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Monographical study for the identification and control of diptera pest species on Romanian wheat crops

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Abstract. During 1978-2006, the agro-ecological research on the main species of wheat diptera pests, on integrated control systems and strategy of their management were performed, as part of sustainable development technology of wheat crop. The studies approached the species characteristics, the attack diagnosis, the parallel evolution of populations and losses, insecticides effect, the biological efficiency and selective moment of treatments; the main objectives were: integrated diptera pest control and forecast of losses, protection and use of the natural reservoir of entomophagous in regional diptera populations limitation, in cereal agroecosystems. The research proved the crucial role of entomophagous as natural predators, and their efficiency in decreasing wheat pests abundance, in normal conditions.
Key Words: Opomyzidae, Anthomyiidae, Chloropidae, Cecidomyidae; Romanian distribution maps; morphology; life-cycle, beneficials entomophagous fauna; integrated control.

Rezumat. În perioada 1978-2006, au fost efectuate cercetări agro-ecologice privind principalele specii de diptere dăunătoare pe grâu, sistemele de control integrat şi strategia de administrare a acestora, ca parte a dezvoltării durabile a tehnologiilor de cultivare a grâului. Studiile au abordat caracteristicile speciilor de diptere dăunătoare, diagnosticarea atacurilor, evoluţia comparativă a populaţiilor şi a pierderilor produse, efectul insecticidelor, eficienţa biologică şi momentul propice pentru aplicarea tratamentului; principalele obiective au fost: controlul integrat al dipterelor dăunătoare şi prevederea pagubelor, protejarea şi utilizarea rezervorului natural de specii entomofage în reducerea populaţiilor zonale de diptere din agroecosistemele cerealiere. Cercetările au dovedit importanţa deosebită a entomofagilor ca prădători naturali şi eficienţa acestora în reducerea dăunării la grâu, în condiţii normale.
Cuvinte cheie: Opomyzidae, Anthomyiidae, Chloropidae, Cecidomyidae, hartă de distribuţie, morfologie, ciclu de viaţă, beneficiile faunei entomofage; control integrat.

Introduction. The Diptera group occupies an important place within the pests composition of wheat crops in Romania. Studies concerning the structure and the distribution of Diptera species attacking wheat crops in autumn and in spring, in Romania, proved a considerable increase of populations, especially in Transylvania, Moldavia and Oltenia, during 1978-1985 (Bărbulescu et al 1973; Malschi et al 1980; Mustea et al 1982; Malschi 1976, 1980, 1982, 1989; Malschi & Mustea 1992). During the last years, the increase of damages produced by Diptera larvae was noticed in the wheat crops intensely affected by climatic unfavourable conditions and by the exploitation system with incomplete or incorrect crop technologies (Malschi 1993, 1997, 2003, 2004, 2005, 2006, 2007).

In order to achieve an applicative research synthesis, the present work offers the basic knowledge for the identification of species, by correlating the morphological, ecological, habital and geographical critera, for the forecast of losses and for an integrated control strategy.

The research regarding the control of the species complex of wheat diptera pests was carried out at Agricultural Research and Development Station Turda, in the special conditions of 1980-2006 period, when the attacks of main diptera wheat pests have been increased. The study presents the main species of wheat diptera pests and the actual adequate strategy of their integrated control, referring to the species characterization, the attack diagnosis, the parallel evolution of populations and losses, insecticides efficiency, cultural measures and entomophagous natural predators involved in the limitation of pest populations.

Methodology. During 1978-1985, the study on the *structure of Diptera species* attacking wheat crops in autumn and in spring and on the *distribution of main species in Romania*, were made with the cooperation of County Plant Protection Centers, Central Laboratory of Phytosanitary Quarantine Bucarest and Research Institute for Cereals and Industrial Crops Fundulea, for sample gathering.

The data on the *biology, ecology and experimental control* of phytophagous flies were obtained by investigations in cereal agro-ecosystems of Central Transylvania, in the period 1980–2006, at the Agricultural Research and Development Station Turda. Insect pests and useful entomophagous were captured by means of complex traps / field plot, including: pitfall soil traps, white adhesive sticky traps and 100 double sweep net catches, in 3 samplings. According to the natural agroentomocenotic model, studies on prey compositions and feeding rate per day and per individual predator were made in feeding trials with wheat diptera pests, under laboratory conditions. The results were statistically processed using regression, correlation and variance analysis methods.

Description, Biology and Distribution of Species. The study gathered a considerable amount of data on arthropod fauna, biological and agro-ecological features, in order to construct an appropriate integrated control system of main diptera species damaging wheat crops. During the last years, increased pest density in some fields, and unexpected attacks were the result of certain zone specific factors: - a many years, permanent enlargement of biologic reserve of pests (Table 1); - graduate increasing of microclimate aridity; - decrease of grain crop surfaces; - exploitation farming systems with incomplete or incorrect crop technologies (Malschi et al 1980; Malschi & Mustea 1992, 1996, 1997; Malschi 1976, 1980, 1989, 1993, 1997, 1998, 2003, 2004, 2005, 2006).

Increased damages produced by diptera larvae were noticed in certain zone cereal crops, intensely affected by unfavorable climatic conditions and by inadequate crop technologies. So, the early emergence of crops in September resulted in dangerous manifestations of frit fly *(Oscinella frit L),* hessian fly *(Mayetiola destructor Say.)* and black fly *(Phorbia securis Tiensuu)* attacks*.* The attacks produced in spring by yellow small fly *(Opomyza florum F)* and wheat bulb fly *(Delia coarctata Fll.)* were increased when the emergence of wheat was achieved in October. The late emergence of crops in November, favoured the preferential attack of black flies *(Phorbia penicillifera Jermy* and *Ph. securis).* The most intense diptera attack was noticed in early spring (Table 2).

