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Enzyme electrophoretic studies on the *Aphis fabae* group (Homoptera, Aphididae)

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Abstract

The taxa of the *Aphis fabae* group *s.str.* are morphologically difficult to separate or inseparable. Vertical starch gel electrophoresis of members of the *Aphis fabae* complex *s.str.* and *s.l.* was carried out to find specific isozymic characters. Analysis of the banding patterns of 17 genetic loci reveals that each of the 18 taxa investigated can be clearly identified. A biochemical key is presented.

1 Introduction

Also in the aphidological taxonomy new biochemical methods began to prevail among which especially isozyme electrophoresis attained a particular importance (BLACKMAN *et al*., 1989; LAMPEL, 1985; MENKEN and ULENBERG, 1987). In addition to Switzerland (LAMPEL and BURGENER, 1987; ODERMATT, 1981) there exist study groups, which pursue aphid taxonomy with the help of isozyme electrophoresis also in Australia (HALES, 1991), in Finland (SUOMALAINEN *et al*., 1980), in Germany (EGGERS-SCHUMACHER, 1987; GRUPPE, 1988; TOMIUK, 1980, 1987; TOMIUK and WÖHRMANN, 1983; TOMIUK *et al*., 1979; WÖHRMANN and HALES, 1989), in Great Britain (BAKER, 1978, 1979; BERANEK, 1974; BLACKMAN, 1979; BROOKES and LOXDALE, 1987; FFRENCH-CONSTANT *et al*., 1988; FURK, 1979; LOXDALE *et al*., 1983), in Japan (TAKADA, 1979), and in the USA (STEINER *et al*., 1985). Hereby we refer especially to the work of GRUPPE. He succeeded in distinguishing electrophoretically subspecies of *Myzus cerasi* (F.).

A special problem represent the so-called "black aphids" of the *Aphis fabae* group. Morphological methods to separate the taxa, which partly spread important plant pathogenic viruses, were often tried (DE FLUITER, 1949; FRANSSEN, 1927, 1931; HEIE, 1986; JACOB, 1945; JANISCH, 1926; JONES, 1942; STROYAN, 1984). Nevertheless, until today, it is impossible to distinguish exactly all the members of the *Aphis fabae* group *s.str.* Host plant tests (very time consuming), that were made e.g. by JANISCH (1926), IGLISCH (1968), MÜLLER (1982), and THIEME (1987) were sometimes more successful.

BERANEK (1974), FURK (1979), ODERMATT (1981), TOMIUK (1980, 1987), and TOMIUK *et al*. (1979) made electrophoretic studies with at least one or several members of the *Aphis fabae* complex, though they did not succeed in distinguishing all taxa of the group. This paper deals with our own electrophoretic results that could be obtained after some years of intensive work.

2 Material and methods

The material used in this work is listed in Table 1. For the *A. fabae* group *s.str.*, the ability of the collected aphids of settling special host plants have been tested in most cases, and clones have been isolated. Specimens destined for mounting were stored in ethanol (80 %) and then treated according to HEINZE (1952). Samples for electrophoresis were stored at -30 °C. Supernatant fractions were prepared for electrophoresis from homogenates of 20 adult individuals of the same clone or the same isolated colony. The enzymes were separated at 4 °C during the appropriate time on vertical starch gels (SIGMA, 47 g/500 ml buffer), using standard procedures described in detail by AYALA *et al*. (1972), BREWER (1970), HARRIS and HOPKINSON (1976-1978), RICHARDSON *et al*. (1986), and SHAW and PRASAD (1970). The theory of the electrophoretic method is discussed e.g. by FERGUSON (1980), HARRIS and HOPKINSON (1976-1978), and RICHARDSON *et al*. (1986).

Table 1. **List of taxa investigated**
The members of the *A. fabae* group *s.str*. are printed in bold

Taxa	Number of samples	Number of populations	Origin*	References+
Aphis armata Hausmann, 1802	9	5	CH	M, I, S
Aphis barberae Robinson, 1980	10	4	CA	H, S
Aphis cacaliasteris Hille Ris Lambers, 1947	6	2	CH	I
Aphis euonymi Fabricius, 1775	9	4	CH	H, I, M, S
Aphis fabae cirsiiacanthoidis Scopoli, 1763	41	15	CH, LI	H, I, M, S
Aphis f. fabae Scopoli, 1763	16	4	CH	H, I, M, S
Aphis f. mordwilkoi Börner & Janisch, 1922	59	12	CH	H, M, S
Aphis f. philadelphi Börner, 1921	8	2	CH	M
Aphis f. solanella Theobald, 1914	21	10	CH	H, I, M, S
Aphis hederae Kaltenbach, 1843	53	6	CH, IT	I, S
Aphis ilicis Kaltenbach, 1843	5	2	CH	H, I, S
Aphis janischi (Börner, 1940)	6	3	CH	H?
Aphis lantanae Koch, 1854	8	4	CH	I
Aphis newtoni Theobald, 1927	8	2	CH	H, I, S
Aphis rumicis Linnaeus, 1758	17	5	CH	I, S
Aphis sambuci Linnaeus, 1758	21	6	CH	I
Aphis tripolii Laing, 1920	8	2	DE	I
Aphis vaccinii (Börner, 1940)	16	7	CH	S?
Aphis veratri Walker, 1852	16	4	CH	
Aphis viburni Scopoli, 1763	4	1	CH	H, I, S

* CA = Canada, CH = Switzerland, DE = Germany, LI = Liechtenstein, IT = Italy
\+ Authors who put the concerned taxon into the *Aphis fabae* or "black aphid" group:
H = HEIE, 1986; I = IGLISCH, 1970; M = MÜLLER and STEINER, 1990; S = STROYAN, 1984
No material could be obtained from the following taxa: *Aphis brohmeri* Börner, 1952 (H, I, S), *Aphis epipactis* Theobald, 1927 (S), ***Aphis f. eryngii*** E.E. Blanchard, 1923 (H), *Aphis podagrariae* Schrank, 1801 (H, I, S), and *Aphis pseudolysimachiae* Heikinheimo, 1978 (H).

The 17 isozymes assayed were the following ones: Acid phosphatase~ (ACP EC 3.1.3.2), Aspartate aminotransferase° (GOT EC 2.6.1.1), Creatine kinase* (CK EC 2.7.3.2), Esterases° (EST-2, EST-3, EST-4, and EST-5 EC 3.1.1.1/2/8), Glucose-phosphate isomerase° (GPI EC 5.3.1.9), Glycerol-3-phosphate dehydrogenase~ (αGPD EC 1.1.1.8), Hexokinase* (HK-1 EC 2.7.1.1), Isocitrate dehydrogenase° (IDH EC 1.1.1.42), Leucine aminopeptidase° (LAP-1 and LAP-2 EC 3.4.11.1), Malic enzyme° (ME EC 1.1.1.40), Phosphoglucomutase* (PGM EC 2.7.5.1), Pyruvate kinase° (PK EC 2.7.1.40), and Sorbitol dehydrogenase~ (SORDH EC 1.1.1.14).

Three buffer systems have been used:

*N-(3-aminopropyl)-morpholine-citrate, pH 7.0, at 9 V/cm for 6 h. Stock solution: 200 mM Citric acid, adjusted to the desired pH with N-(3-aminopropyl)-morpholine; electrode: 1 in 10 dilution, gel: 1 in 200 dilution (CLAYTON and TRETIAK, 1972, modified).

°Tris-borate-$MgCl_2$, pH 8.8, at 12 V/cm for 3 and 4 h, respectively. Stock solution: 1.3 M Tris, 713 mM Boric acid, 60 mM NaOH and 10 mM $MgCl_2$; electrode: 1 in 10 dilution, gel: 1 in 100 dilution, additional 1 mM $MgCl_2$/l.

~Tris-borate, pH 8.0, at 20 V/cm for 5 h. Stock solution: 150 mM Tris and 220 mM Boric acid; electrode: 1 in 10 dilution, gel: 1 in 100 dilution (SHAW and PRASAD, 1970, modified).

Table 2. **Electromorphs of seventeen loci for all taxa investigated**
The electromorphs determining a species are printed in bold

Enzymes Taxa	LAP–2	CK	EST–2	αGPD	HK–1	GOT	IDH	LAP–1	ME	PK	EST–3	EST–4	EST–5	GPI	PGM	ACP	SORDH
A. armata	100	100	100	100	100	100	101	100	100	100	–	99	100	100	100	100	101
A. cacaliasteris	100	99	101	100	99	100	101	99	100	100	–	–	**91**	100	100	106	**99**
A. euonymi	100	100	100	100	100	100	101	100	100	100	–	100	100	101	100	100	100
A. f. cirsiiacanthoidis	100	100	100	100	100	100	101	100	100	100	–/100	100	100	100	100	100	101
A. f. fabae	100	100	100	101	100	100	101	100	100	100	–	99	100	101	100	100	101
A. f. mordwilkoi	100	100	100	100	100	100	101	100	100	100	–/100	–/100	100	101	100	100	101
A. f. philadelphi	100	100	100	101	100	100	101	100	100	101	–	100	100	101	100	100	101
A. f. solanella	100	100	–/100	100	100	100	100	100	100	100	100	99	100	100	100	100	101
A. hederae	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
A. ilicis	100	100	100	100	100	101	**102**	100	100	100	–	100	100	101	100	**101**	101
A. lantanae	100	100	–	100	100	101	101	99	100	100	100	–	100	99	**96**	98	**102**
A. newtoni	100	100	101	101	100	100	101	100	100	100	–	100	–	101	100	100	101
A. rumicis	100	100	100	101	99	101	101	100	**93**	99/100	–	100	–	100	100	100	101
A. sambuci	100	101	–	100	100	**104**	101	99	100	100	**99**	–	**106**	98/100	**97**	98	**98**
A. tripolii	100	99	100	**–**	**–**	100	100	100	**98**	100	100	**104**	100	99	**98**	**103**	100
A. vaccinii	100	101	100	100	100	100	101	100	100	100	–	100	100	101	100	100	101
A. veratri	100	100	–	100	99	101	101	**101**	100	99	**98**	–	–	101	100	106	100
A. viburni	**96**	100	100	101	100	100	101	100	100	100	–	100	100	100	100	100	100

After the electrophoretic run, the gels were cut horizontally and stained by very specific enzyme-substrate reactions. For each enzyme the designation of the electromorphs (Table 2) was made by comparison to the most frequent variant of *Aphis hederae*, to which was attributed the index 100. The other electromorphs were calculated by using the formula for the relative mobility index ($RMI_{X,i}$) which has been defined by LAMPEL and BURGENER (1987) and ZURWERRA *et al*. (1986, 1987). Using this method effects due to inhomogenities in starch gels could be reduced, and it was possible to compare the different analyses. To estimate NEI's genetic identities between the taxa, the correlation coefficients $\bar{I}$ as defined by NEI (1972) were calculated over all loci, comparing the populations in pairs. The results are presented graphically in the form of a dendrogram according to the unweighted pair-group arithmetic average (UPGMA) clustering analysis (SNEATH and SOKAL, 1973), which has been computed on a Macintosh, using SYN-TAX IV (PODANI, 1990) data analysis program.

3 Results

3.1 Electrophoretic data

Electromorphs of all loci investigated are listed in Table 2 in order of increasing interspecific variability of each taxon. Relatively conservative enzymes (i.e. enzymes with low interspecific variation) are presented on the left side, while enzymes with high interspecific variation are arranged on the right side. The coefficients of genetic similarity $\bar{I}$ are shown in the correlation matrix in Table 3. The result of the UPGMA clustering analysis is presented as dendrogram in Fig. 1. It can be seen that the values of genetic similarity $\bar{I}$ vary between 0.35 and 0.97. For the lachnid genus *Cinara* LAMPEL and BURGENER (1987) found a comparable congeneric span of 0.22 to 0.99 with 13 loci investigated. In our experiments the level to distinguish species is 0.93 with exception of *A. sambuci* and *A. rumicis* which showed an intraspecific $\bar{I}$-value of 0.93 as well. LAMPEL and BURGENER could separate species from 0.90 downwards. MENKEN and ULENBERG (1987) erected a table of sibling species pairs of different arthropods (mostly insects). Hence it follows that their $\bar{I}$-values vary within a range from 0.211 up to 0.979. Conspecific populations have a genetic identity "above 0.85, with the great majority above 0.95" (MENKEN, 1989; MENKEN and ULENBERG, 1987), and subspecies range between 0.78 and 0.98 (cf. Fig. 2 in MENKEN and ULENBERG, 1987). Thus the transitions between the different taxonomic ranks are very flexible and often overlapping. It must be established for each taxonomic group to investigate on which levels the taxa can be separated. Other groups can be looked only as a general approximation.

3.2 General remarks on the enzymes investigated

ACP and SORDH are very specific monomeric enzymes, because for both five electromorphs could be noticed. According to BERANEK (1974) ACP showed no variation within the *Aphis fabae* group *s.str*.

EST: As described by FURK (1979) and TOMIUK (1980), five loci were realized. All isozymes were monomers. Due to another buffer system used, EST-5 ran instead to the anode to the cathode. Since EST-1 showed a very weak activity, it was not evaluated. Because of missing bands, the loci EST-2, EST-3, EST-4, and EST-5 sometimes could not be detected. Therefore the presence of null alleles was suspected, which "may be quite common for multiple-locus enzyme complexes (e.g. esterases)" (RICHARDSON *et al.*, 1986).To characterise the different enzymes, specific inhibitors as discussed in ARURKAR and KNOWLES (1968), AUGUSTINSSON (1968), and BERANEK (1974) have been used. In agreement with BERANEK, EST-1 was resistant to all inhibitors used. Thus its nature is unknown, but it could only be detected using 1-naphthyl-acetate as substrate. EST-2 and EST-3 have been identified as carboxylesterases (EC 3.1.1.1). They were detectable by using 1-naphthyl-acetate as well. EST-4 and EST-5 appeared only using 2-naphthyl-acetate as substrate. They have been slightly inhibited by EDTA and eserine, which could indicate the presence of aryl- (EC 3.1.1.2) or cholinesterases (EC 3.1.1.8).

Table 3. **Coefficients of genetic similarity (Ī-values)**
N: number of group

Taxa	N	*lan.*	*sam.* 1	*sam.* 2	*ili.*	*fab.*	*phi.*	*new.*	*cir.* 3	*cir.* 4	*arm.*	*euo.*	*mor.* 5	*mor.* 6	*mor.* 7	*vac.*	*hed.*	*sol.* 8	*sol.* 9	*vib.*	*rum.* 10	*rum.* 11	*ver.*	*cac.*	*tri.*
A. lantanae (lan.)		1.00	0.53	0.53	0.52	0.45	0.39	0.40	0.52	0.56	0.52	0.52	0.52	0.56	0.53	0.45	0.50	0.50	0.52	0.39	0.27	0.33	0.41	0.40	0.33
A. sambuci (sam.)	1		1.00	0.93	0.32	0.32	0.26	0.33	0.45	0.44	0.45	0.39	0.39	0.38	0.40	0.45	0.38	0.38	0.39	0.32	0.20	0.27	0.28	0.47	0.13
A. sambuci (sam.)	2			1.00	0.32	0.32	0.26	0.33	0.39	0.38	0.39	0.39	0.39	0.38	0.40	0.45	0.31	0.31	0.32	0.26	0.13	0.20	0.28	0.40	0.13
A. ilicis (ili.)					1.00	0.69	0.69	0.65	0.75	0.73	0.69	0.75	0.81	0.79	0.77	0.75	0.67	0.67	0.63	0.56	0.52	0.58	0.47	0.32	0.32
A. fabae fabae (fab.)						1.00	0.88	0.84	0.81	0.79	0.88	0.81	0.88	0.85	0.90	0.81	0.67	0.79	0.75	0.75	0.58	0.65	0.40	0.39	0.39
A. f. philadelphi (phi.)							1.00	0.84	0.81	0.79	0.75	0.81	0.88	0.85	0.84	0.81	0.67	0.67	0.63	0.75	0.65	0.65	0.40	0.32	0.32
A. newtoni (new.)								1.00	0.77	0.75	0.71	0.77	0.84	0.81	0.80	0.77	0.63	0.63	0.65	0.71	0.60	0.67	0.41	0.47	0.27
A. f. cirsiiacanthoidis (cir.)	3								1.00	0.97	0.94	0.88	0.94	0.91	0.90	0.88	0.85	0.85	0.81	0.81	0.65	0.71	0.40	0.52	0.39
A. f. cirsiiacanthoidis (cir.)	4									1.00	0.91	0.85	0.91	0.94	0.88	0.85	0.88	0.88	0.85	0.79	0.63	0.69	0.39	0.50	0.44
A. armata (arm.)											1.00	0.81	0.88	0.85	0.90	0.81	0.79	0.91	0.88	0.75	0.58	0.65	0.40	0.52	0.39
A. euonymi (euo.)												1.00	0.94	0.91	0.90	0.88	0.85	0.73	0.69	0.81	0.52	0.58	0.53	0.45	0.45
A. f. mordwilkoi (mor.)	5												1.00	0.97	0.97	0.94	0.79	0.79	0.75	0.75	0.58	0.65	0.47	0.45	0.39
A. f. mordwilkoi (mor.)	6													1.00	0.94	0.91	0.82	0.82	0.79	0.73	0.56	0.63	0.45	0.44	0.44
A. f. mordwilkoi (mor.)	7														1.00	0.90	0.75	0.81	0.77	0.71	0.53	0.60	0.48	0.47	0.40
A. vaccinii (vac.)																1.00	0.73	0.73	0.69	0.69	0.52	0.58	0.40	0.45	0.39
A. hederae (hed.)																	1.00	0.88	0.85	0.79	0.50	0.56	0.39	0.44	0.56
A. f. solanella (sol.)	8																	1.00	0.97	0.67	0.50	0.56	0.32	0.44	0.50
A. f. solanella (sol.)	9																		1.00	0.63	0.45	0.52	0.33	0.45	0.45
A. viburni (vib.)																				1.00	0.58	0.65	0.33	0.39	0.39
A. rumicis (rum.)	10																				1.00	0.93	0.48	0.33	0.20
A. rumicis (rum.)	11																					1.00	0.41	0.40	0.27
A. veratri (ver.)																							1.00	0.48	0.14
A. cacaliasteris (cac.)																								1.00	0.27
A. tripolii (tri.)																									1.00

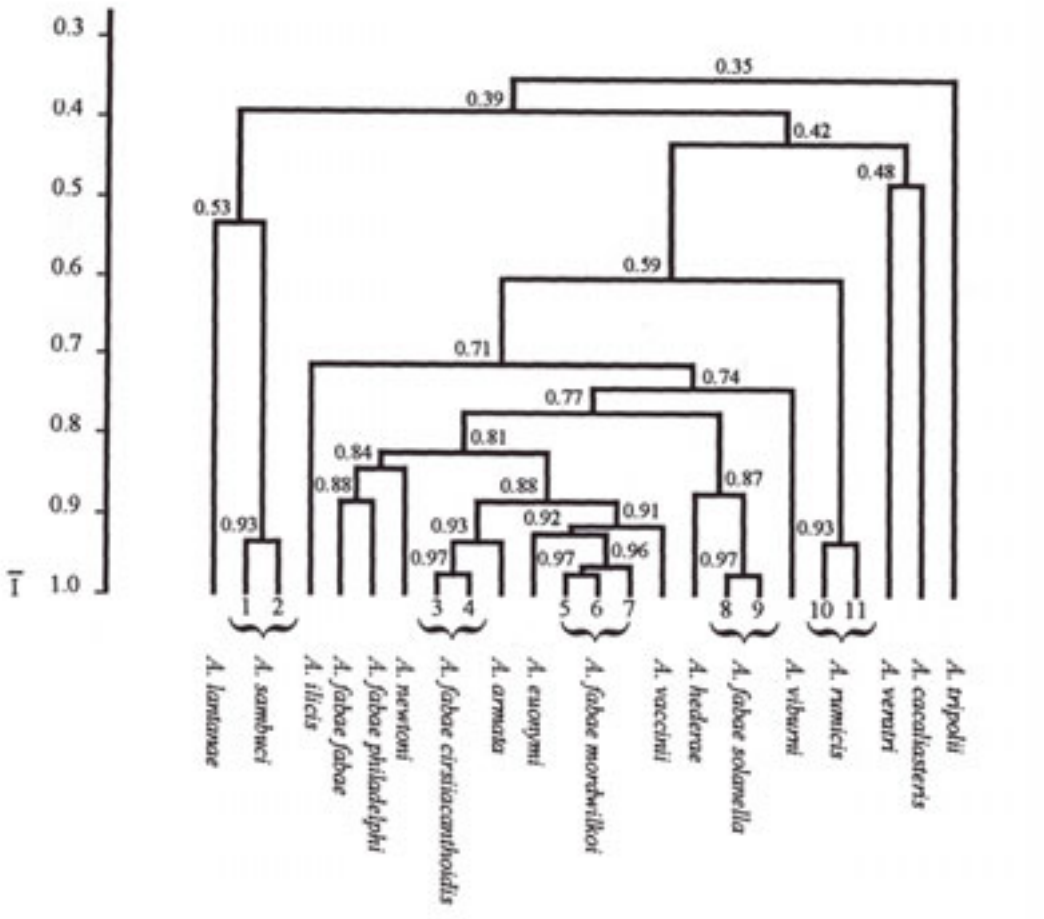
However, it was not possible to clear up this problem. BERANEK classified them as cholinesterases.

