doi: 10.17221/34/2014-PPS

Changes in *Meligethes aeneus* (Coleoptera: Nitidulidae) Susceptibility to Lambda-cyhalothrin in the Czech Republic between 2009 and 2011

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Abstract

Seidenglanz M., Poslušná J., Rotrekl J., Kolařík P., Hrudová E., Tóth P., Havel J., Spitzer T., Bernardová M. (2015): **Changes in** *Meligethes aeneus* (Coleoptera: Nitidulidae) **susceptibility to lambda-cyhalothrin in the Czech Republic between 2009 and 2011**. Plant Protect. Sci., 51: 13–32.

Susceptibility of *Meligethes* sp. (mainly *M. aeneus*) from the Czech Republic was tested with lambda-cyhalothrin (111 samples in 2009, 125 in 2010, and 102 in 2011) through the use of IRAC method No. 011, Vers. 3. Resistant samples were the most frequent in all three years and their proportions increased from 33% to 62% between 2009 and 2011. The last samples classified as highly susceptible were recorded in 2010. The mean percentage mortalities for a common European field rate of 7.5 g a.i/ha were 82.2% in 2009, 78.92% in 2010, and 67.45% in 2011(according to Abbott's formula). The values of LC_{50} ranged from 0.084 to 47.27 g a.i./ha in 2009, from 0.051 to 46.78 g a.i./ha in 2010, and from 0.238 to 19.92 g a.i./ha in 2011. Only in 17.65% of samples there were LC_{90} values below the European field rate in 2011.

Keywords: pollen beetles; pyrethroid resistance; esteric pyrthroids; adult vial tests; IRAC

The first case of reduced susceptibility of pollen beetles, *Meligethes aeneus* F. (Coleoptera: Nitidulidae), to pyrethroids in Europe was reported in 1999 in the Champagne region in north-eastern France (Ballanger *et al*. 2007). Based on this evidence resistance monitoring activities were initiated in many other European countries (Zimmer & Nauen 2011a,b). Consequently, the resistant pollen beetles were also discovered in 2000 in Switzerland (Derron *et al*. 2004) and in Sweden (Djurberg & Gustafsson 2007), in 2003 in Finland (Tiilikainen & Hokkanen 2008), in 2004 in Poland (Wegorek 2005; Wegorek *et al*. 2006, 2009; Philippou *et al*. 2011) and in 2007 in Luxembourg (Eickermann *et al*. 2008). The first cases of pyrethroid resistance in Denmark were described in 2000 and 2001 and confirmed in 2003 (Hansen 2003, 2008). Since 2002, when the first resistant pollen beetles were observed in Germany, the number of positive records has rapidly increased in this country (Heimbach 2005, 2007; Nauen 2005, 2007; Heimbach & Műller 2006; Thieme *et al*. 2006, 2008). In 2006 more than 50% of the winter oilseed rape acreage in Germany was affected (Thieme *et al*. 2008). In 2007 resistant pollen beetles were also recorded for the first time in the Czech Republic (Kocourek *et al*. 2007; Seidenglanz *et al*. 2011, 2012, 2013; Stará *et al*.

Supported by the Ministry of Agriculture of the Czech Republic, Projects No. QJ1230077 and No. QH81218.

doi: 10.17221/34/2014-PPS

2010; Zimmer & Nauen 2011a). However, we cannot exclude the possibility that the resistant pollen beetles appeared even earlier in the Czech Republic (Kocourek 2013). Currently pyrethroid-resistant pollen beetles are probably most dominant in Western and Central Europe and are becoming established in the North and East (Slater *et al*. 2011). The UK (and maybe Austria) are slightly less affected by the phenomenon and it seems that *Meligethes* samples from Ukraine and some Baltic states (Estonia and Latvia) remain fully susceptible to pyrethroids (Richardson 2008; Veromann & Toome 2011; Zimmer & Nauen 2011a,b). It is clear that the main oilseed-rape-growing areas of Europe are affected by the problem. Furthermore the selection pressure for resistance is still high because pyrethroids are the main agent used, and often in sequence within one season, for the control of all main insect pests in oilseed rape (Thieme *et al*. 2010; Heimbach & Müller 2013).

The aim of the paper is to present a change in resistance levels of *Meligethes aeneus* from the Czech Republic to esteric pyrethroids (lambda-cyhalothrin used in tests) in the course of three years (2009–2011). Insecticide Resistance Action Committee (IRAC; www.irac-online.org) laboratory test No. 11, Vers. 3 was used.

MATERIAL AND METHODS

Samples of *Meligethes* adults (*M. aeneus* highly predominated in the catches) from different localities in the Czech Republic were collected mainly from winter oilseed rape fields (in some cases spring rape, white mustard and poppy fields were used, too) in the course of April, May, June, and July 2009–2011 (Figures 1–3 and Table 1–3). Each of the *Meligethes* samples was tested with lambda-cyhalothrin; a total of 111 samples in 2009, 125 samples in 2010, and 102 samples in 2013 were tested and compared. Lambda-cyhalothrin (analytical standard; batch number: HUD6A 3514) was obtained from Syngenta Czech Ltd. (Prague, Czech Republic).

The 'adult vial test' recommended by the IRAC was used for testing (IRAC method No. 011, Vers. 3). The inner surfaces of the glass vials (all with the same inside area: 37.97cm^2; P-Lab; Prague, Czech Republic) were coated with different concentrations of lambda-cyhalothrin. 1 ml of solution for every concentration was used per vial. Vials with the solutions were rotated on a roller mixer at room temperature until the acetone completely evaporated. At the start of the coating process, the inner surface of the vials was completely covered with the solution. Five concentrations were prepared per test: 0 g a.i./ha = untreated control; 0.3 g a.i./ha (= 0.003 µg a.i/cm^2); 1.5 g a.i./ha (= 0.015 µg a.i./cm^2); 7.5 g a.i./ha (= 0.075 µg a.i./cm^2), and 37.5 g a.i./ha (= 0.375 µg a.i./cm^2). The rate 7.5 g a.i./ha (= 0.075 µg a.i./cm^2) is the European (and also Czech) lambda-cyhalothrin registered dose (= 100% field rate). For every sample three replicates were used for each tested concentration. Ten (8–12) adult pollen beetles were placed in each vial. The vials with beetles were stored in constant environment facilities at 18 ± 2°C and 16 : 8 h light : dark. After 24 h the beetles were tipped out of the vials and scored on filter discs. Insects incapable of coordinated movement (IRAC; www.irac-online.org) were scored as dead for computing $LC_{50–90}$ values and for establishing the effectiveness of individual rates. On the basis of the recorded effects induced by the concentrations 1.5 and 7.5 g a.i./ha Pyrethroid Resistance Indices (PRI) for individual samples were calculated (more detailed description in Table 4). Resistance ratio (RR) values were first calculated separately for each of the three *Meligethes* collection seasons on the basis of the lowest $LC_{50–90}$ values recorded in each of the three years (2009–2011) (Tables 1–3). Secondly the lowest LC_{50} value recorded during the three years (minimal LC_{50} = 0.051 g a.i./ha; sample No. 36 in 2010) served as a basis for the RR (LC_{50}) comparison used in Table 6.

The $LC_{50–90}$ values were estimated by Probit analysis using Polo Plus software, Vers. 2 (LeOra Software, Berkeley, USA). On the basis of mortality recorded in control vials all mortality figures were corrected according to Abbott's formula (Abbott 1925). Further statistical analysis was performed with Statistica software Vers. 10 (STATSOFT, Inc. 1984–2013). Analysis of variance (ANOVA) and appropriate post-test (Tukey test) were performed to test significant differences in mean percentage mortalities in the compared *Meligethes* samples induced by the three concentrations tested: 1.5, 7.5, and 37.5 g a.i./ha.

RESULTS

In 2009 almost 12% of samples were highly susceptible (PRI1) and 18% were susceptible (PRI2). 25% of samples were moderately resistant (PRI3). Resistant (PRI4) samples predominated in the collection and the portion of highly resistant (PRI5) samples was the same as the portion of highly susceptible ones (Tables 1 and 4). The mean percentage mortality from

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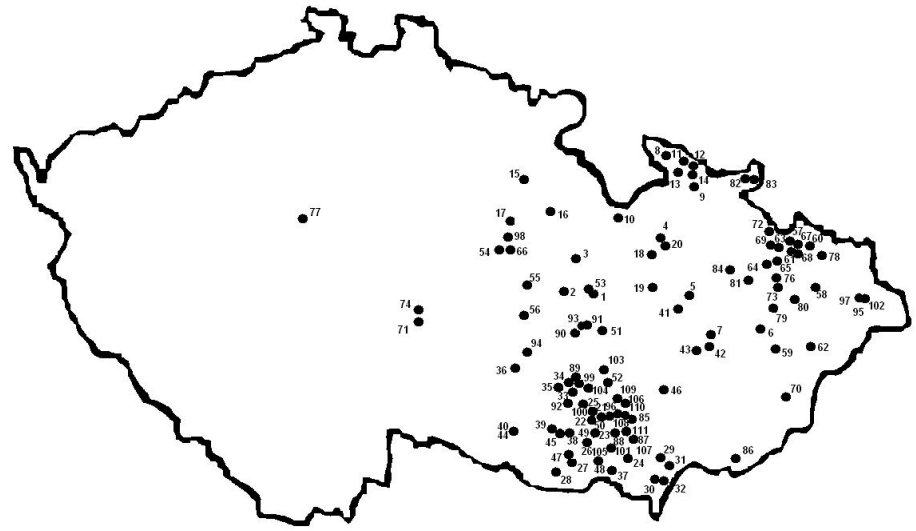

Figure 1. The spots on the map of the Czech Republic mark the places where the *Meligethes* subpopulations tested in 2009 were sampled. In total, 111 samples were compared. The numbers of the spots corresponds with the population numbers used in Table 1 and in Figures 4A–C

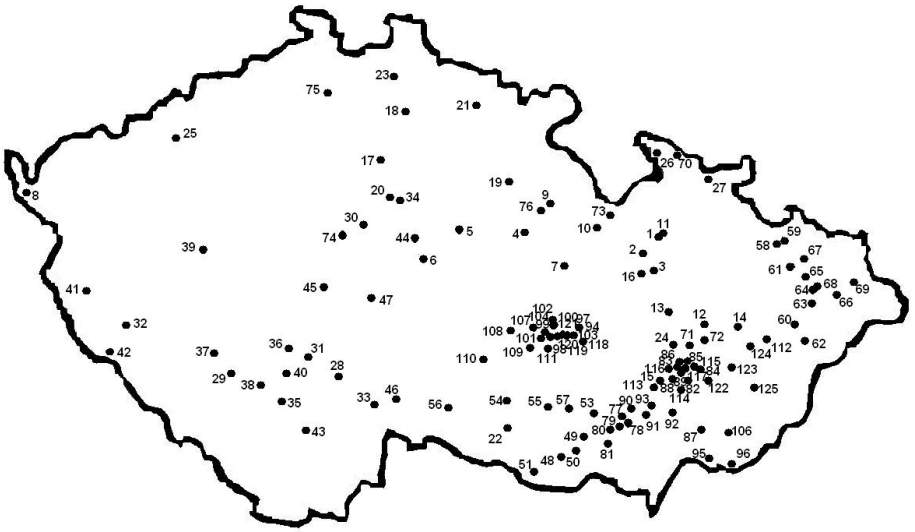

Figure 2. The spots on the map of the Czech Republic mark the places where the *Meligethes* subpopulations tested in 2010 were sampled. 125 samples in total were compared. The numbers of the spots corresponds with the population numbers used in Table 2 and in Figures 5A–C

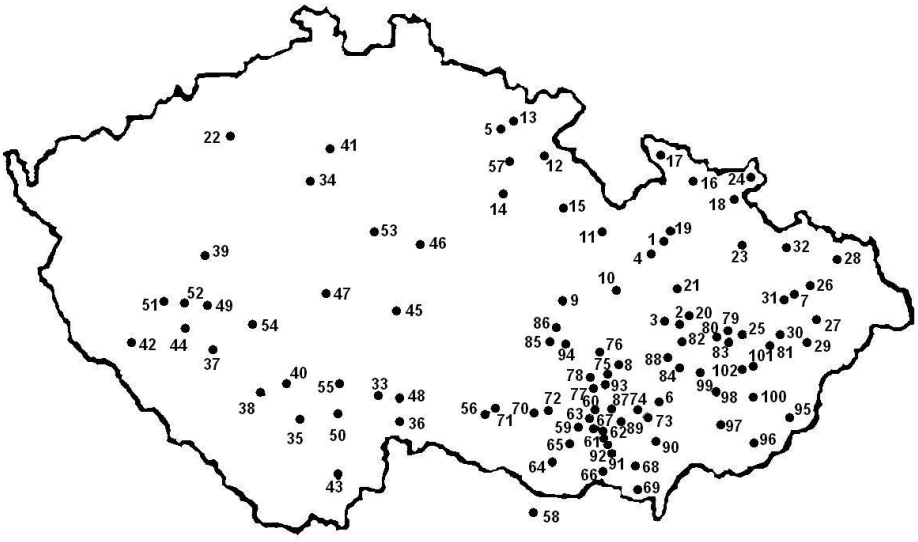

Figure 3. The spots on the map of the Czech Republic mark the places where the *Meligethes* subpopulations tested in 2011 were sampled. In total, 102 samples were compared. The numbers of the spots corresponds with the population numbers used in Table 3 and in Figures 6A–C

