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Entomological Research in Mediterranean Forest Ecosystems

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MEDINSECT 4

“ENTOMOLOGICAL RESEARCH IN MEDITERRANEAN FOREST ECOSYSTEMS”

A symposium,
IUFRO Working Groups “7-03-14”, “7-03-06” and “7-03-01”
Antalya (Turkey), April 10-14, 2014

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MEDINSECT 4 – Entomological Research in Mediterranean Forest Ecosystems

Preface

This special issue of the Turkish Journal of Forestry is the proceedings of a Symposium held in Antalya (Turkey) from April 10 to 14, 2014, organized jointly by the Süleyman Demirel University at Isparta (Turkey), the University of Orléans (France), University of Padova (Italy) and the Canadian Forest Service. The symposium gathered scientists of three IUFRO working groups: 7-03-14 “Entomological Research in Mediterranean Forest Ecosystems”, 7-03-06 “Integrated Management in Forest Defoliating Insects” and 7-03-01 “Cone and Seed Insects”. It was the fourth meeting of 7-03-14 (after Rabat 2002, Estoril 2008 and Hammamet 2012), the eighth meeting of 7-03-06 (started in 1992), and the ninth meeting of 7-03-01 (started in 1983).

Each IUFRO Working group focuses on a special topic and gathers scientists from any part of the world. The 7-03-14 IUFRO group is interested in all aspects of Mediterranean forest entomology. All Mediterranean regions are presently facing a crucial challenge. Mediterranean forest ecosystems have been shaped at a deeper extent than any other type of biome by centuries or millennia of human pressure. These pressures have been particularly aggressive in the Mediterranean basin but also, at least some of them, in other Mediterranean parts of the world. Insects have always played an important role in the energy transfers and in the functioning of all terrestrial ecosystems. This is particularly true for the forested ones and especially in the Mediterranean regions where biodiversity and endemism of living -organisms is exceptionally high. The aim of the 7-03-14 group is to understand the functioning of the relationships between insects and the other components of the Mediterranean forest ecosystems, and to foresee their modifications under global change, with an objective of sustainable forest management for human needs.

The 7-03-06 IUFRO group deals with the integrated management of forest defoliating insects and the motivation to join MEDINSECT relies on the great importance of the defoliator guild in the Mediterranean forests, where large areas are yearly affected by heavy defoliations caused by key species such as gypsy moth in broadleaved stands and pine processionary moth in coniferous stands. As these forests are facing the challenges of climate change and anthropogenic impacts, their protection is becoming more and more important for the preservation of biodiversity and the numerous ecosystem services associated with the Mediterranean forests. There is a growing need to implement new knowledge of the systems with new control methods, in the awareness that biocontrol is in the long term the only way to manage these forests. Communication with stakeholders and citizens becomes thus essential to achieve the aims of the 7-03-06 group, and these proceedings are an important step in this direction.

The 7-03-01 IUFRO group is concerned with all aspects of cone and seed insect research, including biology, ecology, impacts on forest natural regeneration and seed orchards management, monitoring and pest management. Cone and seed insects are considered the most important seed predators during the pre-dispersal phase of seed development. Although they received little attention until recently, these insects are important factors in forest and tree health and their economic and ecological impact is a source of growing concern to foresters. In particular, as climate change is expected to cause tree species and populations to be less well adapted to local conditions, numerous regeneration management strategies are increasingly being considered to address the need to adapt to future conditions, including assisted natural regeneration, changes in seed transfer zones, select and assisted migration. Cone and seed insects can negatively impact most of these strategies as they rely on the production, dissemination and plantation of selected plant material and the conservation and propagation of genotypes adapted to potential future climate. For the past 10 years, a significant amount of cone and seed insect research has taken place in Mediterranean ecosystems, which was the main motivation to join MEDINSECT in this meeting.

The Antalya meeting included 52 oral and 27 poster presentations in five sessions. After welcome addresses given by M. Ali Fuat Ünal, Forest General Directorate, and M. Neşat Erkan, Director of the West Mediterranean Forestry Research Institute, the meeting was opened by F. Lieutier, A. Battisti, J. N. Candau and M. Avcı. A presentation of the IUFRO 7-03 Entomology Unit by Andrew Liebhold followed Emin Zeki Başkent then presented the Turkish forest, its history and future, and Mahmut Eroğlu and Ertuğrul Bilgili the structure and topics of the forest entomology research in Turkey. Session 1 was dedicated to “Insect biodiversity and population genetics”, session 2 to “Emerging and exotic pests”, session 3 to “Insect biology, relations with host trees and other organisms”, session 4 to “Population dynamics and invasion processes”, and the 5th session focused on “Forest decline, insect survey and control, forestry practice”. A field visit of forest entomological problems (pine processionary, cedar moth, cedar bark beetles …) allowed evaluation of and largely discussing cedar and pine damage by insects.

This special issue of the Turkish Journal of Forestry gathers some of the papers presented at the meeting and subsequently sent by the authors to be published. They are in English or French but all contain summaries in English and Turkish. All papers have been reviewed by independent experts before being accepted in the proceedings.

François Lieutier
Mustafa Avcı
Andrea Battisti
Jean-Noël Candau

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MEDINSECT 4 – Entomological Research in Mediterranean Forest Ecosystems

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We gratefully acknowledge the Forest General Directorate (Ankara/TURKEY) and the Director of the West Mediterranean Forestry Research Institute, who encouraged us to organize the symposium and accepted to give the introductory lectures.

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The numerous reviewers of the chapters are also thanked for their constructive remarks. We warmly thank our numerous Turkish colleagues (foresters, scientists, technicians, administrators), who contributed to the success of the symposium by taking charge of all practical aspects of its organization.

François Lieutier
Mustafa Avcı
Andrea Battisti
Jean-Noël Candau

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Araştırma

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2016, 17(Special Issue): 1-6 | Research article (Araştırma makalesi)

Review of oak gall wasps phylogeographic patterns in Turkey suggests a main role of the Anatolian diagonal

Serap Mutun

Abstract: Distribution of genetic variation across a species range is shaped both by historical and contemporary factors such as topographical barriers, presence of diverse micro- and macrohabitats, complex geologic history and past climatic fluctuations. Signatures of the past events and the varied topography can be observed not only in plant taxa but also in the obligate parasites of plants such as oak gall wasps. The mountain barriers in Anatolia running from the southeastern towards the northern part of Turkey is accepted as a major faunistic and floristic belt, and is thought to underlie much of the genetic diversity in the region. Current findings show that complicated geologic history and a variety of mountainous areas have left imprints on the phylogenies and phylogeography of oak gall wasp taxa. Indeed, several oak gall wasp species studied across Turkey revealed the presence of this notorious pattern into west and east division of the genetic variation with respect to the location of the Turkish highlands. A number of published studies on the distribution and the allocation of the genetic diversity of several oak gall wasp species in Anatolia, which is located at the junction of several phytogeographic provinces, express the importance of an apparent genetic break in the examined oak gall wasp species.

Keywords: Anatolia, Anatolian diagonal, Oak gall wasps, Genetic break, Geographic barriers

Türkiye'deki mazı arılarının filocoğrafi örüntülerine dair inceleme, Anadolu çaprazının temel rolü

Özet: Bir türün sahip olduğu genetik varyasyonun yayılış alanı içindeki dağılımı mikro ve makrohabitatların çeşitliliği, topoğrafik bariyerler, alanın jeolojik tarihi ve geçmişteki iklimsel değişiklikler gibi hem tarihsel hem de bugünkü faktörler tarafından belirlenir. Topoğrafi ve tarihsel olayların etkileri sadece bitki taksonlarında değil aynı zamanda bitkilerin zorunlu parazitleri olarak kabul edilen gal arıları gibi taksonlarda da görülür. Ülkemizin güneydoğu kısmından başlayarak kuzeye doğru ilerleyen dağ sinsilelerinin Anadolu fauna ve florasını şekillendiren bariyerler arasında olduğu kabul edilmektedir ve bölgedeki genetik çeşitliliğin dağılımını da belirleyen önemli faktörlerden biri olduğu düşünülür. Elde edilen son bilgiler ülkemizin oldukça karmaşık jeolojik tarihi ve farklı dağlık alanların meşe gal arılarının filocoğrafik yapısının şekillenmesinde oldukça etkili olduğunu göstermiştir. Ülkemizdeki meşe gal arısı türlerinde genetik varyasyonun doğu ve batı şeklindeki dağılım ve yapılanması dikkat çekicidir. Fitocoğrafik alanların çakışma noktasında yer alan Anadolu'dan çalışılan meşe gal arısı türlerindeki mevcut genetik farklılaşma gal arısı türlerinde populasyon genetik yapısındaki kesintiye işaret etmektedir.

Anahtar kelimeler: Anadolu, Anadolu diagonali, Meşe gal arıları, Genetik ayrım, Coğrafik bariyerler

1. Importance of Anatolia: A hotspot and refuge area

Current population genetic structure of a species is governed by historical and contemporary factors, and physical barriers such as mountain ranges are thought to be crucial for shaping the phylogeographic structure of many species (Avise, 2000). Turkey hosts more than 10000 plant and 80000 animal species (Demirsoy, 1999), which is much higher than the neighboring areas. Besides, recent studies have revealed that genetic diversity is also higher in Turkey compared to many of the European populations of the investigated taxa. Such high genetic diversity is thought to be due to the heterogeneous topography of Anatolia, complicated geologic history of the area, varied climates, the presence of diverse phytogeographic regions, and unique geologic location of Turkey.

Turkey is located in the Alpine–Himalayan Mountain belt between Eurasia, Africa and Arabia, with complex geological history which is a result of the collision of the Arabian and African plates with the European plate, promoting the closure of the Tethys Sea (Rögl, 1999). The mountain ranges presently seen in Anatolia formed during the Oligocene with a collision between Indian and Asian continental masses followed by Africa and Eurasia, the last collision ending up with the formation of the Taurus Mountains. In consequence, the most important upshot of Tertiary for Anatolia was the upfolding of the Anatolian highlands (Bozkurt, 2001) which was named as the Anatolian Diagonal by Davis in 1971. The Anatolian

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Diagonal is a line of mountain ranges that runs from the south of Gümüşhane- Bayburt in the north to southwest across Turkey to the Taurus Mountains (Davis, 1971; Ekim and Güner, 1986). This mountain belt has been proposed as a significant geographic barrier shaping current species composition distributed across Turkey and dividing species/lineage distribution into east and west (Davis, 1971; Ekim and Güner, 1986; Çıplak et al., 1993; Mutun, 2010). Turkey is located at the junction of three major phytogeographic regions as Mediterranean, Euro-Siberian, and Irano-Turanian (Avcı, 1993). It is also important to note that the Anatolian Diagonal divides the Irano-Turanian phytogeographic region in Turkey into eastern and western areas (Figure 1).

Anatolia not only acted as a corridor for the dispersal of African animals during the Early Miocene, but also played a significant role as refuge area during the climatic fluctuations of the Pleistocene. Indeed, Turkey acted as as a large non-homogeneous refuge area playing important role for different taxa to help them to escape from the analogous effects of both glacial and interglacial cycles (Çıplak, 2008). Many plant and animal species are thought to expand their range after the glacial cycles from refugia to the present day-distribution (Hewitt, 2004). Moreover, in addition to the detection of great amount of genetic variation in diverse animal groups in Turkey, Anatolia has been proposed as the source of genetic diversity for many European species including oak gall wasps (Challis et al., 2007; Rokas et al., 2003).

Many western Palearctic species are thought to originate from eastern parts of their distribution range including Turkey, and those easterly located populations represent significant centers of genetic diversity (Rokas et al. 2003). Besides, recent studies have indicated that multiple oak gall wasp lineages diverged prior to the arrival of modern oaks in the western Palearctic and oak gall wasp lineages spread westwards from Anatolia (Stone et al., 2007).

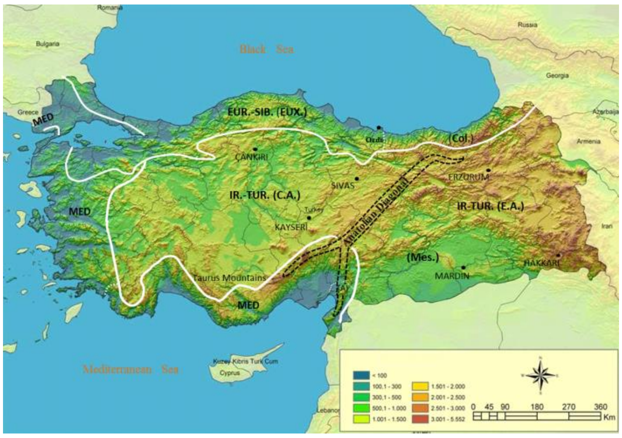

Figure 1. Representation of the Anatolian Diagonal and the approximate location of the phytogeographic regions in Turkey. Col.: Colchic, EUR.SIB.(EUX.) Euro-Siberian (Euxin), IR.TUR. (C.A.): Irano-Turanian (Central Anatolian), IR.TUR (E.A.): Irano-Turanian (East Anatolian), Mes.: Mesopotamia, MED: Mediterranean. The location of the Diagonal is modified from Davis (1971).

Indeed, several western Palearctic oak gall wasps currently ranging from Iberia to Iran pointed out an eastern origin (Challis et al., 2007). From the phylogeographic point of view, glacial refugia are assumed to harbor high diversity of genotypes and major lineages within a species (Hewitt, 2000). In fact, researches have shown that Turkish genetic variation was greatest among all examined Palearctic populations and had several otherwise rare alleles, and represented the source for pre-Pleistocene colonization of European gall wasps (Rokas et al., 2003).

2. Review of phylogeographic patterns for oak gall wasps in Anatolia

Oak gall wasps with nearly 1300 species constitute the primary group of insects that induce galls mainly in the members of *Quercus*, and are accepted as obligatory parasites of their hosts being highly specialized for different plant parts, tissues and organs (Stone and Cook, 1998). Turkey constitutes one of the oak-rich regions with 20 defined species and hybrids between these oak taxa from three sections of the genus *Quercus* (Kasaplıgil, 1992).

Members of the different oak sections host a variety of gall wasp species with high species diversity in Turkey (Mutun et al., 2014). Since oak gall wasps are obligate parasites of their plant hosts, their distribution is directly correlated with the range of their specific oak host. They may be good candidates for studying both the effects of geographical barriers and of oak gall wasp distributions. In recent years, there is growing number of studies in Turkey to search for if a general pattern is observed in gall wasps to distinguish the factors responsible for creating the current genetic structure. Thus, the main objective of this study is to make a brief evaluation through using the up to date published data currently present on oak gall wasp species from Turkey to see if i) a general phylogeographic pattern is observed, and ii) the major mountain lines shaped the oak gall wasp population structure.

In recent years, several studies concerning oak gall wasps revealed the amount of genetic diversity present in the Turkish populations, the allocation the genetic variation across the species range, and the phylogeographic structure within species (Dinç and Mutun, 2011; Mutun, 2011; Mutun et al., 2013). Previous studies on oak gall wasps in the Palearctic region showed that the highest genetic variation is observed in the Turkish populations. In a study conducted on *A. coriarius* using mitochondrial DNA cytochrome b gene, nucleotide diversity was revealed as 0. 005 and 0.006 in Iranian and Lebanese populations, respectively; however nucleotide diversity was 0.015 in Turkey (Challis et al., 2007). Other similar investigations on the Anatolian oak gall wasps showed that the genetic diversity across the Turkish populations was quite high (Table 1). Average haplotype and nucleotide diversity in *A. lucidus* was 0.808 and 0.115, respectively (Mutun, 2011). Likewise, in *A. caputmedusae* haplotype and nucleotide diversity was 0.463 and 0.101 (Mutun, 2010), and in *A. quercustozae* haplotype and nucleotide diversity was 0.450 and 0.050, respectively (Dinç and Mutun, 2011).

Table 1. Genetic diversity estimates for different oak gall wasp taxa from Turkey

	Genetic diversity			
Species	Haplotype div.	Nucleotide div.	Marker	Reference
Andricus caputmedusae	0.4631 ± 0.00447	0.101214 ± 0.00027	PCR-RFLP, mtDNA	Mutun, 2010
A. lucidus	0.8089 ± 0.00041	0.115542 ± 0.00016	PCR-RFLP, mtDNA	Mutun, 2011
A. quercustozae	0.4573 ± 0.00856	0.054948 ± 0.00017	PCR-RFLP, mtDNA	Dirç & Mutun, 2011
A. lignicola	0.3251 ± 0.00109	0.008795 ± 0.00516	mtDNA sequencing	Karagözoglu, 2013
A. gallaetinctoriae	0.3415 ± 0.01289	0.025720 ± 0.00009	PCR-RFLP, mtDNA	Mutun et al., 2013
Cynips quercusfolii	0.7285 ± 0.11431	0.009240 ± 0.00611	mtDNA & nDNA seq	Dirç & Mutun, 2014
Trigonaspis synapsis	0.8554 ± 0.00002	0.013461 ± 0.00121	mtDNA & nDNA seq	Atay, 2014

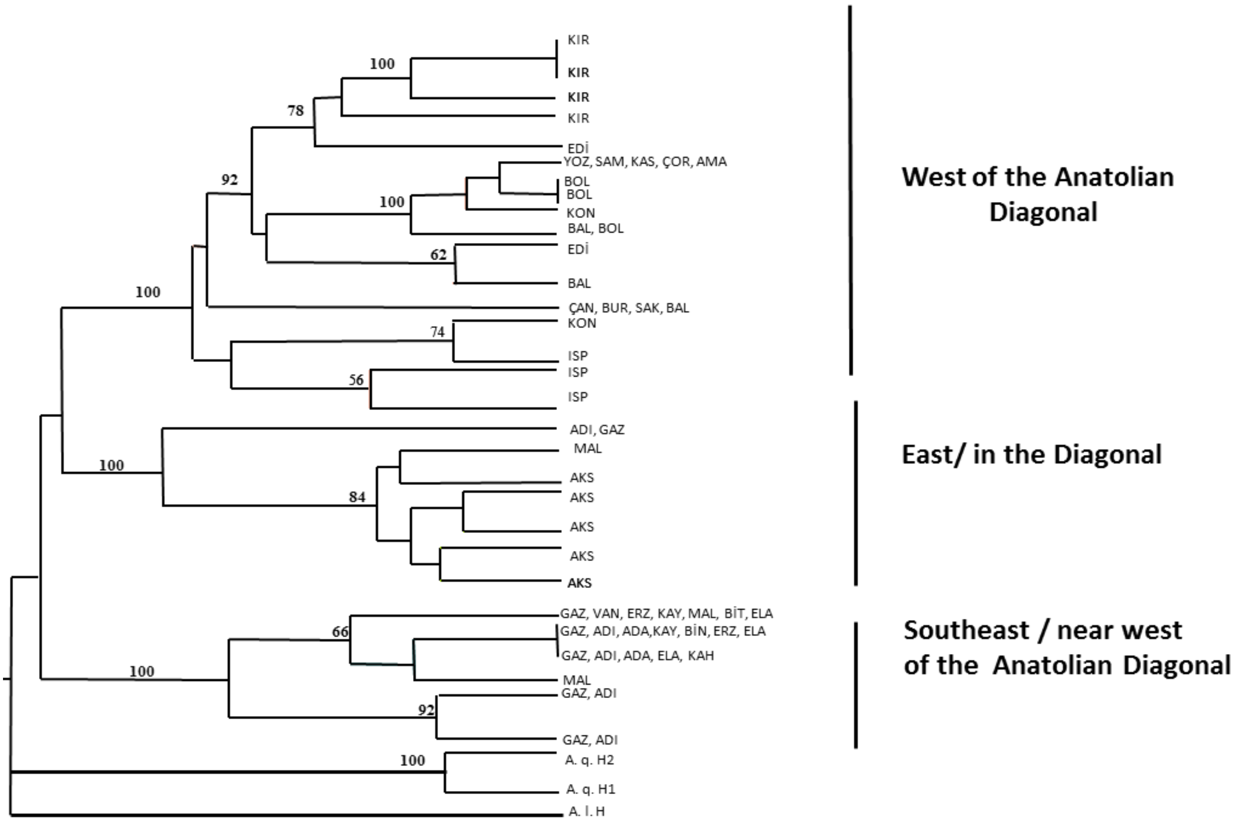

Figure 2. Dendrogram showing three major clades in *A. caputmedusae* (from Mutun, 2010)

The allocation of genetic diversity among the Turkish oak gall wasp populations has been also studied across the distribution range of the examined taxa (Dinç and Mutun, 2011; Mutun, 2010; Karagözoğlu, 2013; Atay, 2014). The geographic distribution of the genetic variation within *A. caputmedusae* in Turkey was divided into mainly East/in the Diagonal, Southeast/nearwest of the Diagonal, and West of the Diagonal (Figure 2) (Mutun, 2010). A conspicuous break in the partitioning of the genetic variation was proposed to be associated with the mountain belts in Anatolia (Figure 3).

