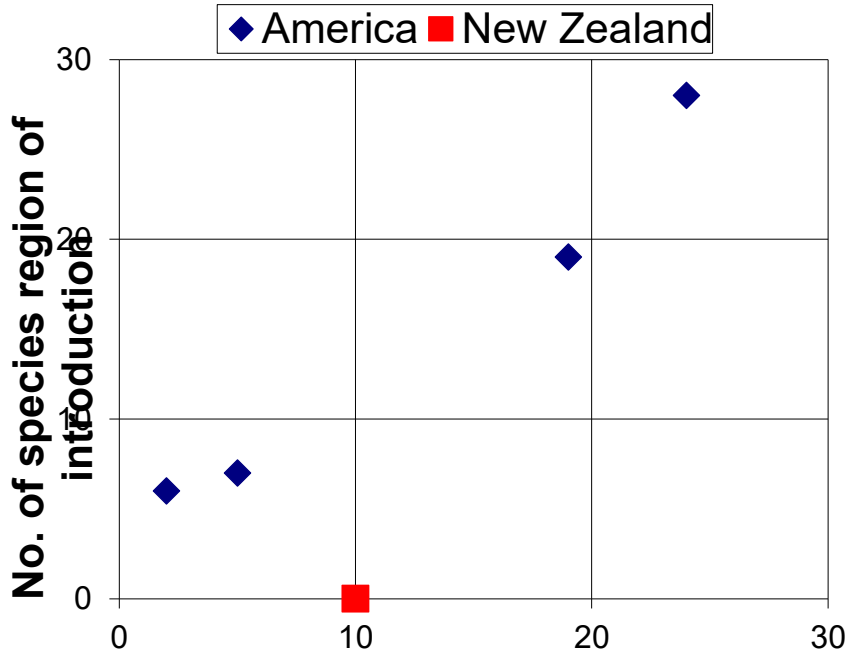
Parasitoids of European *Agrilus* spp. and their potential for controlling invasive *Agrilus* spp.

Marc Kenis, Michael Eisenring, Martin M. Gossner, M. Lukas Seehausen

Why studying parasitoids of native *Agrilus* spp. before the arrival of EAB and other *Agrilus* spp. in Western and Central Europe?

1. We can expect that the parasitoids of native *Agrilus* spp. will be those attacking invasive *Agrilus* spp. in priority.
   - Taxonomic relatedness is the most important factor driving parasitoid host range: For an invasive species, the presence of congeneric species in the area of introduction increases the chance of being parasitized.

Example: European *Coleophora* spp. Introduced in North America and New Zealand



Why studying parasitoids of native *Agrilus* spp. before the arrival of EAB and other *Agrilus* spp. in Western and Central Europe?

2. We can expect that lots of entomologists will study the ecology / population dynamics of invasive Agrilus spp. once they arrive, including their parasitoids. So, it is good to know the species to expect in advance.

Why studying parasitoids of native *Agrilus* spp. before the arrival of EAB and other *Agrilus* spp. in Western and Central Europe?

3. We could expect some of these species to reach high rates of parasitism and become important natural biocontrol agents.

In North America: Native parasitoids are not important on EAB

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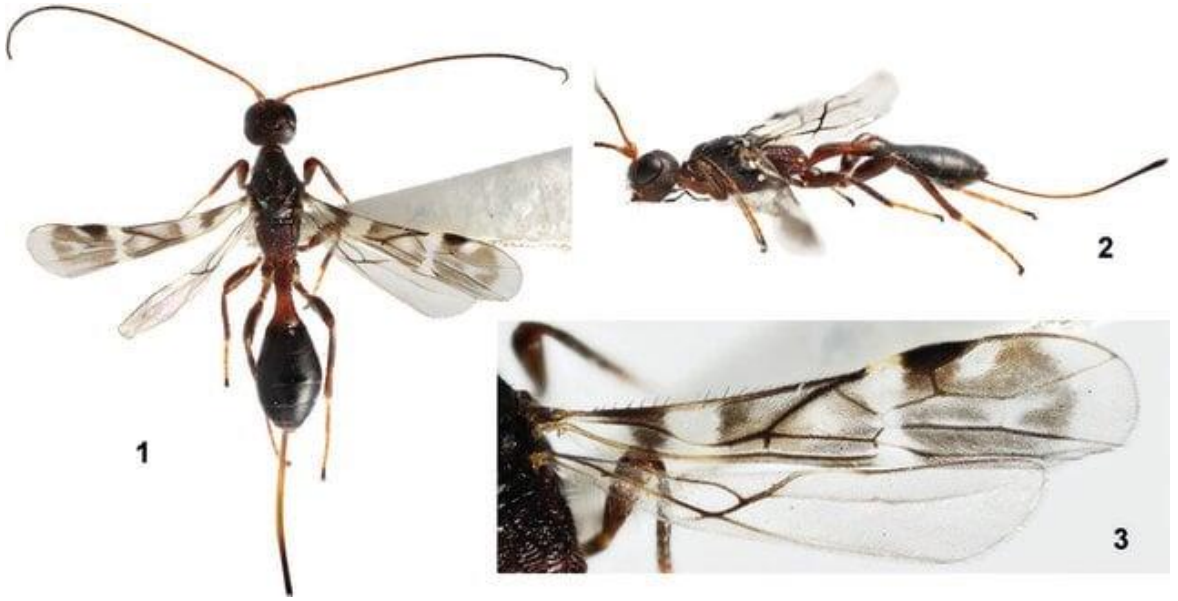
In Western Russia: *Spathius polonicus* is locally very abundant



