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HARMFULNESS OF *DELIA ANTIQUA* (DIPTERA: ANTHOMYIIDAE) IN GARLIC IN SOUTHEAST AND CENTRAL MORAVIA

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Abstract

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The aim of the three year research was to determine the first occurrence of *Delia antiqua* (Meigen, 1826) (Diptera: Anthomyiidae), specify its bionomics, compare its harmfulness on different garlic varieties, find out the effect of temperature on their life cycle and how their abundance influences garlic yield in regional agriculture areas traditionally growing garlic such as southeast and central Moravia. There was a significantly higher infestation of *Delia antiqua* on the edge (32.3 larvae) of study plot than in the middle (16.3 larvae) from 2010 to 2012. Intensive laying eggs of *D. antiqua* takes place between 9–11 a.m. and 16–18 p.m. hours at the edges of the study plot. The highest number of laid eggs was of 28 per one plant in Nedakonice. The development lasted 15 days at 21 °C under laboratory conditions.

Keywords: pests, onion maggot, yield, tuber vegetables, *Allium sativum*

INTRODUCTION

Delia antiqua (Meigen, 1826) (Diptera: Anthomyiidae) damages in all areas of growing onions and garlic in the Czech Republic. The first mention of damage to onions was in 1922, on garlic in 1938 (Šefrová, 2008). Baudyš (1935) considered it as a major pest of garlic on the contrary with Dušek *et al.* (1983) who claimed that *Delia antiqua* is a rare pest on garlic preferring onions and chives. The host plants are species of the genus *Allium* including onion, garlic, leek and chive. More damage is caused to sown crops than from seedlings. It is found throughout all Europe, North and South America and Asia (Miller, 1956; Vernon *et al*., 1989; Michelsen, 2012). Pupae overwinter in the soil from which the adults hatch in early May. The flying skill is bears the signs of a little hesitation. The females are mature about a week after hatching. Maturity fattening takes place mostly on flowers of willows and Apiaceae. The eggs are laid shallow on land or the soil to the neck of root but also on the base of the leaves of host plants. The laying is carried out either individually or in groups of 10 to 30 pieces (Mowry, 1993) taking place mainly at the edges of areas. Hausmann *et al.* (1989) reported that one bulb could be infested up to 50 larvae. Mature plants are more resistant to infestation (Walter *et al*., 1996). The females live for about two weeks, one female can lay hundreds of eggs (Harris *et al*., 1987). The hatching begins 2–4 weeks after laying (Finch *et al*., 1986). Hatched larvae penetrate into the tissues of plants and infect them by various bacteria breaking down plant tissue and producing the optimal environment to larvae. One larva can infect up to 10 plants per row (Walter *et al*., 1996). The saprophagous larvae of the fly *Muscina stabulans* (Fallen, 1817) and the fruit fly *Drosophila phalera* (Meigen, 1830) often develop on the rotting bulb. The grown larvae leave the plant and pupate in the soil. In June and July, there is hatching the second generation of flies whose larvae develop in mature bulbs, and after the completion of their

development, they pupate in the soil. The part of pupae overwinters. The third generation can hatch from remaining pupae infesting chive (*Allium schoenoprasum* L.) (Aihara *et al*., 1985). Abundance of *Delia antiqua,* its biology, the control possibilities and the influence on yield were carried out in central and southeast Moravia.

MATERIALS AND METHODS

The experiments were carried out on five study plots at different altitudes – in Nedakonice (178 m a.s.l.), Olomouc (241 m a.s.l.), Dolní Němčí (256 m a.s.l.), Suchá Loz (306 m a.s.l.) and Vápenky (484 m a.s.l.) between 2010–2012. Two winter varieties (Blanin and Dukát) were planted. The garlic was put manually in 0.15×0.20 m in depth 0.08 m from mid to late October. Before seeding, the garlic bulbs were manually split into individual cloves so as not to damage the outer peel. The cloves were stained 0.4% fungicide solution Rovral Aquaflo (active substance iprodione) for 20 minutes before planting. No insecticide was applied during the growing season. Manual loosening and weeding were carried out during the vegetation. Harvesting was manually carried out at the beginning of July. Garlic bulbs were finally drying in well-ventilated storage areas. Health status of garlic was assessed visually in individual study plots from the end of February at regular weekly intervals. At the time of the intense occurrence of pest, the study plots were checked 2 times a week from April to July. The pest was determined on plants per 1 m^2 on ten randomly selected places on the periphery and in the central part of the vegetation. Fifty plants of each part from the study plots around the edges and in the middle were evaluated to determine the difference in intensity of plant infestation by *D. antiqua*. All the developmental stages of pest were detected in the above-ground plant parts. When visible symptoms of damage were noticed, the plant was removed from the soil with root system. The bulbs of garlic were cleared of packaging peels and split into individual cloves, among which the larvae and puparia were collected.

