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DIPTERA PESTS OCCURRING ON VEGETABLE CROPS IN POLAND

A review

Jerzy Henryk SZWEJDA
Professor emeritus
The National Institute of Horticultural Research, 96-100 Skierniewice, Poland

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ABSTRACT

In Poland, the share of Diptera in the species composition of the harmful entomofauna occurring on vegetable crops ranges from 20 to 25%. They occur on all vegetables grown in Poland (over 80 species and botanical varieties). Since the systematic registration of pests inhabiting crops in Poland in 1919, over 70 species of flies have been listed as pests of vegetable plants. Species from three families dominate in terms of population and numbers: Anthomyiidae with 12 species (*Delia radicum*, on early and late cultivars of cruciferous vegetables, mainly broccoli, cauliflower, white cabbage, kohlrabi, and radishes; *Delia platura* occurs annually on bean and cucumber; *Delia antiqua* on onion and garlic; and *Pegomya hyoscyami* on beetroot), Cecidomyiidae with 10 species (two species dominate, *Contarinia nasturtii* and *Dasineura napi*, on cruciferous vegetables), and Agromyzidae with 23 species (*Liriomyza bryoniae* on cucumbers, tomatoes, and peppers, and *Phytomyza gymnostoma* on leeks). Short-term, gradational occurrence of some dominant species was found, including *Botanophila gnava* (lettuce), *Chamaepsila rosae* (carrot, parsley), *Delia platura* (asparagus, bean), *Delia radicum* (broccoli, cauliflower, kohlrabi, radishes, white cabbage), *Phytomyza gymnostoma* (leek), *Oscinella frit* (corn), and *Suillia lurida* (garlic). However, they did not affect the level of plant production in the following years of cultivation. Apart from phytophagous species, taxa with a different trophic structure are common. These are copro-, necro-, sapro-, and zoophagous species. The most numerous were flies from the Drosophilidae family (*Drosophila busckii*, *Drosophila limbata*, *Scaptomyza pallida*, Fanniidae (*Fannia canicularis*, *Fannia scalaris*), Heleomyzidae (*Tephrochlamys tarsalis*), and Muscidae (*Muscina levida*, *Muscina stabulans*, *Phaonia trimaculata*). Natural enemies of insects play an important role in vegetable agrocenoses. Species belonging to the order of Coleoptera beetles (Carabidae and Staphylinidae), Syrphidae, Tachinidae, and Muscidae, mainly *Phaonia trimaculata* larvae, play the most important role in reducing the number of Diptera. In addition, the number of phytophages is limited by other organisms, e.g., Diplopoda, Nematoda, Arachnida, and pathogens of viral, bacterial, and fungal origin.

Key words: Drosophilidae, Fanniidae, Heleomyzidae, Muscidae, Syrphidae, Tachinidae, vegetable crops

INTRODUCTION

Vegetable cultivation in Poland dates back to the early Middle Ages. Their presence in the agricultural landscape significantly influenced the appearance of harmful entomofauna, preferring vegetables as host plants. Vegetable crops are part of a diverse agricultural landscape in which various fauna and flora depend on the surrounding environment.

Knowledge of the dipterofauna occurring in vegetable agrocenoses, mainly in terms of nutritional requirements, is necessary to explain the mechanisms of its potential harmfulness and consequently cause economic losses. Their share in the species composition of the harmful entomofauna on vegetable crops ranges from 20 to 25% (Szwejda 2015).

A characteristic feature of the described Diptera is a different trophic structure regarding individual developmental stages. In the imaginary stage,

*Corresponding author
e-mail: jerzy.szwejda@inhort.pl

the majority of flies are licking exophages. They are melitophages, i.e., feeding on flower nectar, plant sap, and other substances leaking from living or dead plant or animal organisms. They also use water. On the other hand, larvae in the preimaginal stage use different types of food: living, dead, decaying, or pathogen-infested plant tissues.

The systematics and Latin nomenclature of the discussed species were adopted according to the current catalog of "Fauna Europaea" (https://fauna-eu.org), also using the studies of Bogdanowicz et al. (2004, 2007).

REVIEW OF SPECIES

Diptera pests of cruciferous vegetables (Brassicaceae)

Host plants:

• species of *Brassica oleracea*
– Brussels sprout (*Brassica oleracea* L. var. *gemmifera* L.);
– broccoli (*Brassica oleracea* L. var. *italica* Plenck);
– cauliflower (*Brassica oleracea* L. var. *botrytis* L.);
– Chinese cabbage (*Brassica rapa* L. subsp. *chinensis* Hanelt);
– kale (*Brassica oleracea* L. var. *sabellica* L.);
– kohlrabi (*Brassica oleracea* L. var. *gongylodes* L.);
– red cabbage (*Brassica oleracea* L. var. *capitata* L. f. *rubra*);
– Savoy cabbage (*Brassica oleracea* var. *sabauda* L.);
– white cabbage (*Brassica oleracea* L. var. *capitata* L. f. *alba*);

• other species of *Brassica*
– black radish (*Raphanus sativus* L. var. *niger* (Mill.) S. Kerner);
– horseradish (*Armoracia rusticana* G.Gaertn.);
– radish (*Raphanus sativus* var. *sativus* L.);
– rutabaga (*Brassica napus* L. var. *napobrassica* L.);
– turnip (*Brassica rapa* L. var. *rapifera* Metzg.).

The Diptera species found on all species and botanical varieties of *Brassica* cultivated in Poland are listed in Table 1. They belong primarily to three families: Anthomyiidae, Cecidomyiidae, and Agromyzidae.

Table 1. Diptera species occurring on cruciferous vegetables (Brassicaceae)

Species	Frequency of occurrence
Cecidomyiidae	
Contarinia nasturtii (Kieff.)	A
Dasineura napi (Loew)	A
Dasineura armoraciae (Vimmer)	C
Gephyraulus raphanistri (Kieff.)	C
Agromyzidae	
Phytomyza rufipes (Meigen)	B
Liriomyza strigata (Meigen)	C
Phytomyza horticola (Goureau)	C
Heleomyzidae	
***Tephrochlamys tarsalis* (J.W.Zetterst.)	C
Drosophilidae	
**Drosophila busckii* (Coquillett)	A
**Drosophila funebris* (J.Fabr.)	C
**Drosophila limbata* (von Roser)	B
**Scaptomyza pallida* (J.W.Zetterst.)	B
Anthomyiidae	
***Botanophila fugax* (Meigen)	B
Delia floralis (Fallén)	C
Delia florilega (J.W.Zetterst.)	C
Delia platura (Meigen)	B
Delia radicum (L.)	A
Fanniidae	
****Fannia canicularis* (L.)	A
****Fannia scalaris* (J.Fabr.)	A
Muscidae	
****Muscina levida* (Harris)	A
*****Phaonia trimaculata* (Bché.)	A