Table 1

Populations dynamics and attack potential of wheat flies at ARSD Turda (1989-2004)

Diptera species/period		*1989-1999*	*2000-2002*	*2003-2006*	*EDT /vegetative stage*
		20-25.04	10.03-20.04	10-15.04.	*Tillering*
Delia coarctata,	1	16% plants	26% plants	10% plants	5-10% plants
Opomyza florum,	2	6% tillers	11% tillers	7% tillers	
Phorbia penicillifera,		10-28.05	4-10.05	20-25.05.	*End of tillering*
Phorbia securis,	1	17% plants	28% plants	71% plants	10-15 % plants
Meromyza nigriventris	2	12% tillers	23% tillers	43% tillers	
Oscinella frit, etc.	3	65 tillers/m^2	186 tillers/m^2	275 tillers/m^2	

1=% attacked plants, 2=% dead hart tillers, 3=dead hart tillers-larvae/m^2, Economic density threshold=EDT

Table 2

Dynamics of diptera pest attack in cereal crops during 2000-2003 in Central Transylvania

Winter wheat	2000	2001	2002	Average
Dead hart tillers-larvae/m^2	97	145	317	186
% Dead hart tillers	13.7%	18%	12.6-62%	14.7- 31%
Spring wheat	2000	2001	2002	Average
Dead hart tillers-larvae/m^2	31	71	390	164
% Dead hart tillers	5%	9%	42%	19%

Species Structure and Abundance. The mentioned Diptera species are on their main geographical area and posess considerable high biological reserves and attack possibilities on winter wheat crops. The ecological factors and agrotechnical methods determined the distribution range, the composition of species and the economic impact of attacks, in different cereal areas of the country (Alexandri 1945; Bărbulescu et al 1973; Mustea et al 1982; Malschi 1980, 1993, 1997, 2001, 2006; Perju & Malschi 2001; Perju et al 2001).

Sweep net catches of adults, and larval examinations of tillers attacked (the dead-heart tillers) proved the presence of different species. Considering their structural dominance and the losses produced, the most important species belonged to the families: Opomyzidae, Anthomyiidae, Chloropidae and Cecidomyidae. Autumn infestations were caused mainly by *Oscinela frit, Phorbia securis, Delia platura*, *Mayetiola destructor*. The most important attacks in early spring were produced by *Opomyza florum, Delia coarctata, Phorbia penicillifera* and *Ph. securis* (Figure 1).

Figure 1. Wheat plants attacked by diptera larve in April, at the end of tillering, at 13-33 DC vegetation stage

The following figures provide illustrations and data about: the occurence and distribution maps of species (Figure 2); the evolution of attacks and losses produced on wheat plants (Figure 3); the external morphology of the main pest species (Figure 4). The distribution maps of the species uses the maps on the Universal Transverse Mercator System (from Lehrer, 1977); original (watercolours) paintings and completions on the synthesis of species morphology, from: F. Pétré, in Balakhovskii & Mesnil 1935; S. Panin, in Săvescu 1962; A. Z. Znamenskii, in Beliaev 1965; Ringdahl, in Bei Bienko 1970; Jermy 1953; V. Gh. Radu & F. Dan 1973.

Description and Distribution Maps of the Species. Fam. OPOMYZIDAE: *Opomyza florum* F. has 1 generation / year: adult (3.5 mm, brown dominant colour of the body), June-November; egg (0.6 mm), October -[ ] -April, in soil near the coleoptyle; larva (7 mm), April; pupa (5 mm), May, in the attacked tillers.

Fam. ANTHOMYIIDAE: *Delia coarctata* Fll. has 1 generation / year: adult (7 mm, grey dominant colour of the body), June-September; egg (1 mm), August - [ ] -March, in soil; larva (8 mm), March-April; pupa (7 mm), April-May, in soil.

Delia platura Mg. has 3-4 generations / year; adult (6 mm, grey dominant colour of the body), April-Octomber; egg (1 mm), in soil; larva (8 mm); pupa (6 mm), in the dead-heart tillers or in soil.

Phorbia securis Tiensuu has 2 generations / year: adult (5 mm, black dominant colour of the body), April-May, August-September; egg (1.14 mm), April-May, September, on coleoptyle; larva (7.5 mm), May, September; pupa (5.5 mm), May-[ ]-August, Octomber-[ ]-March, in soil.

