BIOLOGY AND BEHAVIOUR OF THE BARK BEETLE, *TOMICUS DESTRUENS* (WOLLASTON 1865) (COLEOPTERA: SCOLYTIDAE) IN ALLEPO PINE OF ALGERIA

G. CHAKALI[1]

With 1 figure and 1 table

ABSTRACT. The aim of this work is to elucidate further details of the biology, feeding behaviour and ecology of the bark beetle *Tomicus destruens* (Wollaston, 1865). In recent years, this species has caused considerable damage to pine plantations in Algeria, especially its main host Aleppo pine, *Pinus halepensis* growing in arid areas. The results showed that the beetle has one generation per year, from April to the beginning of October; adults disperse and cause primary damage by colonizing new shoots and branches of host trees growing close to the reproduction site. By the end of autumn and during the winter, females cause secondary damage by oviposition into constructed galleries between host pine bark and sapwood.

RESUMO. Ao longo dos últimos anos na Argélia, o pinheiro de alepo, *Pinus halepensis* Mill. tem sido bastante atacado por *Tomicus destruens*. A amplitude das perdas silvícolas e os desgastes sofridos pelos pinhais das zonas semi-áridas suscitam uma particular atenção. No seu meio natural, *Tomicus destruens* apresenta uma geração anual. Ao longo da sua evolução, os imagos procuram para uma alimentação nutritiva, especialmente os ramos jovens dos últimos dois anos. O segundo tipo de estragos resulta da acção das fêmeas na altura da postura, pela sua participação na abertura de galerias de reprodução que escavam entre a casca e o lenho activo. As particularidades biológicas e ecológicas recolhidas são apresentadas e analisadas.

[1]Agricultural and Forest Zoology National Institute Agronomy, El-Harrach 16200 Algiers (Algeria), e-mail: chakgahdab@yahoo.com; g.chakali@ina.dz

INTRODUCTION

Bark-beetles from the genus *Tomicus* Latreille 1802 are considered to be the most important pests of pine forests in Europe and Asia. *Tomicus destruens* is common in pine forests of the Circum-mediterranean region and also in the Archipelago of Madeira (Gallego & Galian, 2001). The pine shoot beetle, infests *Pinus pinaster*, *P. pinea*, *P. halepensis*, *P. brutia* and *P. canariensis* (Pfeffer, 1995). This insect is even regarded as the most significant pest of the Aleppo pine. The importance of the losses caused by this large pine's shoot beetle has been recorded particularly by Carle (1973) and Raoul De Pontivy (1978). These authors reported the damage caused by *T. destruens* to *P. pinea* and *P. halepensis* in Southern continental France. Severe attacks were also recorded in Italy during the eighties (Nanni & Tiberi, 1997). Here, Central and Northern coastal pinewoods have endured intense decline due to *T. destruens.*

Acording to Carle (1973) *T. destruens* has been considered to be a synonym of *Tomicus piniperda* (Linnaeus, 1758) however, now they are considered two different species. Indeed both species occur in pine stands, causing considerable damage to them. In natural forests and pine plantations of the Mediterranean area, *Tomicus destruens* multiplies rapidly due to the poor physiological conditions of the pine forests growing in these harsh climatic conditions. *Tomicus destruens* is responsible for the decay recorded in the natural forests of *Pinus halepensis* in semi-arid areas (Chakali, 2005).

The present study describes and analyzes the biological and ecological behavior of the pine shoot beetle *Tomicus destruens* in forests growing in the area of Djelfa (Algeria).

MATERIAL AND METHODS

Study area

The current study was conducted in the forest of Senalba Chergui (20,000ha), located in the surroundings of Djelfa, at 300 kilometers south from Algers capital, between 36°36' and 36°42' N; 3° and 3°12' E. Senalba forest lies on the slopes of the main ridge of the Ouled Naïls mountains and occupies their eastern part. It is located in the high plains of the Saharan Atlas at an average altitude of 1200 meters in an area with a cold semi-arid climate. From the floristic point of view these plantations were heterogeneous being composed mainly by natural stands of Aleppo pine, *Pinus halepensis*. This species has been planted also in nearby areas to reconstitute degraded clearings. Observations were made in two sites on the northern and southern slopes of the mountainous chains of Ouled Naïl. This choice was made due to the decline of pine

plantations in this area, which allowed obtaining useful information on the ecology of the insect.

Biological cycle

Development of *T. destruens* was studied in the field and in the laboratory from 1998 to 2003. In average, field sampling was conducted three times per month. The observations were made more regularly during the reproduction period, and on average two sampling trips were done per week to collect information on the biology of *T. destruens*.

