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## Cedar forests under threat of new pests

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**Abstract:** During our studies on the insects of cedars - including field observations, sampling and rearing - we have often identified known or new pests on the tree. At the same time, we have noticed the sporadic presence of other insects, which feed only on cedar but cause insignificant damage. We have nevertheless noticed that these insects can cause outbreaks that harm the tree. In addition, we have noted the sudden apparition on cedar of unknown insects, or species living on other trees that currently constitute a threat to the cedar forest. In this chapter, those new cedar pests and their threats, both in natural forests and in artificial ones in Western and Eastern Mediterranean, are presented. Their symptoms on cedar and the possible causes of their outbreaks are considered. In order to know the potential pests in advance, an inventory of all the insects living on cedar is provided. Because of the complexity of the phenomenon of the emergence of new pests on cedar, we propose to combine efforts in the Mediterranean basin, in a tighter coordination between researchers interested in these trees.

**Keywords:** Cedar, Insects, New pests, Phytophagous, Xylophagous, Mediterranean basin

## Les forêts de Cèdre sous la menace de nouveaux ravageurs

**Résumé :** Au cours de nos recherches sur les insectes du cèdre qui consistent en des observations sur le terrain, des échantillonnages, des élevages,... nous avons souvent identifié des ravageurs connus ou nouveaux sur l'arbre. Dans le même temps, nous avons noté la présence sporadique d'autres insectes, qui se nourrissent uniquement sur le cèdre, mais leurs dégâts étaient insignifiants. Actuellement, nous avons remarqué que ces insectes peuvent pulluler pour nuire à l'arbre. En outre, nous avons observé l'apparition soudaine sur le cèdre de certains insectes inconnus ou vivant sur d'autres arbres pour constituer actuellement une menace pour la forêt de cèdres. Nous allons présenter dans cet article ces nouveaux ravageurs et leurs menaces sur l'arbre dans les forêts de cèdres naturelles et artificielles dans l'Ouest et l'Est Méditerranéen. Leurs symptômes sur le cèdre et les causes possibles de leur apparition seront pris en considération. Dans le but de connaître à l'avance les éventuels ravageurs, la connaissance de l'ensemble des insectes vivant sur le cèdre est soulignée. Devant la complexité du phénomène de l'apparition des nouveaux ravageurs sur cèdre, nous proposons de conjuguer tous les efforts dans ce domaine, dans le bassin méditerranéen, en une coordination étroite entre les chercheurs s'intéressant à l'arbre.

**Mots clés :** Cèdre, Insectes, Nouveaux ravageurs, Phytophages, Xylophages, Bassin méditerranéen

## Yeni zararlıların tehdidi altındaki sedir ormanları

**Özet:** Saha gözlemleri, örneklem ve kültüre alma dâhil olmak üzere sedir ağaçlarındaki böceklerle ilgili çalışmalarımızda, genellikle ağaçlarda bilinenlerin yanı sıra yeni zararlılar tespit edilmiştir. Aynı zamanda, sadece sedirde beslenen ancak önemli bir zarara yol açmayan diğer böceklerin de bulunduğu görülmüştür. Fakat bu böceklerin ağaçlara zarar veren salgınlara yol açma potansiyeli belirlenmiştir. Ayrıca, bilinmeyen böceklerin veya diğer ağaçlarda yaşayan başka türlerin sedir ağaçlarında aniden ortaya çıkmasının, sedir ormanına tehdit teşkil edebileceği gözlemlenmiştir. Bu bölümde, Batı ve Doğu Akdeniz'deki hem doğal ormanlar hem de yapay ormanlarda bulunan yeni sedir zararlıları ve bunların yol açtığı tehditler sunulmaktadır. Bu zararlıların sedir ağaçları üzerindeki belirtileri ve yol açtıkları salgınlara muhtemel nedenleri de değerlendirilmektedir. Potansiyel zararlıları önceden bilmek için, sedir ağaçlarında yaşayan tüm böceklerin bir envanteri temin edilmiştir. Sedir ağaçlarında yeni zararlıların ortaya çıkması karmaşık bir olgu olduğu için, bu ağaçlarla ilgilenen araştırmacılar arasında daha sıkı bir koordinasyon sağlayarak Akdeniz havzasındaki çabaların birleştirilmesi önerilmiştir.

**Anahtar kelimeler:** Sedir, Böcekler, Yeni zararlılar, Bitkiyle beslenen böcekler, Oduncu, Akdeniz Havzası

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## 1. Introduction

Because of their scenic beauty, cedar forest sites have always attracted the attention of naturalists in general and entomologists in particular. Hence the genus *Cedrus* and its different species<sup>1</sup> in the Mediterranean have been the subject of entomological studies of varying importance. Older, casual entomological works have therefore been carried out in natural cedar forests and these are particularly interesting with regard to beetles and traditionally-known pests of the tree. Subsequently, other pests have been discovered. As the cedar has been widely introduced around Europe, since the 19th century especially, and constitutes artificial cedar forests in some places, some pests followed the tree into its new area of introduction. Without their natural enemies, these pests have caused serious damage and even threatened the artificial cedar forests.

