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Role of Parasitoid Complex in Limiting the Population of Diamondback Moth in Moldavia, Romania

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Abstract

The complex of parasitoid and hyperparasitoid species which is associated with diamondback moth (*Plutella xylostella* (L.)), a destructive pest of cabbage in Romania, is presented. Over 25 species of Ichneumonidae and Braconidae are identified, which act as primary and secondary parasitoids. For each species, abundance, constancy, dominance, the biocenotic affinity and the contribution of each species in limiting the population of diamondback moth is analyzed. The dynamics of these species over time, from one crop to another and from one area to another are discussed. Also discussed are those species which play a role in biological control of this pest, and those which could be used in biocontrol.

Introduction

Diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae) is one of the most serious pests of cabbage in Romania. In Moldavia this species completes two or three generations in one crop season (Peiu et al. 1971, 1973). The greatest damage occurs when the infestation takes place in young plants. In older plants the larvae develop mainly on the outer leaves. Such damage is of little economic significance. Larvae from the first and second generations cause the greatest damage in Moldavia.

Our research was aimed at clarifying the complex of parasitoids that limited the population of DBM.

Materials and Methods

The research was conducted in three stages: 1967-72, 1979-82 and 1990. In the first stage, we emphasized identification of the parasitoid species and their interrelationship. In the second and third stages, the importance of each species within the biocenotic complex and the contribution of each species in limiting populations of DBM was considered.

Based on the material collected from over 40 localities in Moldavia during the study period, we found that DBM was controlled by a complex of parasitoid species that reduced the populations of this pest by 80-90% or even more.

We collected 16,961 mature larvae and pupae of DBM. They were reared in the laboratory for adult parasitoid emergence, identification and synecological studies.

Results and Discussion

Of the 16,981 larval specimens collected from 1967 to 1972 (Table 1), 1514 larvae and pupae (8.9%) died due to diseases and insecticides. A total of 4777 pupae emerged into DBM

adults (28.2%). The balance of the collection, 10,670 specimens, emerged into parasite adults. They belonged to 28 species, as follows.

Table 1. The synecological analysis of the parasitoid species in the populations of DBM.

Species	Abundance	Dominance	Constancy	Index of ecological significance
Diadegma fenestralis	3,182	18.76 D5	88 C4	16.50 W5
Diadegma armillata	1,773	10.45 D5	79 C4	8.25 W4
Diadegma chrysosticta	1,749	10.31 D5	76 C4	7.83 W4
Diadegma vestigialis	754	4.44 D3	52 C3	2.30 W3
Diadromus subtilicornis	623	3.67 D3	45 C2	1.65 W3
Diadegma cerophaga	560	3.30 D3	62 C3	2.04 W3
Diadromus collaris	364	2.14 D3	42 C2	0.89 W2
Diadromus ustulatus	347	2.04 D3	38 C2	0.77 W2
Diadegma tibialis	251	1.47 D2	44 C2	0.64 W2
Diadegma trochanterata	227	1.33 D2	43 C2	0.57 W2
Apanteles fuliginosus	215	1.26 D2	39 C2	0.49 W2
Diadegma gracilis	81	0.47 D1	20 C1	0.09 W1
Diadegma gibbula	54	0.31 D1	15 C1	0.04 W1
Diadegma holopyga	41	0.24 D1	26 C2	0.06 W1
Diadegma interrupta	39	0.22 D1	16 C1	0.03 W1
Itoplectis alternans	36	0.21 D1	27 C2	0.05 W1
Phaeogenes ischiomelinus	36	0.21 D1	16 C1	0.03 W1
Dicaelotus parvulus	32	0.18 D1	19 C1	0.03 W1
Itoplectis viduata	25	0.14 D1	18 C1	0.02 W1
Itoplectis tunetanus	24	0.14 D1	11 C1	0.01 W1
Diadegma monospila	22	0.12 D1	14 C1	0.01 W1
Hyposoter ebeninus	8	0.04 D1	7 C1	0.002 W1
Apanteles ruficrus	8	0.04 D1	8 C1	0.003 W1
Apanteles rubecula	4	0.02 D1	4 C1	0.0008 W1
Nepiera moldavica	3	0.01 D1	1 C1	0.0001 W1