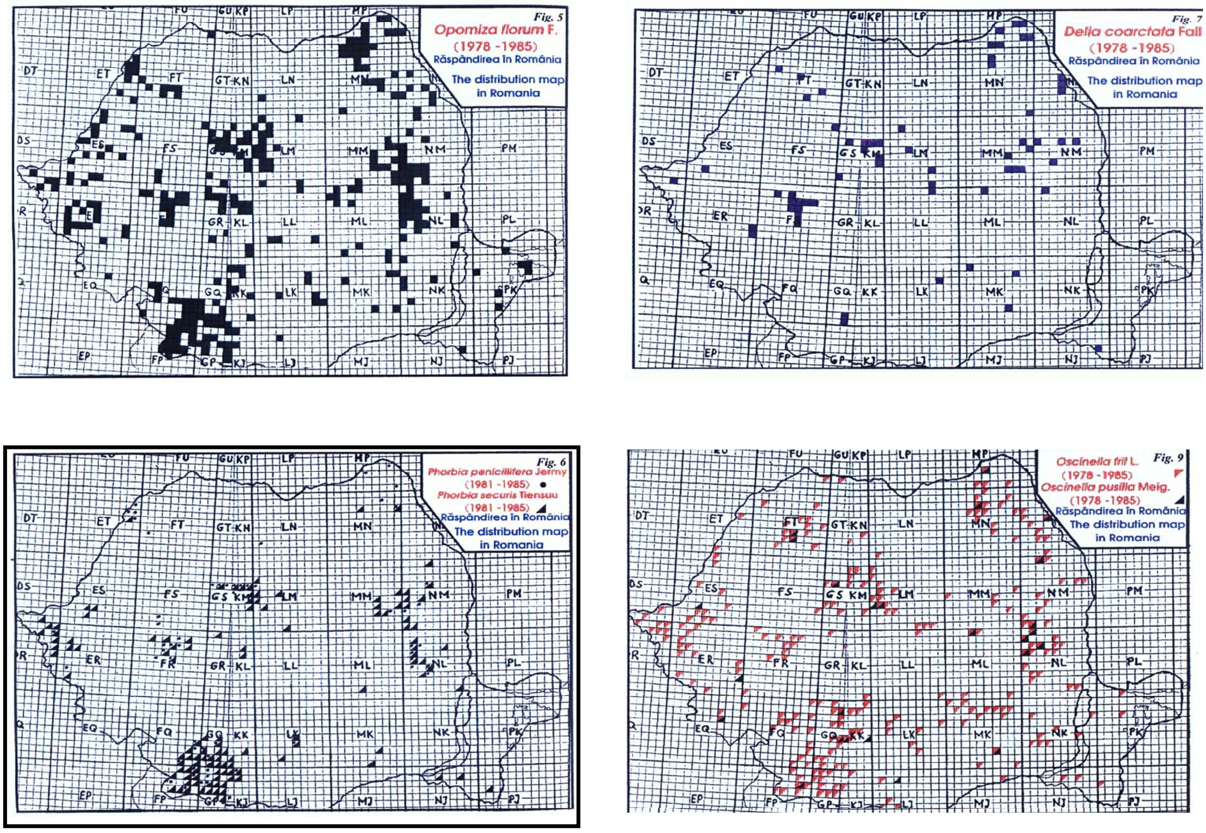

Figure 2. The occurence and distribution maps of wheat flies species (Malschi 1989, 1997)

Phorbia penicillifera Jermy has 1 generation / year: adult (4-5 mm, black dominant colour of the body), March-April; egg (1.14 mm), April, on coleoptyle; larva (6mm), April-May; pupa (5 mm), May-[ ]-March, in soil.

Fam. CHLOROPIDAE*:* *Oscinella frit* L. and *Oscinella pusilla* Mg. have 5-6 generations / year: adult (2.5 mm black-brown dominant colour of the body), April - October; egg (1 mm), under the sheath of first foliage leaf of young plants and tillers or on ear; larva (4.5 mm); pupa (3 mm), on plant at the attack place.

Chlorops pumilionis Bjerk. has 2 generations/year: adult (3.5 mm, yellow dominant colour of body), May-June, July-September; egg (1 mm), on the top of flagleaf; larva (6mm), June, September-[ ]-May, on the straw below the ear, at the stem base.

Elachiptera cornuta Fll. has 3-4 generations / year: adult (3 mm, black-brown dominant colour of body), April-May, September; larva (5 mm) at the stem base of young plants; pupa (4 mm), at the attack place.

Lasiosina cinctipes Fll. has 2 generations / year: adult (3 mm, yellow dominant colour of body), May-June, July-September; larva (5 mm), June on spikelets, September-[ ]-May, on young plants; pupa (5 mm), May, July, at the attack place.

Meromyza nigriventris Macq. has 2 generations / year: adult (4 mm, yellow dominant colour of body), May, July-September; egg (1 mm), June, September, on the last higher leaf; larva (6 mm), April, September in the ear flowers, at the ear or stem base; pupa (6 mm) May, July, at the attack place.

Fam. CECIDOMYIDAE: *Mayetiola destructor* Say. has 3-4 generations / year: adult (2.5-3.5 mm, brown dominant colourr of body), April, June, (August), September; egg (0.6 mm), above the main leaf; larva (4 mm), under the sheath of leaf and pupa (4mm), May, June,(August), September -[ ]-April, at the attack place or in soil.