Orlova-Bienkowskaja and Belokobylskij 2014

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Several examples of successful control of invasive insects by local natural enemies:

E.g. *Lathrolestes luteolator* on *Profenusa thomsoni* in Canada

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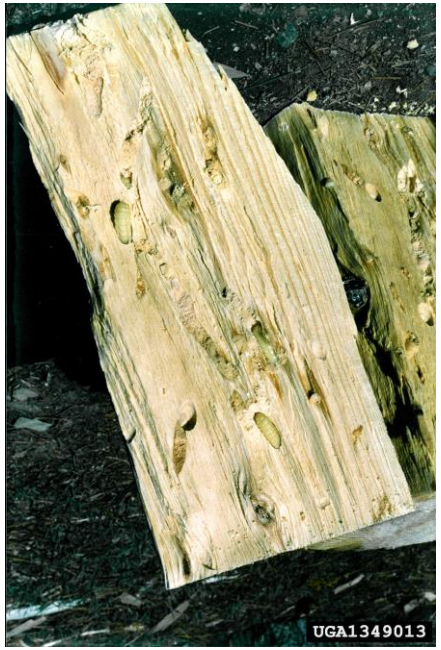
Several examples of successful control of invasive insects by local natural enemies:

E.g. *Ibalia leucospoides ensiger* on *Sirex noctilio* in North America

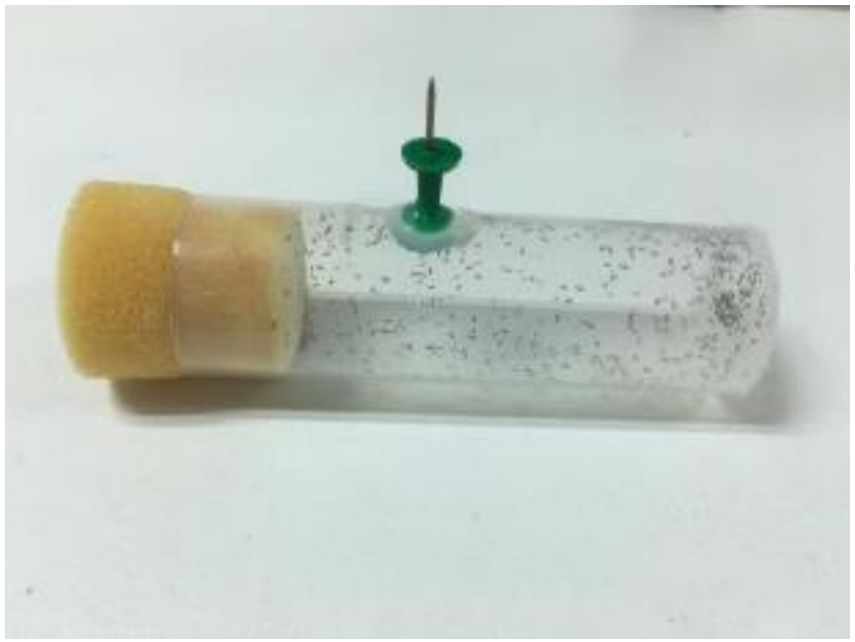
Photo: H. Goulet



Why studying parasitoids of native *Agrilus* spp. before the arrival of EAB and other *Agrilus* spp. in Western and Central Europe?

4. The knowledge of local natural enemy complex is Important for conducting (pre-emptive) biocontrol activities:

- **Augmentative/inundative biocontrol** ??