Primary parasitoids

A. Family Ichneumonidae: 1. *Itoplectis viduata* Grav., 2. *I. tunetanus* Schm., 3. *I. alternans* Grav., 4. *Nepiera moldavica* Const. and Must., 5. *Diadegma armillata* Grav., 6. *D. cerophaga* Grav., 7. *D. chrysosticta* Gmel, 8. *D. fenestralis* Holmgr., 9. *D. gibbula* Brsch., 10. *D. gracilis* Grav., 11. *D. holopyga* Thoms., 12. *D. interrupta* Holmgr., 13. *D. monospila* Thoms., 14. *D. tibialis* Grav. 15. *D. trochanterata* Thoms., 16. *D. vestigialis* Rtzbg., 17. *Hyposoter ebeninus* Grav., 18. *Dicaelotus parvulus* Grav., 19. *Diadromus subtilicornis* Grav., 20. *D. ustulatus* Holmgr., 21. *Thyraeella collaris* Grev., 22. *Phaeogenes ischiomelinus* Grav.

B. Family Braconidae: 1. *Apanateles fuliginosus* Wesm., 2. *A. rubecula* Marsh., 3. *A. ruficrus* (Hal.).

C. Family Pteromalidae: *Dibrachys cavus* (Walk.). D. Family Eulophidae: 1. *Tetrastichus* sp., 2. *Geniocerus* sp.

Secondary parasitoids

A. Family Ichneumonidae: *Mesochorus vittator* Zett., of *Diadegma armillata* Grav.; *Lysibia varitarsus* of *Apanteles fuliginosus* (Wesm.).

B. Family Eulophidae: *Pleurotropis* sp. of *Diadegma armillata* and *Apanteles fuliginosus*; C. Family Pteromalidae: *Eupteromalus* sp. of *Diadegma armillata*.

The action of the secondary parasitoids limits the efficiency of the primary parasitoids in controlling DBM populations. However, their presence is negligible and has no significant economic impact.

The interrelations between the species of this biocenotic complex are shown in Fig. 1.

Studies of parasitoid species identified in this complex (Table 1) indicate that there is considerable variation in these parasite species. Their high numbers and the high rate of parasitism puts *D. fenestralis* (18.8%) in the first place, followed by *D. armillata*, *D. chrysosticta*, *D. vestigialis*, *Diadromus subtilicornis*. Other species play a minor role in reducing host populations.

The relation between the parasitoid species varies from sample to sample in the same locality, from time to time during the year, from year to year and from area to area.

The large number of species that seem to parasitize DBM raises a legitimate question: Is each species closely associated with this host, or have some species reached this parasite complex more or less accidentally? To answer this question we carried out a synecological analysis of the populations of parasitoids within the biocenotic complex. Table 1 lists abundance, dominance, constancy and the index of ecological significance for each species.

The species are listed according to their abundance. The highest value is assigned to *D. fenestralis* with 3182 individuals, followed by *D. armillata* with 1773 individuals and *D. chrysosticta* with 1749 individuals. The lowest values were assigned to *A. rubecula* and *Nepiera moldavica* with only three individuals each.

To judge the importance of the presence of parasitoid species within this complex, we carefully analyzed their constancy as a structural indicator because this indicates the contribution of a species participating in the realization of the structure of the biocenosis.

From the ecological parameters we can deduce that species *D. fenestralis*, *D. armillata* and *D. chrysosticta* act as euconstant parasitoids, whereas *D. vestigialis* and *D. cerophaga* act as constant parasitoids. This means that all these species can be found in all the cabbage fields from Moldavia, wherever DBM attacks cabbage. Eight species act as accessory parasitoids and the other species can be considered as accidentally present in this complex.

