OBSERVATIONS ON THE OVERWINTERING FORMS OF
SCOLYTUS AMYGDALI (COLEOPTERA: CURCULIONIDAE)
IN TUNISIA

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ABSTRACT: The almond bark beetle, Scolytus amygdali is an economically important insect pest of many cultivated species of stone fruit trees grown in the Mediterranean region. During the winter in the center region of Tunisia, the activity of this beetle pest decreases and it overwinters in larval forms. The mean number of entrance holes during the winter was 31 (± 27.155). The attack number gradually decreased from October to December and it was significantly different during the sampling dates. The attack number and the date of sampling are negatively related. Same observation was noticed for the number of oviposition. The composition of the overwintering population of S. amygdali showed that the most available forms were; young larvae followed by old larval stages and pupal stages. Larvae of S. amygdali entered into overwintering behavior from late November. The life cycle of S. amygdali restarts when temperature goes warmer (late February).

KEY WORDS: Overwintering population, Scolytus amygdali, Tunisia.

The cultivated almond tree, Prunus dulcis (Mill.) is planted in all regions of Tunisia but has the greatest economic importance in the centre and south regions (Demangeon, 1932). This tree is attacked by many pests and diseases, among them the bark beetle Scolytus amygdali Geurin-Meneville 1847 (Coleoptera: Curculionidae) is considered as a serious insect pest (Cherif & Trigui, 1990; Zeiri et al., 2010; Zeiri et al., 2011a,b). The damage caused to infested trees is usually destruction of the phloem which results in death of the host tree (Avidov & Harpaz, 1969; Elzinga, 1997). This bark beetle is an economic insect pest of many cultivated species of stone fruit trees especially peach, plum, apricot, and almond throughout the Mediterranean region but only a few studies on this beetle have been carried out in Tunisia (Cherif & Trigui, 1990; Zeiri et al., 2010; Zeiri et al., 2011a,b). In Morocco, Benazoun (1983) gave a detailed study on its biology. However, despite the various studies of S. amygdali performed throughout the Mediterranean region few gave any specific information about the exact number of larval instars (Benazoun, 1983) or the forms of the overwintering population of this pest.

The aim of this study was to investigate the overwintering forms of S. amygdali and composition of the population during winter as a data gathering exercise to improve effective pest management.
MATERIAL AND METHODS

Insects and host material
We set up the experimental material for this study in an orchard in the center of Tunisia [09G29’00”; 39G59’40”] during the winter of 2010. Host trees were chosen randomly covering the entire orchard. Five healthy branches (50–60 cm long) were cut from different trees every week during the early winter starting from 23rd October 2010 until 29th November 2010 (when we found the active period of attack by S. amygdali stopped). We then installed the cut branches 1 m from ground level on a randomly selected tree. The cutted experimental branches were spaced with equal distances between them and left for possible attack by S. amygdali in the field on different arbitrary trees. We recorded meteorological data for the experimental field daily.

Branch dissection
After fifteen days, the material was returned to the laboratory for dissection. Every week, three branches of each observation date were examined. At each examination the branches were examined for beetle entrance holes, each of which corresponded to one attack by a new pest insect. The attack rate was calculated by subtracting the initial hole count from the final hole count. This accumulation of entrance holes was converted to an estimation of pest density per unit area, based upon the assumption that the sample branch was a cylinder of measured circumference and height 50 to 60 cm.

For a descriptive analysis, the hole density was compared across dates by means of ANOVA tests, and probable correlation was studied using SPSS version 17.0.

The attack number (AN) was given to represent the number of maternal galleries. As there was no previous work about the precise number of larval instars of S. amygdali, analyzed larvae were divided into two groups: young larvae and mature larvae, based on size and distribution in the gallery system. The female fecundity (oviposition rate), the percentage of young larvae, the percentage of mature larvae, and the percentage of pupae under the bark were calculated for all dates.

RESULTS

Temperature and precipitation conditions of the experimental almond orchard
During October the temperatures ranged between a maximum of 26.7 °C and a minimum of 24.4 °C. The temperature started decreasing from November (21.6 °C) to January (17.5 °C). It started to rise again from February until it reached 20.5 °C in March.

Variation of entrance holes during the winter
The variation of the mean number of holes per branch counted by date of observation with the temperatures and the precipitation are shown in the Figure 1. The cumulative number of holes and its variation with date of observation shown in Figure 1 indicate that the rate of attack decreased as the winter progressed. The mean number of entrance holes during the winter was 31 (± 27.15) with a minimal and maximal values of 0 and 63 respectively. A sum of 155 holes has been counted in total.