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat
*saprophagous species; **phyto- and saprophagous species; ***copro-, necro-, and saprophagous species; ****zoophagous species

Among the Anthomyiidae, the dominant species is *Delia radicum* (Ruszkowski 1933; Ruszkowski et al. 1935; Ogijewicz 1938; Brooks 1951; Szwejda 1975, 1977, 1988, 2003). This species occurs in two or three generations per year, depending on climatic and soil conditions. This species has been noted as a pest since the beginning of the nineteenth century (Belke 1861). *Delia radicum* larvae damage the underground parts of infested plants (roots and root neck) and above-ground parts: petioles of lower leaves and generative parts. The larvae of the first generation damage the underground parts of all brassicas (mainly head cabbage, broccoli, cauliflower, kohlrabi, and radishes), and the second and third generations damage the heads of Brussels sprouts and the lower leaves of Chinese and Savoy cabbage. In broccoli and cauliflower, the larvae burrow into the branches of the roses. Kale and red cabbage are less preferred (Szwejda 1975, 1980, 2003). *Botanophila fugax* larvae are abundant in maturing heads of Brussels sprouts. They often feed in corridors previously excavated by *Delia radicum* (Szwejda 1980, 2003). Anthomyiidae are common in neighboring countries (Dušek 1969; Łoginowa 1980; Crüger 1991). In the Czech Republic and Germany, *Botanophila fugax* was also mentioned as a pest of cauliflower roses (Dušek 1969; Crüger 1991).

Delia platura and the less numerous *Delia florilega* occur on late cultivars of *Brassica*. Their larvae drill corridors in the thicker veins of the lower leaves, e.g., head cabbage, Chinese cabbage, Savoy cabbage, heads of Brussels sprouts, and in the lower part of the thickening of the kohlrabi touching the ground (Szwejda 1974, 1979, 2003; Beiger 2001). Another species, *Delia floralis*, was abundant in national agrocenoses in the 1920s and 1930s (Ruszkowski 1933; Ruszkowski et al. 1935; Ogijewicz 1938). It is common in neighboring countries (Dušek 1969; Łoginowa 1980; Crüger 1991) and in the Scandinavian countries (Rygg & Sömme 1972; Jørgensen 1976; Havukkala & Virtanen 1985).

Species of the family Cecidomyiidae are common. The most numerous is *Contarinia nasturtii* (Ruszkowski 1933; Ruszkowski et al. 1935; Szwejda 1985). Its larvae damage the heart leaves of cabbage, destroying the growth cone and seed shoots. Damaged shoots, e.g., cauliflower and head cabbage, are twisted, and the flower buds dry up. On the other hand, kohlrabi and rutabaga have a distorted and cracked lower part of the stem, which is an edible thickening (Szwejda 1985; Szadziewski 1999). Damage at an economic level to seed production, mainly head cabbage, cauliflower, kale, and rutabaga, is caused by *Dasineura napi* – the larvae of this species damage pods and seeds. As a result of sucking the sap from the walls, the pods become distorted, dry out, and break prematurely (Ruszkowski 1933; Ruszkowski et al. 1935; Szwejda 1985; Szadziewski 1999). It causes the most significant damage to radish, cauliflower, and cabbage (Ruszkowski 1933; Ruszkowski et al. 1935; Szwejda 1985; Szadziewski 1999). Less numerous is *Gephyraulus raphanistri*. Its larvae damage flower buds to an extent that prevents the formation of pods. On horseradish plantations, similar damage is caused by *Dasineura armoraciae* (Szadziewski 1999), also in neighboring countries (Łoginowa 1980; Rygg & Brække 1980).

There are also numerous species from the family Agromyzidae. *Phytomyza rufipes* is common. Its larval feeding results in leaf mines, primarily broccoli, cauliflower, kohlrabi, Chinese cabbage, swede, and turnip (Szwejda 1985). Two other species are constantly present in cruciferous vegetables: *Liriomyza strigata* and *Phytomyza horticola* (Ruszkowski 1933; Szwejda 1974, 2003). Their larvae mine the leaf blade of younger leaves (Beiger 1989, 2001). The listed species of Agromyzidae are also common in neighboring countries (Łoginowa 1980; Roháček & Máca 1982; Crüger 1991).

In addition to phytophages, species with a different trophic structure occur on cruciferous vegetables. These are: *Drosophila busckii*, *Drosophila funebris*, *Drosophila limbata*, *Scaptomyza graminum*, *Scaptomyza pallida* (Drosophilidae), *Fannia canicularis*, *Fannia scalaris* (Fanniidae), *Tephrochlamys tarsalis* (Heleomyzidae), and *Muscina levida* (Muscidae) (Sznabl 1881; Bobek 1890; Szwejda 1980, 2003). The larvae of these species inhabit damaged parts of plants, accelerating the rotting processes caused, e.g., by infecting tissues with pathogens, mainly of bacterial and fungal origin. Most occur

in damaged leaves and heads of Brussels sprouts, white, Chinese, and Savoy cabbage. The larvae mainly feed in corridors previously excavated by phytophagous species (Niswonger 1911; Szwejda 1974, 1980). In the final period of vegetation of cruciferous vegetables, species from the families Drosophilidae, Heleomyzidae, Fanniidae, and Muscidae accounted for over 55% of the total biomass of identified phytophagous Diptera larvae (Szwejda 1974, 1980, 1988, 2003). *Phaonia trimaculata* larvae are often found in tissues previously damaged by pests. They lead a predatory lifestyle, attacking the larvae of other species of flies. (Brooks 1951; Szwejda 1974, 1979, 2003).

These phyto- and saprophagous species are also common on *Brassica* crops in neighboring countries (Tischler 1965; Łoginowa 1980; Roháček & Máca 1982; Crüger 1991).

Diptera pests of bulbous vegetables (Amaryllidaceae)

Host plants:

– chives (*Allium schoenoprasum* L.);
– garlic (*Allium sativum* L.);
– leek (*Allium porrum* L.);
– onion (*Allium cepa* L.).

On Polish lands, the tradition of growing Amaryllidaceae (onion and garlic) dates back to the sixteenth century. Hence, they are inhabited by numerous polyphagous dipterofauna belonging to nine families. In addition to phytophagous species, these include copro-, necro-, and saprophages that penetrate the tissues of previously damaged plants, accelerating the processes of rotting and plant decomposition (Table 2).