Likewise, in *A. quercustozae* samples collected from 16 populations scattered both sides of the Anatolian Diagonal produced three major clades as 'Eastern and Western Clade', 'Western Clade', and 'Eastern Clade' supporting further the existence of a genetic break in the Anatolian oak gall wasp taxa (Figure 4 and 5) (Dinç and Mutun, 2011).

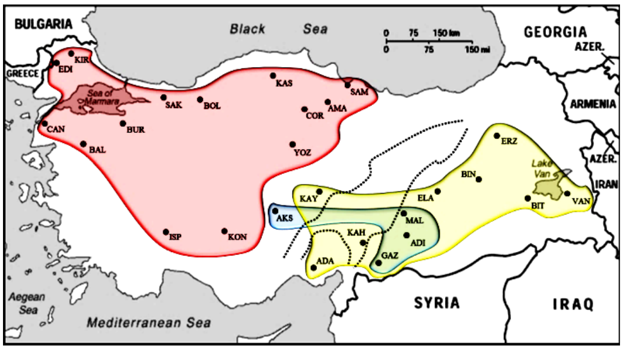

Figure 3. Representation of the major clades of *A. caputmedusae*. Dotted lines indicate the Anatolian Diagonal.

● : West of the Anatolian Diagonal,
● : East/In the Diagonal,
● : Southeast/near West of the Anatolian Diagonal.

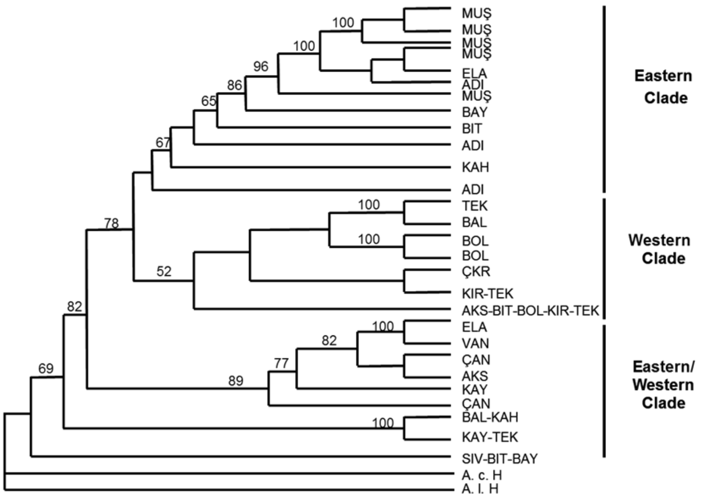

Figure 4. Dendrogram of the 28 haplotypes of *A. quercustozae* presenting three clade structure in theTurkish populations (from Dinç and Mutun, 2011)

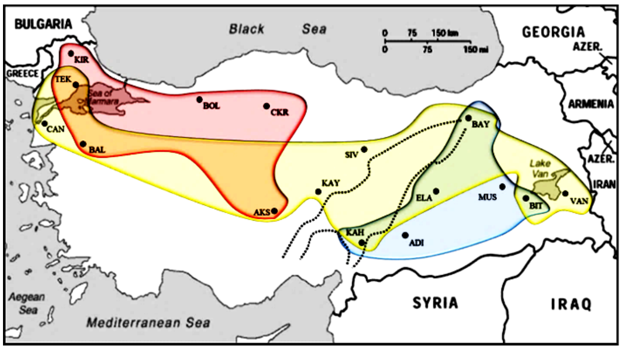

Figure 5. Representation of the major clades of *A. quercustozae*. Dotted lines indicate the Anatolian Diagonal.
●: Western Clade, ●: Eastern Clade, ●: Eastern/Western Clade.

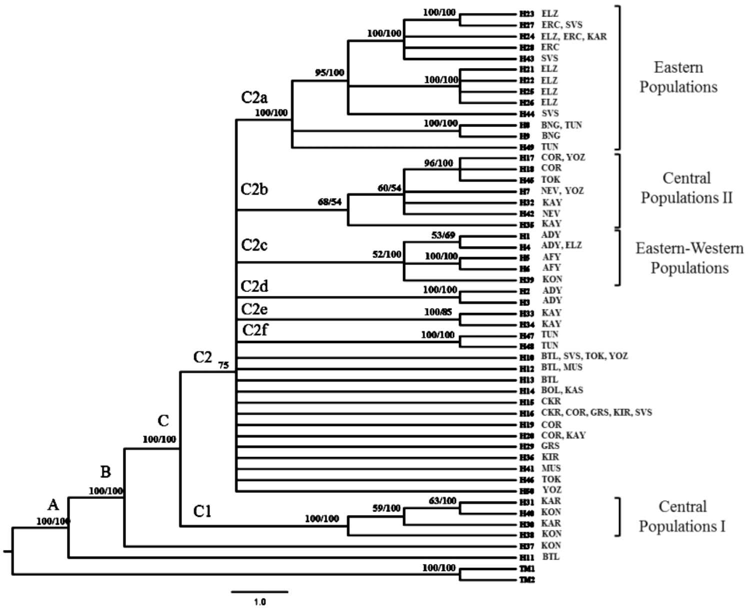

Figure 6. The consensus tree of maximum parsimony and maximum lilkelihood of mitochondrial cytochrome b gene of *T. synapsis* (from Atay, 2014)

A latest study on *Trigonaspis synapsis* from Anatolia (Atay 2014) showed a much more complex ditribution pattern of haplotypes indicating though shallow but supporting evidence with an eastern haplotype being the most basal one in the maximum parsimony, maximum likelihood and Bayesian phylogenetic trees (Figure 6). Furthormore, the placement of a 'Central Populations I' haplogroup in the tree was remarkable. In a large polytomic part of the three the grouping of four haplogroup structure produced 'Eastern Populations', Central Populaton II', and a clade referred to a mix of populations covering 'Eastern-Western Populations' (Figure 7). The formation of the major haplogroups was shown to be closely correlated with the effect of the Pleistocene climatic fluctuations together with the topographic barriers in Anatolia.

The similarity of a genetic break in some degree in the Anatolian oak gall wasp taxa have been also reported for A. *gallaetinctoria*e producing three major haplogroups within the sampled range of the species from Turkey (Figure 8 and 9) (Mutun et al., 2013). The distribution pattern of *A. gallaetinctoriae* haplotypes reflect also the partitioning of some shared haplotypes between some westerly and easterly located populations with respect to the location of the Anatolian Diagonal.

Latest studies expose the presence of high genetic diversity in the Turkish populations of oak gall wasps and underlie the importance of Anatolia as a source of genetic diversity for European taxa (Rokas et al. 2003, Challis et al., 2007). Similar results have also been reported from other species including plants (Ansell et al., 2011) and various animal groups such as bicolored shrew (Dubey et al., 2007), yellow-necked field mouse (Michaux et al., 2004), Anatolian mountain frog (Veith et al., 2003), fishes (Hrbek et al., 2002), ground squirrels (Gündüz et al., 2007) and grasshoppers (Korkmaz et al., 2010). In addition to the studies searching for the amount of genetic variation in the Turkish populations, the distribution of this diversity across Turkey and the factors shaping the contemporary pattern are also the subject of recent studies. Among these, studies of species distribution and regional composition have suggested that, together with the Tertiary history of Turkey, the Anatolian Diagonal is responsible for breaks in distributions at both specific and generic levels (Çıplak, 2004). In addition to the Diagonal, several other altitudinal belts in Anatolia have been proposed either to fragment species/lineage distributions or provide limits for east-west or north-south distributions (Çıplak, 2008). Thus, defining range distributions of lineages or genetic structuring of individual species including oak gall wasps has particular importance in understanding the biogeography of Anatolia. In the Turkish oak gall wasp taxa it seems that either deep or shallow there is a genetic break in the allocation of the genetic variation. Further and more detailed studies on oak gall wasps are still necessary for revealing a general pattern to be drawn for the genetic break shown by the investigated species from Anatolia.

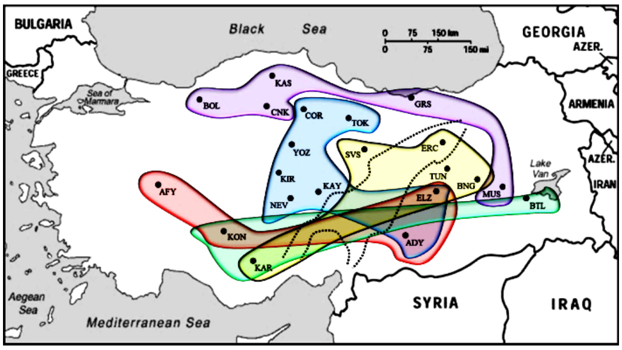

Figure 7. Location of the major haplogroups of *T. synapsis*. ●: Eastern-Western Populations, ●: Central Populations II, ●: Eastern Populations, ●: Central Populations I, ●: Mixed haplogroup.

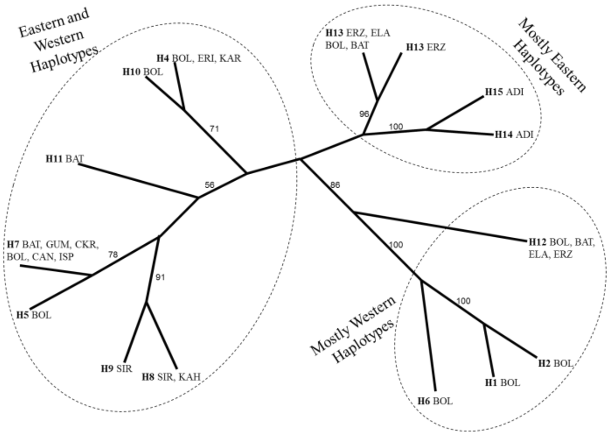

Figure 8. Unrooted Dollo parsimony majority-rule consensus tree of *A. gallaetinctoriae* haplotypes (modified from Mutun et al., 2013)

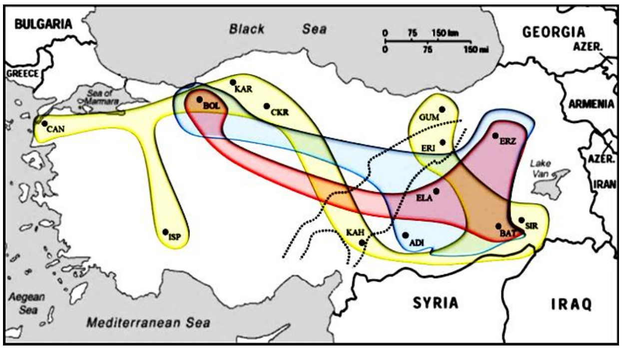

Figure 9. Distribution of main haplogroups of *A. gallaetinctoriae*. ●: Mostly Western Haplotypes, ●: Mostly Eastern Haplotypes, ●: Eastern and Western Haplotypes

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2016, 17(Special Issue): 7-10 | Research article (Araştırma makalesi)

Inventaire des galles de chêne-liège (*Quercus suber*) et chêne zeen (*Quercus faginea*) dans les forêts de l’Est Algérien

Rym Ghanem[a,*], Yasmine Adjami[a], Hiba Daas[a], Mohamed Laid Ouakid[a], Juli Pujade-Villar[b]

Résumé : Les subéraies algériennes sont constituées, essentiellement de chêne-liège (*Quercus suber*) et de chêne zeen (*Quercus faginea*), elles abritent une entomofaune très diversifiée dont les espèces gallicoles. Nous nous sommes intéressés à la récolte et l’identification des différentes galles qui s’installent sur les différents organes du chêne-liège (*Quercus suber*) et du chêne zeen (*Quercus faginea*). Nous avons choisi cinq forêts de l’Est algérien, la forêt du Parc National d'El Kala, la forêt d’El Gourah à El Taref, la forêt domaniale d’Oued Bechih à Souk-Ahras, la forêt de l’Edough à Annaba et la forêt de Collo (Skikda). Les récoltes concernent les feuilles, les bourgeons, les chatons, les rameaux et les fruits. Nous avons observées 12 espèces d’insectes gallicoles (Hymenoptera: Cynipidae). Nous citons ceux réparties sur les feuilles (*Neuroterus minutulus, Neuroterus saltans, Neuroterus quercusbaccarum*), sur les bourgeons (*Andricus hispanicus, Andricus pseudoinflator, Biorhiza pallida*), sur les chatons (*Andricus grossulariae, Andricus quercusramuli*), sur les rameaux (*Callirhytis glandium, Synophrus olivieri* et *Synophrus politus*) et sur les glands (*Callirhytis glandium*).

Mots clés : Chêne-liège, Galles, Cynipidae, Nord-Est Algérien

Inventory of galls in oaks (*Quercus suber, Quercus faginea*) in the east Algerian’s forests

Abstract: The Algerian forests are essentially constituted of *Quercus suber* and *Quercus faginea*; they shelter a much-diversified entomofaune among which the species gall. We were interested in the collection and identification of the various galls which settle down on the different organs of the *Quercus suber* and of the *Quercus faginea*. We have chosen four eastern Algerian forests to realize our work, the forest of the National Park of El Kala, the national forest of Ouled Bechih in Souk-Ahras, the forest of Edough in Annaba and the forest of Collo (Skikda). The samplings concern leaves, buds, flowers, twigs and acorns of the trees of *Quercus suber* and *Quercus faginea*. We have highlighted12 species of galls. Weincluded those distributed on leaves (*Neuroterus minutulus, Neuroterus saltans* and *Neuroterus quercusbaccarum*), buds (*Andricus hispanicus, Andricus pseudoinflator, Biorhiza pallida*), flowers (*Andricus grossulariae, Andricus quercusramuli*), twigs (*Callirhytis glandium, Synophrus olivieri* and *Synophrus politus*) and acorns (*Callirhytis glandium*).

Keywords: Cork oak, Galls, Cynipidae, Algerian northeast forest

Doğu Cezayir’de meşe (*Quercus suber, Quercus faginea*) ormanlarında gal envanteri

Özet : Cezayir ormanları esas olarak *Quercus suber* and *Quercus faginea* türlerinden oluşmaktadır; bu türler arasında mazı sineğinin de bulunduğu çok çeşitli entomofaunaya ev sahipliği yapmaktadır. Bu çalışmada, *Quercus suber* ve *Quercus faginea* ağaç Coleoptera inventory larının farklı organlarına yerleşen çeşitli mazı sineğinin toplanması ve tespit edilmesini amaçladık. Çalışmamızı gerçekleştirmek üzere Cezayir’in doğusunda bulunan ormanları, El Kala Milli Parkında yer alan ormanı, Souk-Ahras’taki Ouled Bechih Milli ormanını, Annaba’daki Edough ormanını ve Collo ormanını (Skikda) seçtik. Örnekler, *Quercus suber* ve *Quercus faginea* ağaçlarının yapraklarından, sürgünlerinden, çiçeklerinden, dallarından ve palamutlarından alınmıştır. 12 mazı türü tespit ettik. Yapraklarda (*Neuroterus minutulus, Neuroterus saltans* ve *Neuroterus quercusbaccarum)*, sürgünlerde (*Andricus hispanicus, Andricus pseudoinflator, Biorhiza pallida*), çiçeklerde (*Andricus grossulariae, Andricus quercusramuli*), dallarda (*Callirhytis glandium, Synophrus olivieri* ve *Synophrus politus*) ve palamutlarda (*Callirhytis glandium*) dağılım gösterenleri çalışmaya dahil ettik.

Anahtar kelimeler: Cork meşe, Galls, Cynipidae, Kuzeydoğu Cezayir

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1. Introduction

Les Fagacées ont un rôle déterminant dans les forêts méditerranéennes. Le genre *Quercus* comptent parmi les écosystèmes les plus riches sur le plan entomologique où les arbres et le sous-bois offrent un abri et une nourriture à une entomofaune très diversifiée. Les galles sont des structures anormales déformantes des végétaux pouvant affecter aussi bien les feuilles, que les pédoncules, les bourgeons ou les chatons mais aussi les rameaux, les racines, les radicelles et les fruits (Dajoz, 1980). Ces galles peuvent entraîner un effet de dépérissement précoce des organes de la plante-hôte (West & Shorthouse, 1982 ; Williams et Whitham, 1986 ; Bagatto et al., 1996), les fruits avortent (Stone & Schönrogge, 2003). Les gallicoles se recrutent parmi les Diptères Cécidomyides, les Homoptères ainsi que chez de rares Coléoptères et surtout les Hyménoptères qui sont les plus connus dans ce genre de formation et représentés plus particulièrement par la famille des Cynipidae (Meyer, 1987 ; Shorthouse & Rohfritsch, 1992 ; Stone & Schönrogge, 2003).

Comme pour la plupart des pays d'Afrique du Nord, les galles en Algérie, ont été très peu étudiés jusqu'à présent. Les premières contributions à la connaissance faunistique de cette famille sont de Marchal en 1897, suivi par le travail de Houard en 1912 et 1914. L'actualisation des données par Pujade-Villar et al. (2012), sur les espèces gallicoles reste un document de base. Nous nous sommes intéressés à la récolte et l'identification des différentes galles qui évoluent sur le chêne-liège (*Q. suber*) et le chêne zeen (*Q. faginea*) issues de cinq forêts de l'Est algérien : la forêt du parc national d'El Kala, la forêt d'El Gourah à El Taref, la forêt domaniale de Ouled Bechih à Souk-Ahras, la forêt de l'Edough à Annaba et la forêt de Collo (dans la commune de Beni Zid, située au Sud-Ouest de la wilaya de Skikda).