Attack number and fecundity
The attack number (AN) per week ranged from a mean of 20.95 (±0.78) on 23 October to 11.69 (± 4.36) on the 3rd November (Fig. 2). It again increased on 10
November and decreased by the end of the month until it reached 0 in December. The results show a statistical difference for the number of attacks (F = 61.10; df (6); P = 0.000) and the fecundity represented by the number of eggs/female during the winter (F = 7.10; df (6); P = 0.000) over 6 months of sampling. There was a negative correlation between the sampling date and the number of attacks (R = -0.24; P = 0.002). The same observation was noted for the fecundity (R = -0.15; P = 0.000). On both criteria the level of infestation decreased through the winter as temperatures became lower.

**Composition of the hibernation population of S. Amygdali**

The composition of the overwintering population of *S. amygdali* in terms of percentage (Fig. 3) shows that the most abundant forms were young larvae followed by mature larval stages. We found pupal stages appearing from February onwards into March, when the temperature became warmer than the winter. Starting from March, adults of the winter generation began to emerge and search for suitable hosts for feeding and reproduction. Some pupal forms of the almond bark beetle were found during the winter (Fig. 4a) but it seems that most overwinter as young larvae or mature larvae (Figs. 4b,c,d) in hibernation tunnels (Fig. 5).

**DISCUSSION**

During the winter of 2010/2011, we found that larvae of *S amygdali* entered into overwintering behavior from late November until February when pupal forms started to appear. The adult beetle attack activity estimated by the number of new entrance holes stopped during December, and there were no flying adults observed. A similar observation was made in the relation to the behavior of females in terms of the number of maternal galleries and fecundity, as measured by the number of larval side galleries. Both parameters decreased as temperatures became colder. The most commonly encountered overwintering forms were larval stages, which remained inactive throughout the winter and only resumed their activity from the second week of February of the following year when the temperature started to increase a little. Pupation occurred, and the first swarming adults appeared, from the end of March into the first week of April. Similar observations were reported for this pest in Tunisia in the region of Sfax (Cherif & Trigui, 1990). These authors noted that the overwintering forms were mainly larvae, with a few pupae and emergence of overwintering forms was in March (Cherif & Trigui, 1990). In Morocco, the winter generation of *S. amygdali* was seen to fly in February (or early March) to the end of April (Benazoun, 1983). Buhroo & Lakatos (2007) noticed similar behavior in the related *Scolytus nitidus* which overwinters in its larval stages from the last week of November to the end of February, with the first swarming adults appearing in the third week of April. Observations of *S. scolytus* on elm (Beaver, 1967) and of *S. mali* on apple (Rudinsky et al., 1978), also recorded overwintering in the larval stages. However, Masood et al. (2009) revealed that the mango bark beetle, *Hypocryphalus mangiferae* overwintered as an immature adult under the phloem from late November to early February to avoid temperatures as low as 15 °C resuming its activity in mid-January. Another strategy is found in the banded elm bark beetle, *Scolytus schevyrewi*, which overwinters as pupae or as newly eclosed adults under the bark that then emerge from April to May (Li et al., 1987; Yang et al., 1988; Wang, 1992; Liu & Haack, 2003).

It is likely that the differences in the overwintering behavior of bark beetle species can be explained by a combination of species-specific variation and
different environmental factors as well the variation of the biochemical composition of host trees (Ayyberk & Cebeci, 2010). Information on the timing of hibernation and the life stages involved should help in programs to control the almond bark beetle. This work suggests that more detailed studies are needed in order to understand better its biology and to prepare a strong database to fight this pest attacking many important economic trees and also forest trees.

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LITERATURE CITED


Figure 1. Evolution of cumulated holes, entrance holes of S. amygdali with temperature and precipitation during the winter.

Figure 2. Variation of the attack number and fecundity during the winter.
Figure 3. Composition of the overwintering population of *S. amygdali* (in percentage).

Figure 4. Hibernation forms of *S. amygdali* under the Scanning Electron Microscope: a. pupa in dorsal view, b. larva in ventral view, c. larva in lateral view, d. larval cephalic capsule in lateral view.

Figure 5. Hibernation tunnels of *S. amygdali* in the sapwood of host.