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ALMOND SEED WASP, EURYTOMA AMYGDALI, A NEW FRUIT PEST IN THE ROMANIAN FAUNA

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Abstract

The almond seed wasp (Eurytoma amygdali Enderlein) is a wasp from the order Hymenoptera, Eurytomidae family. The almond wasp is an important pest for almonds in the European, the Caucasus and the Middle East almond growing countries. In Romania the almond crop has regained interest among farmers. Recent observations confirm that this insect is present also in Romania, in the Dobrogea region. Almond fruits attacked by Eurytoma amygdali have been collected from the spontaneous flora, kept in laboratory conditions and microscopically observed, before, in time and after pupation. This paper might be of interest for farmers, pest-control products companies, as well for the pheromone traps R & D industry.

Key words*: almonds, pest control, ecologic.*

INTRODUCTION

The almond seed wasp (ASW), *Eurytoma amygdali* Enderlein, is the most important pest of almond fruits in Europe. Different authors reported damages up to 50% of the yield, in Bulgaria (Ivanov, 1960), over 70% losses (Zerova & Fursov, 1991), Cakar (1980) reported damages up to 71%, in former Yugoslavia, 35-79% in Greece (Mentjelos & Antjemis, 1970). The presence of the ASW has been reported in many countries in south-eastern Europe, Middle East and some of the Mediterranean countries. In Romania this species hasn't been reported, but Perju (2002) presumed in his book that the ASW can be found in the Dobrogea area.

Over the time, the ASW has been confused with the plum seed wasp, *Eurytoma schreineri* Schr. Schreiner reported in 1908 in Russia, in the Astrakhan region, a pest for the plum seeds, considering being the ASW. Over the years, in 1925, Ustinov finds the same plum wasp in Ukraine. In fact it was a new species, *Eurytoma schreineri* Schr., the differences between the two species, considering the morphologic characters, have been done by Nikolskaia in 1961 (Minoiu & Lefter, 1987).

The ASW is a univoltine and a monophagous species, feeding on different species of almonds, as *Prunus bucharica, Prunus dulcis, Prunus fenzliana, Prunus scoparia* (Golestaneh et al., 2013). It oviposits in March-April into the nucellar tissue of the developing seed in the almond. The larva feeds with the seed until all or almost the entire embryo is consumed. The larva then enters diapause within the intact seed integument. At that time, by the end-May-beginning-June, the fruit shrivels, and it changes from green to grey or yellowish grey (Figure 1). Most of the infested fruits remain attached to the tree past harvest time and well into the next year. Their color gradually turns dark grey to almost black, the change being caused by saprophytic fungi. The larvae pupate in March and the wasps emerge in March-April (Plaut, 1971).

The imago encloses in March-April (end of April in Romania) from the pupa within the infested fruit. It gnaws a hole through the thin parched integument of the emptied seed and through the hard shriveled pericarp of the fruit

(Figure 2), through which it then emerges (Plaut, 1971).
According to Cakar (1980) in Yugoslavia 87.5% of larvae break diapause and pupate in the first year, 12% pass into adulthood in the second year, and 0.5% of larvae remain in diapause more than two years.

Figure 1. Almond fruits shriveled, changed it's color from green to grey or yellowish grey

In laboratory conditions, Plaut (1973) showed that females were attracted to almond fruits and males were not. Fresh almond leaves had little to none, attraction for females.
Nourbakhsh (1998) found that, young almond fruits are sensitive to wasp drilling and usually fall in the first stages of growth. In contrast, the larger ones remain on the tree, and *E. amygdali* larvae feed with their kernel.
Many researchers have tried to understand the behavior of ASW females and on which criteria they choose in which fruit to oviposit. Some presume that certain chemical stimuli (kairomones) emitted from the unripe fruits of almond cultivars might influence the host finding behaviour of females. These compounds may not be present at adequate or specific ratios in all the genotypes and cultivars (Saeidi, 2021).
Flight and other activities were observed and summarized. In sunny weather the wasps concentrated in the morning on the eastern side, and in the afternoon on the western side of the trees. Males were often observed in a flying "dance", oscillating slowly in a horizontal line in a plane parallel to the periphery of the tree, at a distance of about 10 cm from the tree and at amplitude of about 6 cm, singly or in swarms of up to about 60 individuals. Males and females were observed alighting on the upper side of leaves and sitting or walking there, much more often than on the underside. Females were observed on fruits, probing or ovipositing; males were seen to alight nearby and court them. Sometimes two to four females sat on the same fruit, although there was no lack of unoccupied fruit in the vicinity. Plaut (1973) concluded that the wasps tend mainly to remain in the tree crown in which they emerged. No correlation between fruit load and amount of infestation by the almond wasp of individual trees was observed.
The almond trees are supposed to be present in Dobrogea area since ancient times. The Greek colonists, that built many fortresses in the area, on the Pontus Euxin shores, along the Danube and in land, brought with them, among other cultivated species, almonds (Cociu, 2011). The soil is dryer and calcareous, favourable to this crop and in some areas, the almond can be found in the spontaneous flora.
The almond crop is regaining in interest for the Romanian farmers. In Dobrogea, new almond orchards have been established in the last decade.
The purpose of this paper is to report the presence of the almond seed wasp (*Eurytoma amygdali* Enderlein) in Romania. This article can be of interest for farmers who intend to develop new orchards or possess one and also for the researchers in the field.

