in BC, did not establish on DT in CO or WY.



Bob Richard, USDA APHIS  
PPQ, Bugwood.org



# Future prospects

- Most (all?) foreign exploration / host testing is being performed at the CABI facility in Switzerland and European cooperators.
- Emphasis in on agents for yellow toadflax.
- *Mecinus* is successful on Dalmatian, but there are no good agents for yellow.

# Future prospects

- 1) *Rhinusa linariae*
- Collectable populations from YT in BC re-introduced into CO last summer.
- Unknown level of impact.



Rosemarie De Clerck-Floate, Agriculture and Agri-Food Canada

# Future prospects

- 2) *Rhinusa brondelii* / *R. pilosa*
- Stem galling weevils on Dalmatian / yellow toadflax, respectively.



Figure 5 *Rhinusa brondelii* field galls on *Linaria genistifolia* in mid May 2007

# Future prospects

- 2) *R. pilosa* (Ex. Yellow toadflax)
- Tested against 35 species so far, will continue testing more species.
- Seems to have a substantial impact on the plant under lab conditions.



# Future prospects

- 3) *Mecinus heydeni*
- Stem-boring weevils on Dalmatian and yellow toadflax
- Weevils overwinter in soil (not in stem).
- Recent molecular work indicates that there may be separate species on yellow, *L. genistifolia* and *L. genistifolia* spp *macedonica*





# Future prospects

- 3) *Mecinus heydeni* and *M. laeviceps*
- Host specificity testing in progress for species from *L. vulgaris* and from *L. genistifolia*



# Future prospects

- 4) Recent molecular work indicates that there are two “sister” species of *M. janthinus* as well.
- One, originally collected from *L. dalmatica* spp. *macedonica* and *L. genistifolia* is now widespread in NA.



# Future prospects

- 4) Recent molecular work indicates that there are two “sister” species of *M. janthinus* as well.
- One, originally collected from *L. dalmatica* spp. *macedonica* and *L. genistifolia* is now widespread in NA. A second species, collected from *L. vulgaris* is was released into NA, but is only(?) established in Alberta on yellow toadflax.



# Toadflax Biological Control Agents

## Dalmatian toadflax

Defoliating moth

*Calophasia lunula*

Root-galler

Stem-galler

*Rhinusa brondelii*\*

Stem-borer

*Mecinus janthinus* (!!)

Stem-borer

*Mecinus laeviceps*\*

\*Still in  
development  
phase

## Yellow toadflax

*Rhinusa linariae*

*Rhinusa pilosa*\*

*Mecinus nr. janthinus*\*

*Mecinus heydeni*\*



# Summary

- Toadflaxes exhibit a high degree of genetic variability in NA, and the area of origin and taxonomic status of Dalmatian toadflax is not yet known, but it is closely related to *L. genistifolia* and *L. dalmatica* spp. *macedonica*.
- Of the current biological control agents, only *Mecinus janthinus* on Dalmatian toadflax appears to significantly impact population size.
- Several potential new agents are currently being studied by CABI. For each of these, it appears that there are separate, genetically and behaviorally distinct species on “Dalmatian toadflax” and yellow toadflax, providing a nice example of coevolution or parallel cladogenesis.



# Summary



- Most of the development research is performed by CABI, with funding from:
- Wyoming Biological Control Steering Committee, USDA-APHIS, USDA Forest Service, Ministry of Forests and Range, British Columbia Provincial Government, Agriculture and Agri-Food, Canada