Occurrence of adults was determined using coloured PVC bowls (yellow, red, green and blue). Five pieces of each colour bowls filled with 4% formalin were located in the distance 1 m^2 from each other. Colour sticky boards (yellow, white, and blue) were placed on the edges and across the surface of the study plots. Sticky boards and coloured bowls were checked from March to July twice a week. The temperature on the surface of the soil was measured for 24 hours using Datalogger (GAR 195) at all study plots. It recorded the highest afternoon and the lowest night temperature on the surface of the soil from February to July. Abundance of the pest was evaluated using a four-point scale (Tab. I) in which the density of *Delia antiqua* adults was counted on 1 m^2 and in 1 bowl. The number of its larvae was counted in 1 garlic bulb. The average yield was taken from each plot of 200 m^2 because the pest monitoring was carried out in the same size of research plot. The results were processed by analysis of variance followed by testing using the Tukey test at $\alpha = 0.05$, Statistica 10.

I: *Scale to determine abundance of Delia antiqua by the number of individuals per 1 m^2/in 1 bowl/in 1 garlic bulb*

Category of abundance	The density of 1 m^2/ in 1 bowl/in 1 garlic bulb
1 – without occurrence	0
2 – weak occurrence	less than 10
3 – middle occurrence	10–20
4 – strong occurrence	more than 20

RESULTS AND DISCUSSION

Delia antiqua occurred in all five study plots from 2010 to 2012. Occurrence of adults was detected using coloured bowls. The first occurrence of adults is shown in Tab. II. The range of the first occurrence among study plots in 2010 was 7 days (20. 5.–27. 5.), in 2011 for 9 days (11. 5.–20. 5.), and in 2012 for 7 days (16. 5.–23. 5.). In neither case, the first occurrences correlated with the altitude. The dependence of occurrence of adults on altitude was not statistically proved. It was probably greatly influenced by other factors such as microclimate, exposure, and surrounding vegetation.

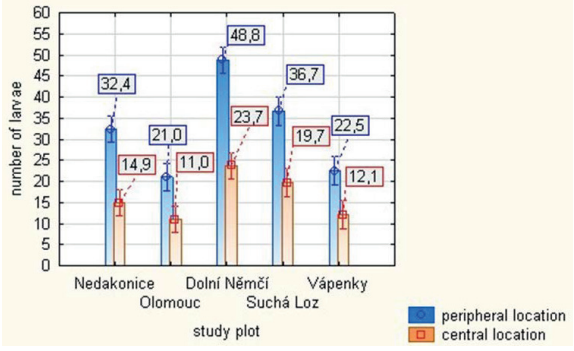
Abundance of *Delia antiqua*

Among the various experimental years, there was not any significant difference in the abundance of larvae. The difference in intensity of infestation of garlic by *Delia antiqua* between the edge and the middle of the study plots is shown in Fig. 1 and Tab. II. There was a significantly higher infestation on the edge (32.3 larvae/bulb) of study plot than in the middle (16.3 larvae/bulb) from 2010 to 2012 (Figs. 2, 6). The intensity of damage in both varieties was significantly higher at the edge of study plot (Fig. 3). The Blanin variety (26.0 larvae/bulb) was significantly more infested than the Dukát variety (22.6 larvae/bulb) (Fig. 4). In Dolní Němčí, both garlic varieties were the most attacked (36.2 larvae/bulb) (Fig. 5). The second most infested study plot was Suchá Loz (28.2 larvae/bulb) followed by Nedakonice (23.6 larvae/bulb), Vápenky (17.3 larvae/bulb), and Olomouc (16.00 larvae/bulb). Loosjes (1976), Whitfield (1981), Finch *et al.* (1986), Vernon *et al.* (1987), and Vernon *et al.* (1989) explain the reason of creation of the edge effect. The highest intensity of occurrence of adults of *Delia antiqua* is on the edge of study plot in the morning and in the afternoon. The adults of *D. antiqua* do not tolerate high temperatures and direct sunlight intensity. Therefore, they are not active at noon, when there is the highest intensity of sunlight. Their movement is restricted to the edges of cultivated areas where they can find the shelter quickly. The highest edge effect