Table 2. Diptera species occurring on bulbous vegetables (Amaryllidaceae)

Species	Frequency of occurrence			
	onion	garlic	leek	chives
Syrphidae				
******_Eumerus strigatus_ (Fallén)	A			
******_Merodon equestris_ (J.Fabr.)	C	A		
Agromyzidae				
Liriomyza cepae (Hering)	C		C	
Phytomyza gymnostoma Loew	B	C	A	C
Phytomyza albiceps (Meigen)	C			
Heleomyzidae				
Suillia lurida (Meigen)	B	A		
Drosophilidae				
******_Drosophila busckii_ (Coquillett)	A			
Ephydridae				
Hydrellia griseola (Fallén)	C	C		
Chloropidae				
*****_Elachiptera cornuta_ (Fallén)		A		
Anthomyiidae				
Delia antiqua (Meigen)	A	B	B	C
Delia platura (Meigen)	B	B		
Delia florilega (J.W.Zetterst.)	C	C		
Fanniidae				
*******_Fannia canicularis_ (L.)	A	A		
*******_Fannia scalaris_ (J.Fabr.)	A	A		
Muscidae				
*******_Muscina levida_ (Harris)	A	A		
*******_Muscina stabulans_ (Fallén)	A	A		

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat
*****saprophagous species; ******phyto- and saprophagous species; *******copro-, necro-, and saprophagous species

In Poland, in all onion-growing regions, the leading pest is *Delia antiqua* (Ruszkowski 1933; Ruszkowski et al. 1935; Ogijewicz 1938; Szwejda 1982, 2003; Szwejda & Wrzodak 2009). The first report on its harmfulness comes from the mid-nineteenth century (Belke 1861). In Poland, this species occurs in two generations per year. Apart from onion and its varieties, the larvae damage garlic and leek, and to a lesser extent, chives (Szwejda 1988; Szwejda & Wrzodak 2009). The decline of the second generation is mainly caused by predatory beetles from the Staphylinidae and Carabidae families (Szwejda 1988, 1996).

Of the remaining Anthomyiidae, there are two species: *Delia platura* and the less numerous *Delia florilega* (Ruszkowski et al. 1935; Szwejda 2003). Second-generation larvae of both species feed between onion scales, in garlic, and in the lower part of the leek. They constitute, on average, 20% of all *Delia* sp. species occurring on the discussed crops (Szwejda 1988, 2003). On garlic and onion cultivated in the autumn–spring cycle since the 1970s, *Suillia lurida* caused significant losses in terms of profitability (Szwejda 1988). In the spring, they drill holes in the middle leaf, preventing the formation of garlic cloves and onion heads. Since the 1950s, this species has moved from southern Europe, e.g., Bulgaria through Romania, Hungary, Ukraine, Slovakia, and the Czech Republic to Poland (Nikolova 1959; Szwejda 1998a). In the nineteenth century, this species was already identified in Poland on wild garlic in nonagricultural environments (Siła-Nowicki 1873).

Species of the family Agromyzidae are common. In the early 1990s, significant economic losses were recorded in leek crops when a gradational occurrence of *Phytomyza gymnostoma* was recorded in the regions of south-eastern Poland: Leżajsk, Rzeszów, Kraków (Kuźma 1995; Sionek 1998, 2001). In later years, the range of its occurrence covered the central part of the country (Szwejda 1998b). In the early spring period, the first generation of this species damages onions and garlic from autumn planting. On the other hand, leek and chives are damaged in the summer by the next generation (Sionek 2001). Other leaf miner species include *Liriomyza cepae* and *Phytomyza albiceps*. Their larvae mine onion leaves and leek (Beiger 2001). They were recorded on many other crop species (Narkiewicz-Jodko 1985; Szwejda & Wrzodak 2007).

Eumerus strigata (Syrphidae) is abundant in the final phase of onion growth. Its larvae take over plants previously damaged by *Delia antiqua* larvae, deepening the processes of their decay (Ruszkowski 1933; Ruszkowski et al. 1935; Ogijewicz 1938; Szwejda 1998a, 2003; Szwejda & Wrzodak 2007). A related species, *Merodon equestris*, occurs sporadically, and its larvae damage onions and garlic (Ogijewicz 1938; Szwejda 1988).

Larvae of *Drosophila busckii* (Drosophilidae) were often found between the scales of ripening onions (bulbs) and in seeds stored in poorly ventilated storage rooms (Szwejda 1998a, 2003). It is a polyphagous species found on many other crops. Its larvae feed on rotting and fermenting tissues of many crops (Szwejda 2003). Locally, there is a fly from the Ephydridae family, *Hydrellia griseola*, whose larvae drill short mines in the leaves of onions and leeks (Beiger 2001). This species is often found in moist, grassy environments (Beiger 2001; Zatwarnicki & Kunderak 2007).

At the end of the growing season, after the first year of cultivation, damaged, rotting parts of onions (bulbs), garlic cloves, and the lower part of the leek are infested with numerous copro-, necro-, and saprophagous species. They accounted for over 40% of all flies inhabiting these crops throughout the growing season. The most numerous are *Fannia canicularis*, *Fannia scalaris, Muscina stabulans*, *Muscina levida* (Szwejda 2003), and *Elachiptera cornuta* (Szwejda 1988, 2003).

The phyto- and saprophagous species are common on other crops (Tischler 1965; Osmołowki 1980; Crüger 1991).

Diptera pests of nightshade vegetables (Solanaceae)

Host plants:

– eggplant (*Solanum melongena* L.);
– tomato (*Solanum lycopersicum* L.);
– pepper (*Capsicum annuum* L.).

Over 90% of eggplant, tomato, and pepper plantations are grown in unheated plastic tunnels. They are dominated by species from the families Agromyzidae and Drosophilidae (Table 3).

The larvae of all species of Agromyzidae mine the leaves, hollowing out winding corridors in them. More than 10 larvae can feed on one leaf. Severely infected leaves die and wither (Macias & Szwejda 2001). In open field cultivation, Agromyzidae do not pose a threat, unlike crops under cover, where they are obligatorily combated. The dominant species is *Liriomyza bryoniae*, whose number exceeds 50% of all recorded Agromyzidae crops. Ripening, cracked, or damaged tomato fruits are often infested with Drosophilidae larvae. *Drosophila busckii* dominates. *Drosophila funebris* occurs sporadically (Szwejda 1980; Szwejda & Rogowska 2011). Their larvae live in rotting and fermenting fruits carrying bacterial, fungal, or viral origin.

The described species are also common in neighboring countries (Tischler 1965; Osmołowski 1980; Crüger 1991).

Diptera pests of cucurbit vegetables (Cucurbitaceae)

Host plants:
- pumpkin (*Cucurbita pepo* L.);
- muskmelon (*Cucumis melo* L.);
- cucumber (*Cucumis sativus* L.).

For years, the greatest threat has been caused by flies belonging to two families: Anthomyiidae and Agromyzidae (Table 4).