2. Matériel et Méthodes

Les forêts choisies pour la récolte des Cynipidés, sont toutes situées dans l'Est de l'Algérie. La première est une forêt située sur le littoral dans le Parc National d'El-Kala, la deuxième est la forêt de Gourah situé dans la willaya de El Tarf, la troisième est une forêt de haute montagne situé dans la willaya de Souk-Ahras, la quatrième forêt est situé dans le massif de l'Edough à Annaba, la dernière forêt est située dans la région de Collo. Les caractéristiques écologiques de ces forêts sont résumées dans le tableau 1.

Tableau 1. Caractéristiques écologiques des sites étudiés.

Placettes	Distance à la mer (km)	Altitude	Peuplement
Subéraie El Gourah	40	1200m	*Q. suber –Q. faginea*
Subéraie El Kala	7	12m	*Q. suber*
Subéraie Souk-Ahras	100	800m	*Q. suber –Q. faginea*
Subéraie Edough	5	950 m	*Q. suber- Q. faginea*
Subéraie Collo	50	900m	*Q. suber- Q. faginea*

Les Cynipidés gallicoles présentent des tailles et des formes très variables, ce qui nécessite une observation minutieuse de chaque partie des arbres (Rameaux, feuille, tige, fruit, bourgeons…), nous avons aussi ramassé les glands tombés au niveau du sol. Les échantillons ont été prélevés en automne et au printemps durant les saisons 2009/2010 et 2010/2011. Les différents échantillons récoltés sont placés dans des sacs en plastiques on notant toute information nécessaire concernant cette récolte. Un examen minutieux des feuilles permet de faire ressortir les différentes galles de cet organe. Concernant les glands, une dissection longitudinale du fruit met en évidence les éventuelles galles. Au laboratoire, les galles trouvées en été triées par espèce et placées dans des boites d'élevage jusqu'à l'émergence des adultes.

L'identification d'insectes gallicoles a été réalisée grâce à une collection de ce groupe dans notre laboratoire et confirmé par le laboratoire de Biologie animale de l'Université de Barcelone.

3. Résultats

Toutes les espèces identifiées appartiennent à l'ordre des Hyménoptères et à la famille des Cynipidae, dix d'entre elles appartiennent à la tribu des Cynipini, et deux à la tribu des Synergini. Elles sont réparties toutes entre cinq genres dont les plus représentés sont le genre *Andricus* et *Neuroterus* (Tableau 2).

Tableau 2. Liste des espèces d'insectes inducteurs des galles (Hymenoptera : Cynipidae) identifiées sur *Quercus suber* et *Quercus faginea* et leur localisation dans les régions d'étude. 1: El Kala; 2: Souk-Ahras; 3: Edough; 4: Collo; 5: El Gourah.

Espèces	Génération	Plante hôte	Organe attaqué	Régions d'étude
Andricus grossulariae	Sexué	*Q.suber*	Chatons	2+5
Andricus hispanicus	Asexué	*Q. faginea*	Bourgeons	2+5
Andricus pseudoinflator	Sexué	*Q. faginea*	Bourgeons	5
Andricus quercusramuli	Sexué	*Q. faginea*	Chatons	2+5
Neuroterus quercusbaccarum	Sexué	*Q. faginea*	Feuilles	5
Biorhiza pallida	Sexué	*Q. faginea*	Bourgeons	2+5
Neuroterus minutulus	Asexué	*Q.suber*	Feuilles	1+2+3+4
Neuroterus saltans	Asexué	*Q.suber*	Feuilles	1+2+4
Callirhytis glandium	Asexué	*Q.suber*	Glands	2+3+4
	Sexué	*Q. faginea*	Rameaux	1
Synophrus olivieri	/	*Q.suber*	Rameaux	1+3+4
Synophrus politus	/	*Q.suber*	Rameaux	1+3+4

C'est incontestablement la subéraie de Souk-Ahras qui présente la plus grande richesse spécifique concernant les galles (*Andricus grossulariae, Andricus hispanicus, Andricus quercusramuli, Biorhiza pallida, Neuroterus minutulus, Neuroterus saltans* et *Callirhytis glandium* (asexué et sexué)), elle est suivie des forêts d'El Gourah (*Andricus grossulariae, Andricus hispanicus, Andricus pseudoinflator, Andricus quercusramuli, Neuroterus quercusbaccarum* et *Biorhiza pallida*). La forêt du littorale El Kala semble moins riche en galles (*Neuroterus minutulus, Neuroterus saltans, Synophrus politus* et *Synophrus olivieri*) et la subéraie d'Edough (*Neuroterus minutulus, Synophrus politus, Synophrus olivieri* et *Callirhytis glandium* (asexué)). (Table 2).

4. Discussion

Une galle ou cécidie est une formation végétative, provenant d'une excroissance anormale de la plante. Elle est définie aussi comme un fruit issu de l'action conjuguée de deux organismes bien distincts, ou de deux patrimoines génétiques indépendants entrant localement en interaction intime (Mani, 1964; Dajoz, 1980 ; Giuntoli, 1985; Pujade-Villar, 1986; Meyer, 1987; Shorthouse et Rohftitsch, 1992; Dauphin, 1994; Buss, 2003). Les galles se rencontrent sur de très nombreux végétaux. Près de 50% des galles connues dans l'hémisphère nord sont sur des arbres de la famille des Fagaceae, et en particulier sur des *Quercus* et *Fagus* ou tous les organes peuvent être atteints (Dajoz, 1980). En Afrique du Nord, 86% des Cynipidae se développent sur le genre *Quercus* (Askew, 1984).

Dans cinq forêts de l'est Algérien, nous avons recensé10 espèces de Cynipini évoluant sur le chêne-liège et le chêne zeen. Certaines espèces provoquent des galles uniquement sur le chêne zeen et d'autres sur le chêne-liège et une espèce trouvé sur les deux chênes. De nombreuses espèces produisent leurs galles sur les bourgeons exclusivement du chêne zeen, parmi lesquelles on cite les galles récoltés dans les forêts de Souk-Ahras et Gourah tel que la forme sexuée de *Andricus pseudoinflator* et *Biorhiza pallida,* et la forme asexuée de *Andricus hispanicus. Andricus pseudoinflator* est citée pour la première fois en Algérie par Pujade-Villar et al. (2011). Les galles des formes sexuées et asexuées de cet insecte se trouvent sur les bourgeons du *Quercus faginea*. *Andricus hispanicus* a été mentionnée en Algérie par Houard (1912) sous la dénomination d'*A.kollari*, cité aussi par Pujade-Villar (2010).

On a également récolté des galles du genre *Neuroterus* sur les feuilles des deux chênes étudiés. La forme asexuée des deux galles *Neuroterus minutulus* et *Neuroterus saltans* est présente dans les forêts de chêne-liège d'El Kala, Collo et Souk-Ahras. Ces espèces sont aussi présentes dans les subéraies en Tunisie sur *Q. suber* (Pujade-Villar & Benjamâa 2011). La forme sexuée de *Neuroterus quercusbaccarum* a été trouvée dans les forêts de chêne zeen de Gourah, elle est citée en Algérie par Houard (1912). Nous avons dénombré des galles au niveau des chatons dans les forêts de Souk-Ahras et Gourah, la forme sexuée d'*Andricus grossulariae* sur chêne-liège et également *Andricus quercusramuli* sur chêne zeen. La forme sexuée d'*Andricus grossulariae* citée par Houard (1912), est une espèce hétéroecique formant des galles de la génération sexuée sur les chatons du chêne-liège, et celles de la forme asexuée dans les bourgeons de chêne zeen (Pujade-Villar et al., 2011).

Sur les glands du chêne-liège se développe la forme sexuée de *Callirhytis glandium* alors que la forme asexuée est retrouvée sur les rameaux du chêne zeen, cette galle se développe dans les forêts de Souk-Ahras, Edough et Collo. Le genre *Synophrus* est représenté par deux espèces dans nos sites d'étude : *Synophrus politus* et *Synophrus olivieri,* ces espèces ont perdu la capacité d'induire leurs propres galles mais quelques-unes ont la faculté d'induire le développement de tissus de la plante nutritive dans les galles d'autres cynipidés.

Cette étude ne constitue qu'une ébauche d'un inventaire à mener dans cette région sur les galles et reste à compléter.

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Inventaire des Coléoptères des subéraies du Nord-Est Algérien

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Résumé : La faune entomologique est un élément essentiel dans la dynamique et le fonctionnement des écosystèmes forestiers. Le rôle écologique ainsi que le caractère bio-indicateur de certaines espèces d'insectes peuvent indiquer l'état sanitaire des forêts et déterminer certains facteurs liés à la dégradation de celles-ci. Au niveau des subéraies Algériennes, de nombreuses attaques d'insectes touchant principalement les feuilles, les fruits ainsi que le tronc du chêne ont étés signalés. L'action de certains Coléoptères phytophages (Curculionidae,..) est l'une des principales causes de la défoliation, les xylophages affaiblissent l'arbre tandis que les ravageurs des glands ont un impact direct sur la régénération. Afin de déterminer la relation entre la faune entomologique et le dépérissement des forêts de chêne-liège en Algérie, nous avons réalisé un inventaire des Coléoptères de deux subéraies de l'Est Algérien (la subéraie du Parc National d'El-Kala et la subéraie Souk-Ahras) en ayant recourt aux différentes techniques utilisées dans le domaine de l'entomologie (Récolte à vue, Pots Barber, Pièges aériens). Nous avons recensé plus de 100 espèces de Coléoptères appartenant à 25 différentes familles, dont 68 espèces récoltées au Parc National d'El-Kala et 41 espèces à Souk-Ahras. L'étude du régime alimentaire (coprophagie, saproxylie, prédation, phytophagie ou décomposition) a permis d'évaluer le rôle écologique des espèces inventoriées dans les écosystèmes forestiers.

Mots clés: Subéraie, Algérie, El Kala, Souk-Ahras, Entomofaune, Coléoptères

Coleoptera inventory in cork oak stands of North-Eastern Algeria

Abstract: Insect fauna is an essential element in the dynamics and functioning of forest ecosystems. The ecological role and bio-indicator status of certain species can indicate the sanitary status of forests and helps identifying factors related to their degradation. Many attacks of pest insects affecting primarily the leaves, the acorns and the trunk of the oak have been reported. Action of some phytophagous Coleoptera (Curculionidae …) is one of the main defoliation causes, the borers weakening the tree, while acorn's pests have directly impact regeneration. These attacks can weaken cork oak populations and contribute to their decline. An inventory of Coleoptera was conducted to determine the richness, the diversity, and the ecological role of inventoried species. Sampling was conducted in two cork forests in North-Eastern Algeria (El Kala and Souk Ahras) with different techniques used in the field of entomology (visual collecting, pitfall trap, and aerial traps). We identified 100 species of Coleoptera belonging to 25 different families with diversified feeding types (coprophagous, saproxylic, predatory, herbivorous or decomposers). Calculation of ecological indexes allowed situating the different populations in their environment.

Keywords: Cork-oak, Entomology, Coleoptera, El Kala, Souk-Ahras

Kuzeydoğu Cezayir'de mantar meşesi meşcerelerinde Coleoptera envanteri

Özet: Böcek faunası, orman ekosistemlerinin dinamikleri ve işleyişi açısından elzemdir. Belirli türlerin ekolojik rolü ve biyolojik gösterge statüsü, ormanların sağlık durumu hakkında bir gösterge olabilir ve ormanların bozulmasıyla ilgili faktörlerin belirlenmesine yardımcı olur. Öncelikle meşe ağaçlarının yapraklarına, palamutlarına ve gövdesine zarar veren böceklerin yaptığı pek çok saldırı bildirilmiştir. Bazı fitofagoz kınkanatlıların hareketleri (Curculionidae …), yaprak dökülmesine yol açan ana nedenlerden biridir, kurtlar ise ağaçların zayıflamasına neden olurken palamut zararlıları doğrudan genleşmeyi etkilemektedir. Bu saldırılar, mantar meşelerini zayıflatabilir ve çürümesine katkı sağlamaktadır. Kınkanatlılarla ilgili bir envanter çıkarılarak envanteri çıkarılan türlerin zenginliği, çeşitliliği ve ekolojik rolü belirlenmiştir. Örnekler, entomoloji alanında kullanılan farklı tekniklerin (görsel toplama, çukur tuzak ve hava tuzağı) yardımıyla Kuzeydoğu Cezayir'de bulunan iki meşe ormanından (El Kala ve Souk Ahras) alınmıştır. Farklı beslenme alışkanlıklarına (koprofaj, saproksilik, avcı, otobur veya ayrıştırıcılar) sahip 25 farklı familyadan 100 kınkanatlı türü tespit ettik. Ekolojik endekslerin hesaplanması sayesinde farklı popülasyonların kendi ortamlarında konumları belirlenmiştir.

Anahtar kelimeler : Montado, Cezayir, El Kala, Souk Ahras, Entomofauna, Beetles

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1. Introduction

Les forêts hébergent une importante faune dont les insectes, une classe extrêmement diversifiée et d'une grande importance pour les écosystèmes (Wiggins, 1983; Finnamore, 1996). Ils participent à toute la gamme des processus naturels essentiels au maintien des systèmes biologiques, et représentent aujourd'hui plus de 75% des espèces animales connues. (Wiggins et al. 1991). C'est le cas des chênaies qui offrent un abri et une nourriture à une entomofaune très diversifiée (Pujade-Villar *et al;* 2010).

Malgré quelques dégâts spectaculaires, parfois destructeurs, l'influence des insectes est le plus souvent positive voire indispensable au bon équilibre de la forêt (Nicolas, 2009). Les insectes représentent en effet une part prépondérante de la biodiversité animale forestière. Ce sont des acteurs du fonctionnement des écosystèmes qui interviennent à tous les niveaux des réseaux trophiques. Ils peuvent être consommateurs primaires (insectes phytophages), consommateurs secondaires ou tertiaires (prédateurs, super-prédateurs, parasites, hyperparasites). Les saprophages (saproxylophages, nécrophages, coprophages, détritivores) sont des acteurs indispensables du cycle de la matière (matière organique, éléments minéraux…). La présence ou l'absence de cortèges d'espèces permet de vérifier le bon fonctionnement de l'écosystème. Les insectes sont de ce fait de bons indicateurs de la qualité de l'écosystème et de l'impact de la gestion sur le milieu forestier (Nageleisen & Bouget, 2009).

Les subéraies Algériennes sont comprises entre les frontières marocaines et tunisiennes et s'étendent du littoral méditerranéen au Nord jusqu'aux chaînes telliennes au sud sur des superficies entre 429000 et 480 000 ha selon les inventaires et les auteurs (Boudy, 1955; Valette, 1992; Zine, 1992) abritant une diversité biologique significative. Plusieurs organismes (insectes, plantes, champignons …) interagissent directement ou indirectement avec les arbres et constituent des éléments naturels et intégraux des écosystèmes (Chararas, 1977).

Les inventaires réalisés sur la faune entomologique des subéraies de l'Est Algérien notamment sur les subéraies du Parc National d'El-Kala ont démontré une forte présence d'espèces appartenant à l'ordre des Coléoptères. On a enregistré une forte action des Coléoptères xylophages dans les subéraies du Parc National d'El-Kala, qui se traduit par des trous et des galeries sur les troncs des arbres (Adjami, 2009). La présente étude s'appuie sur ce résultat afin de démontrer le rôle qu'exerce chaque espèce dans la dynamique de l'écosystème forestier et leur impact sur l'état sanitaire des subéraies. Elle consiste à dresser un inventaire des coléoptères récoltés dans deux subéraies dont l'une présente des signes de dépérissement et l'autre est une subéraie saine (Ghanem, 2013) L'impact des coléoptères récoltés dans les deux subéraies est déterminé à travers le régime alimentaire de chaque espèce.

2. Matériel et méthodes

2.1. Présentation de la région d'étude

Le présent inventaire a été réalisé au niveau de deux subéraies du Nord-Est Algérien (Figure 1). La première subéraie est située au niveau du Parc National d'El-Kala (PNEK) qui constitue un patrimoine naturel important par la richesse biologique de ses habitats, il est composé d'une mosaïque particulière d'écosystèmes et caractérisée par des zones humides classées RAMSAR. Une superficie de 1300ha est occupée par les forêts de chêne-liège, dont les plus exploitées sont les subéraies du massif de Brabtia où nous avons effectué notre récolte. Les subéraie de Brabtia se caractérisent par un état sanitaire dégradé et dépérissant.

La deuxième subéraie se situe au niveau de wilaya de Souk-Ahras dans la forêt de Ouled Bechih, nous avons choisi une station qui se situe à 700m d'altitude et dont le peuplement de chêne-liège présente un aspect dominant (Pure), elle se situe à 50 km de la mer et orientée vers le Nord, et se caractérise par un sous-bois réduit, une forte fréquentation humaine et un pâturage abondant. Le taux de recouvrement de la station est de 75% et la subéraie présente un état sain non dépérissant.

2.2. Les techniques de récolte

Pour établir l'inventaire des Coléoptères vivants dans le peuplement du chêne-liège des deux subéraies étudiées, nous avons procédé aux différentes techniques de récolte couramment utilisés dans le domaine de l'entomologie.

La récolte à vue

Ces récoltes ont été effectuées entre Mars, Avril et Mai : Elles ont impliqués des observations minutieuses de la surface des troncs et des infractuosités du liège des arbres. Tous les adultes présents entre le collet et les premières branches ont été prélevés et mis dans des boites en plastiques aérées.

Les pièges Barber

Les pièges sont constitués de gobelets en polystyrène (20 cl) enterrés jusqu'au bord supérieur de façon à créer un puit dans lequel les insectes marcheurs vont choir. Une plaque (pierre, tuile ou écorce), disposée à un centimètre au-dessus du bord supérieur du piège, protège de l'eau de pluie. Ces pièges ont été rendus attractifs par l'addition de 4 cl de l'eau vinaigrée et de sel (conservateur), dans chaque station on a mis 30 pots séparés les uns aux autres d'une distance de 3 mètres.

Figure 1. Localisation des deux régions d'étude

*Les pièges aériens*Les pièges aériens permettent de capturer les coléoptères en vol. Ces pièges sont constitués de bouteilles en plastique de 5L qu'on accroche à une branche d'arbre à l'aide d'un cordon ou une ficelle. Une ouverture de 10cm X 10cm est taillée sur l'une des faces du piège pour permettre l'entrée des insectes. Le même mélange vinaigre-sel utilisé dans les pots barber est utilisé également dans les pièges aériens.

2.3. Conservation et identification

Les insectes récoltés au cours du temps sont conservés séparément dans des boites en plastiques munies d'étiquettes. Les insectes ont été placés dans un flacon en verre ont été conservés dans l'alcool éthylique 70°. Les espèces récoltées ont été identifiées selon des clés d'identification au laboratoire de L'Université Badji-Mokhtar et confirmé au laboratoire de: Universitat de Barcelona, Facultat de Biologia, Département de Biologia Animal, Barcelona, Spain.

2.4. Analyse et mise en forme des résultats

Les résultats sont analysés par le calcul de paramètres et d'indices écologiques permettant de déduire des orientations et des suggestions de gestion et d'aménagement des deux subéraies.