Why studying parasitoids of native *Agrilus* spp. before the arrival of EAB and other *Agrilus* spp. in Western and Central Europe?

4. The knowledge of local natural enemy complex is Important for conducting (pre-emptive) biocontrol activities:

- **Conservation biocontrol** measures through the enhancement of these parasitoids (and predators):

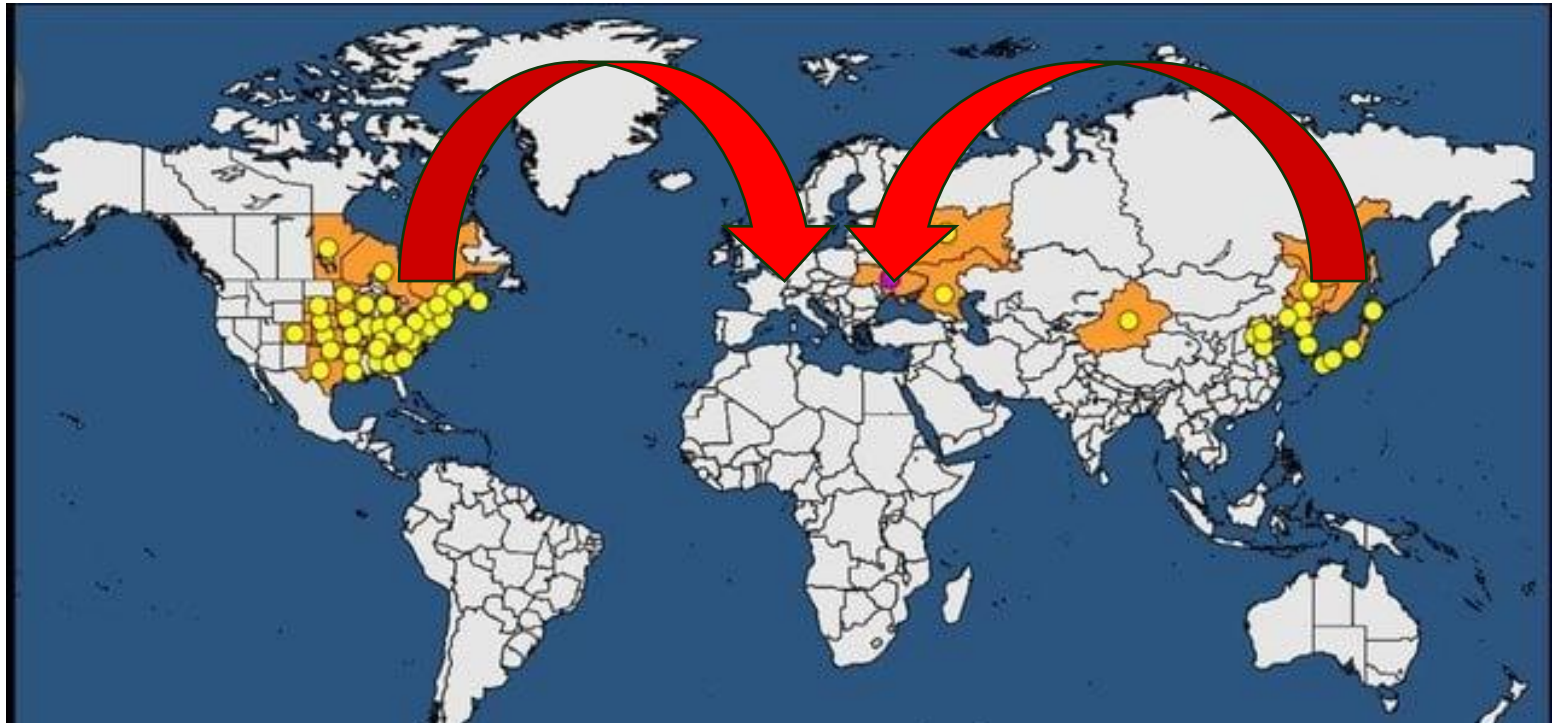
  Sylvicultural practices to enhance natural enemies, e.g.:

  - Managing logging waste
  - Provide food and shelters for natural enemies through dead trees

Why studying parasitoids of native *Agrilus* spp. before the arrival of EAB and other *Agrilus* spp. in Western and Central Europe?

4. The knowledge of local natural enemy complex is Important for conducting (pre-emptive) biocontrol activities:

- In **classical biological control**, it is essential to know the local natural enemy complex of an invasive pest before releasing an exotic natural enemy (e.g. to prevent competition or fill in an empty niche.