Table 3. Diptera species occurring on nightshade vegetables (Solanaceae)

Species	Frequency of occurrence		
	tomato	pepper	eggplant
Agromyzidae			
Liriomyza bryoniae (Kaltenb.)	A	B	B
Liriomyza huidobrensis (Blanchard)	C		
Liriomyza strigata (Meigen)	C	C	C
Liriomyza trifolii (Burgess)	C		
Phytomyza albiceps (Meigen)	C	C	C
Phytomyza horticola (Goureau)	C	C	
Drosophilidae			
******Drosophila busckii* Coquillett	A		
*****Drosophila funebris* (J.Fabr.)	C		

A – species occurring in each vegetation season; B – species posing periodic threat; C – species posing a local threat
*****saprophagous species; ******phyto- and saprophagous species

Table 4. Diptera species occurring on cucurbit vegetables (Cucurbitaceae)

Species	Frequency of occurrence		
	cucumber	pumpkin	muskmelon
Agromyzidae			
Phytomyza horticola (Goureau)	C	C	C
Liriomyza strigata (Meigen)	A	C	C
Liriomyza bryoniae (Kaltenb.)	C	C	C
Phytomyza albiceps (Meigen)	A	C	C
Anthomyiidae			
Delia florilega (J.W.Zetterst.)	C	C	
Delia platura (Meigen)	A	C	

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat

Delia platura and *Delia florilega*, two species of Anthomyiidae, cause the greatest damage to cucumber and pumpkin plantations (Balachowski & Mesnil 1936; Hennig 1953; Dušek 1969; Szwejda 1974, 2011). The melon is damaged occasionally, with *Delia platura* as dominant. Both species belong to polyphagous species which, apart from Cucurbitaceae, damage many other crops, e.g., bean, cabbage, onion, peas, celery, sunflower seeds, and asparagus (Ruszkowski 1933; Ruszkowski et al. 1935; Studziński et al. 1981; Szwejda 1985, 1999, 2003). They occur in three generations per year, but the greatest damage is caused by the first generation, whose larvae feed on germinating seeds and in the subcotyledons of emerging plants. In the autumn, second- and third-generation larvae feed on damaged and rotting tissues of various crops (Szwejda 2015).

The most numerous species of Agromyzidae are *Liriomyza bryoniae* and *Phytomyza albiceps* (Ruszkowski 1933; Narkiewicz-Jodko 1985; Beiger 2001). They drill corridors in the leaf blades of plants all over the plant.

The described species are also common in neighboring countries (Balachowski & Mesnil 1936; Tischler 1965; Osmołowski 1980; Crüger 1991).

Diptera pests of apiaceous vegetables (Apiaceae)

Host plants:

– celery (*Apium graveolens* L.);
– dill (*Anethum graveolens* L.);
– carrot (*Daucus carota* L.);
– parsley (*Petroselinum crispum* (Mill.) Fuss.);
– parsnip (*Pastinaca sativa* L.).

The tradition of growing celeriac (Apiaceae) dates back to the sixteenth century. They have long been host plants to many pests, including the Diptera: Cecidomyiidae, Psilidae (rust flies), Tephritidae, and Agromyzidae (Table 5).

The leading pests of carrots, parsnips, and celery include *Chamaepsila rosae* (Ruszkowski 1933; Ruszkowski et al. 1935; Ogijewicz 1938; Narkiewicz-Jodko 1985; Szwejda & Wrzodak 2007). As a pest causing significant damage to carrots in Poland, it was already described in the nineteenth century (Belke 1861). It prefers carrots as a host plant (Szwejda 1999, 2001). In permanent areas of celery vegetable cultivation, *Chamaepsila rosae* rarely migrates to other areas of agrocenoses because its development is related to the place of settlement. Imagines stay all their lives in clusters with perennial vegetation surrounding the plantation, where females leave only to lay eggs (Ellis & Ester 1999). The larvae of the first generation damage the emerging seedlings and young plants (up to the three- to four-leaf stage), and the second-generation larvae drill corridors in the roots of carrots and other Apiaceae (Szwejda 2001, 2015).

Euleia heraclei causes the most significant damage to celery crops. The larvae are biting cake faces in the leaves. With a massive pest occurrence, heavily damaged, over 50% of the leaf surface turns brown and dries up (Narkiewicz-Jodko 1985; Nawrot 2008). This species also occasionally damages parsley, parsnips, and dill (Narkiewicz-Jodko 1985; Beiger 2001).

Diptera from the Agromyzidae family are common on all celeriac vegetables. The dominant species is *Phytomyza albiceps*, whose larvae drill winding corridors in the leaves. Other species cause similar damage: *Liriomyza bryoniae*, *Liriomyza strigata*, *Phytomyza horticola, Phytomyza mylini*, and *Napomyza lateralis* (Beiger 2001).

Significant damage is caused by species from the family Cecidomyiidae on seed plantations of carrot, parsley, parsnip, and dill, (Szadziewski 1999; Nawrot 2008). *Kiefferia pericarpiicola* dominates. Females of this species lay eggs during flowering of the umbels. As a result of the feeding of the larvae, swollen spherical galls are formed, which prevent the formation of the seeds. The umbels are infested with *Lasioptera carophila* and *Napomyza lateralis* larvae (Szadziewski 1999). The described species are also common in neighboring countries (Tischler 1965; Berim 1980; Crüger 1991).

Diptera pests of leguminous vegetables (Fabaceae)

Host plants:

– broad bean (*Vicia faba* L.);
– bean (*Phaseolus vulgaris* L.);
– peas (*Pisum sativum* L.);
– lentil (*Lens culinaris* Medik.).

Diptera belonging to three families, Anthomyiidae, Cecidomyiidae (gall gnats), and Agromyzidae, are important as leguminous vegetables (Table 6).

Table 5. Diptera species occurring on apiaceous vegetables (Apiaceae)

Species	Frequency of occurrence				
	carrot	parsley	celery	parsnip	dill
Cecidomyiidae					
Kiefferia pericarpiicola (Bremi)	C	C		C	C
Lasioptera carophila (Loew)	C	C		C	C
Psilidae					
Chamaepsila rosae (J.Fabr.)	A	A	B	B	
Tephritidae					
Euleia heraclei (L.)		C	A	C	C
Agromyzidae					
Phytomyza horticola (Goureau)	C	C	C	C	C
Liriomyza bryoniae (Kaltenb.)	C	C	C	C	C
Liriomyza strigata (Meigen)	C	C	C	C	C
Napomyza lateralis (Fallén)	C	C	C	C	C
Phytomyza albiceps (Meigen)	C	C	B	C	C
Phytomyza mylini (Hering)	C			C	C

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat

Table 6. Diptera species occurring on leguminous vegetables (Fabaceae)

