JOURNAL OF PLANT PROTECTION RESEARCH
Vol. 46, No. 2 (2006)

THE OCCURRENCE OF SOME LEPIDOPTERA PESTS ON DIFFERENT CABBAGE VEGETABLES

Beata Jankowska

Agricultural University, Department of Plant Protection
Al. 29 Listopada 54, 31-425 Kraków, Poland
e-mail: jankowskab@bratek.ogr.ar.krakow.pl

Accepted: June 23, 2006

Abstract: In 1993–1997 the occurrence of Lepidoptera pests: *Pieris rapae* L., *Pieris brassicae* L., *Mamestra brassicae* L., and *Plusia gamma* L. were observed on the nine different late cabbage vegetables; Savoy cabbage cv. Vertus, white cabbage cv. Amager, red cabbage cv. Langendijker, brussel sprouts cv. Maczuga, cauliflower cv. Pionier, blue kohlrabi cv. Masłowa, white kohlrabi cv. Delikates, kale cv. Zielony Kędzierzawy and broccoli cv. Piast. The field observations showed that butterflies differentiated among host-species for oviposition. The butterfly females of all species preferred for oviposition the brussel sprouts and deposited a substantially larger number of eggs on leaves of them.
Plant species with green leaves were more preferred than the red leaf ones.

Key words: *Pieris rapae* L., *Pieris brassicae* L., *Mamestra brassicae* L., *Plusia gamma* L., cabbage vegetables

INTRODUCTION

Brassica crops are the major field vegetables grown in Poland. Several Lepidoptera pests attack cabbage vegetables and the most serious damage are caused mainly by the larvae of several species as: small white butterfly (*Pieris rapae* L.), large white butterfly (*Pieris brassicae* L.), cabbage moth (*Mamestra brassicae* L.), and diamondback moth (*Plutella xylostella* L.). All caterpillars of larges butterflies feed on foliage and produce large, irregular holes, while the older ones of *P. rapae* and *M. brassicae* penetrate into the heads of cabbage or cauliflower plants. The stimulant for feeding behaviour in the larvae correspond closely with the oviposition stimulant for the adult (Chew 1980). Several factors determine searching and choosing of host plant by insects: visual stimuli such as: colour and intensity of the reflected light, tactile stimuli experienced when a body of an insect touches the surface of a plant and finally chemical stimuli including both odors and tastes (Dąbrowski 1973, 1988; Renwick and Chew 1984). Crucifer-feeding specialists, such as the cabbage Lepidoptera pests, usually respond to glucosinolates (GS) and some of their breakdown products, e.g.,

isothiocyanates (ITC) (van Loon et al. 1992; Pivnick et al. 1994; Renwick and Lopez 1999). Despite the fact that cabbage vegetables are botanical varietes of one species (*Brassica oleracea* L. var. *sylvestris*), they show considerable morphological differences within the group (Peterman and Tschirner 1987). Therefore, although they are all attacked by the same pests, their attractiveness for these pests varies.

The aim of the study was to compare the infestation of the different cabbage vegetables by the Lepidoptera pests. The detailed information on the occurrence of diamondback moth are presented by Jankowska (2005). This paper presents the results of field studies on the occurrence of *Pieris rapae* L., *Pieris brassicae* L., *Mamestra brassicae* L and *Plusia gamma* L. on nine late cruciferous vegetables.

MATERIALS AND METHODS

Host-plant preference for oviposition of butterflies was observed under field conditions. Observations were carried out in the Plant Protection Experimental Station at Mydlniki near Krakow during the period 1993–1997, on typical brown soil with a pH of 6.5 and C_{org} content of 1.8%. The following nine late cruciferous vegetables: Savoy cabbage cv. Vertus white cabbage cv. Amager, red cabbage cv. Langendijker, brussel sprouts cv. Maczuga, cauliflower cv. Pionier, blue kohlrabi cv. Masłowa, white kohlrabi cv. Delikates, kale cv. Zielony Kędzierzawy and broccoli cv. Piast (except 1993), were grown on 30 m^2 plots in four replications. Each plot contained 90 plants (10 plants of each vegetable, 60 x 60 cm spacing), located in such a way that the plants of the same cultivar never adjoining. Other vegetables – broad bean, tomatoes, pepper, carrot, onion and red beet were cultivated near the experimental plots. No insecticidal treatment was applied. Every 3–4 days, 12 plants from each vegetable were inspected during the experiment and eggs and larvae of the butterflies were counted. The Duncan multiple test ($\alpha < 0.05$) was used for the statistical analysis of the results.

