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

A. Zeiri*, H. Ayberk, A. A. Buhroo***, M. Braham**** and M. Braham*******

* Department of Biology, Faculty of Sciences of Bizerte, Bizerte, TUNISIA. E-mail: asma_zairi@yahoo.fr
** Department of Forest Entomology and Protection, Faculty of Forestry, Istanbul University, Istanbul, TURKEY.
*** P. G. Department of Zoology, University of Kashmir, Hazratbal, INDIA.
**** Laboratory of Entomology, Regional Center of Research on Horticulture and Organic Agriculture, The University of Sousse, Sousse, TUNISIA.
***** Department of Olive tree Physiology, Institute of the Olive Tree Station of Sousse, TUNISIA.

[Zeiri, A., Ayberk, H., Buhroo, A. A., Braham, M. & Braham, M. 2015. Observations on the overwintering forms of *Scolytus amygdali* (Coleoptera: Curculionidae) in Tunisia. Munis Entomology & Zoology, 10 (1): 209-214**]**

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 eh 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 1m 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 shows 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 (Ayberk & Cebeci, 2010). Information on the timing of hibernation and the life stages invovled 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.

ACKNOWLEDGEMENTS

The authors would like to thank the Regional Center of Research on Horticulture and Organic Agriculture (CRRHAB) and the Olive Institute for the valuable help in the field and the laboratory work.

LITERATURE CITED

Avidov, Z. & Harpaz, I. 1969. Plant Pests of Israel. Jerusalem: Israel University Press.

Ayberk, H. & Cebeci, H. 2010. *Scolytus rugulosus* (Müller) (Coleoptera, Scolytidae)- a new pest of *Acer undulatum* Pojark in Turkey. Journal of Animal and Veterinary Advances, 9 (17): 2325-2326.

Balachowsky, A. 1949. Faune de France, Coleopteres Scolytides. Paul Lechevaleir, Paris.

Beaver, R. A. 1967. Notes on the biology of the bark beetles attacking elm in Wytham Wood, Berks. Entomologist's Monthly Magazine, 102: 156-162.

Benazoun, A. 1983. Etude bioécologique sur les scolytes de l'amandier *Ruguloscolytus amygdali* GUERIN (Col, Scolytidae) au Maroc. Thèse de doctorat d'état en sciences naturelles. Univ. Paris. VI. Pp. 140.

Benazoun, A. & Schvester, D. 1990. Biologie et cycle de *Scolytus (Ruguloscolytus) amygdali* GUERIN au Maroc. Actes de l'Institut Agronomique et Vétrinaire Hassan II, 10: 21-34.

Bolu, H. & Legalov, A. A. 2008. On the Cucurlionoidea (Coleoptera) fauna of Almond (*Amygdalus communis* L.) Orchards in South-eastern and Eastern Anatolia in Turkey. Baltic Journal of Coleopterology, 8: 75-86.

Buhroo, A. A. & Lakatos, F. 2007. On the biology of the bark beetle *Scolytus nitidus* Schedl (Coloeoptera: Scolytidae) attacking apple orchards. Acta Silvatica et Lignaria Hungarica, 3: 65-74.

Cherif, R. & Trigui, A. 1990. *Ruguloscolytus amygdali* Guerin [*Scolytus amygdali*], scolytid of fruit trees in Noyau in the mid-southern regions of Tunisia. Annales de l'Institut National de la Recherche Agronomique de Tunisie, 63 (1): Note I. p 12.

Choate, P. M. 1999. Introduction to the identification of beetles (Coleoptera). Dichotomous Keys to some Families of Florida Coleoptera. Wood, Berks. Entomologist's Monthly Magazine, 102: 156-162.

Demangeon, A. 1932. La situation économique de la Tunisie. In: Annales de Géographie. t. 41, n°231. Pp. 326-327.

Elzinga, R. J. 1997. Fundamentals of Entomology. 4th edn, Upper Saddle River, New Jersey: Prentice Hall.