Insects can therefore have negative impacts on cedar forests and even hinder their productivity, in artificial areas especially but also in its natural range. The insects collected on cedar trees can be categorized into phytophagous, xylophagous, saproxylophagous and entomophagous. Although this last category is beneficial to the tree, other species belonging to the first two categories often cause damage to cedar. In addition, other phytophagous and xylophagous insects living on cedar and known as simple parasites or considered as potential pests may become harmful when they reach outbreak populations. Most of those insects are considered monophagous and feed only on cedars. However, this very strict host plant - insect relationship is challenged because some insects associated to other trees are able to feed on the cedar and even jeopardize the tree. This seems to be a new phenomenon that concerns artificial cedar forests more than natural ones.

Some pests were unknown and suddenly appeared to damage cedars, especially in Eastern Mediterranean forests. Between the time of collecting the insect and having it identified by a specialist, the pest had caused huge damage. Thus, we now need to inventory all the insects supported by the tree to know in advance any potential pests and avoid surprise and delays. We urge our colleagues in the Eastern Mediterranean countries to compile inventories of insects associated with cedar in the same way as we have done in North Africa (Mouna, 2013).

In this chapter, we focus on the emergence of new pests and their threats to the tree in Western and Eastern Mediterranean cedar forests. Phytophagous or xylophagous insects, hosted by the cedar or from other trees, will be considered. Their symptoms on the tree and the possible causes of their outbreaks will be presented.

## 2. Insects hosted by cedar

### 2.1. Phytophagous insects

It is known that in natural forest systems, insect populations are kept in balance simultaneously by the action of a series of abiotic (climate, etc.) and biotic (natural enemies) factors. Examples are numerous, but we can consider *Cinara* (*Cedrobium*) *laportei* (Hem. Aphididae), which does not damage cedar forests within its native distribution, but was killing cedars in France before the introduction of its selective parasite. *Pauesia cedrobii* (Hym. Braconidae) was then introduced from Morocco to France to control the aphid (Fabre and Rabasse, 1987). The result is spectacular and the parasite is definitively established in the country.

Some other insects that are known as harmless have recently caused outbreaks that damage the tree. It is important to highlight in this respect that Bovey (1970) pointed out that we should pay greater attention to species that do not necessarily have an economic interest. Thus, some insects such as *Scythropus warioni* (Col., Curculionidae) consume new needles during the summer (Figure 1). Its damage is still localized, but some trees were defoliated at more than 50% of their needles in the Middle Atlas (Morocco). Nevertheless *Calomicrus pardoi* (Col. Chrysomelidae) is the most redoubtable phytophage of the cedar. Its damages at the adult stage were estimated at about 35% of destroyed needles in a large area of forest in Morocco, during August.

In Turkey, we find its congener *Calomicrus apicalis*, which has spread over 3000 ha of forest since 2000. It damages the cedar (Figure 2) in the spring, and pine trees (*Pinus*) as well (Aytar et al., 2011).

In the same context, new pests have been detected in recent years in areas of natural cedar forest. The most important one is the cedar sawfly of Lebanon *Cephalcia tannourinensis* (Hym. Pamphiliidae), which suddenly appeared in the country (Nemer et al., 2005) and is damaging cedars at a large scale in the Tannourine Hadath-El-Jebbeh forest in the north of Lebanon. The pest is the only *Cephalcia* species that feeds on cedar needles among a huge number of congeners<sup>2</sup>. Adults emerge in late April and mate soon after. The female lays her eggs directly on the side of sclosed spring buds of about a centimeter of length. After a few days of incubation (7 to 10), the larvae hatch from the eggs and feed on the new buds. The larval life cycle lasts thirty days and the larvae go through three developmental stages before entering the soil to pupate. In the soil, larvae enter diapause until spring of the following year, during which they metamorphose into adults. There is an observable sexual dimorphism in adults, whose females have a yellow spot on the abdomen and are of larger size compared to males (Nemer, 2008).

<sup>1</sup> *Cedrus atlantica* in Morocco and Algeria and *Cedrus libani* which includes three subspecies (Sabatier et al, 2003): *C. libani brevifolia* Cyprus, *C. libani libani* in Lebanon and Syria and *C. libani stenocoma* in Turkey.