Species	Frequency of occurrence			
	peas	broad bean	bean	lentil
Anthomyiidae				
Delia florilega (J.W.Zetterst.)	C		C	
Delia platura (Meigen)	B		A	
Cecidomyiidae				
Contarinia pisi (Loew)	A	C		
Agromyzidae				
Agromyza lathyri (Hendel)	C	C		
Agromyza nana (Meigen)		C		
Phytomyza horticola (Goureau)	C	C	C	C
Liriomyza congesta (Becker)	C	C		
Liriomyza pisivora (Hering)	B	B		
Liriomyza strigata (Meigen)	B	B		
Liriomyza xanthocera (Czerny)		C		C
Ophiomyia orbiculata (Hendel)	C	C		C
Phytomyza albiceps (Meigen)	B	B		

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat

Two species of Anthomyiidae dominate: *Delia platura* and less numerous *Delia florilega* (Ruszkowski et al. 1935; Szwejda 1985, 2002; Wnuk 1994). The larvae of the first generation (out of three occurring in a year) damage the germinating seeds and subcotyledons, mainly beans, in which they drill galleries. Peas grown on soils with undecomposed organic fertilizer may be massively damaged by *Delia platura* larvae during emergence (Szwejda 2002). In the case of broad beans and lentils, both species occur sporadically. Anthomyiidae are among the most dangerous pests of beans and peas in other countries, e.g., France (Balachowsky & Mesnil 1936), Germany (Hennig 1953; Tischler 1965), the Czech Republic (Dušek 1969), Belarus, Ukraine, and Russia (Głuszczenko 1980), as well as in the USA (Kim & Eckenrode 1987).

Contarinia pisi (Cecidomyiidae) causes the greatest damage to peas during flowering (Ruszkowski et al. 1935; Ogijewicz 1938; Wnuk 1994; Szadziewski 1999). The larvae of this species damage flower buds, flowers, and top parts of plants. Controlled plants are deformed and do not form pods. This species is also sporadically found on broad beans (Narkiewicz-Jodko 1985).

Species from the Agromyzidae family are common on field beans and peas. Their larvae burrow into the leaves and pods. In all areas of broad bean and pea cultivation, *Liriomyza pisivora*, *Liriomyza strigata*, and *Phytomyza albiceps* are most common (Studziński et al. 1981; Wnuk 1994; Szwejda 1998a; Beiger 2001; Nawrot 2008). The mentioned species of Cecidomyiidae and Agromyzidae are common in neighboring countries (Głuszczenko 1980; Crüger 1991).

Diptera pests of asteraceous vegetables (Asteraceae)

Host plants:

– lettuce (*Lactuca sativa* L.);
– chicory (*Cichorium intybus* L.).

Diptera of the Agromyzidae and Anthomyiidae family are common on lettuce and chicory (Table 7).

Liriomyza strigata (Agromyzidae) was the most common on lettuce and chicory. Their larvae mine the leaves to the extent that they die (Beiger 2001). The greatest threat to lettuce plantations is *Botanophila gnava* (Anthomyiidae) (Studziński et al. 1981; Szwejda 1988). The larvae feed inside the seed heads and eat the seeds. In the 1970s, yield losses on unprotected plantations in central and southwestern Poland amounted to 50% of the harvest. In the Czech Republic, this decrease reached 90% (Szwejda 1985). In recent years, this species has occurred sporadically.

Diptera pests of amaranthaceous vegetables (Amaranthaceae)

Host plants:

– red beet (*Beta vulgaris* L. subsp. *vulgaris* L.);
– spinach (*Spinacia oleracea* L.).

For years, red beet and spinach have been dominated by species belonging to three families: Agromyzidae, Drosophilidae, and Anthomyiidae (Table 8).

The dominant Anthomyiidae are *Pegomya hyoscyami* and the locally occurring *Pegomya betae* (Hurej 1988; Górski et al. 2010). They damage the leaves by chewing the crumb between the upper and lower cuticles, forming whitish spots forming on the leaf blade. For many years, both species were considered one taxon (Ruszkowski 1925, 1933, 1960; Ruszkowski et al. 1935; Ogijewicz 1938; Hennig 1953; Pietrucha 1980). However, they were described in France as separate species (D'Aguilar & Missonnier 1957). Another species, *Pegomya conformis*, requires explanation. Ruszkowski (1937) identifies this species with *Pegomya hyoscyami*. However, the Polish Fauna list lists it as a separate species (Kaczorowska 2007).

Agromyzidae are common, the larvae of which drill galleries in the leaf blade. The most numerous are *Liriomyza bryoniae* and *Liriomyza strigata* (Studziński et al. 1981; Łabanowski 2000). The leaves of *Scaptomyza graminum* (Beiger 2001) are similar.

The described species also occur in countries bordering Poland (Pietrucha 1980; Benada et al. 1984; Crüger 1991).

Diptera pests of polygonaceous (buckwheat, knotweed) vegetables (Polygonaceae)

Host plants:

– rhubarb (*Rheum rhaponticum* (L.);
– sorrel (*Rumex acetosa* L.).

On rhubarb and sorrel, Anthomyiidae species *Pegomya bicolor* and *Pegomya solennis* occur in small populations (Beiger 2001). Their larvae drilled short corridors in the leaf blade (Crüger 1991). On sorrel, two species of Cecidomyiidae were found: *Contarinia rumicis*, whose larvae damage flower buds, and *Jaapiella rubicundula* larvae, damaging inflorescences (Szadziewski 1999) (Table 9).

Diptera pests of asparagus vegetables (Asparagaceae)

Host plant: asparagus (*Asparagus officinalis* L.)

Diptera belonging to four families were found on asparagus: Cecidomyiidae, Tephritidae, Agromyzidae, and Anthomyiidae (Table 10).

Table 7. Diptera species occurring on asteraceous vegetables (Asteraceae)

Species	Frequency of occurrence	
	lettuce	chicory
Agromyzidae		
Phytomyza horticola (Goureau)	C	C
Liriomyza bryoniae (Kaltenb.)	B	C
Liriomyza strigata (Meigen)	A	B
Anthomyiidae		
Botanophila gnava (Meigen)	A	

A – species occuring in each growing season; B – species posing periodic threat; C – species posing a local threat

Table 8. Diptera species occurring on amaranthaceous vegetables (Amaranthaceae)

Species	Frequency of occurrence	
	red beet	spinach
Agromyzidae		
Amauromyza flavifrons (Meigen)	C	
Liriomyza bryoniae (Kaltenb.)	B	
Liriomyza strigata (Meigen)	B	
Drosophilidae		
Scaptomyza graminum (Fallén)	C	
Anthomyiidae		
Pegomya betae (Curtis)	C	C
Pegomya conformis (Fallén)	C	
Pegomya hyoscyami (Panz.)	A	C

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat

Table 9. Diptera species occurring on polygonaceous vegetables (Polygonaceae)

Species	Frequency of occurrence	
	rhubarb	sorrel
Cecidomyiidae		
Contarinia rumicis (Loew)		C
Jaapiella rubicundula (Rübsaamen)		C
Anthomyiidae		
Pegomya bicolor (Wiedemann)	C	C
Pegomya solennis (Meigen)	C	C