Indices écologiques : Nous avons calculé l'indice de diversité ou l'indice de Shannon (H') (Magurran, 1988), l'équitabilité (E) afin de déterminer le degré d'équilibre et de complexité des deux peuplements d'insectes étudiés. (Benyacoub, 1993), et l'indice de Sorensen ou l'analyse de similitude qui nous a permis d'apprécier la similitude ou la différence existante entre la composition spécifique du peuplement d'insectes récoltés dans la subéraie d'El Kala et ceux récoltés à Souk-Ahras (Magurran, 1988).

Composition trophique : Les espèces identifiées ont été classées selon le régime alimentaire des formes adultes ou celui des larves si l'adulte ne s'alimente pas, afin de déterminer le rôle joué par chaque espèce.

3. Résultats

L'inventaire réalisé compte près de 100 espèces appartenant essentiellement aux familles des : Scarabaeidae, Carabidae, Curculionidae, Tenebrionidae, Cerambycidae, Cleridae, Coccinellidae, Chrysomelidae, Staphylinidae et Histeridae (Figure 2). Au niveau du Parc National d'El-Kala (nous avons recensé 68 espèces appartenant à 19 familles dont la majorité est représenté par Scarabaeidae avec 23,18%, suivi des Carabidae et les Tenerionidae avec 13,04%, et les Chrysomelidae avec 11,59%. Les Curculionidae représentent 11,24% de l'ensemble des espèces et le reste est réparti sur les 14 familles restantes. Dans les subéraies de Souk-Ahras, nous avons inventorié 41 espèces de Coléoptères réparties sur 14 familles. La famille des Carabidae est la plus riche avec un taux de 24,39% de l'ensemble des espèces inventoriées, suivi des Curculionidae avec un taux de 21,95%, puis la famille des Scarabaeidae avec 9,75%. Les Tenebrionidae et les Staphylinidae représentent des taux de 7,31%, les Chrysomelidae représentent 4,87% et le reste est réparti sur les huit familles restantes : Silvanidae, Coccinellidae, Corticaridae, Cerambycidae, Cleridae, Nitidulidae, Malachiidae et Histeridae. Deux espèces sont en cours d'identification.

Le peuplement de Coléoptères du Parc National d'El-Kala est caractérisé par une dominance d'espèces appartenant à la Super-famille des Scarabaeoidea : La famille des Scarabaeidae compte le plus grand nombres d'espèces et elle est représentée essentiellement par les Cétoines : *Tropinota hirta, Oxythyrea funesta, Protaetia oblonga, Protaetia morio* et *Protaetia opaca.* La famille des Lucanidae est représenté par deux espèces du genre *Dorcus* et l'espèce *Sinodendron cylindricum.* Les Geotrupidae comptent une seule espèce : *Trypocopris vernalis.*

La famille des Carabidae, des Tenebrionidae et des Chrysomelidae comptent un nombre d'espèces presque équivalent. Les Carabidae sont représentés par 10 espèces dont : *Nebria andalusia, Carabus sp, Siagona sp, Pterostichus oblongopunctatus* et la Cicindelle *Cicindela flexuosa.*

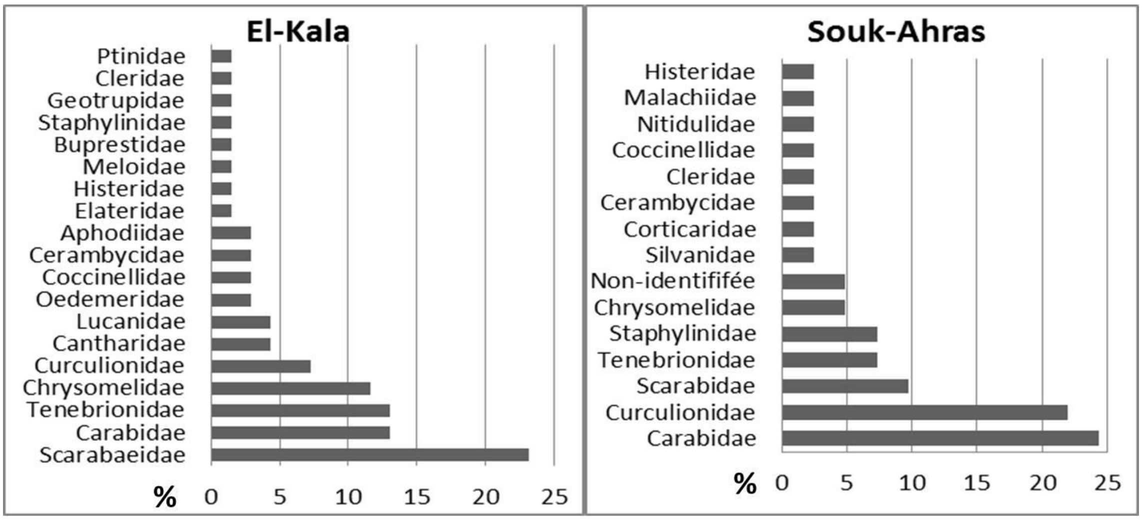

Figure 2. Importance relative des diverses familles de coléoptère

La famille des Curculionidae compte 5 espèces, les Cantharidae en comptent 3, Les Cerambycidae et les Coccinellidae comptent 2 espèces et les Oedemeridae sont représentés par 2 espèces du genre *Oedemera*.

Chacune des familles Meloidae, Elatridae, Staphylinidae, Histeridae et Buprestidae compte une seule espèce. Trois espèces appartennant à la famille des Cleridae, Ptinidae, et Aphodiidae sont en cours d'identification. (Tableau 1).

Concernant les espèces récoltés à Souk-Ahras, Les Carabidae sont dominants avec 9 espèces appartiennent essentiellement au genre *Carabus* et *Harpalus* les Curculionidae récoltés appartiennent surtout au genre *Barypeithes* et *Otiorynchus.* Les Scarabaeidae sont représentés par 4 espèces, les Staphylinidae sont représenté par 3 espèces et chacune des familles Tenebrionidae, Corticaridae et Chrysomelidae comptent deux espèces.

Nous avons également recensé une seule espèce pour chacune des familles : Silvanidae, Cerambycidae, Cleridae, Coccinellidae, Nitidulidae, Malachiidae et Histeridae. Deux espèces en cours d'identification appartiennent à la famille des Elatridae et des Ptinidae. (Tableau 2). Concernant les espèces communes, nous avons mis en évidence 12 espèces appartenant à 9 familles différentes (Tableau 3).

Tableau 1. Composition du peuplement de Coléoptères récoltés dans la subéraie d'El-Kala

Familles	Espèces	Familles	Espèces
Scarabaeidae	*Tropinota hirta*	Meloidae	*Mylabris variabilis*
	Aphodius erraticus	Elatridae	*Ampedus nigerrimus*
	Oxythyrea funesta	Cerambycidae	*Ergates faber*
	Protaetia morio		*Aegomorphus clavipes*
	Protaetia oblonga	Cleridae	Identification en cours
	Protaetia opaca	Coccinellidae	*Coccinella septempuctata*
	Oryctes nasicornis		*Adalia decepunctata*
	Scarbaeus sacer	Chrysomelidae	*Chrysolina sp*
	Gymnopleurus geoffroyi		*Lachnaia sp*
	Sisyphus schaefferi		*Luperus nigripes*
	Anoxia villosa		*Dicladispa testacea*
	Bubas bubalus		*Plagivolera versicolor*
	Onthophagus amyntas		*Labidostomis taxicornis*
	Onthophagus sp		*Melasoma populi*
	Euoniticellus fulvus		*Oulema melanopus*
Geotrupidae	*Trypocopris vernalis*	Staphylinidae	*Ocypus sp*
Lucanidae	*Dorcus parallelipipedus*	Histeridae	*Hister sp*
	Dorcus musimon	Cantharidae	*Rhagonycha lignosa*
	Sinodendron cylindricum		*Cantharis lateralis*
Carabidae	*Nebria andalusia*		*Malthodes rubricollis*
	Carabus sp	Oedemeridae	*Oedemera femorata*
	Siagona sp		*Oedemera lurida*
	Diachromus germanus	Buprestidae	*Capnodis tenebrionis*
	Cymindis melanocephala	Aphodiidae	Identification en cours
	Synuchus vivalis	Ptinidae	Identification en cours
	Bembidion lampros	Tenebrionidae	*Opatrum sp*
	Aptinus alpinus		*Scaurus striatus*
	Cicindela flexuosa		*Philan gibbus*
	Pterostichus oblongopunctatus		*Asida sp*
Curculionidae	*Brachycerus muricatus*		*Eledona agricola*
	Brachysomus echimatus		*Lagria atripes*
	Donus salivae		*Machlasida sp*
	Mecinus janthinus		*Pimelia bipunctata*
	Rhabdorrynchus cynoglossi		*Biophanes sp*

Tableau 2. Composition du peuplement de Coléoptères récoltés dans la subéraie de Souk-Ahras

Familles	Espèces
Scarabaeidae	*Amphimallon sp*
	Rhizotrogus pallidipennis
	Tropinota hirta
	Aphodius erraticus
Carabidae	*Nebria andalusia*
	Amara equestris zabroides
	Brachinus sp
	Carabus cancellatus
	Calathus luctosus
	Harpalus luteicornis
	Harpalus serripes
	Carabus sp
	Clivina fossor
	Carabus monilis
Curculionidae	*Otiorhynchus sp*
	Otiorynchus rugifron
	Barypeithes sp
	Barypeithes araneiformis
	Identification en cours
	Notaris sp
	Polydrusus sp
	Phyllobius sp
	Deporaus betulae
	Brachycerus muricatus
Tenebrionidae	*Opatrum sp*
	Lagria villosa
Elatridae	Identification en cous
Silvanidae	*Silvanus unidentatus*
Corticaridae	*Stephostethus sp*
	Identification en cours
Cerambycidae	*Plagionotus arcuatus*
Cleridae	*Tillus elongatus*
Coccinellidae	*Coccinella septempuctata*
Chrysomelidae	*Chrysolina sp*
	Lachnaia sp
Staphylinidae	*Ocypus sp*
	Ocalea picata
	Philonthus nitidus
Nitidulidae	*Soronia grisea*
Malachiidae	*Axinotarsus pulicarius*
Histeridae	*Hister sp*
Ptinidae	Identification en cours

Tableau 3. Liste des coléoptères communs aux deux subéraies

Familles	Espèces
Scarabaeidae	*Tropinota hirta*
	Aphodius erraticus
Carabidae	*Nebria andalusia*
	Carabus sp
Curculionidae	*Brachycerus muricatus*
Tenebrionidae	*Opatrum sp*
Coccinellidae	*Coccinella septempuctata*
Chrysomelidae	*Chrysolina sp*
	Lachnaia sp
Staphylinidae	*Ocypus sp*
Histeridae	*Hister sp*
Ptinidae	En cours d'identification

Indices écologiques : Nous avons récolté 228 individus dans le Parc National d'El-Kala et 180 individus à Souk-Ahras. La diversité totale du peuplement récolté est de 3,40 à El-Kala et de 3,07 à Souk-Ahras, ces valeurs importantes de la diversité traduisent la richesse et la complexité des peuplements étudiés dans les deux subéraies. L'équitabilité E est presque égale dans les deux peuplements, elle est de 0,80 dans le Parc National d'El-Kala et de 0,82 à Souk-Ahras. Cette valeur étant proche de 1, indique un équilibre dans la distribution d'abondance des espèces recensées. L'indice de similitude de 16,5 indique une grande différence qualitative dans la composition des deux peuplements (Tableau 4).

Organisation trophique: Selon leur régime alimentaire, les espèces récoltées se répartissent entre cinq catégories trophiques (Figure 3).

Tableau 4. Paramètres structuraux des peuplements de Coléoptères des deux subéraies

	Suberaie d'El-Kala	Suberaie de Souk-Ahras
Indice de Shannon	H'=3,40	H'=3,07
Équitabilité	E=0,80	E=0,82
Indice de Sorensen (similitude)	Qs=16,51	

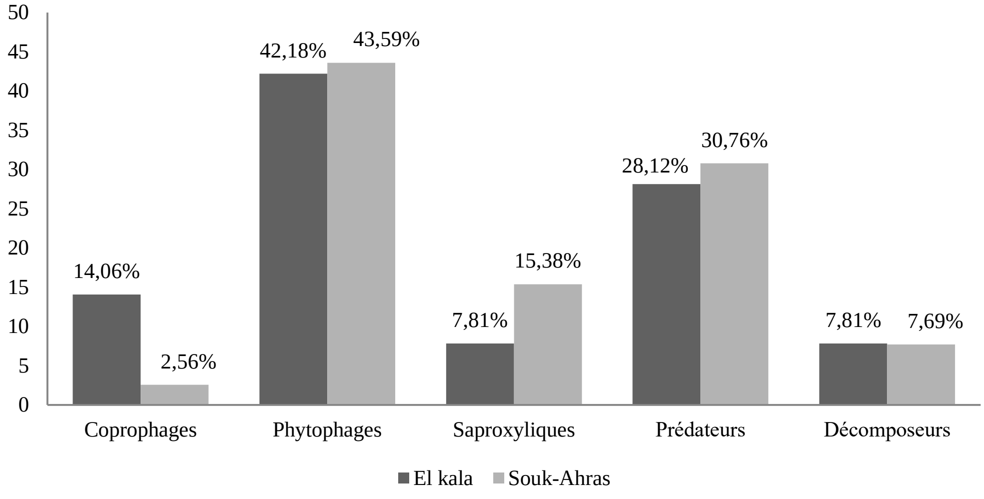

Figure 3. Répartition trophique de l'entomofaune recensée dans les deux subéraies

Les phytophages sont les plus abondants dans les deux subéraies avec un taux de 42,18% de l'ensemble des espèces recensées à El-Kala et 43,59% à Souk-Ahras, ils se nourrissent essentiellement de végétaux et comptent un grand nombre de défoliateurs appartenant surtout à la famille des Curculionidés à Souk-Ahras et à la famille des Chrysomelidae à El-Kala. Les prédateurs représentent 30,76% des coléoptères récoltés à Souk-Ahras et 28,12% à El-Kala. La majorité de ces prédateurs sont des Carabidés. Les coléoptères Saproxyliques s'attaquent aux troncs des arbres de chêne-liège et se nourrissent de bois mort, on a compté 15,38% à Souk-Ahras et seulement 28,12% à El-Kala. La majorité de ces espèces sont Saproxyliques à la forme larvaire et appartiennent à différentes familles dont les Scarabidae, Cerambicidae et Lucanidae. Les décomposeurs récoltés dans les deux subéraies sont des Tenebrionidae, ils représentent des taux presque équivalents qui ne dépassent pas 8% dans les deux stations. À Souk-Ahras, une seule espèce est considérée comme coprophage appartenant à la famille des Scarabéidés : *Aphodius erraticus.* Tandis qu'à El-Kala 14,06% de la récolte sont des Coprophages.

4. Discussion

La faune entomologique des subéraies du Parc National d'El-Kala ainsi que de Souk-Ahras constitue un maillon essentiel dans le fonctionnement et la dynamique des deux forêts. Les différences constatées semblent provenir de l'état sanitaire des deux subéraies. En effet la forêt de Souk-Ahras présente un meilleur état sanitaire et meilleure gestion que les forêts du PNEK (Daas et al., 2014; Ghanem, 2014). Le peuplement de Coléoptères des deux stations présente une richesse et une diversité importante et un équilibre dans la distribution des espèces. Toutefois, la richesse spécifique est plus importante dans le PNEK, et les deux peuplements présentent des différences significatives dans la composition.

L'inventaire réalisé au niveau du parc national d'El Kala compte 228 individus appartennant à 68 espèces, répartient sur 19 familles dont la majorité appartienne à la famille des Scarabaeidae. A Souk-Ahras nous avons ressencé 41 espéces appartennant à 14 familles avec une dominance des Carabidae. La diversité est importante dans les deux peuplements, l'indice de Shannon est plus elevé pour le peuplement d'El Kala ce qui indique que ce dernier est plus diversifié que celui de Souk-Ahras. La distribution des espèces est équilibrée dans les deux peuplements, il semble que la composition des deux peuplements soit differente du fait d'un état sanitaire différent des deux forêts, la forêt d'El Kala étant en dépérissement. Les Coprophages sont plus abondant à El-Kala ce qui indique la présence d'une activité de pâturage importante. Selon Ouelmouhoub, 2005, la subéraie est très fréquentée pour cette activité, l'élevage constitue une part importante des activités socioéconomiques de la population du Parc. Les éleveurs dans le village d'El Mellah pratiquent les trois types d'élevage : bovin, ovin et caprin. Les troupeaux sont lâchés quotidiennement dans les subéraies de Brabtia, du début de matinée (8h) jusqu'en soirée (18h), les horaires de pâturage varient selon la saison.

La présence de bétail dans le milieu forestier favorise le maintien d'une faune particulière inféodée aux bouses, crottins, etc. En facilitant l'enfouissement et le recyclage des matières fécales, les animaux coprophages contribuent de façon importante à l'amélioration des sols des milieux pâturés (Aouinty**,** 1990). Le rôle des Coprophages dans l'amélioration des sols étant bénéfique n'explique pas l'état sanitaire détérioré de la subéraie étudiée, cependant on peut considérer la présence de ces espèces comme bio-indicateur de surpâturage dont l'impact sur la régénération du chêne-liège est largement connu.

Les larves de plusieurs Scarabaeidae se développent dans le bois pourri de vieux chênes blessés, voire morts, dans les souches, ainsi que dans le terreau qui se forme dans leur creux. Ces vers blancs qui ne semblent pas rechercher d'essences particulières sont aussi capables de se développer dans le sol, aux dépends des feuilles mortes et des racines des jeunes arbres. En Algérie, la larve abonde dans le terreau des vieux troncs et dans le bois décomposé des feuillus (Villemant et Fraval, 1991). Il est indispensable de mettre en évidence l'importance du bois mort dans l'écosystème forestier. Or, le groupe faunistique faisant référence dans la qualification des milieux boisés à évolution naturelle est celui des Coléoptères saproxyliques, dont bon nombre d'espèces sont qualifiées «d'indicateurs de la bonne conservation du système forestier» (Villemant et Fraval, 1991). Le cortège de Coléoptères Saproxyliques est plus riche à Souk-Ahras que dans le Parc National d'El-Kala. De nombreuses espèces d'Elateridae sont saproxyliques sans être saproxylophages, les larves zoophages chassent les autres insectes sous les écorces des bois pourrissants. Les Histeridae sont des prédateurs sous-corticoles d'autres petits insectes qu'ils chassent sous les écorces déhiscentes des troncs morts. En terme d'exigences, ces espèce recherchent pour leur développement exclusivement les troncs et grosses branches mortes non écorcés. Les Silvanidae, sont des saproxylique mycophage, Les insectes de cette famille recherchent les champignons se développant dans les bois morts d'essences feuillues variées. Il est fort probable que les champignons ingérés facilitent la digestion des fibres de bois dont l'insecte se nourrit.