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doi: 10.17221/34/2014-PPS

Table 1. Results of susceptibility testing of Czech *Meligethes* subpopulations to lambda-cyhalothrin in 2009 (total of 111 populations compared; method IRAC 011, Vers. 3, exposure 24 h)

Population No.	Locality (district)	Date of sampling	Mean contact (%) lab. effect of the rate		PRI (1–5)[b]	LD_{50}	95% CL	RR (LD_{50})	LD_{90}	95% CL	RR (LD_{90})	LD_{95}	95% CL	RR (LD_{95})
			7.5 g a.i./ha[a]	1.5 g a.i./ha[a]		(g a.i/ha)			(g a.i/ha)			(g a.i/ha)		
1	Hradec n/Svitavou (SY)	22.4.	81.87	62.23	4	0.767	0.339–1.355	9.13	10.648	5.225–39.945	17.78	22.443	9.448–125.157	25.59
2	Lezník u Poličky (SY)	22.4.	96.67	73.33	3	0.372	0.111–0.701	4.43	3.581	1.817–15.208	5.98	6.802	3.016–48.404	7.76
3	Vlčkov (UO)	22.4.	66.67	0.00	4	6.373	3.907–9.864	75.87	16.736	10.641–45.870	27.94	22.005	13.206–75.909	25.09
4	Rapotín (SU)	23.4.	71.80	56.67	4	1.020	0.575–1.601	12.14	24.518	12.735–69.643	40.93	60.393	26.725–232.672	68.86
5	Žerotín (OL)	28.4.	76.67	63.33	4	1.440	0.704–2.583	17.14	14.121	6.796–56.213	23.57	26.975	11.356–153.212	30.76
6	Velká u Hranic (PR)	28.4.	80.00	26.67	4	2.829	1.755–4.523	33.68	21.373	11.637–57.481	35.68	37.918	18.657–126.012	43.24
7	Krčmaň (OL)	28.4.	73.33	20.00	4	3.468	1.991–6.117	41.29	20.048	10.295–68.303	33.47	32.968	15.327–144.866	37.59
8	Javorník (JE)	5.5.	61.20	37.33	4	2.728	1.283–5.574	32.48	56.269	20.302–485.040	93.94	132.708	38.845–1966.941	151.32
9	Česká Ves (JE)	5.5.	62.40	12.73	4	6.118	1.957–30.524	72.83	120.338	25.983–34 320.215	200.90	280.011	45.960–295906.169	319.28
10	Lichkov (UO)	5.5.	56.67	46.67	4	1.625	0.226–5.238	19.35	151.814	25.550–225 024.007	253.45	549.444	59.151–7 639 478.966	626.50
11	Velká Kraš (JE)	7.5.	60.00	30.00	4	4.026	2.773–6.000	47.93	62.454	32.997–160.098	104.26	135.866	63.572–425.428	154.92
12	Vidnava (JE)	7.5.	46.67	26.67	5	5.332	2.325–15.104	63.48	171.811	42.329–6 171.374	286.83	459.837	85.489–38 251.995	524.33
13	Tomíkovice (JE)	7.5.	60.93	34.67	4	5.211	1.751–21.763	62.04	116.663	25.888–21 547.564	194.76	281.607	47.088–179 647.981	321.10
14	Stará Červená Voda (JE)	7.5.	66.77	52.63	4	2.608	0.773–7.294	31.05	79.151	20.207–4 796.058	132.14	208.265	39.742–38 707.404	237.47
15	Libřice u Jaroměře (HK)	12.5.	66.67	29.10	4	1.664	0.212–5.890	19.81	105.373	18.675–224 563.925	175.91	341.541	40.179–7 385 981.836	389.44
16	Čestice (RK)	12.5.	81.80	53.70	4	0.761	0.183–1.701	9.06	47.867	15.182–729.556	79.91	154.869	35.944–6 007.666	176.59
17	Sezemice (PU)	12.5.	73.33	31.53	4	1.838	0.488–4.850	21.88	113.729	25.548–9 630.522	189.86	366.222	57.455–113 207.894	417.58
18	Bludov (SU)	21.5.	83.33	50.00	4	1.298	0.755–2.058	15.45	14.333	7.740–39.189	23.93	28.313	13.538–99.932	32.28
19	Mohelnice (SU)	21.5.	83.33	43.33	4	1.060	0.319–2.321	12.62	24.53	8.779–282.535	40.95	59.771	17.041–1452.857	68.15
20	Vikýřovice (SU)	21.5.	83.33	50.00	4	1.182	0.376–2.547	14.07	36.28	12.551–416.064	60.57	95.76	25.868–2314.723	109.19
21	Troubsko I (BI)	15.4.	90.00	80.00	3	0.632	0.176–1.323	7.52	6.705	2.950–42.429	11.19	13.096	4.987–149.129	14.93
22	Radostice (BI)	20.4.	90.00	60.00	3	1.039	0.231–2.555	12.37	16.566	5.790–276.845	27.66	36.317	10.402–1449.059	41.41
23	Němčičky u Pravlova (BV)	20.4.	96.67	80.00	3	0.240	0.103–0.400	2.86	2.82	1.757–5.939	4.71	5.669	3.158–15.858	6.46
24	Hustopeče (BV)	21.4.	100.00	86.67	2	0.190	0.063–0.318	2.26	1.262	0.802–2.929	2.11	2.158	1.248–7.257	2.46
25	Ostrovačice (BI)	22.4.	100.00	80.00	2	0.404	0.212–0.616	4.81	2.188	1.339–5.622	3.65	3.532	1.960–12.125	4.03
26	Jezeřany (ZN)	23.4.	93.33	83.33	3	0.084	0.001–0.301	1.00	2.843	1.118–23.622	4.75	7.721	2.664–284.122	8.80
27	Kašenec (ZN)	23.4.	96.67	90.00	3	0.209	0.033–0.432	2.49	1.941	1.001–8.278	3.24	3.649	1.682–29.931	4.16
28	Práče (ZN)	23.4.	93.33	83.33	3	0.111	0.022–0.251	1.32	2.974	1.668–7.423	4.96	7.551	3.679–30.187	8.61
29	Čejč (HO)	27.4.	96.67	60.00	3	0.933	0.369–1.807	11.11	9.501	4.365–45.510	15.86	18.342	7.339–136.087	20.91
30	Moravský Žižkov (BV)	27.4.	86.67	56.67	4	0.752	0.134–1.841	8.95	23.644	7.718–476.710	39.47	62.85	15.771–3560.521	71.66
31	Mutěnice (HO)	27.4.	86.67	90.00	4	0.224	0.022–0.579	2.67	6.431	2.704–42.814	10.74	16.655	5.750–265.12	18.99
32	Prušánky (HO)	27.4.	100.00	66.67	2	0.619	0.414–0.864	7.37	3.312	2.155–6.642	5.53	5.326	3.190–12.767	6.07
33	Rudka (BI)	28.4.	90.00	83.33	3	0.126	0.013–0.329	1.50	3.946	1.895–15.786	6.59	10.476	4.226–876	11.95
34	Lesní Hluboké (BI)	28.4.	90.00	40.00	3	1.716	1.195–2.454	20.43	8.073	5.125–16.354	13.48	12.523	7.401–29.298	14.28
35	Velká Bíteš (ZR)	28.4.	90.00	83.33	3	0.319	0.031–0.810	3.80	6.303	2.491–64.182	10.52	14.679	4.828–396.812	16.74
36	Měřín (ZR)	28.4.	96.67	66.67	3	0.753	0.262–1.495	8.96	8.609	3.900–43.564	14.37	17.185	6.728–141.203	19.60
37	Dolní Dunajovice (BV)	5.5.	80.00	70.00	4	0.510	0.065–1.292	6.07	20.224	6.733–390.736	33.76	57.415	14.451–3 429.420	65.47

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38	Moravský Krumlov (ZN)	5.5.	96.67	76.67	3	0.160	0.000–0.650	1.90	10.457	2.994–1191.935	17.46	34.189	7.264–55 392.456	38.98
39	Dukovany (TR)	5.5.	100.00	83.33	2	0.256	0.052–0.482	3.05	1.834	0.977–8.723	3.06	3.207	1.520–29.274	3.66
40	Jaroměřice n/R. I (TR)	5.5.	93.33	66.67	3	0.351	0.102–0.700	4.18	7.861	3.815–30.314	13.12	18.97	7.710–121.861	21.63
41	Unčovice (OL)	16.6.	80.00	70.00	4	0.608	0.152–1.309	7.24	13.974	5.615–107.995	23.33	33.977	11.053–533.549	38.74
42	Brodek u Prostějova (PV)	16.6.	78.90	46.67	4	1.419	0.741–2.416	16.89	24.887	11.742–92.937	41.55	56.059	22.490–298.774	63.92
43	Biskupice (PV)	16.6.	86.67	70.00	4	0.185	0.034–0.440	2.20	16.788	7.358–80.953	28.03	60.279	19.973–600.712	68.73
44	Jaroměřice n/R. II (TR)	18.6.	93.33	83.33	3	0.247	0.104–0.418	2.94	3.311	2.032–7.072	5.53	6.915	3.777–19.687	7.88
45	Dolní Dubňany (TR)	18.6.	96.67	63.33	3	0.516	0.232–0.871	6.14	4.681	2.532–14.821	7.81	8.746	4.172–39.536	9.97
46	Vyškov (VY)	18.6.	63.33	63.33	4	1.225	0.383–2.672	14.58	29.16	10.213–369.678	48.68	71.631	19.843–1 952.297	81.68
47	Miroslav (ZN)	8.6.	100.00	86.67	2	0.160	0.027–0.317	1.90	1.442	0.819–4.464	2.41	2.692	1.379–14.740	3.07
48	Nová Ves u Pohořelic (BI)	8.6.	90.00	76.67	3	0.251	0.010–0.769	2.99	15.36	5.008–367.133	25.64	49.331	11.834–5 139.363	56.25
49	Trboušany (BI)	8.6.	80.00	50.00	4	1.067	0.612–1.666	12.70	24.772	12.992–68.391	41.36	60.406	27.131–223.204	68.88
50	Ořechov (BI)	8.6.	100.00	73.33	2	0.225	0.007–0.636	2.68	4.289	1.624–69.044	7.16	9.887	3.167–616.121	11.27
51	Skrchov u Letovic (BK)	23.6.	93.33	73.33	3	0.217	0.032–0.497	2.58	4.413	2.077–21.273	7.37	10.374	4.109–102.033	11.83
52	Podlesí u Kuřimi (BI)	23.6.	93.33	60.00	3	0.500	0.174–0.935	5.95	6.276	3.059–26.755	10.48	12.857	5.376–88.742	14.66
53	Svitavy (SY)	23.6.	93.33	83.33	3	0.194	0.019–0.498	2.31	4.996	2.185–28.634	8.34	12.541	4.586–164.316	14.30
54	Chrudim (CR)	30.6.	83.33	46.67	4	1.093	0.296–2.519	13.01	22.34	7.767–326.332	37.30	52.557	14.616–1 737.962	59.93
55	Vojtěchov u Hlinska (CR)	30.6.	80.00	33.33	4	2.229	1.671–2.968	26.54	12.593	8.515–21.673	21.02	20.574	13.032–39.476	23.46
56	Světnov u Žďáru n/S (ZR)	30.6.	80.00	66.67	4	1.097	0.628–1.725	13.06	12.696	7.025–32.838	21.20	25.418	12.465–84.610	28.98
57	Opava-město (OP)	22.4.	100.00	100.00	1	0.540	0.446–0.656	6.43	1.175	0.929–1.649	1.96	1.465	1.123–2.180	1.67
58	Jistebník u Studénky (NJ)	23.4.	28.33	6.67	5	10.091	4.164–34.691	120.13	56.552	20.470–1626.954	94.41	92.181	29.023–5 365.168	105.11
59	Kelečsko-Kelč (VS)	22.4.	100.00	49.80	2	0.912	0.358–1.963	10.86	4.795	2.166–48.476	8.01	7.677	3.074–141.277	8.75
60	Bolatice (OP)	23.4.	63.20	9.90	4	3.365	1.019–13.496	40.06	31.724	9.234–2538.177	52.96	59.923	14.482–13 341.213	68.33
61	Kylešovice (OP)	28.4.	60.03	5.57	4	5.827	3.289–10.533	69.37	15.719	9.101–73.007	26.24	20.825	11.256–136.365	23.75
62	Zubří (VS)	22.4.	100.00	60.00	2	0.585	0.217–1.093	6.96	4.03	1.961–23.407	6.73	6.964	2.976–68.616	7.94
63	Slavkov u Opavy (OP)	28.5.	43.33	23.33	5	4.914	2.871–8.936	58.50	34.635	16.641–137.236	57.82	60.248	25.740–316.731	68.70
64	Mikolajice (OP)	28.4.	31.67	26.67	5	47.267	17.428–429.442	562.70	16591.44	1 183.806–15 881 031.629	27698.57	87387.4	3 767.884–325 367 512.024	99 643.56
65	Benkovice u Hradce n/Moravicí (OP)	30.4.	100.00	36.67	2	1.739	1.238–2.551	20.70	4.089	2.734–10.499	6.83	5.211	3.284–16.340	5.94
66	Kočí u Chrudimi (CR)	29.4.	31.73	15.87	5	7.249	3.937–14.819	86.30	31.158	15.143–176.567	52.02	47.108	20.682–382.341	53.71
67	Komárov (OP)	3.5.	27.53	10.83	5	8.218	4.915–14.868	97.83	30.621	16.473–118.466	51.12	44.459	21.948–225.639	50.69
68	Raduň (OP)	3.5.	36.10	10.00	5	23.841	10.536–114.623	283.82	937.019	167.399–74571.987	1564.31	2653.035	349.498–490 796.324	3 025.13
69	Stěbořice (OP)	4.5.	40.00	15.00	5	6.579	4.482–9.947	78.32	26.273	15.931–62.714	43.86	38.903	21.882–110.241	44.36
70	Úblo (ZL)	4.5.	38.33	13.33	5	26.546	14.780–65.903	316.02	952.147	261.998–10472.133	1589.56	2626.885	574.628–45 383.802	2 995.31
71	Hořice u Humpolce (PE)	5.5.	100.00	100.00	1	0.262	0.115–0.373	3.12	0.741	0.500–2.593	1.24	0.996	0.622–5.479	1.14
72	Holasovice (OP)	4.5.	50.00	8.33	4	5.876	2.850–13.363	69.95	25.176	11.568–185.116	42.03	38.029	15.803–424.702	43.36
73	Fulnek-Vrchy (NJ)	5.5.	36.67	6.67	5	10.663	6.053–21.618	126.94	75.083	33.051–409.374	125.35	130.569	50.470–998.540	148.88
74	Dolní Kralovice (BN)	5.5.	100.00	100.00	1	0.328	0.200–0.465	3.90	0.812	0.549–2.604	1.36	1.051	0.662–4.680	1.20
75	Zábřeh, Dolní Benešov (BR)	11.5.	27.50	17.07	5	7.615	3.593–19.389	90.65	33.046	14.451–387.183	55.17	50.098	19.594–990.018	57.12
76	Březová (OP)	5.5.	23.60	7.77	5	7.886	2.887–37.291	93.88	59.098	17.553–4391.820	98.66	104.604	26.186–18979.260	119.27
77	Praha-Ruzyně (PZ)	6.5.	100.00	81.87	2	0.210	0.056–0.386	2.50	1.905	1.094–5.611	3.18	3.559	1.820–16.736	4.06
78	Hlučín (OP)	11.5.	66.67	23.33	4	3.101	1.597–6.199	36.92	21.26	9.607–110.270	35.49	36.694	14.665–271.666	41.84