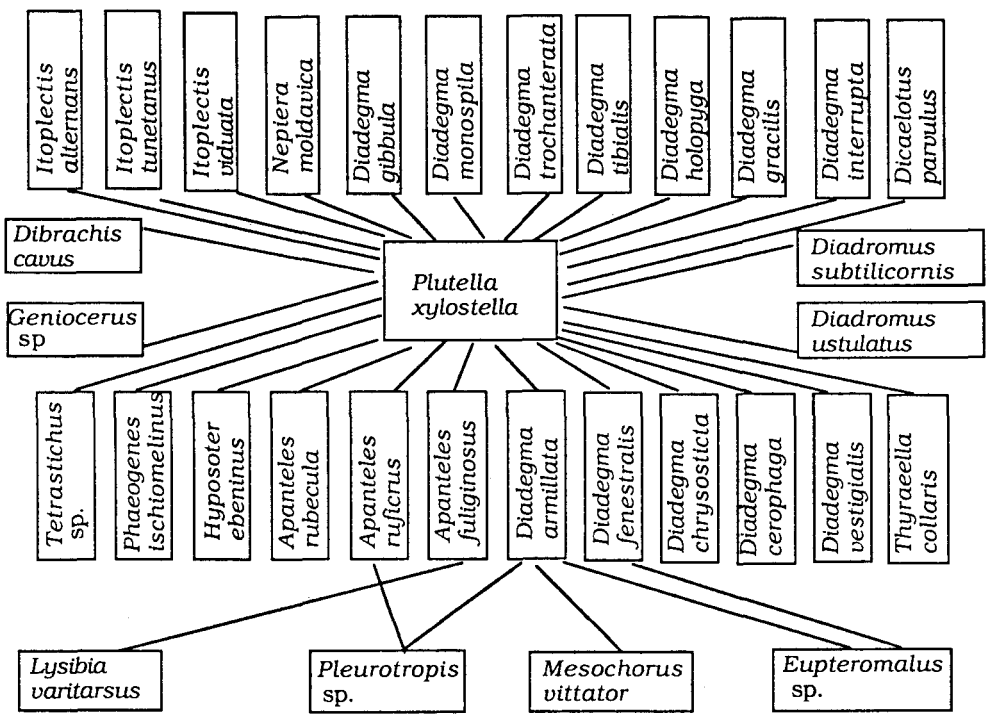

Fig. 1. The complex of parasitoids which limits the population of DBM in Moldavia, Romania.

Dominancy shows the number relationship of the individuals of a given species in contrast to the number of individuals of the other species they associate with. It indicates the relative abundance. The dominance parameter illustrates the participating degree of each species to the realization of biomass production in biocenosis. The species *D. fenestralis*, *D. armillata* and *D. chrysosticta* are eudominant; *D. vestigialis* is dominant; *Diadromus subtilicornis*, *D. ustulatus*, *Diadegma cerophaga* and *Diadromus collaris* are subdominant, followed by three recedent species and all the others subrecedent.

The index of ecological significance (W) represents the relationship between the structural and productive indicators. This shows more eloquently the position of each species in the complex. In this respect, the highest value is that of *D. fenestralis*, followed by *D. armillata* and *D. chrysosticta* with W_4 and by *D. vestigialis*, *D. cerophaga* and *Diadromus subtilicornis* with W_3, after which there follows five species with W_2, the others having reduced values.

Synecological analysis of the data obtained from our research indicates that only a few species make a major contribution in limiting populations of DBM to over 80%. This fact has important practical significance.

In order to convince ourselves that this complex of parasitoid species limits the populations of DBM, we continued our research (Mustata 1979, 1987; Mustata and Tudor 1973; Mustata and Lacatusu 1973).

Our initial survey from 1967 to 1979 identified all the parasite species that interact with the populations of this pest (Table 2). These parasitoid species considerably reduce the populations of DBM. The degree of parasitism varied between 13.9% in Ciurea, on 21 July 1971 and 95.6% in Ungureni on 21 August 1972. In most of the samples the percentage of parasitism is quite high, averaging 60.9%.

The value of the ecological parameters resulting from the analysis of the data obtained from 1979 to 1982 is shown in Table 3.

The data from the last study period (1990) are summarized in Table 4. Here, too, the same parasitoid species manifest themselves as being euconstant or constant, eudominant or dominant, and have a high index of ecological significance although there is reversal in the order and value of the ecological parameters.

We also analyzed the index of biocenotic affinity, the value which confirms the affinity between the main species derived from results obtained in the first stage.

