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in

Zakynthinos G. (ed.).
XIV GREMPA Meeting on Pistachios and Almonds

Zaragoza : CIHEAM / FAO / AUA / TEI Kalamatas / NAGREF
Options Méditerranéennes : Série A. Séminaires Méditerranéens; n. 94

2010
pages 187-201

Geographic distribution and impact of *Eurytoma plotnikovi* Nik. (Hymenoptera: Eurytomidae) and *Megastigmus pistaciae* Walk. (Hymenoptera: Torymidae), insects damaging pistachio nuts in Tunisia

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Abstract. The geographic distribution, the presence and damage levels of *Eurytoma plotnikovi* Nik. and *Megastigmus pistaciae* Walk., insects attacking Pistachio nuts (*Pistacia vera* L.) were assessed in eleven different prefectures covering almost all growing pistachio regions from the north to the south of Tunisia during the period 2001-2007. Nuts were collected by picking at random 10 to 450 from trees when they were still present or collected on the ground after harvest. A total of 85 sites were surveyed of which 67 were inspected once, one site twice, one site 3 times, one site 6 times and one site 7 times. Sixty-three out of 85 sites were infested of which nearly three-quarters were composed with *E. plotnikovi* alone, 19% of infested sites had both insects species and only 6% held *M. pistaciae* alone. The analysis of pest impact on Pistachio nuts showed that *E. plotnikovi* was the most damaging species destroying up to 96.6% of nuts in some sites.

Keywords: *Pistacia vera* – *Eurytoma plotnikovi* – *Megastigmus pistaciae* – Geographical distribution – Damage – Tunisia.

Répartition géographique et impact d'*Eurytoma plotnikovi Nik. (hymenoptera: eurytomidae) *et de* Megastigmus pistaciae Walk. (hymenoptera: torymidae), *insectes ravageurs des fruits du pistachier en Tunisie

Résumé. *La répartition géographique, la présence ainsi que les dégâts d'*Eurytoma plotnikovi *et de* M. pistaciae*, principaux ravageurs des graines du pistachier,* Pistacia vera *L., ont été évalués dans 11 gouvernorats de la Tunisie s'étendant du nord au sud durant la période 2001-2007. Des échantillonnages ont concerné 10 à 450 graines prélevées au hasard sur les arbres ou ramassées sous la frondaison après cueillette. Ainsi 85 sites ont été prospectés dont 67 ont été visités une fois, 1 site à deux reprises, 1 site 3 fois, un site 6 fois et 1 site 7 fois. Les résultats montrent que 63 sites sur les 85 prospectés sont infestés par l'un, l'autre ou les deux insectes à la fois. Parmi eux, les trois quarts hébergent l'insecte* E. plotnikovi *seul, 19% les deux espèces et 6% l'espèce M. pistaciae seule. L'impact de ces ravageurs sur les graines du pistachier montre qu'*E. plotnikovi *est de loin l'espèce la plus dommageable engendrant un pourcentage d'infestation de 96,6% dans certains sites.*

Mots-clés. Pistacia vera – Eurytoma plotnikovi – Megastigmus pistaciae – *Répartition géographique – Dégâts – Tunisie.*

I – Introduction

Pistachio tree (*Pistacia vera* L.) is of great interest for reforestation and exploitation of poor lands. It is well adapted to various climatic conditions and supports long periods of drought. In Tunisia, the entomological fauna that exploits pistachio nuts consists of *Eurytoma plotnikovi* Nik. (Hymenoptera, Eurytomidae) and *Megastigmus pistaciae* (Hymenoptera, Torymidae) (Jarraya, 1977).

The Pistachio seed wasp, *E. plotnikovi* has one generation per year and overwinters as a full grown larva inside the infested pistachio nut, which remains on the tree or on the ground (Fig. 1). The adult begins emergence in late April early May when nuts susceptible for oviposition are available (Fig. 2). The emerging females oviposit inside the unripe pistachio (Fig. 3). The larva feeds on the nut until all or almost all the embryo is consumed then it enters diapause usually by July (Braham, 2005).

Fig. 1. Diapausing larva of *E. plotnikovi*.

Fig.2. Adult female of *E. plotnikovi.*

Fig. 3. Egg of *E. plotnikovi.*

The pistachio seed chalcid, *M. pistaciae* has two generations a year. Adults emergences begin in late May. Females lay eggs into pistachio nuts and larvae feed on kernel (Fig. 4). According to Jerraya and Bernard (1971), 28% of larvae reach adult stage and give the summer generation in nearly one month, adults emergences occurred in late July. Many of them could not bear pistachio endocarp and died. The residual proportion of larvae continues diapause (Fig. 5) till the next spring and gives the first generation (spring generation).

The identity of the species, *E. plotnikovi* occurring in Tunisia was confirmed in May 2006 by Dr Jean-Yves Rasplus (INRA Montpellier, France) using morphological and biochemical analysis. The species *M. pistaciae* was confirmed by Dr Alain Roques (INRA Orléans, France) in October 2007 using adult females. Both species reproduce by thelythokous parthenogenesis; males were very scarce (Jerraya and Bernard, 1971; Jerraya, 1977).