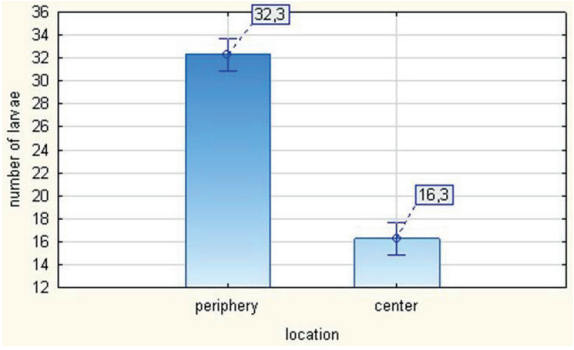
II: *Difference in abundance (intensity of infestation) of garlic by Delia antiqua*

Variety		Dukát variety		Blanin variety		Abundance	
Study plot	Year Date	Middle	Periphery	Middle	Periphery	Ø	Category of abundance
Nedakonice	2010 20. 5.	11.6	18.7	15.2	26.1	**14.1**	3
	2011 15. 5.	8.1	18.3	9.26	22.3	**14.5**	3
	2012 24. 5.	8.3	19.1	11.1	25.8	**16.1**	3
Olomouc	2010 22. 5.	11.2	19.9	11.2	23.2	**16.4**	3
	2011 18. 5.	8.8	18.4	10.0	22.8	**15.0**	3
	2012 16. 5.	4.6	11.4	4.4	10.6	**7.8**	2
Dolní Němčí	2010 24. 5.	16.0	25.8	25.4	34.8	**25.5**	4
	2011 11. 5.	14.7	27.4	15.9	35.3	**23.3**	4
	2012 23. 5.	14.3	25.2	19.0	35.3	**23.5**	4
Suchá Loz	2010 24. 5.	14.6	22.2	16.8	23.1	**19.2**	3
	2011 13. 5.	11.0	21.6	14.7	29.9	**19.3**	3
	2012 21. 5.	11.2	21.8	14.9	27.4	**18.8**	3
Vápenky	2010 27. 5.	14.5	19.4	9.7	25.7	**17.3**	3
	2011 20. 5.	8.4	17.6	9.5	21.1	**14.2**	3
	2012 18. 5.	7.5	17.2	7.9	23.3	**14.0**	3

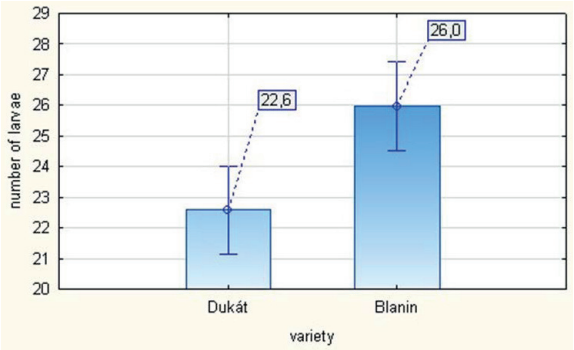
has been demonstrated in the first generation of *D. antiqua* because the crops are not in the appropriate growth stage to provide them the appropriate shelter. The edge effect is significantly lower for the second and third generation because the crops are able to provide sufficient protection. Hawkes (1972) found out the significant edge effect also in green root flies (*Delia radicum* L., 1758) and its morning and afternoon activity. Havukala and Miller (1987) found out that *Delia antiqua* females lay their eggs in the morning and afternoon in the laboratory conditions. *D. antiqua* females lay their eggs on base of the plants and young leaves. Harris *et al.* (1987) observed that the female preferred the young plants at a later growth stage. Finch *et al.* (1986) confirmed that the plants were more resistant to infestation during maturation. Mowry (1993) reported that one female could lay from 10 to 30 eggs per plant. Ishikawa *et al.* (1999) observed that one female has laid of 30 eggs. Hausmann *et al.* (1989) found out that 50 larvae may occur in one plant. Walter *et al.* (1996) reported that one larva could damage up to 10 plants per row. In our three-year experiment, 45 larvae were registered at one plant. This finding corresponds to the result of Hausmann (1989). Taylor *et al.* (2001) reported that onion maggot could destroy from 20 to 60% of plants. Hoffmann *et al.* (2001) reported up to 90% destruction of growth by *D. antiqua*. Walter *et al.* (1996) reported that appropriate protective measures could reduce from 43 to 95% of damage on garlic. A nonwoven crop covers can serve as an effective protection.