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Table 1 to be continued

Population No.	Locality (district)	Date of sampling	Mean contact (%) lab. effect of the rate		PRI (1–5)[b]	LD_{50}	95% CL	RR (LD_{50})	LD_{90}	95% CL	RR (LD_{90})	LD_{95}	95% CL	RR (LD_{95})
			7.5 g a.i./ha[a]	1.5 g a.i./ha[a]		(g a.i/ha)			(g a.i/ha)			(g a.i/ha)		
79	Odry (NJ)	13.5.	74.70	41.60	4	1.993	0.687–5.202	23.73	14.534	5.481–241.283	24.26	25.528	8.323–849.451	29.11
80	Kujavy (NJ)	12.5.	92.30	27.47	3	1.544	0.795–2.889	18.38	10.221	4.896–45.921	17.06	17.467	7.438–110.848	19.92
81	Budišov n/Budišovkou (OP)	15.6.	66.33	29.17	4	2.805	1.560–5.077	33.39	20.383	9.863–80.431	34.03	35.765	15.379–190.386	40.78
82	Karlov (BR)	15.6.	60.00	8.33	4	5.916	3.849–9.114	70.43	20.963	12.795–51.625	35.00	30.006	17.083–88.873	34.21
83	Bohušov (BR)	15.6.	95.00	40.00	3	1.443	0.627–3.069	17.18	8.317	3.730–56.887	13.88	13.667	5.458–147.455	15.58
84	Křišťanovice u Dvorců (BR)	15.6.	71.40	30.40	4	1.932	0.895–3.888	23.00	22.532	9.264–148.666	37.62	45.207	15.777–475.624	51.55
85	Sokolnice (BI)	24.4.	90.00	67.27	3	0.299	0.013–0.863	3.56	9.694	3.308–252.416	16.18	25.985	6.905–2 914.277	29.63
86	Blatnička (HO)	22.4.	100.00	93.33	2	0.129	0.019–0.250	1.54	0.921	0.558–2.398	1.54	1.608	0.906–7.307	1.83
87	Moutnice (BI)	22.4.	96.27	92.10	3	0.160	0.038–0.313	1.90	1.714	0.994–4.386	2.86	3.355	1.757–13.260	3.83
88	Blučina (BI)	20.4.	97.23	91.10	3	0.118	0.013–0.272	1.40	1.59	0.848–4.791	2.65	3.326	1.616–18.345	3.79
89	Braníškov (BI)	10.5.	100.00	100.00	1	0.179	0.072–0.258	2.13	0.634	0.462–1.229	1.06	0.908	0.618–2.423	1.04
90	Věstínek (ZR)	18.5.	100.00	100.00	1	0.156	0.029–0.251	1.86	0.599	0.408–1.560	1.00	0.877	0.561–4.045	1.00
91	Olešnice (BK)	18.5.	100.00	100.00	1	0.179	0.072–0.258	2.13	0.634	0.462–1.229	1.06	0.908	0.618–2.423	1.04
92	Zbraslav-Víska (BI)	18.5.	100.00	100.00	1	0.156	0.029–0.251	1.86	0.599	0.408–1.560	1.00	0.877	0.561–4.045	1.00
93	Velké Tresné (ZR)	18.5.	100.00	100.00	1	0.156	0.029–0.251	1.86	0.599	0.408–1.560	1.00	0.877	0.561–4.045	1.00
94	Kněževes (ZR)	18.5.	100.00	100.00	1	0.156	0.029–0.251	1.86	0.599	0.408–1.560	1.00	0.877	0.561–4.045	1.00
95	Horní Domaslavice II (FM)	10.6.	96.67	93.33	3	0.130	0.009–0.312	1.55	1.514	0.750–6.263	2.53	3.036	1.385–28.157	3.46
96	Modřice (BI)	15.6.	100.00	93.33	2	0.169	0.037–0.297	2.01	0.998	0.617–2.753	1.67	1.65	0.936–7.562	1.88
97	Horní Domaslavice III (FM)	4.7.	100.00	50.00	2	1.391	1.028–1.901	16.56	3.631	2.519–7.084	6.06	4.767	3.132–10.662	5.44
98	Tuněchody (CR)	9.7.	100.00	96.97	2	0.386	0.272–0.523	4.60	0.996	0.695–2.119	1.66	1.303	0.856–3.337	1.49
99	Maršov u Tišnova (BI)	10.5.	100.00	100.00	1	0.211	0.111–0.287	2.51	0.679	0.502–1.275	1.13	0.946	0.652–2.300	1.08
100	Troubsko II (BI)	20.4.	100.00	96.67	2	0.136	0.010–0.255	1.62	0.704	0.426–2.421	1.18	1.122	0.644–8.737	1.28
101	Žabčice I (BI)	20.4.	100.00	96.30	2	0.197	0.058–0.309	2.35	0.803	0.528–2.225	1.34	1.195	0.725–5.299	1.36
102	Horní Domaslavice I (FM)	17.5.	100.00	73.73	2	0.667	0.470–0.913	7.94	2.673	1.789–5.198	4.46	3.961	2.471–9.005	4.52
103	Lažany (BK)	10.5.	100.00	100.00	1	0.328	0.254–0.404	3.90	0.812	0.617–1.360	1.36	1.051	0.756–2.013	1.20
104	Veverská Bítýška (BI)	10.5.	100.00	100.00	1	0.262	0.175–0.335	3.12	0.741	0.555–1.323	1.24	0.996	0.700–2.151	1.14
105	Žabčice II (BI)	27.4.	100.00	56.60	2	0.993	0.673–1.453	11.82	3.872	2.429–8.803	6.46	5.694	3.317–15.459	6.49
106	Stránská skála (BM)	27.4.	100.00	98.33	2	0.155	0.025–0.252	1.85	0.604	0.407–1.704	1.01	0.889	0.561–4.703	1.01
107	Těšany (BI)	27.4.	93.07	88.43	3	0.109	0.006–0.301	1.30	2.329	1.086–9.989	3.89	5.552	2.302–55.945	6.33
108	Brno-Tuřany (BM)	27.4.	100.00	100.00	1	0.156	0.029–0.251	1.86	0.599	0.408–1.560	1.00	0.877	0.561–4.045	1.00
109	Brno-Líšeň (BM)	27.4.	100.00	89.17	2	0.148	0.004–0.334	1.76	1.185	0.590–8.394	1.98	2.14	0.988–50.580	2.44
110	Brno-Slatina (BM)	27.4.	100.00	88.33	2	0.132	0.010–0.293	1.57	1.264	0.671–4.885	2.11	2.398	1.169–20.592	2.73
111	Žatčany (BI)	24.4.	96.67	81.67	3	0.111	0.005–0.334	1.32	3.903	1.685–21.590	6.52	10.715	3.894–158.085	12.22
Means			82.22	60.24		2.520		30.00	185.96		310.45	881.29		1 004.89

[a]effectiveness of the tested rates expressed according to Abbott's formula; [b]Pyrethroid Resistance Index stated according to method IRAC 011, Vers. 3; RR = Resistance Ratio; RR (LD_{50}) based on population No. 26, RR (LD_{90}) and RR (LD_{95}) based on populations Nos 90, 92, 93, 94, and 108

doi: 10.17221/34/2014-PPS

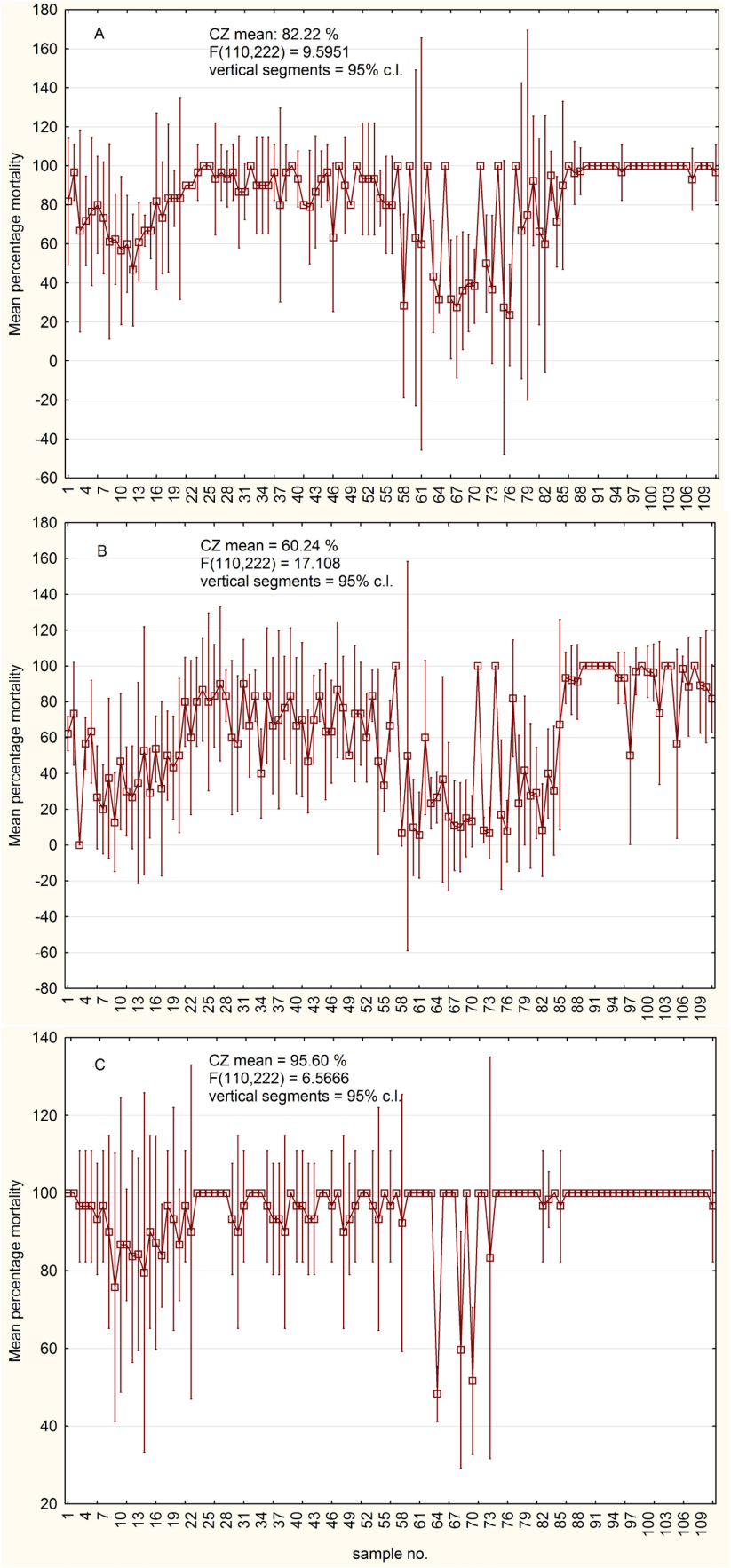

Figure 4. Laboratory contact effects for rates 7.5 g (A), 1.5 g (B), and 37.5 g (C) of lambda-cyhalothrin per ha on *Meligethes* populations tested in 2009