Fig. 4. Adult female of *M. pistaciae.*

Fig.5. Diapausing larva of *M. pistaciae.*

Jerraya and Bernard (1971) indicated that *E. plotnikovi* has a north distribution whereas *M. pistaciae* was mainly located in the south. The population density decreases progressively towards the south for the first species and toward the north for the second.

Our objectives were to determine the geographical distribution of the two species in Tunisia. The knowledge of this distribution is important for these reasons: (i) although the two species cause the same injuries, *E. plotnikovi* is a monovoltive species and *M. pistaciae* has two generations a year; and (ii) the adult flight periods were different consequently the control may be different.

II – Materials and methods

Nuts of the cultivated pistachio [*Pistacia vera* L] were collected from 2001 to 2007 in different sites of 11 prefectures belonging to approximately all the growing regions of pistachio in Tunisia (Fig. 6). The main variety was 'Mateur' but other varieties may be present (Guettari, Achouri, Wahadi, etc.).

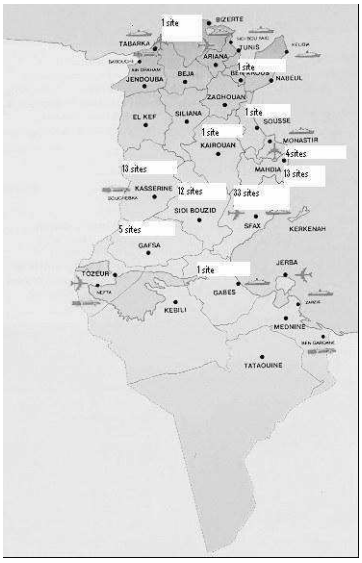

Fig. 6. Map of Tunisia showing surveyed sites of *E. plotnikovi* and *M. pistaciae* during the period 2001-2007.

Table1. Details on prospected sites, numbers of collected pistachio nuts (*Pistacia vera*) and infestation percentages by *E. plotnikovi* and *M. pistaciae* during the period 2001-2007 in Tunisia

Prefecture	Commune	Date of collection	Total number of collected nuts	Number of filled nuts	Number of empty nuts	Number of damaged nuts	% *E. plotni.* infestation	% *M. pista.* infestation
Sfax	Agareb1	15/05/2001	50	18	0	32	64	0
Sfax	Agareb2	15/05/2001	50	10	0	40	80	0
Sfax	Agareb3	15/05/2001	26	7	0	19	73.08	0
Sfax	Agareb4	26/05/2001	30	0	1	29	96.67	0
Sfax	Agareb5	26/05/2001	70	0	11	59	84.29	0
Sfax	Agareb6	13/08/2001	100	11	17	72	72	0
Sfax	Agareb7	13/08/2001	100	14	46	40	40	0
Sfax	Taous	15/05/2001	42	39	0	3	7.14	0
Sfax	Taous	02/06/2001	20	2	0	18	90	0
Sfax	Taous	09/06/2001	180	64	0	116	58.79	0
Sfax	Taous	20/06/2001	54	50	0	4	7.41	0
Sfax	Taous	08/08/2001	400	235	126	39	9.75	0
Sfax	Taous	18/08/2001	400	271	35	94	31.33	0
Sfax	Taous	28/08/2002	100	81	19	0	0	0
Sfax	Mahress1	23/06/2001	49	49	0	0	0	0
Sfax	Mahress2	21/07/2001	30	28	2	0	0	0
Sfax	Mahress3	01/08/2001	80	62	5	13	15	1.25
Sfax	Mahress4	08/08/2001	100	84	13	3	0	3
Sfax	Mahress4	18/08/2001	400	238	122	40	0	10
Sfax	Mahress4	17/03/2007	163	106	54	3	0	1.84
Sfax	Thyna1	23/06/2001	50	50	0	0	0	0
Sfax	Thyna2	23/06/2001	50	50	0	0	0	

Table1 (cont.). Details on prospected sites, numbers of collected pistachio nuts (*Pistacia vera*) and infestation percentages by *E. plotnikovi* and *M. pistaciae* during the period 2001-2007 in Tunisia