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Parasitoids of *Agrilus* spp. in Europe: Anticipating the arrival of *Agrilus planipennis*

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No new data since then.

Table S1. Parasitoids of European *Agrilus* spp. XX = mentioned as reared from the host in a study specifically focused on the host or parasitoid; (XX) = As XX, but parasitoid identification or host-parasitoid association appear doubtful to the authors; X = Record in a catalogue, taxonomic book, host-parasitoid list or from a non-specific study; (X) As X, but parasitoid identification or host-association appear doubtful to the authors.

	A. angustulus	*A. ater*	*A. auricollis*	*A. biguttatus*	*A. convexicollis*	*A. cuprescens =aurichalceus*	*A cyanescens*	*A. graminis*	*A. hastulifer*	*A. integerrimus*	*A. laticornis*	*A. lineola*	*A. macroderus*	*A. mendax*	*A. olivicolor*	*A. pratensis = robertii*	*A. ribesi*	*A. roscidus*	*A. salicis*	*A. sinuatus*	*A. subauratus*	*A. sulcicollis*	*A. suvorovi = populneus*	*A. viridis*
Main hosts[1]	Qu	Po	Ul	Qu	Fr	Ro	Lo	Qu	Qu	Da	Qu	Sa	Ro	So	BL	Po	Ri	Ro	Sa	Py	Sa	Qu	Po	BL
Ichneumonidae																								
Cubocephalus annulatus (Cresson) (MM)						x																		
Deuteroxorides elevator (Panzer) (= *albitarsus* (Gravenhorst))				xx																				
Dolichomitus imperator (Kriechbaumer)				(x)																				
Dolichomitus terebrans (Ratzeburg)			(x)																					
Ephialtes manifestator (L.)				(x)																				
Exochus compressiventris Ratzeburg				(x)																				
Foersteria puber (Haliday) (= *flavipes* Szepligeti)																								(x)
Isadelphus gallicola (Bridgman) (=*Cecidonomus nigriventris* (Thomson))																								x
Ischnoceros caligatus (Gravenhorst)				x																				
Nematopodius formosus Gravenhorst																						(x)		
Scambus sagax (Hartig)				(x)																				
Vipio tentator (Rossi)							x																	
Xorides praecatorius (F.)																						x		xx
Xylophrurus augustus (Dalman) (=dentatus Taschenberg)																								x
Braconidae																								
Atanycolus neesii (Marshall)				x																				xx
A. sculpturatus (Thomson)				(x)																				
Cenocoelius analis (Nees)					x																			
Coeloides scolyticida Wesmael																								x
Doryctes leucogaster (Nees)				(x)																				(x)
D. mutillator (Thunberg)				(x)																				
D. undulatus (Ratzeburg) (= *brachyurus* Marschall)					x	x								x										x
Doryctodes anticus (Wollaston)																								(x)
Eubazus longicaudis (Ratzeburg)						(x)																		
Helcon claviventris Wesmael																								(xx)
Heterospilus rubicola Fischer						x																		
Ipobracon nigrator (Zetterstedt)		x																						
Meteorus sulcatus Szépligeti	x																							
Ontsira antica (Wollaston)																								x
Pareucorystes varinervis Tobias	x		x		x						x											x		x
Polystenus rugosus Forster (= *Eucorystes aciculatus* (Reinhard))	x		x																			x		xx
Rhaconotus aciculatus Ruthe																								(x)
Spathius brevicaudis Ratzeburg																								xx
S. depressus Hedqvist																								x
S. exarator (L.)		(x)																						
S. lignarius (Ratzeburg)				x																				
S. phymatodis Fisher																x								x
S. polonicus Niezabitowski												x											x	x
S. rubidus (Rossi)	x		x	x	x		x				x													x
S. umbratus (F.) (= *curvicaudis* Ratzeburg = *radzayanus* Ratzeburg)			x	xx			x		x							x					x	x		xx
Eulophidae																								
Baryscapus agrilorum (Ratzeburg)				x		x								x									xx	xx
B. hylesini Graham																							x	
Entedon ergias Walker																								x

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- Parasitoid records were found for **24 European *Agrilus* species**.
- **Sixty-four parasitoid species** were recorded, mostly larval parasitoids, some egg parasitoids.
- Many of them may represent **erroneous host-parasitoid associations or misidentifications**
- The biology of most species and their roles in the population dynamics of their hosts have been **very poorly studied**.