RESULTS AND DISCUSSION

All of observed Lepidopterous species have two generations and second generation is more dangerous to the cabbage vegetables. The most serious economic damage of commercial crops of brassicae are caused by caterpillars of the small white butterfly *Pieris rapae* L. In our experiment among the examined butterflies only *P. rapae* L. was observed in each season and occurred on all studied vegetables (Table 1, Figs. 1, 2). The greatest infestation was observed in 1994. Females of *P. rapae* lay single eggs on the underside of leaves, but in the conducted experiments eggs were observed on both the upper and lower surfaces of the leaves. Over all the years of the study a substantially larger number of eggs were noted on brussel sprouts. The lowest number of eggs was noticed on kale and red cabbage (Table 1). During the following period of observation of caterpillars, the greatest number was noticed on brussel sprouts, cauliflower and white cabbage (Table 1).

The second of this species *P. brassicae* L. was noted only on the brussel sprouts in all years of the study. During 1993 and 1994 years only a few batches were noted; in 1993 one on the brussel sprouts and one on the kale, and in the 1994 two on the brussel sprouts. The greatest infestation was observed in 1997. Adult females deposited ribbed, yellow eggs in groups of 8 to 130 on leaf undersides. The significantly larger

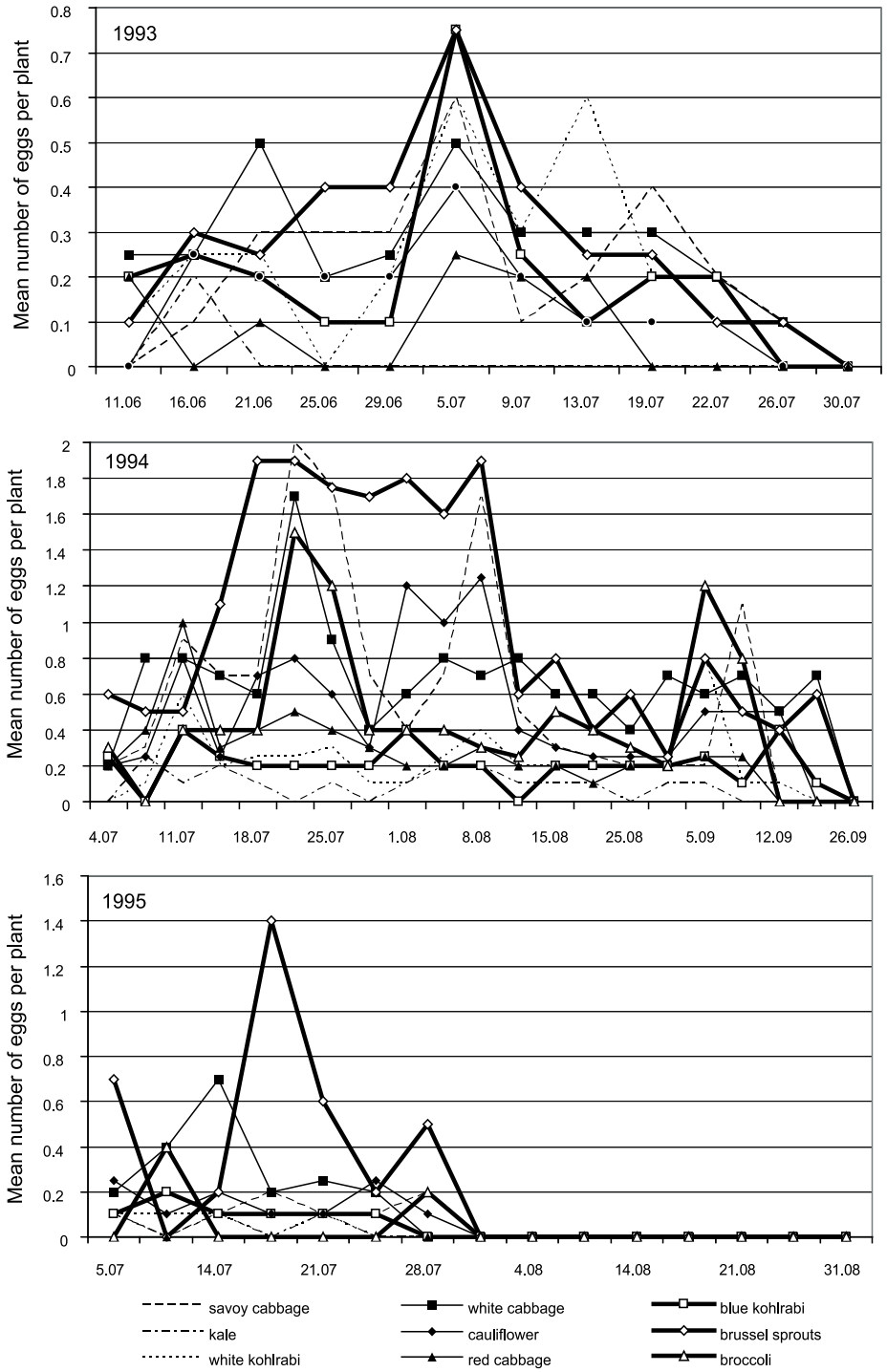

Fig. 1. Egg-laying dynamics of small white butterfly *Pieris rapae* L. on the studied cruciferous vegetables in years 1993–1995

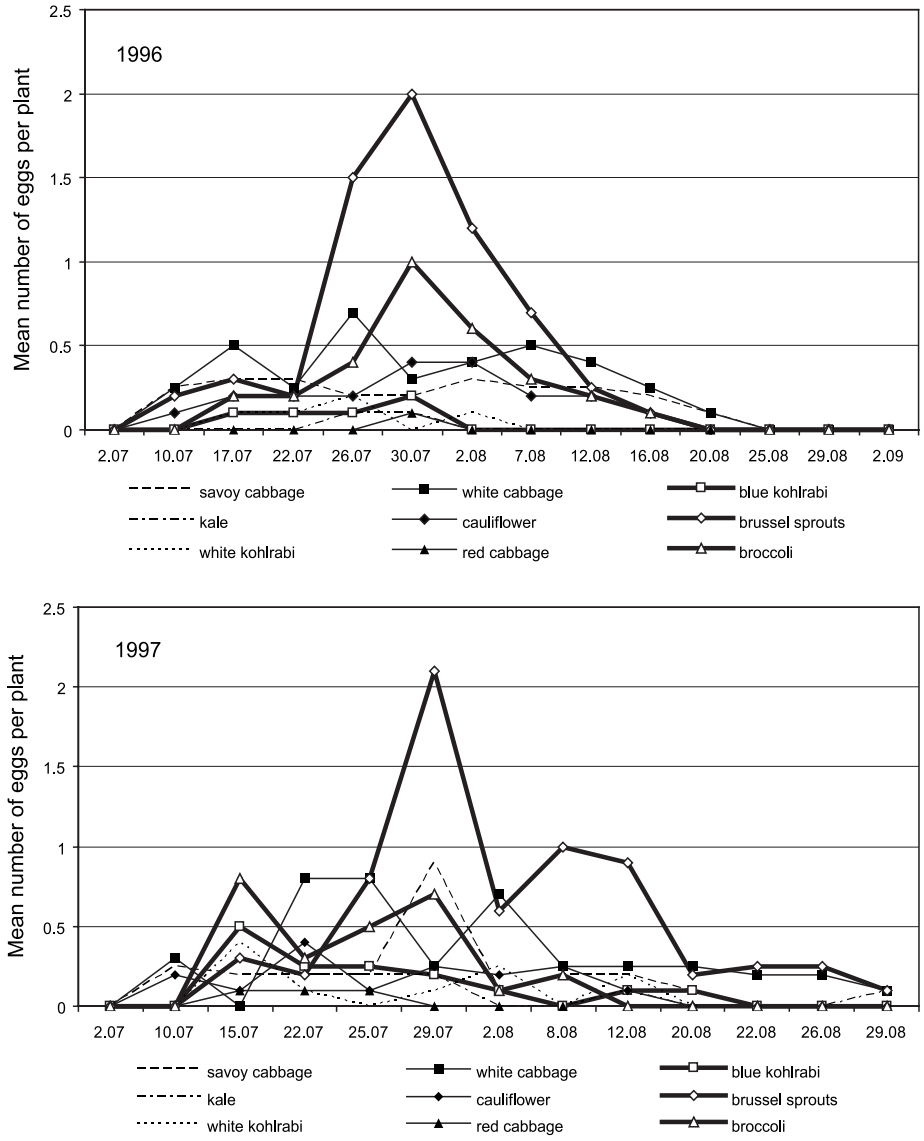

Fig. 2. Egg-laying dynamics of small white butterfly *Pieris rapae* L. on the studied cruciferous vegetables in years 1996–1997

number of eggs was observed also on the brussel sprouts, although the females of two *Pieris* species produced an oviposition – deterring pheromone (ODP) in their accessory glands, which is combined with the egg during oviposition (Schoonhoven et al. 1990 a, b). Also the biggest batches (max. 130), were observed on the brussel sprouts. The occurrence of eggs and larvae of *P. brassicae* is presented in Table 2.