The role of the main parasitoid species in limiting the populations of DBM in Adjudu Vechi and their dynamics in time and space are shown in Fig. 2. The number of DBM adults that emerged was very low. During 1969-71, the DBM emergence was close to 30%, whereas in 1972, 1979, 1980 and 1981 it was 4%. In 1972, it reached 69.5% and in 1990 it declined to 17.9%.

Diadegma armillata, *D. fenestralis*, and *D. chrysosticta* seem to be the major parasitoids limiting the populations of DBM. Other species of primary parasitoids with a clean competition between them also limit the populations of DBM.

Our results on the dynamics of the main parasite species at various locations in Moldavia during 1969 are summarized in Fig. 3, and for 1990 in Fig. 4. The localities shown in Fig. 4 are listed according to their geographical position from the south (Homocea) to the north (Mestecanis) of Moldavia. There is no relationship between the geographic location and populations of DBM or its major parasites.

On the basis of our research we could deduce that populations of DBM in Moldavia are limited by an important complex of natural enemies, their efficiency being very high (about 63%). Some of the parasitoid species are constant or euconstant in populations of DBM. The more important species are *D. fenestralis*, *D. armillata*, *D. chrysosticta* , *D. vestigialis*, *D. cerophaga*, and *Diadromus subtilicornis*. The combined parasitism of these major species and certain minor ones play an important part in DBM control in Moldavia. However, we often found that chemical insecticides were used despite levels of parasitism of almost 90%. In July 1972 in Adjudu Vechi and July 1970 in Scheia, farmers used chemicals to combat DBM although the samples taken only 8-10 days earlier showed only 4-5.5% DBM adult emergence. The balance,

Table 2. The synecological analysis of the parasitoid species in the period 1967-72.

