Diagnosis of the agromyzids Liriomyza bryoniae and L. trifolii by means of starch gel electrophoresis

Menken, S.B.J.; Ulenberg, S.A.

Published in:
Entomologia Experimentalis et Applicata

DOI:

Citation for published version (APA):

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Sex attractants for clearwing moths

already been reported by Brennan (1977).

The 900 : 100 mixture of EZ : Ac and ZZ : Ac was successfully used for monitoring *S. ves- piformis* in the summer of 1982.

We thank G. Szöcs and G. Sziráki at Budapest for doing field experiments in Hungary, A. Wunderlich and W. Nääsig, Frankfurt, who provided *S. vespiformis* male pupae for single cell measurements, and M. Martinez of INRA Station de Zoologie, Versailles, for identification of the insect species dealt with in Table I.

REFERENCES


Accepted: April 28, 1983

Steph B. J. Mennken 1) & Sandrine A. Uelenberg 2): Diagnosis of the agromyzids *Liriomyza bryoniae* and *L. trifolii* by means of starch gel electrophoresis.

To enlarge the character set of the species of the family Agromyzidae an electrophoretic study has been done on two species of this family, *Liriomyza trifolii* (Burgess) and *L. bryoniae* (Kaltenbach).

Seventy-five percent of the known 1800 spe-

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1) Department of Biosystematics, Biological Laboratory, Vrije Universiteit, 1007 MC Amsterdam.
TABLE I

Allozyme frequencies at the 7 diagnostic and 2 other polymorphic loci in Liriomyza bryoniae (L.b.) and L. trifolii (L.t.), the numbers of alleles sampled (n) and the heterozygosity per locus (h)

<table>
<thead>
<tr>
<th>Loci</th>
<th>n</th>
<th>97</th>
<th>98</th>
<th>100</th>
<th>102</th>
<th>104</th>
<th>110</th>
<th>h</th>
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<tbody>
<tr>
<td>Pgm</td>
<td>L.b.</td>
<td>82</td>
<td>.16</td>
<td>---</td>
<td>.65</td>
<td>.11</td>
<td>.07</td>
<td>.01</td>
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<td></td>
<td>L.t.</td>
<td>46</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>Me</td>
<td>L.b.</td>
<td>76</td>
<td></td>
<td></td>
<td>.64</td>
<td>.36</td>
<td></td>
<td>.461</td>
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<tr>
<td></td>
<td>L.t.</td>
<td>60</td>
<td>.98</td>
<td>.02</td>
<td></td>
<td></td>
<td></td>
<td>.039</td>
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<td>Esß-1</td>
<td>L.b.</td>
<td>32</td>
<td>.13</td>
<td></td>
<td>.59</td>
<td>.28</td>
<td></td>
<td>.557</td>
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<td></td>
<td>L.t.</td>
<td>20</td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td>.000</td>
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<tr>
<td>6Pgdh</td>
<td>L. b.</td>
<td>42</td>
<td>.12</td>
<td>.88</td>
<td></td>
<td></td>
<td></td>
<td>.211</td>
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<td></td>
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<td></td>
<td></td>
<td>.25</td>
<td>.75</td>
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<td>.375</td>
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<tr>
<td>Nadh. dh-1</td>
<td>L. b.</td>
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<td>1.00</td>
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<td></td>
<td></td>
<td></td>
<td>.000</td>
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<tr>
<td></td>
<td>L.t.</td>
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<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td>Ald</td>
<td>L.b.</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>L.t.</td>
<td>40</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.000</td>
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<td>Hbdh</td>
<td>L.b.</td>
<td>14</td>
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<td></td>
<td></td>
<td></td>
<td>.000</td>
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<td></td>
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<td></td>
<td></td>
<td>1.00</td>
<td></td>
<td></td>
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<tr>
<td>Mdh</td>
<td>L.b.</td>
<td>38</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>L.t.</td>
<td>38</td>
<td>.97</td>
<td></td>
<td></td>
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<td>.058</td>
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<td>G6pdh</td>
<td>L.b.</td>
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<td>.96</td>
<td>.04</td>
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<td>.077</td>
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<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.000</td>
</tr>
</tbody>
</table>

recorded on more than 100 different hosts. In the Netherlands it causes the most serious damage in chrysanthemums and Gerbera, but it is steadily increasing its host range to include vegetable crops (Jaarboek Plantenziektenkundige Dienst, 1980: 32, 88—90). L. bryoniae occurs exclusively in the Palaearctic Region. In the Netherlands it is known of old as a pest of tomato.

The genus Liriomyza is a taxonomically difficult group, with several species hardly distinguishable on morphological grounds. Because of its economic importance a good identification is important. Although the larvae and the imagines of L. bryoniae and trifolii are morphologically distinguishable (Spencer, 1973: 226—229, 209—214), identification of the pupae cannot be given with certainty. Moreover, the threat of introduction of other pest species, closely related to these, makes unambiguous characterisation extremely valuable.

Enzyme variation has proved to be differential in a number of closely related species (Ayala, 1975; Lakovaara et al., 1976; Menken, 1982) and has therefore been investigated to enlarge the character set of Liriomyza.

Materials and Methods. Mass cultures were produced from individuals collected in the field, at the Glasshouse Crops Research and Experimental Station, Naaldwijk, the Netherlands. Individuals analysed electrophoretically originated from the 15—20th generation in L. trifolii (reared on aubergine, cucumber and tomato), and from the 30—40th in L. bryoniae (reared on tomato).

The L. trifolii samples were put together and treated as one, as no significant differences were observed between subsamples.