<sup>2</sup> *C. tannourinensis* is the first *Cephalcia* species described in the Mediterranean area. The genus lives rather in humid climate and low temperature occurring mainly in central, northern and Eastern Europe and North America.



Figure 1. Damage by *Scythropus warioni* in the Moroccan Middle Atlas (Photo Mouna).



Figure 2. Damage of *Calomicrus apicalis* on cedar in Turkey (Photo Avci)

The defoliation caused by *C. tannourinensis* induces the production of summer buds, which are colonized by a beetle (Nemer, 2008): *Ernobius libanensis* n. sp. (Anobiidae). The small female of this pest lays tiny, white, ellipsoid-shaped eggs on the summer buds during September. These eggs enter diapause during the winter. The following spring, the eggs hatch and give birth to larvae that quickly bore into the bud to empty it during its development, which passes through three stages. A small nymph (2.85 to 3.95 mm), folded on its ventral side, is located at the bottom of the summer buds of the last year. After aestivation, adults emerge early in September from the top of the dried buds (Nemer, 2008).

In Lebanon, the cedar summer buds also induce the appearance of another newly described pest, *Dasyneura cedri* Coutin, 2000 (Dipt. Cecidomyiidae) whose larvae develop in the summer buds, like those of *E. libanensis*. The larvae of *D. cedri* pupate and become adults that emerge in April from the attacked buds (Nemer, 2008). *D. cedri* shares a similar ecological niche as *E. libanensis*, but its development is faster.

Among other potential phytophagous pests whose impact on cedar depends on the size of their populations are some Coleoptera that feed on the needles in North Africa: *Mauroania longula* (Dasytidae); *Cryptocephalus reichei*, *Pachybrachis cedri* and *Calomicrus pinicola*

(Chrysomelidae) and *Brachyderes caudatus*, *Otiorrhynchus kaci*, *Scythropus pineti*, *Caulostrophus subsulcatus*, *Caulostrophus vauloeri*, *Polydrusus maurus* and *Polydrusus (Eudipnus) mollis* (Curculionidae).

There are also species that have been newly recorded on cedar, such as:

- *Prionomeion gaullei* (Hym. Diprionidae), known from Tikjda (Algeria) where some damage was noticed (Fabre and Khemici, 1991). The larvae of this insect consume the cedar needles in the spring (Fabre and Chevin, 1991).
- *Lozotaenia cedrivora* (Lep. Tortricidae) feeds on cedar and was found only in the cedar-fir forest of Babors in Algeria (Chambon et al., 1990);

Other Coleoptera species feed on the reproductive organs in North Africa: *Ernobius pruinosis*, *Ernobius mulsanti* and *Ernobius pini* (Anobiidae).

## 2.2. Xylophagous insects

Among a number of xylophagous insects recorded on cedar with insignificant damage, we find *Phaenops marmottani* (Col. Buprestidae), which has suddenly become a dangerous threat to cedar in North Africa. The insect exists on all dying cedars in Morocco (Mouna, 2009) and in Algeria (Rahmani-Talbi, 2010). This xylophage seems to harm fir trees (*Abies*) as well (Théry, 1928).

We studied 4 classes of cedars that were dying back in Morocco, where *Phaenops marmottani* was the most frequently obtained xylophage. Its external symptoms on the dying cedar trunks are exit holes and resin exudation between the bark and the sapwood (Fig. 3). The exudation of resin normally weakens the trees and exposes them to secondary xylophagous attacks, for example from Scolytinae and other buprestids. The symptoms of *Phaenops marmottani* are noticeable on dead trees as well (Class 4, Fig. 4). It seems that it is a primary insect for several reasons. Debarking logs of the considered classes of dying cedars reveals that the xylophage has already emerged, but the foliage of the trees does not necessarily present external signs of weakness. In addition, the vast majority of the debarked logs still contain liquid resin between the cambium and sapwood.

Its equivalent in Turkey is probably *Orthotomicus tridentatus* (Col. Curculionidae), which was known for a long time as *O. erosus* (Avci and Sarikaya, 2009). This xylophage is responsible for the death of weakened cedars following damage by *Acleris undulana* (Lep. Tortricidae) (Mouna and Fabre, 2005). *Hylastes ater* (Col. Curculionidae) is another polyphagous, boring species that may live on cedar.