La majorité des espèces récoltées à Souk-Ahras étant des Carabidae prédateurs, assurent l'équilibre de la chaine trophique. Ces espèces se nourrissent essentiellement de larves de différents insectes dont les Saproxyliques. Les décomposeurs sont essentiels dans le recyclage de la matière organique, le taux de leur présence dans les deux subéraies est presque équivalent. On peut dire que l'impact que joue la faune entomologique dans le dépérissement des forêts de l'Est Algérien est assez restreint, sauf dans le cas d'invasion ou de forte pullulation. Cependant l'étude du régime alimentaire a permis de déduire d'une manière indirecte certains facteurs responsables de la détérioration de l'état sanitaire de ces subéraies.

Les régimes alimentaires des insectes sont d'une extrême diversité, Selon (Beaumont et Cassier, 1983) il n'y a pas de spécialisation trophique absolue dans la nature, Par ailleurs, il est important de signaler la possibilité dans certains groupes d'observer le passage d'un régime alimentaire à l 'autre; ainsi, certains prédateurs peuvent devenir phytophages. Les Carabidae qui sont carnassiers se nourrissent volontiers, en captivité, de fruits bien mûrs, ce qui rend difficile l'appréciation du régime exacte. A travers cet inventaire, il semble que dans les écosystèmes forestiers, la dynamique des interactions entre les espèces animales soit fonction aussi de l'état sanitaire des forêts.

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2016, 17(Special Issue): 18-22 | Research article (Araştırma makalesi)

Résultats préliminaires d'un inventaire des Blattes forestières: Décomposeurs de la litière des forêts du Nord Est Algérien

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Résumé : Les blattes sont des insectes nocturnes s'abritant dans les endroits qui leur fournissent un microclimat convenable et qui leur permettent d'avoir un accès facile à la nourriture. L'inventaire des espèces africaines est loin d'être complet. En Afrique du Nord, peu de recherches ont été effectuées sur la faune des Orthoptéroïdes et plus particulièrement sur les Dictyoptères. Afin de recenser les différentes espèces de blattes forestières existant dans le Nord Est Algérien, nous avons réalisé un inventaire des espèces qui vivent dans différentes zones : forêts de chêne-liège [subéraies du Parc National d'El-Kala (Tarf), de l'Edough (Annaba) et de Souk-Ahras], forêts d'eucalyptus (Annaba). Quatre espèces de blattes ont été récoltées dans les sites prospectés: *Loboptera decipiens*, *Loboptera angulata*, *Ectobius kervillei* et quelques spécimens d'*Ectobius* non identifiés pour l'instant. Tous ces insectes sont présents dans la litière, principalement de Février à Juin, et leurs effectifs sont fluctuants. Plus de 2000 individus de tous stades ont été capturés parmi lesquels 86% sont du genre *Loboptera* et 14% du genre *Ectobius*.

Mots clés : Inventaire, Forêts Algériennes, Blattes forestières, *Loboptera, Ectobiu.*

Preliminary results of forest cockroaches inventoried: Decomposers of litter in Northeast Algerian forests

Abstract: Cockroaches are species that live at night and shelter in places that provide a suitable microclimate and allow them to have easy access to food. The inventory of African species is far from complete. In North Africa, little research has been conducted on wildlife Orthopteroid and more particularly on the Dictyoptera. To identify different species of cockroaches existing forest in northeastern Algeria, we made an inventory of species that live in various areas: cork oak forests [cork forests of El-Kala National Park (Tarf), of Edough (Annaba) and Souk-Ahras], eucalyptus forests (Annaba). Four species of cockroaches were collected from different sites: *Loboptera decipiens*, *Loboptera angulata*, *Ectobius kervillei* and some yet unidentified specimens *Ectobius*. All these insects are present in the litter, mainly from February to June, and their numbers are fluctuating. More than 2000 individuals of all stages were captured including 86% of the genus *Loboptera* and 14% of such *Ectobius*.

Keywords: Forest Cockroaches, Inventory, Algerian Forests, *Loboptera*, *Ectobius.*

Envanteri çıkarılan orman hamamböceklerinin ön sonuçları: Kuzeydoğu Cezayir ormanlarında ölü örtü ayrıştırıcıları

Özet: Hamamböceği, gece ortaya çıkan ve uygun mikroiklim sağlayan ve yiyeceğe kolay erişim sağlayan yerlerde barınan bir türdür. Afrika türlerinin envanteri henüz tamamlanmamıştır. Kuzey Afrika'da, çiğneyici ağız tipi olan Orthopteroid'ler ve özellikle de Dictyoptera'nın yaban hayatı hakkında çok az araştırma yapılmıştır. Kuzeydoğu Cezayir'deki ormanda yaşayan farklı hamamböceği türlerini belirlemek amacıyla, mantar meşesi ormanları [El-Kala Milli Parkı mantar meşesi ormanları (Tarf, Edough mantar meşesi ormanları (ANnaba) ve Souk-Ahras ormanları], ökaliptüs ormanları (Annaba) olmak üzere farklı alanlarda yaşayan türlerin bir envanterini çıkardık. Farklı alanlardan dört hamamböceği türü toplandı: *Loboptera decipiens*, *Loboptera angulata*, *Ectobius kervillei* ve henüz tespit edilmemiş olan bazı *Ectobius* örnekleri. Tüm bu böcekler, ağırlıklı olarak Şubat ve Haziran arasında ölü örtüde bulunmaktadır ve sayıları ise değişmektedir. *Loboptera* cinsinden %86 ve *Ectobius*'tan %14 olmak üzere tüm evrelerden 2000'den fazla birey toplanmıştır.

Anahtar kelimeler: Envanter, Cezayirli Ormanlar, orman Hamamböcekleri, *Loboptera*, *Ectobius*

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1. Introduction

Le régime omnivore des blattes leur permet de s'accommoder à tous types d'aliments (Gordon, 1996). C'est le cas des espèces nuisibles qui vivent au voisinage de l'homme : comme *Periplaneta americana, Blatta orientalis* (Cornwell, 1976), *Supella longipalpa* et *Blattella germanica* (Cornwell, 1968 ; 1976 ; Gordon, 1968 ; Guillaumin et al., 1969). D'autres blattes sont forestières, par exemple le genre *Ectobius* que l'on peut souvent voir, surtout au niveau du sol, dans la litière. Ces espèces se nourrissent de débris végétaux et participent ainsi à la décomposition des feuilles et à la formation de l'humus.

L'inventaire des espèces africaines est loin d'être complet. En Afrique du Nord, peu de recherches ont été effectuées sur la faune des Orthoptéroïdes et plus particulièrement sur les Dictyoptères (Chopard, 1929 ; 1943). La faune et la flore des forêts algériennes sont très riches en espèces, mais il n'existe malheureusement pas d'inventaire complet. Dans le but de mieux cerner la distribution des blattes dans l'Est algérien, et afin de recenser les différentes espèces de blattes forestières de cette région, nous avons réalisé un inventaire, aussi large que possible, dans les forêts de chêne-liège (subéraies du Parc National d'El-Kala, de l'Edough et de Souk-Ahras) et les forêts d'eucalyptus (Sidi Amar à Annaba).

2. Matériel et Méthodes

Les blattes forestières se rencontrent toujours dans un environnement où se trouve de la végétation. Il y a peu d'indications disponibles sur la biologie de ces arthropodes dans leur milieu naturel au niveau du bassin méditerranéen bien que Chopard (1951) a recensé plus de 54 espèces de blattes, dont 46 espèces forestières. Le manque d'informations concernant les espèces qui vivent en Algérie nous a conduit à réaliser un inventaire des espèces les plus courantes que l'on peut trouver dans les forêts du Nord-Est Algérien.

Les blattes ont été récoltées dans les subéraies du Parc National d'El-Kala (PNEK), les subéraies de l'Edough (Séraïdi), les subéraies de Ouled Bechih (Machrouha, Souk-Ahras) et sous les Eucalyptus (Sidi-Amar, Annaba) (Figure1). Chaque lieu de récolte correspond à trois parcelles de 1m² espacées de 50 mètres. La capture se fait par fouille sur chaque parcelle par deux personnes pendant deux heures durant la matinée. Les individus récoltés sont mis dans des tubes en plastique et emmenés au laboratoire afin d'être déterminé.

Le PNEK (Parc National d'El-Kala) l'un des plus grands parcs nationaux d'Algérie, d'une superficie de 76 438 ha. Le P.N.E.K est caractérisé par une richesse faunistique et floristique diversifiée. Le long d'une coupe Nord-Sud, le relief passe de 0 à 1200 m d'altitude en moins de 40 kms. Le climat de la région d'El-Kala est de type méditerranéen (Emberger, 1971).

Figure 1. Situation géographique des différents sites de récolte

La forêt de l'Edough l'une des plus importantes subéraies de chêne-liège qui se caractérise par une richesse faunistique et floristique diversifiée. Le long d'une coupe Nord-Sud, le relief passe de 0 à 1008 m d'altitude. La flore de l'Edough est caractérisée par deux essences principales: le chêne-liège (3419 ha) au sommet de toutes les pentes orientées au Sud et le chêne zeen qui couvre toutes les parties humides ou fraîches des versants Nord et Est.

Les forêts de Souk-Ahras s'étendent sur près de 89 000 hectares avec une subéraie de 12 000 hectares qui représente plus de 13% des forêts de chêne-liège en Algérie. Les prélèvements ont été effectués dans la forêt de Machrouha (superficie de 6990 ha), constituée principalement de chêne-liège et de chêne-zeen.

Le site d'Eucalyptus de Sidi Amar est une forêt d'Eucalyptus qui se situe à l'intérieur de l'enceinte universitaire de Badji Mokhtar d'Annaba, dans la commune de Sidi Amar de la wilaya d'Annaba.

L'identification des différentes espèces de blattes récoltées est basée sur les critères de Chopard (1951) avant d'être confirmées par Philippe Grandcolas (Muséum national d'Histoire naturelle de Paris) et Horst Bohn (Muséum de Collection zoologique, Munich, Allemagne).

3. Résultats

Quatre espèces de blattes ont été récoltées dans les différents sites : *Loboptera decipiens* (Germar, 1817), *Loboptera angulata* (Chopard, 1943), *Ectobius kervillei* (Bolìvar, 1907) et quelques spécimens d'*Ectobius* en cours d'identification. Tous ces insectes sont présents dans la litière, principalement de Février à Juin, et leurs effectifs sont fluctuants. Plus de 2000 individus de tous stades ont été capturés parmi lesquels 86% du genre *Loboptera* et 14% d'*Ectobius*. On note que la fréquence des espèces est définie par un seul pic enregistré un au mois d'Avril et Mai (présence des quatre espèces récoltées). La richesse specifique diminue pendant l'hiver (Tableau 1).

3.1. Genre Loboptera

On le trouve principalement d'Avril à Juin dans les forêts de chêne-liège et d'eucalyptus (PNEK, Edough et Sidi Amar) (Tableau 2). Dans le PNEK, ce genre est surtout présent en Avril-Mai (respectivement, 46 et 49%

d'individus récoltés), alors que plus de 90% d'individus ont été capturés en Mai dans le massif de l'Edough. Nos résultats montrent également que *Loboptera* abonde dans les forêts de Sidi Amar (76% des récoltes totales) où plus de 60 % des individus ont été récoltés en Mai.

3.2. Genre Ectobius

Les populations du genre *Ectobius* occupent préférentiellement les forêts de moyenne et haute montagne (Edough, Machrouha) et sont surtout présentes à la fin du printemps (Avril-Mai) (Tableau 3). Sur les 281 individus capturés, 59% l'ont été dans le massif de l'Edough et 27% dans les forêts de Machrouha. Les individus provenant du PNEK et de Sidi Amar ne représentent respectivement que 8 et 6% des captures. Dans le site de l'Edough et celui de Sidi Amar, c'est l'espèce *E. kervillei* qui est la plus représentative au niveau des litières des forêts. La plupart des *E. kervillei* a été récoltée en Mai dans les subéraies de l'Edough (plus de 72% des récoltes totales à cette période). Au niveau des subéraies de Machrouha, une trentaine d'individus d'*Ectobius sp.* ont été capturés d'Avril à Mai.

4. Discussion

Les forêts Algériennes sont mal connues au niveau international, à l'exception de quelques citations dans les publications consacrées aux forêts du Maghreb (essentiellement Maroc et Tunisie) (Berchiche, 1986 ; Azzioui et al., 2000). Cette réalité est sans doute le résultat des conditions de terrains difficiles rencontrées ces dernières années. Cependant, à l'échelle nationale, le système forestier n'a pas cessé d'attirer les chercheurs, notamment les forestiers pour des études d'aménagements et les écologistes pour leurs divers inventaires de faune et de flore (Ouelmouhoub, 2005).

D'une façon générale, les forêts du pourtour méditerranéen sont caractérisées par une richesse floristique et faunistique importante. Elles s'étendent sur plus de 81 millions d'hectares (9,4% de la superficie forestière mondiale) et sont constituées d'une mosaïque d'essences forestières, principalement de feuillus (environ 60%). La renommée de cette zone n'est plus à faire du fait de l'existence de nombreux parcs naturels (Houée, 1996).

Il existe beaucoup plus d'espèces végétales et animales dans la forêt que dans les milieux ouverts. Les insectes, qui représentent le groupe animal le plus riche en espèces, jouent dans les forêts des rôles très divers et très importants en tant que phytophages, décomposeurs, pollinisateurs, prédateurs, parasites, ou vecteurs d'organismes pathogènes. Les insectes peuvent également donner une idée de l'état de dégradation d'une forêt sous l'emprise des activités humaines (Dajoz, 1980).

Les insectes que l'on trouve en forêt ont leurs propres exigences écologiques et de nombreuses espèces jouent un rôle important dans la décomposition des matières organiques (feuilles, rameaux, racines, etc…). Ils recyclent la matière organique morte et recréent le cycle de la matière nécessaire à l'existence de la forêt. Les blattes forestières présentent le meilleur exemple des insectes terrestres détritivores qui se nourrissent de tous déchets (excréments, cadavres, feuilles mortes, …etc.) et qui, par voie de conséquence, colonisent largement le sol (Dajoz, 1998).

Selon les différents critères de classification, les blattes se répartissent en plusieurs familles dont celle des Blattellidae qui regroupe les blattes de petite taille telle que *B. germanica*, *Supella longipalpa*, *Blattella asahinai*, *L. decipiens*, etc… (Guillaumin et al., 1969 ; Gordon, 1996). La famille des Blattellidae se compose d'une majorité de genres et d'espèces, elle est divisée en six sous-familles : les Anaplectinae, les Attaphilinae, les Pseudophyllodromiinae (ou Plectopterinae, selon les appellations), les Blattellinae, les Nyctiborinae et les Ectobiinae.

Tableau 1. Phénogramme des blattes récoltées dans les forêts algériennes durant la période d'étude

		Octobre	Février	Mars	Avril	Mai	Juin
1	*Loboptera*		■	■	■	■	
	Ectobius		▒		▒	▒	
2	*Loboptera*				■	■	■
	Ectobius				▒	▒	▒
3	*Loboptera*	■			■	■	
	Ectobius	▒			▒	▒	
4	*Loboptera*				■	■	■
	Ectobius					▒	▒

Tableau 2. Pourcentages et nombre total de *Loboptera* récoltés dans les forêts du Nord-Est algérien

Sites	Octobre	Février	Mars	Avril	Mai	Juin	Total
PNEK	0%	4%	0,44%	46%	49%	0%	228
Edough	0%	0%	0%	2%	96%	1%	161
Machrouha	6%	0%	0%	78%	17%	0%	18
Sidi Amar	0%	0%	0%	26%	61%	14%	1319

Tableau 3. Pourcentages et nombre total d'*Ectobius* dans les forêts du Nord-Est Algérien

Sites	Octobre	Février	Mars	Avril	Mai	Juin	Total
PNEK	0%	50%	0%	5%	45%	0%	*22*
Edough	0%	0%	0%	5%	95%	1%	*166*
Machrouha	13%	0%	0%	41%	45%	0%	*75*
Sidi Amar	0%	0%	0%	0%	89%	11%	*18*

Les Pseudophyllodromiinae et les Blattellinae représentent le groupe le plus large (Bohn et al., 2010). Les Anaplectinae sont généralement considéré comme la branche basale des Blattellidae (McKittrick, 1964; Grandcolas, 1996 ; Klass, 1997 ; Klass & Meier, 2006). Les Pseudophyllodromiinae peuvent constituer un groupe paraphylétique, composé lui même de plusieurs branches dont les Anaplectinae (Klass, 2001; Klass & Meier, 2006). Les Blattellinae, les Ectobiinae et les Nyctiborinae forment aussi un autre groupe monophylétique (Grandcolas 1996; Klass & Meier 2006; Inward et al., 2007).

Le genre *Loboptera* se rencontre principalement en Afrique, en Australie, en Amérique du Sud et dans la région méditerranéenne. Cette blatte fait partie de la sous-famille des Pseudomopinae, voisine de Pseudophyllodromiinae, mais diffère par quelques caractères tels que l'armature des pattes (souvent plus faible), la plaque suranale (souvent prolongée) et la nervation des ailes (Chopard, 1951). Les élytres sont réduits à des petits lobes latéraux et la plaque suranale est souvent de forme triangulaire surtout chez les femelles. Chez les mâles, la plaque sous-génitale est transverse (Chopard, 1951).

Loboptera est une blatte forestière mal connue au niveau de sa biologie et son comportement. Certaines espèces tel que, *L.* decipiens, vivent en Afrique du Nord, en Europe Méridionale et dans le Caucase. On la trouve dans la litière où elle constitue un maillon important de la chaîne alimentaire. Omnivore, elle sert aussi de proies à de nombreux prédateurs comme les araignées, les fourmis et de nombreuses espèces d'oiseaux (Boyer & Rivault, 2004).

L. decipiens, est une blatte commune dans tout le Maghreb (Chopard, 1943). On la trouve fréquemment sous les pierres, dans les endroits un peu humides et dans la litière des maquis et des subéraies, elle vit dans la couche semi- décomposée de la litière. En Algérie, *L. decipiens* a été signalée dès 1943 dans plusieurs régions de l'Ouest (Oran, Tlemcen, Saïda, Aïn-Safra, etc.) mais également dans la région de Blida et Biskra. Dans notre région, cette blatte a été mise en évidence à Hammam Maskhoutine, dans l'Edough (Chopard, 1943) et plus récemment, dans la wilaya d'El Tarf (Bouachria, 2005). En 2004, Cherairia a pu mettre en évidence l'existence de deux espèces de blattes forestières (*L. decipiens* et *Ectobius pallidus*) lors d'un inventaire des Blattidés de la région de Guelma.

Au cours de cette étude, nous avons mis en évidence l'existence d'importantes populations de deux espèces de *Loboptera*, *L. decipiens* et *L. angulata*. Ces dernières abondent dans les forêts d'Eucalyptus de Sidi Amar (plus de 1300 individus récoltés) alors que ces dernières sont moins importantes dans le PNEK et l'Edough (environ 200 individus récoltés) et rares dans la zone de Machrouha (moins de 20 individus dénombré). Parmi les espèces forestières inventoriées, outre la présence de *L. decipiens* (blatte appartenant à la sous-famille des Pseudomopinae) nous avons pu mettre en évidence l'existence dans nos forêts de deux autres espèces du genre *Ectobius, E. kervillei* et une autre espèce en cours d'identification.