European *Agrilus* spp: with reliable data on parasitism

Agrilus viridis

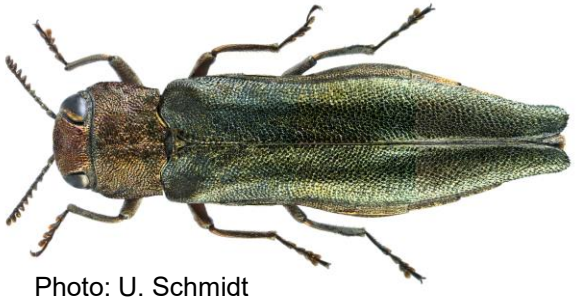


Photo: U. Schmidt

Agrilus biguttatus

Agrilus cuprescens

Photo: U. Schmidt

Agrilus suvorovi (= *populneus*)

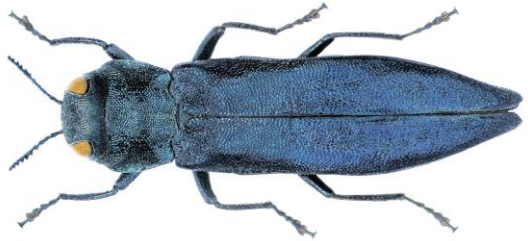
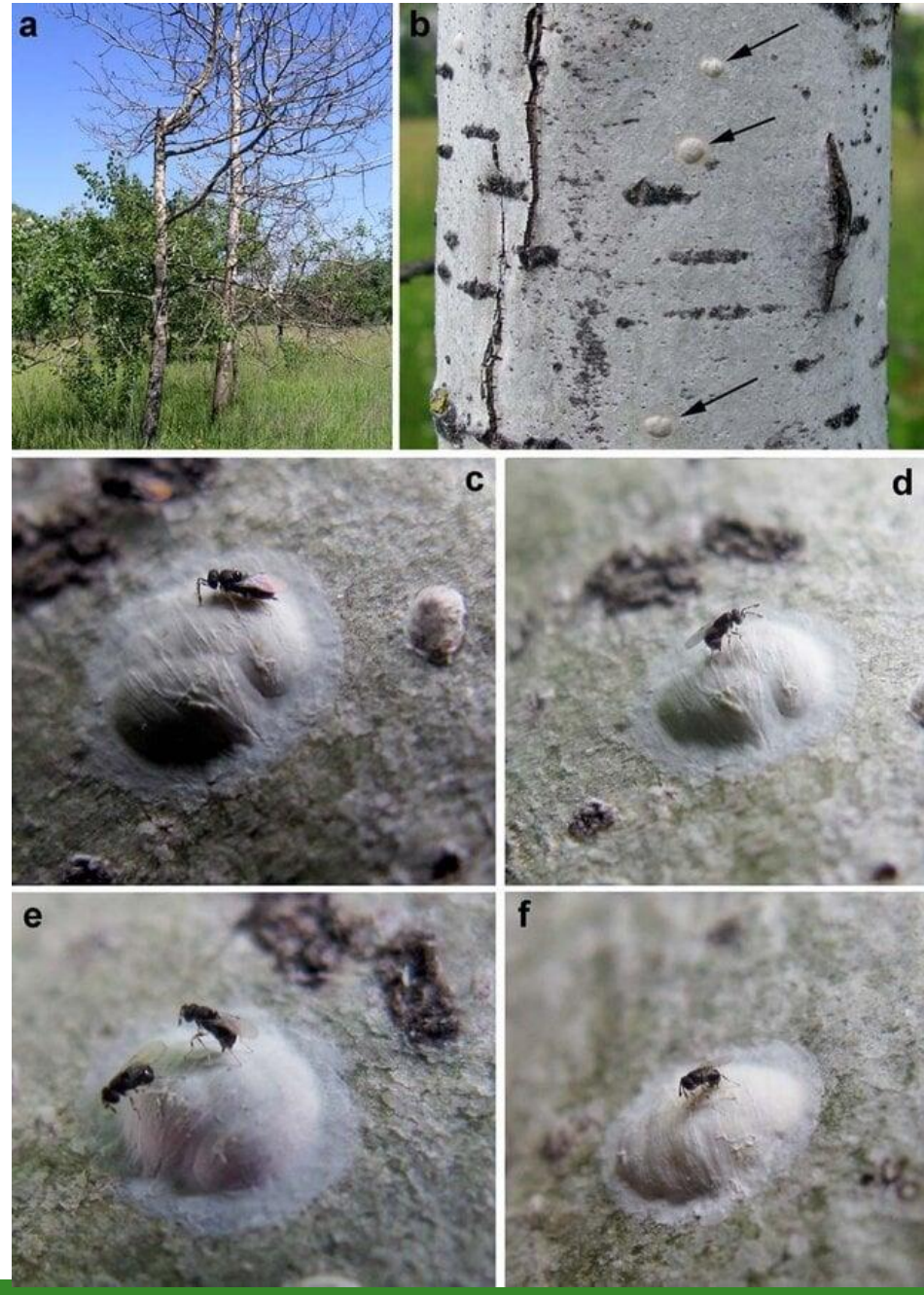