HK, IDH, PGM, and PK are enzymes with more than one locus. Nevertheless for each taxon only the fastest isozyme has been regarded, because the slower ones had often a weak activity. In agreement with TOMIUK (1980), the locus HK-2 is polymorphic and shows a great variability within each taxon. Therefore it was not considered. PGM showed similar banding patterns as in experiments of ODERMATT (1981), but due to different buffer systems, the results cannot be compared directly. In HK-1, IDH, and PK only three electromorphs were present, while in PGM four could be detected.

CK, ME, GOT, αGPD, and GPI were all clearly monomeric. The first four showed three, the last four electromorphs.

LAP: Two monomeric loci were realized. LAP-1 showed a middle variability with three electromorphs. In contrast, LAP-2 was the sole enzyme with only two electromorphs. In *Aphis viburni* the LAP-2 electromorph had a relative mobility of 96. In all other taxa it was 100.

Fig. 1. Dendrogram of the eighteen taxa investigated. Ī: NEI's genetic similarity, 1-11: number of group.



3.3 *Aphis fabae* group *s.str.*

The following seven investigated taxa belong to this complex (IGLISCH, 1968, 1970; MÜLLER, 1982; MÜLLER and STEINER, 1990, combined): *Aphis armata*, *A. euonymi*, *A. fabae cirsiiacanthoidis*, *A. f. fabae*, *A. f. mordwilkoi*, *A. f. philadelphi*, and *A. f. solanella*. According to our investigations *A. barberae* and *A. janischi* are synonyms of *A. f. mordwilkoi* and *A. f. cirsiiacanthoidis*, respectively, and therefore they are treated in this chapter as well.

3.3.1 Aphis armata

It is a black, oligophagous, holocyclic species on *Digitalis* spp. We found this aphid on *D. purpurea* L. and *D. lutea* L. Morphologically *A. armata* could be well separated from *A. solanella* (MÜLLER and STEINER, 1989; STROYAN, 1984). However, it is not possible to distinguish it by morphologic characters from other taxa of the *A. fabae* complex. Electrophoretically this species can be easily separated from all taxa investigated. As between *A. armata* and *A. f. cirsiiacanthoidis* the Ī-value is 0.93, one might question whether the two taxa are species or only subspecies or biotypes (cf. Electrophoretic data). Since *A. armata* is reproductively more or less isolated by host limitation from *A. f. cirsiiacanthoidis* and morphologically indistinguishable, we call them sibling species (cf. MÜLLER, 1990; MÜLLER and STEINER, 1990).

3.3.2 Aphis euonymi

This species is dark brown and lives with few exceptions monoeciously on *Euonymus europaea* L. It is well distinguishable by morphologic (HEIE, 1986; MÜLLER, 1969, 1970; MÜLLER and STEINER, 1986; STROYAN, 1984) and allozymic characters. Hybridization experiments showed, that cross-breeding between *A. euonymi* and some other members of the *A. fabae* group *s.str.* (IGLISCH, 1968; MÜLLER, 1979, 1982) often yielded fertile fundatrices. MÜLLER (1982) has drawn the conclusion to award the "aphids in question at the utmost the position of subspecies", though in comparison to their parents some of the hybrids showed a decreased fitness. He remarked himself that the "sensory host-finding reactions of the hybrids are improper thus effecting elimination of many alatae even among the emigrantes", and in 1986 he wrote that the "hybrid lineages are viable at first nevertheless, but are greatly impeded by post-zygote isolating mechanisms. This proves true especially for combinations with *evonymi*". The hybrids of these sympatric populations are partly reproductively isolated by postzygous or postmating mechanisms. Especially gametic mortality in which sperm transfer occurs but fertilisation fails (MÜLLER, 1978, 1985), hybrid weakness (cf. above), and F_2 breakdown in which the F_2 generation is weak or sterile (MÜLLER, 1985) can be observed. Therefore and according to morphologic data and above all to the results of our electrophoretic analyses (the Ī-values between *A. euonymi* and *A. f. fabae*, *A. f. cirsiiacanthoidis*, *A. f. mordwilkoi*, and *A. f. solanella* are 0.81, 0.88, 0.92 and 0.77, respectively), we raise *A. euonymi* to the species level as it was already decided by EASTOP and HILLE RIS LAMBERS (1976).

3.3.3 Aphis barberae, *A. fabae cirsiiacanthoidis*, *A. f. fabae*, *A. f. mordwilkoi*, *A. f. philadelphi*, *A. f. solanella*, and *A. janischi*

Until today, it is impossible to distinguish exactly these taxa by morphologic criteria. As described above, some hybridizations between other members of the *A. fabae* group *s.str.* and *A. euonymi* yielded to fertile fundatrices. Reciprocal cross-breeding between *A. f. cirsiiacanthoidis*, *A. f. fabae*, and *A. f. solanella* (IGLISCH, 1968; MÜLLER 1979, 1982) yielded partly sterile eggs or no eggs at all, which indicates that a genetic isolation of these sympatric taxa has already taken or takes place (cf. above). Therefore and especially according to our electrophoretic results, we believe that it is acceptable to raise the five taxa *A. f. cirsiiacanthoidis*, *A. f. fabae*, *A. f. mordwilkoi*, *A. f. philadelphi*, and *A. f. solanella* to species. With Ī-values between 0.77 and 0.88 electrophoretically the mentioned taxa are "good species" (cf. LAMPEL and BURGENER, 1987). Between the "good" species *A. vaccinii* on the one side and *A. mordwilkoi* and *A. euonymi* on the other side the Ī-value is 0.91 (see Fig. 1) and therefore remarkably higher than between the above

mentioned five taxa. Five other taxa share the same cluster with the *A. fabae* group *s.str.*: *A. newtoni*, *A. armata*, *A. euonymi*, *A. vaccinii*, and *A. hederae*. *A. newtoni* is standing close to *A. fabae* and *A. philadelphi*. A further sub-group is formed by *A. armata* together with *A. cirsiiacanthoidis*. *A. euonymi* and *A. vaccinii* are located near *A. mordwilkoi*, and *A. hederae* is near *A. solanella*.

Samples from *Cirsium oleraceum* showed the same electrophoretic properties as *A. cirsiiacanthoidis*. They have been members of group 3 (cf. Table 3 and Fig. 1) of *A. cirsiiacanthoidis* together with findings from *Cirsium arvense*, *C. vulgare*, *Rumex crispus*, *Papaver rhoeas*, *Dahlia* sp., *Solanum nigrum*, *Digitalis purpurea*, and *Angelica sylvestris*. Therefore we give *A. janischi* the state of a synonym of *A. cirsiiacanthoidis*. HEIE (1986) already mentioned that "future studies may show that *janischi* is a synonym of *fabae*, which apparently is a more variable species than suggested by BÖRNER". Specimens in group 4 have been collected from *Cirsium arvense*, *Veratrum album*, and *Rumex crispus*. Rarely this species is also feeding on *Solanum*: One population could be found on this plant (cf. *A. solanella* below, and chapter Transfer experiments).

With Ī-values between 0.88 and 0.77 *A. fabae* differs clearly from the other members of the *A. fabae* group *s.str*. The nearest but well distinguishable taxon to *A. fabae* is *A. philadelphi*.

The *A. barberae* specimens on nasturtium (*Tropaeolum* sp.) provided from Canada by ROBERT J. LAMB were not distinguishable from *A. mordwilkoi* by electrophoretic analysis. Electrophoretically they shared group 5 (cf. Table 3 and Fig. 1) with findings from *Aegopodium podagraria*, *Aethusa cynapium*, *Anthriscus sylvestris*, *Arctium lappa*, *A. nemorosum*, *Cynara cardunculus scolymus*, *Tropaeolum majus*, *T. minus*, and *Viburnum opulus*. In transfer experiments they showed quite the same behaviour as *A. mordwilkoi* (cf. Table 5, chapter transfer experiments). So *A. barberae* is regarded as a synonym of *A. mordwilkoi*. STROYAN (1984) as well supposed that "the available evidence points very strongly to this (i.e. *A. barberae*) being a synonym of *mordvilkoi*". Group 6 consists of only one finding from *Epipactis palustris*, and group 7 of two specimens from *Viburnum opulus*. Concerning the very problematic species *Aphis epipactis* which is by STROYAN (1984) thought to be eventually *A. viburni* we add another possibility: It could be a strain of *A. mordwilkoi* as we found this species on *Viburnum opulus*. See also Table 5 (Host plants and transfer experiments).

Fundatrices of *A. philadelphi* from *Philadelphus coronarius* have been individually reared on the same plant, and apterous viviparous females from these clones have been later on used for morphologic and electrophoretic investigations and for host plant tests. Electrophoretically they could be separated easily from other species of the *A. fabae* complex *s.str*.

For *A. solanella* as well it was not difficult to distinguish it from other *A. fabae s.str*. species by electrophoresis. Group 8 (cf. Table 3 and Fig. 1) consisted of findings from *Solanum nigrum*, *Cirsium arvense*, *C. palustre*, and group 9 of one sample from *S. nigrum*.

Table 4 shows the proposition of a revised taxonomic nomenclature of the *Aphis fabae* group *s.str*.

Table 4. **Revised taxonomic nomenclature of the *Aphis fabae* group *s.str*.**

used name	revised name
Aphis armata Hausmann, 1802	no change
Aphis barberae Robinson, 1980	*Aphis mordwilkoi* Börner & Janisch, 1922
Aphis euonymi Fabricius, 1775	no change
Aphis fabae cirsiiacanthoidis Scopoli, 1763	*Aphis cirsiiacanthoidis* Scopoli, 1763
Aphis fabae fabae Scopoli, 1763	*Aphis fabae* Scopoli, 1763
Aphis fabae mordwilkoi Börner & Janisch, 1922	*Aphis mordwilkoi* Börner & Janisch, 1922
Aphis fabae philadelphi Börner, 1921	*Aphis philadelphi* Börner, 1921
Aphis fabae solanella Theobald, 1914	*Aphis solanella* Theobald, 1914
Aphis janischi (Börner, 1940)	*Aphis cirsiiacanthoidis* Scopoli, 1763

3.4 *Aphis fabae* group *s.l.*

Most species of the *A. fabae* group *s.l.*, i.e. *Aphis cacaliasteris*, *A. ilicis*, *A. lantanae*, *A. rumicis*, *A. sambuci*, *A. tripolii*, *A. veratri*, and *A. viburni*, are very easily detectable by electrophoresis because they have at least one single electromorph that they do not share with any other species investigated (see Table 2). Loci that generate such isozymes are called diagnostic loci (EGGERS-SCHUMACHER, 1987; MENKEN and ULENBERG, 1987). In agreement with EGGERS-SCHUMACHER the ME allele could be detected for *A. rumicis* as being diagnostic.

Group 10 and 11 (cf. Table 3 and Fig. 1) of *A. rumicis* differed only by having two different PK electromorphs, 99 and 100, respectively. Three populations belonged to group 10 and two to group 11. Like *A. ilicis* and *A. viburni*, *A. rumicis* stands rather alone, having no closer connection with other members of the *A. fabae* complex.

Group 2 of *A. sambuci* consisted of one finding with a GPI electromorph 98, whereas all other samples had the electromorph 100. The greenish-black so-called *A. sambuci sambuci* and the olive-brown so-called *A. sambuci picta* subspecies (IGLISCH, 1969) from *Sambucus nigra* L. were not distinguishable by electrophoresis. Together with *A. lantanae* this species forms the most isolated group.

A. tripolii is a green species of the *A. fabae* complex, monophagous on *Aster tripolium* L. It had four diagnostic alleles. Two bands (αGPD and HK-1) were absent, a fact which could not be observed in any other species investigated. With the lowest $\bar{I}$-value of 0.35 this species is strongly isolated from all other members of the group as well. Therefore we exclude *A. tripolii* from the *A. fabae* group *s.l.* Already IGLISCH (1970), who put *A. tripolii* into the *A. fabae* group *s.l.*, had some doubts about its grouping in the *A. fabae* kinship.

Even by recognized aphidologists like BÖRNER himself, *A. veratri* and *A. cirsiiacanthoidis*, which also lives on *Veratrum* (group 4 on Fig. 1), have been mistaken (MÜLLER and HORATSCHEK, 1980). However, by electrophoresis these two species are very easily recognizable having a genetic identity of only 0.42. *A. veratri* forms together with *A. cacaliasteris*, a black oligophagous species on Asteraceae (LAMPEL, 1984), a very isolated subgroup of the *A. fabae* complex - the two species being rather isolated themselves from each other. The most isolated subgroup ($\bar{I}$ = 0.39) is formed by *A. sambuci* and *A. lantanae*.

Both *A. newtoni* and *A. vaccinii* are located in the *A. fabae* group *s.str.* cluster (see above). Whereas *A. newtoni* shares the rare electromorph 101 of EST-2 only with *A. cacaliasteris* and the null allele of EST-5 with *A. rumicis*, respectively, *A. vaccinii* shows together with *A. sambuci* the same CK electromorph.

By definition *A. hederae* is the only species that has an $RMI_{x,i}$-value of 100 for all loci. It is closely related to *A. solanella* within the *A. fabae s.str.* group.

3.5 Biochemical key* to the species of the *Aphis fabae* group

* Adapted from AVISE (1974), BERLOCHER (1980), and MENKEN and ULENBERG (1986). Twelve genetic loci have been used as marker and *Aphis hederae* as standard.

1	ACP mobility same or slower than standard	5
-	ACP mobility faster than standard	2
2(1)	GOT mobility same as standard	3
-	GOT mobility faster than standard	4
3(2)	LAP-1 mobility slower than standard	*A. cacaliasteris*
-	LAP-1 mobility same as standard	*A. tripolii*
4(2)	LAP-1 mobility same as standard	*A. ilicis*
-	LAP-1 mobility faster than standard	*A. veratri*
5(1)	ACP mobility slower than standard	6
-	ACP mobility same as standard	7
6(5)	SORDH mobility slower than standard	*A. sambuci*
-	SORDH mobility faster than standard	*A. lantanae*
7(5)	HK-1 mobility slower than standard	*A. rumicis*
-	HK-1 mobility same as standard	8
8(7)	SORDH mobility same as standard	9
-	SORDH mobility faster than standard	10
9(8)	LAP-2 mobility slower than standard	*A. viburni*
-	LAP-2 mobility same as standard	*A. euonymi*
10(8)	CK mobility same as standard	11
-	CK mobility faster than standard	*A. vaccinii*
11(10)	αGPD mobility same as standard	14
-	αGPD mobility faster than standard	12
12(11)	EST-2 mobility same as standard	13
-	EST-2 mobility faster than standard	*A. newtoni*
13(12)	EST-4 mobility slower than standard	*A. fabae*
-	EST-4 mobility same as standard	*A. philadelphi*
14(11)	EST-4 mobility slower than standard	15
-	EST-4 mobility same as standard	16
15(14)	IDH mobility same as standard	*A. solanella*
-	IDH mobility faster than standard	*A. armata*
16(14)	GPI mobility same as standard	*A. cirsiiacanthoidis*
-	GPI mobility faster than standard	*A. mordwilkoi*

3.6 Transfer experiments

In transfer experiments always one viviparous female has been placed on the test plant, to impede that tests were carried out with mixed populations. To prevent influences due to the developmental stage of the host plants, all tests have been realized on young non flowering plants (MÜLLER, 1982; THIEME, 1985, 1986, 1987). The experiments have been accomplished under artificial conditions in climatic chambers (6 h dark, 18 ˚C, 80 % rel. hum., and 18 h light, 25 ˚C, 60 % rel. hum., respectively), using cellophane bags as cages. All tests carried out are listed in Table 5.

3.6.1 Aphis armata

In agreement with IGLISCH (1968), JACOB (1947), MÜLLER and STEINER (1989), and THIEME (1988, 1989) this oligophagous species on *Digitalis* spp. rejected in transfer trials all marking

hosts of the main members of the *A. fabae* group *s.str*., which indicates that the "true" *A. armata* has been under consideration.