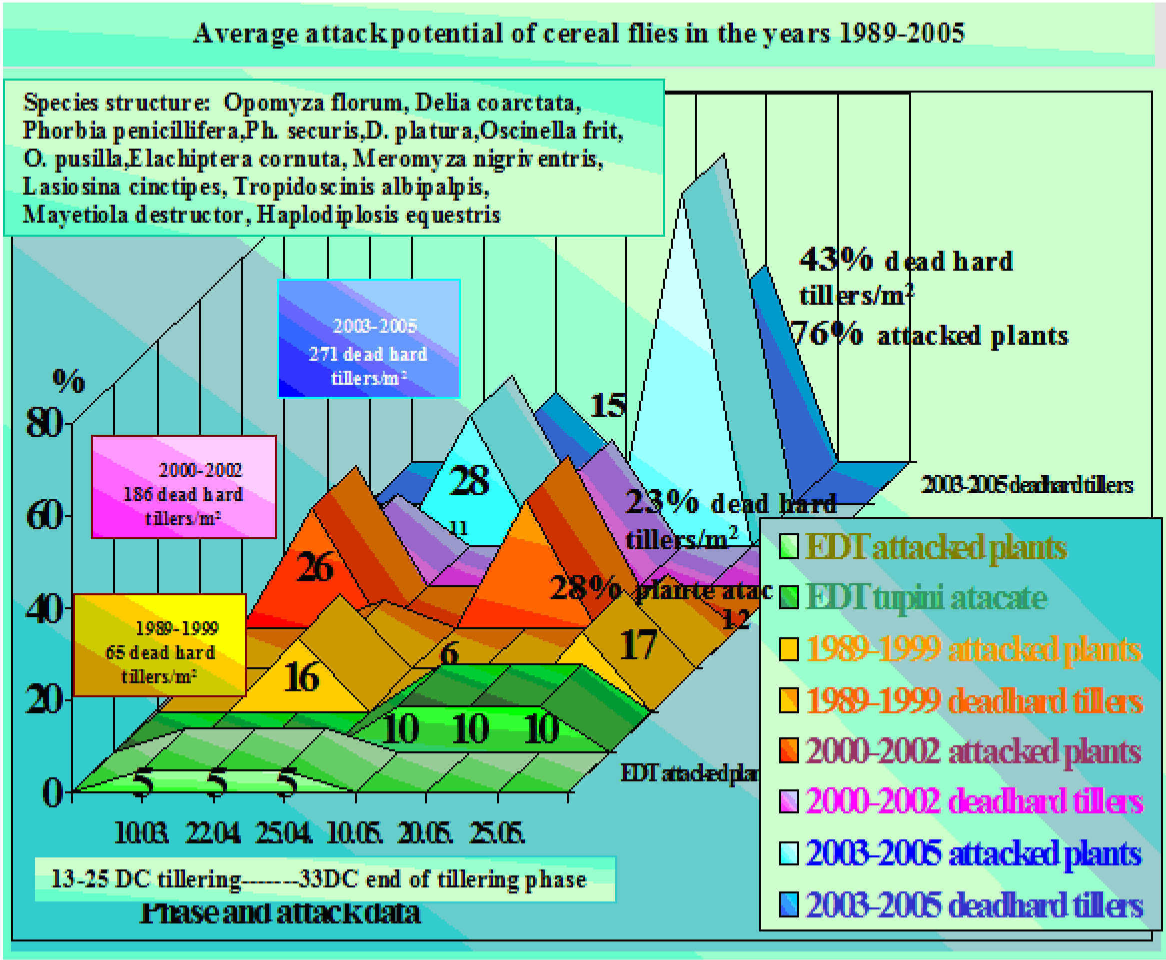

Figure 3. Evolution of attacks and losses produced by wheat flies (Turda 1989-2005) (Malschi 2005, 2006)

Contarinia tritici Kirby has 1 generations / year; adult (3 mm, yellow dominant colour of body), June; larva (2 mm), June, on the ear flowers and kernels, July-[ ]-May, overwintering diapause, in soil; pupa (1.5 mm), May, in soil.
Abbreviations: -[ ]- overwintering or summer diapause.

Experimental Integrated Control. Studies on the main species of wheat diptera pests, on their attack level and actual strategy of their integrated management, were performed, during 1980-2005, at ARDS Turda. On the cereal areas with important biological reserves of diptera pests, it is highly recommended to apply an integrated pest control system; this should be a synthesis of means to use the bio-technological favourable factors, for plant protection against diptera pests of wheat: - wheat varieties with good compensatory capacity after the attack; - preventive plant protection measures and special chemical treatments.

Prophylactic Measures. The results on the experimental control suggest preventive measures to forecast: a late sowing data (first half of October); zone-adapted, adequate agro-tehnological measures, providing a good development of plants and a productive compensatory tillering effect of attacked plants; cultivation of wheat varieties with high compensatory capacity after diptera attack; the seed treatment with insecticides.