Prefecture	Commune	Date of collection	Total number of collected nuts	Number of filled nuts	Number of empty nuts	Number of damaged nuts	% *E. plotni.* infestation	% *M. pista.* infestation
Sfax	Thyna3	21/07/2001	36	34	2	0	0	
Sfax	Thyna4	18/08/2001	100	93	4	3	3	0
Sfax	Thyna5	18/08/2001	50	29	21	0	0	
Sfax	R. Gabes km15	21/07/2001	48	40	7	1	2.08	0
Sfax	R. Gabes km16	31/08/2002	78	27	40	11	7.69	6.41
Sfax	R. Gabes km17	17/03/2007	97	60	30	7	3.09	4.12
Sfax	R Gabes km 18	17/03/2007	81	55	25	1	0	1.23
Sfax	Chaal1	01/08/2001	90	65	25	0	0	0
Sfax	Chaaal2	01/08/2001	90	70	20	0	0	0
Sfax	Chaaal3	28/08/2001	50	41	9	0	0	0
Sfax	Hzeg	05/07/2001	36	27	0	9	22.22	2.78
Mahdia	Melloulech	21/05/2001	20	10	0	10	50	0
Mahdia	Hbira	14/05/2001	34	16	0	18	52.94	0
Mahdia	Hbira	21/05/2001	70	38	0	32	56	0
Mahdia	Hbira	02/07/2001	38	35	0	3	7.89	0
Mahdia	Hbira	30/07/2001	62	39	10	13	20.97	0
Mahdia	Hbira	18/08/2001	78	35	20	23	24.36	5.13
Mahdia	Hbira	20/08/2001	450	374	67	9	1.125	0
Mahdia	Chorbane1	03/08/2001	77	19	11	47	61.04	0
Mahdia	Chorbane2	20/01/2004	82	42	16	24	29.27	0
Mahdia	Souassi1	03/08/2001	76	65	11	0	0	0

Table1 (cont.). Details on prospected sites, numbers of collected pistachio nuts (*Pistacia vera*) and infestation percentages by *E. plotnikovi* and *M. pistaciae* during the period 2001-2007 in Tunisia

Prefecture	Commune	Date of collection	Total number of collected nuts	Number of filled nuts	Number of empty nuts	Number of damaged nuts	% *E. plotni.* infestation	% *M. pista.* infestation
Mahdia	Souassi2	03/08/2001	65	25	40	0	0	0
Mahdia	Souassi3	20/01/2004	74	48	7	19	25.68	0
Mahdia	Souassi1	28/03/2007	56	4	2	50	89.29	0
Sidi Bouzid	BenOun1	27/09/2001	10	10	0	0	0	
Sidi Bouzid	BenOun2	19/04/2007	78	17	15	46	58.97	0
Sidi Bouzid	BenOun3	19/04/2007	55	22	33	0	0	0
Sidi Bouzid	Mezzouna	27/09/2001	300	262	38	0	0	0
Sidi Bouzid	Ksar Ghriss	11/07/2001	84	84	0	0	0	0
Sidi Bouzid	Menzel Bouzaiene1	05/06/2002	27	24	0	3	11.11	0
Sidi Bouzid	Menzel Bouzaiene2	05/06/2002	79	68	11	0	0	0
Sidi Bouzid	Menzel Bouzaiene3	05/06/2002	100	42	57	1	1	0
Sidi Bouzid	Menzel Bouzaiene4	05/06/2002	67	41	19	7	10.45	0
Sidi Bouzid	Sidi Bouzid Est	30/01/2003	59	20	20	19	32.20	0
Sidi Bouzid	Lasoueda	30/01/2003	42	24	15	3	7.14	0
Sidi Bouzid	Gotrana	30/01/2003	39	14	20	5	12.82	0
Kasserine	Mzara1	09/05/2001	30	19	0	11	36.67	0
Kasserine	Mzara2	19/06/2001	56	20	0	36	64.29	0
Kasserine	Mzara3	21/08/2001	36	6	4	26	69.44	2.78
Kasserine	Mzara4	21/08/2001	102	20	25	57	53.92	1.96

Table1 (cont.). Details on prospected sites, numbers of collected pistachio nuts (*Pistacia vera*) and infestation percentages by *E. plotnikovi* and *M. pistaciae* during the period 2001-2007 in Tunisia

Prefecture	Commune	Date of collection	Total number of collected nuts	Number of filled nuts	Number of empty nuts	Number of damaged nuts	% *E. plotni.* infestation	% *M. pista.* infestation
Kasserine	Sbeitla1	23/06/2001	24	18	0	6	25	0
Kasserine	Sbeitla2	28/07/2001	44	15	10	19	43.18	0
Kasserine	Sbeitla3	07/08/2001	50	30	20	0	0	0
Kasserine	Sbeitla4	07/08/2001	35	10	4	21	60	0
Kasserine	Sbeitla5	07/08/2001	51	15	5	31	60.78	0
Kasserine	Rakhmet	28/07/2001	78	9	19	50	64.10	0
Kasserine	Faidh1	28/07/2001	45	35	6	4	8.89	0
Kasserine	Faidh2	07/08/2001	61	23	8	30	45.90	3.28
Kasserine	Majel Belabbes	05/04/2007	117	6	21	90	73.50	3.42
Gafsa	Gafsa city	18/06/2003	39	15	17	7	10.26	7.69
Gafsa	Elguettar1	06/04/2006	71	5	29	37	50.70	1.41
Gafsa	Elguettar2	18/04/2007	79	6	5	68	84.81	1.27
Gafsa	Elguettar3	18/04/2007	46	4	1	41	89.13	0
Gafsa	Elguettar4	18/04/2007	88	4	84	0	0	0
Monastir	Menzel Kamel1	01/06/2002	70	42	20	8	11.43	0
Monastir	Menzel Kamel2	13/03/2004	47	39	6	2	4.26	0
Monastir	Jammel	13/03/2004	100	9	12	79	79	0
Monastir	Menzel Hayet	24/03/2007	56	21	35	0	0	0
Sousse	Chott-Mariem	15/04/2005	50	5	13	32	64	0
Ben Arous	Mornag	05/10/2007	400	140	251	9	100	0
Bizerte	Mateur	19/08/2002	400	337	44	19	4.75	0
Gabès	Route Aéroport	24/10/2007	214	31	183	0	0	0
Kairouan	Sidi Saad	15/08/2002	120	87	33	0	0	0