Janjua, N. A. & Samuel, C. K. 1941. Fruit pests of Baluchistan. Imperial Council of Agricultural Research, 42: 12-28.

Kinawy, M. M., Tadors, A. W. & Abdallah, F. F. 1991. On the biology of the shot-hole bark beetle *Scolytus amygdali* Guer. (Coleoptera: Scolytidae) on pear trees in Egypt. Bulletin of Faculty of Agriculture-University of Cairo, 42: 119-128.

Li, Q. X., Jiang, X. M. & Liu, F. Z. 1987. Preliminary study on the biology of elm bark beetle *Scolytus schevyrewi* (Coleoptera: Scolytidae). Journal of August 1st Agriculture College: 12-18 (In Chinese).

Liu, H. & Haack, R. A. 2003. *Scolytus schevyrewi*: pest report from the exotic forest pest information system for North America. Updated 29.05.2012. Available from: http://spfnic.fs.fed.us/exfor/data/pestreports.

Mandelshtam, M. Y. & Pterov, A. V. 2010. *Scolytus stephani* sp. n.- a new species of bark-beetle (Coleoptera, Curculionidae,Scolytinae) from Northern India with a key to Indian *Scolytus* Geoffroy, 1762 species. Zookeys, 56: 171-178.

Masood, A., Saeed, S., Sajjad, A. & Ali, M. 2009. Life Cycle and Biology of Mango Bark Beetle, *Hypocryphalus mangiferae* (Stebbing), A Possible Vector of Mango Sudden Death Disease in Pakistan. Pakistan Journal of Zoology, 41: 281-288.

Mendel, Z., Ben-Yehuda, S., Marcus, R. & Nestel, D. 1997. Distribution and extent of damage by *Scolytus* spp. to stone and pome fruit orchards in Israel. Insect Science and its Application, 17: 175-181.

Picard, F. 1921. Sur deux scolytes des arbres fruitiers et leurs parasites. Bulletin de la Société de pathologie végétale de France, 8: 16-19.

Rudinsky, J. A., Vallo, V. & Ryker, L. C. 1978. Sound production in Scolytidae: Attraction and stridulation of *Scolytus mali* (Col.: Scolytidae). Zeitschrift für Angewandte Entomologie, 86: 381-391.

Russo, G. 1931. Contributo alla conoscenza degli Scolytidi II. Lo scolitide del mandorlo: *Scolytus amygdali* (Guèr.). Note biologiche. Bollettino del Laboratorio di zoologia generale e agraria della R. Scuola superiore d'agricoltura in Portici, 25: 327-349.

Wang, Z. T. 1992. *Scolytus schevyrewi* Semenov. In: Xiao, G-R (editor) Forest Insects of China (2nd edition), Beijing: China Forestry Publishing House, pp. 633-634 (In Chinese).

Yang, P. H., Hu, Z. L., Zhao, Z. L., Gao, Y. T. & Liu, Y. J. 1988. A preliminary observation on the bionomics of *Scolytus schevyrewi* Semenov. Shaanxi Forest Science and Technology, 1988: 38-41 (In Chinese).

Youssef, N. A., Mostafa, F. F., Okil, A. M. & Khalil, H. R. 2006a. Certain factors affecting infestation of apricot trees with *Scolytus amygdali* in Fayoum. Annals of Agricultural Science, 51: 541-550.

Youssef, N. A., Mostafa, F. F., Okil, A. M. & Khalil, H. R. 2006b. Seasonal flight activity of Scolytus amygdali Guer on apricot trees by using traps logs at Fayoum Governorate. Fayoum. Journal of Agricultural Research and Development, 12: 186-191.

Youssef, N. A., Mostafa, F. F., Okil, A. M. & Khalil, H. R. 2006c. Laboratrory studies on shot-hole borer *Scolytus amygdali* Guer, attacking apricot trees and its associated parasitoids at El-Fayoum Governorate. Annals of Agricultural Science, 51: 523-530.

