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Natural Enemy Complex of *Eurytoma Amygdali* Enderlein, 1907 (Hymenoptera, Eurytomidae) in Eastern Mediterranean Region of Turkey; Notes on Their Interaction and Effectiveness

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Abstract: Natural enemies of *Eurytoma amygdali* Enderlein, 1907 (Hymenoptera, Eurytomidae), which is a serious pest of almonds, *Amygdalus* spp. (Rosaceae), in the Palearctics, were studied in the eastern Mediterranean region of Turkey. Among them *Adontomerus amygdali*[1] (Hymenoptera, Chalcidoidea, Torymidae), *Aprostocetus bucculentus*[11] (Hymenoptera, Chalcidoidea, Eulophidae) are gregarious ectoparasitoids on the larvae of *E. amygdali*. *Pyemotes amygdali* Cobanoglu & Doganlar, 2006 (Acarina, Pyemotidae) is a gregarious ectoparasitoid on prepupae, pupae and newly hatched adults of all of the hymenopterous insects. *Thanasimus* sp. (Coleoptera, Cleridae) is a predator of hymenopterous ones in almond fruits. The natural parasitism on *E. amygdali* by *A. amygdali* was occurred to be 0.38 – 35.20 % in the places where parasitoid was present and by *A. bucculentus* it was less than 5 % in all regions. Parasitism/predation rates by *P. amygdali* and *Thanasimus* sp. which have localized in Hatay province ranged from 7.56 to 44.53% and 0.38 to 11.20 % respectively.

Key words: *Eurytoma amygdali*, natural enemies, Turkey.

INTRODUCTION

The almond wasp, *Eurytoma amygdali* Enderlein, 1907 (Hym., Eurytomidae) is one of the most important pests of *Amygdalus* spp. (Rosaceae) in the Palearctics but is limited in distribution to southeastern Europe, the Middle East and some of the countries of the former Soviet Union. It has been recorded in Armenia, Azerbaijan, Bulgaria, Cyprus, France, Georgia, Greece, Israel, Jordan, Lebanon, Syria, former USSR, Turkey and Yugoslavia[22.9.10.5.23.24.6.18.19.20.21.28.2.29.27.12.14]. In Turkey it has been reported to be the most important pest of almonds where 47.000 tones of yield is obtained annually from 4.7 million almond trees[25]. The life history of almond wasps has been studied or reviewed by many researchers, amongst whom Cakar[2], Plaut[19,20] and Talhouk[24] studied its life cycle; Ekici and Günaydın[6], Klapperich[9] and Tzanakakis *et al*.[27] established its diapause and hibernation characters; Klapperich[10], Plaut[19], Plaut and Mansour[21] and Koulousis and Katsoyannos[13,14] worked on oviposition and reproduction; Tzanakakis *et al*.[27], Tzanakakis and Veeman[26] and Koulousis and Katsoyannos[14] found out the effects of photoperiods/light and temperature.

Eurytoma amygdali has one generation per year. The larvae feed on the developing endosperm of almond fruits. First emergence of adult wasps was observed in late March and April and one egg was laid on unripe green almonds.

The level of infestation of *E. amygdali* on almond seeds reached almost to 60 % in unsprayed orchards[21,14,10,6]. Cakar[2] reported *E. amygdali* can destroy up to 71% of almond fruits via their emergence from the seeds and sometimes the damage caused to crop can reach up to 90% by mummifying the infested almonds[15].

Collecting and destroying mummified fruits and using sex pheromones[17,15] can be mentioned as cultural control practices, but at present, its controlled mainly with systemic or organophosphate insecticides. There have been limited works on the natural enemy complex and biological control of *E. amygdali*. Only some of the researchers described its parasites and gave their host records from some countries such as: *Aprostocetus bucculentus*[11] from Israel, Turkey and the former USSR[7]; *Adontomerus amygdali*[1] (Hymenoptera, Chalcidoidea, Torymidae) from Jordan[1,8]; *Gugolzia bademia* Doğanlar, (Hymenoptera, Chalcidoidea, Pteromalidae) from Turkey[4]. Furthermore Mahunka and Mahunka-Papp[16] described *Pyemotes muraiae* Mahunka and Mahunka-Papp as a parasite of *E. amygdali* from Hungary. These previous studies were mainly concentrated on the diagnosis, description and the distribution of the natural enemies of almond wasp.

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The objectives of the current study were to determine the natural enemies of almond wasp in The eastern Meditereanean part of Turkey with regards to some of their biological aspects and to establish a preliminary understanding of the interactions among natural enemies and almond wasp.