In total the following numbers of individuals
were analysed: *L. bryoniae* — 9 last-instar larvae, 17 pupae, 28 adult flies and *L. trifolii* — 23 last-instar larvae, no pupae, 18 adult flies.

Specimen preparation and electrophoretic and staining techniques followed Menken (1982). The following 15 proteins were analysed (locus abbreviations in parentheses): α-glycerophosphate dehydrogenase (α-Gpdh-1 and -2, referring to the larval and adult locus respectively), glucose-6-phosphate dehydrogenase (G6pdh), hydroxybutyrate dehydrogenase (Hbdh, only active in larvae, sometimes in pupae), isocitrate dehydrogenase (Idh, activity in adults very low), malate dehydrogenase (Mdh), malic enzyme (Me), NADH dehydrogenase (Nadh. dh-1 and -2), 6-phosphogluconate dehydrogenase (6-Pgdh), catalase (Cat), phosphoglucomutase (Pgm), esterase (Esβ-1), aldolase (Ald) and the general protein (Pt-1).

Enzymes are encoded by the same locus in all life stages studied, unless otherwise stated.

Genetic interpretation of the observed variation is inferential.

At each locus the most common electromorph (allozyme) of *L. bryoniae* is arbitrarily designated as 100. All other electromorphs are numbered according to their differences in migration distance from this standard in millimeters (standardisation according to Menken, 1982). Six more enzymes gave no activity at all or demonstrated uninterpretable patterns (fructose dehydrogenase, alcohol dehydrogenase NAD- and NADP-dependent, glutamic-oxaloacetic transaminase, acid phosphatase and leucine aminopeptidase).

**Results and discussion.** Table I lists allozyme frequencies at 7 diagnostic loci (a locus is considered diagnostic when it is sufficient to distinguish the taxon from other taxa with 100% probability), viz.: Hbdh, Me, Nadh. dh-1, 6Pgdh, Pgm, Esβ-1 and Ald. Also listed is the variability at 2 slightly polymorphic enzyme loci (Mdh and G6pdh), that showed a broad overlap in frequencies between the 2 species. The remaining 6 loci are monomorphic in our samples and fixed for the same electromorph in both species, viz.: αGpdh-1 and -2, Idh, Nadh. dh-2, Cat and Pt-1. Fig. 1 depicts genotypic patterns of the diagnostic loci Me and Pgm. These are superior systems for characterisations of the 2 species as all individuals analysed gave sharp banding patterns.

The total information on allozyme frequencies results in a genetic identity (Nei, 1972) $I = 0.573$ and a genetic distance $D = 0.556 \pm 0.223$. Obviously the 2 species are biochemically quite separate and easily distinguishable.

In *Liriomyza trifolii* no pupae were available for electrophoretic analysis. As larval and adult patterns are the same for 6 out of the 7
diagnostic loci (*Hbdh* was only mainly active in larvae) it can be taken for granted that the same locus is expressed in the pupae. Hence *L. bryoniae* and *trifolii* are easy to discriminate as larvae, pupae and adults.

It is not known at what time the transition of the larval a*Gpdh-I* into the adult form (a*Gpdh-2*) occurs during the pupal stage.

There is a notable difference in heterozygosity value between the 2 species. The mean heterozygosity computed over 15 genetic loci for *L. bryoniae* (*H* = 0.123 ± 0.055) is 4 times as large as that for *L. trifolii* (*H* = 0.031 ± 0.025; standard errors of *H* were calculated from the variance among loci: Nei, 1975). According to the niche-width variation hypothesis (Van Valen, 1965) *L. trifolii* should be as polymorphic as *L. bryoniae* as both species have a comparable host plant range (as a parameter of niche breadth). Conclusions, however, must remain very tentative as we are dealing with the nth laboratory generation and we do not know much of processes that may influence heterozygosity levels, such as bottlenecks, in the cultures.

We will continue our study with the characterisation of other important or potentially important pests within the genus *Liriomyza*.

We thank Anton van der Linden, Glassh. Crops Res. & Exp. Station, Naaldwijk for providing laboratory culture material, Ms. L. J. W. de Goffau for the identifications.

REFERENCES


Accepted: May 20, 1983


D. J. HORN1): Selective mortality of parasitoids and predators of *Myzus persicae* on collards treated with malathion, carbaryl, or Bacillus thuringiensis

KEY WORDS: *Diaeretiella rapae* — Encyrtidae — Insecticide — Integrated control — Hymenoptera — Pteromalidae — searching behavior — Syrphidae

Densities of phytophagous insects, especially aphids may increase after application of broad spectrum insecticides. Outbreaks of *Myzus persicae* Sulzzer (green peach aphid) have followed application of botanical, chlorinated hydrocarbon, organophosphate, and carbamate insecticides (Bacon 1960, Pimentel 1961, Ripper 1956). Such outbreaks have been attributed to elimination of predators (Ripper 1956), to increased attractiveness of treated plants (Folsom 1927), to reduced competition and higher host quality after elimination of competitors (Root & Skelsey 1969), or to a combination of these.

Fewer investigators have reported selective effects of insecticides on specific natural enemies. Coats et al. (1979) found that Coccinellidae tolerated some pyrethroids, and Leclere & Smilowitz (1980) noted that *Coleomegilla maculata* (Coccinellidae) was more tolerant of carbaryl, pirimicarb, and methamidiphos than was either *M. persicae* or predaceous Chrysopidae. Ba-Angood & Stewart (1980) found

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1) Dept. of Entomology, The Ohio State Univ., Columbus, OH 43210, U.S.A.