Evaluation of olive bark beetle *(Phloeotribus scarabeoides, Coleoptera, Scolytidae)* damage to olive flower clusters and fruit in the region of Taroudant

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This study presents two methods for evaluating the damage and losses caused to olive by the bark beetle *Phloeotribus scarabeoides* BERN. It emerges that expressing the degree of attack in terms of non-parametric scores does not enable valid relationships to be established between tree infestation status and phenological characteristics. Monitoring of flower cluster and fruit drop, on the contrary, reveals that beetle feeding can cause losses affecting up to 40% of crop production.

INTRODUCTION

Not only do bark beetle infestations deteriorate the wood of the olive and disrupt sap circulation due to the holes the insects bore in the bark and the mother- and larval galleries they dig, they also cause crop losses due to flower and fruit drop caused by post-emergence insect feeding.

The adults overwinter in galleries they cut at the intersection of a shoot and twig, at the base of a leaf or at the point where two small branches fork. In the springtime, after leaving these tunnels, they move to new hosts where they bore feeding galleries in shoots positioned in bud axils or on flower clusters and fruit stalks.

After progeny flight, the adults disperse to neighbouring olive orchards where they continue their development. This is the point when essentially two types of major damage occur:

- Decline and drop of fruiting shoots often bearing several clusters
- Slower sap circulation often causing young shoots to drop.

Although short (5-6 days according to Arambourg, 1964), this stage of imaginal feeding is considered by several authors to be complementary to, and essential for, the development of the genital organs of the insect (Balachowsky, 1949). Jarraya (1979) notes, however, that it is not absolutely necessary since it can feed directly on the wood.

The object of this study was to draw the attention of olive growers to the impact of this type of damage, which can cause heavy losses that so far have gone unnoticed in Moroccan olive orchards during harvest.

MATERIALS AND METHODS

Choice of test orchards

Observations were recorded between March and November over three consecutive years (1995, 1996 and 1997) on olive trees belonging to the 'Picholine marocaine' variety growing in two olive orchards of the Taroudant region of southern Morocco. The initial plan was to monitor hundreds of olive trees in approximately ten orchards located at sites where beetle biology was being tracked. A number of surveys revealed, however, that the trees were very debilitated in several orchards, that they had been attacked in the past, that they were not bearing (no clusters) and that in some cases they were not readily accessible. Hence, we opted to study two orchards only:

– The first is situated close to Agricultural Development Centre 812 at Had Igli. It is well looked after, ten years old and grows more than 500 trees.

– The second is 17km north of the first orchard, lying on the main road between Taroudant and Ouled Berrhil. It is a traditional orchard growing 1700 trees, aged 20+, all of which are in production.

Tree health

One hundred trees were selected in each orchard to monitor bark beetle damage. The trees were numbered, their height and trunk circumference was measured and a number of parameters were examined according to the following scoring system:

0: no leaves, flowers or fruit
1: some leafy shoots (flowering and/or fruiting)
2: one single leafy branch (and/or with flowers - fruit)
3: leaves (and/or flowers - fruit) on less than 2/3 of the tree
4: leaves, flowers or fruit on more than 2/3 of the tree
5: leaves (and/or flower – fruit) on the whole tree

These data were then collated with tree infestation status expressed in terms of the degree of attack (or intensity, estimated by inspecting the amount of sawdust at the exit and entrance holes by naked eye) according to the following scoring system:

0: no attack
1: attacks on less than one branch (some twigs)

2: attacks on one whole scaffold branch
3: attacks on more than one branch and less than 2/3 of the tree
4: attacks on more than 2/3 of the tree
5: attacks on the whole tree.

Evaluation of flower cluster and fruit losses

Flower cluster and fruit losses were monitored once a week on each tree from fruit set to harvest. They were expressed in terms of the percentage of olives attacked in relation to total fallen fruit or to the initial crop load if the weight or number of olives at harvest was known. Losses were evaluated by:

- observing roughly ten clusters to count those that had been attacked by the beetle and that would drop;
- collecting the olives that fell to the ground and counting on-site the number of withered fruits on stalks showing signs of beetle holes or feeding. The rest of the olives were taken to the laboratory where they were examined by binocular loupe to determine other causes of drop.

RESULTS AND DISCUSSION

Status of tree infestation by bark beetle

Each of the orchards was surveyed to determine the overall degree of infestation according to the scoring system described above and the percentage of infested trees per observation period. Because it is a non-parametric score, the overall degree of infestation is expressed as the average of the total scores (DI) and the percentage of the total scores recorded (TI) in relation to the maximum score according to the formula: $M = (T/A \times 5) \times 100$ where T is the total scores, A: the number of trees taken into account; and 5: the maximum score possible on the scale used.