Table 5. **Host plants and transfer experiments with members of the *Aphis fabae* group *s.str.***

+: positive infestation, (+): positive infestation with reduced fitness of the offspring, –: no infestation, ₀: not tested

Taxa of *Aphis fabae* group *s.str.*	Host plants	Test plants										
		D.pur	*C.arv*	*C.ole*	*E. eur*	*V.fab*	*B.vul*	*T.maj*	*A.lap*	*E.pal*	*V.opu*	*S.nig*
A. armata	*Digitalis lutea* L.	+	–	₀	₀	–	₀	–	₀	₀	₀	–
	Digitalis purpurea L. (*D.pur*)	+	–	₀	₀	–	₀	–	₀	₀	₀	–
A. cirsiiacanthoidis	*Angelica sylvestris* L.	₀	+	₀	₀	₀	₀	–	₀	₀	₀	–
	Cirsium arvense (L.) Scop. (*C.arv*)	₀	+	(+)	+	–	₀	–/(+)	₀	+	+	–/+
	Cirsium oleraceum (L.) Scop. (*C.ole*)	₀	+/–	+	₀	₀	₀	+	₀	₀	₀	₀
	Cirsium vulgare (Savi) Ten.	₀	–	₀	₀	₀	₀	+	₀	₀	+	–
	Dahlia sp.	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀
	Digitalis purpurea L.	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀
	Papaver rhoeas L.	₀	₀	₀	₀	(+)	₀	+	₀	₀	₀	–
	Solanum nigrum L. emend. Miller (*S.nig*)	₀	+	₀	₀	₀	₀	₀	₀	₀	₀	(+)
	Rumex crispus L.	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀
	Veratrum album L.	₀	+	₀	₀	–	₀	–	₀	₀	₀	–
A. euonymi	*Euonymus europaea* L. (*E.eur*)	₀	–	₀	₀	(+)	₀	₀	₀	₀	₀	–
A. fabae	*Beta vulgaris* L. (*B.vul*)	₀	–	₀	+	+	+	–	₀	+	(+)	–
	Chenopodium murale L.	₀	₀	₀	₀	+	₀	₀	₀	₀	₀	₀
	Phaseolus vulgaris L.	₀	–	₀	₀	+	+	–	₀	+	₀	–
	Vicia faba L. (*V.fab*)	₀	–	₀	+	+	+	–	₀	+	(+)	–
A. mordwilkoi	*Aegopodium podagraria* L.	₀	₀	₀	₀	₀	₀	+	₀	₀	₀	₀
	Aethusa cynapium L.	₀	₀	₀	₀	₀	₀	+	₀	₀	₀	₀
	Anthriscus sylvestris (L.) Hoffm.	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀
	Arctium lappa L.	₀	–	₀	₀	–/+	₀	+	+	+	+	–
	Arctium nemorosum Lejeune	₀	₀	₀	₀	₀	₀	+	₀	₀	₀	₀
	Cynara cardunculus scolymus (L.) Beger	₀	–	₀	₀	–	₀	+	₀	₀	+	–
	Epipactis palustris (L.) Crantz (*E.pal*)	₀	–	₀	₀	–	₀	+	₀	+	+	₀
	Tropaeolum majus L. (*T.maj*)	₀	–	₀	+	–/+	₀	+	+	+	+	–
	Tropaeolum minus L.	₀	₀	₀	₀	₀	₀	+	₀	₀	₀	₀
	Viburnum opulus L. (*V.opu*)	₀	–	₀	₀	–	₀	+/–	₀	+	+	₀
A. philadelphi	*Philadelphus coronarius* L.	₀	+	₀	₀	–	₀	+	₀	₀	₀	–
A. solanella	*Cirsium arvense* (L.) Scop.	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀	+/–
	Cirsium palustre (L.) Scop.	₀	₀	₀	₀	₀	₀	₀	₀	₀	₀	–
	Solanum nigrum L. emend. Miller	₀	–/+	₀	₀	₀	₀	₀	₀	₀	₀	+

3.6.2 Aphis cirsiiacanthoidis

IGLISCH (1968), MÜLLER (1982, 1985), and THIEME (1988) had always unique results in host plant tests with this species. It accepted *Cirsium arvense* (*C. vulgare* in IGLISCH's experiments) and rejected *Vicia faba* and *Solanum nigrum*. But already LAMPEL (1980) showed, that black aphids from *C. arvense* and *C. vulgare* have been able to infest *S. nigrum*. THIEME (1985, 1987) pointed out, that in special stages of development of the test plant (e.g. fruiting stage) *A. cirsiiacanthoidis* could colonise *S. nigrum*. In our tests some *A. cirsiiacanthoidis* populations have been even able to settle young *Solanum*, and one open air sample originated from a flowering and fruiting *Solanum* plant (cf. *A. solanella* below). The latter accepted *Cirsium arvense* as host plant! Experiments with findings from *Veratrum album* totally agree with tests carried out by MÜLLER and HORATSCHEK (1980). Samples from *Cirsium oleraceum* ("*A. janischi"*) and *C. vulgare* both accepted *Tropaeolum majus*. Also MÜLLER (1985) and THIEME (1988) could show that this plant has been infested by *A. cirsiiacanthoidis*. Surprisingly samples from *C. oleraceum* only partly accepted *C. arvense*, and those from *C. vulgare* did not accept it at all (cf. Discussion). Specimens from *Papaver rhoeas* showed a positive infestation with reduced fitness on *Vicia faba*, accepted *T. majus* and rejected *S. nigrum.* On *Cirsium* they have not been tested, but electrophoretically they were clearly *A. cirsiiacanthoidis*.

3.6.3 Aphis euonymi

According to MÜLLER (1975) *A. euonymi* lives with few exceptions (e.g. *Valeriana officinalis* L.) on *Euonymus europaea* and has weakly accepted *Vicia faba* in our trials. It rejected *Cirsium arvense* and *Solanum nigrum*.

3.6.4 Aphis fabae

Transfer tests showed the same results as known from former experiments (e.g. JANISCH, 1926; MÜLLER, 1982). In addition, this species accepted *Epipactis palustris*, on which also *A. mordwilkoi* could be found. MÜLLER (1985) and THIEME (1987) reported, that *A. fabae* accepted *Arctium lappa*, *Tropaeolum majus*, and *Solanum nigrum* (only THIEME) as well, host plants of *A. mordwilkoi* and *A. solanella*, respectively. But later in THIEME's experiments (THIEME, 1988) *A. fabae* could settle only *A. lappa*.

3.6.5 Aphis mordwilkoi

From BÖRNER and JANISCH (1922) described as a new species, it was from BÖRNER (1952) himself given the rank of a synonym of *A. fabae*. According to JANISCH (1926), MÜLLER (1988), and THIEME (1988) *A. mordwilkoi* rejected also in our tests the marking hosts of *A. cirsiiacanthoidis* and *A. fabae*, and according to MÜLLER (1982, 1988) and MÜLLER and STEINER (1990) also *Solanum nigrum*, the test plant of *A. solanella*. However, some samples have been capable to feed on *Vicia faba*. Our findings from *Cynara cardunculus scolymus* could be clearly identified by host plant tests and electrophoresis as *A. mordwilkoi*, whereas ROBERT and LE GALLIC (1991) identified their findings as *A. cirsiiacanthoidis*. *A. barberae* specimens (cf. ROBINSON, 1980) from Canada had identical electrophoretic properties, and in transfer experiments the same behaviour as *A. mordwilkoi*. LAMB (1980) has been able to observe the occurrence of *A. barberae* on *Cirsium arvense*. Maybe it was not *A. barberae* but *A. cirsiiacanthoidis*, so far not known from Canada. Unfortunately BARBER and ROBINSON (1980) did not test *A. barberae* on *Cirsium*.

3.6.6 Aphis philadelphi

This species has been described by BÖRNER (1921). Later on he gave this taxon the state of a synonym of *A. fabae* (BÖRNER, 1952). MÜLLER and STEINER (1990) have classified it as subspecies of *A. fabae*. According to BÖRNER and JANISCH (1922) and MÜLLER (1988) *A. philadelphi* rejected *Vicia faba*, and in agreement with MÜLLER (1988) it rejected *Solanum nigrum* and accepted *Cirsium arvense*. *Tropaeolum majus* has been accepted as well in our experiments. In tests carried out by BÖRNER (1921) and JANISCH (1926) it also accepted *Euonymus europaea* and *Viburnum opulus*. In JANISCH's experiments it did not accept *C. arvense*. IGLISCH (1968, 1972) could show that *A. cirsiiacanthoidis* and *A. solanella* have been able to infest permanently *Philadelphus coronarius*, the former has even been able to produce both sexual morphs and eggs. FRANSSEN (1931) found *A. fabae* on *Philadelphus*, which makes the confusion perfect. However, according to the electrophoretic results, our samples seem to be a "good" species.

3.6.7 Aphis solanella

In contrast to IGLISCH (1968), MÜLLER (1982, 1986, 1988), THIEME (1988), and THIEME and GOTTSCHALK (1983) this species seems to be rather common on *Cirsium* spp. Four of the ten populations investigated have been found on this plant genus (cf. *A. cirsiiacanthoidis* above). Already BÖRNER and JANISCH (1922), DE FLUITER (1949), and JANISCH (1926) indicated that *A. solanella* (called by them *A. evonymi*) can live on *Cirsium*, and in our tests too, some samples have been able to colonise *C. arvense*.

4 Discussion

All electrophoretic research work done until today with the *Aphis fabae* group was in different manners incomplete. Some examples shall illustrate this statement.

In the investigations of FURK (1979) most findings originated from *Vicia faba*. No transfer experiments have been carried out with samples from *Vicia*, and findings from other plants have been tested only on *V. faba*. According to our own experiments, *Aphis mordwilkoi* was partly capable to infest *V. faba* and some *A. cirsiiacanthoidis* samples could settle *Tropaeolum majus*. Thus it is not known, which species of the *A. fabae* group have been really investigated by FURK. Furthermore it is impossible to determine the taxa of the *A. fabae* complex with only two enzyme systems. Therefore this study must be considered as a preliminary work.

TOMIUK *et al*. (1979) investigated electrophoretically *Aphis sambuci*, *A. solanella*, *A. rumicis*, and *A. fabae*. Whereas it was possible to determine *A. sambuci*, the latter three species were not distinguishable. The material investigated has not been characterised sufficiently, because on *Solanum nigrum* not only *A. solanella* but also *A. cirsiiacanthoidis* can be found. According to THIEME (1988) the five following species of the *A. fabae* group *s.str*., *A. cirsiiacanthoidis*, *A. fabae*, *A. mordwilkoi*, *A. solanella*, and *A. euonymi* can be transferred on *Rumex obtusifolius* L. Therefore it is not clear at all, if really *A. rumicis* has been investigated. The given host plant list of *A. fabae* as well does not always guarantee the presence of the real *A. fabae*. Perhaps beside *A. fabae* the species *A. cirsiiacanthoidis*, *A. mordwilkoi*, *A. philadelphi*, or *A. euonymi* have been investigated.

TOMIUK (1980) made electrophoretic studies with *Aphis sambuci* and the *Aphis fabae* group (*A. euonymi*, *A. fabae*, *A. ilicis*, *A. rumicis*, *A. solanella*, *A. viburni*). He succeeded in distinguishing *A. sambuci* from the *A. fabae* group. Within the *A. fabae* complex he could differentiate only two groups of species. Furthermore it is quite possible, that beside the species mentioned by him he used in his tests also *A. cirsiiacanthoidis*, *A. mordwilkoi*, or *A. philadelphi* without knowing it.

ODERMATT (1981) succeeded in her experiments with only two enzyme systems to distinguish *Aphis cirsiiacanthoidis*, *A. hederae*, *A. rumicis*, and *A. sambuci* and to separate them from *A. fabae* and *A. armata*. The latter two species were not separable by electrophoresis. Unfortunately she did not clear up enough the identity of the material investigated. Especially the

oligophagous *A. armata* has not been transferred to all test plants of the *A. fabae* group *s.str.* used in this work, so that it is not sure if the real *A. armata* has been under consideration. As already discussed above, *A. mordwilkoi* is able to colonise *Vicia faba*. Therefore the sample called
A. fabae could have been also *A. mordwilkoi*.

TOMIUK (1987) calculated NEI's genetic identity Ī between *A. sambuci* and the *A. fabae* group with 16 loci investigated. It corresponds with 0.38 very well with our own average Ī-value of 0.39 (cf. Fig. 1). This proves that isozyme electrophoresis is a valuable method to estimate genetic relationships between taxa. It is even possible to compare results that have been obtained by different electrophoretic manners.

Much more difficult to carry out are transfer experiments (host plant tests), because many factors can influence the results. THIEME (1985, 1986, 1987) could show that the age and reproductive stage (sterile, flowering, or fruiting) of the plants used are of great importance for the results of the tests. Also physiological properties of plants must not be neglected. Very often only a part of the appropriate plants is infested. The climate under which the tests are carried out must not be ignored too. Finally, the conditions of the aphids must be considered. On which plant have they been found? Was it the suitable host, or have the aphids been weakened due to suboptimal conditions? All these questions are difficult to answer. Heretically can be said: As many experimenters, as many results (cf. Transfer experiments). We believe that such tests are really significant only with mono- or oligophagous species. Furthermore it is too difficult to standardise the experiments in such a manner, that they can be carried out by every study group and that reproducible results can be obtained. It is even very difficult to standardise the experiments within one and the same study, which may explain the partly contradictory results in our own tests. Therefore we believe, that for the practitioner in applied entomology it is easier and more reliable to carry out electrophoreses than to realize transfer experiments.

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Zusammenfassung

Enzym-elektrophoretische Studien über die Aphis fabae-Gruppe (Homoptera, Aphididae)

Die Taxa der *Aphis fabae*-Gruppe *s.str.* sind morphologisch nur schwer oder gar nicht unterscheidbar. Deshalb wurde mit Hilfe der vertikalen Stärke-Gel-Elektrophorese versucht, spezifische Isoenzyme der *A. fabae*-Gruppe *s.str.* zu finden, wobei die Untersuchungen auch auf die *A. fabae*-Gruppe *s.l.* erweitert wurden. Durch Analyse des Bandenmusters von 17 genetischen Loci konnte jedes der 18 untersuchten Taxa eindeutig identifiziert werden. Aufgrund der erhaltenen Resultate konnte ein biochemischer Bestimmungsschlüssel erarbeitet werden.

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Morphological studies on the *Aphis fabae* group (Homoptera, Aphididae)

By E. JÖRG and G. LAMPEL

Abstract

The taxa of the *Aphis fabae* group *s.str*. are morphologically difficult to separate or inseparable. Only by vertical starch gel electrophoresis it is possible to distinguish all the members of the whole *Aphis fabae* complex (*Aphis fabae* group *s.str*. and *s.l*.) (JÖRG and LAMPEL, 1994). The present paper deals now with our morphological investigations on this complex.

1 Introduction

Until today, it is impossible to distinguish exactly all the members of the *Aphis fabae* group *s.str*. Morphological methods to separate the taxa were often tried (DE FLUITER, 1949; FRANSSEN, 1927, 1931; HEIE, 1986; JACOB, 1945; JANISCH, 1926; JONES, 1942; STROYAN, 1984).

Host plant tests, carried out e.g. by IGLISCH (1968), JANISCH (1926), JÖRG and LAMPEL (1994), MÜLLER (1982), and THIEME (1987), were in some cases unsatisfying too.

Isozyme electrophoresis was sometimes more successful (survey in JÖRG and LAMPEL, 1994). JÖRG and LAMPEL (1994) succeeded in distinguishing 18 members of the *Aphis fabae* group *s.str*. and *s.l*. by vertical starch gel electrophoresis. The cited work serves as a basis of the present paper. All investigated samples could be clearly separated from each other by electrophoresis, and therefore, it is sure, that really the mentioned taxon has been treated.

2 Material and methods

The material used in this work is listed in JÖRG and LAMPEL (1994). Specimens were stored in ethanol (80%) and then treated according to HEINZE (1952). The prepared aphids were measured and the measures and some indices were used for comparisons. The significance of differences of the indices was tested by the unpaired t-test (Student-test), working on a Macintosh computer with the StatView 4.0 data analysis program (SAGER, 1992).

3 Results

3.3 *Aphis fabae* group *s.str.*

The following seven investigated taxa are members of this group (IGLISCH, 1968, 1970; MÜLLER, 1982; MÜLLER and STEINER, 1990, combined): *Aphis armata* Hausmann, 1802, *A. cirsiiacanthoidis* Scopoli, 1763, *A. euonymi* Fabricius, 1775, *A. fabae* Scopoli, 1763, *A. mordwilkoi* Börner & Janisch, 1922, *A. philadelphi* Börner, 1921, and *A. solanella* Theobald, 1914. According to our investigations (JÖRG and LAMPEL, 1994), *A. barberae* Robinson, 1980, and *A. janischi* (Börner, 1940) are synonyms of *A. mordwilkoi* and *A. cirsiiacanthoidis*, respectively, and therefore they are discussed together with these taxa.