Zeiri, A., Braham, M. & Braham, M. 2011a. First record of *Cephalonomia hypobori* on *Scolytus amygdali* in Tunisia. Tunisian Journal of Plant Protection, 6: 43-47.

Zeiri, A., Braham, M. & Braham, M. 2011b. Laboratory Studies of the Almond Bark Beetle *Scolytus amygdali* Geurin-Meneville, (Coleoptera: Curculionidae: Scolytinae) collected in the Center Region of Tunisia. International Journal of Entomology, 2: 23-30.

Zeiri, A., Mitroiu, M., Braham, M. & Braham, M. 2010. First record of *Cerocephala eccoptogastri* (Hymenoptera: Pteromalidae) on the Almond bark beetle (*Scolytus amygdali* GUERIN) (Coleoptera: Scolytidae) in Tunisia. Analele Ştiinţifice ale Universităţii Al I Cuza"Iaşi,s Biologie animal, 55: 91-95.

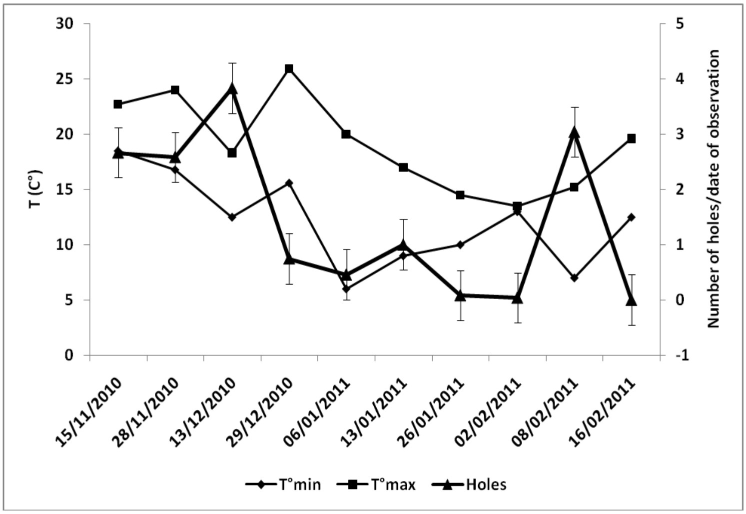

Figure 1. Evolution of cumulated holes, entrance holes of *S. amygdali* with temperature and precipitation during the winter.

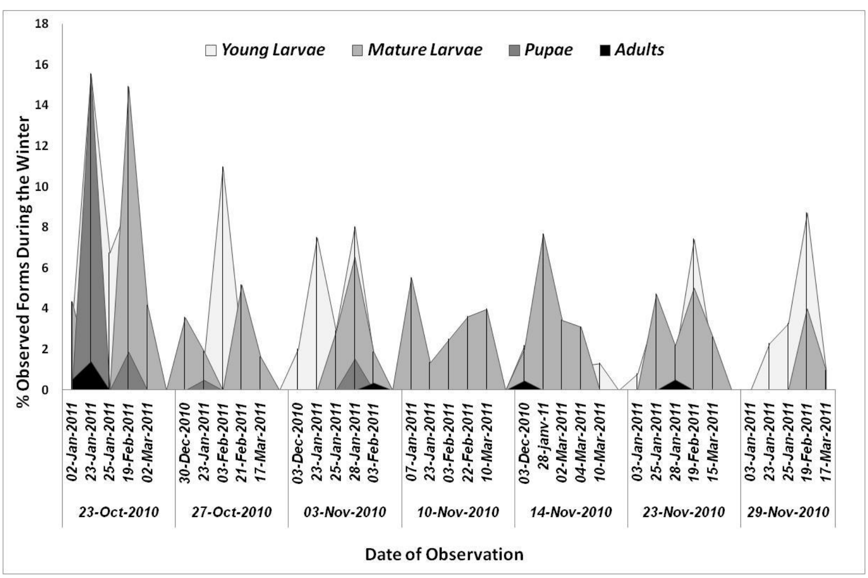

Figure 2. Variation of the attack number and fecundity during the winter.