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Table 2. Results of susceptibility testing of Czech *Meligethes* subpopulations to lambda-cyhalothrin in 2010 (total of 125 populations compared; method IRAC 011, Vers. 3, exposure 24 h)

Population No.	Locality (district)	Date of sampling	Mean contact (%) lab. effect of the rate		PRI (1–5)[b]	LD_{50}	95% CL	RR (LD_{50})	LD_{90}	95% CL	RR (LD_{90})	LD_{95}	95% CL	RR (LD_{95})
			7.5 g a.i./ha[a]	1.5 g a.i./ha[a]		(g a.i/ha)			(g a.i/ha)			(g a.i/ha)		
1	Rapotín (SU)	20.4.	31.10	9.40	5	46.780	16.89–577.08	917.25	3481.637	355.65–3 198 735.32	5 726.38	11 813.81	812.07–38 269 435.8	13185.06
2	Postřelmov (SU)	7.5.	46.67	23.33	5	7.093	3.991–14.344	139.08	129.257	47.346–895.394	212.59	294.321	89.316–3 089.253	328.48
3	Dubicko (SU)	7.5.	56.67	26.67	4	4.964	3.138–8.049	97.33	40.37	21.091–119.492	66.40	73.132	34.190–271.795	81.62
4	Dolní Roveň Litětiny (PU)	13.5.	56.67	23.33	4	7.843	2.752–45.007	153.78	432.094	63.578–432 582.181	710.68	1 346.325	134.56–6 700 636.05	1502.59
5	Přelouč Lhota (PU)	13.5.	53.33	40.00	4	3.303	1.773–6.188	64.76	67.93	26.436–415.019	111.73	160.07	51.346–1 514.281	178.65
6	Úmonín (KH)	13.5.	66.67	56.67	4	1.969	0.554–5.268	38.61	27.771	8.925–788.808	45.68	58.806	15.353–4 171.338	65.63
7	Litomyšl (SY)	13.5.	61.83	30.00	4	4.111	2.750–6.159	80.61	21.983	13.111–50.725	36.16	35.36	19.409–96.991	39.46
8	Hůrka (CH)	17.5.	36.67	10.00	5	7.014	3.317–17.468	137.53	32.971	14.186–316.162	54.23	51.131	19.668–782.412	57.07
9	Častolovice (RK)	19.5.	56.67	20.00	4	5.121	3.203–8.310	100.41	23.944	13.479–67.787	39.38	37.075	19.142–130.063	41.38
10	Nekoř-Bredůvka (UO)	19.5.	66.67	3.33	4	5.346	1.943–15.604	104.82	21.548	8.992–398.883	35.44	31.991	12.129–1 144.472	35.70
11	Rapotín II (SU)	20.5.	73.33	43.33	4	1.820	1.035–3.013	35.69	20.98	10.579–67.301	34.51	41.956	18.545–179.023	46.83
12	Velký Týnec (OL)	24.5.	63.33	20.00	4	3.225	1.519–7.006	63.24	40.861	15.426–337.397	67.21	83.929	26.609–1 131.782	93.67
13	Senice na Hané (OL)	24.5.	50.00	20.00	4	4.985	2.639–10.407	97.75	76.869	28.525–565.058	126.43	166.937	51.634–1 902.082	186.31
14	Jezernice (PR)	24.5.	70.00	10.00	4	3.986	2.003–8.355	78.16	24.699	11.020–136.378	40.62	41.423	16.453–326.896	46.23
15	Vyškov (VY)	24.5.	66.67	36.67	4	1.676	0.704–3.394	32.86	38.267	13.975–340.306	62.94	92.889	27.250–1 503.381	103.67
16	Slavoňov (SU)	24.5.	53.33	36.67	4	8.616	3.336–42.843	168.94	1510.991	162.78–1 932 188.37	2 485.18	6537.16	432.4–45 681 870.65	7295.94
17	Dobrovice (MB)	3.6.	66.67	20.00	4	5.712	2.438–16.319	112.00	130.978	35.171–3 923.897	215.42	318.316	66.443–20 943.476	355.26
18	Turnov (SM)	3.6.	50.00	23.33	4	12.674	5.115–59.028	248.51	337.104	67.787–82 440.751	554.45	854.448	126.254–717 450.628	953.63
19	Dolní Černilov (HK)	3.6.	60.00	13.33	4	6.056	3.027–10.615	118.75	28.576	15.070–133.930	47.00	44.363	21.038–310.253	49.51
20	Nymburk (NB)	3.6.	66.67	56.67	4	1.475	0.548–3.011	28.92	55.359	18.854–595.494	91.05	154.709	40.614–3 374.580	172.67
21	Lánov u Vrchlabí (TU)	3.6.	60.00	16.67	4	10.128	3.494–83.451	198.59	957.534	103.65–4803128.66	1 574.89	3477.12	238.8–121 835 862.6	3880.71
22	Jaroměřice n/R (TR)	19.5.	83.33	66.67	4	0.720	0.158–1.647	14.12	8.869	3.457–112.404	14.59	18.071	5.909–522.168	20.17
23	Liberec (LB)	3.6.	46.67	23.33	5	13.684	6.682–43.338	268.31	520.005	115.735–17 580.847	855.27	1458.333	244.171–102 635.517	1627.60
24	Prostějov (PV)	24.5.	73.33	36.67	4	1.504	0.740–2.700	29.49	28.95	12.497–140.834	47.62	66.952	24.092–499.446	74.72
25	Chomutov (CV)	20.5.	36.67	23.33	5	10.078	4.546–33.445	197.61	142.291	40.007–4 564.217	234.03	301.394	68.086–20 018.838	336.38
26	Javorník (JE)	20.5.	53.33	30.00	4	4.881	2.684–9.524	95.71	99.345	36.905–670.519	163.40	233.414	71.361–2 434.907	260.51
27	Zlaté Hory (JE)	20.5.	56.67	33.33	4	4.008	2.240–7.399	78.59	70.086	28.453–375.394	115.27	157.732	53.647–1245.709	176.04
28	Želeč (TA)	26.4.	53.33	30.00	4	3.263	1.481–7.289	63.98	158.564	42.755–3 136.408	260.80	476.793	95.859–20 251.647	532.14
29	Třebohostice (ST)	26.4.	96.67	96.67	3	0.069	0.000–0.237	1.35	1.176	0.439–6.068	1.93	2.629	1.067–54.794	2.93
30	Tismice (KO)	26.4.	30.00	20.00	5	7.519	3.948–17.027	147.43	70.235	27.131–553.202	115.52	132.325	43.738–1 589.838	147.68
31	Sepekov (PI)	26.4.	83.33	56.67	4	0.569	0.196–1.089	11.16	11.759	5.360–55.601	19.34	27.742	10.475–221.687	30.96
32	Staňkov (DO)	24.5.	96.67	76.67	3	0.373	0.118–0.689	7.31	3.591	1.892–12.825	5.91	6.824	3.168–38.511	7.62
33	Pluhův Žďár (JH)	28.4.	92.20	51.83	3	1.753	1.250–2.406	34.37	5.636	3.876–10.213	9.27	7.847	5.115–16.070	8.76
34	Chvalkovice (NB)	29.4.	30.00	3.33	5	9.261	5.991–15.202	181.59	24.166	14.826–76.706	39.75	31.718	18.250–127.479	35.40
35	Krč (PI)	10.5.	93.33	50.00	3	1.155	0.733–1.749	22.65	6.65	3.927–16.026	10.94	10.924	5.898–32.181	12.19

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36	Hrejkovice (PI)	10.5.	96.67	86.67	3	0.051	0.000–0.205	1.00	1.617	0.613–8.557	2.66	4.309	1.643–98.953	4.81
37	Kasejovice (PJ)	26.4.	93.33	86.67	3	0.211	0.025–0.529	4.14	6.369	2.790–35.977	10.48	16.727	6.004–210.371	18.67
38	Kestřany (PI)	10.5.	96.67	66.67	3	0.912	0.602–1.332	17.88	3.945	2.475–8.722	6.49	5.976	3.475–15.798	6.67
39	Kladruby (RO)	11.5.	96.67	80.00	3	0.363	0.099–0.697	7.12	3.467	1.785–13.554	5.70	6.573	2.987–42.652	7.34
40	Kluky u Písku (PI)	26.4.	100.00	100.00	1	0.082	0.010–0.346	1.61	0.73	0.531–1.321	1.20	0.987	0.683–2.194	1.10
41	Bor u Tachova (TC)	17.5.	53.33	43.33	4	2.021	1.136–3.425	39.63	26.261	12.488–98.354	43.19	54.331	22.294–281.586	60.64
42	Mrákov (DO)	24.5.	76.67	46.67	4	1.025	0.441–1.874	20.10	18.033	8.113–84.463	29.66	40.649	15.317–300.547	45.37
43	Munice (CB)	25.4.	90.47	62.23	3	0.794	0.316–1.479	15.57	6.52	3.199–27.709	10.72	11.843	5.137–76.311	13.22
44	Nebovidy (KO)	26.4.	73.33	13.33	4	4.788	2.524–8.910	93.88	20.376	10.553–82.577	33.51	30.72	14.576–168.595	34.29
45	Neveklov (BN)	13.5.	80.00	60.00	4	0.596	0.177–1.212	11.69	17.915	7.396–112.602	29.47	47.017	15.511–559.200	52.47
46	Nová Včelnice (JH)	31.5.	93.33	66.67	3	0.429	0.037–1.068	8.41	5.585	2.126–119.588	9.19	11.562	3.700–823.034	12.90
47	Ovčíny (BN)	13.5.	83.33	56.67	4	0.791	0.298–1.498	15.51	15.988	7.131–77.368	26.30	37.489	13.884–298.916	41.84
48	Hostěradice (ZN)	28.4.	70.00	36.67	4	4.648	2.699–8.065	91.14	38.709	19.013–138.999	63.67	70.595	30.708–335.504	78.79
49	Jezeřany (ZN)	28.4.	83.33	63.33	4	2.337	0.678–5.152	45.82	11.39	5.164–96.315	18.73	17.846	7.398–274.244	19.92
50	Našiměřice (ZN)	28.4.	80.00	56.67	4	2.329	1.44–3.650	45.67	17.935	10.007–45.815	29.50	31.988	16.149–100.683	35.70
51	Znojmo (ZN)	28.4.	63.33	26.67	4	4.774	3.103–7.396	93.61	30.904	17.469–78.261	50.83	52.476	26.998–161.319	58.57
52	Troubsko I (BO)	26.4.	53.33	36.67	4	6.189	3.432–11.515	121.35	75.278	32.131–393.678	123.81	152.852	55.624–1166.861	170.59
53	Trousko II (BO)	1.6.	90.00	46.67	3	1.779	1.074–2.899	34.88	6.746	3.909–19.413	11.10	9.845	5.284–35.509	10.99
54	Třebíč (TR)	10.5.	83.33	66.67	4	0.720	0.158–1.647	14.12	8.869	3.457–112.404	14.59	18.071	5.909–522.168	20.17
55	Kralice nad Oslavou (TR)	10.5.	86.67	76.67	4	1.400	0.605–2.835	27.45	5.576	2.768–31.341	9.17	8.252	3.769–70.011	9.21
56	Telč (JI)	10.5.	96.67	16.67	3	2.129	1.082–4.582	41.75	8.006	3.901–48.319	13.17	11.655	5.197–101.738	13.01
57	Zakřany (BO)	10.5.	96.67	56.67	3	1.275	0.895–1.808	25.00	4.38	2.880–8.816	7.20	6.214	3.840–14.430	6.94
58	Opava Kylešovice I (OP)	19.4.	90.00	10.00	3	3.354	2.517–4.470	65.76	7.488	5.461–12.531	12.32	9.402	6.610–17.273	10.49
59	Opava Kylešovice II (OP)	10.5.	93.33	13.33	3	2.549	1.283–5.637	49.98	8.647	4.256–52.727	14.22	12.225	5.556–106.965	13.64
60	Hodslavice (NJ)	24.5.	57.77	26.87	4	2.991	1.680–5.271	58.65	24.693	12.102–88.409	40.61	44.924	19.553–213.013	50.14
61	Výškovice u Bílovce (NJ)	24.5.	43.23	13.57	5	20.176	9.573–79.386	395.61	810.572	156.948–53460.580	1333.18	2309.351	328.690–357405.034	2577.40
62	Zubří (ZR)	24.5.	78.27	36.33	4	3.426	1.269–8.349	67.18	36.358	13.216–465.940	59.80	71.026	21.773–1718.634	79.27
63	Příbor (NJ)	24.5.	77.57	56.00	4	0.748	0.150–1.769	14.67	14.583	5.186–239.028	23.99	33.846	9.657–1407.934	37.77
64	Stará Ves n/O. (FM)	25.5.	71.67	37.00	4	3.001	0.638–12.415	58.84	139.514	24.620–239041.508	229.46	414.278	50.067–5426960.271	462.36
65	Klimkovice (OV)	25.5.	44.23	3.70	5	8.353	4.198–19.215	163.78	71.03	27.839–552.311	116.83	130.309	44.078–1545.256	145.43
66	Sviadnov (FM)	25.5.	67.57	28.17	4	3.241	2.018–5.032	63.55	24.354	13.567–65.034	40.06	43.138	21.612–144.741	48.15
67	Velká Polom (OV)	25.5.	86.70	22.07	4	3.271	1.499–5.991	64.14	12.402	6.637–54.897	20.40	18.095	8.944–116.377	20.20
68	Stará Ves n/O II (FM)	23.6.	88.90	32.83	4	2.182	0.954–3.666	42.78	7.677	4.440–29.404	12.63	10.966	5.892–61.845	12.24
69	Horní Těrlicko (KI)	23.6.	96.30	56.67	3	0.854	0.175–2.064	16.75	5.566	2.258–106.883	9.15	9.471	3.391–449.656	10.57
70	Vidnava (JE)	20.4.	50.00	26.67	4	7.481	4.375–14.181	146.69	105.453	42.876–566.648	173.44	223.256	76.959–1715.177	249.17
71	Biskupice (PV)	23.4.	66.67	40.00	4	1.886	0.842–3.691	36.98	61.251	21.578–533.289	100.74	164.305	45.562–2594.361	183.38
72	Brodek u Prostějova (PV)	24.4.	73.33	50.00	4	1.019	0.456–1.837	19.98	19.283	8.626–89.728	31.72	44.387	16.559–324.002	49.54
73	Lichkov (UO)	20.4.	56.67	43.33	4	3.354	1.743–6.456	65.76	48.816	19.802–290.888	80.29	104.294	35.572–949.191	116.40
74	Říčany u Prahy (PH)	11.5.	90.00	66.67	3	0.230	0.029–0.575	4.51	9.907	4.024–74.637	16.29	28.796	9.108–532.914	32.14
75	Česká Lípa (CL)	11.5.	43.33	26.67	5	14.437	6.039–75.112	283.08	1374.769	180.177–442189.343	2261.13	5002.421	437.18–5590126.55	5583.06
76	Čestice (RK)	19.5.	63.33	43.33	4	1.962	0.788–4.122	38.47	95.669	28.462–1491.424	157.35	287.948	64.114–9721.532	321.37