MATERIALS AND METHODS

The field works were conducted on almond trees in different localities, namely Pozanti (Adana province), Nizip (Gaziantep province), Şenköy, Hanyolu, Benlideresi, Altınözü, Dokuzdal, Turfanda, (Hatay province), in The eastern Mediterranean region of Turkey from August to October in 2002 and 2003 and from March to May in 2004.

In order to obtain natural enemies associated with *E. amygdali*, the infested fruits were collected from the trees on which previous years' infested fruits shrivel and remain on the tree as infestation source throughout winter. The sampled fruits were brought to the laboratory and kept in polyethylene jars (25 cm depth and 8 cm in diameter) each including 25 fruits at the room temperature and 60-70% relative humidity. Insect emergence were observed daily and emerging insects were collected, counted, killed by ethyl acetate and prepared for taxonomic studies. Furthermore, to determine some biological aspects of parasitoids such as host, feeding types, sex ratio, early stages of the natural enemies were reared on shriveled almonds in jars in room conditions until adult emergence. The adults of the parasites were identified by the first author. Interactions between the species were identified by studying the remnants of the parasites in the seeds. Each of the fruits from which the adult insects emerged was kept separately in order to obtain the hosts and assess feeding types of natural enemies and the relationships between them. The fruits were boiled in distilled water for 30 minutes to study the cephalic structures of the larvae of *E. amygdali* and of the hymenopterous parasites. After carefully dissecting the seeds, the skins of the last instar larvae in seeds were found andtheir slides were prepared in Enthellane solution for examining the cephalic structures of the species. Having observed the gregarious parasites, each parasitized *E. amygdali* counted towards parasitism rates, disregarding how many parasites emerged from a single infested fruit.

All of the specimens were deposited in the Museum of Plant Protection Department, Agriculture Faculty, Mustafa Kemal University, Antakya, Hatay, Turkey.

RESULTS AND DISCUSSIONS

The natural enemy complex of the *E. amygdali* on the almond trees in The eastern Mediterranean part of Turkey from 2002 to 2004 was consisted of two species of hymenopterous parasitoids, *Aprostocetus bucculentus*, *Adontomerus amygdali* (Boucek) (Hymenoptera; Torymidae), one ectoparasitoid species from Acarina (Pyemotidae), *Pyomotes amygdali* Cobanoglu & Doganlar, 2006 and one predator species from Coleoptera (Cleridae), *Thanasimus* sp.

Table 1 and Table 2 show the coordinates of sampling localities and the distribution of *E. amygdali* and its natural enemies respectively.

Table 1: Geographical detail of sampling sites

Province	Sampling Site	Coordinates (°,', ")	Altitude (m)
Adana	Pozantı	37 28 35 N; 34 54 17 E	1128
Gaziantep	Nizip	37 02 15 N; 37 45 00 E	524
Hatay	Şenköy	36 08 33 N; 36 08 33 E	455
Hatay	Hanyolu	36 01 63 N; 36 12 05 E	578
Hatay	Benlideresi	36 27 70 N; 36 10 39 E	625
Hatay	Altınözü	36 08 35 N; 36 13 92 E	392
Hatay	Dokuzdal	36 00 63 N; 36 13 82 E	697
Hatay	Turfanda	36 00 66 N; 36 11 98 E	472

Table 2: Percentage parasitism/predation rates by natural enemies on *Eurytoma amygdali* Enderline in 2003.

			Parasites						Predator	
			Abrostetus bucculentus		*Adontomerus amygdali*		*Pyemotes amygdali*		*Thanasimus* sp	
Provinces	Site	No. fruit	No. of host*	%	No. of host*	%	No. of host*	%	No. of host*	%
Adana	Pozantı	175	8	4.57	4	2.28	0	0	0	0
Gaziantep	Nizip	85	3	3.38	0	0	0	0	0	0
Hatay	Şenköy	127	0	0	0	0	0	0	0	0
	Hanyolu	239	3	1.26	11	4.60	18	7.56	1	0.42
	Benlideresi	119	0	0	0	0	53	44.53	0	0
	Altınözü	79	2	2.94	10	12.65	0	0	0	0
	Dokuzdal	263	3	1.14	1	0.38	49	18.66	1	0.38
	Turfanda	125	5	4.00	44	35.20	0	0	14	11.20
	Total	1212	24	1.98	70	5.77	120	9.9	16	1.32

*No. of host shows the parasitized/killed host numbers.