Table 1. **Results of measurements of apterous viviparous females of *A. armata*, *A. euonymi*, *A. fabae*, *A. philadelphi*, and *A. solanella*.**

Species	Apterous viviparous females															
	A. armata			*A. euonymi*			*A. fabae*			*A. philadelphi*			*A. solanella*			
Number of specimens investigated	32			35			63			28			81			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.50	1.96	2.56	1.34	1.89	2.66	1.39	1.75	2.10	1.81	2.17	2.48	1.30	2.07	2.75	mm
Total length of antenna	0.96	1.33	1.76	0.88	1.21	1.60	0.77	1.12	1.46	1.01	1.43	1.70	0.86	1.35	1.70	mm
Length of antennal joint III	240	338	480	193	289	426	180	275	380	233	355	433	193	336	473	µm
Length of antennal joint IV	160	230	346	100	184	293	100	177	260	140	260	333	120	234	326	µm
Length of antennal joint V	133	200	280	127	185	253	113	169	226	160	235	286	127	216	286	µm
Length of basal part of antennal joint VI	93	125	167	93	119	147	100	114	133	120	144	167	93	124	160	µm
Length of processus terminalis	220	323	406	260	326	386	193	291	366	246	338	393	226	342	413	µm
Basal diameter of antennal joint III	20	25	33	20	26	32	17	29	37	20	25	32	18	29	38	µm
Longest hair on antennal joint III	46	61	71	38	59	81	25	41	58	42	51	66	17	35	66	µm
Secondary rhinaria on antennal joint III	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint IV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint V	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Length of apical rostral segment	113	133	153	107	129	153	100	123	140	133	149	153	120	143	167	µm
Accessory hairs on apical rostral segment	1	2	3	2	2	3	1	2	3	2	2	3	2	2	3	
Frons	186	212	246	173	210	246	173	198	220	193	219	233	180	216	266	µm
Joint II of hind tarsus	100	123	153	93	116	153	80	114	133	113	125	140	93	119	140	µm
Siphuncular length	186	259	393	133	237	373	120	222	326	186	268	346	167	335	453	µm
Caudal length	167	207	253	147	201	266	160	200	253	193	216	246	147	222	293	µm
Caudal hair number	11	15	21	8	13	22	7	13	21	13	16	23	9	15	23	
Ratios																
Apical rostral segment/Hind tarsus II	0.96	1.10	1.27	0.96	1.11	1.27	0.94	1.08	1.25	1.10	1.20	1.28	1.10	1.21	1.35	
Longest hair III/Basal diameter III	2.19	2.46	2.83	1.28	2.34	3.27	0.75	1.44	2.31	1.67	2.03	2.38	0.68	1.24	2.08	
Processus terminalis/Basal part VI	2.06	2.58	3.17	2.19	2.76	3.38	1.93	2.54	3.12	1.91	2.34	2.70	2.00	2.77	3.59	
Body/Apical rostral segment	11.8	14.7	17.5	11.9	14.5	18.1	11.2	14.2	17.4	12.3	14.5	16.4	10.7	14.4	18.0	
Siphunculi/Cauda	1.00	1.24	1.64	0.84	1.16	1.51	0.75	1.11	1.47	0.97	1.24	1.52	0.93	1.51	1.88	

Table 2. **Results of measurements of alate viviparous females of *A. armata*, *A. euonymi*, *A. fabae*, *A. philadelphi*, and *A. solanella*.**

Species	Alate viviparous females															
	A. armata			*A. euonymi*			*A. fabae*			*A. philadelphi*			*A. solanella*			
Number of specimens investigated	21			21			56			24			76			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.52	2.01	2.45	1.58	2.03	2.46	1.33	1.76	2.27	1.78	2.10	2.66	1.26	2.03	2.54	mm
Total length of antenna	0.94	1.42	1.60	1.04	1.28	1.49	0.80	1.16	1.39	1.28	1.44	1.60	0.86	1.34	1.63	mm
Length of antennal joint III	240	336	393	233	314	393	213	290	380	293	346	400	180	331	433	µm
Length of antennal joint IV	147	255	293	147	217	286	113	191	260	226	267	306	127	231	300	µm
Length of antennal joint V	127	223	266	153	200	246	107	178	226	213	239	266	133	213	266	µm
Length of basal part of antennal joint VI	93	133	153	100	123	147	87	115	133	127	147	167	100	124	147	µm
Length of processus terminalis	240	370	420	300	337	373	206	300	366	286	345	406	260	339	406	µm
Basal diameter of antennal joint III	18	23	28	17	23	27	17	24	32	20	22	30	17	22	33	µm
Longest hair on antennal joint III	33	49	58	28	46	66	23	33	45	30	40	50	13	31	50	µm
Secondary rhinaria on antennal joint III	9	14	19	8	15	28	3	13	18	10	15	26	8	19	30	
Secondary rhinaria on antennal joint IV	0	2	6	0	2	9	0	1	6	0	1	4	0	4	14	
Secondary rhinaria on antennal joint V	0	0	1	0	0	0	0	0	1	0	0	0	0	0	3	
Length of apical rostral segment	113	132	147	107	128	147	100	119	133	133	144	160	113	135	160	µm
Accessory hairs on apical rostral segment	2	2	2	2	2	2	2	2	3	1	2	3	1	2	3	
Frons	160	186	226	167	187	206	153	169	186	180	191	213	140	183	200	µm
Joint II of hind tarsus	100	124	133	100	116	133	93	112	127	113	124	133	93	114	127	µm
Siphuncular length	147	211	260	133	221	333	107	172	233	173	220	266	153	248	346	µm
Caudal length	133	182	220	133	177	233	120	158	200	160	183	206	120	186	226	µm
Caudal hair number	12	15	19	12	15	20	7	12	21	11	17	22	10	15	21	
Ratios																
Apical rostral segment/Hind tarsus II	0.95	1.07	1.13	1.00	1.11	1.22	0.94	1.07	1.21	1.10	1.16	1.22	1.06	1.18	1.31	
Longest hair III/Basal diameter III	1.65	2.09	2.50	1.31	2.04	2.86	0.89	1.42	2.08	1.50	1.80	2.15	0.64	1.42	2.33	
Processus terminalis/Basal part VI	2.40	2.79	3.12	2.29	2.79	3.33	2.18	2.62	3.07	1.88	2.36	2.85	2.25	2.75	3.56	
Body/Apical rostral segment	13.4	15.2	17.2	13.7	15.8	17.8	11.7	14.7	18.0	12.8	14.6	17.3	11.2	15.0	19.4	
Siphunculi/Cauda	1.07	1.16	1.28	1.00	1.23	1.52	0.85	1.08	1.30	1.04	1.19	1.30	1.00	1.33	1.67	

Table 3. **Comparison of the results of measurements of *A. janischi* and *A. cirsiiacanthoidis*.**

Species	Apterous viviparous females									Alate viviparous females						
	A. janischi			*A. janischi* HEIE (1986)			*A. cirsii-acanthoidis*			*A. janischi*			*A. cirsii-acanthoidis*			
Number of specimens investigated	24						89			7			51			
Characters	min	ø	max	min	max		min	ø	max	min	ø	max	min	ø	max	
Body length	1.98	2.49	2.72	1.8	2.7		1.52	2.07	2.67	1.97	2.22	2.70	1.70	2.14	2.61	mm
Total length of antenna	1.17	1.56	1.78				0.91	1.31	1.71	1.25	1.39	1.71	1.06	1.34	1.60	mm
Length of antennal joint III	280	418	519				213	333	466	266	315	453	253	335	406	µm
Length of antennal joint IV	173	288	380				107	222	340	213	252	340	167	239	326	µm
Length of antennal joint V	186	254	313				133	207	300	173	223	313	147	213	260	µm
Length of basal part of antennal joint VI	113	146	167				87	125	173	120	141	167	93	125	160	µm
Length of processus terminalis	286	341	373				213	316	393	333	347	366	260	325	393	µm
Basal diameter of antennal joint III	25	35	42				18	28	40	20	23	32	18	23	30	µm
Longest hair on antennal joint III	50	63	66				27	48	75	45	60	66	28	40	55	µm
Secondary rhinaria on antennal joint III	0	0	0				0	0	0	5	11	24	8	17	26	
Secondary rhinaria on antennal joint IV	0	0	0				0	0	0	0	1	4	0	2	8	
Secondary rhinaria on antennal joint V	0	0	0				0	0	0	0	0	0	0	0	2	
Length of apical rostral segment	147	160	173				120	141	160	147	153	160	107	137	160	µm
Accessory hairs on apical rostral segment	2	2	3	2	2	(3)	1	2	4	2	2	3	1	2	3	
Frons	206	237	253				160	211	260	200	205	213	160	183	200	µm
Joint II of hind tarsus	113	133	147				93	120	147	120	123	133	107	119	133	µm
Siphuncular length	233	332	413				147	280	386	213	252	300	160	238	300	µm
Caudal length	213	258	300				180	225	280	160	191	220	153	194	233	µm
Caudal hair number	13	19	26	15	19		10	16	25	17	20	23	10	15	19	
Ratios																
Apical rostral segment/Hind tarsus II	1.10	1.20	1.32	1.3	1.4		1.00	1.17	1.33	1.16	1.24	1.28	1.00	1.15	1.29	
Longest hair III/Basal diameter III	1.48	1.82	2.27	2.2	3.5		1.31	1.75	2.43	1.58	2.67	3.33	1.31	1.72	2.31	
Processus terminalis/Basal part VI	2.04	2.34	2.83	2.2	3.0		1.78	2.56	3.92	2.12	2.49	2.89	2.00	2.63	3.25	
Body/Apical rostral segment	13.0	15.6	17.9				11.7	14.6	17.6	12.8	14.5	16.9	13.0	15.7	18.0	
Siphunculi/Cauda	1.03	1.29	1.50	1.1	1.4	(2.0)	0.81	1.24	1.62	1.14	1.32	1.48	1.00	1.23	1.48	

Table 4. **Comparison of the results of measurements of *A. barberae* and *A. mordwilkoi*.**

Species	Apterous viviparous females									Alate viviparous females									
	A. barberae			*A. barberae* ROBINSON (1980)			*A. mordwilkoi*			*A. barberae*			*A. barberae* ROBINSON (1980)			*A. mordwilkoi*			
Number of specimens investigated	20						72			20						52			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.33	1.67	1.92	1.54		2.26	1.62	2.05	2.42	1.52	1.74	2.14	1.59		2.40	1.70	2.08	2.45	mm
Total length of antenna	0.90	1.09	1.28	0.98		1.57	0.91	1.31	1.57	1.07	1.17	1.28	1.29		1.72	1.09	1.35	1.49	mm
Length of antennal joint III	186	246	333	190		370	200	322	400	213	264	293	290		400	260	323	373	µm
Length of antennal joint IV	113	163	220	140		280	120	215	280	160	186	213	200		320	173	227	266	µm
Length of antennal joint V	133	164	200	140		260	113	210	266	160	184	213	190		310	167	217	260	µm
Length of basal part of antennal joint VI	100	110	127	90		140	100	130	153	107	119	133	120		150	107	132	147	µm
Length of processus terminalis	260	306	346	280		420	233	338	420	273	318	346	340		440	240	352	393	µm
Basal diameter of antennal joint III	17	23	30				17	27	33	17	20	22				17	22	27	µm
Longest hair on antennal joint III	42	56	68	20		60	38	58	70	33	42	55	20		40	25	48	58	µm
Secondary rhinaria on antennal joint III	0	0	0				0	0	0	8	12	16	10		23	9	14	21	
Secondary rhinaria on antennal joint IV	0	0	0				0	0	0	0	2	5	0		6	0	2	6	
Secondary rhinaria on antennal joint V	0	0	0				0	0	0	0	0	0	very rarely 1-3			0	0	0	
Length of apical rostral segment	120	132	140				127	152	173	120	131	140				133	147	160	µm
Accessory hairs on apical rostral segment	2	2	3		2		1	2	4	2	2	3		2		2	2	3	
Frons	180	199	220				186	218	253	167	178	186				160	194	233	µm
Joint II of hind tarsus	100	108	120	100		140	100	124	147	100	110	120	100		140	107	120	133	µm
Siphuncular length	140	200	266	150		330	153	283	380	133	165	200	160		280	153	232	280	µm
Caudal length	167	196	226	120		260	173	236	286	153	169	186	90		220	153	199	233	µm
Caudal hair number	10	15	19	10		19	11	17	27	9	15	19	12		22	12	17	26	
Ratios																			
Apical rostral segment/Hind tarsus II	1.12	1.23	1.33				1.10	1.23	1.38	1.06	1.19	1.33				1.05	1.23	1.44	
Longest hair III/Basal diameter III	1.92	2.47	3.17				1.67	2.19	2.73	1.67	2.17	2.73				1.36	2.20	3.09	
Processus terminalis/Basal part VI	2.29	2.80	3.13				2.09	2.61	3.24	2.28	2.69	3.06				2.20	2.66	3.17	
Body/Apical rostral segment	11.1	12.6	13.9				11.7	13.5	15.8	11.3	13.3	15.3				11.4	14.2	16.9	
Siphunculi/Cauda	0.84	1.02	1.22				0.86	1.19	1.49	0.87	0.98	1.07				0.88	1.16	1.33	

3.3.1 Aphis armata

All observed morphs were dull brownish black to black in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. First antennal segment with (4)-5 hairs. Siphunculi and cauda brown. Abdomen with in general weakly (only sometimes well) developed marginal and some spinal sclerites, postsiphuncular and intersegmental pleural muscle sclerites; dorsal cuticle with strong reticulation; 4 marginal tubercles on abdominal segments I and VII, and (0)-1-3-(4-6) smaller ones on segments II-IV-(VI). According to THIEME (1989) and STROYAN (1984), *A. armata* has 0-4 marginal tubercles on segments II-IV. Abdominal tergite VIII bears (2-3)-4-5-(6-9) hairs. Frons nearly straight. Siphunculi squamous; cauda broad and blunt. Measurements see Tab. 1.

Alate viviparous female: Antennae brown. First antennal segment with (4)-5 hairs. Marginal and spinal sclerites well developed, also presiphuncular sclerites present. (0-1)-2-3-(4-6) marginal tubercles on segments II-IV (and VI); on tergite VIII (2-3)-4-6-(7) hairs. Frons straight. Measurements see Tab. 2.

Alate male: 0-(1) marginal tubercles on abdominal segments II-IV; tergite VIII with 2-3 hairs (MÜLLER and STEINER, 1989).

Lives monoecious-holocyclically in the inflorescences and on the lower surface of leaves of different *Digitalis* spp. and is visited by ants.

3.3.2 Aphis cirsiiacanthoidis

In this chapter *A. cirsiiacanthoidis* is treated together with *A. janischi* (cf. Discussion). The data given below are from twelve different *A. cirsiiacanthoidis* populations, with comparable data for *A. janischi* (three populations) in square brackets.

All morphs were dull black in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. First antennal segment with (3-4)-5-(6) [5-(6)] hairs. Siphunculi and cauda brown. Abdomen with often well developed marginal and spinal sclerites and with dorsal crossbands on segments VII-VIII, postsiphuncular and intersegmental pleural muscle sclerites; dorsal cuticle with reticulation; 4 marginal tubercles present on abdominal segments I and VII, and 0-2-3-(4-6) [(0)-1-3-(4-7)] smaller ones on segments II-IV-(VI); tergite VIII with 2-4-6-(7-10) [3-6-(7-13)] hairs. Frons w-shaped. Siphunculi squamous; cauda blunt. Measurements see Tab. 3.

MÜLLER and STEINER (1990) published a determination key based on the number of hairs on antennal joint I. After this key *A. cirsiiacanthoidis* should have only 3 hairs (30 specimens measured). In our 113 examined specimens (*A. janischi* included) 3 was the minimal number (only one specimen), and more than 91% had even 5 hairs on segment I. Furthermore about 21% of our specimens had more than 3 marginal tubercles on the abdominal segments II-IV-(VI). On HEIE's drawings (HEIE, 1986), at least 3 tubercles on one side and 4 on both sides can be easily recognised. MÜLLER and STEINER (1990) give a range of 0-3. Thus, it is impossible to determine with this key the Swiss material.

Alate viviparous female: Antennae brown. First antennal segment with (3-4)-5-(6) [5-(6-7)] hairs. Marginal, spinal and presiphuncular sclerites well developed. 0-6 [(2-5)-6-(7)] marginal tubercles on abdominal segments II-IV-(V); tergite VIII with 2-5-(6) [2-8] hairs. Frons nearly straight. Measurements see Tab. 3.

The male is alate (IGLISCH, 1970).

According to IGLISCH's experiments (IGLISCH, 1972), the primary hosts of *A. cirsiiacanthoidis* are the shrubs *Euonymus europaea* L., *Viburnum opulus* L., and *Philadelphus coronarius* L. Secondary hosts are mostly several *Cirsium* spp. and rarely *Solanum nigrum* L. emend. Miller, which has been already reported by JÖRG and LAMPEL (1994), LAMPEL (1980), and THIEME (1985, 1987).

3.3.3 Aphis euonymi

All observed morphs were dull reddish to blackish brown in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. Siphunculi and cauda brown. First antennal joint with (4)-5-(6) hairs. Abdomen with weakly (only sometimes well) developed marginal and some spinal sclerites, postsiphuncular and intersegmental pleural muscle sclerites; dorsal cuticle with reticulation; always 4 small marginal tubercles on abdominal segments I and VII, and 0-(1-3) smaller ones on segments II-IV (four specimens with 1 tubercle on segment II or III, three with 2 tubercles on segments II-IV, and two specimens with 3 tubercles on segments III and IV). STROYAN's *A. euonymi* has 0 tubercles on the abdominal segments II-VI (STROYAN, 1984), but HEIE (1986) reported the possibility of up to 2 additional tubercles. Tergite VIII with (2-3)-4-(5-10) hairs. Frons nearly straight, sometimes with short antennal tubercles. Siphunculi squamous; cauda broad and blunt. Measurements see Tab. 1.

As already discussed above for *A. cirsiiacanthoidis*, according to MÜLLER and STEINER (1990), also *A. euonymi* should have only 3 hairs on antennal joint I. But our 35 examined specimens had at least 4 and more than 80% of them 5 hairs on this segment. Furthermore, the specimens of MÜLLER and STEINER had no marginal tubercles on the abdominal segments II-IV; in contrast, about 25% of our specimens had 1-3 of these tubercles. Therefore, the above mentioned key is not valid too for the Swiss *A. euonymi* populations.

Alate viviparous female: Antennae brown. Antennal joint I with (4)-5-(6) hairs. Marginal and spinal sclerites well developed, also presiphuncular sclerites present. 0-(1-3) marginal tubercles on segments II-IV (5 specimens with 1 tubercle on segment II or III, 1 specimen with 3 on segments II-IV). Tergite VIII with (3)-4-(5-6) hairs. Frons straight. Measurements see Tab. 2.

The male is alate (HEIE, 1986; JONES, 1943; STROYAN, 1984).

It lives mostly monoecious-holocyclically on young shoots of *Euonymus europaea* and is attended by ants. Occasionally it can feed on *Valeriana officinalis* L., *Dahlia* sp., *Sedum maximum* (L.) Hoffm. (MÜLLER and STEINER, 1986), *Valeriana dioica* L., *V. tripteris* L. (MÜLLER, 1975), and on *Rumex obtusifolius* L., *Arctium lappa* L., and *Capsella bursa-pastoris* (L.) Medikus (HEIE, 1986).

3.3.4 Aphis fabae

All morphs are dull greenish black to black in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. First antennal segment with (3)-4-5-(6) (mostly 5) hairs. One specimen had on one antenna only 3 and two specimens had 6 hairs. Siphunculi and cauda brown. Abdomen with weakly developed marginal and some spinal sclerites, postsiphuncular and intersegmental pleural muscle sclerites; dorsal cuticle with reticulation; 4 marginal tubercles present on abdominal segments I and VII, and 0-(1-5) smaller ones on segments II-IV. Tergite VIII bears (2-3)-4-(5-7) hairs. Frons w-shaped. Siphunculi squamous; cauda blunt. Measurements see Tab. 1.

Alate viviparous female: Antennae brown. First antennal segment with (4)-5-(6) hairs. Marginal and spinal sclerites well developed, also presiphuncular sclerites present. 0-1-(2-4) marginal tubercles on abdominal segments II-IV; tergite VIII with 2-6 (mostly 4) hairs. Frons nearly straight. Measurements see Tab. 2.

Alate male: Similar to alate viviparous female (HEIE, 1986).

Fundatrix: Antennae and tibiae pale with brown proximal and distal parts. Abdominal sclerites absent, with exception of crossbands on segments VII and VIII and stigmal plates. On abdominal segments II-IV 0-4 marginal tubercles present. Tergite VIII with 6-10 hairs. Measurements see Tab. 10.

It is a (sub-)heteroecious-holocyclic, polyphagous species. IGLISCH (1972) could show, that its primary host is *Euonymus europaea*. The most important secondary hosts are *Vicia faba* L., *Phaseolus* sp., *Chenopodium* sp., and *Beta vulgaris* L. In literature, *Papaver* sp. is also

mentioned. During our own investigations (JÖRG and LAMPEL, 1994), we found on this plant genus *A. cirsiiacanthoidis* and not *A. fabae*.

3.3.5 Aphis mordwilkoi

A. barberae is treated together with *A. mordwilkoi* (cf. Discussion). The given data are from eight *A. mordwilkoi* populations and in square brackets from two *A. barberae* populations.