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Table 2 to be continued

Population No.	Locality (district)	Date of sampling	Mean contact (%) lab. effect of the rate		PRI (1–5)[b]	LD_{50}	95% CL	RR (LD_{50})	LD_{90}	95% CL	RR (LD_{90})	LD_{95}	95% CL	RR (LD_{95})
			7.5 g a.i./ha[a]	1.5 g a.i./ha[a]		(g a.i/ha)			(g a.i/ha)			(g a.i/ha)		
77	Telnice (BO)	20.4.	100.00	66.67	2	0.964	0.690–1.348	18.90	2.914	1.957–5.856	4.79	3.987	2.523–9.253	4.45
78	Žatčany (BO)	20.4.	100.00	63.33	2	0.420	0.176–0.713	8.24	3.741	2.050–11.973	6.15	6.954	3.355–32.664	7.76
79	Měnín (BO)	20.4.	100.00	76.67	2	0.171	0.004–0.442	3.35	2.246	0.975–24.919	3.69	4.656	1.781–196.522	5.20
80	Blučina (BO)	20.4.	100.00	66.67	2	0.214	0.041–0.436	4.20	2.617	1.367–9.990	4.30	5.325	2.425–36.908	5.94
81	Žabčice (BO)	20.4.	100.00	60.00	2	0.699	0.430–1.048	13.71	3.577	2.153–8.970	5.88	5.683	3.121–17.962	6.34
82	Koválovice (BO)	23.4.	100.00	63.33	2	0.529	0.281–0.829	10.37	3.363	1.952–9.362	5.53	5.679	2.964–21.239	6.34
83	Dřevnovice (PV)	23.4.	100.00	56.67	2	0.993	0.642–1.561	19.47	3.872	2.285–10.859	6.37	5.694	3.098–20.056	6.35
84	Kojetín (PR)	23.4.	96.67	53.33	3	0.669	0.344–1.090	13.12	5.848	3.192–17.453	9.62	10.813	5.227–43.974	12.07
85	Němčice nad Hanou (PV)	29.4.	93.33	66.67	3	0.961	0.613–1.430	18.84	4.843	2.961–11.048	7.97	7.66	4.314–21.157	8.55
86	Dobromilice u Skale (PV)	29.4.	100.00	66.67	2	0.357	0.131–0.626	7.00	3.384	1.840–11.254	5.57	6.404	3.055–32.547	7.15
87	Stříbrnice (PR)	29.4.	100.00	40.00	2	1.319	0.824–2.118	25.86	6.222	3.520–17.770	10.23	9.659	5.000–34.507	10.78
88	Ivanovice na Hané (VY)	29.4.	93.33	43.33	3	0.839	0.477–1.324	16.45	6.292	3.543–17.043	10.35	11.138	5.630–39.074	12.43
89	Nezamyslice (PV)	29.4.	100.00	36.67	2	1.127	0.586–2.089	22.10	5.704	2.858–26.982	9.38	9.034	4.067–61.383	10.08
90	Blažovice (BO)	26.4.	100.00	100.00	1	0.281	0.163–0.385	5.51	0.775	0.560–1.406	1.27	1.033	0.712–2.264	1.15
91	Hodějice (VY)	26.4.	100.00	63.33	2	0.485	0.240–0.777	9.51	3.379	1.931–9.794	5.56	5.857	2.992–23.415	6.54
92	Nesovice (VY)	26.4.	100.00	26.67	2	1.627	0.694–4.350	31.90	6.37	2.806–92.975	10.48	9.38	3.736–247.299	10.47
93	Letonice (VY)	26.4.	90.00	30.00	3	1.984	1.005–3.979	38.90	9.066	4.407–46.794	14.91	13.946	6.146–102.608	15.56
94	Olešnice na Moravě (BK)	10.5.	100.00	36.67	2	0.958	0.521–1.644	18.78	5.139	2.711–19.416	8.45	8.272	3.926–43.077	9.23
95	Vnorovy (HO)	10.5.	100.00	86.67	2	0.184	0.039–0.317	3.61	1.037	0.626–3.798	1.71	1.694	0.920–11.493	1.89
96	Velká nad Veličkou (HO)	10.5.	100.00	33.33	2	1.659	1.013–2.865	32.53	5.12	2.944–17.707	8.42	7.048	3.768–31.374	7.87
97	Bystřice nad Perštejnem (ZR)	10.5.	100.00	46.67	2	0.958	0.457–1.819	18.78	5.139	2.510–28.506	8.45	8.272	3.604–70.174	9.23
98	Dolní Rožínka Rozsochy (ZR)	24.5.	100.00	96.67	2	0.206	0.056–0.320	4.04	0.823	0.530–3.000	1.35	1.219	0.715–7.929	1.36
99	Horní Rožínka (ZR)	24.5.	100.00	86.67	2	0.160	0.025–0.305	3.14	1.209	0.693–4.417	1.99	2.147	1.103–15.197	2.40
100	Písečné (ZR)	24.5.	100.00	96.67	2	0.185	0.038–0.298	3.63	0.785	0.503–2.932	1.29	1.183	0.691–8.476	1.32
101	Zvole u Bystřice (ZR)	24.5.	100.00	100.00	1	0.077	0.011–0.272	1.51	0.63	0.423–1.321	1.04	0.918	0.596–2.867	1.02
102	Velké Janovice (ZR)	1.6.	93.33	63.33	3	0.418	0.144–0.774	8.20	5.844	2.954–21.623	9.61	12.347	5.356–72.187	13.78
103	Pivonice (ZR)	1.6.	100.00	43.33	2	0.756	0.450–1.161	14.82	4.623	2.684–12.238	7.60	7.723	4.053–26.206	8.62
104	Domanínek (ZR)	1.6.	100.00	90.00	2	0.306	0.137–0.472	6.00	1.393	0.866–3.926	2.29	2.141	1.214–8.621	2.39
105	Věchov (ZR)	1.6.	80.00	63.33	4	0.371	0.134–0.664	7.27	3.936	2.105–13.054	6.47	7.686	3.596–38.806	8.58
106	Popovice (BO)	2.6.	100.00	63.33	2	0.699	0.376–1.144	13.71	3.577	1.984–12.222	5.88	5.683	2.846–26.716	6.34
107	Nové Město na Moravě (ZR)	13.6.	96.67	86.67	3	0.252	0.071–0.466	4.94	2.267	1.254–7.214	3.73	4.225	2.082–21.311	4.72
108	Žďár nad Sázavou (ZR)	13.6.	96.67	96.67	3	0.155	0.025–0.266	3.04	0.632	0.407–1.480	1.04	0.941	0.590–3.668	1.05
109	Bohdalec (ZR)	13.6.	100.00	93.33	2	0.302	0.146–0.449	5.92	1.157	0.744–3.158	1.90	1.694	1.001–6.475	1.89
110	Jamné (JI)	13.6.	100.00	100.00	1	0.063	0.005–0.268	1.24	0.608	0.386–1.283	1.00	0.896	0.569–2.936	1.00
111	Dolní Rozsíčka (ZR)	13.6.	100.00	86.67	2	0.169	0.024–0.313	3.31	0.998	0.585–3.631	1.64	1.65	0.888–11.866	1.84
112	Těšice (PR)	17.6.	60.00	40.00	4	1.718	0.890–3.040	33.69	29.87	13.084–139.394	49.13	67.112	24.690–468.193	74.90

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113	Vyškov-Nouzka (VY)	18.6.	70.00	36.67	4	1.812	0.835–3.691	35.53	15.771	6.767–98.863	25.94	29.124	10.834–283.829	32.50
114	Pačlavice (KM)	23.6.	100.00	73.33	2	0.171	0.023–0.375	3.35	2.246	1.156–8.936	3.69	4.656	2.103–36.694	5.20
115	Měrovice (PR)	24.6.	100.00	100.00	1	0.083	0.008–0.320	1.63	0.706	0.495–1.410	1.16	0.986	0.656–2.617	1.10
116	Želeč (PV)	25.6.	100.00	70.00	2	0.262	0.067–0.503	5.14	2.994	1.581–10.954	4.92	5.973	2.747–37.029	6.67
117	Mořice (PV)	25.6.	100.00	90.00	2	0.306	0.137–0.472	6.00	1.393	0.866–3.926	2.29	2.141	1.214–8.621	2.39
118	Tasovice u Kunštátu (BK)	19.7.	96.67	76.67	3	0.332	0.115–0.594	6.51	3.229	1.759–10.379	5.31	6.15	2.953–30.115	6.86
119	Bystřice n/P (ZR)	19.7.	96.67	66.67	3	0.587	0.307–0.936	11.51	4.253	2.421–11.799	7.00	7.456	3.803–27.651	8.32
120	Rodkov (ZR)	19.7.	96.67	60.00	3	0.443	0.172–0.787	8.69	5.15	2.689–17.743	8.47	10.32	4.677–53.809	11.52
121	Ždánice (ZR)	19.7.	100.00	96.67	2	0.407	0.291–0.556	7.98	1.012	0.706–2.149	1.66	1.311	0.863–3.315	1.46
122	Kroměříž (KM)	20.4.	40.00	3.33	5	9.253	6.540–13.198	181.43	31.199	20.545–64.832	51.31	44.577	27.296–105.997	49.75
123	Roštění (KM)	1.7.	50.00	30.00	4	3.566	1.771–7.561	69.92	34.914	14.054–248.377	57.42	66.665	22.975–735.493	74.40
124	Vitonice (KM)	1.7.	33.33	0.00	5	10.275	7.625–13.975	201.47	24.811	17.454–48.257	40.81	31.855	21.296–71.070	35.55
125	Kostelec u Zlína (ZL)	1.7.	66.67	3.33	4	5.475	4.027–7.377	107.35	13.216	9.391–24.956	21.74	16.967	11.476–36.674	18.94
Means			78.92	48.96	4	3.150		61.76	97.25		159.95	310.02		346.00

[a]effectivenaess of the tested rates expressed according to Abbott's formula; [b]Pyrethroid Resistance Index stated according to method IRAC 011, Vers. 3; RR = Resistance Ratio; RR (LD_{50}) based on population No. 36, RR (LD_{90}) based on population No. 110, and RR (LD_{95}) based on population No. 110.

a common European field rate (7.5 g a.i/ha) recorded for the whole assemblage was 82.22% (expressed according to Abbott's formula). However, the effects of the concentrations tested on individual samples varied significantly ($F_{110, 222}$ = 9.5951, P = 0.0000). The variability was relatively high, the mortality is ranging from 23.60% to 100% in the assemblage (Figure 4A, Table 1). A concentration equivalent to a fifth of the field rate (1.5 g a.i./ha) showed somewhat higher variability in effects ($F_{110, 222}$ = 17.108, P = 0.000). The values ranged from 0–100% (CZ mean = 60.24%) throughout the collection (Figure 4B, Table 1). The effects of five-fold higher concentration (37.5 g a.i./ha) were more stable but not uniform ($F_{110, 222}$ = 6,5666, P = 0.000; Figure 4C). The LC_{50} values ranged from 0.084 g a. i./ha to 47.27 g a. i./ha in the collection (Tables 1 and 5). Almost 46% of samples exceeded an RR (LC_{50}) value of 15 and almost 32% of them exceeded 30 (more in Table 6). Values of LC_{90} stated for 59 samples (53.15%) in the assemblage exceeded the registered rate (7.5 g a.i./ha; Table 1).