Abundance	Dominance	Constancy	Index of ecological significance	Species	Biocenotic affinity																											
					Diadegma fenestralis	*Diadegma armillata*	*Diadegma vestigialis*	*Diadegma chrysosticta*	*Diadegma cerophaga*	*Diadromus subtilicornis*	*Diadromus ustulatus*	*Diadegma trochanterata*	*Diadegma tibialis*	*Apanteles fuliginosus*	*Diadegma gracilis*	*Diadromus collaris*	*Diadegma holopyga*	*Diadegma interrupta*	*Itoplectis alternans*	*Diadegma gibbula*	*Itoplectis tunetanus*	*Itoplectis viduata*	*Phaeogenes ischiomelinus*	*Diadegma monospila*	*Dicaelotus parvulus*	*Hyposoter ebeninus*	*Apanteles ruficrus*	*Nepiera moldavica*	*Apanteles rubecula*					
1,470	15.71 D_5	90 C_4	14.13 W_5	*D. fenestralis*	66	73	71	66	39	40	40	36	23	16	27	22	11	30	16	12	16	12	14	22	10	10	1	4	1			
1.183	12.64 D_5	77 C_4	9.73 W_4	*D. armillata*		51	60	62	48	36	56	34	21	18	28	26	14	31	18	18	21	14	16	20	6	14	2	2	2			
637	6.80 D_4	56 C_3	3.80 W_3	*D. vestigialis*			62	48	32	33	41	24	18	17	22	17	15	20	17	11	25	12	15	27	16	9	5	3	3			
582	6.21 D_4	77 C_4	4.78 W_3	*D. chrysosticta*				56	42	46	38	29	21	24	25	15	9	23	15	13	19	14	14	23	9	14	0	4	4			
366	3.91 D_3	69 C_3	2.69 W_3	*D. cerophaga*					42	31	51	34	23	20	21	29	18	38	20	27	17	13	15	13	7	12	2	2	5			
345	3.68 D_3	43 C_2	1.58 W_3	*D. subtilicornis*						36	41	29	31	17	28	17	11	17	10	32	28	26	7	16	12	16	0	8	6			
283	3.02 D_3	41 C_2	1.23 W_3	*D. ustulatus*							35	34	12	39	29	22	11	18	14	18	10	16	11	30	12	12	4	9	7			
182	1.94 D_2	52 C_3	1.00 W_3	*D. trochanterata*								40	30	18	17	18	20	36	18	18	19	17	16	14	10	9	3	0	8			
143	1.52 D_2	39 C_2	0.59 W_2	*D. tibialis*									5	25	24	28	12	26	24	24	15	22	7	22	18	8	4	4	9			
89	0.95 D_1	28 C_2	0.26 W_2	*A. fuliginosus*										13	16	4	0	28	19	34	20	10	4	17	5	23	0	6	10			
68	0.72 D_1	18 C_1	0.12 W_2	*D. gracilis*											4	16	13	17	8	5	18	23	21	22	7	6	0	0	11			
30	0.32 D_1	24 C_1	0.07 W_1	*D. collaris*												20	5	15	9	21	4	5	0	25	20	11	7	7	12			
29	0.30 D_1	22 C_1	0.06 W_1	*D. holopyga*													38	12	16	16	11	13	5	29	14	6	0	0	13			
27	0.28 D_1	13 C_1	0.03 W_1	*D. interrupta*														28	22	16	11	13	16	11	14	6	0	0	14			
26	0.27 D_1	30 C_2	0.08 W_1	*I. alternans*															14	6	6	6	16	16	11	0	14	0	15			
26	0.27 D_1	18 C_1	0.04 W_1	*D. gibbula*																12	35	13	4	26	7	15	5	0	16			
23	0.24 D_1	16 C_1	0.04 W_1	*I. tunetanus*																	11	11	14	6	15	15	0	0	17			
16	0.17 D_1	11 C_1	0.02 W_1	*I. viduata*																		11	6	6	10	7	10	1	18			
16	0.17 D_1	13 C_1	0.01 W_1	*P. ischiomelinus*																			25	23	5	15	0	0	19			
14	0.14 D_1	11 C_1	0.01 W_1	*D. monospila*																				8	5	10	0	0	20			
14	0.14 D_1	24 C_1	0.03 W_1	*D. parvulus*																					13	0	0	8	21			
6	0.06 D_1	9 C_1	0.003 W_1	*H. ebeninus*																						0	0	25	22			
6	0.06 D_1	11 C_1	0.006 W_1	*A. fuficrus*																							0	14	23			
3	0.03 D_1	1 C_1	0.0003 W_1	*N. moldavica*																								0	24			
2	0.02 D_1	2 C_1	0.0004 W_1	*A. rubecula*																									25			

Table 3. The synecological analysis of the parasitoid species in the period 1979-82.

Species	Abundance	Dominance	Constancy	Index of ecological significance
Diadegma chrysosticta	792	17.11 D5	88 C4	15.05 W5
Diadegma fenestralis	723	15.62 D5	92 C4	14.37 W5
Diadegma armillata	267	2.77 D4	96 C4	5.53 W4
Diadromus collaris	192	4.15 D3	80 C4	3.32 W3
Diadromus cerophaga	149	3.22 D3	68 C3	2.15 W3
Diadegma subtilicornis	98	2.12 D3	52 C3	1.10 W3
Diadegma tibialis	87	1.88 D2	60 C3	1.12 W3
Apanteles fuliginosus	74	1.60 D2	68 C3	1.08 W3
Diadegma vestigialis	67	1.45 D2	48 C2	0.69 W2
Diadromus ustulatus	52	1.52 D2	40 C2	0.44 W2
Diadegma trochanterata	36	0.78 D2	36 C2	0.28 W2
Diadegma gibbula	24	0.52 D1	8 C1	0.04 W1
Phaeogenes ischiomelinus	20	0.43 D1	40 C2	0.17 W2
Dicaelotus parvulus	18	0.39 D1	28 C2	0.10 W2
Diadegma interrupta	10	0.22 D1	28 C2	0.06 W1
Diadegma gracilis	9	0.19 D1	16 C1	0.03 W1
Itoplectis alternans	8	0.70 D1	28 C2	0.19 W2
Itoplectis viduata	7	0.15 D1	28 C2	0.04 W1
Diadegma holopyga	7	0.15 D1	24 C1	0.03 W1
Diadegma monospila	6	0.13 D1	20 C1	0.02 W1
Hyposoter ebeninus	2	0.04 D1	8 C1	0.003 W1
Itoplectis tunetanus	1	0.02 D1	4 C1	0.0008 W1
Apanteles ruficrus	1	0.02 D1	4 C1	0.0008 W1
Apanteles rubecula	1	0.02 D1	4 C1	0.0008 W1

Table 4. The synecological analysis of the parasitoid species in the year 1990.