Table 1. Occurrence of small white butterfly eggs and caterpillars on the studied cabbage vegetables (1993–1997)

Vegetable	1993		1994		1995		1996		1997	
	mean number/plant		mean number/plant		mean number/plant		mean number/plant		mean number/plant	
	eggs	larvae	eggs	larvae	eggs	larvae	eggs	larvae	eggs	larvae
Savoy cabbage	1.3 cd	0.35 ab	4.23 de	0.53 abc	0.3 a	0.1 ab	1.2 bc	0.1 a	1.1 be	0.95 b
White cabbage	1.6 d	0.75 b	4.53 e	0.67 c	0.9 b	0.15 abc	1.85 d	0.1 a	2.d	1.7 c
Blue kohlrabi	1.1 bc	0.1 a	1.27 ab	0.27 ab	0.3 a	0 a	0.2 a	0 a	0.75 abc	0.2 a
Kale	0.1 a	0.1 a	0.53 a	0.17 a	0.15 a	0 a	0.1 a	0 a	0.5 ab	1.1 bc
Cauli-flower	0.8 b	0.15 b	3.37 cd	0.77 c	0.5 ab	0 a	0.9 b	0.05 a	0.75 abc	0.25 a
Brussels sprout	1.65 d	0.25 ab	6.73 f	0.63 bc	1.75 c	0.25 c	3.2 e	0.25 b	3.3 e	1.55 bc
White kohlrabi	1.3 cd	0.1 a	1.43 b	0.17 a	0.2 a	0.2 bc	0.2 a	0 a	0.5 ab	0.25 a
Red cabbage	0.45 a	0.3 ab	1.83 b	0.47 abc	0 a	0.15 abc	0.05 a	0 a	0.15 a	0 a
Broccoli	x	x	3.13 c	0.17 a	0.3 a	0.05 ab	1.5 c	0.05 a	1.3 cd	0.25 a

Values followed by the same letter do not differ at 5% level of significance (Duncans multiple test)

Table 2. Occurrence of large white butterfly eggs and caterpillars on the studied cabbage vegetables (1995–1997) (No. of specimens per 12 plants)

Vegetable	Savoy cabbage	White cabbage	Blue kohlrabi	Kale	Cauli-flower	Brussel sprouts	White kohlrabi	Red cabbage	Broccoli
1995									
Egg clusters	2 a	6 b	0 a	0 a	1 a	4 b	1 a	0 a	1 a
Eggs	116	189	0	0	35	233	48	0	30
Mean number of eggs/cluster	58	31	0	0	35	58.3	48	0	30
Larvae	35	39	0	0	49	17	36	0	11
1996									
Egg clusters	0 a	7 b	0 a	0 a	1 a	9 c	1 a	0 a	0 a
Eggs	0	337	0	0	30	492	67	0	0
Mean number of eggs/cluster	0	48.1	0	0	30	54.7	67	0	0
Larvae	48	139	0	0	2	121	42	0	0
1997									
Egg clusters	1 a	6 a	0 a	1 a	0 a	40 b	7 a	0 a	1 a
Eggs	30	322	0	53	0	1832	238	0	21
Mean number of eggs/cluster	30	53.7	0	53	0	45.8	34	0	21
Larvae	0	18	18	4	0	517	71	0	0

Values followed by the same letter do not differ at 5% level of significance (Duncans multiple test)

Only in 1997 the occurrence of two other species of butterflies: cabbage moth (*Mamestra brassicae* L.) and Silver Y moth (*Plusia gamma* L.) was noticed. The occurrence of eggs and larvae *M. brassicae* is presented in Table 3, and the occurrence eggs and larvae of *P. gamma* is presented in Table 4. Both of them deposited a substantially larger number of eggs on leaves of brussel sprouts. The eggs of these butterflies were not found on cauliflower and broccoli.