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat

Table 10. Diptera species occurring on asparagus vegetables (Asparagaceae)

Species	Frequency of occurrence
Cecidomyiidae	
Contarinia florum (Rübsaamen)	C
Tephritidae	
Plioreocepta poeciloptera (Schrank)	A
Agromyzidae	
Ophiomyia simplex (Loew)	C
Ptochomyza asparagi (Hering)	C
Anthomyiidae	
Delia platura (Meigen)	B

A – species posing a threat during each season in all areas of cultivation; B – species posing periodic threat; C – species posing a local threat

Plioreocepta poeciloptera (Tephritidae), which causes the greatest damage to asparagus plantations in Poland, is systematically present in all areas of cultivation (Ruszkowski 1933, 1937; Ruszkowski et al. 1935; Narkiewicz-Jodko 1985; Szwejda 2002, 2011). Its larvae dig galleries along the entire length of the protrusions coming from the ground. The damaged shoot is deformed, twisting in the shape of a pastoral. This species, at the level of threat, also occurs on asparagus in other countries, e.g., the Netherlands (Nijveldt 1957), France (Schvester 1963), Hungary (Bodor 1965), and Germany (Hassan 1970; Crüger 1991).

In the 1990s, national plantations were threatened by *Delia platura* (Anthomyiidae), which was destroyed by emerging asparagus bracts (Szwejda 1999). The larvae feeding resulted in strongly distorted and twisted shoots. *Delia platura* females lay their eggs in soil rich in organic matter. Only the larvae of the first generation (out of three occurring during the year) are pests. In the areas of asparagus cultivation with decomposed organic manure, this problem did not occur (Szwejda 2011).

Two species of Agromyzidae occur locally but in small numbers: *Ophiomyia simplex*, whose larvae dig shallow galleries under the skin in the lower part of the shoot, and *Ptochomyza asparagi* larvae mining coniferous asparagus leaves (Beiger 2001; Szwejda 2002). The generative parts damage the larvae of *Contarinia florum* (Cecidomyiidae). Their feeding causes deformation of flower buds (Szadziewski 1999).

This species is a known pest of asparagus, e.g., on plantations in Hungary (Bodor 1965), France (Roussie 1972), Czech (Bartoš 1968), and Germany (Hassan 1970).

Diptera pests of corn (*Zea* L.) (Poaceae)

Host plant: sweet corn (*Zea mays* var. *saccharata* Kcke.)

Diptera have been among the leading pests of corn for years. The greatest threat are species from the families Chloropidae, Agromyzidae, and Anthomyiidae (Table 11).

For years, *Oscinella frit* (Chloropidae) has been causing the greatest damage in all areas of sweet and fodder corn cultivation (Kania 1962; Gołębiewska 1997; Mrówczyński et al. 2007; Bereś & Pruszyński 2008). This species was known as a pest in the nineteenth century (Sznabl 1881). In the 1920s and 1930s, *Oscinella frit* was a leading pest of cereals, often causing damage to over 50% of crops (Ruszkowski 1933; Prüffer 1937; Ogijewicz 1938). At that time, the cereal crop only locally occurred on corn crops. Only since the beginning of the 1950s have such significant yield losses been recorded that they threatened the profitability of corn cultivation (Kania 1962). The course of the weather, characterized by low air temperature and frequent precipitation in the spring, significantly impacts its numbers (Bereś et al. 2007; Mrówczyński et al. 2007). *Oscinella frit* occurs in three generations per year. The biggest threat is the first generation. The larvae of this generation take over the plants when the leaves are rolled up in a tubular manner, biting holes in them. Damaged plants form side shoots, on which deformed panicles and cobs are formed (Kania 1962). A related species, *Oscinella pusilla,* damages plants similarly but occurs sporadically (Gołębiowska 1997).

Elachiptera cornuta (Chloropidae) is also common; the larvae feed on the rotting parts of the corn, mainly in the vaginal leaves of the cobs, carrying pathogenic microorganisms. Its larvae are often found in places damaged by *Oscinella frit* (Kania 1962). *Elachiptera cornuta* is a saprophagous species found in rotting plant parts of many crops, e.g., in cruciferous and bulbous vegetables (Szwejda 1988, 2003).

The importance of Agromyzidae as corn pests is increasing (Bereś & Pruszyński 2008). *Cerodontha incisa* larvae mine leaves (Kania 1962; Beiger 2001). Most damaged plants are found along the edges of the plantation, in the vicinity of balks and mid-field afforestation (Kania 1962). Another leaf-mining species is less numerous, *Pseudonapomyza atra* (Beiger 2001).

Corn is also a host plant for species from the Anthomyiidae family (Ruszkowski 1933; Ruszkowski et al. 1935). In recent years, an increasing threat from *Delia platura* larvae has been found (Boroń & Mrówczyński 2005; Mrówczyński et al. 2007; Bereś & Pruszyński 2008). Of the three generations occurring during the year, the first generation is essential because it damages germinating seeds and the emergence of corn (Bereś 2011).

The described dates from the Chloropidae, Agromyzidae, and Anthomyiidae families are common in developing countries, including Poland (Tischler 1965; Szapiro 1980; Crüger 1991).

Underground root pests occurring on vegetable crops

Host plants: all vegetables

The root zone of agricultural plants, including vegetables, is inhabited mainly by flies from the Bibionidae and Tipulidae families (Czwalina 1893; Ruszkowski 1933, 1937; Opyrchałowa 1976; Mikołajczyk 1981; Mrówczyński et al. 2007; Nawrot 2008; Sądej et al. 2008). In Poland, 19 species from the Bibionidae family (Mikołajczyk 1981, 2007) and 87 from the Tipulidae family have been found (Skibińska & Chudzicka 2007). Diptera occurring on underground parts of vegetable plants are presented in Table 12.

Bibionidae

Bibionidae prefer drier environments, being more numerous on lighter soils rich in organic matter (Tischler 1965). *Bibio hortulanus* and *Bibio marci* occur in one generation, and *Dilophus febrilis* in two generations per year (Opyrchałowa 1976; Mikołajczyk 1981, 2007; Narkiewicz-Jodko 1985). Females often lay their eggs in compost soil or freshly fertilized with manure, regardless of the crop species. Larvae of early developmental stages feed on organic remains in the ground, and older larvae pass on plant food. They damage the germinating seeds, root neck, and roots. They feed until late autumn. The threshold of danger requiring interventional protective measures is the presence of 10 larvae per 1 m^2 of the area (Bereś & Pruszyński 2008). They cause the most tremendous damage to cruciferous vegetables, lettuce, onions, cucumbers, corn, and vegetables grown under cover (Ruszkowski 1933, 1937; Narkiewicz-Jodko 1985; Boczek 1988; Bereś & Pruszyński 2008).