Le genre *Ectobius* fait parti de la sous-famille des Ectobiinae qui ne comprend que dix genres mais compte plus de 2000 espèces répertoriées à la surface du globe (Chopard, 1951). Les oothèques sont produites et transportées pendant un à deux jours entre juin et septembre; elles passent l'hiver dans le sol et les nymphes éclosent au printemps. Les larves d'*Ectobius* arrivent au stade adulte courant mai-juin. Les adultes meurent entre septembre et octobre et le cycle continu. Ces blattes ont une préférence pour les plaines côtières et sablonneuses. Bien qu'omnivores comme tous leurs congénères, leur nourriture est essentiellement constituée de matière végétale morte, y compris le papier (Chopard, 1951).

Au cours de notre travail nous avons récolté deux espèces du genre *Ectobius* dans les quatre sites explorés. Durant le printemps, la présence d'adultes d'*Ectobius sp.* a pu être mis en évidence dans la litière des subéraies de Machrouha à Souk-Ahras. Cette blatte a également été récoltée dans les subéraies du PNEK, mais avec des niveaux de population plus au moins importantes. Une étude plus approfondie sur ces espèces pourrait nous renseigner sur la structure et la dynamique de la population d'*Ectobius* dans les subéraies de Machrouha et celles du PNEK.

La deuxième espèce, *E. kervillei,* colonise essentiellement le sol des subéraies de l'Edough et celui des forêts d'Eucalyptus. Cette espèce de blatte est très mal connue sur le plan biologique, écologique et comportemental. Elle a été décrite par Bolivar en 1907 et, en 1981, Failla & Messina ont présentés quelques caractéristiques biologiques de l'espèce. Le massif de l'Edough a été la seule zone de récolte importante avec près de 200 spécimens capturés. Nous avons pu montrer que cette espèce représentait plus de 50% de la faune Blattoptères de la subéraie de l'Edough durant le mois de mai (apparition des adultes) et qu'elle était peu abondante dans la litière d'eucalyptus.

La composition de la faune Blattoptère peut varier d'une région à une autre du globe et la convenance de l'habitat dépend de nombreux facteurs biotiques et abiotiques (Rust et al., 1995). Nos résultats montrent que tous ces facteurs jouent un rôle sur la distribution des blattes en général et d'*Ectobius* en particulier dans les forêts du Nord-Est Algérien. L'altitude et les différents facteurs climatiques influence la distribution des insectes puisque, comme le montre nos résultats, les populations d'*Ectobius* occupent plus les forêts de moyenne et haute montagne (Edough, Machrouha) et prolifèrent à la fin du printemps mais surtout en été.

5. Conclusion

Nous avons pu mettre en évidence l'existence, dans les forêts de Nord-Est Algérien, de trois espèces de blattes: *L. decipiens*, *L. angulata*, *E. kervillei* et *Ectobius sp*. Ces blattes sont présentes dans les litières forestières durant presque toute l'année avec des effectifs fluctuants.

Lors de l'inventaire effectué dans quatre sites différents (PNEK, Edough, Machrouha et Sidi Amar), nous avons pu montrer que la distribution de ces blattes diffère en fonction de l'altitude, les conditions climatiques et l'essence végétale prédominante.

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Dung beetles (Coleoptera: Scarabaeoideae) between a natural forest and a reforested steppe (Djelfa, Algeria)

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Abstract: Steppe ecosystems are characterized by significant biological diversity, and this is the result of a long adaptation process to difficult agro-climatic conditions. Feces of large or small herbivorous animals must be destroyed to be recycled. This process is involving the activity of various soil organisms. Among the most active insects are Scarabaeoidea. Our study was conducted in two grazed ecosystems in djelfa pasture, situated in the semi-arid region; the first one is a pinewood forest, located in the Senalba. The second one is an Aleppo pine reforested stand, part of the Green Dam that was launched decades ago to stop desertification. Dung beetles were captured using baited pitfall traps during the period 2009-2010. 1435 beetles belonging to 42 species were trapped. The faunas of senalba and of Moudjbara were compared. The fauna in the reforested stand is poorer than the one of the natural forest. The natural forest might provide favorable microclimatic conditions for some species such as *Chironitis furcifer*, *Aphodius fimetarius* and *A. felscheanus*. Results showed a significant seasonal variation in the composition, and diversity. There were four periods of activity during the course of the year. Temporal turnover was highest in September and in February, Dungs beetle dominate during summer and autumn in Moudjbara while in the Sénalba they dominate during autumn and winter. This study reveals that natural forest is the most suitable habitat to the installation Scarabaeidae unlike reforestation, this could be the result of a limited grazing in the reforested steppe.

Keywords: Scarabaeoidea, Pinewood forest, Reforested steppe

Doğal orman ve yeniden ormanlaştırılmış bozkır alandaki (Djelfa, Cezayir) gübre böcekleri (Coleoptera: Scarabaeoideae)

Özet: Step ekosistemleri, zorlu agro-iklimsel koşullara uyum sağlamak için geçirdikleri uzun adaptasyon süreci sonucunda önemli bir biyolojik çeşitliliğe sahiptir. Büyük ve küçük otobur hayvanların dışkıları bertaraf edilmeli veya geri dönüştürülmelidir. Bu süreç, çeşitli toprak canlılarının faaliyetini içermektedir. Scarabaeoidea familyasında yer alan böcekler, bu süreçte en aktif böceklerden biridir. Çalışmamız, yarı kurak bir alan olan Djelfa otlağında bulunan iki adet otlatma ekosisteminde gerçekleştirilmiştir. Bu ekosistemlerden biri, Senalba bölgesinde yer alan çam ormanıdır. Diğer ekosistem ise, çölleşmeyi durdurmak için yıllar önce başlatılan Green Baraj (Green Dam) projesinin bir parçası olan yeniden ormanlaştırılmış Halep çamı meşceresidir. Gübre böcekleri, 2009-2010 döneminde yemli kapan pusuları ile toplandı. 42 türe ait 1435 tuzakla yakalandı. Senalba ve Moudjbara faunaları karşılaştırıldı. Yeniden ormanlaştırılmış meşcere doğal ormandaki faunadan daha zayıf bir faunaya sahiptir. Doğal orman, *Chironitis furcifer*, *Aphodius fimetarius* ve *A. felscheanus* gibi bazı türler için daha elverişli mikroiklimsel koşullar sağlayabilir. Çalışmanın sonuçları, yapı ve çeşitlilik açısından önemli mevsimsel değişimlerin olduğunu göstermiştir. Yıl içerisinde dört faaliyet dönemi tespit edilmiştir. Zamansal değişim oranı eylül ve şubat aylarında en yüksek seviyeye ulaşmıştır. Gübre böcekleri yaz ve sonbahar aylarında Moudjbara bölgesinde yoğunlaşırken Sénalba bölgesinde sonbahar ve kış aylarında yoğunlaşmıştır. Bu çalışma, yeniden ormanlaştırılmış bölgenin aksine doğal ormanın Scarabaeidae için en uygun habitat olduğunu göstermektedir. Bu durum yeniden ormanlaştırılmış bozkır alanda sınırlı otlama imkânının bir sonucu olabilir.

Anahtar kelimeler: Scarabaeoidea, Çam ormanı, Yeniden ormanlaştırılmış bozkır

1. Introduction

Les écosystèmes steppiques se caractérisent par une diversité biologique appréciable, fruit d'une adaptation millénaire aux conditions agro-climatiques particulièrement difficiles de ces régions. Ces écosystèmes connaissent une importante régression du couvert végétal et de la productivité pastorale. Ils sont également soumis à une forte

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dégradation qui tend à se généraliser suite d'une part, à un processus de désertification accentué, d'autre part à l'action anthropique. Dans les écosystèmes pâturés, la production fourragère est assez étroitement dépendante de la dynamique de recyclage de la matière organique produite et de la quantité d'éléments minéraux disponibles. Les déjections des animaux herbivores, grands ou petits, doivent être détruites pour être recyclées, processus auquel participent activement divers organismes ; parmi les plus actifs se trouvent les coléoptères Scarabaeoidea. Les bousiers (Scarabaeidae) ont été utilisés comme bioindicateurs de la qualité de l'habitat en raison de leur sensibilité aux changements environnementaux. De nombreuses recherches ont été conduites dans les régions tempérées et tropicales, ainsi qu'en témoignent les travaux de plusieurs auteurs comme Walter (1980), Rougon et Rougon (1980, 1983), Cambefort (1982), Desiere (1983), Davis (1989), Lumaret et al. (1992), Lumaret et Kadiri (1995) soulignant le rôle fondamental joué par les Scarabéidés coprophages dans la dégradation des déjections animales. Les communautés de coprophages sont maintenant bien connues en France grâce aux travaux de Lumaret (1983, 1989), Kadiri et al. (1997), Errouissi (2003), Errouissi et al. (2004), en Espagne par Verdu Faraco (1998) et Lumbreras Vicente (1998), en Afrique centrale par Moretto (2010) et en Afrique tropicale par Cambefort (1984, 1985), Cambefort et Bordat (2003), Kouadio Kra et al. (2010). En revanche, peu de travaux leur ont été consacrés au Maroc et en Tunisie, où plusieurs sites ont été prospectés, avec la mise en évidence d'espèces-clés qui jouent un rôle majeur à certaines périodes de l'année (Janati et al., 1999 ; Janati, 2000 ; Haloti et al., 2006 ; Errouissi et al. ; 2009). En Algérie jusqu'à présent, aucun travail n'a été fait dans ce sens. Ce groupe d'insectes est de surcroît bien connues sur le plan taxonomique, grâce surtout aux travaux de Kocher (1953, 1958, 1969) et de Baraud (1985, 1987), et aux contributions d'Aguesse et Bigot (1979), Dewhurst (1979), Aouinty (1986), Tauzin (1990), Chavanon (1990) et Chavanon et Bouraada (1995). L'objectif de notre travail est de montrer comment, au cours d'une même année, se structurent les communautés de coléoptères coprophages dans deux formations forestières situées au milieu de la steppe algérienne, l'une naturelle l'autre artificielle.

2. Materiel et méthodes

2.1. Stations d'étude

Nous avons opté pour le choix de deux écosystèmes forestiers pâturés, au milieu d'une région steppique et pastorale (Djelfa), située à 300 km au sud d'Alger la capitale, classés dans le semi-aride. Le premier écosystème est une forêt naturelle de Pin d'Alep associé au Genévrier Oxycèdre, Genévrier de Phénicie, c'est le massif de Sénalba. Les coordonnées de la station sont (34° 40' N; 3° 09' E), à 1226 m d'altitude. La deuxième station est un reboisement de Pin d'Alep situé dans le barrage vert (34° 38' N; 3° 18' E), à 1200 m d'altitude, un projet lancé depuis les années 70 pour limiter le phénomène de désertification, et qui s'étale le long d'une ceinture de l'est du pays jusqu'à l'ouest, parcourant la région steppique avec 3 millions d'Ha. Une station qui a été soumise à plusieurs fois à des traitements biologiques contre la chenille processionnaire (Figures 1 et 2).

2.2. Collecte des insectes

Les coléoptères coprophages ont été piégés mensuellement entre mai 2009 et avril 2010. Les piégeages ont été réalisés selon le même protocole standard que celui pratiqué par la plupart des auteurs, avec trois pièges à coprophages de type CSR (Lobo et al. 1988) disposés le même jour dans chacune des stations. Placés à une distance de 25 m l'un de l'autre, les pièges consistent en un récipient collecteur de 25 cm de profondeur (cuvette) enterré au ras du sol et *recouvert d'une grille métallique à larges mailles supportant l'appât (environ 300 g de bouse de vache). Les insectes attirés tombent dans le récipient préalablement rempli aux trois-quarts avec un liquide conservateur. Les pièges sont relevés 72 heures après leur mise en place. Pour pallier l'inconvénient de l'hétérogénéité des appâts, de la bouse fraîche a été collectée auparavant en grande quantité, au même moment (printemps), puis homogénéisée et conditionnée en sacs plastiques avant d'être congelée. Au fur et à mesure des besoins, les bouses sont décongelées et utilisées comme appât, retrouvant à la fois leur texture, leur fluidité et leur attraction initiale. Un tel protocole permet de la sorte de comparer objectivement les stations entre elles selon leurs effectifs ou leur composition faunistique, et les relevés entre eux pour une même station. L'étude quantitative de la diversité spécifique peut être réalisée selon diverses approches qui sont fondées sur l'usage d'indices de diversité dont la formulation est plus au moins complexe (Ramade, 1989). Les spécimens identifiés ont été traités par les indices de diversité (Indice de Shannon et Equitabilité) ainsi que par l'analyse DECORANA ou DCA «Detrended Correspondence Analysis» Minchin (1987), une technique basée sur l'ordination des données en moyenne réciproques (RA) (Hill et Gauch 1980).

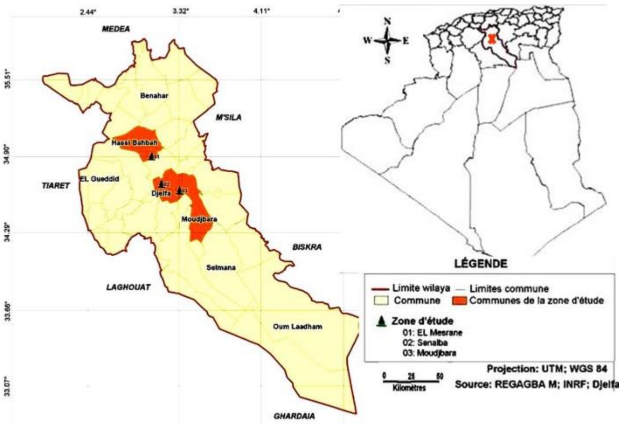

Figure 1. Situation géographique des stations d'étude dans la région de Djelfa

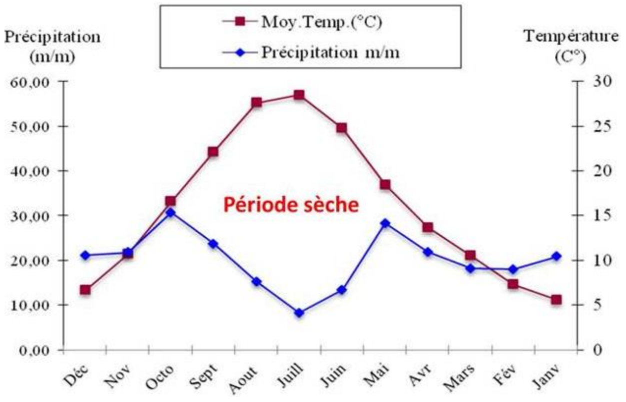

Figure 2. Diagramme Ombrothermique établi pour la région d'étude pour la période (1980-2010)

3. Résultats

3.1. Richesse spécifique des Scarabaeoidea coprophages

Durant l'année d'étude, 1435 individus de Scarabaeoidea coprophages ont été récoltés. Ces derniers appartiennent à 3 familles (Scarabaeidae, Aphodiidae et Geotrupidae), 9 genres et 42 espèces. Parmi les espèces récoltées, un maximum de 36 espèces est noté dans la pinède de Sénalba avec un nombre de 1221 individus. Le reboisement de Moudjbara est moins représenté avec 29 espèces et 214 individus (Tableau 1). Parmi les Scarabaeoidea coprophages, c'est la famille des Aphodiidae qui présente les nombres les plus élevés en espèces et en individus, suivie par les Scarabaeidae puis les Geotrupidae, qui ne sont représentés qu'avec 19 individus appartenant à une seule espèce (Figure 3).

Les Scarabaeoidea font partie des espèces xérophiles qui forment des peuplements en général assez riches en espèces (Paulian, 1988), mais où les individus peuvent pulluler avec des effectifs plus au moins importants.

Le nombre d'espèces capturées dans nos stations est une valeur quantitative qui relève de l'étude de l'organisation des peuplements considérés. La famille des Scarabaeidae, qui comprend à la fois des insectes rouleurs (Scarabaeinae) et des insectes fouisseurs (Coprinae), est représentée ici par les Scarabaeini (1 espèce), les Gymnopleurini (1 espèce) pour la guilde des rouleurs, et les Coprini (15 espèces), dont 10 espèces Onthophagini, 4 espèces Onitini et une seule Oniticellini pour la guilde des fouisseurs. La famille des Geotrupidae (espèces également fouisseuses) n'est représentée que par une seule espèce. Les Aphodiidae sont bien représentés en nombre (24 espèces résidentes, toutes de la tribu des Aphodiini) (Tableau 2).

Tableau 1. Richesse spécifique et abondance par famille

Famille	Richesse spécifique		Abondance	
	Sénalba	Moudjbara	Sénalba	Moudjbara
Scarabaeidae	13	10	108	35
Aphodiidae	22	18	1104	169
Geotrupidae	1	1	9	10
Totaux	36	29	1221	214
	42		1435	

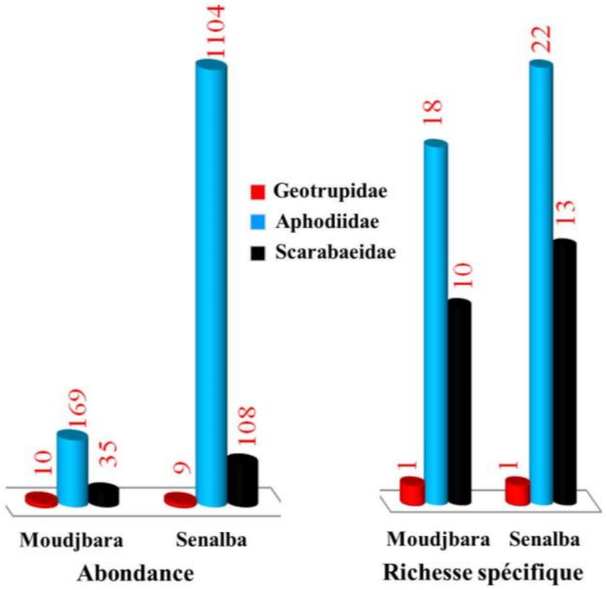

Figure 3. Abondance et richesse spécifique des différentes familles

3.2. Variations saisonnières de la richesse spécifique des Scarabaeoidea coprophages

Le tableau 3 rassemble les indications sur la richesse spécifique et l'effectif annuels et saisonniers des stations. Pour la richesse annuelle, les différences entre stations sont faibles, la richesse totale étant comprise 36 espèces (station de Sénalba) et 29 espèces (station de Moudjbara). Dans la forêt Sénalba, la richesse spécifique est maximale en hiver (19 espèces) alors que dans la station de Moudjbara, elle l'est en été (12 espèces). La valeur minimale est enregistrée au printemps dans la station de Sénalba et en hiver dans la station de Moudjbara.