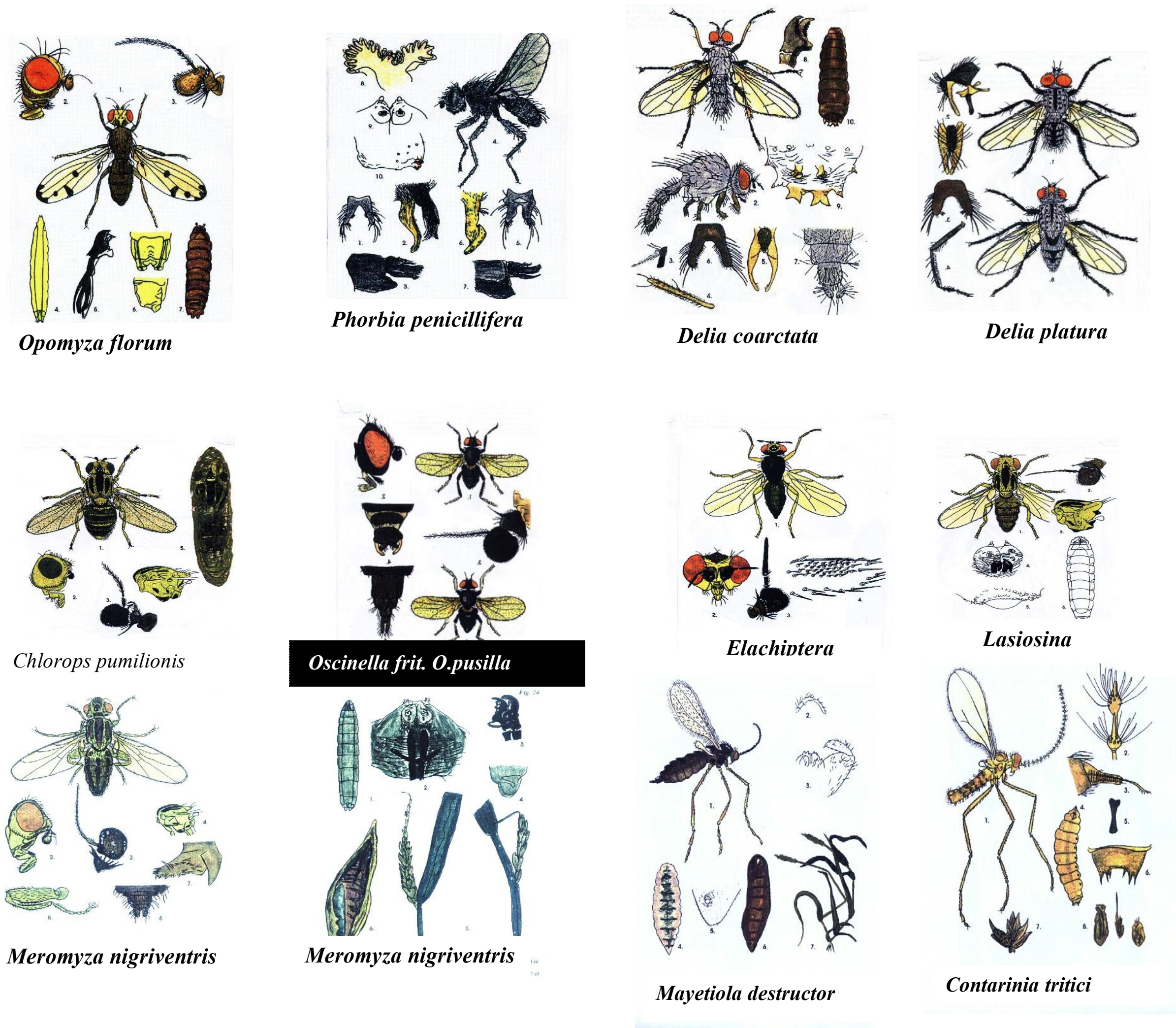

Figure 4. External morphology of wheat diptera species (Malschi 1976, 1997)

Experimental Chemical Control Measures. Insecticides Efficiency. Special chemical control has to be suitable to the biology and ecology of diptera species, and keep the losses within the adequated economic damage thresholds. Insecticides have to be biologically efficient; good knowledge is needed concerning the side-effects of insecticides on the active useful entomophagous fauna, especially predators (*Carabidae, Staphylinidae, Sylphidae, Coccinellidae, Nabidae, Aranea etc.*) involved in controling the diptera pests population levels. Protection and sustainable use of auxiliary activity of enthomophagous natural reservoir in cereal agroecosystems are also important.

The preventive seed and field treatments with insecticides are only partly efficient (50-75% larval mortality) due to life-cycle characteristics of different species and particular feeding behaviors of larvae within wheat tillers. The variety of insecticidal products used on the cereal field crops was subject of the research on the efficiency of insecticidas, in order to introduce a successful control of the main diptere species in Central Transylvania conditions. During 1980-2005, the biological efficiency and selective moment of application were tested for different insecticides: organophosphorus, organochlorous, carbamats, syntethic pyrethroids, neonicotinoids, fipronil, acetamiprid etc.

Preventive seed insecticide treatments also had a partial efficiency in controlling diptera pests (Table 3).

Table 3

Efficiency of insecticide seed treatments of winter wheat, on the control of diptera pest species spring attack: *Opomyza florum, Delia coarctata, Phorbia securis, Ph. penicillifera*.

Insecticide	***Product***	***Dose/t seed***	***Efficiency %***	***Grain yield %***
Check (normal values)		-	- (163 larve/m^2)	100 (3964 kg/ha)
Fipronil	COSMOS 250 FS	2.5 l	40	115
Imidacloprid	YUNTA 246 FS	2.0 l	44	111
Thiametoxam	CRUISER 350 ST	1.5 l	19	116
	CRUISER 350 ST	3.0 l	25	117
A 1540 ES	SIGNAL	2.0 l	41	98
	SIGNAL	2.5 l	50	108
Tefluthrin 300	TEFLUTHRIN 300	0.17 l	47	107
	TEFLUTHRIN 300	0.33 l	42	112
Tefluthrin 200	TONIC	0.5 l	42	109
	TONIC	1.0 l	35	108
Gama HCH	LINDAN 750 SC	1.2 l	59	93
	LINDAN HC	1.35 l	82	100
	DACSEED	3.0 kg	53	103
	MASTERLIN	2.0 kg	57	102
	PROTILIN AL 81 PTS	3.0 kg	46	106
	SUMIDAN 350 ST	1.8 l	47	99

Some experimental insecticide treatments applied in autumn had notable effect: dimethoate, trichlorphon or dimethoate with deltametrin resulted in yields increase of 15-32 %. In early spring, the effect of insecticides applied on the early and on the late emergent wheat crops significantly increased yields with 9-15 % when dimethoate, trichlorphon or carbaril, or dimethoate with deltametrin or with methylpirimiphos were uesd (Malschi & Mustea 1996).

The insecticide treatment is recomended to be applied in spring, at the moment of the maximum biological efficiency. That is at the I-th larval instar of *Opomyza florum* and *Delia coarctata* and simultaneously, at the adult flying of *Phorbia securis* and *Phorbia penicillifera*. At this special moment it is possible to obtain a partial larval mortality, of only 50-75% (Table 4). Particular agroecological zonal conditions, the different diptera species attacking on wheat crops, having different bio-ecological behaviours, make very difficult the choose of the optimal moment to apply spring treatments for the control of diptera pests.

The optimal moment for spring treatments was at the first larval instar of *O. florum* and *D. coarctata,* and the simultaneously adult flying of *Phorbia penicillifera* and *Ph. securis*. The biological effect of applied insecticides significantly increased wheat yields with 7-21 % when dimethoate, chlorpyriphos-etil, chlorpyriphos-metil, bensultap, fipronil, acetamiprid, lufenuron, thiacloprid, thiametoxam, or different complex insecticides, as fenitrotion with esfenvalerat, were used (Tables 5 and 6).

In the special conditions of years 2000-2005, characterized by arid microclimate, excessive dryness and warmth, the insecticide control was especially necessary, because the attack of main species of wheat diptera pests was increasing and superposing. As a part of cultural integrated system, usual insecticides treatments (neonicotinoids, fipronil, acetamiprid, novaluron, organophosphoric, pirethroids etc.) were tested, in crucial moments for adult and larvae control, in April, at the end of tillering phase, in 13-33 DC stage. The treatments were efficient in the control of all dangerous pests of the wheat fields at this moment. The high efficiency of the insecticides on main dangerous diptera species resulted in increasing yields, recommending the integrated pest management, with an adequate technology and modern insecticides control strategy.