Table 3. Occurrence of cabbage moth (*Mamestra brassicae* L.) eggs and caterpillars on the studied cabbage vegetables in 1997 (No. of specimens per 12 plants)

Vegetable	Savoy cabbage	White cabbage	Blue kohlrabi	Kale	Cauli-flower	Brussel sprouts	White kohlrabi	Red cabbage	Broccoli
Egg clusters	1 a	1 a	1 a	13 b	0 a	10 b	0 a	1 a	0 a
Eggs	8	12	15	511	0	260	0	26	0
Mean number of eggs/cluster	8	12	15	39	0	26	0	26	0
Larvae	1	2	1	3	3	2	1	0	0

Values followed by the same letter do not differ at 5% level of significance (Duncans multiple test)

Table 4. Occurrence of silver Y moth (*Plusia gamma* L.) eggs and caterpillars on the studied cabbage vegetables in 1997 (No. of specimens per 12 plants)

Vegetable	Savoy cabbage	White cabbage	Blue kohlrabi	Kale	Cauli-flower	Brussel sprouts	White kohlrabi	Red cabbage	Broccoli
Egg clusters	1 a	1 a	2 a	3 a	0 a	13 c	3 a	7 b	0 a
Eggs	15	42	26	24	0	338	48	126	0
Mean number of eggs/cluster	15	42	13	8	0	26	16	18	0
Larvae	1	1	0	2	0	1	0	0	0

Values followed by the same letter do not differ at 5% level of significance (Duncans multiple test)

Phytophagous insects locate plants for oviposition mainly under the influence of odor and visual stimuli (Renwick and Chew 1994). Crucifer-feeding specialist, such as the cabbage pests *Plutella xylostella* (L.), *Pieris rapae* L., *P. brassicae* L., *Mamestra brassicae* L. usually respond to glucosinolates (GS) and some of their breakdown products, e.g., isothiocyanates (ITC) (van Loon et al. 1992; Pivnick et al. 1994; Renwick and Lopez 1999). According to van Loon et al. (1992) and Renwick et al. (1992) oviposition in crucifer specialist such as two pieris species on non-host plants or artificial leaves is stimulated by the presence of glucosinolates (GS). Also Schoonhoven (1972), Chew and Robbins (1984), Renwick and Radke (1985), noted that *Pieris* butterfly adult females use the glucosinolates or their hydrolysis products as positive signals for the recognition of suitable host plants during oviposition. Results of Carlson et al. (1987), Gow Chin Yen

and Que-King Wei (1993) and Ciska et al. (1994) study revealed that a brussel sprouts contains more of that substance than other vegetables, and this may explain why the females of all species of examined butterflies preferred these vegetables for laying eggs.

Over the years of the intensive occurrence of *P. brassicae*, the laying of eggs was not observed only on two of examined vegetables: red cabbage and blue kohlrabi. It suggest that plant species with green leaves are preferred to the red leaf ones. Various researches have drawn the conclusion that the colour of a plant becomes the primary factor in the location of a plant by invading females of cabbage butterflies (Radcliffe and Chapman 1966; Dunn and Kempton 1976; Dąbrowski 1973, 1988).

The most important factor decreasing the number of eggs of butterflies was *Trichogramma* sp. (*Hymenoptera: Trichogrammatidae*). These tiny wasps parasitize the eggs of many lepidoptera (Kot and Plewka 1968; Kadłubowski 1973; Kot 1973; Głowacki 1878). Female wasps lay the egg in a butterfly egg, the host egg turns black as the larval parasite matures within it. This parasitoid is used extensively around the world as a biological control agent for the control of lepidopterous pests.

According to Kot (1973) and Kot and Plewka (1982) the effectiveness of *Trichogramma* is greater when laying the eggs on single *P. rapae* than on complex deposits of *P. brassicae*. It is not consistent with the observations being described in this paper. The role of egg parasitoids on the reduction of Lepidoptera pests population over the years is presented in Table 5.