A total of 85 sites were surveyed of which 67 were inspected once, one site twice (Souassi1), one site 3 times (Mahress4), one site 6 times (Hbira) and one site 7 times (Taous) (Table 1). The collections were done by picking at random 10 to 450 pistachio nuts from trees when they are still present or collected on the ground after harvest. Prospected sites were composed of pistachio orchards different in size and trees numbers varying from 11 to >500.

The nuts were dissected in the laboratory under binocular microscope and the numbers of filled, empty (not pollinated) and damaged pistachios were counted. The infested pistachios were sorted on eggs, larvae, pupae and adults of either *E. plotnikovi* or *M. pistaciae*. Both species are morphologically distinguishable at eggs, larval and adult stages (Figs 1-5) as well as damage features; the first species consumes entirely the kernel whereas the last species does not (Davatchi, 1958). However for more precision, nuts with exit holes were eliminated from the sample because when emerged both species practically left the same exit holes features.

We calculated: (i) the occurrence ratio = the number of sites where either *E. plotnikovi* or *M. pistaciae* or both were present / the total number of visited sites; (ii) the percentage of infestation by *E. plotnikovi* = total number of infested nuts with either eggs, larvae, pupae or adults of *E. plotnikovi* / total number of collected nuts; and (iii) the percentage of infestation by *M. pistaciae* = total number of infested nuts with either eggs, larvae, pupae or adults of *M. pistaciae* / total number of collected nuts. We included the un-pollinated nuts in the calculation of the percentage of infestation because according to Jerraya (1977) both insect species lay eggs in pollinated and un-fertilized pistachios.

III – Results

Sixty three out of 85 sites were infested of which nearly three-quarters were composed with *E. plotnikovi* alone, 19% of infested sites had both insects species and only 6% held *M. pistaciae* alone (occurrence ratio of 0.74).

The percentage of infestation varied between zero and 96%. The percentages of presence of *E*. plotnikovi and *M. pistaciae* according to prefectures are shown in Fig. 7.

Nine prefectures out of 11 were found infested. *E*. plotnikovi is present in all infested sites. Both species were present in four prefectures (Sfax, Mahdia, Kasserine and Gafsa) and only one prefecture held *M. pistaciae* alone (two sites located in Sfax prefecture; Mahress4 surveyed three times and R Gabes km 18 surveyed once, Table 1).

1. Mortality factors affecting *E. plotnikovi*

The details of eggs, larvae, pupae and adults inside nuts are given in Tables 2 and 3. Mortalities affecting *E*. *plotnikovi* are mostly shown at egg stage and small larvae. The mortalities are nil at pupae and adult stages.

2. Analysis of *M. pistaciae* infestation

A. Sfax prefecture

At the site of Mahress3, *M. pistaciae* is present with 1.25% of infestation representing only 1 infested nut out of 80 collected ones on August 1, 2001 (Table 4). This nut contained 1 female ready to emerge or failed emergence. Regarding the date, if the female succeeds emergence it will be impossible for it to lay eggs due to the hardening shell of the pistachio and would be condemned to death.