Table 4

Insecticides efficiency on the experimental control of *Opomyza florum F., Delia coarctata Fll., Phorbis securis Tiensuu, Ph. penicilifera Jermy*. diptera species spring attack, in winter wheat fields

Diptera species			*Opomyza, Delia*	*Phorbia*	*Opomyza, Delia, Phrobia*
Period of treatments (April)			1983 - 85	1986 - 88	1990 - 97
Dead-heart tillers percent (attack average)			9.9	9.7	8.3 - 7.8
Insecticides	Product	Doses / ha	Insecticide	efficiency	(E %)
Lindane	LINDATOX 20 EC	2.0 l	39.4	-	-
Endosulfan	THIONEX 35 EC	2.0 l	-	-	49
Lindane + dimethoate	SINOLINTOX 10 G	20.0 kg	-	72.9	-
Dimethoate	SINORATOX 35 EC	2.0 l	53.5	72.5	52.0
Dimethoate	SINORATOX 35 EC	3.0 l	30.3*	70.4	-
Dimethoate	SINORATOX 5 G	40.0 kg	-	51.7	-
Dimethoate + Deltamethrin	SINORATOX 35 + DECIS 2,5	1.5 l +0.4 l	65.6 *	68.4	-
Dimethoate + Methylpirimiphos	SINORATOX 35 EC + ACTELIC 50 EC	1.5 l +0.5 l	-	84.0	-
Methylpirimiphos	ACTELIC 50	1.0 l	-	70.7	-
Trichlorphon	ONEFON 80	1.2 kg	41.4*	75.5	63.2
Malathion	CARBETOX 50	1.0 l	-	63.3	-
Quinalphos	ECALUX 25 CE	1.5 l	-	61.5	-
Phonophos	DYFONAT	3.0 kg	-	68.6	-
Fhonophos	DYFONAT 10 G	10.0 kg	-	70.7	-
Phoxim	FOXIM 0,1 %	0.3 l	-	66.3	-
Phoxim	VOLATON 5 G	15.0 kg	-	64.4	-
Diazinon	BASUDINE 10 G	15.0 kg	-	75.0	-
Diazinon	BASUDINE 600 EC	2.0 l	-	-	69
Diazinon	DIAZOL 48 EC	0.9 l	-	-	53
Chlorpiryphos	PYRINEX 50 EW	2.5 l	-	-	29
Fenoxycarb	INSEGAR 25 WP	0.3 kg	-	-	66
Pirimicarb	FERNOS 50 DP	0.6 kg	-	72.7	-
Carbaril	OLTITOX 50	1.0 kg	-	61.2	
Bensultap	VICTENON 50 WP	0.5 kg	-	68.8	51.6
Methamil	LANNATE 80 WS	0.3 kg	-	72.4	-
Oxamyl	VYDATE 24 L	0.6 l	-	74.0	-
Oxamyl	VYDATE 10 G	20.0 kg	-	66.4	-
Cypermathrin	POLYTRIN 200 SC	0.1 l	-	-	50.5
Alphamethrin	FASTAC 10 EC	0.2 l	-	67.6	56.8
Beta-Cyfluthrin	BULLDOCK 25 EC	0.3 l	-	-	31
Thurintox	THURINTOX	0.06 l	-	67.3	-
Acetamipirid	MOSPILAN 20 SP	0.06 kg	-	-	51
Fipronil	REGENT 80 WG	0.025 kg	-	-	45
*) - Special autumn treatments.	DL p 0.1 % (arcsin $\sqrt{\%}$)		3.81	4.79	5.65

Table 5

Efficiency of insecticides for winter wheat *Opomyza florum, Delia coarctata*, *Phorbia penicillifera, Phorbia secures, Oscinella frit* diptera-larvae-pest control, applied between April 10-20, during 2000-2002

Insecticide	*Product and dose/ha*	*Efficiency* %	*Grain yield* Kg/ha	%	Difference
Control (186 larvae/m^2)		-	4343	100.0	-
Fipronil	REGENT 200 SC 90 ml	45	4778	110.0	434***
Clorpirifos metil	RELDAN 40 EC 1250 ml	44	5039	116.0	695***
Bensultap	VICTENON 50 WP 400 g	43	4635	106.7	291*
Acetamiprid	MOSPILAN 20 SP 100 g	56	4778	110.0	434***
Fenitrotion-fenvalerat	ALPHA-COMBI26/25 500 ml	47	4865	112.0	521***
Thiacloprid	CALYPSO 480 EC 100 ml	29	4735	109.0	391**
Thiametoxam	ACTARA 25 WG 60 g	45	4661	107.3	317**
Lufenuron	MATCH 050 EC 300 ml	58	4844	111.5	500***
Clorpirifos-etil	PYRINEX 25EC 3500 ml	50	4952	114.0	608***
Dimetoat	DIMEZIL 40 EC 2000 ml	47	5256	121.0	912***
Average		46	4842	111.5	499
		DL p 5%-225 kg; DLp 1%-303 kg; DLp 0.1%-404 kg			

Table 6

Effect of the treatment applied at the end of weat tillering, in 2003, on diptera and other pests

Product and dose/ha	*Grain yield* Kg/ha	%	Difference
Application data : 12 May			
Control	1949	100	-
DECIS 25 WG 30 g	2380	122	431*
ALPHA-COMBI 26,25 500 ml	2218	114	269
MOSPILAN 20 SP 100 g	2306	118	357
CALYPSO 480 SC 100 ml	2201	113	252
ACTARA 25 WG 60 g	2110	108	161
REGENT 200 SC 90 ml	2210	113	261
VICTENON 50WP 500 g	2173	112	224
PYRINEX 26 ME 3000 ml	2039	105	90
		DLp5%=405; DLp1%=555; DLp0.1%=755.	