The developmental stages of *T. destruens*' life cycle (egg-larval, nymphal and imaginal) were studied at the site of reproduction in twenty infested standing trees during autumn, winter and spring of each year. During each field trip, tree crown yellowing and the presence of holes in the bark generally surrounded by resin were recorded since these indicate the presence and activity of *T. destruens*. Samples of bark of the trees attacked by insects were thoroughly examined and taken for further studies in the laboratory. Data collected allowed the characterization of the insect's life cycle.

Alive tree shoots

After the emergence of the first adults from the bark (mid-April), fifty young pine trees were examined periodically in the neighborhood of the dying pine trees. For each young tree, ten shoots grown in the last year were collected and examined. These samples were helpful to elucidate which was the additional feeding period of young adult beetles necessary to reach sexual maturation. When first infested shoots were recorded, several young branches attacked by *T. destruens* were cut periodically during summer in order to establish the preferential sites sought by the adults for the attacks. The infested shoots were easily recognizable by the presence of entrance holes of adults, often surrounded by a characteristic resin exudation. The variables measured for each shoot were: outdistance the entrance hole (cm), diameter of the shoot at the entrance hole (mm), diameter of the tunnel gallery (mm), length of the tunnel gallery (cm), individual weight (mg) and volume consumed (mm^3). During autumn the length and diameter of the tunnels inside each shoot were measured to calculate the volume of wood dug by the insect. The length and diameter of the tunnels were measured starting from the entrance hole.

The adults found in the shoot were preserved individually in tubes, sexed and weighed separately in an automatic electronic (1/1000) Weighing-machine.

Statistical analyses

The feeding behaviour of males and females was compared for six variables using an analysis of variance (ANOVA). The variables considered were: position of the entrance hole (cm), diameter of the shoot at the entrance hole (mm), diameter of the tunnel gallery (mm), length of the tunnel gallery (cm), individual weight (mg) and volume consumed (mm^3). All variables were compared simultaneously using multiple analyses of variance (MANOVA). ANOVA and MANOVA analyses were performed with statistical package *Statistica*.

RESULTS

Biological cycle

Adults were active from the end of autumn, winter and spring, despite the temperature fall that was on average 7°C and 5°C in January and December respectively, and 8°C with 12°C in February and March. After mating, each female built a gallery running parallel to the fiber of the host tree; egg niches were formed by the sides of the main tunnel. The first oviposition was detected at about the second week of November and young adults emerged at the end of March of the following year. Females can repeat oviposition several times during their lifespan giving rise to sister generations. VALLET (1981) recorded this characteristic also for *T. piniperda*.

Egg galleries were more than 5 cm. long, sometimes exceeding 15 cm. When the attack density per tree was a high, gallery showed a tendency to become shorter due to the limited subcortical area available for each female. Under these conditions, females generally abandoned their first host tree to look for more favorable places where to complete oviposition. When the attack density per tree was low, females did not abandon their host tree and their galleries were longer. The same results were obtained in the studies carried out by SAUVARD (1989) and AMEZAGA & GARBISU (2000) for *T. piniperda* breeding in *P. sylvestris* in France.

T. destruens larvae feed in the galleries that are perpendicular to the main gallery, starting from mid-November until the beginning of May of the following year. Pupation began at the first days of April and finished around the second week of May. The temperatures most favourable for pupal development were between 15 and 20°C. The larvae were observed to feed in their galleries, which lie perpendicular to the main gallery, from mid-November to the beginning of May of the following year. Chronology data of the development stages of *T. destruens* are summarized in Fig. 1.

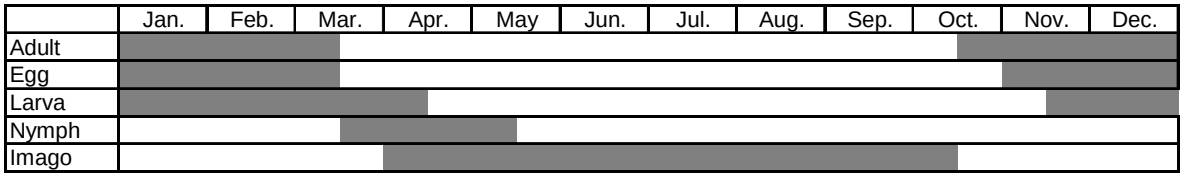

Fig. 1- Biological cycle of *Tomicus destruens* studied in *Pinus halepensis* in a semi-arid area of Algeria (Djelfa) indicating mean air temperature for the three years of study (1998-2003).