Figure 1 gives an idea of the trend of tree infestation. At first glance, the trees in the first orchard appeared to be vigorous, less infested and less conducive to the development of bark beetle. They did in fact receive regular technical care: tillage in January-February, post-harvest pruning, fertilisation in April, weekly gravity-fed irrigation, crop health protection, etc.

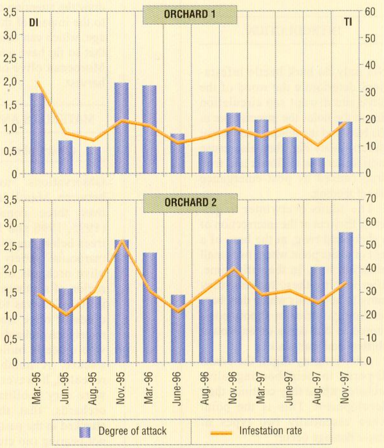
Conversely, the second orchard was relatively more infested. It did not receive the necessary care and pruning brush was piled up along the sides, thus contributing to the severity of beetle infestation.

In both orchards the trees seemed to be at greater risk of infestation at two particular periods:

- The first was in March, coinciding with beetle emergence and the resumption of activity by the adults belonging to the overwintering generation whose flights may be phased over four months (February-May), thus giving rise to larger populations (Benazoun, 1992).
- The second was in November, corresponding to the flights of the summer-autumn generation, which continue through to November-December. These adults seek shelter or try to find sites where their progeny can overwinter without risk in galleries tunnelled at the intersection of a shoot and a twig, at the base of a leaf or at the point where two branches fork.

Tree susceptibility to such attacks is certainly heightened by various sources of stress as well as by other factors linked to the insect and pruning wood that determine the extent to which the trees are attractive to the adults. As has already been documented in many species, tree susceptibility and the attractiveness of pruning wood to beetle attack are probably dependent on biochemical mechanisms that vary according to the trees, especially if the orchards are very heterogeneous as is the case in the Taroudant region.

FIGURE 1
Trend of tree infestation by *P. scarabeoides*



We set out to examine whether it was possible to link these differences to various external traits of the olive tree. This is above all a practical approach over the long term. The fact is that when surveying certain tree traits, valid relationships between the collected data can only be established after several years. The observations we report are for no more than two years. The connection between the attack index on the one hand and the density of foliage and extent of fruiting on the other emerged clearly in the first orchard whereas it was negative in the second one. It is surprising that these correlations are not any clearer. Trees with sparse foliage would appear to be more exposed to bark beetle infestations but trees with dense foliage are not spared either, because they too can come under attack and suffer considerable damage. This would appear to suggest that factors other than the bark beetle are involved and would confirm the general poor health of these orchards.

More often than not this type of damage goes unnoticed and is difficult to quantify in terms of production and income. Olive growers only become aware of the need to combat this pest when they can translate losses into money terms. This is the line taken in the second aspect of this study.

Estimation of losses

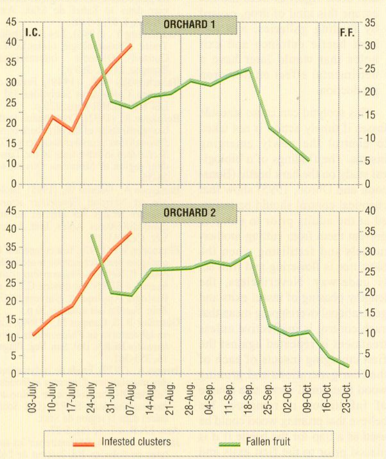
The data gleaned on analysing the demographic composition of sub-cortical populations of *P. scarabeoides* and on observing beetle entries and exits show that there are at least three generations a year, with some time-lags depending on the year (Benazoun and Oubrou, 1995):

- An overwintering generation whose progeny flights occur between February and late April.
- A spring generation whose adults emerge and lay eggs from June until August.
- A summer generation whose flights begin in August and continue through to November. The end of the second flight may emerge at the same time as the start of the third flight. Together these adults then engender the overwintering generation.

Each generation has two stages:

- An airborne stage when the adults leave their sub-cortical gallery systems and move to new trees for maturation feeding on the terminal section of shoots or at the base of fruiting clusters. Next they locate a definitive site to mate and create new gallery systems.
- A sub-cortical stage where, assisted by the male, the female establishes the tunnels where the progeny will then develop into adults.