Photo: U. Schmidt

Egg parasitism

Oobius zahaikevitshi (*Encyrtidae*)

- Only well-described parasitoid of *Agrilus* spp. in Europe
- > 50% of *A. viridis* eggs in hazel groves in Italy (Moraglio et al., 2013).
- Also well studied on *A. suvorovi* in Ukraine (Gumovsky et al. 2013)



Gumovsky et al. 2013

Larval parasitism

Tetrastichus heeringi (Eulophidae)

- gregarious larval koinobiont endoparasitoid
- Specific to *Agrilus* spp.
- Most abundant parasitoid of *A. viridis* and *A. cuprescens*
- Parasitism rates over 50% are reported
- Two other Eulophidae reported on A. viridis: *Baryscapus agrilorum* and *Quadrastichus misellus*

Hansson and Schmidt 2020

Larval parasitism

Spathius spp. (Braconidae)

- Most frequently cited Braconidae of *Agrilus* spp.
- Several species, but taxonomy is confusing
- Most commonly cited: *S. rubidus* and *S. umbratus*
- Idiobiont ectoparasitoids, developing on larvae previously paralysed by the female parasitoid.
- Often gregarious, some solitary
- Usually generalists, e.g. *S. rubidus* is known from 69 beetle species from different families
- *S. polonicus* most important European parasitoid on EAB so far – **but needs further studies**

Photo: P. Andersen

Larval parasitism

Polystenus rugosus (Braconidae)

- Recorded from several Buprestidae, including *A. viridis*, *A. angustulus, A. auricollis .and A. sulcicollis*
- Idiobiont ectoparasitoids, developing on larvae previously paralysed by the female parasitoid.

Photo: Zdeněk Hyan

Larval parasitism

Xorides praecatorius (Ichneumonidae)

- Recorded from *A. viridis*, *A. sulcicollis* … and many xylophagous beetles, especially Cerambycidae
- Idiobiont ectoparasitoids, developing on larvae previously paralysed by the female parasitoid.

Photo: Zdeněk Hyan

Comparison potential Asian biocontrol agents for EAB – native parasitoids

Asian parasitoids	Native parasitoids
Oobius agrili	*Oobius zahaikevitshi*
Tetrastichus planipennisi	*Tetrastichus heeringi*
Spathius galinae, S. agrili	*Spathius polonicus, S. rubidus, S. umbratus, S. brevicaudis*, etc.

! Potential competitive interactions

By host plant

European *Agrilus* species on *Fraxinus*: ***Agrilus convexicollis***

Parasitoids poorly known.

Three Braconidae cited:

- *Cenocoelius analis*
- *Doryctes undulatus*
- *Pareucorystes varinervis*

Photo: U. Schmidt

By host plant

European *Agrilus* species on *Betula*: ***Agrilus betuleti and A. padulicola***

No parasitoid record

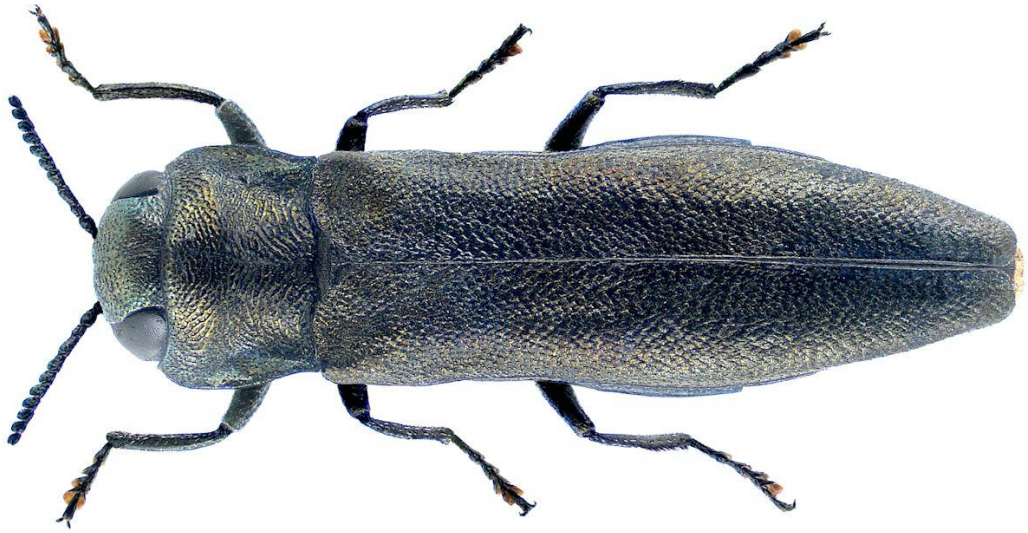
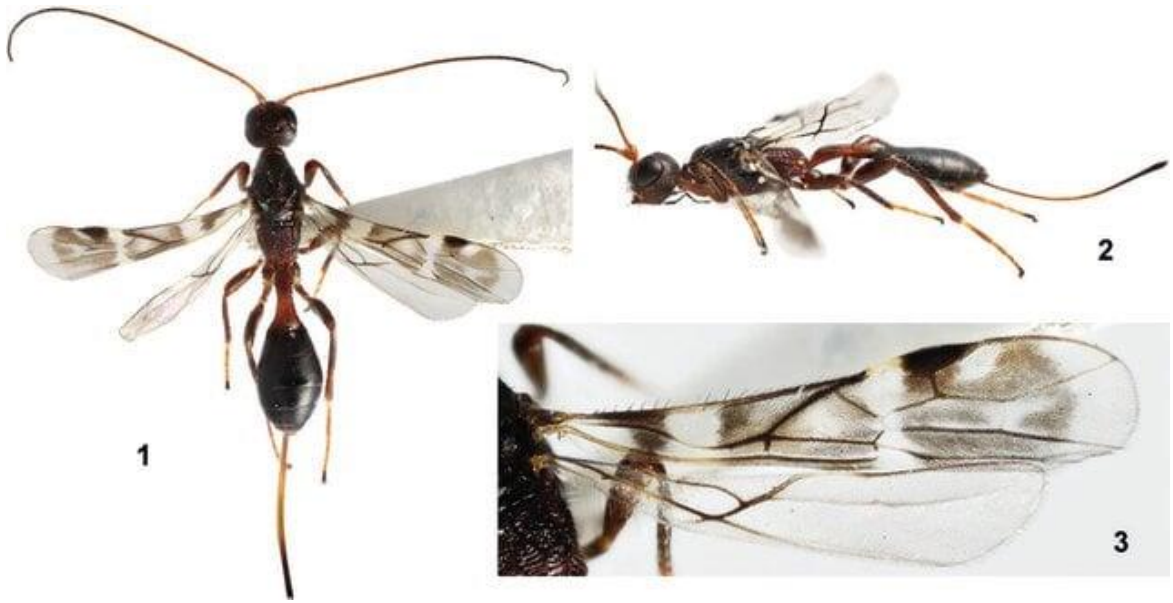


Photo: U. Schmidt

By host plant

Known hosts of *Spathius polonicus*

- *Agrilus suvorovi* — *Populus*
- *A. viridis* — Broadleaves
- *A. lineola* — *Salix*
- *Lamprodila mirifica* — *Ulmus*
- *Melanophila picta/decastigma* — *Populus*
- *Sphenoptera davatchii* — Rosaceae
- *S. kaznakowi* — ???
- *Coraebus fasciatus* — *Quercus*