All observed morphs were dull black in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. First antennal segment with (4)-5-(6) [(4)-5-(6)] hairs. Siphunculi and cauda brown. Abdomen with well developed marginal and some spinal sclerites, postsiphuncular and intersegmental pleural muscle sclerites; dorsal cuticle with reticulation; 4 marginal tubercles present on abdominal segments I and VII, and 0-2-(3-5) [0-(1-3)] smaller ones on segments II-IV. For *A. barberae*, ROBINSON (1980) states that marginal tubercles are present on "abdominal segments I and VII, rarely on other abdominal segments". (2)-3-5-(6-9) [2-4-(5)] hairs are present on abdominal tergite VIII (ROBINSON, 1980: 2-5). Frons nearly straight. Siphunculi squamous; cauda blunt. Measurements see Tab. 4.

Alate viviparous female: Antennae brown. First antennal segment with (3-4)-5-(6) [(4)-5] hairs. Marginal and spinal sclerites well developed, also presiphuncular sclerites present. 0-2-(3-4) [0-1-(2)] marginal tubercles on abdominal segments II-IV (ROBINSON, 1980: "occasionally on abdominal segments II-VI"); tergite VIII with (2-3)-4-(5-8) [2-4-(5)] hairs (ROBINSON, 1980: 2-4). Frons nearly straight. Measurements see Tab. 4.

Male alate, with 2-4 hairs on abdominal tergite VIII (ROBINSON, 1980).

It is a heteroecious-holocyclic, polyphagous species. According to BÖRNER and JANISCH (1922), the primary host is *Viburnum opulus*. Secondary hosts are numerous herbaceous plants. The most important are: *Aegopodium podagraria* L., *Aethusa cynapium* L., *Anthriscus sylvestris* (L.) Hoffm., *Arctium lappa* L., *A. nemorosum* Lejeune, *Cynara cardunculus scolymus* (L.) Beger, *Epipactis palustris* (L.) Crantz, *Tropaeolum majus* L., and *T. minus* L. (JÖRG and LAMPEL, 1994).

3.3.6 Aphis philadelphi

All observed morphs were dull black in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. (4)-5-(6) hairs on first antennal segment. Siphunculi and cauda brown. Abdomen with often well developed dark marginal and spinal sclerites, pre- and postsiphuncular and intersegmental pleural muscle sclerites; dorsal cuticle with reticulation; 4 marginal tubercles on abdominal segments I and VII, (0-1)-2-4-(5) smaller ones on segments II-IV; tergite VIII with (2)-3-4-(5-6) hairs. Frons nearly straight, often with very short antennal tubercles. Siphunculi squamous; cauda blunt. Measurements see Tab. 1.

Alate viviparous female: Antennae brown. (4)-5-(6) hairs on first antennal segment. Abdominal sclerites darker. (1)-2-(3-5) marginal tubercles on segments II-IV-(V); on tergite VIII 3-5-(6) hairs. Measurements see Tab. 2.

One alate male mating a female could be observed.

Fundatrix: Antennae and tibiae pale with brown proximal and distal parts. Abdominal sclerites absent, with exception of crossbands on segments VII and VIII and stigmal plates. 0-5 marginal tubercles on segments II-IV; tergite VIII with 3-7 hairs. Measurements see Tab. 10.

This species lives monoecious-holocyclically in curled leaves of *Philadelphus coronarius*. It can be reared on *Cirsium arvense* (L.) Scop., *Tropaeolum majus*, *Euonymus europaea*, and *Viburnum opulus* (cf. JÖRG and LAMPEL, 1994).

3.3.7 Aphis solanella

All morphs are dull black in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. First antennal segment with (4)-5-(6) hairs. According to MÜLLER and STEINER (1990) *A. solanella* should have only 3 hairs on the first antennal joint (28 specimens measured). In our own investigations about 81% of 81 measured specimens had 5 hairs. As discussed above for *A. cirsiiacanthoidis* and *A. euonymi*, the determination key of MÜLLER and STEINER (1990) is also not usable for Swiss *A. solanella* material. Siphunculi and cauda brown. Abdomen with weakly developed marginal and spinal sclerites, postsiphuncular and intersegmental pleural muscle sclerites; dorsal cuticle with reticulation; abdomen with 4 marginal tubercles on segments I and VII, and 0-5-(6) smaller ones on segments II-IV. Two specimens had only 1, and eight only 2 tubercles on these segments. For British material STROYAN (1984) gives a range of 3-7, and HEIE (1986) points out that about 40-50% of all specimens are without tubercles on segments II-IV. Tergite VIII with (2)-3-4-(5-8) hairs. Frons w-shaped. Siphunculi squamous; cauda blunt. Measurements see Tab. 1.

Alate viviparous female: Antennae brown. First antennal segment with (3-4)-5-(6) hairs. Marginal sclerites and dorsal crossbands well developed, presiphuncular sclerites are also present. 0-5-(6) marginal tubercles on segments II-IV; tergite VIII with (2-3)-4-(5-7) hairs. Measurements see Tab. 2.

The male is alate (IGLISCH, 1970).

It is a heteroecious-holocyclic, oligophagous species. According to the investigations made by IGLISCH (1972) the primary host is *Euonymus europaea*. The most important secondary host is *Solanum nigrum*, but very often also *Cirsium* spp. are settled (cf. JÖRG and LAMPEL, 1994; STROYAN, 1984).

3.4 *Aphis fabae* group *s.l.*

The species of the *A. fabae* group *s.l.* (see JÖRG and LAMPEL, 1994) *Aphis cacaliasteris* Hille Ris Lambers, 1947, *A. hederae* Kaltenbach, 1843, *A. ilicis* Kaltenbach, 1843, *A. lantanae* Koch, 1854, *A. newtoni* Theobald, 1927, *A. rumicis* Linnaeus, 1758, *A. sambuci* Linnaeus, 1758, *A. vaccinii* (Börner, 1940), *A. veratri* Walker, 1852, and *A. viburni* Scopoli, 1763, are sufficiently characterised by their morphology in combination with their host plants. By its morphology (see below), especially the green colour, and its genetic identity (cf. JÖRG and LAMPEL, 1994), *A. tripolii* Laing, 1920, must be excluded from the *A. fabae* group *s.l.*

3.4.1 Aphis cacaliasteris

All observed morphs dull black in life.

Prepared material:

Apterous viviparous female: Antennae dark brown, proximal part of joint III pale. First antennal segment with 5-6 hairs. Tibiae, siphunculi, and cauda dark brown. Abdomen with small marginal, postsiphuncular and intersegmental pleural muscle sclerites and crossbands on segments VII and VIII; dorsal cuticle with reticulation, most visible on sclerotic areas; 4 large marginal tubercles always present on abdominal segments I and VII, and 0-7 smaller ones on segments II-VI (LAMPEL, 1984: 0-1); tergite VIII with 7-11 hairs. Frons nearly straight. Siphunculi squamous, nearly cylindrical; cauda blunt. Measurements see Tab. 5.

Alate viviparous female: Abdomen with rather great marginal sclerites, one great spinal sclerite on segment VI, and crossbands on segments VII and VIII (HILLE RIS LAMBERS, 1946-47).

Oviparous female: First antennal segment with 5-6 hairs. Cauda pale brown. Abdomen sometimes with additional spinal sclerites on segment VI; 1-5 marginal tubercles on segments II-VI (LAMPEL, 1984: 0-1); tergite VIII with 10-13 hairs. Measurements see Tab. 9.

Alate male: Antennal segment III completely dark brown. First antennal segment with (4)-5-6-(7-8) hairs. Abdominal sclerites stronger developed; 0-2 marginal tubercles on segments II-VI (LAMPEL, 1984: 0-1); tergite VIII with 5-9 hairs. Measurements see Tab. 9.

Lives monoecious-holocyclically on stems, inflorescences, and the lower surface of leaves of *Senecio fuchsii* Gmel., visited by ants. According to LAMPEL (1984) it feeds also on other *Senecio* spp., and *Adenostyles* spp.

3.4.2 Aphis hederae

Apterous and alate viviparous females dull dark brown in life; larvae bright brown.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with exception of proximal and distal parts. (4)-5-(6) hairs on first antennal segment. Siphunculi and cauda brown. Abdomen with sometimes weakly developed spinal sclerites on segments VI-VIII and intersegmental pleural muscle sclerites; occasionally with darker marginal and postsiphuncular sclerites; stigmal plates well developed; dorsal cuticle reticulate; 4 marginal tubercles normally present on abdominal segments I and VII, 0-5 smaller ones on segments II-IV and VI; tergite VIII with 2-(3-4) hairs. Frons with distinct antennal tubercles. Siphunculi squamous; cauda blunt. Measurements see Tab. 5.

Alate viviparous female: Antennae completely brown. (4)-5 hairs on first antennal segment. Abdomen with well developed marginal and postsiphuncular sclerites; 0-5 marginal tubercles on abdominal segments II-IV and VI; on tergite VIII 2-(3) hairs. Frons straight. Measurements see Tab. 6.

Male apterous, oviparous female with barely swollen hind tibiae and few scent plaques (STROYAN, 1984).

Lives monoecious-holocyclically on young shoots of *Hedera helix* L. and is often visited by ants.

3.4.3 Aphis ilicis

Colour in life: Apterous viviparous females dull dark brown, alate viviparous females with dull black thorax and bright brown abdomen, larvae dull bright brown.

Prepared material:

Apterous viviparous female: Antennae pale with exception of the proximal and distal parts, tibiae pale with brown distal area. First antennal segment with 5-(6) hairs. Siphunculi and cauda dark brown. Abdomen with distinct spinal, marginal and postsiphuncular sclerites on segments VI-VIII and intersegmental pleural muscle sclerites; dorsal cuticle with distinct reticulation; 4 marginal tubercles present on abdominal segments I and VII, and 3-6 smaller tubercles on segments II-IV-(V); tergite VIII with (2-3)-4 hairs. Frons straight. Siphunculi squamous; cauda broad and blunt. Measurements see Tab. 5.

Alate viviparous female: Antennae completely brown. First antennal segment with (4)-5-(6) hairs. Abdomen with 3-5 marginal tubercles on segments II-IV; on tergite VIII (2-3)-4 hairs. Measurements see Tab. 6.

According to FRANSSEN (1931) and STROYAN (1984), the males are alate.

It lives monoecious-holocyclically in young curled leaves of *Ilex aquifolium* L. and is visited by ants.

3.4.4 Aphis lantanae

According to STROYAN (1984), two forms (subspecies) (*A. coriaria* Börner, 1952, and *A. lantanae* Koch, 1854 *s.str.*) can be distinguished morphologically. By electrophoresis, no differences could be detected between the two taxa, and therefore, according to EASTOP and HILLE RIS LAMBERS (1976), all specimens have been simply called *A. lantanae* in JÖRG and LAMPEL (1994). Nevertheless, two forms are clearly distinguishable by morphological characters in our material, e.g. by the length of the processus terminalis of the antennae and the siphuncular

length. But in opposition to STROYAN (1984), our *A. coriaria* has always a longer processus terminalis than *A. lantanae s.str*. (cf. Tab. 5 and 6).

- *A. lantanae* form *"coriaria"*

Apterous and alate viviparous females are dull dark brown and larvae dull bright brown in life.

Prepared material:

Apterous viviparous female: Body lemonshaped. Antennae and tibiae pale with exception of proximal and distal parts. (4)-5-(6) hairs on first antennal segment. Siphunculi pale with a distal brown zone, cauda brown. Abdomen with sclerites, united to crossbands on segments I-VIII, postsiphuncular sclerites, and intersegmental pleural muscle sclerites; dorsal cuticle with reticulation; 4 marginal tubercles always present on abdominal segments I and VII, (1-5)-6-7 smaller ones on segments II-IV (and VI); tergite VIII with 3-13 hairs. Frons nearly straight. Siphunculi squamous; cauda broad and blunt.

Alate viviparous female: Antennae dark brown, tibiae brown with paler median part. First antennal segment with 4 and 5 hairs. Siphunculi brown. Marginal and spinal sclerites (no crossbands on segments I-VI) present on all abdominal segments; 6 marginal tubercles on segments II-IV; 5 hairs on tergite VIII.

The males are apterous or alatiform (STROYAN, 1984).

- *A. lantanae* form *"lantanae"*

Apterous viviparous females and larvae dull greenish black, alate viviparous females shiny greenish black in life.

Prepared material:

Apterous viviparous female: Siphunculi completely brown and shorter than in *A. coriaria*, cauda narrow and blunt. (4)-5 hairs on first antennal segment. Abdominal crossbands only on segments VII and VIII, sometimes some weak marginal sclerites; without dorsal reticulation; (1-3)-4-(5-6) marginal tubercles on segments II-IV; on tergite VIII 2-3-4-(5-6) hairs.

Alate viviparous female: Antennae completely brown. First antennal segment with (4)-5 hairs. Marginal sclerites more distinct and present on all abdominal segments; (1)-2-3-(4) marginal tubercles on segments II-IV; 2-3-(4) hairs on tergite VIII.

The male is alate (STROYAN, 1984).

Both forms live monoecious-holocyclically on *Viburnum lantana* L. in curled leaves, in the inflorescences and infructescences. Often they are attended by ants.

Table 5. **Results of measurements of apterous viviparous females of *A. cacaliasteris*, *A. hederae*, *A. ilicis*, *A. lantanae*, and *A. newtoni*.**

Species	Apterous viviparous females																		
	A. cacaliasteris			*A. hederae*			*A. ilicis*			*A. lantanae*						*A. newtoni*			
										coriaria			*lantanae*						
Number of specimens investigated	18			40			11			18			10			27			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.44	1.86	2.70	1.14	1.57	1.98	1.70	1.97	2.26	1.87	2.04	2.24	1.41	1.53	1.65	1.25	1.56	1.90	mm
Total length of antenna	0.96	1.23	1.58	0.82	1.07	1.42	1.20	1.37	1.50	1.17	1.30	1.44	0.85	0.98	1.12	0.91	1.21	1.42	mm
Length of antennal joint III	233	310	406	206	293	366	286	351	400	253	290	326	173	232	313	186	260	346	µm
Length of antennal joint IV	160	238	340	93	184	266	173	229	273	147	194	240	120	145	180	120	187	240	µm
Length of antennal joint V	153	204	280	113	153	233	173	220	260	147	183	206	113	142	167	133	176	206	µm
Length of basal part of antennal joint VI	113	134	167	80	102	140	113	129	147	107	123	133	100	110	120	100	119	153	µm
Length of processus terminalis	180	231	280	220	257	333	300	332	400	353	401	433	220	252	293	280	370	433	µm
Basal diameter of antennal joint III	18	23	32	13	20	30	22	24	28	20	24	28	18	19	20	20	27	33	µm
Longest hair on antennal joint III	50	61	78	17	33	60	66	73	80	66	81	91	33	37	43	15	21	45	µm
Secondary rhinaria on antennal joint III	0	2	8	0	5	14	0	0	0	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint IV	2	7	12	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint V	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Length of apical rostral segment	107	121	140	113	130	147	133	140	147	147	152	160	113	125	133	93	106	120	µm
Accessory hairs on apical rostral segment	2	3	5	2	2	3	2	2	2	2	2	2	2	2	2	1	2	2	
Frons	173	199	246	167	197	233	193	208	220	206	221	253	167	178	186	167	188	206	µm
Joint II of hind tarsus	107	123	147	73	88	113	107	117	127	107	119	127	93	105	113	107	116	127	µm
Siphuncular length	133	184	260	173	265	393	200	269	333	206	257	293	133	147	173	140	187	226	µm
Caudal length	147	175	220	140	179	220	206	238	273	153	191	206	153	168	186	133	171	200	µm
Caudal hair number	14	17	23	5	10	13	14	16	18	13	17	21	10	13	18	8	11	13	
Ratios																			
Apical rostral segment/Hind tarsus II	0.94	0.98	1.05	1.24	1.48	1.67	1.11	1.19	1.25	1.21	1.29	1.44	1.06	1.19	1.29	0.83	0.91	1.00	
Longest Hair III/Basal diameter III	2.11	2.73	3.18	1.00	1.58	2.29	2.63	2.98	3.43	2.35	3.37	4.08	1.67	1.98	2.27	0.50	0.81	1.80	
Processus terminalis/Basal part VI	1.50	1.73	1.95	1.94	2.54	3.17	2.25	2.58	3.00	2.94	3.27	3.61	2.06	2.30	2.59	2.33	3.12	3.82	
Body/Apical rostral segment	12.7	15.2	19.3	9.5	12.1	14.2	12.7	14.1	15.4	12.1	13.4	14.9	10.7	12.3	13.6	12.5	14.7	17.0	
Siphunculi/Cauda	0.87	1.04	1.22	1.17	1.47	1.90	0.97	1.12	1.32	1.11	1.35	1.48	0.78	0.87	1.00	0.95	1.09	1.22	

Table 6. **Results of measurements of alate viviparous females of *A. hederae*, *A. ilicis*, *A. lantanae*, and *A. newtoni*.**

Species	Alate viviparous females															
	A. hederae			*A. ilicis*			*A. lantanae*						*A. newtoni*			
							coriaria			*lantanae*						
Number of specimens investigated	30			10			1			7			18			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.17	1.82	2.46	1.57	1.78	1.95		2.26		1.33	1.46	1.65	1.49	1.73	2.05	mm
Total length of antenna	0.88	1.18	1.55	1.15	1.22	1.30	1.33	1.34	1.34	0.88	0.97	1.10	1.25	1.34	1.44	mm
Length of antennal joint III	220	319	460	280	312	340	326	330	333	220	245	273	266	314	360	µm
Length of antennal joint IV	120	204	300	167	192	220	193	206	220	140	147	160	180	225	266	µm
Length of antennal joint V	127	179	253	180	202	220	186	196	206	120	141	160	180	200	220	µm
Length of basal part of antennal joint VI	80	113	133	100	119	133	133	133	133	100	108	127	113	122	133	µm
Length of processus terminalis	213	278	380	293	304	313	373	386	400	213	244	293	340	385	420	µm
Basal diameter of antennal joint III	15	19	30	18	19	20	25	25	25	15	17	20	15	21	30	µm
Longest hair on antennal joint III	17	30	58	50	56	65	75	75	75	30	33	37	12	26	46	µm
Secondary rhinaria on antennal joint III	9	15	23	8	11	13	20	21	22	9	12	14	12	15	18	
Secondary rhinaria on antennal joint IV	0	3	6	0	0	0	3	3	3	0	2	5	3	6	8	
Secondary rhinaria on antennal joint V	0	0	1	0	0	0	0	1	1	0	0	1	0	1	3	
Length of apical rostral segment	113	131	147	107	117	127	147	147	147	113	117	120	93	100	113	µm
Accessory hairs on apical rostral segment	1	2	4	1	2	2		2		1	2	3	2	2	2	
Frons	160	181	220	153	166	173		193		153	161	167	160	173	193	µm
Joint II of hind tarsus	73	90	120	100	107	113	127	127	127	87	99	107	113	119	127	µm
Siphuncular length	167	271	446	147	172	193	213	216	220	113	123	133	147	171	206	µm
Caudal length	107	157	200	173	186	200		167		133	147	160	140	158	173	µm
Caudal hair number	8	10	12	15	16	17		15		12	14	18	8	11	13	
Ratios																
Apical rostral segment/Hind tarsus II	1.22	1.46	1.67	1.00	1.09	1.19	1.16	1.16	1.16	1.06	1.18	1.31	0.78	0.84	0.94	
Longest Hair III/Basal diameter III	1.00	1.54	2.92	2.67	2.94	3.25	3.00	3.00	3.00	1.80	2.06	2.22	0.54	1.25	1.93	
Processus terminalis/Basal part VI	1.89	2.48	3.17	2.20	2.58	3.00	2.80	2.90	3.00	2.00	2.25	2.59	2.68	3.16	3.53	
Body/Apical rostral segment	10.3	13.7	17.0	13.8	15.2	16.4		15.4		11.7	12.5	13.7	16.0	17.3	19.1	
Siphunculi/Cauda	1.25	1.70	2.26	0.80	0.93	1.04	1.28	1.30	1.32	0.75	0.84	0.91	1.00	1.07	1.19	