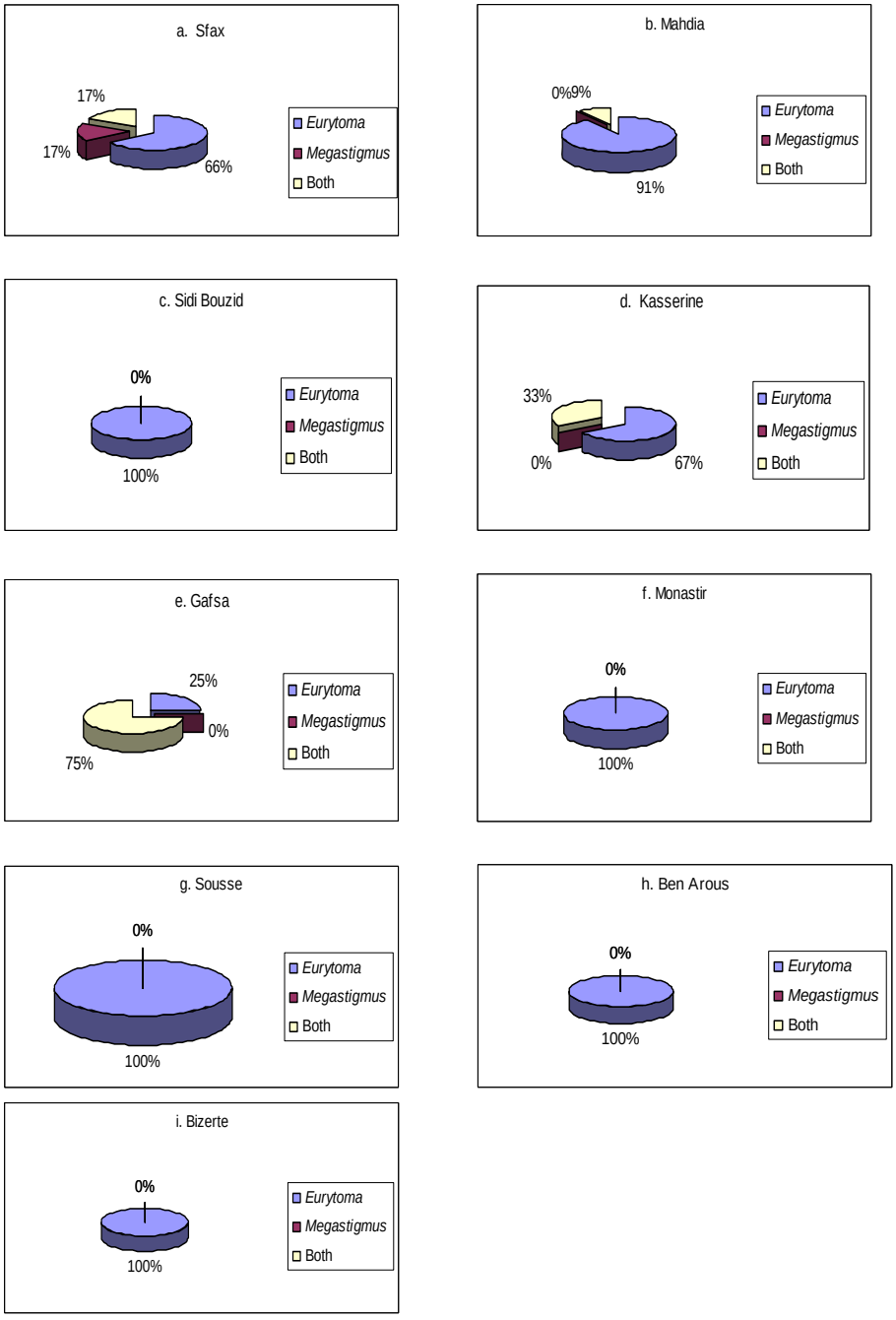

Fig. 7. Percentages of presence of *E. plotnikovi*, *M. pistaciae* in infested orchards according to prefectures (Gabès and Kairouan prefectures have zero infestation).

Table 2. Details of eggs and larvae inside nuts and corresponding percentage of mortality of *E. plotnikovi* in surveyed sites where *E. plotnikovi* is present in Tunisia during 2001-2007