The frequencies of samples with certain PRIs in the 2010 collection are shown in Table 4. The portion of highly susceptible (PRI1) samples had decreased and the predominance of resistant (PRI4) samples became more obvious in 2010 (Tables 2 and 4). The mean percentage mortality induced by the common European field rate (7.5 g a.i./ha) recorded for the whole assemblage was 78.92%. This means a 4% decrease on the previous year. The effects of the concentration varied significantly in many cases ($F_{124, 250}$ = 9.2365, P = 0.0000) and the variability in the values (ranging from 30% to 100%) was relatively high again (Figure 5A, Table 2). The effects of a concentration equivalent to a fifth of the field rate (1.5 g a.i./ha) on the individual samples differed significantly too ($F_{124, 250}$ = 9.0454, P = 0.000). A decrease in percentage mortality induced by lambda-cyhalothrin was recorded between the years 2009 and 2010 (Figures 4B and 5B). The effects of a five-fold higher concentration (37.5 g a.i./ha) ranging from 50% to 100% (CZ mean: 94.18%) and the differences were significant in some cases ($F_{124, 250}$ = 7.4056, P = 0.000; Figure 5C). The LC_{50} values ranged from 0.051 g a.i./ha to 46.78 g a.i./ha in the collection (Tables 2, 5, and 6). 64% of samples exceeded RR (LC_{50}) value 15 and almost 49% of them exceeded the value 30 (more in Table 6). The LC_{90} values estimated for 66 (52.8%) samples in the collection exceeded the registered rate (7.5 g a.i./ha, Table 2).

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Table 3. Results of susceptibility testing of Czech *Meligethes* subpopulations to lambda-cyhalothrin in 2011 (total of 102 populations compared; method IRAC 011, Vers. 3, exposure 24 h)

Population No.	Locality (district)	Date of sampling	Mean contact (%) lab. effect of the rate		PRI (1–5)[b]	LD_{50}	95% CL	RR (LD_{50})	LD_{90}	95% CL	RR (LD_{90})	LD_{95}	95% CL	RR (LD_{95})
			7.5 g a.i./ha[a]	1.5 g a.i./ha[a]		(g a.i/ha)			(g a.i/ha)			(g a.i/ha)		
1	Rapotín (SU)	18.4.2011	63.33	23.33	4	4.4	2,866–6,834	18.49	28.486	16,081–71,724	13.70	48.372	24,883–147,187	13.80
2	Lutín (OL)	20.4.2011	53.33	16.67	4	9.77	5,175–21,864	41.06	101.214	38,322–870,110	48.66	196.357	62,885–2657,734	56.01
3	Pěnčín (PV)	20.4.2011	36.67	6.67	5	8.521	5,432–13,806	35.80	29.699	17,421–85,023	14.28	29.699	17,421–85,023	8.47
4	Bludov (SU)	20.4.2011	16.67	13.33	5	13.935	8,638–25,687	58.55	78.303	38,233–332,047	37.65	127.732	55,693–717,901	36.43
5	Pilníkov (TU)	22.4.2011	73.33	10.00	4	5.719	2,379–15,551	24.03	52.523	18,332–799,035	25.25	98.483	29,123–2741,237	28.09
6	Rostěnice (VY)	27.4.2011	60.00	33.33	4	3.502	2,120–5,837	14.71	36.534	18,028–121,694	17.56	71.023	30,835–308,778	20.26
7	Kujavy (NJ)	28.4.2011	63.33	6.67	4	6.587	3,118–15,740	27.68	54.354	20,941–500,402	26.13	98.869	32,801–1461,520	28.20
8	Ráječko (BK)	4.5.2011	80.00	53.33	4	0.779	0,182–1,762	3.27	52.469	16,089–920,180	25.23	173.04	38,422–8087,197	49.36
9	Polička (SY)	4.5.2011	33.33	13.33	5	19.921	8,879–89,178	83.70	992.52	171,441–80203,622	477.17	3005.614	376,398–581502,622	857.28
10	Moravská Třebová (SY)	4.5.2011	43.33	10.00	5	7.825	5,377–11,617	32.88	33.963	20,763–77,117	16.33	51.491	29,184–137,617	14.69
11	Nekoř-Bredůvka (UO)	11.5.2011	76.67	13.33	4	3.643	2,441–5,482	15.31	18.926	11,360–41,992	9.10	30.195	16,788–78,252	8.61
12	Náchod (NA)	12.5.2011	70.00	10.00	4	4.89	2,734–9,009	20.55	32.34	15,688–124,180	15.55	55.265	24,027–279,930	15.76
13	Trutnov (TU)	9.5.2011	58.33	6.67	4	5.788	3,144–11,375	24.32	35.549	16,569–164,999	17.09	59.469	24,751–377,664	16.96
14	Hradec Králové (HK)	11.5.2011	53.33	3.33	4	6.196	1,908–30,260	26.03	44.621	13,248–5003,790	21.45	78.092	19,687–24818,789	22.27
15	Rychnov n/ Kněž. (RK)	11.5.2011	66.67	6.67	4	5.819	3,224–11,066	24.45	42.42	19,680–184,861	20.39	74.497	30,640–440,517	21.25
16	Písečná (JE)	20.5.2011	66.67	20.00	4	3.225	1,684–6,283	13.55	40.861	16,890–229,802	19.64	83.929	29,528–701,037	23.94
17	Javorník (JE)	20.5.2011	33.33	20.00	5	9.784	4,535–31,177	41.11	186.748	49,484–5380,403	89.78	430.855	90,112–25053,623	122.89
18	Měs. Albrechtice (BR)	20.5.2011	56.67	20.00	4	4.56	2,843–7,561	19.16	41.369	20,856–130,372	19.89	77.299	34,640–309,549	22.05
19	Rapotín II (SU)	20.5.2011	83.33	56.67	4	1.274	0,671–2,134	5.35	13.495	6,982–42,284	6.49	26.348	12,003–111,410	7.52
20	Topolany (OL)	22.6.2011	76.67	50.00	4	1.171	0,404–2,398	4.92	43.5	15,369–423,909	20.91	121.211	33,151–2390,893	34.57
21	Uničov (OL)	22.6.2011	90.00	26.67	3	2.011	1,294–3,082	8.45	12.67	7,357–29,979	6.09	21.351	11,355–60,576	6.09
22	Žichov (TP)	23.6.2011	70.00	23.33	4	4.899	2,686–8,823	20.58	59.349	26,481–271,143	28.53	120.37	46,094–786,970	34.33
23	Horní Benešov (BR)	13.6.2011	50.60	7.67	4	7.294	4,119–11,120	30.65	22.435	14,079–66,983	10.79	30.851	18,024–123,335	8.80
24	Osoblaha (BR)	13.6.2011	22.93	8.13	5	9.477	5,590–17,660	39.82	31.181	16,935–129,694	14.99	43.704	21,917–241,467	12.47
25	Lipník n/B. (PR)	24.5.2011	53.33	30.00	4	3.237	0,600–18,256	13.60	540.185	53,258–86926956,747	259.70	2304.374	130,971–9858187245,001	657.27
26	Bravantice (OP)	23.5.2011	30.27	15.10	5	7.402	5,258–10,347	31.10	28.864	18,854–58,549	13.88	42.452	25,863–100,190	12.11
27	Štramberk (NJ)	22.5.2011	74.30	38.80	4	1.994	1,235–3,137	8.38	16.213	8,896–43,270	7.79	29.367	14,490–97,838	8.38
28	Ostrava-Koblov (OV)	19.5.2011	55.40	45.70	4	2.167	0,562–5,073	9.11	25.918	9,731–360,277	12.46	52.372	16,470–1599,464	14.94
29	Žárová, Val. Mez. (VS)	16.5.2011	15.40	5.57	5	9.65	4,567–23,710	40.55	53.62	22,263–530,374	25.78	87.19	31,925–1398,485	24.87
30	Hustopeče n/B. (PR)	16.5.2011	39.62	34.33	5	4.76	2,72–8713	20.00	36.26	17,117–151,689	17.43	64.48	26,888–365,638	18.39
31	Fulnek (NJ)	13.5.2011	25.50	19.07	5	7.071	3,046–19,542	29.71	77.26	25,622–1240,753	37.14	152.18	42,139–4475,552	43.41
32	Opava (OP)	10.5.2011	25.10	21.77	5	13.821	5,152–145,445	58.07	589.95	78,56–1635294,52	283.63	1709.91	156,157–25064010,176	487.71
33	Deštná (JH)	2.5.2011	90.00	80.00	3	0.296	0,063–0,643	1.24	6.852	3,192–30,559	3.29	16.698	6,495–136,311	4.76
34	Dřínov (ME)	19.6.2011	60.00	6.67	4	5.473	3,964–7,625	23.00	15.447	10,487–30,449	7.43	20.729	13,316–46,786	5.91