Tipulidae

Two species cause the most significant damage to vegetable crops: *Tipula oleracea* and *Tipula paludosa* (Ruszkowski 1933, 1937; Ogijewicz 1938; Tischler 1965; Opyrchałowa 1976; Narkiewicz-Jodko 1985). They occur in two generations per year. Older larvae overwinter in the soil. Most often, they occur on crops located on wet and peaty soils. In the spring, they damage germinating seeds and young plants. Later, the larvae nibble at the roots or shoots at the base, causing the plants to wilt and die. The threshold of danger for vegetable crops is the presence of 10 larvae per 1 m^2 of surface. Accumulating several dozen larvae in one place destroys the plants during the growing season, visible as empty spots in the field. Significant damage was recorded in the 1920s and 1930s, when they massively inhabited, e.g., plantations of cucumber, cauliflower, and cabbage, as well as lettuce, peas, beans, and onions (Ruszkowski 1933, 1937; Ruszkowski et al. 1935). The oldest information about the harmfulness of Tipulidae in Poland refers to *Tipula oleracea*. Its larvae damaged cabbage roots (Belke 1861). The discussed species, Bibionidae and Tipulidae, are common in the countries neighboring Poland (Tischler 1965; Osmołowski 1980; Crüger 1991).

Table 11. Diptera pests occurring on corn (*Zea mays* L.)

Species	Frequency of occurrence
Chloropidae	
**Elachiptera cornuta* (Fallén)	A
Oscinella frit (L.)	A
Oscinella pusilla (Meigen)	C
Agromyzidae	
Cerodontha incisa (Meigen)	C
Pseudonapomyza atra (Meigen)	C
Anthomyiidae	
Delia platura (Meigen)	B

A – species occurring in each growing season; B – species posing periodic threat; C – species posing a local threat

*saprophagous species

Table 12. Underground root pests of Diptera occurring on vegetable crops

Species	Frequency of occurrence
Bibionidae	
Bibio marci (L.)	A
Bibio hortulanus (L.)	A
Dilophus febrilis (L.)	B
Tipulidae	
Tipula oleracea (L.)	A
Tipula paludosa (Meigen)	A

A – species occurring in each season; B – species posing periodic threat

Table 13. Diptera occurring on vegetable crops in Poland

Species[1]	Preferred host plants
Bibionidae	
Bibio hortulanus (Linnaeus, 1758)	all vegetable crops
Bibio marci (Linnaeus, 1758)	all vegetable crops
Dilophus febrilis (Linnaeus, 1758)	all vegetable crops
Tipulidae	
Tipula oleracea (Linnaeus, 1758)	various vegetable crops
Tipula paludosa (Meigen, 1830)	as above
Cecidomyiidae	
Contarinia florum (Rübsaamen, 1917)	asparagus
Contarinia nasturtii (Kieffer, 1888)	cruciferous vegetables
Contarinia pisi (Loew, 1850)	broad bean, peas
Contarinia rumicis (Loew, 1850)	sorrel
Dasineura armoraciae (Vimmer, 1936)	cruciferous vegetables
Dasineura napi (Loew, 1850) *Dasineura brassicae* (Winnertz, 1853)[1]	cruciferous vegetables
Gephyraulus raphanistri (Kieffer, 1886)	cruciferous vegetables
Jaapiella rubicundula (Rübsaamen, 1891)	sorrel
Kiefferia pericarpiicola (Bremi, 1847) *Kiefferia pimpinellae* (Loew, 1874)[1]	carrot, parsnip, parsley
Lasioptera carophila (Loew, 1874)	dill, carrot, parsnip, parsley
Syrphidae	
Eumerus strigatus (Fallén, 1817)	onion
***Merodon** (*Lampetia*)[1] *equestris* (Fabricius, 1794)	garlic, onion
Psilidae	
Chamaepsila (*Psila*)[1] *rosae* (Fabricius, 1794)	carrot, celery, parsnip, parsley
Tephritidae	
Euleia (Philophylla[1]*) heraclei* (Linnaeus, 1758)	celery, dill, parsnip, parsley
Plioreocepta poeciloptera (Schrank, 1776)	asparagus

Agromyzidae	
Agromyza lathyri (Hendel, 1923)	broad bean, peas
Agromyza nana (Meigen, 1830)	broad bean
Amauromyza flavifrons (Meigen, 1830)	red beet
Phytomyza horticola (Goureau, 1851)	cruciferous vegetables, eggplant, broad bean, carrot, celery, chicory, cucumber, dill, lentil, lettuce, muskmelon, peas, pepper, pumpkin, parsley, red beet, tomato
Cerodontha (Poemyza)[1] *incisa* (Meigen, 1830)	sweet corn
Ophiomyia[1] (*Hexomyza*) *simplex* (Loew, 1869)	asparagus
Liriomyza bryoniae (Kaltenbach, 1858)	cucumber, lettuce, muskmelon, pepper, pumpkin, parsley, red beet, spinach, tomato
Liriomyza cepae (Hering, 1927)	garlic, leek, onion
Liriomyza congesta (Becker, 1903)	broad bean, peas
Liriomyza huidobrensis (Blanchard, 1926)	eggplant, pepper, tomato
Liriomyza pisivora (Hering, 1954)	broad bean, peas
Liriomyza strigata (Meigen, 1830)	cruciferous vegetables, eggplant, broad bean, carrot, celery, chicory, cucumber, dill, lettuce, muskmelon, peas, pepper, pumpkin, parsley, red beet, tomato
Liriomyza trifolii (Burgess & Comstock, 1880)	eggplant, pepper, tomato
Liriomyza xanthocera (Czerny & Strobl, 1909)	broad bean, gentil
Phytomyza (*Napomyza*)[1] *gymnostoma* (Loew, 1858)	chive, garlic, leek, onion
Napomyza lateralis (Fallén, 1823)	dill, carrot
Ophiomyia orbiculata (Hendel, 1931)	broad bean, lentil, peas
Phytomyza albiceps (Meigen, 1830)	eggplant, broad bean, carrot, celery, cucumber, dill, onion, peas, pepper, pumpkin, parsley, parsnip, tomato
Phytomyza mylini (Hering, 1954)	dill, carrot, pepper
Phytomyza rufipes (Meigen, 1830)	cruciferous vegetables
Pseudonapomyza atra (Meigen, 1830)	sweet corn
Ptochomyza asparagi (Hering, 1942)	asparagus
Heleomyzidae (Heleomyzid flies)	
Suillia lurida (Meigen, 1830) *Suillia univittata* (von Roser, 1840)[1]	garlic, onion
***Tephrochlamys tarsalis* (Zetterstedt, 1847)	cruciferous vegetables
Drosophilidae (small fruit flies)	
***Drosophila busckii* (Coquillett, 1901)	cruciferous vegetables, garlic, onion, tomato
**Drosophila funebris* (Fabricius, 1787)	cruciferous vegetables, garlic, onion, tomato
**Drosophila limbata* (von Roser, 1840)	cruciferous vegetables
**Scaptomyza pallida* (Zetterstedt, 1847)	cruciferous vegetables
Scaptomyza (*Drosophila*)[1] *graminum* (Fallén, 1823)	red beet