Prefecture	Commune	*E. plotni.* eggs			*E. plot.* small larvae			*E. plot.* old larvae		
		Alive	Dead	% mortality	Alive	Dead	% mortality	Alive	Dead	% mortality
Sfax	Agareb1	1	0	0	27	4	12.90	0	0	0
Sfax	Agareb2	1	0	0	32	7	17.95	0	0	0
Sfax	Agareb3	12	0	0	7	0	0	0	0	0
Sfax	Agareb4	0	9	100	5	15	75	0	0	0
Sfax	Agareb5	0	23	100	17	19	52.78	0	0	0
Sfax	Agareb6	0	0	0	0	0	0	72	0	0
Sfax	Agareb7	0	0	0	0	0	0	40	0	0
Sfax	Taous	1	0	0	2	0	0	0	0	0
Sfax	Taous	0	10	100	6	2	25	0	0	0
Sfax	Taous	0	15	100	66	35	34.65	0	0	0
Sfax	Taous	0	0	0	4	0	0	0	0	0
Sfax	Taous	0	0	0	0	0	0	39	0	0
Sfax	Taous	0	0	0	0	0	0	94	0	0
Sfax	Mahress3	0	0	0	0	0	0	12	0	0
Sfax	Mahress4	0	0	0	0	0	0	0	0	0
Sfax	Mahress4	0	0	0	0	0	0	0	0	0
Sfax	Mahress4	0	0	0	0	0	0	0	0	0
Sfax	Thyna4	0	0	0	0	0	0	3	0	0
Sfax	R. Gabes km15	0	0	0	0	0	0	1	0	0
Sfax	R. Gabes km16	0	0	0	0	0	0	6	0	0
Sfax	R.Gabes km17	0	0	0	0	0	0	3	0	0
Sfax	R Gabes km 18	0	0	0	0	0	0	0	0	0
Sfax	Hzeg	0	0	0	0	0	0	8	0	0
Mahdia	Melloulech	0	2	100	8	0	0	0	0	0
Mahdia	Hbira	13	0	0	5	0	0	0	0	0
Mahdia	Hbira	10	6	37.5	16	0	0	0	0	0
Mahdia	Hbira	0	0	0	0	0	0	3	0	0
Mahdia	Hbira	0	0	0	0	0	0	13	0	0
Mahdia	Hbira	0	0	0	0	0	0	19	0	0
Mahdia	Hbira	0	0	0	0	0	0	9	0	0
Mahdia	Chorbane1	0	0	0	0	0	0	47	0	0
Mahdia	Chorbane2	0	0	0	0	0	0	24	0	0
Mahdia	Souassi3	0	0	0	0	0	0	19	0	0
Mahdia	Souassi1	0	0	0	0	0	0	50	0	0
Sidi Bouzid	BenOun2	0	0	0	0	0	0	10	0	0
Sidi Bouzid	Menzel Bouzaiene1	0	1	100	2	0	0	0	0	0
Sidi Bouzid	Menzel Bouzaiene3	0	0	0	0	0	0	0	0	0
Sidi Bouzid	Menzel Bouzaiene4	0	1	100	6	0	0	0	0	0
Sidi Bouzid	Sidi Bouzid Est	0	0	0	0	0	0	19	0	0
Sidi Bouzid	Lasoueda	0	0	0	0	0	0	3	0	0
Sidi Bouzid	Gotrana	0	0	0	0	0	0	5	0	0
Kasserine	Mzara1	3	0	0	8	0	0	0	0	0
Kasserine	Mzara2	0	0	0	36	0	0	0	0	0
Kasserine	Mzara3	0	0	0	0	0	0	25	0	0
Kasserine	Mzara4	0	0	0	0	0	0	55	0	0
Kasserine	Sbeitla1	0	0	0	6	0	0	0	0	0
Kasserine	Sbeitla2	0	0	0	0	0	0	19	0	0
Kasserine	Sbeitla4	0	0	0	0	0	0	20	1	4.76

Table 2 (cont.). Details of eggs and larvae inside nuts and corresponding percentage of mortality of *E. plotnikovi* in surveyed sites where *E. plotnikovi* is present in Tunisia during 2001-2007

Prefecture	Commune	*E. plotni.* eggs			*E. plot.* small larvae			*E. plot.* old larvae		
		Alive	Dead	% mortality	Alive	Dead	% mortality	Alive	Dead	% mortality
Kasserine	Sbeitla5	0	0	0	0	0	0	31	0	0
Kasserine	Rakhmet	0	0	0	0	0	0	50	0	0
Kasserine	Faidh1	0	0	0	0	0	0	4	0	0
Kasserine	Faidh2	0	0	0	0	0	0	28	0	0
Kasserine	MajelBelabbes	0	0	0	0	0	0	81	0	0
Gafsa	Gafsa city	0	0	0	0	0	0	4	0	0
Gafsa	Elguettar1	0	0	0	0	0	0	31	0	0
Gafsa	Elguettar2	0	0	0	0	0	0	14	0	0
Gafsa	Elguettar3	0	0	0	0	0	0	19	0	0
Monastir	Menzel Kamel1	0	0	0	8	0	0	0	0	0
Monastir	Menzel Kamel2	0	0	0	0	0	0	2	0	0
Monastir	Jammel	0	0	0	0	0	0	79	0	0
Sousse	Chott-Mariem	0	0	0	0	0	0	32	0	0
Ben Arous	Mornag	0	0	0	0	0	0	9	0	0
Bizerte	Mateur	0	0	0	0	0	0	19	0	0

Table 3. Details of pupae and adults and corresponding percentage of mortality of *E. plotnikovi* in surveyed sites where *E. plotnikovi* is present in Tunisia during 2001-2007

Prefecture	Commune	*E. plotni* pupae			Adul. *E. plot* inside nuts		
		Alive	Dead	% mortality	Alive	Dead	% mortality
Sfax	Agareb1	0	0	0	0	0	0
Sfax	Agareb2	0	0	0	0	0	0
Sfax	Agareb3	0	0	0	0	0	0
Sfax	Agareb4	0	0	0	0	0	0
Sfax	Agareb5	0	0	0	0	0	0
Sfax	Agareb6	0	0	0	0	0	0
Sfax	Agareb7	0	0	0	0	0	0
Sfax	Taous	0	0	0	0	0	0
Sfax	Taous	0	0	0	0	0	0
Sfax	Taous	0	0	0	0	0	0
Sfax	Taous	0	0	0	0	0	0
Sfax	Taous	0	0	0	0	0	0
Sfax	Taous	0	0	0	0	0	0
Sfax	Mahress3	0	0	0	0	0	0
Sfax	Mahress4	0	0	0	0	0	0
Sfax	Mahress4	0	0	0	0	0	0
Sfax	Mahress4	0	0	0	0	0	0
Sfax	Thyna4	0	0	0	0	0	0
Sfax	R. Gabes Km15	0	0	0	0	0	0
Sfax	R. GabesKm16	0	0	0	0	0	0
Sfax	R.Gabes km17	0	0	0	0	0	0
Sfax	R Gabes km 18	0	0	0	0	0	0
Sfax	Hzeg	0	0	0	0	0	0
Mahdia	Melloulech	0	0	0	0	0	0