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35	Dříteň (ČB)	23.5.2011	93.33	56.67	3	0.544	0,201–0,996	2.29	6.811	3,411–25,960	3.27	13.946	6,025–82,698	3.98
36	Hospříz (JH)	2.5.2011	96.67	73.33	3	0.857	0,582–1,218	3.60	3.212	2,097–6,598	1.54	4.671	2,852–11,265	1.33
37	Kasejovice (PJ)	2.5.2011	96.67	70.00	3	0.558	0,314–0,852	2.34	2.808	1,688–7,422	1.35	4.439	2,430–15,334	1.27
38	Kestřany (PI)	2.5.2011	87.57	63.33	4	1.328	0,870–1,950	5.58	6.318	3,954–13,391	3.04	9.83	5,714–24,573	2.80
39	Kladruby (RO)	2.5.2011	83.33	66.67	4	0.522	0,189–0,968	2.19	7.523	3,738–28,166	3.62	16.023	6,832–93,320	4.57
40	Kluky (PI)	2.5.2011	100.00	76.67	2	0.437	0,131–0,813	1.84	2.698	1,355–17,187	1.30	4.52	2,008–53,394	1.29
41	Kokořín (ME)	19.6.2011	53.33	3.33	4	6.523	2,402–20,284	27.41	27.793	11,216–642,722	13.36	41.916	15,225–1952,262	11.96
42	Koloveč (DO)	2.5.2011	90.00	63.33	3	0.538	0,228–0,934	2.26	5.511	2,919–17,950	2.65	10.657	4,953–50,356	3.04
43	Borovany (ČB)	2.5.2011	86.67	60.00	4	1.531	0,820–2,636	6.43	9.502	5,006–30,823	4.57	15.942	7,596–68,118	4.55
44	Komorno (PJ)	4.7.2011	100.00	63.33	2	0.651	0,384–0,989	2.74	3.621	2,147–9,417	1.74	5.89	3,169–19,682	1.68
45	Křivsoudov (BN)	22.5.2011	58.73	23.33	4	6.826	2,842–19,574	28.68	177.317	45,512–7420,293	85.25	446.445	87,249–45741,572	127.34
46	Nebovidy (KO)	26.5.2011	40.00	6.67	5	6.954	2,637–24,819	29.22	35.528	12,955–1066,879	17.08	56.412	18,137–3475,169	16.09
47	Neveklov (BN)	9.5.2011	76.67	70.00	4	0.888	0,390–1,588	3.73	14.859	7,064–58,267	7.14	33.029	13,326–194,944	9.42
48	Nová Včelnice (JH)	9.5.2011	90.00	66.67	3	0.808	0,363–1,434	3.39	4.652	2,433–18,078	2.24	7.641	3,604–42,956	2.18
49	Příkosice (RO)	2.5.2011	90.00	63.33	3	0.285	0,054–0,621	1.20	5.359	2,521–25,773	2.58	12.309	4,872–114,182	3.51
50	Sviny (TA)	2.5.2011	86.67	73.33	4	0.856	0,338–1,650	3.60	5.425	2,609–28,469	2.61	9.158	3,929–75,657	2.61
51	Šlovice (PS)	31.5.2011	66.67	43.33	4	2.5	1,193–4,924	10.50	34.692	14,123–216,329	16.68	73.12	25,071–717,588	20.86
52	Šťáhlavy (PM)	22.5.2011	86.67	43.33	4	1.184	0,624–1,994	4.97	14.657	7,347–49,010	7.05	29.912	13,047–137,634	8.53
53	Tismice (KO)	9.5.2011	70.00	20.00	4	2.974	1,738–4,858	12.50	24.287	12,807–74,116	11.68	44.045	20,700–174,902	12.56
54	Tochovice (PB)	2.6.2011	86.67	50.00	4	0.628	0,358–0,957	2.64	3.008	1,839–7,337	1.45	4.69	2,636–14,501	1.34
55	Želeč (TA)	2.5.2011	80.00	56.67	4	2.298	1,136–5,250	9.66	18.283	8,462–110,609	8.79	32.913	13,173–297,840	9.39
56	Štěměchy (TR)	26.5.2011	90.00	50.00	3	1.24	0,695–2,034	5.21	6.556	3,644–19,919	3.15	10.51	5,312–41,723	3.00
57	Zaloňov (NA)	4.6.2011	86.67	63.33	4	0.967	0,397–1,781	4.06	15.907	7,556–61,883	7.65	35.183	14,259–206,742	10.04
58	Pfaffendorf (Austria)	27.4.2011	83.33	50.00	4	1.169	0,559–2,142	4.91	8.396	4,140–32,995	4.04	14.68	6,465–80,950	4.19
59	Ivančice (BO)	27.4.2011	83.33	70.00	4	0.238	0,006–0,766	1.00	15.38	4,849–534,068	7.39	50.16	11,477–9538,071	14.31
60	Troubsko (BO)	26.4.2011	76.67	50.00	4	1.118	0,173–3,002	4.70	85.079	19,687–8418,872	40.90	290.494	45,960–130927,768	82.86
61	Hrušovany u Brna (BO)	20.4.2011	50.00	20.00	4	4.284	2,206–7,409	18.00	114.91	25,893–318,44	55.25	291.96	47,246–1018,796	83.27
62	Syrovice (BO)	20.4.2011	43.33	26.67	5	7.632	3,954–18,207	32.07	234.084	66,528–3438,895	112.54	617.787	137,165–16405,323	176.21
63	Radostice (BO)	20.4.2011	60.00	36.67	4	1.571	0,630–3,199	6.60	64.601	20,799–807,770	31.06	185.281	45,437–4779,672	52.85
64	Hor. Dunajovice (ZN)	27.4.2011	90.00	86.67	3	0.701	0,105–1,810	2.95	5.094	1,947–109,610	2.45	8.939	3,034–515,089	2.55
65	Rybníky (ZN)	27.4.2011	76.67	50.00	4	1.351	0,451–2,855	5.68	14.2	5,959–103,642	6.83	27.66	9,963–356,748	7.89
66	Pasohlavky (BV)	2.5.2011	86.67	40.00	3	1.134	0,080–3,633	4.76	18.342	5,272–2568,352	8.82	40.377	9,392–30307,400	11.52
67	Ořechov (BO)	2.5.2011	76.67	53.33	4	1.052	0,540–1,771	4.42	12.688	6,552–39,107	6.10	25.701	11,639–107,428	7.33
68	Starovičky (BV)	2.5.2011	63.00	23.34	4	3.276	1,478–5,934	13.76	26.395	13,008–108,908	12.69	47.688	20,742–288,716	13.60
69	Lednice (BV)	2.5.2011	46.67	30.00	5	4.421	1,464–16,297	18.58	803.391	97,339–1068725,719	386.25	3511.104	257,996–30740369,101	1001.46
70	Studenec (TR)	4.5.2011	86.67	43.33	4	0.732	0,133–1,776	3.08	12.658	4,426–274,363	6.09	28.398	7,996–1711,358	8.10
71	Rokytnice n/Rok. (TR)	4.5.2011	83.33	70.00	4	0.388	0,015–1,189	1.63	16.88	5,076–822,733	8.12	49.192	11,068–12621,390	14.03
72	Náměšť n/Osl. (TR)	4.5.2011	66.67	73.33	4	0.392	0,012–1,216	1.65	38.363	9,640–6159,361	18.44	140.665	23,390–190255,751	40.12
73	Slavkov u Brna (VY)	9.5.2011	73.33	36.67	4	3.477	1,939–6,147	14.61	32.042	15,350–121,742	15.40	60.138	25,346–308,994	17.15
74	Tvarožná (BO)	21.4.2011	70.00	16.67	4	5.071	3,175–8,086	21.31	26.478	15,016–69,875	12.73	42.303	21,999–136,544	12.07
75	Lipůvka (BK)	24.5.2011	36.67	20.00	5	6.564	4,484–9,838	27.58	30.513	18,336–71,075	14.67	47.171	26,187–129,958	13.45

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Table 3 to be continued

Population No.	Locality (district)	Date of sampling	Mean contact (%) lab. effect of the rate		PRI (1–5)[b]	LD_{50}	95% CL	RR (LD_{50})	LD_{90}	95% CL	RR (LD_{90})	LD_{95}	95% CL	RR (LD_{95})
			7.5 g a.i./ha[a]	1.5 g a.i./ha[a]		(g a.i/ha)			(g a.i/ha)			(g a.i/ha)		
76	Lysice (BK)	24.5.2011	56.67	16.67	4	7.383	3,141–20,412	31.02	98.21	30,248–2689,676	47.22	204.541	49,361–12497,200	58.34
77	Mor. Knínice (BO)	27.4.2011	83.33	60.00	4	1.086	0,567–1,815	4.56	12.511	6,461–39,160	6.01	25.014	11,323–106,375	7.13
78	Čebín (BO)	27.4.2011	73.33	36.67	4	1.635	0,780–2,707	6.87	27.26	11,787–115,561	13.11	60.527	22,245–383,270	17.26
79	Veselíčko (PR)	29.5.2011	70.00	33.33	4	1.487	0,471–3,532	6.25	27.613	9,125–522,468	13.28	63.208	16,661–2733,104	18.03
80	Penčice (PR)	27.6.2011	100.00	40.00	2	1.605	1,179–2,226	6.74	4.239	2,901–8,497	2.04	5.583	3,616–12,860	1.59
81	Těšice (PR)	21.4.2011	53.33	16.67	4	7.953	5,065–13,128	33.42	61.243	31,333–195,532	29.44	109.237	49,857–442,967	31.16
82	Bedihošť (PV)	1.5.2011	43.33	30.00	5	8.56	4,605–19,428	35.97	204.995	64,051–2275,702	98.56	504.366	126,184–9401,276	143.86
83	Prosenice (PR)	19.6.2011	80.00	26.67	4	3.027	2,135–4,281	12.72	10.387	6,837–20,859	4.99	14.733	9,113–34,096	4.20
84	Dobromilice (PV)	1.5.2011	40.00	13.33	5	6.753	4,217–11,322	28.37	25.78	14,523–81,377	12.39	37.689	19,555–150,102	10.75
85	Zvole (ZR)	2.5.2011	83.33	73.33	4	0.447	0,141–0,866	1.88	8.16	3,913–33,809	3.92	18.584	7,506–127,661	5.30
86	Písečné (ZR)	29.5.2011	63.33	53.33	4	2.124	0,959–4,350	8.92	18.45	7,879–122,181	8.87	34.05	12,578–357,922	9.71
87	Brno (BM)	2.5.2011	90.00	86.67	3	0.741	0,185–1,63	3.11	3.944	1,937–48,587	1.90	6.334	2,506–156,778	1.81
88	Dobrochov (PV)	1.5.2011	90.00	56.67	3	0.33	0,135–0,538	1.39	2.08	1,227–6,061	1.00	3.506	1,858–14,877	1.00
89	Brno-Tuřany (BM)	21.4.2011	43.33	26.67	5	3.947	1,539–10,177	16.58	61.346	19,325–1450,951	29.49	133.527	33,734–6948,192	38.09
90	Dambořice (HO)	9.5.2011	26.67	23.33	5	7.115	2,527–31,071	29.89	40.522	13,724–3790,385	19.48	66.355	19,357–16947,742	18.93
91	Vranovice-Pozorčice (BO)	18.5.2011	80.00	60.00	4	1.831	0,756–3,858	7.69	9.003	4,190–62,241	4.33	14.14	5,935–157,054	4.03
92	Žabčice (BO)	18.5.2011	100.00	26.67	2	1.722	1,028–3,054	7.24	6.027	3,326–21,639	2.90	8.597	4,383–39,902	2.45
93	Kuřim (BO)	27.4.2011	73.33	60.00	4	1.812	0,512–6,170	7.61	20.276	7,349–298,516	9.75	40.208	12,229–1222,207	11.47
94	Bratrušín (ZR)	29.5.2011	90.00	56.67	3	1.02	0,606–1,587	4.29	7.177	4,095–18,540	3.45	12.48	6,433–40,710	3.56
95	Haluzice (ZL)	18.5.2011	63.33	3.33	4	4.831	3,481–6,747	20.30	14.5	9,762–28,604	6.97	19.801	12,587–44,755	5.65
96	Uherský Brod (UH)	18.5.2011	70	6.67	4	4.126	2,715–5,887	17.34	13.163	8,652–29,853	6.33	18.289	11,230–50,615	5.22
97	Modrá (UH)	18.5.2011	66.67	5.67	4	4.361	1,538–14,609	18.32	19.944	7,645–546,561	9.59	30.688	10,532–1745,389	8.75
98	Drahlov (KM)	24.5.2011	80	17.67	4	3.414	2,467–4,747	14.34	10.469	7,062–20,331	5.03	14.383	9,163–31,888	4.10
99	Kojetín (PR)	24.5.2011	46.67	26.67	5	5.028	2,163–11,835	21.13	90.808	29,237–1599,466	43.66	206.248	52,925–7428,694	58.83
100	Mladcová (ZL)	11.5.2011	86.67	13.33	4	3.401	2,535–4,589	14.29	8.408	5,974–14,960	4.04	10.869	7,382–21,581	3.10
101	Hlinsko (PR)	11.5.2011	40	0	5	13.942	9,448–21,375	58.58	65.673	37,992–178,970	31.57	101.905	53,790–342,546	29.07
102	Bořenovice (KM)	11.5.2011	70	16.67	4	3.735	2,106–5,485	15.69	14.292	8,935–42,978	6.87	20.907	11,917–87,008	5.96
Means			67.45	35.94		3.89		16.34	62.34		29.97	174.73		49.84

[a]effectiveness of the tested rates expressed according to Abbott's formula; [b]Pyrethroid Resistance Index stated according to method IRAC 011, Vers. 3; RR = resistance ratio; RR (LD_{50}) based on population No. 59, RR (LD_{90}) and RR (LD_{95}) based on population No. 88

doi: 10.17221/34/2014-PPS

Table 4. Classification of *Meligethes* subpopulations by pyrethroid resistance indices (PRI) assigned according to method IRAC 011, Vers. 3 (2009–2011)

Insecticide	Season	Proportion of subpopulations with certain PRI (%)				
		1	2	3	4	5
Lambda-cyhalothrin	2009	11.71	18.02	25.23	33.33	11.71
	2010	4.00	22.40	21.60	43.20	8.80
	2011	0.00	3.92	13.73	61.77	20.59

PRI1 = highly susceptible population (lab. effectiveness of both 7.5 and 1.5 g a.i./ha rates is 100% according to Abbott's formula); PRI2 = susceptible population (lab. effectiveness of rate 7.5 g a.i./ha is 100 % according to Abbott's formula, lab. effectiveness of rate 1.5 g a.i./ha is lower); PRI3 = moderately resistant population (lab. effectiveness of rate 7.5 g a.i./ha is between 90–99.99% according to Abbott's formula); PRI4 = resistant population (lab. effectiveness of rate 7.5 g a.i./ha is between 50–89.99% according to Abbott's formula); PRI5 = highly resistant population (lab. effectiveness of rate 7.5 g a.i./ha is below 50% according to Abbott's formula)

The frequencies of samples with certain PRI in the 2011 collection are shown in Table 4. The highly susceptible (PRI1) samples disappeared from the assemblage and the proportion of susceptible (PRI2) samples markedly decreased in 2011. The proportions of resistant (PRI4) and highly resistant (PRI5) samples significantly increased in the 2011 assemblage in comparison with the previous two years (Tables 3 and 4). The mean percentage mortality caused by the common European field rate (7.5 g a.i./ha) recorded for the whole assemblage was 67.45%. That means an 11.47% decrease between 2010 and 2011 and a 14.77% decrease between 2009 and 2011. The effects of lambda-cyhalothrin on the various samples differed significantly ($F_{101, 204}$ = 7.1420, P = 0.0000) and the variability in values (ranging from 15.40% to 100 %) was even higher than in the previous years (Figure 6A, Table 3). The effects of a concentration equivalent to a fifth of the field rate (1.5 g a.i./ha) on the individual samples differed significantly, too ($F_{101, 204}$ = 11.338, P = 0.000). The decrease in mean percentage mortality induced by this concentration continued even between the years 2010 and 2011 (Figures 4B–6B). The effects of a five-fold higher concentration (37.5 g a.i./ha) ranged from 63% to 100% (CZ mean 92.22%) and the differences were significant in some cases ($F_{101, 204}$ = 3.7104, P = 0.000; Figure 6C). The proportions of samples fully susceptible to this concentration show a gradual decrease over the three years. The values of LC_{50} ranged from 0.238 g a.i./ha to 19.921 g a.i./ha in the collection (Tables 3 and 5). 83% of samples exceeded RR (LC_{50}) value 15 and almost 65% of them exceeded the value 30 (more in Table 6). The LC_{90} values estimated for 84 (82.35%) samples in the collection exceeded the registered rate (7.5 g a.i./ha, Table 3).