MATERIALS AND METHODS

Almond fruits containing ASW were collected from the spontaneous almonds situated in northern Dobrogea, in Greci, Tulcea County.
The fruits were collected in mid-December 2021, kept in cold conditions for two months. In February 2022, fruits have been deposited under laboratory condition at temperature

room, around 22-24°C, in petri dishes. After around 15 days the adults started to perforate the fruit and come out of it (Figure 2). Some of the fruits were cracked to evaluate the larvae and the pupae.

Figure 2. Almond perforated by the *Eurytoma amygdali*

The larva, pupae and adults of *Eurytoma amygdali* were microscopically examined at the Research Center for Studies of Food Quality and Agricultural Products, of USAMV of Bucharest.

The morphological characters of larvae and adults were compared with those presented in the dichotomic identification key of Plaut (1972) Zerova & Fursov (1991) for adults.

RESULTS AND DISCUSSIONS

The morphological identification was based on both the larvae and the adult's morphological characters. *Eurytoma amygdali* can be distinguished from other *Eurytoma* spp. of stone fruits by the following characters. Mesepisternum is without a keel at the ventral margin, the gaster of the female presents a distinctly upturned apex (Figure 5), the tergite 7 is almost twice as long as the tergite 6, the forewing has a distinctly darkened spot on the disc and the gastral petiole is distinctly longer than the hind coxa (Zerova & Fursov, 1991).

The larva (Figure 3) was described by Plaut (1972), as white (sometimes gray), except for the brown mandibulae, its body being composed by the head and 12 segments, is legless, with a tapering posteriorly; length of the neonates is 0-47 mm, and of the grown larvae, up to 10 mm.

The larvae hatch during late March and April (May in Romania), after the fruit has grown to its final size, but while the embryo is still small. After hatching, the larvae move through the nucellus and the embryo sac to feed on the embryo. Usually, the embryo grows to its normal size, supplying the larva with sufficient food for its entire development. When the larva is full grown, all that remains of the seed is the shriveled seed coat, some embryonic debris and the larval excrements. The larva then enters diapause, diminishing somewhat in size.

Although up to five eggs per fruit have been observed under natural conditions, and two eggs per fruit are common, not more than two grown larvae per seed have been found, and this very rarely.

Figure 3. Larvae of *Eurytoma amygdaly* (original)

The larva exits diapause and pupates in January-February (March-April in Romania), and adults emerge after the flowering stage of the almond in March-April. Infested fruits of almond shrivel but remain attached to the tree.

Not all larvae break diapause in the first year, and some may not emerge until two or three years after oviposition (Zerova & Fursov, 1991).

The pupa (Figure 4) changes in color from white to almost entirely black during its development. The fresh pupa is entirely white and the last larval exuvia remains attached to the tip of the abdomen. Plaut (1972) noticed that the males develop faster than the females.

The identification key of the adult ASW is described by Zerova & Fursov (1991), as it follows.

The Female (Figure 5), has the length of 7-8 mm, sometimes 5-6 mm. The body is slender, elongated, with the gaster narrowed apically. Body, antennae, coxae, hind and femora are black; fore and middle femora fuscous medially, brown basally and apically. All tibiae are reddish, only medially is slightly fuscous. The tarsi is dark yellow, apical segments are fuscous.

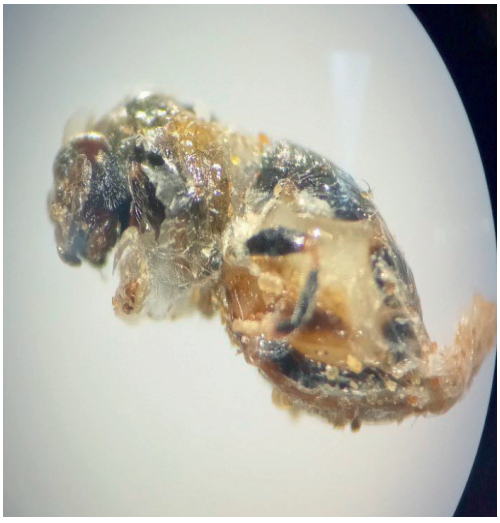

Figure 4. Pupae of *Eurytoma amygdaly* (original)