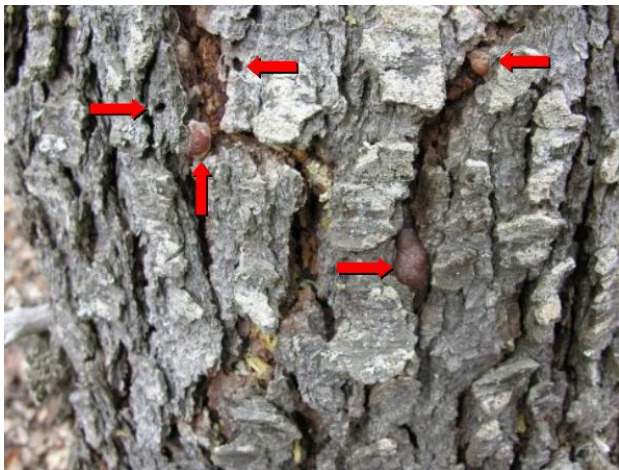


Figure 3. External symptoms of *Phaenops marmottani* (exit holes and resin exudation: arrows) on a cedar trunks in the process of dying back (Photo Mouna).



Figure 4. Symptoms of *Phaenops marmottani* on a dead cedar tree (Photo Mouna).

### 3. Insects from other tree species

Additional threats to the tree are shifts of insect pests from other tree species to cedar. The phenomenon seems to be new and examples are more numerous in artificial cedar forests than in natural ones:

- *Dichelia numidicola* (Lep. Tortricidae), which lives mainly on Numidian fir (*Abies numidica*), was found on cedar in Algeria (Fabre and Khemici, 1991).
- *Choristoneura murinana* (Lep. Tortricidae) and *Megastigmus suspectus* (Hym. Torymidae), which are known in Turkey and Europe on fir species, feed on cedar as well in France;
- The xylophagous Coleoptera *Orthotomicus erosus* and *Ips sexdentatus* (pests of maritime pine *Pinus pinaster*) and *Pityokteines curvidens* and *Pityogenes quadridens* (secondary xylophagous pests of fir) were recorded on cedar in France (Fabre et al., 1999);
- The two Scolytinae (i) *Scolytus carpini*, frequently obtained from the cedar breeding logs, but usually feeds on Fagaceae and (ii) *Scolytus amygdali*, which normally feeds on fruit trees, was abundantly obtained breeding in

cedar logs in Algeria, where it is considered as primarily xylophagous on the tree (Rahmani-Talbi, 2010)<sup>3</sup>.

### 4. Conclusion

Particular attention should be paid to phytophagous pests in general and potential pests in particular. In order to do so, we need to know all the insects living on cedar, especially in the eastern Mediterranean forests. In the western Mediterranean, where the majority of these insects are known, we have seen that some species that are not considered as pests in the literature nevertheless do outbreak to harm the tree. For example, *Phaenops marmottani* (Col. Buprestidae), the xylophagous beetle which was thought to be harmless to cedar, or at least considered a secondary wood-borer, does suddenly outbreak.

The three pests found in Lebanon were new to science, so we can wonder regarding their origin. Why have they appeared now? Do they only exist in Lebanon or are they also present elsewhere? We have checked in vain for the presence of *Cephalcia tannourinensis* in other natural cedar forests in the Mediterranean basin (Morocco, Algeria, Cyprus, Syria and Turkey) using yellow traps. The use of its pheromone - a mixture of germacrene D, an allofarnesene and alpha cadinol (Nemer, 2008) - is necessary to confirm its absence or presence in other cedar forests. Are global changes behind unusual phenomena in our forests?

We know that climate change is responsible for the migration of forest pests northward and altitudinally in the USA and Canada. An example, among others, is the case of *Dendroctonus ponderosae* (Col. Curculionidae), which killed millions of hectares of pine forest in the two countries. In our region, the pine processionary moth's *Thaumetopoea pityocampa* (Notodontidae) range has expanded to the north in Europe in recent years.

The passage of insect pests from other tree species to cedar is an additional threat to the tree in its natural and artificial habitats. Thus, the pest problem should be considered via a tight collaboration between researchers in all Mediterranean countries, including Europe where cedar forest is not native.

To efficiently counter cedar pests, a basic knowledge of their biology and ecology is needed to try to use the intrinsic capacities of forest systems. Biological control is promising in forests, considering the success of the introduction in France of the Hymenoptera: Braconidae *Pauesia cedrobii* from Morocco for the control of the aphid *Cinara (Cedrobium) laportei*, a pest of cedars. Integrated pest management may give good results as well and contribute to a decrease in expenses allocated for the protection of the cedar forests.

Some inherent aspects of cedar insects have not yet been considered, such as the physiological state of the tree, or soil, in relation to phytophagous damage. Therefore, multidisciplinary collaboration between entomologists,

<sup>3</sup> According to Beaver, the *Scolytus* genera is normally exigent in the choice of food plant. If the identification of the two species is confirmed, it would open new areas of research to discover the cause of the shift of some species of the genus *Scolytus* living on leafy plants to resinous ones.

mycologists, foresters, ecologists, conservation biologists and motivated politicians, physiologists and chemists is desirable in order to preserve this forest heritage in all Mediterranean countries where it occurs.

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