Table 7. **Results of measurements of apterous viviparous females of *A. rumicis*, *A. sambuci*, *A. tripolii*, *A. vaccinii*, *A. veratri*, and *A. viburni*.**

	Apterous viviparous females																		
Species	*A. rumicis*			*A. sambuci*			*A. tripolii*			*A. vaccinii*			*A. veratri*			*A. viburni*			
Number of specimens investigated	39			29			15			39			32			19			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.74	2.03	2.32	1.79	2.66	3.18	1.58	1.85	2.26	1.33	1.67	2.10	1.63	1.93	2.50	1.36	1.65	1.92	mm
Total length of antenna	1.12	1.30	1.44	1.18	1.51	1.79	0.64	0.91	1.26	0.88	1.14	1.52	1.07	1.29	1.62	0.96	1.16	1.36	mm
Length of antennal joint III	240	344	413	253	384	493	140	221	326	213	296	413	200	277	366	193	267	340	µm
Length of antennal joint IV	180	230	273	167	255	333	100	160	253	133	197	286	127	183	273	140	187	240	µm
Length of antennal joint V	180	218	253	180	253	313	100	143	200	127	182	246	147	186	240	140	175	206	µm
Length of basal part of antennal joint VI	100	114	127	127	164	193	80	98	120	93	112	140	113	127	153	100	110	120	µm
Length of processus terminalis	233	282	333	253	304	386	140	191	253	193	255	340	280	414	513	293	338	393	µm
Basal diameter of antennal joint III	22	27	33	25	34	45	20	24	28	15	23	32	23	31	45	20	23	25	µm
Longest hair on antennal joint III	22	35	46	15	41	61	10	13	13	18	33	50	38	54	66	61	71	83	µm
Secondary rhinaria on antennal joint III	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	
Secondary rhinaria on antennal joint IV	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint V	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Length of apical rostral segment	107	117	127	147	156	173	87	101	113	100	107	120	127	138	147	133	135	140	µm
Accessory hairs on apical rostral segment	1	2	3	1	2	3	2	2	2	1	2	3	1	2	3	2	2	3	
Frons	200	217	240	220	252	293	153	186	213	167	188	220	186	213	253	173	191	206	µm
Joint II of hind tarsus	107	119	133	107	142	167	80	93	107	93	109	127	93	109	127	107	115	120	µm
Siphuncular length	206	277	320	386	566	699	167	226	300	127	192	293	213	296	386	147	209	260	µm
Caudal length	167	203	233	153	199	226	153	193	233	160	192	240	140	169	193	147	186	246	µm
Caudal hair number	11	14	17	8	15	24	4	7	10	9	14	19	9	14	18	11	14	17	
Ratios																			
Apical rostral segment/Hind tarsus II	0.85	0.99	1.06	0.92	1.12	1.41	1.00	1.09	1.15	0.83	0.98	1.14	1.11	1.27	1.47	1.11	1.17	1.25	
Longest Hair III/Basal diameter III	0.81	1.29	1.79	0.59	1.18	1.78	0.38	0.52	0.67	0.93	1.42	2.25	1.22	1.72	2.25	2.67	3.08	3.50	
Processus terminalis/Basal part VI	2.06	2.49	2.94	1.36	1.88	2.47	1.62	1.94	2.24	1.76	2.28	2.75	2.42	3.27	4.06	2.71	3.08	3.56	
Body/Apical rostral segment	15.4	17.2	19.1	11.7	17.1	21.6	16.1	18.3	21.0	12.5	15.7	19.9	11.9	14.0	17.0	10.2	12.3	14.4	
Siphunculi/Cauda	1.12	1.36	1.57	2.42	2.84	3.23	1.04	1.17	1.30	0.79	0.99	1.29	1.25	1.76	2.23	0.96	1.12	1.30	

Table 8. **Results of measurements of alate viviparous females of *A. rumicis*, *A. sambuci*, *A. tripolii*, *A. vaccinii*, *A. veratri*, and *A. viburni*.**

Species	Alate viviparous females																		
	A. rumicis			*A. sambuci*			*A. tripolii*			*A. vaccinii*			*A. veratri*			*A. viburni*			
Number of specimens investigated	34			7			10			22			15			13			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.89	2.16	2.54	1.71	1.86	2.11	1.58	1.72	1.90	1.31	1.75	2.18	1.81	2.04	2.18	1.50	1.68	1.87	mm
Total length of antenna	1.22	1.39	1.60	1.22	1.29	1.41	0.93	0.97	1.02	1.02	1.21	1.42	1.33	1.50	1.60	1.09	1.17	1.25	mm
Length of antennal joint III	273	354	420	240	273	313	220	251	286	273	310	373	286	335	366	233	274	313	µm
Length of antennal joint IV	220	263	320	186	210	233	140	161	180	160	218	286	186	232	260	167	191	220	µm
Length of antennal joint V	193	237	280	193	215	246	133	143	153	153	202	253	180	207	240	160	179	200	µm
Length of basal part of antennal joint VI	100	117	153	133	142	153	93	99	107	100	117	133	120	133	147	107	112	120	µm
Length of processus terminalis	266	315	386	333	359	386	186	205	220	233	272	340	446	490	526	286	327	353	µm
Basal diameter of antennal joint III	20	24	30	18	23	27	15	18	23	17	20	25	23	30	35	18	22	25	µm
Longest hair on antennal joint III	22	34	46	15	24	33	7	10	12	17	28	42	45	52	66	50	53	58	µm
Secondary rhinaria on antennal joint III	5	9	20	17	21	25	7	10	14	8	13	19	6	7	10	8	14	20	
Secondary rhinaria on antennal joint IV	0	0	4	0	1	7	0	3	6	0	1	3	0	0	0	0	3	6	
Secondary rhinaria on antennal joint V	0	0	0	0	0	0	0	2	3	0	0	1	0	0	0	0	0	0	
Length of apical rostral segment	107	118	140	140	147	153	93	100	107	93	105	113	133	139	140	113	119	120	µm
Accessory hairs on apical rostral segment	2	2	3	2	2	2	1	2	3	1	2	2	2	2	3	2	2	2	
Frons	167	186	200	173	183	200	140	155	167	153	167	180	180	191	206	160	168	173	µm
Joint II of hind tarsus	113	120	147	113	122	133	87	90	93	93	111	127	107	111	113	100	107	120	µm
Siphuncular length	200	237	320	300	343	393	147	173	186	127	169	220	240	302	333	140	164	193	µm
Caudal length	147	177	206	120	131	147	133	143	160	133	163	193	133	160	180	133	153	167	µm
Caudal hair number	11	14	16	10	13	17	7	7	10	9	14	19	11	14	18	12	13	18	
Ratios																			
Apical rostral segment/Hind tarsus II	0.82	0.98	1.17	1.10	1.20	1.35	1.00	1.11	1.15	0.89	0.95	1.00	1.18	1.25	1.31	1.00	1.11	1.20	
Longest Hair III/Basal diameter III	0.88	1.45	2.00	0.67	1.05	1.43	0.38	0.60	0.78	0.67	1.39	2.08	1.42	1.73	2.06	2.00	2.49	2.92	
Processus terminalis/Basal part VI	2.33	2.71	3.27	2.41	2.53	2.65	1.87	2.07	2.21	2.00	2.32	2.68	3.23	3.71	4.28	2.56	2.93	3.19	
Body/Apical rostral segment	15.7	18.4	21.2	11.7	12.7	13.8	15.9	17.3	19.1	13.1	16.6	20.4	13.6	14.7	15.9	12.7	14.1	15.6	
Siphunculi/Cauda	1.13	1.34	1.55	2.30	2.61	2.95	1.05	1.21	1.30	0.85	1.03	1.20	1.68	1.89	2.14	1.00	1.08	1.19	

Table 9. **Results of measurements of oviparous females and males of *A. cacaliasteris*, *A. vaccinii*, and *A. veratri*.**

	Oviparous females									Males									
Species	*A. cacaliasteris*			*A. vaccinii*			*A. veratri*			*A. cacaliasteris*			*A. vaccinii*			*A. veratri*			
Number of specimens investigated	4			4			19			10			1			21			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	2.06	2.16	2.34	1.10	1.39	1.76	1.50	1.65	1.78	1.74	1.88	2.02		1.46		1.34	1.46	1.55	mm
Total length of antenna	1.17	1.23	1.30	0.64	0.78	1.04	1.09	1.14	1.23	1.44	1.48	1.52	1.26	1.27	1.28	1.14	1.24	1.36	mm
Length of antennal joint III	286	300	320	133	174	240	186	214	240	386	411	433	326	333	340	200	244	280	µm
Length of antennal joint IV	206	241	273	80	116	167	147	180	213	280	294	313	253	253	253	186	231	280	µm
Length of antennal joint V	206	216	233	107	131	173	140	163	193	213	239	253	213	213	213	147	185	226	µm
Length of basal part of antennal joint VI	127	134	140	87	97	107	107	118	127	140	156	167	113	113	113	93	108	120	µm
Length of processus terminalis	213	221	226	147	186	273	326	363	406	253	274	293	273	273	273	333	360	393	µm
Basal diameter of antennal joint III	25	27	28	17	20	23	23	28	33	22	25	27	20	21	22	23	28	33	µm
Longest hair on antennal joint III	61	65	66	12	21	33	33	45	53	50	55	66	25	27	28	37	46	55	µm
Secondary rhinaria on antennal joint III	0	2	5	0	0	0	0	0	0	34	40	48	28	30	31	1	4	11	
Secondary rhinaria on antennal joint IV	5	8	10	0	0	0	0	0	0	16	23	28	16	17	17	3	7	12	
Secondary rhinaria on antennal joint V	0	0	0	0	0	0	0	0	0	3	6	9	3	6	9	0	2	6	
Length of apical rostral segment	120	122	127	80	87	100	113	120	127	120	124	127		93		113	118	120	µm
Accessory hairs on apical rostral segment	2	3	4	2	2	2	2	2	4	2	3	4		1		2	2	4	
Frons	200	203	206	153	163	180	180	199	220	173	180	186		167		180	198	220	µm
Joint II of hind tarsus	120	122	127	80	94	113	93	100	107	120	122	127	100	100	100	93	101	107	µm
Siphuncular length	180	194	200	87	115	167	193	220	240	133	138	147	113	120	127	167	194	226	µm
Caudal length	180	193	206	107	120	153	140	153	167	133	141	147		140		120	137	153	µm
Caudal hair number	19	20	22	12	15	21	14	17	18	14	15	17		14		12	14	18	
Ratios																			
Apical rostral segment/Hind tarsus II	1.00	1.00	1.00	0.86	0.93	1.08	1.13	1.20	1.27	0.95	1.02	1.06	0.93	0.93	0.93	1.13	1.18	1.29	
Longest Hair III/Basal diameter III	2.18	2.44	2.67	0.64	1.03	1.46	1.32	1.63	2.00	2.00	2.26	2.50	1.25	1.28	1.31	1.20	1.65	2.06	
Processus terminalis/Basal part VI	1.60	1.65	1.70	1.57	1.90	2.56	2.68	3.07	3.47	1.56	1.76	2.00	2.41	2.41	2.41	2.78	3.36	3.93	
Body/Apical rostral segment	17.2	17.7	18.5	12.8	16.1	18.6	12.5	13.7	14.8	14.2	15.1	16.0		15.6		11.7	12.3	12.9	
Siphunculi/Cauda	0.96	1.01	1.11	0.81	0.94	1.09	1.30	1.44	1.57	0.91	0.98	1.10	0.81	0.86	0.90	1.19	1.41	1.62	

3.4.5 Aphis newtoni

Apterous viviparous females dull black, greenish black, or brown, alate viviparous females with black head and thorax and dull greenish grey abdomen, larvae dull greenish brown or bright brown in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts. First antennal segment with 5-(6) hairs. Siphunculi and cauda brown. Abdomen with marginal sclerites on segments I-VI, postsiphuncular sclerites, and intersegmental pleural muscle sclerites, crossbands on segments VII and VIII, occasionally some spinal sclerites; dorsal cuticle reticulate; 4 great marginal tubercles on abdominal segments I and VII, and (5)-6 great tubercles on segments II-IV-(V); tergite VIII with 3-5-(6) hairs. Frons straight. Siphunculi squamous; cauda blunt. Measurements see Tab. 5.

Alate viviparous female: Antennae brown. (4)-5-(6) hairs on first antennal segment. 6-(7-8) great marginal tubercles on segments II-IV-(V); on tergite VIII 2-4 hairs. Measurements see Tab. 6.

Male apterous (HEIE, 1986; STROYAN, 1984).

Lives monoecious-holocyclically on different *Iris* spp., mainly on the basal parts of the leaves and sometimes also in the inflorescences and infructescences, and is visited by ants.

3.4.6 Aphis rumicis

Apterous viviparous females dull brownish black to black, alate viviparous females with black head and thorax, larvae dull bright to dark brown.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with brown proximal and distal parts, sometimes whole antennae brown. First antennal segment with (4)-5 hairs. Siphunculi and cauda brown. Abdomen with well developed marginal, postsiphuncular and intersegmental pleural muscle sclerites and with some spinal sclerites; dorsal cuticle with strong reticulation; 4 marginal tubercles on abdominal segments I and VII, and 0-(5-6) smaller ones on segments II-IV (and VI); tergite VIII with (3-4)-5-8-(9) hairs. Frons nearly straight, sometimes with small antennal tubercles. Siphunculi squamous; cauda blunt. Measurements see Tab. 7.

Alate viviparous female: Antennae brown. First antennal segment with 5-(6) hairs. Spinal sclerites well developed. 0-1-(2-6) marginal tubercles on segments II-IV; on tergite VIII 2-7 hairs. Measurements see Tab. 8.

The male is apterous (HEIE, 1986; JONES, 1942; STROYAN, 1984), smaller than any other morph, and its abdomen shows a well developed sclerotic pattern (JONES, 1942).

Lives monoecious-holocyclically mainly in longitudinally curled leaves, rarely also outside and in the inflorescences of *Rumex crispus* L., attended by ants. According to MÜLLER (1969) it feeds also on *R. obtusifolius* L. and *R. maritimus* L., and according to STROYAN (1984) sometimes also on *Rheum rhaponticum* L.

Table 10. **Results of measurements of fundatrices of *A. fabae*, *A. philadelphi*, and *A. sambuci*.**

Species	Fundatrices									
	A. fabae			*A. philadelphi*			*A. sambuci*			
Number of specimens investigated	4			5			3			
Characters	min	ø	max	min	ø	max	min	ø	max	
Body length	1.55	1.88	2.10	1.84	1.92	2.06	2.34	2.71	3.02	mm
Total length of antenna	0.64	0.82	0.91	0.74	0.80	0.85	0.88	0.99	1.07	mm
Length of antennal joint III	213	326	400	273	304	333	333	387	426	µm
Length of antennal joint IV	100	147	173	133	158	167	160	178	186	µm
Length of basal part of antennal joint V	100	118	133	120	125	133	140	150	160	µm
Length of processus terminalis	133	144	167	87	111	140	127	141	160	µm
Basal diameter of antennal joint III	22	26	30	18	20	22	27	32	40	µm
Longest hair on antennal joint III	17	29	40	33	36	42	42	44	50	µm
Secondary rhinaria on antennal joint III	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint IV	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint V	0	0	0	0	0	0	0	0	0	
Length of apical rostral segment	100	117	127	113	116	120	133	138	147	µm
Accessory hairs on apical rostral segment	2	2	2	1	2	2	2	2	2	
Frons	167	193	206	186	192	200	220	229	240	µm
Joint II of hind tarsus	93	102	107	100	103	107	120	120	120	µm
Siphuncular length	100	191	260	140	159	180	260	316	366	µm
Caudal length	127	175	193	173	184	206	167	189	200	µm
Caudal hair number	9	12	14	15	16	18	8	13	16	
Ratios										
Apical rostral segment/Hind tarsus II	1.07	1.14	1.20	1.13	1.13	1.13	1.11	1.11	1.11	
Longest Hair III/Basal diameter III	0.69	1.13	1.60	1.54	1.78	2.00	1.25	1.42	1.69	
Processus terminalis/Basal part VI	1.17	1.22	1.33	0.65	0.89	1.17	0.87	0.94	1.14	
Body/Apical rostral segment	14.9	16.1	17.5	15.7	16.6	17.2	17.5	19.7	20.8	
Siphunculi/Cauda	0.79	1.07	1.34	0.81	0.87	0.92	1.56	1.67	1.83	

3.4.7 Aphis sambuci

The dull greenish-black so-called *A. sambuci sambuci* and the olive-brown so-called *A. sambuci picta* subspecies (IGLISCH, 1969) were not distinguishable nor by electrophoresis (JÖRG and LAMPEL, 1994) neither by morphological data. Specimens from secondary hosts are dull green to bluish green.

Prepared material:

Apterous viviparous female: Antennae, tibiae, siphunculi and cauda brown. (5)-6-9-(10-11) hairs on first antennal segment. Abdomen with stigmal plates, often with postsiphuncular sclerites and crossbands on segments VII and VIII, and rarely with intersegmental pleural muscle sclerites; dorsal cuticle without reticulation; always 10 great marginal tubercles on abdominal segments I-IV and VII, occasionally on segment V 1-2 additional tubercles; tergite VIII with (2)-3-4-(5-6) hairs. Frons straight. Siphunculi squamous; cauda blunt. Measurements see Tab. 7.

Alate viviparous female: Antennae brown. 7-9-(11) hairs on first antennal segment. Spinal sclerites on segments I and VI-VIII. 8-(9) great marginal tubercles on segments I-IV-(V) and VII; 2-4 hairs on tergite VIII. Measurements see Tab. 8.