Adontomerus amygdali: Material studied: Adana, Pozantı 11 ♀♀, 3 ♂♂, 14 -15. x. 2003, 4 ♀♀, 2 ♂, 25. iv. 2004, (Leg. M. Doganlar); Hatay, Hanyolu, 6 ♀♀, 2 ♂♂, 15.v. 2003, 23 ♀♀, 11 ♂♂, 29. iv. - 4. v. 2004; Turfanda, 54 ♀♀, 17 ♂♂, 22. iv -9. v. 2004; Altınözü, 14 ♀♀, 12 ♂♂, 25. iv - 8.v. 2004; Dokuzdal, 5 ♀♀, 2 ♂♂, 25.iv. 2004 (Leg. M. Doganlar). All of the specimens were reared from larvae of *E. amygdali* in seeds of almond. *Adontomerus amygdali* is an idiobiont gregarious ectoparasitoid. It attacks fourth instar larvae of *E. amygdali* and deposits 2-7 eggs onto the host during May and June. After hatching, larvae feed externally on the almond wasp larvae and development proceeds over a period of 2-2.5 months in field conditions. Pupae are formed in the almond and they normally hibernate until next year till the almond trees set new fruits in March and April. Emerging virgin females of *A. amygdali* feed 2-3 hours and then mate. The first eggs are deposited in almonds 2-3 weeks after mating. The sex ratio of this parasitoid is 1:2.45 (male:female) and it has one generation a year.

In this study, *A.amygdali* was observed to be the most effective hymenopterous parasitoid of *E. amygdali*. It represented %2.28 of the emerged parasitoids in the Adana-Pozanti region and % 0.38-35.20 of the emerged parasitoids in the different localities of Hatay (Table 2).

Aprostocetus bucculentus: Material studied: Adana, Pozantı, 21 ♀♀, 9 ♂♂, 14 -15. x. 2003, 2 ♀♀, 2 ♂♂, 17. iv. 2004, (Leg. M. Doganlar); Hatay, Hanyolu, 6 ♀♀, 3 ♂♂, 17.v. 2003, 13 ♀♀, 7 ♂♂, 12. iv. -24. v. 2004; Turfanda, 26 ♀♀, 8 ♂♂, 12. iv -23. v. 2004; Altınözü, 9 ♀♀, 4 ♂♂, 11. iv -9.v. 2004; Dokuzdal, 15 ♀♀, 6 ♂♂, 27.iv.-6.v. 2004 (Leg. M. Doganlar). The specimens were reared from larvae of *E. amygdali* in seeds of almond. *Aprostocetus bucculentus* is also an idiobiont gregarious ectoparasite of *E. amygdali*. It prefers the last instar larvae for laying eggs. Normally 14 (5-23) eggs were deposited by *A. buculentus* on the host larvae in damaged seeds. In April and May first emergence from damaged almond seeds was observed and as soon as adults emerged mating started. The first eggs were deposited in almond in May or June. The eggs aestivate during summer and they hatch in September. The sex ratio of this parasitoid is 1:2.35 (male:female) and it has one generation a year.

Aprostocetus bucculentus was the most common species observed in this study. It was detected from almost all localities in The Eastern Mediterranean region in 2003-2004. Although it comprised about 4.57 % of emerged parasitoids in Pozantı, in other localities parasitism rate by *A. bucculentus* was found to be less than %3.

Pyemotes amygdali: It is a gregarious ectoparasite. Even though it especially prefers the larvae and prepupae of its host, it can also parasitize pupae and adults. Adults enter into the damaged fruits holes opened for emergence. Females hold on *E. amygdali* by their tarsi and then start feeding. In the seeds, 3 or 5 *Pyemotes* adults paralyse the host and feed on it, but in the laboratory conditions up to 38 *Pyemotes* observed to feed on a single *E. amygdali* larva in multi-well plates. It was also observed that *Pyemotes* adults can develop rapidly when feed on prepupae of *E. amygdali* and the pupae were the least preferred food source. Adults of *E. amygdali* were killed when they were caught emerging from the pupae. Parasite can give a generation in 6-10 days in room conditions. In the current study *P. amygdali* were detected only from three localities of Hatay province, Hanyolu, Benlideresi and Dokuzdal with the rates of parasitism %7.56, % 44.53 and % 18.66 respectively.