Table 5. Role of egg parasitoids on the reduction of Lepidoptera pests population in 1993–1997

	Pieris rapae L.			*Pieris brassicae* L.			*Mamestra brassicae* L.			*Plusia gamma* L.		
	eggs	parasitized	%	eggs	parasitized	%	eggs	parasitized	%	eggs	parasitized	%
1993	1200	192	16	58	58	100	76	76	100	0	0	0
1994	3574	679	19	185	130	70	18	18	100	0	0	0
1995	792	143	18	651	234	36	66	66	100	0	0	0
1996	1549	279	18	926	204	22	140	140	100	0	0	0
1997	1616	275	17	2496	649	26	832	707	85	619	619	100

During the observations, the parasitization of *P. rapae* oscillated from 16% to ranged 19%, while in case of *P. brassicae* ranged from 22% to 36%, reaching 50% at the end of the period of laying the eggs. According to Wiech's (1993) observations, the parasitization of *P. brassicae* was only about 1.5%.

In 1965–1967 *T. evanescens* was introduced from Poland into Missouri and southern California as the initial phase of a biological control program on the imported cabbageworm), according to Rice and Hahr (1994), parasitization of *P. rapae* eggs in Wisconsin reached 99%. The works of Kałmuk (1994) realized at Mydlniki showed that the parasitization of *P. rapae* reached the level of 8–18%. The greatest parasitization was observed in the case of *Mamestra brassicae* and *Plusia gamma* where the *Trichogramma* parasited all eggs in cluster. Injac and Krnjajić (1990) noted that *T. evanescens* parasited the eggs of *M. brassicae* in 16.7% (max. 80%), and from one egg two wasps emerged.

REFERENCES

Carlson D.G., Daxenbicher M.E., van Etten C.H. 1987. Glucosinolates in crucifer vegetables: Broccoli, Brussels Sprouts, Cauliflower, Collards, Cale, Mustard Greens, and Kohlrabi. J. Amer. Soc. Hort. Sci. 112: 173–178.

Chew F.S. 1980. Foodplant preferences of Pieris caterpillars (*Lepidoptera*). Oecologia 26: 347–353.

Chew F.S., Robbins R. 1984. Egg-laying in butterflies. p. 65–79. In "The Biology of Butterflies" (R.I. Vane-Wright, P.R Ackery, eds.). Symposia of the Royal Entomological Society of London, 11, Academic Press.

Ciska E., Piskuła M., Martyniak-Przybyszewska B., Waszczuk B., Kozłowska H. 1994. Glukosinolates in various cabbage cultivars grown in Poland. Pol. J. Food Nutr. Sci. 3/44: 219–226.

Dąbrowski Z.T. 1973. Cechy roślin decydujące o ich atrakcyjności lub repelentności dla roślinożernych roztoczy i owadów. I. Ogólna charakterystyka powiązań między roślinami a stawonogami. Wiad. Ekol. 19: 257–281.

Dąbrowski Z.T. 1988. Podstawy Odporności Roślin na Szkodniki. PWRiL, W-wa, 260 pp.

Dunn J.A., Kempton D.P.H. 1976. Varietal differences in the susceptibility of Brussels sprouts to lepidopterous pests. Ann. Appl. Biol. 82: 11–19.

Głowacki J. 1978. Pasożytnicze błonkówki. p. 211–266. In "Biologiczne Metody Walki ze Szkodnikami Roślin" (J. Boczek, J. Lipa, eds.). PWN, W-wa, 594 pp.

Gow-Chin Yen, Que-King Wei. 1993. Myrosinase Activity and Total Glucosinolate Content of Cruciferous Vegetables, and Some Properties of Cabbage Myrosinase in Taiwan. J. Sci. Agric. 61: 471–475.

Injac M., Krnjajić S. 1990. The role of natural enemies in reduction of the *Mamestra brassicae* L. population density in the region of Belgrade. Zaštita bilja 41, 1: 111–124.

Jankowska B. 2005. The comparison of the occurrence of the diamondback moth *Plutella xylostella* L. (*Lepidoptera, Plutellidae*) on the different cabbage vegetables. Veg. Crops Res. Bull. 62: 153–163.

Kadłubowski W. 1973. Metoda uwalniania kruszynka i ocena jego skuteczności działania. Zesz. Probl. Post. Nauk Rol. 144: 181–191.

Kałmuk J. 2004. Badania nad składem gatunkowym, biologią I efektywnością parazytoidów szkodliwych motyki na warzywach kapustnych ze szczególnym uwzględnieniem tantnisia krzyżowiaczka *Plutella xylostella* L. Ph. D. thesis, AR Kraków.

Kot J. 1973. Potencjalne możliwości kruszynka w ograniczaniu liczebności populacji szkodników. Zesz. Probl. Post. Nauk Rol. 144: 139–161.