Fundatrix: Spinal sclerites on segments VI-VIII, sometimes additional sclerites on other segments. 10-12 marginal tubercles on segments I-V and VII; tergite VIII with 2-4 hairs. Cauda broad and blunt. Measurements see Tab. 10.

Male alate and similar to alate viviparous female, but smaller (HEIE, 1986).

To fulfil the whole life cycle, it is necessary to migrate from the primary host *Sambucus nigra* L. to the roots of herbaceous plants like *Rumex* spp., *Saxifraga* spp., and some Caryophyllaceae (MÜLLER, 1969), because males are only produced on secondary hosts or in colonies founded on *Sambucus* by virgino-gynoparae coming back from secondary hosts (HEIE, 1986; IGLISCH, 1966; LAMPEL, 1968).

3.4.8 Aphis tripolii

Apterous and alate viviparous female and alate male dull green in life, larvae dull bright green. Head and thorax of alatae black.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with a brown area distally, siphunculi pale to pale brown, and cauda pale. First antennal segment with (4)-5-(6) hairs. Abdomen without visible sclerites; dorsal cuticle reticulate; always 4 marginal tubercles on abdominal segments I and VII, and (1-5)-6 smaller ones on segments II-IV; tergite VIII with 2-(3) hairs. Frons nearly straight. Siphunculi squamous; cauda long, narrow, and blunt. Measurements see Tab. 7.

Alate viviparous female: Antennae and siphunculi brown, tibiae pale with brown proximal and distal parts. First antennal segment with 5-(6) hairs. Dorsal cuticle without reticulation. 6 marginal tubercles on abdominal segments II-IV; 2-3 hairs on tergite VIII. Measurements see Tab. 8.

Alate male: Antennae brown, siphunculi and cauda pale brown. First antennal segment with (4)-5 hairs. Marginal and postsiphuncular sclerites present. Dorsal cuticle without reticulation. 0 marginal tubercles on segments II-IV; 2 hairs on tergite VIII.

Lives monoecious-holocyclically on the upper stem and the leaves and in the inflorescences of *Aster tripolium* L.

3.4.9 Aphis vaccinii

Adults dull dark brown to black, larvae dull dark brown in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with a brown area proximally and distally, siphunculi and cauda brown. (3-4)-5 hairs on first antennal segment. Abdomen with well developed marginal and spinal sclerites on all segments and with intersegmental pleural muscle sclerites; dorsal cuticle reticulate; 4 marginal tubercles on abdominal segments I and VII, and 0-

(1-5) smaller ones on segments II-IV; tergite VIII with 2-4-(5-9) hairs. Frons nearly straight. Siphunculi squamous; cauda blunt. Measurements see Tab. 7.

Alate viviparous female: Antennae brown. First antennal segment with (3-4)-5 hairs. Abdomen with pre- and postsiphuncular sclerites, dorsal cuticle not reticulate. (0)-1-4-(5-6) marginal tubercles on abdominal segments II-IV; 2-3-(4) hairs on tergite VIII. Cauda slightly pointed. Measurements see Tab. 8.

Oviparous female: Antennae and tibiae pale with a brown area proximally and distally (hind tibiae completely brown with numerous scent plaques), siphunculi and cauda brown. (4)-5 hairs on first antennal segment. Abdominal sclerites less distinct, dorsal cuticle reticulate. 0-1 marginal tubercle on segments II-IV; 13-15-(16-33) hairs on tergite VIII. Measurements see Tab. 9.

Alate male: Antennae, siphunculi and cauda brown, tibiae pale with brown proximal and distal parts. First antennal segment with 5 and 6 hairs. Marginal, spinal and postsiphuncular sclerites well developed. Dorsal cuticle without reticulation. 0 marginal tubercle on abdominal segments II-IV; 5 hairs on tergite VIII. Measurements see Tab. 9.

Lives monoecious-holocyclically on young shoots of *Vaccinium uliginosum* L., often together with the green species *Acyrthosiphon knechteli* (Börner, 1950), rarely on *V. myrtillus* L., and is visited by ants. According to FIDLER (1951) and HEIE (1986) it feeds also on *V. vacillans* Kalm. and *Andromeda polifolia* L. After BÖRNER (1952) it lives "usually only in bogs". We detected a strong preference of sun exposed plants.

3.4.10 Aphis veratri

All observed morphs dull dark greenish brown in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with proximal and distal brown parts, siphunculi and cauda brown. First antennal segment with 5-10 hairs. Abdomen with some weak marginal sclerites, well developed crossbands on segments VII and VIII and stigmal plates; dorsal cuticle weakly reticulate, most distinct on sclerotic areas; 4 marginal tubercles on abdominal segments I and VII, and (2-3)-4-6-(7) smaller ones on segments II-IV-(V); tergite VIII with 5-7-(8-10) hairs. Frons nearly straight. Siphunculi squamous and slightly constricted; cauda broad and blunt. Measurements see Tab. 7.

Alate viviparous female: Antennae sometimes completely brown. First antennal segment with (5-6)-7-(8) hairs. Abdomen with well developed marginal, intersegmental muscle and postsiphuncular sclerites, sometimes with additional spinal sclerites on segments I-VI, dorsal cuticle reticulate. (2-4)-5-6 marginal tubercles on segments II-IV-(V); (6-7)-8-(9-12) hairs on tergite VIII. Measurements see Tab. 8.

Oviparous female: Like apterous viviparous female, but antennae always brown, hind tibiae hardly swollen, with scent plaques. First antennal segment with 5-7 hairs. (2-3)-4-6 marginal tubercles on segments II-IV-(V); 12-19 hairs on tergite VIII. Measurements see Tab. 9.

Apterous male: Like apterous viviparous female, but antennae brown. (5)-6-(7) hairs on first antennal segment. 2-5 marginal tubercles on segments II-IV (and VI); (4-5)-6-(7-8) hairs on tergite VIII. Measurements see Tab. 9.

Lives monoecious-holocyclically on the lower surface of leaves of *Veratrum album* L. and is attended by ants. Due to beginning senescence, the infested leaves are often brownish yellow. *A. cirsiiacanthoidis*, which can be also found on *V. album* (JÖRG and LAMPEL, 1994; MÜLLER and HORATSCHEK, 1980), feeds sometimes also on the lower surface of leaves, but mostly on the upper stem and in the inflorescences. *A. veratri* could never be found on these parts of the plant.

3.4.11 Aphis viburni

All observed morphs dull black in life.

Prepared material:

Apterous viviparous female: Antennae and tibiae pale with proximal and distal brown areas, siphunculi and cauda brown. 5-6-(7) hairs on first antennal segment. Abdomen with pale marginal, intersegmental muscle and postsiphuncular sclerites and with crossbands on segments VII and VIII, occasionally with spinal sclerites on other segments; dorsal cuticle with reticulation; always 4 marginal tubercles on abdominal segments I and VII, and at least 6, mostly 7-8-(9-10), slightly smaller ones on segments II-VI; tergite VIII with (2-3)-4-(5) hairs. Frons nearly straight. Siphunculi squamous; cauda blunt. Measurements see Tab. 7.

Alate viviparous female: Antennae brown. First antennal segment with (4)-5-6 hairs. Marginal, pre-, and postsiphonal sclerites great and brown, crossbands on segments I and VI-VIII. (6)-8-(9) marginal tubercles on segments II-VI; 2-4 hairs on tergite VIII. Measurements see Tab. 8.

Apterous male: Abdomen showing often the complete dorsal pattern of the alate viviparous female (JONES, 1945).

Lives without host-alternation (MÜLLER, 1969) in curled leaves of *Viburnum opulus* and is visited by ants.

4 Discussion

Since, due to different host plants, the age of clones (cf. Tab. 11 and 12) or other influences, high significant differences often already occur in absolute values, t-tests have been made only with the ratios.

Tab. 23-27 show that, comparing the ratios inside three clones, significant differences very often appear. Already SHAPOSHNIKOV (1986) reported, that within one clone of *Dysaphis foeniculus* (Theobald), due to different host plants, the allometry of some parts of the body can change. He drew the conclusion, that according to this fact, not infrequently new species have been described erroneously. *A. mordwilkoi* and *A. sambuci* showed in our tests similar phenomena as *D. foeniculus* (cf. Tab. 11 and 12). It must be pointed out, that the host plants used in our tests are the plants on which the aphids normally can be found in nature (JÖRG and LAMPEL, 1994; THIEME, 1988). BLACKMAN *et al*. (1987) made the observation, that variation can also occur in relation to the age of a clone. Such a variation could be detected by us in a clone of *A. fabae* (Tab. 11). In this clone the ratios Body/Apical rostral segment and Siphunculi/Cauda are significantly different on two different dates (cf. Tab. 26 and 27).

A. barberae and *A. mordwilkoi* show in four of the five ratios significant differences (Tab. 18-22), but one *A. mordwilkoi* clone shows on three different host plants also significant differences. That means, that the variation within one clone of *A. mordwilkoi* is as great as the variation between *A. mordwilkoi* and *A. barberae*. In addition it must be mentioned, that the spans of all measured values are strongly overlapping (see Tab. 4). Therefore, and according especially to our electrophoretic results and host plant tests (JÖRG and LAMPEL, 1994), we regard *A. barberae* nevertheless as a synonym of *A. mordwilkoi*. The rearing of a clone of *A. sambuci* on two distinct host plants results in three significantly different ratios.

A. janischi and *A. cirsiiacanthoidis* are in three ratios significantly different (Tab. 18-22). But also here, the spans of the values are strongly overlapping (see Tab. 3). The sometimes slightly higher values of *A. janischi* may probably come from nutritional influences of the host plant *Cirsium oleraceum* (L.) Scop., on which *A. janischi* has been found. Higher values could also be detected for *A. mordwilkoi*, which has been reared on *Tropaeolum majus* (see Tab. 11), and *A. sambuci*, which has been kept on *Sambucus nigra* (Tab. 12). According our electrophoretic results (JÖRG and LAMPEL, 1994) and the above made statements, we insist on regarding *A. janischi* as a synonym of *A. cirsiiacanthoidis*.

Inside the *A. fabae* group *s.str*., *A. armata* is the species with the highest degree of difficulty to be separated from the other ones. In comparison with *A. cirsiiacanthoidis*, *A. euonymi*, and *A.*

fabae, only two ratios are significantly different, with *A. philadelphi* three, and with *A. mordwilkoi* and *A. solanella* four. The comparison of *A. cirsiiacanthoidis* with *A. philadelphi* results also only in two distinct ratios; *A. cirsiiacanthoidis*/*A. fabae* and *A. philadelphi*/*A. solanella* have three different ratios. All other comparisons result in four to five significant different ratios (Tab. 13-17), but the spans of the values are also in nearly all cases strongly overlapping (see Tab. 1-4). Thus, for the *A. fabae* group *s.str*. it is impossible to erect a simple determination key based on morphological and biological (host plants) data (cf. JÖRG and LAMPEL, 1994). Perhaps, future studies will result in keys based on discriminant analysis of the morphological data of the investigated populations, as it has been done by BINAZZI and DE SILVA (1993) for two *Cinara* species.

The ratios of the members of the *A. fabae* group *s.l.* are for all combinations in most cases high significantly different (t-tests). But as the measured values are very often overlapping (see Tab. 5-8), it is also not possible to erect a general determination table for all species using only morphological characters. Easily determinable by some characters are *A. tripolii* (green colour, siphunculi pale, longest hair on antennal segment III of apterae 10-13 µm), *A. lantanae coriaria* (siphunculi only proximal pigmented, longest hair on antennal segment III at least 66 µm), *A. sambuci* (ratio Siphunculi/Cauda of apterae > 2.11), *A. cacaliasteris* (2-12 secondary rhinaria on antennal joint IV in apterae in combination with the ratio Apical rostral segment/Hind tarsus II 0.94-1.05), and partly *A. hederae* (up to 5 secondary rhinaria on antennal joint IV in combination with the ratio Apical rostral segment/Hind tarsus II 1.24-1.67). On the other hand, using the combination of host plant and morphology, all species of the *A. fabae* group *s.l.* are easily distinguishable from each other. This fact has been already used, e.g. by HEIE (1986), MÜLLER (1969), and STROYAN (1984). Unfortunately MÜLLER's key is not useful for all the Swiss material, because the spans given in this key do not always correspond with our values. To quote as an illustration, his ratio Siphunculi/Cauda for *A. sambuci* is simply 3, our ratio ranges between 2.42 and 3.23. The body length is 2.2-3.2 mm, our measured values are 1.79-3.18 mm. According to MÜLLER (1969), *A. vaccinii* and *A. rumicis* do not have any marginal tubercles on abdominal segments II-IV. We counted sometimes up to 5 tubercles for the first and even up to 6 for the latter species.

To draw some conclusions from the preceding work of JÖRG and LAMPEL (1994) and the present paper, one can state that it is possible to distinguish electrophoretically the members of the *A. fabae* group *s.str*. and *s.l*., but it is impossible to determine all the members of the mentioned groups by a general key based only on morphological characters. Host plant tests are only partly useful, and very difficult to standardise. By morphology in combination with host plants, the members of the *A. fabae* group *s.l.* are easily distinguishable.

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Table 11. **Comparison of measurements of one clone of *A. fabae* and *A. mordwilkoi*, respectively.**

	Alate viviparous females of one *A. fabae* clone						Apterous viviparous females of one *A. mordwilkoi* clone									
Host plant	*Vicia faba*			*Vicia faba*			*Vib. opulus*			*Trop. majus*			*Rumex crispus*			
Date of collection	10.5.89			6.9.89			6.7.89			11.12.89			23.1.90			
Number of specimens investigated	16			11			20			10			10			
Characters	min	ø	max	min	ø	max	min	ø	max	min	ø	max	min	ø	max	
Body length	1.46	1.81	2.08	1.33	1.52	1.76	1.71	1.95	2.14	1.95	2.07	2.34	1.10	1.41	1.70	mm
Total length of antenna	1.01	1.21	1.38	0.80	0.97	1.09	0.94	1.11	1.33	0.99	1.31	1.49	0.66	0.82	1.12	mm
Length of antennal joint III	260	311	353	213	242	280	200	256	333	266	312	360	127	183	300	µm
Length of antennal joint IV	140	203	253	113	147	180	133	173	220	180	217	260	80	112	180	µm
Length of antennal joint V	147	188	220	107	138	160	140	179	220	113	206	246	93	122	173	µm
Length of basal part of antennal joint VI	100	120	133	87	99	113	93	115	133	100	120	133	80	93	113	µm
Length of processus terminalis	246	308	360	206	263	306	273	316	366	233	361	406	193	236	286	µm
Basal diameter of antennal joint III	18	25	30	17	20	25	18	22	27	25	28	32	17	20	27	µm
Longest hair on antennal joint III	28	36	43	23	27	33	27	42	55	46	61	70	25	40	66	µm
Secondary rhinaria on antennal joint III	9	14	18	3	11	16	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint IV	0	1	6	0	2	5	0	0	0	0	0	0	0	0	0	
Secondary rhinaria on antennal joint V	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	
Length of apical rostral segment	107	121	127	100	110	120	127	134	147	147	152	153	113	127	147	µm
Accessory hairs on apical rostral segment	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	
Frons	153	168	180	153	161	173	180	193	200	200	209	213	153	168	193	µm
Joint II of hind tarsus	93	115	127	93	104	113	100	112	120	120	126	133	87	96	107	µm
Siphuncular length	127	186	233	107	133	173	147	175	206	260	298	353	87	129	213	µm
Caudal length	133	164	193	120	126	140	160	182	200	206	226	253	120	153	200	µm
Caudal hair number	9	12	16	7	10	13	11	13	16	16	18	20	11	14	17	
Ratios																
Apical rostral segment/Hind tarsus II	0.94	1.05	1.21	0.94	1.06	1.13	1.12	1.20	1.33	1.15	1.20	1.28	1.27	1.32	1.38	
Longest hair III/Basal diameter III	1.11	1.42	1.86	1.07	1.41	1.82	1.45	1.90	2.31	1.75	2.19	2.47	1.25	1.93	2.58	
Processus terminalis/Basal part VI	2.18	2.56	2.84	2.20	2.65	3.07	2.39	2.75	3.14	2.72	3.03	3.24	2.27	2.55	2.77	
Body/Apical rostral segment	13.7	14.9	16.4	11.7	13.8	15.2	13.2	14.6	15.9	12.7	13.6	15.3	9.8	11.0	12.1	
Siphunculi/Cauda	0.95	1.13	1.27	0.85	1.05	1.30	0.85	0.96	1.07	1.22	1.31	1.49	0.68	0.83	1.07	

Table 12. **Comparison of measurements of one clone of *A. sambuci* on two distinct host plants.**

	Apterous viviparous females of one *A. sambuci* clone						
Host plant	*Sambucus nigra*			*Rumex crispus*			
Date of collection	3.7.89			23.1.90			
Number of specimens investigated	8			11			
Characters	min	ø	max	min	ø	max	
Body length	1.79	1.94	2.13	1.38	1.48	1.63	mm
Total length of antenna	1.18	1.26	1.41	0.85	0.95	1.04	mm
Length of antennal joint III	253	284	326	167	199	233	µm
Length of antennal joint IV	167	205	240	107	134	160	µm
Length of antennal joint V	180	204	240	120	148	180	µm
Length of basal part of antennal joint VI	127	138	167	100	112	120	µm
Length of processus terminalis	293	316	346	233	252	273	µm
Basal diameter of antennal joint III	25	26	28	17	20	25	µm
Longest hair on antennal joint III	15	16	17	12	13	15	µm
Secondary rhinaria on antennal joint III	0	0	0	0	0	0	
Secondary rhinaria on antennal joint IV	0	0	0	0	0	0	
Secondary rhinaria on antennal joint V	0	0	0	0	0	0	
Length of apical rostral segment	147	155	167	133	139	147	µm
Accessory hairs on apical rostral segment	2	2	3	2	2	4	
Frons	220	222	233	186	199	206	µm
Joint II of hind tarsus	107	115	127	87	89	100	µm
Siphuncular length	386	443	519	240	288	353	µm
Caudal length	153	163	173	100	118	127	µm
Caudal hair number	8	10	12	9	12	13	
Ratios							
Apical rostral segment/Hind tarsus II	1.28	1.35	1.41	1.47	1.57	1.69	
Longest hair III/Basal diameter III	0.59	0.63	0.67	0.53	0.64	0.73	
Processus terminalis/Basal part VI	2.13	2.32	2.47	2.06	2.26	2.41	
Body/Apical rostral segment	11.7	12.5	13.3	9.9	10.6	11.3	
Siphunculi/Cauda	2.42	2.71	3.00	2.11	2.44	2.79	