Orlova-Bienkowskaja and Belokobylskij 2014

By host plant

Known hosts of *Atanycolus capparti*

- *Agrilus bilineatus* *Fagaceae*
- *A. liragus* *Populus*

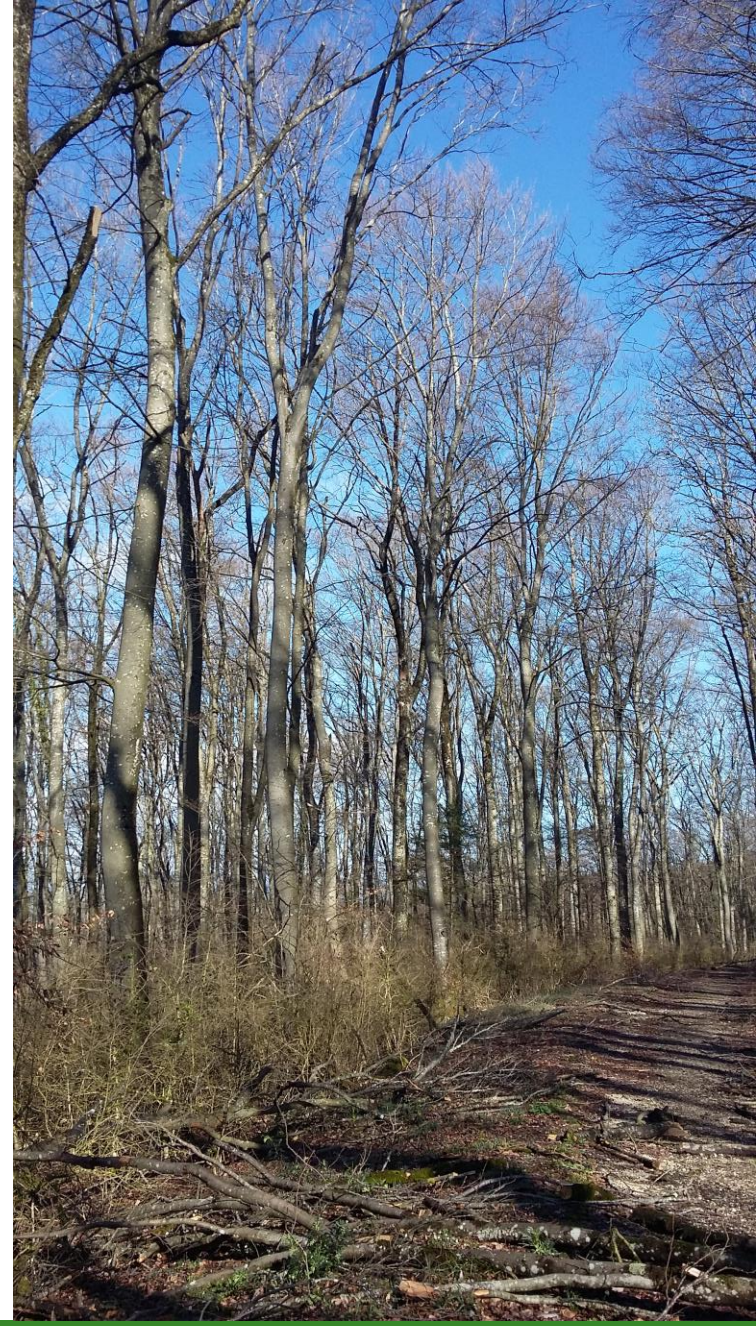
PARASEARCH:

Small project in Switzerland with WSL that included:

- Surveys for parasitoids of European *Agrilus* spp.
- Lab rearing methods for European *Agrilus* spp.
- Testing EAB parasitoids on European species
- Assessment of European parasitoids on EAB

PARASEARCH:

Surveys for parasitoids of *Agrilus* spp. on beech in spring 2022 and 2023 in the Swiss Jura after a beech dieback period



PARASEARCH:

Surveys for parasitoids of *Agrilus* spp. on beech in spring 2022 and 2023 in the Swiss Jura after a beech dieback period

Mostly from *A. viridis*, probably also some *A. angustulus*

Four parasitoids obtained to the adult stage:

- *Tetrastichus heeringi* (most abundant)
- *Spathius rubidus*
- *Polystenus rugosus*
- *Xorides praecatorius*

No reliable quantitative data could be obtained

PARASEARCH:

Surveys for parasitoids of *Agrilus* spp. - 2 methods

Photoeclectors or cages

- *Agrilus* spp. Were mostly in thick logs
- Low density, with many other insects
- Difficult to associate parasitoids to hosts

Debarking

- Trees with thick bark, very hard to debark
- Big mortality/waste
- Some parasitoids and hosts are difficult to rear to the adult stage

Summary

- Parasitoids of European *Agrilus* spp. are poorly studied, with very few quantitative data
- They are very difficult to study, needing high beetle densities and means (even worse for predators)
- The most important European parasitoids belong to the same genera as the Asian parasitoids that are candidate for release
- A good knowledge is an important component of potential pre-emptive biological control programmes, especially conservations biocontrol and classical biocontrol
- It is essential to continue studying parasitism and predation on EAB in Europe.

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
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Swiss Agency for Development and Cooperation SDC