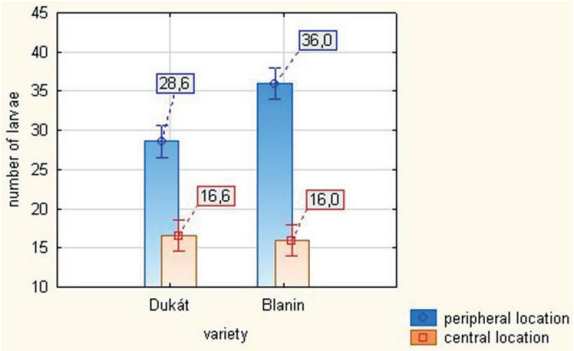
1: *Abundance of Delia antiqua in peripheral and central location on individual study plots from 2010 to 2012*



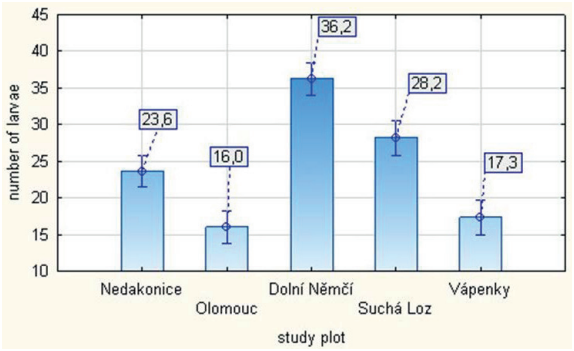
2: *Abundance of Delia antiqua in peripheral and central location from 2010 to 2012*



4: *Influence of variety on the abundance of Delia antiqua from 2010 to 2012*



3: *Abundance of Delia antiqua in Dukát and Blanin varieties from 2010 to 2012*



5: *Abundance of Delia antiqua in individual study plots from 2010 to 2012*

The results of our study are almost identical with those findings. The highest number of eggs laid by one plant was of 28 with an average number of 14 on the study plot Nedakonice. In Dolní Němčí, there was a maximum of 25 eggs with an average number of 12. In Suchá Loz, there was a maximum of 21 eggs with an average number of 10. In Vápenky, there was a maximum of 19 eggs with an average number of 9. In Olomouc, there was a maximum of 17 with an average number of 8.

As Ishikawa *et al* (1999) indicated the development of *D. antiqua* takes approximately 17 days at 23 °C in closed conditions. In our conditions at 21 °C, the development lasted 15 days. Decaying plant tissue

6: *Imago of Delia antiqua (photo by Šefrová)*

of bulbous plants and humidity are necessary for the larvae development. In our observation, we found out that the intensive egg laying takes place between 9–11 am and 16–18 pm at the edges of the study plots. The intensity of oviposition was not proved in the middle of the study plot for the second and third generation. Judd and Whitfield (1997) reported that the adults of *D. antiqua* were attracted to yellow sticky boards. In our experiments, adults were not attracted by these boards.

CONCLUSION

Delia antiqua occurred in all five study plots from 2010 to 2012. The first occurrence of adults was found out in Dolní Němčí on 11. 5. in 2011 using a yellow bowl. The dependence between the abundance of *D. antiqua* and the altitude has not statistically been proved. Yellow sticky boards did not attract adults of *D. antiqua*. In all the years, there was significantly higher abundance of *D. antiqua* on the edge (32.3 larvae) of study plot than in the middle (16.3 larvae). Blanin variety (26.0 larvae) was significantly more infested than the Dukát variety (22.6 larvae). The varieties (Blanin and Dukát) grown in Dolní Němčí were most significantly infested (36.2 larvae). The maximum number of larvae per one plant registered in Dolní Němčí reached 45 larvae. Intensive laying eggs of *D. antiqua* takes place between 9–11 a.m. and 16–18 p.m. hours at the edges of the study plot. The highest number of laid eggs was of 28 per one plant in Nedakonice. The development lasted for 15 days at 21 °C under laboratory conditions.

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