Table 3 (cont.). Details of pupae and adults and corresponding percentage of mortality of *E. plotnikovi* in surveyed sites where *E. plotnikovi* is present in Tunisia during 2001-2007

Prefecture	Commune	*E. plotni* pupae			Adul. *E. plot* inside nuts		
		Alive	Dead	% mortality	Alive	Dead	% mortality
Mahdia	Hbira	0	0	0	0	0	0
Mahdia	Hbira	0	0	0	0	0	0
Mahdia	Hbira	0	0	0	0	0	0
Mahdia	Hbira	0	0	0	0	0	0
Mahdia	Hbira	0	0	0	0	0	0
Mahdia	Hbira	0	0	0	0	0	0
Mahdia	Chorbane1	0	0	0	0	0	0
Mahdia	Chorbane2	0	0	0	0	0	0
Mahdia	Souassi3	0	0	0	0	0	0
Mahdia	Souassi1	0	0	0	0	0	0
Sidi Bouzid	BenOun2	36	0	0	0	0	0
Sidi bouzid	Menzel Bouzaiene1	0	0	0	0	0	0
Sidi Bouzid	Menzel Bouzaiene3	0	0	0	0	0	0
Sidi Bouzid	Menzel Bouzaiene4	0	0	0	0	0	0
Sidi Bouzid	Sidi Bouzid Est	0	0	0	0	0	0
Sidi Bouzid	Lasoueda	0	0	0	0	0	0
Sidi Bouzid	Gotrana	0	0	0	0	0	0
Kasserine	Mzara1	0	0	0	0	0	0
Kasserine	Mzara2	0	0	0	0	0	0
Kasserine	Mzara3	0	0	0	0	0	0
Kasserine	Mzara4	0	0	0	0	0	0
Kasserine	Sbeitla1	0	0	0	0	0	0
Kasserine	Sbeitla2	0	0	0	0	0	0
Kasserine	Sbeitla4	0	0	0	0	0	0
Kasserine	Sbeitla5	0	0	0	0	0	0
Kasserine	Rakhmet	0	0	0	0	0	0
Kasserine	Faidh1	0	0	0	0	0	0
Kasserine	Faidh2	0	0	0	0	0	0
Kasserine	MajelBelabbes	5	0	0	0	0	0
Gafsa	Gafsa city	0	0	0	0	0	0
Gafsa	Elguettar1	5	0	0	0	0	0
Gafsa	Elguettar2	45	0	0	8	0	0
Gafsa	Elguettar3	21	0	0	1	0	0
Monastir	Menzel Kamel1	0	0	0	0	0	0
Monastir	Menzel Kamel2	0	0	0	0	0	0
Monastir	Jammel	0	0	0	0	0	0
Sousse	Chott-Mariem	0	0	0	0	0	0
Ben Arous	Mornag	0	0	0	0	0	0
Bizerte	Mateur	0	0	0	0	0	0

Table 4. Details of *M. pistaciae* infestation and percentage mortality of old larvae and adults inside nuts in sites where the insect is present. Numbers of eggs, small larvae and pupae were zero (not represented in the table)

Prefecture	Commune	*M. pista.*	old	larvae	Adults	*M. pista.*	inside nuts
		Alive	Dead	% mortality	Alive	Dead	% mortality
Sfax	Mahress3	0	0	0	1	0	0
Sfax	Mahress4	3	0	0	0	0	0
Sfax	Mahress4	2	0	0	7	31	81.57
Sfax	Mahress4	2	0	0	0	1	100
Sfax	R. GabesKm16	0	0	0	0	5	100
Sfax	R.Gabes km17	4	0	0	0	0	0
Sfax	R Gabes km 18	0	0	0	0	1	100
Sfax	Hzeg	1	0	0	0	0	0
Mahdia	Hbira	4	0	0	0	0	0
Kasserine	Mzara3	1	0	0	0	0	0
Kasserine	Mzara4	1	0	0	0	1	100
Kasserine	Faidh2	0	0	0	0	2	100
Kasserine	MajelBelabbes	0	0	0	0	4	100
Gafsa	Gafsa city	3	0	0	0	0	0
Gafsa	Elguettar1	1	0	0	0	0	0
Gafsa	Elguettar2	1	0	0	0	0	0

At Mahress4 surveyed three times (two in 2001 and one during 2007) only *M. pistaciae* is present with a percentage of infestation varying from 1.8 to 10%. The population was composed of old larvae and adults with a high percentage of dead females inside nuts varying from 81.5 to 100%.