Kot J., Plewka T. 1968. Spasożytowanie jaj bielinka kapustnika (*Pieris brassicae* L.) i bielinka rzepnika (*Pieris rapae* L.) przez kruszynka zmiennego (*Trichogramma evanescens* Westw.) w warunkach naturalnych. Pol. Pismo Ent. 32: 619–625.

Kot J., Plewka T. 1982. Biocenotyczna redukcja szkodników. Zesz Probl. Post. Nauk Rol. 251: 121–135.

Loon J.J.A. van, Blaakmeer A., Griepink F.C., van Beek T.A., Schoonhoven L.M., de Groot A. 1992. Leaf surface compounds from *Brassica oleracea* (*Cruciferae*) includes oviposition by *Pieris brassicae* (*Lepidoptera: Pieridae*). Chemoecology 3: 39–44.

Peterman J., Tschirner W. 1987. Interesująca Botanika. Wiedza Powszechna. W-wa, 230 pp.

Pivnick K.A., Jarvis B.J., Slater G.P. 1994. Identification of olfactory cues used in host-plant finding by diamondbackmoth, *Plutella xylostella* (*Lepidoptera: Plutellidae*). J. Chem. Ecol. 20: 1407–1427.

Radcliffe E.B., Chapman R.K.1966. Plant resistance to insect attack in commercial cabbage varieties. Econ. Ent. 59: 116–120.

Renwick J.A.A., Chew F.S. 1994. Oviposition behavior in Lepidoptera. Annu. Rev. Entomol. 39: 377–400.

Renwick J.A.A., Radke C.D. 1985. Constituents of host-and non-host plants deterring oviposition by the cabbage butterfly, *Pieris rapae.* Entomol. Exp. Appl. 39: 21–26.

Renwick J.A.A., Radke C.D., Sachdev-Cupta K., Städler E. 1992. Leaf surface chemicals stimulating oviposition by *Pieris rapae* on cabbage. Chemoecology 39: 33–38.

Renwick J.A.A., Lopez K. 1999. Experience-based food consumption by larvae of *Pieris rapae*: Addiction to glucosinolates? Entomol. Exp. Appl. 91: 51–58.

Rice S.E., Hahr D.M. 1994. Biological control of insect pests of cabbage and other cruciferous. Practical Approaches to Biological Control. University of Wisconsin: 17–23.

Schoonhoven L.M. 1972. Secondary plant substances and insects. Phytochemistry 5: 197–224.

Schoonhoven L.M., Beerling E.A.M., Braaksma R., van Vugt Y., 1990a. Does the imported Cabbageworm, *Pieris rapae* use an oviposition deterring pheromone? J. Chem. Ecol. 16 (5): 1649–1655.

Schoonhoven L.M., Beerling E.A.M., Klijnstra J.W., van Vugt Y., 1990b. Two related butterfly species avoid oviposition near each other's eggs. Experientia 46. Birkhauser Verlag.: 526–528.

Wiech K. 1993. Wpływ współrzędnej uprawy późnej kapusty z koniczyną białą i fasolą szparagową na występowanie szkodliwej i pożytecznej entomofauny. Zesz. Probl. AR Krak., Rozpr. Hab. 177, 74 pp.

POLISH SUMMARY

WYSTĘPOWANIE NIEKTÓRYCH SZKODLIWYCH MOTYLI NA RÓŻNYCH WARZYWACH KAPUSTNYCH

W latach 1993–1997 obserwowano występowanie szkodliwych motyli: bielinka rzepnika (*Piersi rapae* L.), bielinka kapustnika (*Pieris brassicae* L.), piętnówki kapustnicy (*Mamestra brassicae* L.), i błyszczki jarzynówki (*Plusia gamma* L.) na dziewięciu późnych warzywach kapustowatych: kapuście włoskiej odm. Vertus, kapuście białej odm. Amager, kapuście czerwonej odm. Langendijker, kapuście brukselskiej odm. Maczuga, kalafiorze odm. Pionier, kalarepie niebieskiej odm. Masłowa, kalarepie białej odm. Delikates, jarmużu odm. Zielony Kędzierzawy oraz brokule włoskim odm. Piast.

Samice wszystkich obserwowanych gatunków motyli najchętniej składały jaja na kapuście brukselskiej. Odmiany o liściach zielonych były częściej wybierany niż o czerwonym zabarwieniu.