Tableau 2. Richesse spécifique dans les deux stations d'étude

Famille	Sous famille	Tribu	Genre	Nombre d'espèces
Scarabaeidae	Scarabaeinae	Gymnopleurini	*Gymnopleurus*	1
		Scarabaeini	*Scarabeus*	1
	Coprinae	Onitini	*Bubas*	2
			Chironithis	2
		Oniticellini	*Euoniticellus*	1
		Onthophagini	*Onthophagus*	10
Aphodiidae	Aphodiinae	Aphodiini	*Aphodius*	23
			Heptaulacus	1
Geotrupidae	Geotrupinae	Geotrupini	*Geotrupes*	1
	Total		9	42

Tableau 3. Variations saisonnières de la richesse spécifique (S.) et de l'effectif

Station	Printemps		Été		Automne		Hiver		Total	
	S.	Effectif	S.	Effectif	S.	Effectif	S.	Effectif	S.	Effectif
Sénalba	10	34	12	62	17	885	19	240	36	1221
Moudjbara	9	17	12	98	11	81	8	18	29	214
Total	17	51	18	160	22	966	20	258	42	1435

En analyse de la figure 4, on constate que, dans la forêt de Sénalba, la richesse spécifique se rapproche durant les deux saisons humides (hiver et automne), alors que son nombre d'individus le plus important est observé uniquement durant cette dernière saison. La saison estivale caractérise la station de Moudjbra en nombre d'espèces et en nombre d'individus.

Deux périodes principales d'activité se détachent en région méditerranéenne ; la première qui va de la fin de l'hiver jusqu'au début de la sécheresse estivale, correspond à la ponte de la plus part des espèces. La deuxième période qui correspond à la sortie de beaucoup d'imagos immatures, coïncide avec les premières pluies automnales. C'est la période de regain d'activité pour de nombreuses espèces avant leur repos hivernal. Certaines espèces, comme les Géotrupes, se reproduisent à ce moment là (Errouissi et al. 2004).

3.3. *Comparaison des guildes de coprophages selon les stations en fonction de l'effectif et de la biomasse des espèces.*

3.3.1. La guilde des rouleurs

Dans ce premier cas, les imagos détachent une parcelle d'excréments et l'emportent par roulage à une distance plus ou moins grande du dépôt avant de l'enterrer dans un endroit convenable pour leur propre consommation ou pour l'édification de nids pédotrophiques servant à la réception de la ponte. Sénalba et Moudjbara ne sont représentées qu'avec une seule espèce chacune (avec respectivement *Scarabaeus sacer* et *Gymnopleurus mopsus*). Sur l'ensemble de l'année, cette guilde est très faible à la fois en effectifs (0,08% à Sénalba et 0,46% à Moudjbara du total des coprophages capturés) et en biomasse (entre 1,26 % à Moudjbara et 2,61 % à Sénalba).

3.3.2. La guilde des fouisseurs

Dans les régions arides ou semi-arides, l'enfouissement a l'avantage de soustraire une ressource fragile et fugace des effets très rapides de la dessiccation, un nid en profondeur conservant l'humidité initiale (Lumaret, 1989). Dans nos relevés, cette guilde compte à la fois des représentants des Geotrupidae et des Coprinae. La richesse en fouisseurs est sensiblement la même entre les deux stations (entre 10 et 13 espèces) (Tableau 4).

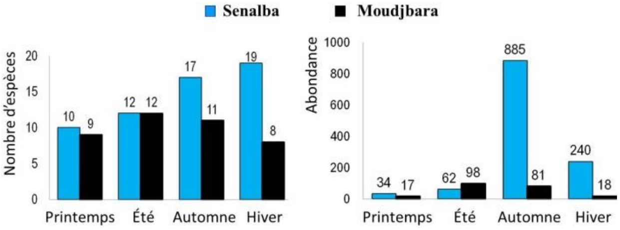

Figure 4. Variations saisonnières de la richesse spécifique et de l'abondance

Tableau 4. Nombre d'espèces par guilde et par station

Station	Rouleurs	Fouisseurs	Résidents	Total
Senalba	1	13	22	36
Moudjbara	1	10	18	29

Certaines espèces sont communes, il s'agit de *Chironitis irroratus, Onthophagus nebulosus.* La famille des Geotrupidae n'est représentée qu'avec une seule espèce. Certaines espèces ne sont rencontrées que dans la station de Moudjbara (*Euoniticellus pallens* et *Onthophagus taurus*). Dans la forêt naturelle de Sénalba, les fouisseurs sont à seulement 9,52% du nombre total annuel, et 20,54% à Moudjbara (Figures 5 et 6). Dans cette dernière, c'est l'espèce *Chironitis irroratus* qui domine par son effectif (36,36% des fouisseurs). En analysant les figures 5 et 6, on constate que la guilde des fouisseurs domine dans les deux stations par sa biomasse, elle représente 82,54% de la biomasse totale de toutes les guildes à Moudjbara, 68,81% à Sénalba. Dans la station de Moudjbara c'est *Geotrupes niger* qui domine par la biomasse cumulée de ses représentants, tandis qu'à Sénalba *Bubas bubaluoides* est le fouisseur le plus dominant par sa biomasse.

3.3.3. La guilde des résidents

Il s'agit d'espèces dont le développement larvaire se déroule en totalité, ou pour une large part, à l'intérieur même des déjections (cas des *Aphodius*), ce qui nécessite que l'activité des insectes et surtout leur reproduction intervienne pendant les périodes fraîches et humides de l'année lorsque les déjections exploitées sont de petite taille sinon, il y a un problème de dessiccation trop rapide (Lumaret 1975, Lumaret & Kirk 1987). Selon Lumaret (1989), une autre stratégie consiste à exploiter des excréments plus gros, mais avec le risque de rentrer en concurrence avec les rouleurs et les fouisseurs qui confisquent très rapidement une très large part de la ressource trophique en l'enfouissant dans des terriers profonds.

Cette guilde n'est représentée que par les Aphodiidae qui comptent autant d'espèces que les Scarabaeidae. Des espèces communes présentes dans les deux stations sont au nombre de 14 espèces; c'est le cas d'*Aphodius bedinus*, *A. bonnairei*, *A. longispina* et *A.melanosticus*. Au contraire, d'autres espèces ont une distribution plus restreinte. Ainsi, *Aphodius felscheanus* et *A. fimetarius* sont limitées à la forêt naturelle de Sénalba. À Sénalba, les résidents représentent annuellement 90,4% du total des captures pour seulement 28,57% de la biomasse totale des Scarabéides (Figure 5). Ils sont encore à 79% du total des captures face à une biomasse de 16,19% à Moudjbara (Figure 6).

Généralement les espèces de grande taille (≥50 mg)) arrivent tardivement sur l'excrément et y restent longtemps, alors que les espèces de petite taille (<50 mg) arrivent plus tôt et migrent plus facilement d'un excrément à l'autre. Cette migration entre les excréments est un phénomène important dans la dynamique des communautés de bousiers. Les espèces qui arrivent tôt peuvent être qualifiées de «spécialistes» puisqu'elles présentent une niche trophique étroite; elles sont caractérisées par un développement rapide, une importante fécondité et une grande capacité de vol. Les espèces tardives sont qualifiées de « généralistes » avec une niche trophique large. Représentants les plus symboliques de la faune bousière. Les interactions étroites entre les coprophages de la même sous-famille qui exploitent en même temps la masse stercorale, sont minimisées par des biologies différentes selon les espèces (modalité de colonisation, cycles biologiques, comportement de nidification) (Lumaret et al. 1989).

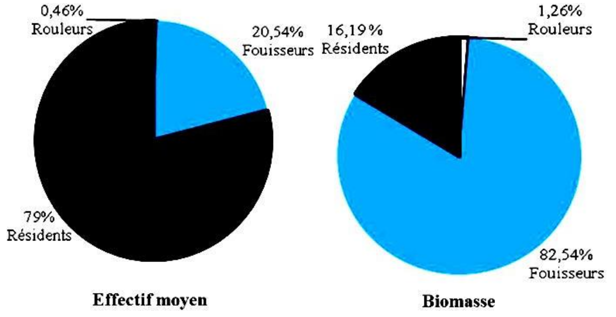

Figure 5. Comparaison des guildes de coprophages selon l'effectif moyen et la biomasse des espèces dans la station de Sénalba

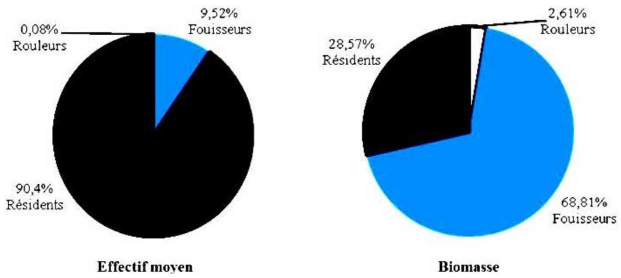

Figure 6. Comparaison des guildes de coprophages selon l'effectif moyen et la biomasse des espèces dans la station de Moudjbara

3.4. Diversité et équitabilité

Pour chaque station, les valeurs de la diversité H' de Shannon ont été calculées globalement sur un cycle annuel. Les résultats ont montré une diversité égale à 2,278 dans la station de Moudjbara, tandis que Sénalba présente une diversité faible (H'= 1,580) (Tableau 5). L'équitabilité E (valeurs comprises entre 0 et 1) est de 0,441 dans la station de Sénalba, elle croit dans la station de Moudjbara (0,676).

3.5. Analyse bioinformatique des résultats (DECORANA)

Le graphe de la figure 7 illustre la disposition des stations à partir de l'analyse DECORANA, en montrant une ordination selon les axes 2 et 3. La station Moudjbara se place entre les extrémités positives des deux axes avec ses 5 propres espèces. La forêt naturelle de Sénalba se met dans la partie négative entre les deux axes, avec la présence de certaines espèces qui la caractérisent vraiment, comme *Chironitis furcifer, Aphodius fimetarius* et *Aphodius felscheanus,* ajoutant la particularité de la présence de *Bubas bubaloides* avec *Bubas bison.*

4. Discussion

L'analyse de la structure des communautés de Scarabéides coprophages de deux formations forestières (la forêt naturelle de Sénalba et le reboisement de Moudjbara), conduit à des arrangements d'espèces différents induisant une organisation fonctionnelle. À la limite de notre échantillonnage, 1435 individus ont été récoltés, appartenant à 3 familles (Scarabaeidae, Aphodiidae et Geotrupidae), 9 genres et 42 espèces. Sénalba est plus riche en espèces et en effectifs que le reboisement de Moudjbara. Les Scarabéidés coprophages constituent un groupe écologiquement organisé en communautés d'espèces complémentaires (guilde). Les Aphodiinae ou les résidents constituent la guilde la plus dominante dans les deux stations par sa grande richesse (24 espèces) ainsi que par ses effectifs importants (entre 79,68% et 90,4% du total dans les deux stations). Ce sont par contre les fouisseurs qui constituent la guilde dominante par ses biomasses malgré une richesse et des effectifs moindres. Les rouleurs sont pratiquement très faibles, ils ne sont représentés que par deux espèces (*Scarabeus sacer* et *Gymnopleurus mopsus*). L'analyse DECORANA nous a montrés une séparation des deux écosystèmes forestiers étudiés avec la spécificité de certaines espèces liées soit à la nature du sol soit aux conditions biotiques de la station.

Tableau 5. Récapitulatif des mesures de diversités des espèces des Scarabaeoidea coprophages dans les deux stations d'étude (S : Richesse ; E : Equitabilité ; H : Indice de diversité de Shannon ; D : Indice de Simpson)

	S	E	H	D
Sénalba	36	0,441	1,580	0,5881
Moudjbara	29	0,676	2,278	0,7947

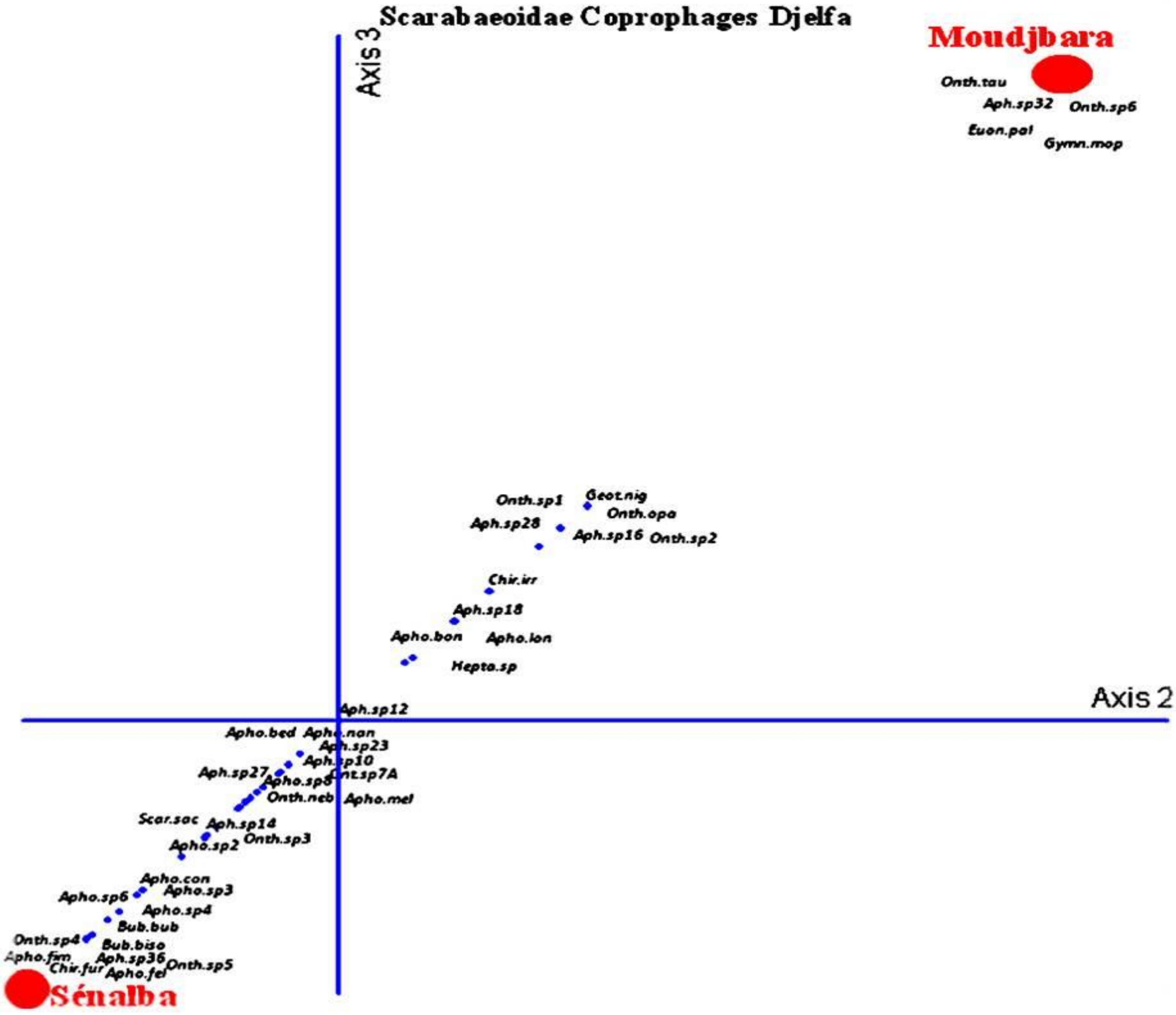

Figure 7. Ordination des deux stations pour les espèces Scarabaeoidea Coprophages, selon les axes 2 et 3 de l'analyse DECORANA

La forêt naturelle offre certainement des conditions microclimatiques favorables pour certaines espèces (humidité élevée, peu d'éclairage), elle constitue un milieu moins perturbé. L'étude révèle que Sénalba est un biotope plus propice à l'installation des Scarabéidés contrairement au reboisement de Moudjbara, et ceci pourrait être le résultat d'un pâturage limité dans les steppes boisées. Ce groupe d'insectes, a un impact non négligeable en termes d'écologie sur l'environnement. L'intérêt de notre travail est d'avoir montré que d'autres recherches de ce type sont nécessaires en Algérie, en particulier dans les régions steppiques où les pratiques d'élevages sont importantes, afin que l'on puisse mieux appréhender le fonctionnement des communautés de coprophages.

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2016, 17(Special Issue): 31-39 | Research article (Araştırma makalesi)

A review of the "summer" *Thaumetopoea* spp. (Lepidoptera: Notodontidae, Thaumetopoeinae) associated with *Cedrus* and *Pinus*

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Abstract: The species of the genus *Thaumetopoea* (Lepidoptera, Notodontidae, Thaumetopoeinae) are important from the point of view of forestry and human health as they are defoliators of trees and they release urticating hairs at the larval stage that are a source of allergy. Within the genus, there are two groups associated with conifers which are characterized by larval feeding in winter or in spring-summer, so the groups are called 'winter' and 'summer' processionary moths. This review collects the information about the species of the 'summer' *Thaumetopoea* species from Eurasia. Information includes morphological, biological, and ecological traits of *Th. bonjeani, Th. cheela, Th. ispartaensis, Th. libanotica, Th. pinivora and Th. sedirica*. *Thaumetopoea cheela* is proposed to be included in this group based on indirect evidence presented in this paper. Information is collected from the literature and checked, where it was possible, with museum and collected specimens. An identification key based on morphological and biological traits is proposed. The conifers of the genus *Cedrus* seem to be associated with the summer *Thaumetopoea*, although more work is needed in order to clarify the evolutionary history of the group.

Keywords: *Thaumetopoea* summer, *Thaumetopoea cheela,* Morphological traits

Cedrus ve *Pinus* ile ilişkili "yazlık" *Thaumetopoea* spp. (Lepidoptera: Notodontidae, Thaumetopoeinae) türlerine yönelik bir değerlendirme

Özet: *Thaumetopoea* familyasında yer alan türler (Lepidoptera, Notodontidae, Thaumetopoeinae), yaprak zararlısı böcekler olmaları ve alerji kaynağı olarak larva evresinde kaşındırıcı kılları olması nedeniyle ormancılık ve insan sağlığı açısından önemlidir. Bu familya içerisinde, ibreli ağaçlarla ilişkili olan ve larvaları ilkbahar ve yaz aylarında beslenen iki grup yer almaktadır, bu gruplar 'kışlık' ve 'yazlık' çam kese böcekleri olarak adlandırılmaktadır. Bu çalışmada, Avrasya bölgesinde yayılan 'yazlık' *Thaumetopoea* türleri hakkında bilgi toplanmıştır. Bu bilgiler, *Th. bonjeani, Th. cheela, Th. ispartaensis, Th. libanotica, Th. pinivora* ve *Th. sedirica* türleri hakkında morfolojik, biyolojik ve ekolojik özellikleri içermektedir. Bu tebliğde sunulan dolaylı kanıtların ışığında *Thaumetopoea cheela* türünün bu grupta yer aldığı öne sürülmektedir. Bilgiler literatürden elde edilerek mümkün olduğunca müze ve toplanan örneklerle kontrol edilmiştir. Morfolojik ve biyolojik özelliklere dayalı bir tanımlama anahtarı önerilmiştir. *Cedrus* cinsinde yer alan ibreli ağaçların yazlık *Thaumetopoea* ile ilişkili olduğu anlaşılmaktadır ancak bu grubun evrimsel geçmişini açıklamak için daha fazla çalışmaya ihtiyaç duyulmaktadır.