It was established that *Pyemotes* is an olygophagous parasite which also demonstrates seconder parasitoid characteristics. *Pyemotes* was associated with larvae, prepupa and pupal stages of *E. amygdali* as well as other parasitoids of *E. amygdali* in the reported localities.

Thanasimus *sp*: It was the only predator recovered in this study. It is a clerid (Coleoptera) prefers adults of *A. amygdali*. It has been obtained from 3 localities (Turfanda, Hanyolu and Dokuzdal) of Hatay province. The ratios of the fruit with *Thanasimus* sp. ranged between 0.38 to 11.20 % (Table 2).

Conclusions: In the eastern Mediterranean two specific hymenopterous parasitoids, *A. amygdali, A. bucculentus* and an olygophagous mite, *P. amygdali* were identified as natural enemies attacking to the larval and adult stages of *E. amygdali*. Although the natural enemies generally do not have high-level parasitism rates, they can show localized higher levels of parasitism as *A. amygdali* in Turfanda and *Pyemotes* in Benlideresi 35.20% and 44.53%, respectively. *Adontomerus amygdali* and *A. bucculentus* are found common species in the study areas, but *Pyemotes* is found only in 3 villages (Table 2). This could be due to the positive effects of the respected sites to the species where the species localize. Another species, *G. bademia*, was also recorded as a solitary primer parasitoid on *E. amygdali* in Elazığ province of The eastern Anatolia and its natural parasitism was also very low, ranged in 5.62-7.17(6.38) % in all of the regions[4].

The relationship between *E. amygdali* and its natural enemies illustrated in the diagram (Figure 1). In total, *A. amygdali* and *A. bucculentus* parasitize *E. amygdali* 5.77 % and 1.98 % respectively, which are considered inadequate levels for biological control of the pest. Furthermore, these parasitoids are under secondary parasitism effect in some localities. Especially in Benlideresi the parasitism rates drop visibly when they were under pressure by *P. amygdali* (Table 2). Besides, *A. amygdali* was under pressure of *Thanasimus* sp. in some localities.

Pyemotes amygdali was observed to be the most effective natural enemy in the current study. It can complete a generation in 6 - 10 days in room conditions

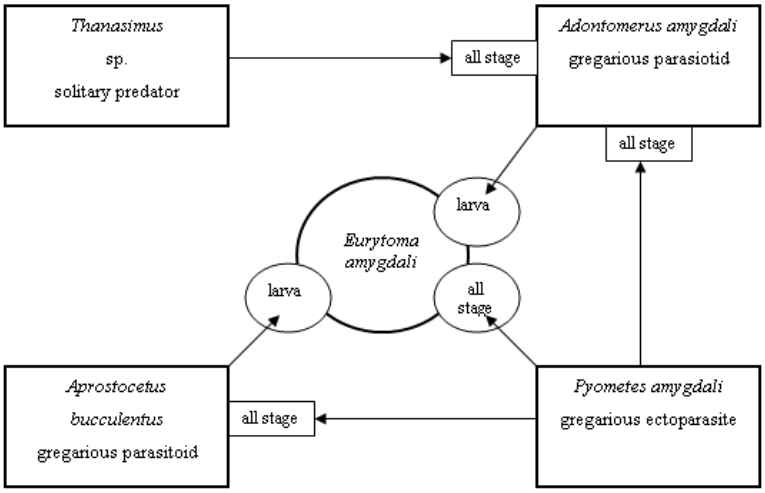

Fig. 1: Natural enemies of *Eurutoma amygdali* and their relationship.

and has a greater reproductive potential (Unpublished data). However, if present, *Pyemotes* attacked other hymenopterous parasitoids as well as *E. amygdali*. For biological control strategy of the pest, this situation is in favour of *Pyemotes* in the case of low effectivity of the hymenopter parasitoids. Our hypothesis is that *Pyemotes*, the most effective natural enemy in this study, could have increased its effectivity by parasitising the other parasitoids whose parasitism rates were already low and for this reason these two hymenopterous parasitoids can be accepted as secondary (alternative) hosts for *P. amygdali*. Having lower effectivities and regarding their distribution, these hymenopterous parasitoids can be considered to have secondary importance for the biological control of the pest and *P. amygdali* can be distinguished as the key natural enemy and due to the aforementioned reasons *P. amygdali* thought to have a potential as a biological control agent for *E. amygdali*.

There was not any other study on the natural enemy complex of *E. amygdali* and our findings shows that further work is needed to understand the relationship among the natural enemies and their effective usage as biological control agents on *E. amygdali*.

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