The R.Gabes km16 and R.Gabes km17 sites both harbor *M. pistaciae* and *E. plotnikovi*. In the first site the population of *M. pistaciae was* composed only of dead females inside the nuts who failed to emerge (August, 31, 2002) and the second with diapausing larvae (Table 4).

The site of Hzag, surveyed on July 5, 2001 represents a low percentage of infestation by *M. pistaciae* (2.77%) composed of only one diapausing larva.

B. Mahdia prefecture

The site of Hbira surveyed on August 18, 2001 with a percentage of infestation by *M. pistaciae* of 5.12 was composed of diapausing larvae (Table 4).

C. Kasserine prefecture

The sites of Mzara3 and Mzara4 surveyed on August 21, 2001 were infested by both species where *E. plotnikovi* predominates (Table 1). *M. pistaciae* population was composed of diapausing larvae (one larva by site) plus the last site which has a dead female inside the nut (Table 4).

The sites of Faidh2 and MajelBelabbes surveyed on August 7, 2001 and April 7, 2007 harbored both insects with a low percentage of *M. pistaciae* infestation (Table 1). Both sites were composed of dead adult females inside nuts (100%) (Table 4).

D. Gafsa prefecture

Three sites (Gafsa city, Elguettar1, Elguettar2) harboring both insects where *E. plotnikovi* predominates. *M. pistaciae* populations were composed of diapausing larvae (Table 4).

IV – Discussion

Our study shows that *E. plotnikovi* is widely distributed in Tunisia outperforming *M*. *pistaciae*. Similarly, in Iran, surveys carried out by Basirat and Seyedoleslami (2000) in Isfahan province to determine the presence and damage levels by *E. plotnikovi* and *M. pistaciae* showed that the first insect was the dominant species and its damage varied between 0.8 -75%. Jalilvand and Gholipour, (2002) found in Qazvin province similar results with 92.5% frequency for the first species compared with 2.5% frequency for the last one beside 5% frequency presence for *Cyrtoptyx pistaciae*.

Four hypotheses may explain the occurrence of *E. plotnikovi* according to *M. pistaciae :* the adult emergence periods, the aptitude of development in unpollinated nut, the pesticides applications and the prolonged larval diapause. We evaluated each of these in turn: (i) the early emergence of the first species (about one month earlier) permits the rapid colonization of Pistachio nuts already available. Braham (2005) indicated that adult emergence begins in late April early May and egg laying started in early May picking on May 6 and May 18. According to Jerraya (1977) adults appear during the month of May and continue flying until mid June. However *M. pistaciae* adults were noticed from the end of May to early June (Jerraya and Bernard, 1971); (ii) It is much likely that *E. plotnikovi* is capable of developing in unpollinated, unfertilized nuts; which allows it to survive periods of low pollination (Braham, personal observation). However, that possibility needs to be further investigated; (iii) usually, chemical treatments operated to manage both insects were undertaken in late May June using contact insecticides to kill adults. At that period, most of females *E. plotnikovi* had already laid eggs. In fact our observations showed that attacked nuts (bearing eggs or small larvae) do not always show signs of insect infestation and are presumably un-attacked and hence controls are ineffective. However adults of *M. pistaciae* had begun their emergence and logically were killed; and (iv) the ability of the species to extend larval diapause in pistachio up to four years allowing it to bridge periods when nuts were unavailable, (e.g. in 2007, flowering and fruiting were affected by the occurrence of mild autumn and winter given no nut production).

M. pistaciae suffers high adult mortality particularly for the summer generation (Table 4). When we consider all sites where the species is present, 85% of adults failed to emerge and were found dead inside pistachio nuts. (e.g. in Mahress4 where *E. plotnikovi* is absent 81.6% of adult *M. pistaciae* was observed on August 18, 2001 and 100% adult mortality on March 17, 2007).

Our survey demonstrates that *E. plotnikovi* is the major insect attacking Pistachio nut. The insect is spreading occupying areas where the concurrent species *M. pistaciae* was in the past known as the main pest mainly in the south regions. We can assume that the first species dominates in nearly all growing *Pistacia vera* regions in Tunisia and constitutes the major insect pest for which control is urgently needed.

To better understand the mechanisms involving the decrease of *M. pistaciae* populations and its possible extinct, much more studies relating to the biology and ecology of both species are required. Those relating to *E. plotnikovi* are being done, but much less than those related to *M. pistaciae* due mainly to the scarcity of its population.

Acknowledgements

This article is dedicated to our colleague and friend Rachid Cherif who passed away too early. Most of this work was done in Olive Institute of Sfax when the first author was a researcher there. We wish to thank Dr T. Jardak, the former General Director of the Institute and Dr M. Ksantini for their help and suggestions. We also thank Dr Jean-Yves Rasplus (INRA Montpellier) and Dr Alain Roques (INRA Orléans) respectively for *E. plotnikovi* and *M. pistaciae* species confirmation.

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