The head dorsally is slightly broader than the pronotum, in frontal view is broader than high. The eyes are small; gena distinctly longer than longitudinal diameter of eye. The clypeus is with a smooth ventral margin; the face above clypeus is with a few slender, indistinct, short carinae. The head and thorax are dorsally with a large setigerous punctures, are round, distributed sparsely and surrounded by a smaller foveae. The pubescence of the head and thorax is long, dense and silver-white. The antennae are inserted higher than the median part of the face. The scrobes are deep clearly margined. The Scape is distinctly swollen medially. The funicle is long, slender, with a short pubescence, 6 segmented. The club has 2 segmented.

The thorax is slightly convex; the pronotum 2.5 times as broad as long. The mesepisternum is slightly concave ventrally, without keel. The propodeum is widely concave medially, with a large median carina and large irregular foveae in laterally. The hind coxa is densely pubescent, with a dense foveate sculpture and a small vertical comb distally.

The gaster is slightly longer than the head plus thorax. The surface of the tergites is with indistinct punctures. The tergite 9 elongates, and is not shorter than the targite 8. The gaster is rounded, the petiole slightly longer than the hind coxae.

The forewing is with a distinct large fuscous, marking in the middle part of the disk. The veins are dark-brown.

Figure 5. Adult female of *Eurytoma amygdaly*

The male (Figure 6) has the length of 5-6 mm. Has the color and the sculpture as the female. The antennae presents 7 segmented flagellum, which is not clearly separated into the funicle and the club. The pubescence of the flagellum is short; the segmental setae are about equal in length to the width of segments.

E. amygdali it's a phytophagous species, that feed only by the fruits of *Amygdalus communis,*

A. fenzeliana and *A. bucharica* (the latter two are new host records for this species). This species is restricted to the genus *Amygdalus,* and records from other host plants are probably erroneous.
This species was described by Enderlein (1907) from material reared from the fruits of *A. communis.* Records of *E. amygdali* from plum most probably refer to *E. schreineri.*
Furthermore an attempt to extract the DNA barcode, by the larvae and adults had been initiated, by a DNeasy blood & tissue kit, without any success.
The differences between the ASW and the plum seed wasp are very little. Different papers (Duval & Millan, 2008; Talmaciu et al., 2006a; 2006b) point out that the same products were used to combat both of the species. Thus we can take in consideration also the measurements of control of the plum seed wasp populations.

Figure 6. Aldult male of *Eurytoma amygdaly*

It has been observed the presence of the ASW for many years in the area, and it can be presumed that it is in big numbers, as the wild almonds aren't pest treated.
For an integrated pest management insecticides based on lambda-cyhalothrine and deltramethin have been successfully applied on plum to combat *Eurytoma schreineri* (Talmaciu et al., 2006), almond (Duval & Millan, 2008). Some argue that the ASW can be successfully controlled with one treatment, if it is applied in the right moment (Katsoyannos et al., 1992).
Minoiu & Lefter (1987) are recommending to incorporate into the soil, the fruits that turn yellowish and fall from the tree, for a better combat of the plum seed wasp. This would work for the ASW as well, considering the close biology of the two species. A good way of doing this is by working the soil between plants per row, under the canopy, after the fruits fall in June.
The biological pest control of the ASW could be achieved, in certain conditions. Soil working between plants per row would be a necessity, collecting the mummified fruits remained in the trees, and applying certain foliar treatments. As some indicated, azadirachtin cannot be used to combat the plum seed wasp (Talmaciu et al., 2006a; 2006b). Some biological insecticides based on spinosad, are homologated for combating *Euritoma schreineri* in Romania. These measures could represent a very efficient control of the ASW population in the almond orchards, in Romania.
To keep the populations under control, it is recommended to place bottles with glass tube with infested almond fruits, placed in the orchards for detecting the first adult emergences in the field. One or two days after the first emerged male, it is recommended to apply foliar treatments in the orchard (Duval & Millan, 2008).
The present mention comes in the help of farmers to understand, identify and to keep under control the ASW populations in their plantations. The paper also provides new opportunities for the researchers in the field, to find out ways to better understand this species, and it's behavior, to elaborate new control strategies to keep the ASW populations under control in plantations.

CONCLUSIONS

Eurytoma amygdali has been identified as the pest found in the fruits collected from the wild almonds in Greci, Tulcea County.
Morphological observations and the behaviour of the pest, points out the ASW is the species affecting the almond fruits in the region.
The nowadays advances in technology offers methods of pest management both integrated and biologically.
Further studies are required to establish the period of emergence and the efficiency of the different products on the market.

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