Species	Abundance	Dominance	Constancy	Index of ecological significance
Diadegma fenestralis	979	32.89 D5	100 C4	32.89 W5
Diadegma chrysosticta	375	12.60 D5	71 C3	8.94 W4
Diadegma armillata	323	10.85 D5	78 C4	8.96 W4
Diadromus subtilicornis	180	6.04 D4	57 C3	3.44 W3
Diadromus collaris	142	4.77 D3	57 C3	2.71 W3
Diadegma vestigialis	50	1.68 D2	57 C3	0.95 W2
Diadegma cerophaga	45	1.57 D2	42 C2	0.65 W2
Apanteles fuliginosus	43	1.44 D2	42 C2	0.60 W2
Diadegma tibialis	21	0.70 D1	50 C2	0.35 W2
Diadromus ustulatus	12	0.40 D1	35 C2	0.14 W2
Diadegma trochanterata	9	0.30 D1	35 C2	0.10 W2
Diadegma holopyga	5	0.16 D1	28 C2	0.04 W1
Diadegma gibbula	4	0.12 D1	21 C1	0.02 W1
Diadegma gracilis	4	0.12 D1	21 C1	0.02 W1
Itoplectis viduata	2	0.06 D1	14 C1	0.008 W1
Itoplectis alternans	2	0.06 D1	14 C1	0.008 W1
Diadegma monospila	2	0.06 D1	14 C1	0.008 W1
Diadegma interrupta	2	0.06 D1	14 C1	0.008 W1
Apanteles ruficrus	1	0.03 D1	7 C1	0.002 W1
Apanteles rubecula	1	0.03 D1	7 C1	0.002 W1

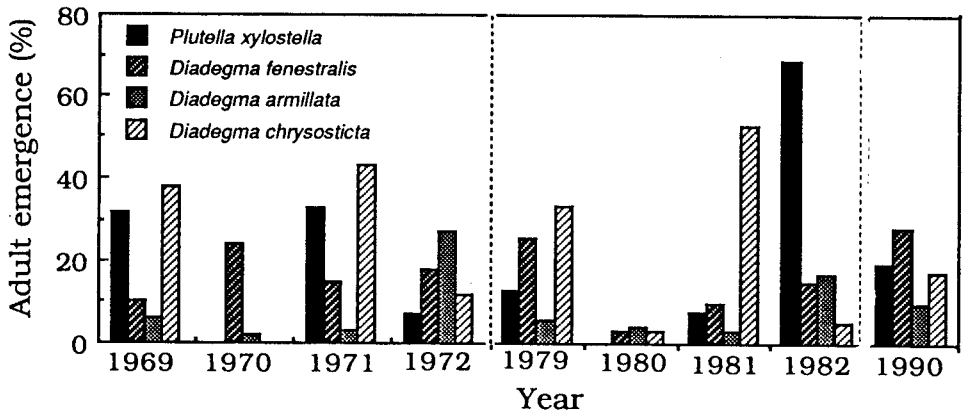

Fig. 2. Population dynamics of DBM and its major parasitoids during 1969-72, 1979-82 and 1990 at Adjudu Vechi.