Side Effect of Insecticides on Entomophagous Arthropods. In order to protect and use the activity of beneficial predators: *Chrysopidae, Nabidae, Coccinellidae, Carabidae, Staphylinidae, Cantharidae, Malachiidae, Aranea* etc an ecological study was performed on the side-effects of insecticides on the main predator species wich populate wheat field crops (Hassan et al 1985; Wetzel 1995; Malschi & Mustea 1996, 1997).

The results of field and semi-field tests (Malschi 1998, 2003) showed the initial slightly harmful toxicity of some insecticides on the useful entomophagous predators, in early spring application and when synthethic pyrethroids were used (Table 7).

Table 7

Side-effects of insecticides on beneficial arthropods. Results of the field and semi-field initial toxicity tests on the treatments for the wheat pests control in Transylvania.

Beneficial predator species			1		2		3	4		5			6	7	8	9
Date of treatments:			02 05	02 05	31 05	20 06	31 05	02 05	20 06	02 05	20 06	20 06*	20 06*	20 06	20 06	20 06
Insecticid	Preducts and dose/ha		Initial toxicity on beneficials													
Endosulfan	Thionex 35 EC	2.0 l	4	-	-	4	4	-	4	-	3	3	4	4	-	4
Dimethoate	Sinoratox 35 EC	1.5 l	-	-	4	3	-	-	1	-	4	-	-	-	-	-
Dimethoate	Sinoratox 35 EC	3.5 l	-	-	4	3	4	-	4	-	4	4	4	4	4	4
Diazinon	Basudine 600 EC	1.0 l	-	-	4	-	4	-	4	-	4	-	-	4	4	4
Diazinon	Diazol 48 EC	0.9 l				4	4		4		3	2	4	3		4
Chlorpiryfos	Pyrinex 50 EW	2.0 l				4	4		4		3	3	4	4		
Cypermethrin	Polytrin 200 SC	0.1 l	2	1	2	1	4	1	4	4	1	2	3	4		
Alphamethrin	Fastac 10 EC	0.1 l	1			1	4		4	2	3	2	4	3	4	4
Zetamethrin	Fury 10 EC	0.1 l			1	1	4		4		3		4	4	4	4
Deltamethrin	Decis 2.5 EC	0.3 l				2	4		4		4	2	2	3	4	1
Esfenvalerat	Sumi-alpha 5 EC	0.2 l			1		3		3		4		4	3	4	4
Bensultap	Victenon 50 WP	0.5kg			1		4		4		4			4	4	4
Acetamiprid	Mospilan 20 SP	0.1kg			1		4		4			2	4			4
Fipronil	Regent 80 WG	25 g			2		3		3		4		4	4		

*1. Harpalus distinguendus, 2. Poecilus cupreus, 3. Pseudophonus pubescens, 4. Aranea, 5. Coccinella 7-punctata, 6. Chrysopa carnea, 7. Nabis, 8. Tachyporus hypnorum, 9. Malachius bipustulatus. *Larvae.* Scale (percent mortality): 1=harmless (<25%); 2=slightly harmful (25-50%); 3=moderately harmful (51-75%); 4=harmful (>75 %), (Hassan et al 1985).

Compensatory Effect of Wheat Plants After Diptera Attack on Winter Wheat Varieties. The study showed the wheat high compensatory capacity after the diptera attack, consisting in 60-80% for Transylvania, Turda 95, Arieşan, Apullum varieties. The application of adequate zonal technological measures is important for a good development and for the productive compesatory tillering capacity of wheat plants after different diptera species attack. The following multiannual averages of grain yield losses after spring attack of diptera were recorded in areas cultivated with winter wheat varieties: - for *Delia coarctata* attack: 0.92-1.49 g grain losses/plant, with 62.4-75.1 % compensatory effect on attacked plants; for *Opomyza florum* attack: 0.66-1.38 g grain losses/plant, with 71-84.4 % compensatory capacity of plants after the attack; for *Phorbia securis* attack; 1.03-1.22 g grain losses/plant, with 59.3-71.5 % compensatory effect on attacked plants. This means grain yield losses between 414-662 kg/ha for *D. coarctata* attack, 297-621 kg/ha for *O. florum* attack, and 464-549 kg/ha for *Ph. securis* attack, on different wheat varieties and considering an average density of 450 plants/m^2 and 10% diptera attacked plants in the spring.

Interspecific Relationships Between Diptera Pests and Beneficial Poliphagous Predators. The cereal agroecosystems in Central Transylvania are rich in useful arthropod fauna, involved in the limitation of population density and economic importance of pests. Beneficial entomophagous developed an intensive and efficient destruction of phytophagous on cereal field crops, including diptera. Therefore, a study regarding useful arthropod populations and theirs importance in cereal field crops was carried out. The well-known systematic groups of predators: *Aranea; Dermaptera; Thysanoptera (Aeolothripidae); Heteroptera (Nabidae etc.); Coleoptera (Sylphidae, Coccinellidae, Carabidae, Cicindelidae, Staphylinidae, Cantharidae, Malachiidae); Diptera (Syrphidae, Scatophagidae, Empididae etc.); Hymenoptera (Formicidae etc); Neuroptera (Chrysopidae)* are well represented in the structure of arthropod fauna, in cereal agroecosystems of Central Transylvania. The diverse flora populating the field borders and the forestry belts, proved to be the main cause of the useful species abundance, of their survival, increasing of populations and seasonal migration into the field crops (Welling 1990; Rupert & Molthan 1991; Malschi & Mustea 1995; Malschi 2003). The abundance and the quality of activity of entomophagous populations, the natural biological control of important zone pests, were higher in systems with protective forestry belts and with field marginal herbs. Such conditions are not only favourable for the development of entomophagous arthropod fauna, but also conserve the zonal biodiversity.