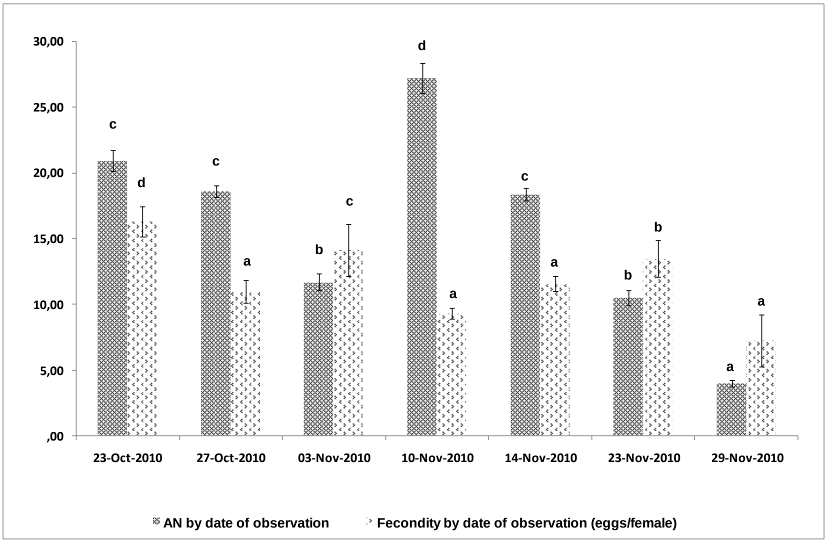

Figure 3. Composition of the overwintering population of *S. amygdali* (in percentage).

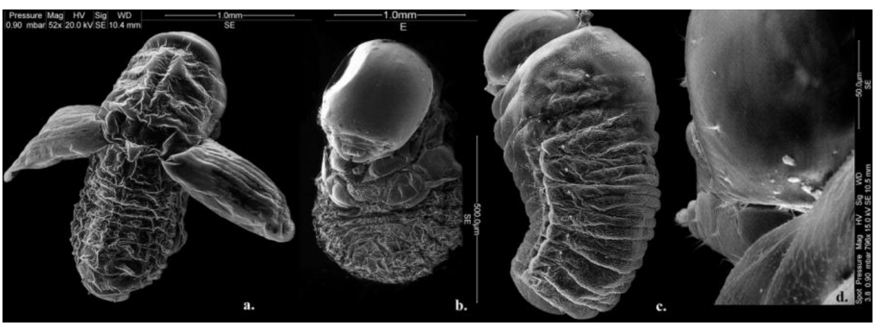

Figure 4. Hibernation forms of *S. amygdali* under the Scanning Electron Microscope: a. pupa in dorsal view, b. larva in ventral view, c. larva in lateral view, d. larval cephalic capsule in lateral view.

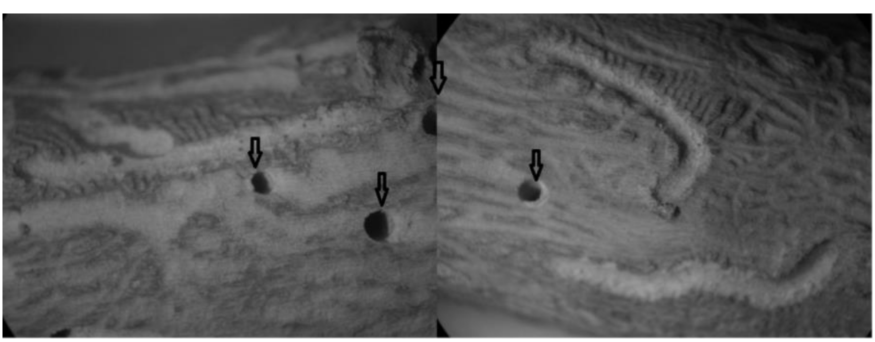

Figure 5. Hibernation tunnels of *S. amygdali* in the sapwood of host.