Table 13. **Unpaired t-test for the ratio Apical rostral segment/Hind tarsus II of apterous viviparous females of the *Aphis fabae* group *s.str.***
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
armata, cirsiiacanthoidis	233	-6.708	<.0001	ss
armata, euonymi	124	-1.500	.1361	ns
armata, fabae	172	1.298	.1961	ns
armata, mordwilkoi	197	-14.132	<.0001	ss
armata, philadelphi	112	-8.790	<.0001	ss
armata, solanella	215	-11.419	<.0001	ss
cirsiiacanthoidis, euonymi	243	5.372	<.0001	ss
cirsiiacanthoidis, fabae	291	10.669	<.0001	ss
cirsiiacanthoidis, mordwilkoi	316	-6.989	<.0001	ss
cirsiiacanthoidis, philadelphi	231	-1.906	.0578	ns
cirsiiacanthoidis, solanella	334	-4.326	<.0001	ss
euonymi, fabae	182	3.308	.0011	ss
euonymi, mordwilkoi	207	-12.583	<.0001	ss
euonymi, philadelphi	122	-7.175	<.0001	ss
euonymi, solanella	225	-9.913	<.0001	ss
fabae, mordwilkoi	255	-20.465	<.0001	ss
fabae, philadelphi	170	-12.523	<.0001	ss
fabae, solanella	273	-17.021	<.0001	ss
mordwilkoi, philadelphi	195	3.980	<.0001	ss
mordwilkoi, solanella	298	3.141	.0019	ss
philadelphi, solanella	213	-1.370	.1720	ns
Species	Mean	Variance	Std. Dev.	Std. Err.
armata	1.095	.005	.071	.009
cirsiiacanthoidis	1.174	.006	.080	.006
euonymi	1.115	.005	.072	.009
fabae	1.082	.003	.059	.005
mordwilkoi	1.230	.003	.056	.005
philadelphi	1.196	.002	.048	.006
solanella	1.208	.004	.062	.005

Table 14. **Unpaired t-test for the ratio Longest hair III/Basal diameter III of apterous viviparous females of the *Aphis fabae* group *s.str.***
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
armata, cirsiiacanthoidis	229	18.127	<.0001	ss
armata, euonymi	126	1.699	.0918	ns
armata, fabae	176	22.567	<.0001	ss
armata, mordwilkoi	198	7.513	<.0001	ss
armata, philadelphi	112	12.419	<.0001	ss
armata, solanella	218	26.463	<.0001	ss
cirsiiacanthoidis, euonymi	241	-11.227	<.0001	ss
cirsiiacanthoidis, fabae	291	8.994	<.0001	ss
cirsiiacanthoidis, mordwilkoi	313	-14.661	<.0001	ss
cirsiiacanthoidis, philadelphi	227	-6.893	<.0001	ss
cirsiiacanthoidis, solanella	333	15.233	<.0001	ss
euonymi, fabae	188	14.632	<.0001	ss
euonymi, mordwilkoi	210	2.731	.0068	ss
euonymi, philadelphi	124	4.159	<.0001	ss
euonymi, solanella	230	19.052	<.0001	ss
fabae, mordwilkoi	260	-21.500	<.0001	ss
fabae, philadelphi	174	-12.739	<.0001	ss
fabae, solanella	280	4.856	<.0001	ss
mordwilkoi, philadelphi	196	4.454	<.0001	ss
mordwilkoi, solanella	302	27.894	<.0001	ss
philadelphi, solanella	216	16.690	<.0001	ss
Species	Mean	Variance	Std. Dev.	Std. Err.
armata	2.461	.032	.179	.023
cirsiiacanthoidis	1.753	.078	.279	.021
euonymi	2.337	.278	.528	.063
fabae	1.435	.104	.323	.029
mordwilkoi	2.192	.061	.247	.021
philadelphi	2.029	.037	.192	.026
solanella	1.243	.111	.333	.026

Table 15. **Unpaired t-test for the ratio Processus terminalis/Basal part VI of apterous viviparous females of the *Aphis fabae* group *s.str.***
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
armata, cirsiiacanthoidis	226	.558	.5776	ns
armata, euonymi	117	-3.532	.0006	ss
armata, fabae	168	1.021	.3088	ns
armata, mordwilkoi	188	-.675	.5004	ns
armata, philadelphi	106	5.179	<.0001	ss
armata, solanella	207	-3.923	.0001	ss
cirsiiacanthoidis, euonymi	239	-4.695	<.0001	ss
cirsiiacanthoidis, fabae	290	.573	.5668	ns
cirsiiacanthoidis, mordwilkoi	310	-1.673	.0953	ns
cirsiiacanthoidis, philadelphi	228	4.810	<.0001	ss
cirsiiacanthoidis, solanella	329	-6.323	<.0001	ss
euonymi, fabae	181	5.272	<.0001	ss
euonymi, mordwilkoi	201	3.762	.0002	ss
euonymi, philadelphi	119	9.388	<.0001	ss
euonymi, solanella	220	-.357	.7212	ns
fabae, mordwilkoi	252	-2.237	.0262	s
fabae, philadelphi	170	4.609	<.0001	ss
fabae, solanella	271	-6.463	<.0001	ss
mordwilkoi, philadelphi	190	6.885	<.0001	ss
mordwilkoi, solanella	291	-4.778	<.0001	ss
philadelphi, solanella	209	-9.367	<.0001	ss
Species	Mean	Variance	Std. Dev.	Std. Err.
armata	2.582	.074	.272	.037
cirsiiacanthoidis	2.556	.095	.309	.023
euonymi	2.758	.072	.269	.033
fabae	2.535	.077	.277	.026
mordwilkoi	2.611	.067	.258	.022
philadelphi	2.342	.043	.207	.028
solanella	2.774	.102	.319	.026

Table 16. **Unpaired t-test for the ratio Body/Apical rostral segment of apterous viviparous females of the *Aphis fabae* group *s.str*.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
armata, cirsiiacanthoidis	119	.348	.7285	ns
armata, euonymi	65	.441	.6609	ns
armata, fabae	93	1.611	.1106	ns
armata, mordwilkoi	102	4.662	<.0001	ss
armata, philadelphi	58	.603	.5486	ns
armata, solanella	111	.905	.3676	ns
cirsiiacanthoidis, euonymi	122	.277	.7821	ns
cirsiiacanthoidis, fabae	150	1.801	.0737	ns
cirsiiacanthoidis, mordwilkoi	159	5.989	<.0001	ss
cirsiiacanthoidis, philadelphi	115	.429	.6685	ns
cirsiiacanthoidis, solanella	168	.984	.3263	ns
euonymi, fabae	96	1.005	.3174	ns
euonymi, mordwilkoi	105	3.967	.0001	ss
euonymi, philadelphi	61	.103	.9185	ns
euonymi, solanella	114	.444	.6580	ns
fabae, mordwilkoi	133	3.900	.0002	ss
fabae, philadelphi	89	-.976	.3319	ns
fabae, solanella	142	-.485	.6282	ns
mordwilkoi, philadelphi	98	-4.346	<.0001	ss
mordwilkoi, solanella	151	-3.554	.0005	ss
philadelphi, solanella	107	.337	.7371	ns
Species	Mean	Variance	Std. Dev.	Std. Err.
armata	14.725	2.629	1.621	.287
cirsiiacanthoidis	14.625	1.718	1.311	.139
euonymi	14.545	2.899	1.703	.288
fabae	14.246	1.494	1.222	.154
mordwilkoi	13.482	1.115	1.056	.124
philadelphi	14.507	1.145	1.070	.202
solanella	14.380	3.606	1.899	.211

Table 17. **Unpaired t-test for the ratio Siphunculi/Cauda of apterous viviparous females of the *Aphis fabae* group *s.str*.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
armata, cirsiiacanthoidis	239	-.017	.9868	ns
armata, euonymi	131	2.853	.0050	ss
armata, fabae	187	5.321	<.0001	ss
armata, mordwilkoi	204	2.227	.0270	s
armata, philadelphi	117	.060	.9523	ns
armata, solanella	221	-8.595	<.0001	ss
cirsiiacanthoidis, euonymi	246	3.187	.0016	ss
cirsiiacanthoidis, fabae	302	6.496	<.0001	ss
cirsiiacanthoidis, mordwilkoi	319	2.773	.0059	ss
cirsiiacanthoidis, philadelphi	232	.078	.9383	ns
cirsiiacanthoidis, solanella	336	-11.995	<.0001	ss
euonymi, fabae	194	2.206	.0285	s
euonymi, mordwilkoi	211	-1.141	.2550	ns
euonymi, philadelphi	124	-3.013	.0031	ss
euonymi, solanella	228	-11.701	<.0001	ss
fabae, mordwilkoi	267	-4.065	<.0001	ss
fabae, philadelphi	180	-5.422	<.0001	ss
fabae, solanella	284	-16.874	<.0001	ss
mordwilkoi, philadelphi	197	-2.215	.0279	s
mordwilkoi, solanella	301	-14.267	<.0001	ss
philadelphi, solanella	214	-8.504	<.0001	ss
Species	Mean	Variance	Std. Dev.	Std. Err.
armata	1.240	.026	.162	.020
cirsiiacanthoidis	1.240	.034	.184	.014
euonymi	1.161	.025	.157	.019
fabae	1.109	.025	.158	.014
mordwilkoi	1.187	.024	.155	.013
philadelphi	1.238	.015	.124	.017
solanella	1.507	.050	.224	.018

Table 18. **Unpaired t-test for the ratio Apical rostral segment/Hind tarsus II of apterous viviparous females of *A. barberae*, *A. mordwilkoi*, *A. janischi*, and *A. cirsiiacanthoidis*.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
barberae, mordwilkoi	178	-.136	.8922	ns
janischi, cirsiiacanthoidis	218	-2.172	.0310	s
Species	Mean	Variance	Std. Dev.	Std. Err.
barberae	1.228	.003	.057	.009
mordwilkoi	1.230	.003	.056	.005
janischi	1.202	.003	.052	.008
cirsiiacanthoidis	1.174	.006	.080	.006

Table 19. **Unpaired t-test for the ratio Longest hair III/Basal diameter III of apterous viviparous females of *A. barberae*, *A. mordwilkoi*, *A. janischi*, and *A. cirsiiacanthoidis*.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
barberae, mordwilkoi	180	6.173	<.0001	ss
janischi, cirsiiacanthoidis	216	-1.572	.1175	ns
Species	Mean	Variance	Std. Dev.	Std. Err.
barberae	2.473	.079	.280	.044
mordwilkoi	2.192	.061	.247	.021
janischi	1.821	.028	.167	.025
cirsiiacanthoidis	1.753	.078	.279	.021

Table 20. **Unpaired t-test for the ratio Processus terminalis/Basal part VI of apterous viviparous females of *A. barberae*, *A. mordwilkoi*, *A. janischi*, and *A. cirsiiacanthoidis*.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
barberae, mordwilkoi	173	4.227	<.0001	ss
janischi, cirsiiacanthoidis	216	4.375	<.0001	ss
Species	Mean	Variance	Std. Dev.	Std. Err.
barberae	2.802	.041	.201	.033
mordwilkoi	2.611	.067	.258	.022
janischi	2.341	.031	.176	.027
cirsiiacanthoidis	2.556	.095	.309	.023

Table 21. **Unpaired t-test for the ratio Body/Apical rostral segment of apterous viviparous females of *A. barberae*, *A. mordwilkoi*, *A. janischi*, and *A. cirsiiacanthoidis*.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
barberae, mordwilkoi	90	-3.359	.0011	ss
janischi, cirsiiacanthoidis	110	-3.410	.0009	ss
Species	Mean	Variance	Std. Dev.	Std. Err.
barberae	12.608	.850	.922	.206
mordwilkoi	13.482	1.115	1.056	.124
janischi	15.641	1.243	1.115	.232
cirsiiacanthoidis	14.625	1.718	1.311	.139

Table 22. **Unpaired t-test for the ratio Siphunculi/Cauda of apterous viviparous females of *A. barberae*, *A. mordwilkoi*, *A. janischi*, and *A. cirsiiacanthoidis*.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
barberae, mordwilkoi	181	-6.460	<.0001	ss
janischi, cirsiiacanthoidis	224	-1.654	.0995	ns
Species	Mean	Variance	Std. Dev.	Std. Err.
barberae	1.019	.010	.099	.016
mordwilkoi	1.187	.024	.155	.013
janischi	1.287	.017	.132	.019
cirsiiacanthoidis	1.240	.034	.184	.014

Table 23. **Unpaired t-test for the ratio Apical rostral segment/Hind tarsus II of one clone of *A. fabae*, *A. mordwilkoi*, and *A. sambuci*, respectively.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
fabae 10.5.89, *fabae* 6.9.89	49	-.395	.6948	ns
mordwilkoi on *Viburnum*, *mordwilkoi* on *Tropaeolum*	58	.001	.9992	ns
mordwilkoi on *Viburnum*, *mordwilkoi* on *Rumex*	58	-8.146	<.0001	ss
mordwilkoi on *Tropaeolum*, *mordwilkoi* on *Rumex*	38	9.797	<.0001	ss
sambuci on *Sambucus*, *sambuci* on *Rumex*	36	-12.096	<.0001	ss
Clone	Mean	Variance	Std. Dev.	Std. Err.
fabae 10.5.89	1.053	.003	.050	.009
fabae 6.9.89	1.060	.004	.062	.014
mordwilkoi on *Viburnum*	1.204	.003	.058	.009
mordwilkoi on *Tropaeolum*	1.204	.001	.038	.008
mordwilkoi on *Rumex*	1.322	.001	.038	.008
sambuci on *Sambucus*	1.349	.002	.042	.011
sambuci on *Rumex*	1.566	.004	.062	.013

Table 24. **Unpaired t-test for the ratio Longest hair III/Basal diameter III of one clone of *A. fabae*, *A. mordwilkoi*, and *A. sambuci*, respectively.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
fabae 10.5.89, *fabae* 6.9.89	48	.045	.9644	ns
mordwilkoi on *Viburnum*, *mordwilkoi* on *Tropaeolum*	57	-5.587	<.0001	ss
mordwilkoi on *Viburnum*, *mordwilkoi* on *Rumex*	57	-.402	.6889	ns
mordwilkoi on *Tropaeolum*, *mordwilkoi* on *Rumex*	38	-2.721	.0098	ss
sambuci on *Sambucus*, *sambuci* on *Rumex*	36	-.833	.4101	ns
Clone	Mean	Variance	Std. Dev.	Std. Err.
fabae 10.5.89	1.417	.036	.189	.034
fabae 6.9.89	1.414	.059	.243	.056
mordwilkoi on *Viburnum*	1.904	.039	.197	.032
mordwilkoi on *Tropaeolum*	2.194	.030	.172	.039
mordwilkoi on *Rumex*	1.934	.153	.391	.087
sambuci on *Sambucus*	.627	.001	.031	.008
sambuci on *Rumex*	.641	.004	.063	.013

Table 25. **Unpaired t-test for the ratio Processus terminalis/Basal part VI of one clone of *A. fabae*, *A. mordwilkoi*, and *A. sambuci*, respectively.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
fabae 10.5.89, *fabae* 6.9.89	44	-.926	.3596	ns
mordwilkoi on *Viburnum*, *mordwilkoi* on *Tropaeolum*	56	-6.514	<.0001	ss
mordwilkoi on *Viburnum*, *mordwilkoi* on *Rumex*	56	4.258	<.0001	ss
mordwilkoi on *Tropaeolum*, *mordwilkoi* on *Rumex*	34	-9.869	<.0001	ss
sambuci on *Sambucus*, *sambuci* on *Rumex*	35	1.610	.1165	ns
Clone	Mean	Variance	Std. Dev.	Std. Err.
fabae 10.5.89	2.559	.049	.221	.044
fabae 6.9.89	2.626	.076	.276	.060
mordwilkoi on *Viburnum*	2.748	.026	.162	.026
mordwilkoi on *Tropaeolum*	3.032	.018	.133	.031
mordwilkoi on *Rumex*	2.554	.024	.156	.037
sambuci on *Sambucus*	2.319	.011	.103	.027
sambuci on *Rumex*	2.257	.015	.124	.026

Table 26. **Unpaired t-test for the ratio Body/Apical rostral segment of one clone of *A. fabae*, *A. mordwilkoi*, and *A. sambuci*, respectively.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
fabae 10.5.89, *fabae* 6.9.89	25	2.762	.0106	s
mordwilkoi on *Viburnum*, *mordwilkoi* on *Tropaeolum*	28	3.081	.0046	ss
mordwilkoi on *Viburnum*, *mordwilkoi* on *Rumex*	28	11.244	<.0001	ss
mordwilkoi on *Tropaeolum*, *mordwilkoi* on *Rumex*	18	-7.491	<.0001	ss
sambuci on *Sambucus*, *sambuci* on *Rumex*	17	7.311	<.0001	ss
Clone	Mean	Variance	Std. Dev.	Std. Err.
fabae 10.5.89	14.931	1.052	1.026	.256
fabae 6.9.89	13.844	.947	.973	.293
mordwilkoi on *Viburnum*	14.555	.635	.797	.178
mordwilkoi on *Tropaeolum*	13.634	.513	.716	.227
mordwilkoi on *Rumex*	11.043	.683	.826	.261
sambuci on *Sambucus*	12.503	.412	.642	.227
sambuci on *Rumex*	10.632	.227	.477	.144

Table 27. **Unpaired t-test for the ratio Siphunculi/Cauda of one clone of *A. fabae*, *A. mordwilkoi*, and *A. sambuci*, respectively.**
Hypothesized difference = 0. DF: Degrees of freedom, ss: difference high significant, s: difference significant, ns: difference not significant

Combination	DF	t-Value	P-Value	Signif.
fabae 10.5.89, *fabae* 6.9.89	52	2.845	.0063	ss
mordwilkoi on *Viburnum*, *mordwilkoi* on *Tropaeolum*	58	-19.563	<.0001	ss
mordwilkoi on *Viburnum*, *mordwilkoi* on *Rumex*	58	5.888	<.0001	ss
mordwilkoi on *Tropaeolum*, *mordwilkoi* on *Rumex*	38	-17.507	<.0001	ss
sambuci on *Sambucus*, *sambuci* on *Rumex*	36	4.815	<.0001	ss
Clone	Mean	Variance	Std. Dev.	Std. Err.
fabae 10.5.89	1.129	.007	.085	.015
fabae 6.9.89	1.043	.019	.137	.029
mordwilkoi on *Viburnum*	.957	.004	.064	.010
mordwilkoi on *Tropaeolum*	1.313	.005	.070	.016
mordwilkoi on *Rumex*	.831	.010	.101	.023
sambuci on *Sambucus*	2.713	.035	.187	.047
sambuci on *Rumex*	2.440	.026	.161	.034

Zusammenfassung

Morphologische Studien über die Aphis fabae-Gruppe (Homoptera, Aphididae)

Die Taxa der *Aphis fabae*-Gruppe *s.str.* sind morphologisch nur schwer oder gar nicht unterscheidbar. Nur mit Hilfe der vertikalen Stärke-Gel-Elektrophorese ist es möglich, die Mitglieder des gesamten *A. fabae*-Komplexes (*A. fabae*-Gruppe *s.str.* und *s.l.*) zu unterscheiden (JÖRG und LAMPEL, 1994). In der vorliegenden Arbeit werden nun die Resultate unserer morphologischen Untersuchungen über diesen Komplex präsentiert.

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