Table 6. Proportions (%) of *Meligethes* populations with RR (LD_{50})* exceeding values 15, 30, 50, 100, 200, and 500 in the three collections (2009–2011)

Meligethes collection	Exceeding value					
	15	30	50	100	200	500
2009	45.95	31.53	22.52	15.32	3.60	1.80
2010	64.00	48.80	28.80	18.40	4.80	0.80
2011	83.33	64.71	51.96	28.43	3.92	0.00

*the lowest LD_{50} recorded in the three collections served as a base for RR (LD_{50}) calculations (minimal LD_{50} = 0.051 g a. i./ha; population No. 36 in 2010)

DISCUSSION

Although the situation was already unsatisfactory in 2009 pyrethroid resistance (lambda-cyhalothrin used as a reference product for the group of esteric pyrethroids) in pollen beetle populations from Czech Republic has continued to increase (Tables 1–6; 2012–2013; Seidenglanz *et al.* 2014a,b). Highly susceptible samples disappeared entirely from Czech oilseed rape fields in 2011. Accordingly, resistant

Table 5. Minimal and maximal $LD_{50–95}$ values estimated for lambda-cyhalothrin (g a.i./ha) in the three *Meligethes* collections (2009–2011)

Meligethes collection	Number of populations	Minimal lethal dose			Maximal lethal dose		
		LD_{50}	LD_{90}	LD_{95}	LD_{50}	LD_{90}	LD_{95}
2009	111	0.084	0.599	0.877	47.27	16 591.44	87 387.4
2010	125	0.051	0.608	0.896	46.78	3 481.64	11 813.81
2011	102	0.238	2.08	3.506	19.921	992.52	3 511.104

doi: 10.17221/34/2014-PPS

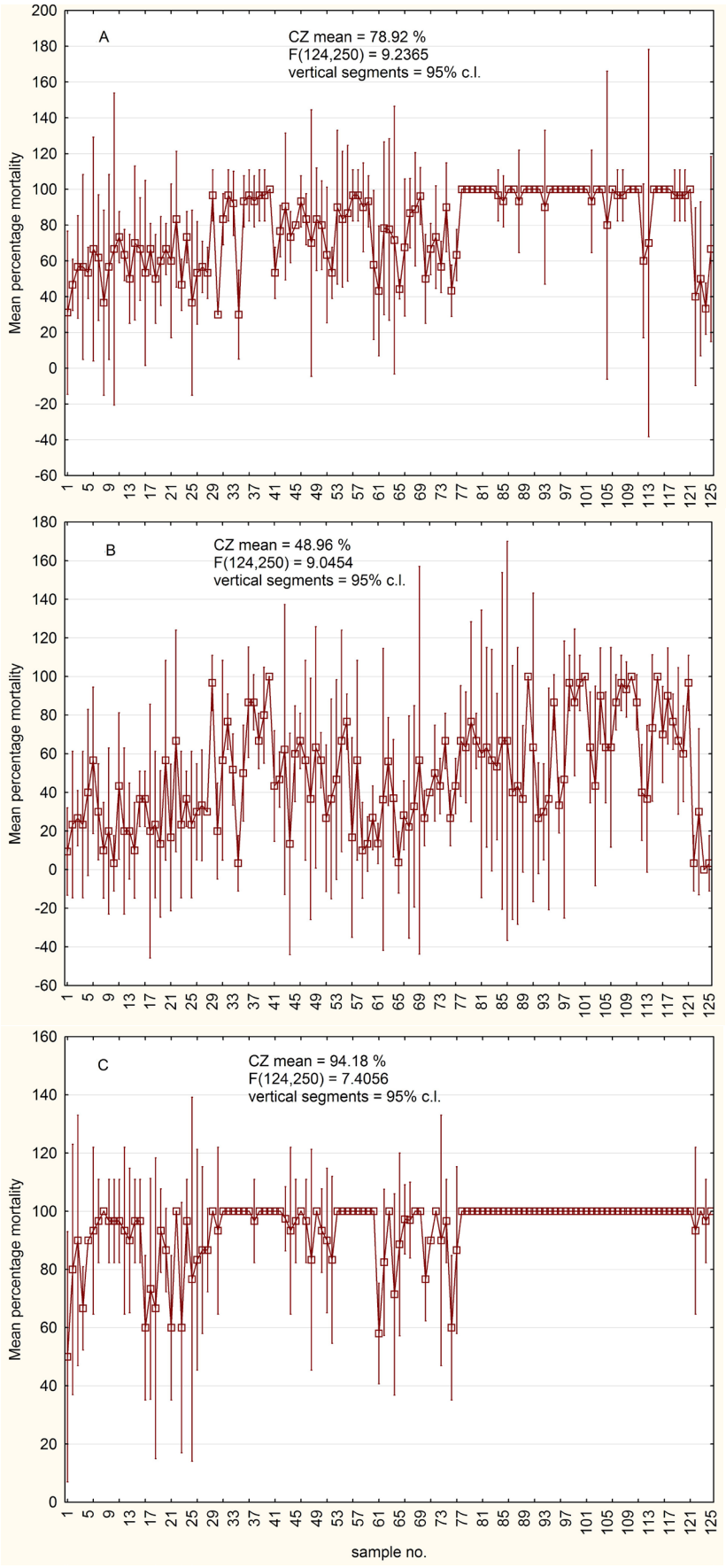

Figure 5. Laboratory contact effects for rates 7.5 g (A), 1.5 g (B), and 37.5 g (C) of lambda-cyhalothrin per ha on *Meligethes* populations tested in 2010

doi: 10.17221/34/2014-PPS

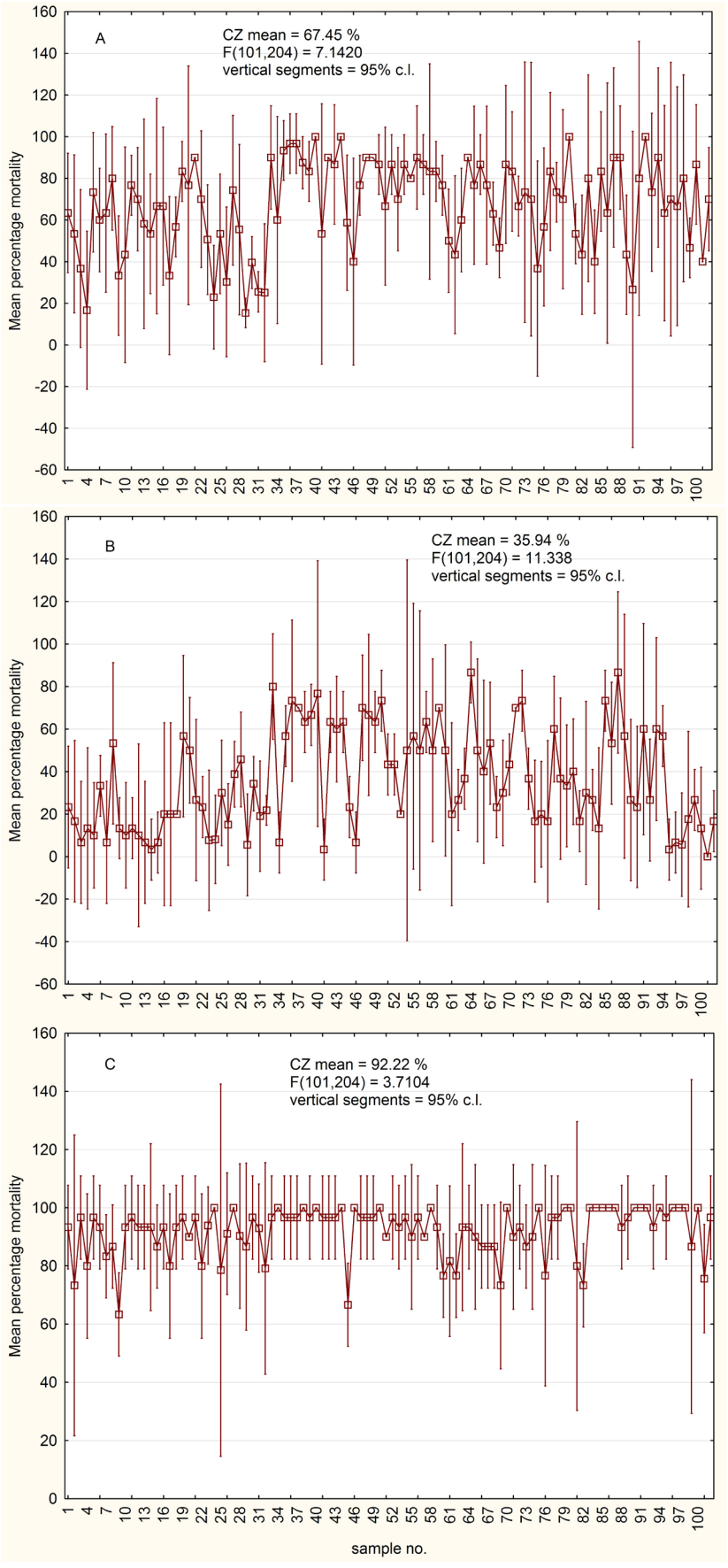

Figure 6. Laboratory contact effects for rates 7.5 g (A), 1.5 g (B), and 37.5 g (C) of lambda-cyhalothrin per ha on *Meligethes* populations tested in 2011

doi: 10.17221/34/2014-PPS

and highly resistant samples showed a marked increase in the course of the three seasons. Zimmer and Nauen (2011a) summarised the results of tests on 50 *Meligethes* populations sampled in 9 European countries practically at the same time as we did it (in 2009 and 2010). Two Czech samples were also included in their collection. From the comparison of the data published here with their comprehensive study some differences emerge. The three Czech collections (2009, 2010, 2011) seem to be more variable than the Zimmer and Nauen's collection. Extremely resistant samples occurred in the Czech collections from 2009 (and the frequencies were not negligible), so the mean LC_{50-90} values estimated for the collections are substantially higher than European means published in Zimmer and Nauen's study. On the other hand, the minimal LC_{50-90} values recorded in the Czech and Zimmer and Nauen's collections are similar (excluding the most susceptible Ukraine sample). The comparison probably indicates that the phenomenon of resistance to pyrethroids in *Meligethes aeneus* had been a greater problem of Czech oil-seed rape growers much earlier before monitoring started (2008–2009) and that the levels of resistance of Czech *Meligethes* populations could have been even higher than they were in western Europe in 2009 and 2010. On the basis of a large body of data published by Heimbach and Műller (2013) it is possible (despite our previous statement) to conclude that the levels of pyrethroid resistance in pollen beetles (*M. aeneus*) were somewhat lower in the Czech Republic than in Germany at that time (2009–2011). Heimbach and Műller (2013) recorded a dramatic decline in susceptible samples in Germany from 2005. Pyrethroid resistance increased very rapidly from year to year. Highly susceptible samples disappeared in 2009 (in Czech Republic in 2011) and susceptible samples in 2010 (in Czech Republic the last susceptible population was recorded in 2012; Seidenglanz *et al*. 2014b). Since 2009, pollen beetle samples classified as highly resistant have been dominant in Germany. Resistant and highly resistant samples increased to 95.5% in 2011. At the same time (2011) the proportion of resistant and highly resistant samples in Czech Republic was 82.36% (Table 4).

Intensity of winter oil-seed rape growing and the proportion of arable soil regularly given over to the crop has increased considerably in the Czech Republic (yellow country) in the last 10–15 years. Winter oil-seed rape is one of the few relatively profitable crops for Czech farmers and the cost of insecticidal applications is relatively low in comparison with prices of the seed produced. So farmers do not think carefully of the real necessity of insecticidal applications (number, type and timing of them). In fact they are not willing to decrease the number of insecticidal sprays applied during the spring months. Three (sometimes four) insecticidal applications from the beginning of April till mid May are common practice in the Czech Republic (Kazda & Andr 2010). Most Czech farmers are aware (at least since 2010) of the existence of *Meligethes* resistance to pyrethroids and they have reduced their use of this group of insecticides in sprays primarily aimed at pollen beetles. Because pollen beetles are usually present early in the year, when *Ceutorhynchus napi* and *C. pallidactylus* are controlled, and they are also still present in the crop when *Dasineura brassicae* needs controlling, selection in the *Meligethes* population continues because the pyrethroids are still being used against the other mentioned insect pests. Recently registered insecticides with substantially different modes of action (pymetrozine and indoxacarb) provide some hope for the future. Appropriate incorporation of the active ingredients into spring control schedules could decrease the selection pressure for resistance (Seidenglanz *et al*. 2014a).

Kocourek's findings (2013) show that for winter oil-seed rape growing, in practice there is marked discrepancy between the principles of Integrated Pest Management and the field reality (for all field crops grown in the Czech Republic). This indicates a huge need for essential changes to the whole system of Pest Management used in the Czech winter oil-seed rape fields. Contemporary practices can result in the loss of susceptibility in other common insect pests (*Ceutorhynchus* spp., *Phyllotreta* spp.) to insecticides (not only to pyrethroids) over the next few years (Seidenglanz *et al*. 2014b). First indications of resistance of *Ceutorhynchus obstrictus* to acetamiprid (Kocourek *et al*. 2013) and *Phyllotreta* spp. to thiacloprid (Seidenglanz *et al*. 2014b) were recorded in the Czech Republic in 2013.

Acknowledgements. The authors would like to thank Eoghan O'Reilly for revision of the manuscript.

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Received April 10, 2014
Accepted after corrections September 18, 2014

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