Feeding behaviour of adults in live tree shoots

The first imagos emerge from the third week of April and young beetles immediately fly to infest young shoots in the pine plantations. The results of the study carried out during the summer season demonstrate that the adults particularly seek two-year-old shoots for feeding during maturation.

An analysis of the six variables considered describing feeding behaviour in relation to sex, showed that males and females differ significantly in feeding behaviour for all variables (Table 1). These differences were probably related to the morphology of the shoot.

To determine the significative level for the six variables were performed multiple analyses of variance (MANOVA). The transformed value R Rao of Wilks' Lambda was 2.48 and the significance level (p-value) associated with the R of Rao statistics for each effect was significant (p=0.025). This showed that feeding behaviour is different among male and females but not all the variables showed the same degree of significance.

Although the distance of the entrance hole in the tree shoots was studied in a different number of males and females, the number of samples for each sex was rather similar. It is very likely that there is an attraction mechanism (ex. aggregation of the individuals of the same sex) which would explain the differences in distribution of males and females. During our research we never encountered couples in the same gallery.

If several imagoes choose different points on the same branch to feed up to reach sexual maturation, the tunnel will be limited in length, and the adults would have to change frequently shoots up to complete their nutritional intake. The entrance hole chosen by insects depend on the diameter of the branch and certainly on the food quality of its host. When the shoot is vigorous, the insect remains on the same shoot, which provides better nutritive elements. On the contrary, if the diameter of the shoot is small and not exceeding the width of the insect, it will seek the axis of the second shoot where the diameter is greater, allowing the imago to feed appropriately.

Table 1 - Comparisons of male and female feeding behaviour registered in live tree shoots for six variables. The results of comparisons for each variable among male and females (ANOVA) and comparisons for all variables for both sexes (MANOVA) are indicated.

Sexes	Distance of the entrance hole in shoot (cm)	Diameter of shoot at the entrance hole (mm)	Diameter of tunnel gallery (mm)	Length of tunnel gallery (cm)	Individual weight (mg)	Volume of bark consumed (mm^3)
Male						
Mean	20.28	5.72	2.59	2.44	7.52	13.39
Extreme values	(8 - 33)	(4 - 9)	(2 - 4)	(1- 7)	(5 – 10)	(2 – 39)
Standard deviation	6.01	0.95	0.51	1.19	0.99	8.36
Number	98	98	98	98	98	98
Female						
Mean	22.11	5.95	2.73	2.61	7.94	15.79
Extreme values	(6 -35)	(4 – 8)	(2 – 4)	(1 – 6)	(5 – 10)	(4 – 48)
Standard deviation	6.17	0.95	0.48	1.05	1.03	8.35
Number	97	97	97	97	97	97
ANOVA	F(4.390) P= 0.037*	F(2.856) P= 0.092	F(4.488) P= 0.035*	F(1.129) P= 0.289	F(8.650) P=0.003**	F(4.034) P= 0.046*
MANOVA	R Rao (6.188) = 2.48					

DISCUSSION

Tomicus destruens has one generation per year. It appears from our field observations that the tree surfaces exposed to the South are more favorable for the development of this pest compared to the surfaces facing northwards which may be related to differences in local microclimates related to bark exposure. The study of trees in summer demonstrated that adults prefer two-year-old shoots for feeding until they reach sexual maturation. The chronology of the various phases of development was similar under different environmental condition, which has been reported also to occur in *T. destruens* (CARLE, 1973; ABGRALL & SOUTHERNON, 1991).

The ecological conditions seem to determine at least partly the biological behaviour of this species. For adults the period of emergence and feeding remained more or less constant between sites beginning the first days of April and continuing during spring and summer. However, for reproduction the timing of oviposition differed among sites. Oviposition was prolonged at low altitudes, whereas in semi-arid zones the period of oviposition was more reduced.

Two-year-old shoots of Aleppo pine are sought by *T. destruens* for feeding and the damage caused becomes more important when the adults destroy successively the young branches of the treetops. Other observations showed that adults occupy shoots of the third year even when they feed on leaves or the stems of cones. This feeding behavior and the impairment of tree growth for several years have an important impact on tree regeneration especially when attacks occur during sequential years on the same seedlings.

The presence of *T. destruens* in semi-arid forests shows that this species is adapted to these climatic conditions. We currently observe that there is a decline of pine forests when *T. destruens* is breeding on them. At the end of autumn and during winter, breeding adults cause death to trees of 50 to 120 years. From April to the beginning of autumn, adults during their nutritional feeding phase migrate to shoots of young plantations growing close their reproduction sites. These migrations allow a high dispersion over time and facilitate the successful reproduction of *T. destruens*.

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