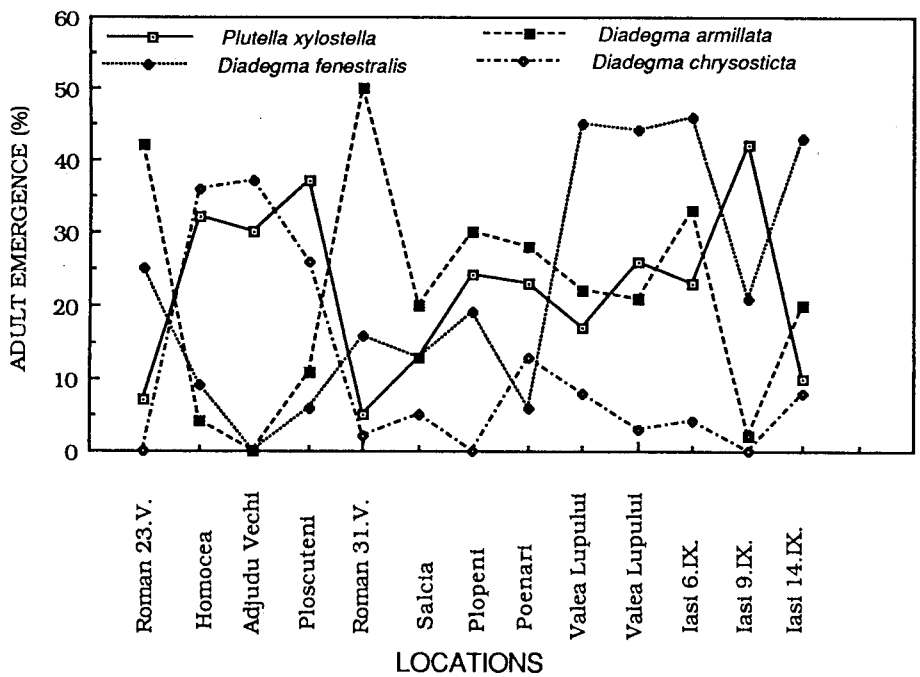

Fig. 3. Population dynamics of DBM and its major parsaitoids at various locations during 1969.

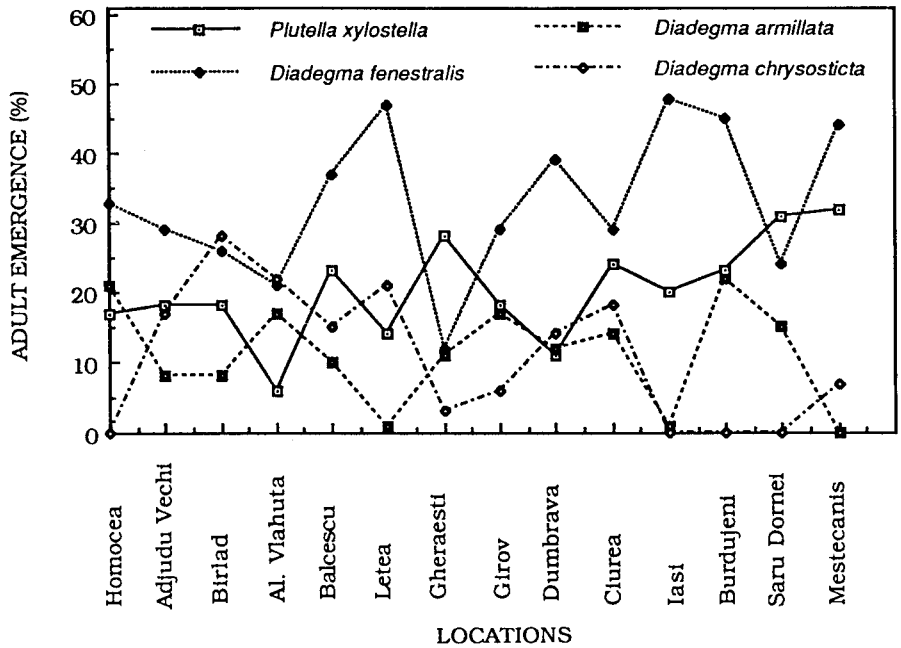

Fig. 4. Population dynamics of DBM and its major parasitoids at various locations during 1990.

over 95%, were parasitized. In these circumstances, treatment with insecticides is not justified, and adversely affects beneficial fauna with unpredictable consequences.

To combat pests we must know precisely the activity of the parasitoid and predatory species which limit pest populations. It is important that our interventions in natural ecosystems be done on the basis of thorough biocenotic data. Our intervention must be made in such a way that it does not affect the beneficial fauna. Otherwise we can provoke unpredictable disturbances in the biological equilibrium.

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