Ephydridae	
Hydrellia griseola (Fallén, 1813)	leek, onion
Chloropidae	
[*]*Elachiptera cornuta* (Fallen, 1820)	garlic, sweet corn
Oscinella frit (Linnaeus, 1758)	sweet corn
Oscinella pusilla (Meigen, 1830)	sweet corn
Anthomyiidae	
[**]*Botanophila* (*Phorbia*)[1] *fugax* (Meigen, 1826)	cruciferous vegetables
Botanophila (*Phorbia*)[1] *gnava* (Meigen, 1826)	lettuce
Delia (*Hylemyia*)[1] *antiqua* (Meigen, 1826)	garlic, chive, leek, onion, shallot
Delia (*Hylemyia*)[1] *floralis* (Fallén, 1824)	cruciferous vegetables
Delia (*Hylemyia*)[1] *florilega* (Zetterstedt, 1845)	cruciferous vegetables, asparagus, bean, celery, lettuce, cucumber, peas, pepper, pumpkin, parsley
Delia (*Hylemyia*)[1] *platura* (Meigen, 1826)	cruciferous vegetables, asparagus, bean, celery, cucumber, lettuce, peas, pepper, pumpkin, parsley, sweet corn
Delia radicum (Linnaeus, 1758) *Hylemyia brassicae* (Bouché, 1833)[1]	cruciferous vegetables
Pegomya betae (Curtis, 1847)	red beet, spinach
Pegomya bicolor (Wiedemann, 1817)	sorrel
Pegomya conformis (Fallén, 1825)	red beet
Pegomya hyoscyami (Panzer, 1809)	red beet
Pegomya solennis (Meigen, 1826)	sorrel
Fanniidae	
[***]*Fannia canicularis* (Linnaeus, 1761)	cruciferous vegetables, garlic, leek, onion
[***]*Fannia scalaris* (Fabricius, 1794)	cruciferous vegetables, garlic, leek, onion
Muscidae	
[***]*Muscina levida* (Harris, 1780) *Musca assimilis* (Fallen, 1823)[1]	cruciferous vegetables, garlic, leek, onion
[***]*Muscina stabulans* (Fallén, 1817)	cruciferous vegetables, garlic, leek, onion
[****]*Phaonia trimaculata* (Bouché, 1834)	cruciferous vegetables, garlic, leek, onion

[1]Latin nomenclature (genus and species) published in previous studies
[*]saprophagous species; [**]phyto- and saprophagous species; [***]copro-, necro-, and saprophagous species; [****]entomophagous species

CONCLUSIONS

The composition of harmful Diptera occurring in vegetable agrocenoses in Poland is typical for the Central European dipterofauna, including many cosmopolitan species common on other continents. They inhabit not only agricultural areas but also nonagricultural ones.

Diptera, next to Hemiptera, belong to the most numerous phytophagous insects inhabiting vegetable crops. They occur on all vegetables grown in Poland (over 80 species and botanical varieties). Since the systematic registration of pests inhabiting crops in Poland in 1919, over 70 species have been listed as Diptera pests of vegetable plants.

The existing physiographic conditions in our country did not significantly affect the range of occurrence of individual species of the discussed insects. As numerous studies cited in the literature show, in the bionomics of the discussed insects, all occurring species are easily adaptable to the existing soil and climatic conditions prevailing in the place of their occurrence. The same species dominate plantations regardless of location, i.e., in the northern, central, or southern part of the country. Their seasonal population and numerical variability in agrocenoses depend mainly on the location of the plantation and its buffer zone, soil type, access to host plants, and weather conditions. The combined effect of local climatic factors (air and soil temperature, pressure, precipitation, and atmospheric sediments), insolation, cloudiness, air currents, humidity, and climatic factors (latitude, length of day, height above sea level, surface relief, type of substrate, vegetation cover) regulates the survival and spread of pests.

Species marked with the symbol "A" in Tables 1 to 12 are persistently present in numerous populations at a level threatening crops. Among the harmful dipterofauna presented in Table 13, species from three families are predominant. From Anthomyiidae (12 species), *Delia radicum*, on early and late cultivars of cruciferous vegetables, mainly broccoli, cauliflower, white cabbage, kohlrabi, and radishes; *Delia platura* occurs annually on bean and cucumber plantations; *Delia antiqua* on onion and garlic; and *Pegomya hyoscyami* on red beet. From Cecidomyiidae (10 species), two species, *Contarinia nasturtii* and *Dasineura napi*, are dominant on cruciferous vegetables. Agromyzidae (23 species) is the most numerous group of Diptera, with the dominant species being *Liriomyza bryoniae* on tomatoes and cucumbers and *Phytomyza gymnostoma* on leeks.

Short-term, gradational occurrence of some dominant species was found, including *Botanophila gnava* (lettuce), *Chamaepsila rosae* (carrot, parsley), *Delia radicum* (broccoli, white cabbage), *Delia platura* (bean, asparagus), *Phytomyza gymnostoma* (leek), *Oscinella frit* (corn), and *Suillia lurida* (garlic). However, they did not affect the level of plant production in the following years of cultivation. They resulted from differences in the life cycles of individual species, which was significantly influenced by the progressing urbanization of agricultural areas, changes in the structure and technology of cultivation, and soil and climate changes. They have been the main drivers for the movement of several species in search of other areas and crops that would ensure their survival.

Apart from phytophagous species, taxa with a different trophic structure are common. These are copro-, necro-, sapro-, and zoophagous species. The most numerous were flies from the Drosophilidae family (*Drosophila busckii*, *Drosophila limbata*, *Scaptomyza pallida*), Fanniidae (*Fannia canicularis*, *Fannia scalaris*), Heleomyzidae (*Tephrochlamys tarsalis*), and Muscidae (*Muscina levida*, *Muscina stabulans*, *Phaonia trimaculata*).

In agrocenoses, natural enemies of insects play an essential role. Among entomophages, species belonging to the orders of Coleoptera (Carabidae and Staphylinidae), Syrphidae, Tachinidae, and Muscidae, mainly *Phaonia trimaculata* larvae, play the most significant role in reducing the number of flies. In addition, the number of phytophages is limited by other organisms, e.g., Diplopoda, Nematoda, Arachnida, and pathogens of viral, bacterial, and fungal origin.

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