FIGURE 2
Evaluation of *P. scarabeoides*-induced losses in terms of flower clusters and fruits in the region of Taroudant



In this study we focused on the spring and summer generations. Maturation feeding by the adults of these generations often causes the clusters to wither and fall off and even leads to the drop of fruiting shoots bearing several clusters (a cluster bears an average of 1-3 olives).

Inspection of the selected trees revealed that the percentage of formed clusters that were destined to drop varied respectively in the first and second orchard from 9% to 35% in July, reaching 40% in August. Figure 2 illustrates this variation and shows that this drop increases notably in August (the hottest month). The heat may debilitate the trees, heighten the chances of infestation of the target organs and favour the settlement of *P. scarabeoides*, the development of which is speeded up in such conditions (Arambourg, 1964; Benazoun, 1992; Jarraya, 1979; González and Campos, 1990). However, after 7 August no infested cluster was observed in either orchard. This shows that, while a xylophagous species, the bark beetle is also a formidable anthophagous insect whose economic impact goes unnoticed by many farmers.

In addition, during the fruiting period, the olives that dropped between 24 July and 23 October were collected to assess bark beetle-induced losses. It emerges that in late July, the number of fallen fruits was relatively higher in both orchards. In our opinion, this was cumulative fruit drop that had not been observed between the start of fruit set and 24 July. In any event, percentage losses varied from 16% to 30% between the start of August and the third week of September and decreased from 12% to 2% between the end of September and the second fortnight of October.

The gradual trend of losses and damage can be attributed to two factors. One is that pruning wood is left in the vicinity of the orchards where it is not treated or burned in time: the other is that the high summer temperatures (July–August) deteriorate the wood, making it more attractive to the adults as a launching pad for maturation feeding on bearing trees. Moreover, from late September until late October, bark beetle-induced drop tends to decline considerably. This makes the adults from the spring and summer generations (June-August) more dangerous because the damage they cause can affect both crop production and the wood. Hence, it is necessary to supplement the treatments applied to control the overwintering-generation adults when such supplemental treatment is justified by periodic monitoring of the adults that emerge from the spring and summer generations. However, in most cases, such fruit drop is due to ripening and weight gain. Initially, the plan was to express losses in terms of the percentage drop with respect to the initial crop load (Arambourg, 1986; Jarraya, 1983). However, the farmers mixed the crop of all the trees in each orchard, making it impossible to determine the crop load. Hence, evaluation was limited to assessing bark beetle losses in relation to the weekly drop recorded at each inspection.

CONCLUSIONS

The findings of the study conducted in the Taroudant region reveal that the losses caused by *P. scarabeoides* are due to two types of damage:

- The first is to the wood (adult entrance and exit holes, galleries, ...), the impact of which is not readily estimated or quantified.
- The second is in the form of flower cluster and fruit drop between June and September, which is caused by maturation feeding and can be quantified. It was found that as much as 40% or more of the clusters that formed were destined to fall. The percentage of fruit collected after dropping can be as high as 30% in relation to the total drop recorded from the start of fruit set until the end of June. Upon analysis, it has been presumed that drop is relatively low in comparison with the initial crop load. However, it was observed that even vigorous trees did not escape this kind of drop, caused by feeding galleries, and had bark beetle entrance and exit holes that would later have a detrimental effect on tree crop production.

This scolytid can cause sizeable losses if timely action is not taken to control the newly emerging insects. The findings of a biological study on the bark beetle (Benazoun and Obrou, 1995) show that chemical control should be targeted at the adults prior to entry to prevent them from cutting mother-tunnels and fertilising when the olive tree is flowering and fruit set is underway. Nevertheless, the lengthy phasing of insect exits and generational overlapping mean that such control is ineffective unless treatment is repeated against the first emerging insects of each of the four generations and pruning wood that could serve as a source of infestation is removed. We believe that pruning wood could be used as a trap for the beetle if it is placed prior to the first exits and then burned after the entries.

Laboratory tests on various insecticides have shown that two synthetic pyrethroids – Deltamethrin and Cypermethrin – are relatively effective (El Mouden, 1992).

Other prophylactic measures can be envisaged to strengthen olive resistance to bark beetle attacks:

1. Keep the trees healthy against attacks by other pests such as the olive psyllid *Euphyllura olivina*, the olive fly *Bactrocera oleae*, the coleopteran *Bostrycidae* belonging to the genus *Xylomedes*, the leopard moth *Euzophera pinguis*, and others.
2. Remove and burn pruning wood and any debilitated, dying trees.
3. Till the soil properly, and regularly apply the necessary water, fertiliser and manure.

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