Table 8

The attack of wheat diptera pests on the agroecosistems in open field area (at Turda) and with protective forestry belts (at Bolduț), at Agricultural Research Station Turda, in Central Transylvania

Turda	*Bolduţ*
25 % dead hard tillers	5.5 % dead hard tillers

Laboratory Tests and Investigations on the role of the main species of predatory entomophagues as regulators of diptera pest populations in cereal agroecosystems, demonstrated that various species feed preferentially on cereal flies (Table 9). The results of laboratory feeding trials with larvae and pupae of diptera (*Opomyza florum*, *Phorbia securis*), showed the importance of dominant predatory species, theirs feeding habits, prey composition and feeding rate per day and individual predator. Our data were in good aggreement with the literature (Basedow 1990; Welling 1990; Wetzel 1995; Baicu 1996; Malschi & Mustea 1995, 1996, 1997; Malschi 2003). *Coccinella septempunctata L.(Coccinellidae,) Malachius bipustulatus* L. (*Malachiidae*), *Cantharis fusca* L. (*Cantharidae*), *Chrysopa carnea* Stephn. (*Chrysopidae*), *Nabis spp. (Nabidae), Sylpha obscura* (*Sylphidae*), *Tachyporus hypnorum* L., *Staphylinus spp*. (*Staphylinidae*), *Poecilus cupreus* L., *Harpalus rufipes* De Geer*, Amara aenea De Geer (Carabidae*) consumed larvae and pupae of wheat diptera pests (*Opomyza florum*, *Phorbia securis*).

Conclusions. The present study provides useful faunistic, biological and agro-ecological data, to suggest suitable measures in order to achieve a real integrated control of diptera species damaging wheat, an actual strategy of diptera pests management as part of the technological system for sustainable development of wheat crops in Transylvania.

The described main Diptera species were located on their main geographical area and displayed considerable high biological reserves and attack possibilities on winter wheat crops. Ecological factors and agrotechnical methods determined the distribution range, species composition and economic importance of the attack in different cereal areas of country.

Table 8

Individual daily feeding rate of predators with wheat diptera larvae in laboratory trials

Entomophagous predators	*Opomyza florum*		*Phorbia securis*	
	larvae	*pupae*	*larvae*	*pupae*
Chrysopa carnea Stephn.(Chrysopidae) *(larva)*	3	1	2	-
Nabis ferus (Nabidae) *(adult)*	3	4	3	4
Coccinella 7-punctata L. (Coccinellidae) *(adult)*	5	7	5	7
Propylaea 14-punctata L (Coccinellidae) *(adult)*	-	2	-	-
Malachius bipustulatus L. (Malachiidae) *(adult)*	-	-	3	-
Cantharis fusca L. (Chantaridae) *(adult)*	2	-	4	-
Staphylinus caesareus Cederh (Staphylinidae)	1	-	4	4
Tachyporus hypnorum L. (Staphylinidae)	1	-	1	-
Poecilus cupreus L. (Carabidae)	5	10	5	7
Pseudophonus pubescens De Geer (Carabidae)	1	-	2	1
Harpalus distinguendus Duft. (Carabidae)	-	-	2	2
Harpalus aeneus L. (Carabidae)	-	2	4	2
Amara aenea De Geer (Carabidae)	-	-	8	-
Sylpha obscura L. (Sylphidae)	1	4	2	4
Necrophorus vespillo L. (Sylphidae)			4	8

Early emergence of crops in September made possible dangerous attacks of frit fly *(Oscinella frit L),* hessian fly *(Mayetiola destructor Say.)* and black fly *(Phorbia securis Tiensuu*). Biological potential and attacks produced in spring, by yellow small fly *(Opomyza florum F*) and wheat bulb fly *(Delia coarctata Fll.),* were increased when wheat emerged in October. The late emergence of crops in November, favoured the preferential spring attack of black flies *(Phorbia penicillifera Jermy* and *Ph. securis).*

On cereal areas with an important biological reserves of diptera pests, the following integrated plant protection preventive measures are suitable to apply: late sowing date (in the first half of October); adequate technological measures for a good development of plants; cultivation of wheat varieties with productive tillering compensatory capacity after the attack; seed treatment with insecticides.

In the special conditions of 2000-2006, characterised by arid microclimate, excessive dryness and warmth, the insecticide control was necessary, as the attack of main species of wheat diptera pests was increasing and overlaping. Usual insecticide treatments (tiacloprid, thiametoxam, fipronil, bensultap, acetamiprid, dimethoate, clorpirifos-metil, deltametrin, lambda-cihalotrin, novaluron, lufenuron, fenitrotion with fenvalerat, clorpirifos with cipermetrin, dimethoate with cipermetrin etc.) were tested, in the selective treatment moments, for wheat diptera-larvae-pest control. In April, at the end of tillering phase, in 13-33 DC stage, the treatments proved to be equally efficient in the control of other dangerous pests of the wheat fields, especially on leafhoppers, aphids, trips, cereal leaf beetles. The high efficiency of the insecticidas in the control of main dangerous diptera species, the obtained increased yields of 7-21 % and the supplementary protection resulting from the activity of useful entomophagous arthropod fauna, recommended an integrated pest management, with an adequate technology and modern insecticides pest control strategy.

The study showed the important role of entomophagous natural predators, their efficiency in decreasing wheat pests abundance, in normal conditions. Abundance and activity of entomophagous populations were higher in systems with protective forestry belts and with field marginal herbs, favourable for the development of entomophagous arthropod fauna and also preserving the local biodiversity.

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