Anahtar kelimeler: Yazlık *Thaumetopoea, Thaumetopoea cheela,* Morfolojik özellikler

1. Introduction

The subfamily Thaumetopoeinae includes several species called processionary moths. These moths are of great importance for ecology and forestry because the larvae feed on trees and shrubs of different families (both broadleaved and coniferous) menacing both growth and survival of trees, especially in the Mediterranean countries (Masutti & Battisti, 1990). Moreover, these species threaten human and animal health because of the presence of urticating setae in larvae and / or adults (Battisti et al., 2011). These hairs are likely used as a defense strategy against vertebrate predators and are responsible for allergic reactions also of strong intensity in humans (Maier et al., 2003).

Historically, the subfamily has been considered as a self-standing family and divided into three subgroups according to their geographic distribution (Kiriakoff, 1970), then treated as a subfamily of Notodontidae based on a cladistics analysis (Miller, 1991). Recent studies, based on morphological (Schintlmeister, 2013) and molecular (Zahiri

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et al., 2011; Zahiri et al., 2013) data, confirm the subfamily status of Thaumetopoeinae within the Notodontidae.

In this subfamily, the genus of *Thaumetopoea sensu lato* contains the most studied species, for which a recent molecular analysis has defined the phylogenetic relationships, and the evolution of biological traits, in some Palaearctic species (Simonato et al., 2013), which are mainly distributed in the Mediterranean and Iranoturanic areas (Agenjo, 1941; Kiriakoff, 1970) (Figure 1).

Some authors split this genus in three genera (de Frëina & Witt, 1987; Schintlmeister, 2013): a) *Traumatocampa* (*bonjeani* Powell, *ispartaensis* Doganlar & Avci, *jordana* Staudinger, *libanotica* Kiriakoff & Talhouk, *pinivora* Treitschke, *pityocampa* Denis & Schiffermüller, *sedirica* Doganlar, *torosica* Doganlar, *wilkinsoni* Tams); b) *Thaumetopoea* (*apologetica* Strand, *cheela* Moore, *dhofarensis* Wiltshire, *processionea* Hübner, *solitaria* Frey), and c) *Heliantocampa* (*herculeana* Rambur). However, this morphological partition is not completely supported from a reassessment of the key morphological traits and by the recent molecular phylogeny of Simonato et al. (2013), suggesting that these species should be provisionally treated as part of a single genus. Within the *Thaumetopoea* species feeding on coniferous trees, Simonato et al. (2013) identified two clusters based on the timing of larval feeding in winter or in spring-summer, confirming the groups called 'winter' and 'summer' processionary moths by Démolin (1989).

The aims of this paper are to review the information about the summer *Thaumetopoea* species, which include *Th. bonjeani, Th. ispartaensis, Th. libanotica, Th. pinivora* according to Simonato et al. (2013), and two other species (*Th. sedirica* and *Th. cheela*) which were not included in that study. The final aim is to organize and synthetize the knowledge about this group and produce a key based on the wing traits as developed by Agenjo (1941).

2. Materials and methods

2.1. Systematics

Information about types, collections and number of specimens were obtained from catalogue of Schintlmeister (2013). Descriptions, biogeographic information, and morphological traits were collected from literature and checked with specimens from museum collections. Wings morphology and name of fasciae are based on Heath and Emmet (1976).

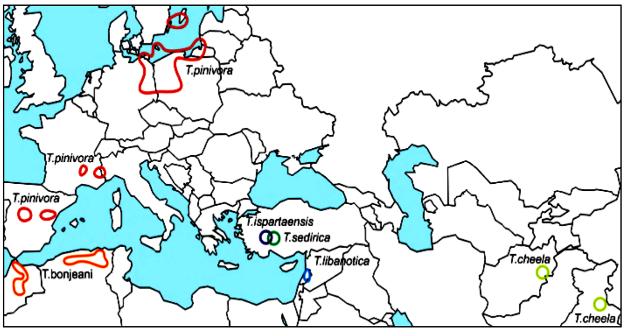


Figure 1. Geographic distribution of the summer *Thaumetopoea* spp.

2.2. Materials

Thaumetopoea bonjeani: 3♂, 2♀: likely from Morocco, Witt Museum, Munich.

Thaumetopoea cheela: 2 ♂: Afghanistan, Surobi district, 1100 m, 07.VII.1961 and 08.VII.1961; legit G. Ebert, 1970 - The Bavarian State Collection of Zoology; Munich.

Thaumetopoea ispartaensis: 3 ♂, 1 ♀: Turkey, Isparta – Senirkent, 1100 – 1600 m. Collected on *Cedrus libani* and sent by Mustafa Avci from Isparta Suleyman Demirel University to Department of Agronomy, Food, Natural Resources, Animals and the Environment; University of Padua.

Thaumetopoea libanotica: holotype ♂, allotype; Lebanon, Bcharre, Eklosion Beirut, 8.VIII.1974; collection A.S. Talhouk - The Bavarian State Collection of Zoology; Munich.

Thaumetopoea pinivora: 1 ♂: unintelligible collected site; IX.1917; collection Thurner - The Bavarian State Collection of Zoology; Munich. 1 ♀: from Russia, Ostpreussen (Oblast' Kaliningrad), VI.1909; collection Forster - The Bavarian State Collection of Zoology; Munich.

Thaumetopoea sedirica: 1 ♂, 1 ♀: from Turkey, Isparta–Sarkikaragac, 1400m, 38°02' 18"N, 31°22'35"E, 28.VIII.1967; legit (Det.) by M. Doganlar, 2005. Collected on Cedrus libani and sent by M. Doganlar to Department of Agronomy, Food, Natural Resources, Animals and the Environment; University of Padua.

3. Results

3.1. General morphological traits

Moths of this subfamily are small or medium size. Body covered by grayish hairs (de Frëina & Witt, 1987). Eyes naked; ocelli absent such as chaetoseme; palpi small and rudimentary, proboscis atrophied (Kiriakoff, 1970). Forewing shape and veins very similar to the Notodontidae ones; without tooth on dorsum and with apices rounded (de Frëina & Witt, 1987). Vein, using Hampson & Meyrick classification, (Heath & Emmet, 1976) 2 start at 4/5 of cell, 3 and 4 separated, 5 start at middle of discal spot; they are concave (de Frëina & Witt, 1987; Kiriakoff, 1970). Veins 6, 7, 8 + 9 and 10 are stalked. Width of forewing is about twice hindwing (Kiriakoff, 1970).

3.2. Description of species

3.2.1. *Thaumetopoea bonjeani* (Powell, 1922): 188; (*Cnethocampa bonjeani*)

Syntype: unspecified number of ♂♂ and ♀♀, Morocco, d'Azrou Forest, 500 m to North of Douar de Garde – The Natural History Museum, London. Not examined.

Description (Figure 2): According to Agenjo (1941) this species is really similar to *Th. pinivora*. This statement is strongly corroborated by molecular analysis (Simonato et al., 2013).

Male. Antennae bipectinate, long and yellowish in ground color (Agenjo, 1941; de Frëina & Witt, 1987). Palpus with first segment longer and thicker than second segment (Agenjo, 1941). Canthus present; with 5 teeth and upper side straight (Agenjo, 1941). Upper tooth smaller (de Frëina & Witt, 1987). Foreleg epiphysis present and well developed. Thorax blackish, with some whitish hairs, which turn into brownish-gray ventrally (de Frëina & Witt, 1987). Abdomen ochreous (de Frëina & Witt, 1987) or golden and blackish (Agenjo, 1941). Wingspan 30-34 mm. Forewing ground color ash gray, generally. Three dark fasciae present, with yellow edge (Agenjo, 1941). Basal fascia, more or less straight, from radial vein to inner margin of wing (Agenjo, 1941); this fascia is often barely visible (de Frëina & Witt, 1987). Shape of ante-median and post-median fasciae clearly distinguish *Th. bonjeani* from *Th. pinivora*, i. e. ante-median fascia forms an obtuse angle outwardly, changing direction straight just before dorsum (Agenjo, 1941). External edge of post-median fascia jagged. Ante and post-median fasciae more or less parallel, especially near costa and dorsum (Agenjo, 1941). A V-shaped discal spot present. Fringes on termen present, alternatively gray and white-yellow (Agenjo, 1941). Hindwing whitish with reddish fluff at margin. Fluff more abundant at anal margin. Fringes alternatively gray and whitish. Anal spot present and well developed (Agenjo, 1941).

Male genitalia. Up to 4 mm when fully stretched. Uncus shorter than gnathos and thin (Doganlar and Avci, 2001). Tegument thin. Valvae basally concave turning into convex apically. Valvae narrow, with a small protuberance on tip. Fultura distinctive, big, with jagged edges similar to that *Th. processionea* (Agenjo, 1941). Aedeagus broad basally (Doganlar and Avci, 2001) and curved, such as *Th. pinivora*, but bigger.

Female. Similar to *Th. pityocampa* and *Th. pinivora* (Agenjo, 1941). Wingspan 34-38 mm, with the wing ground color pale and not well defined (de Frëina & Witt, 1987). Anal scales straight, long acute, with sharpened base; poorly pigmented at the center (Agenjo, 1941). From literature we known that ratio, between length and width, greater than 2.5 (El Yousfi, 1989; Simonato et al., 2013).

Remarks: head covered by a tuft on scapus of brownish hairs, like in *Th. pinivora*. Canthus small. Discal spot brownish.

Larva. Larva has been described by Démolin (1989) mainly on a comparison with *Th. pityocampa*, from which it can be easily distinguished because of the long white hairs implanted on the trapezoid plates at both sides of the body. In addition, the urticating setae are black instead of orange-red and the anterior edge of the integumental areas carrying them (the 'mirror') is characterized by very long white hairs. Démolin (1989) provides a pictorial description of the hairs among the five larval instars (Planche 12 and 12 bis) as well as photographs of the mature larvae (Planche 13 and 14) which are compared to those of *Th. pinivora*.

Life history: Larvae are social and monophagous on *Cedrus atlantica* (Démolin, 1989; El Yousfi, 1989; Rahim et al., 2014), preferring low humidity forests (de Frëina and Witt, 1987). The adults emerge between August and September, mating at night, immediately after emergence. The oviposition occurs on the underside of the cedar branches, during the night. The eggs are then covered with bark-colored scales, making them less visible. The number of eggs per egg batch is extremely variable. After 8 months, between March and April, larvae hatch and group in colonies, building very light silk tents , until to achievement the fifth instar (between June and July) (Rahim et al., 2014). Then larvae leave the tree in a procession, in the early hours of the morning and pupate in the soil (El Yousfi, 1989). *Thaumetopoea bonjeani* has an annual development cycle (Démolin, 1989; Rahim et al., 2014) (Table 1). The sex pheromone has been identified and results similar to that of *Th. pinivora* and *Th. libanotica* (Frérot, 2014).

Distribution: *Thaumetopoea bonjeani* was found originally in the Atlas Mountains of Morocco (Agenjo, 1941) and later in mountains of Algeria (de Frëina and Witt, 1987; Rahim et al., 2014) (Figure 1).

3.2.2. *Thaumetopoea cheela* Moore, 1883: 18;

Syntype: 1 ♂, 1 ♀, North-West India, Umballa district – The Natural History Museum, London. Not examined.

Description (Figure 2): Based on the original description of Moore (1883), who defined it as very similar to *Th. pinivora*.

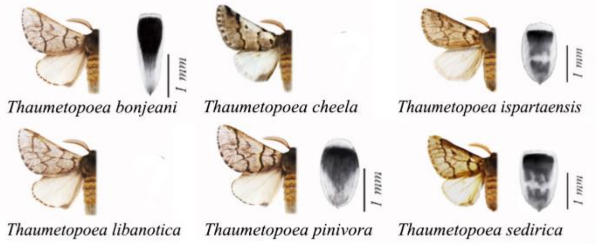
Male. Antennae yellow. Head covered by grayish-brown hairs. Legs thickly clothed with grayish-brown hairs in femur and tibia. Tarsi yellow. Thorax hairs grayish-brown. Ochreous yellow segmental bands present on abdomen. Wingspan 31 mm. Forewing brownish-gray ground color with sparse white scaled; scales disposed longitudinally. Forewings have 3 dark fasciae in basal, ante-median and post-median positions. Post median fascia zig-zagged. Each fasciae bordered with a marked ochreous-yellow edge like in *Th. pinivora*. Fringes alternately gray and white. Hindwing whitish with a dark spot in the anal angle.

Female. Wingspan 35 mm. Wing ground color paler than male and not well defined. Head darker brownish-gray; thorax and abdomen have darker brown tuft.

Remarks: dark tuft on scapus. Canthus present and notched, with 6 or 7 teeth. Foreleg epiphysis present. Forewing basal line reduced to some dark points; a brown discal spot bordered present, with white scale; a dark brown pre-apical spot present. Fringes of hindwings more whitish than in the forewing.

No information about genitalia, female scale, larvae and life history is available.

Distribution: from Afghanistan, Surobi district (specimens collected by G. Ebert, see above), to N-W of India, Umballa district (Moore, 1883).



Thaumetopoea bonjeani *Thaumetopoea cheela* *Thaumetopoea ispartaensis*

Thaumetopoea libanotica *Thaumetopoea pinivora* *Thaumetopoea sedirica*

Figure 2. Males of summer *Thaumetopoea* spp. considered in the study, together with the scales of the anal tuft of female moths, whenever available.

3.2.3. *Thaumetopoea ispartaensis* Doganlar & Avci, 2001: 20 (*Traumatocampa ispartaensis*);

Holotype: ♂, Turkey, Isparta, Kapidagi: Senirkent (1100-1500 m) – Plant protection Department, Mustafa Kemal University, Antakya, Turkey. Not examined.

Description (Figure 2): This species is very similar to *Th. bonjeani* (Doganlar & Avci, 2001).

Male. Antennae light brown and bipectinate (Doganlar and Avci, 2001). Palpus thin, with second segment long twice as first (Doganlar et al., 2005). Head covered by dark brown hairs (Doganlar and Avci, 2001). Canthus notched, developed, with 7 teeth, 2 long and 5 small (Doganlar and Avci, 2001). Foreleg epiphysis present (Simonato et al., 2013). Thorax dorsally covered by dark brown hairs (Doganlar and Avci, 2001). Abdomen light brown, with reddish hairs and dark bands laterally (Doganlar and Avci, 2001). Wingspan 26-29 mm. Forewing ground color whitish-gray, with three typical dark brown fasciae. According with Doganlar and Avci (2001), forewing has a really small basal fascia; ante-median and post-median fasciae more or less parallel between costa and dorsum. Post-median fascia more serrated in the middle (Doganlar and Avci, 2001) like in *Th. pinivora*. Discal spot vague with light brown color and halfmoon-shaped (Doganlar and Avci, 2001). Hindwing whitish, without fasciae. Fringes grayish-brown. A vague anal spot sometimes present. Grayish fasciae on anal margin present. Reverse sides of all wings without any particular ground colors (Doganlar and Avci, 2001).

Male genitalia. Uncus long large with curved tip; gnathos long, triangular and broad. Pedunculus, which is inferiorly articulated with the vinculum (Steinmann and Zombori, 1984), well developed and broad in the middle. Valvae with a short apical projection on ventral margin, thicker towards tip. Internal margin of valvae slightly concave while costal margin curved apically; tip of valvae narrow. Ventral side without teeth (Doganlar and Avci, 2001).

Aedeagus slightly longer than valva, curved basally and widen medially. Saccus not developed (Doganlar and Avci, 2001).

Female. Wingspan 34-37 mm. Wing ground color paler than male and not well defined; hindwing without dark margin or anal spot (Doganlar and Avci, 2001). Head and thorax dark with grayish hairs; abdomen yellowish with light brown bands. Last tergit with many scales, pointed with 2 spots (Doganlar et al., 2005). Ratio between length and width near to 2 (Doganlar et al., 2005; Simonato et al., 2013).

Remarks: head with a tuft of whitish-yellow hairs that cover scapus; brown hairs present near canthus. Legs thin with few hairs. A pair of spurs present in the others legs. Thorax covered ventrally by whitish-yellow hairs. Three fasciae on forewing with yellow edges in the same positions such as in *Th. pinivora*. Basal fascia with yellow edge that is most visible in the internal side. Ante-median fascia C shaped with outwardly smooth tip. Ends near dorsum of ante-median and post-median fasciae divergent. Forewing with vague pre-apical light brown spot and gray fringes. Light grayish band present at anal margin. Hindwing lighter at anal margin and pale on reverse side; a vague light brown spot in the center present; scales with two black spot: one to the apex and a big one near the base. Fultura hexagonal as long as wide.

Life history: Larvae are social and monophagous on *Cedrus libani* (Doganlar and Avci, 2001). Adults emerge between August and September, mating at night, immediately after emergence. Eggs are laid on the underside of cedar branches, during the same night. Eggs are covered with bark-colored scales, such as in *Th. bonjeani*. The number of eggs per egg batch is extremely variable. After almost 7 months, between the end of March and the end of April, larvae hatch and group in colonies, spinning light silk tents, until to achievement the fifth instar (end of June to mid-July). Then, mature larvae pupate on sunny soil near cedar forest. No extended diapause was observed (Avci and İpekdal, 2014) (Table 1).

Distribution: Turkey, Isparta region (Doganlar and Avci, 2001) (Figure 1), in cedar stands of the Taurus Mountains (Avci and İpekdal, 2014).

3.2.4. *Thaumetopoea libanotica* Kiriakoff & Talhouk, 1975: 1

Holotype: ♂, Lebanon, Eklosion, Bcharre – Faculty of Agricultural Sciences, American University of Beirut. Not examined.

Description (Figure 2): *Male*. Antennae bipectinate and light brown (Kiriakoff and Talhouk, 1975). Palpus small. Head ochreous-brown dorsally and blackish ventrally; a tuft of whitish-gray hairs cover scapus (Kiriakoff and Talhouk, 1975). Canthus notched, not well developed, with 5 teeth; the upper ones smaller (Doganlar and Avci, 2001). Legs with pale hairs, as well as in thorax ventral side; tarsi yellow (Kiriakoff and Talhouk, 1975). Foreleg epiphysis present (Simonato et al., 2013). Thorax dorsally brown with grayish hairs. Abdomen gray, slightly brown with whitish segmental bands. Lateral and anal tufts are grays (Kiriakoff and Talhouk, 1975). Wingspan 26 mm. Forewing ground color brownish-gray, with 3 dark fasciae with pale edges (Kiriakoff and Talhouk, 1975). Fasciae in basal, ante-median and post-median positions. Basal fascia and ante-median fascia V-shaped, with tip outwardly. Basal fascia sometimes discontinued near costa; ante-median fascia with a sharp angle just before dorsum. Post-median fascia continuous and serrated, often with a sharp angle just before dorsum. Upper ends of medians fasciae more or less parallel; instead lower ends more convergent (Kiriakoff and Talhouk, 1975). Discal spot triangular shaped, brownish-gray colored. Vague pre-apical spot present. Fringes whitish, alternate with grayish-brown ones. Hindwing whitish with light brown margin and a vague brownish anal spot. Whitish-gray fringes present. Undersides of wings pale and not well defined (Kiriakoff and Talhouk, 1975).

Male genitalia. Uncus short, curved and tapered distally. Gnathos triangular with rounded corners (Kiriakoff and Talhouk, 1975), bigger than uncus (Doganlar and Avci, 2001); Vinculum narrow. Valvae oval, with tip slightly elongated and rounded, without projection. Aedeagus slightly longer than valvae; wide basally and narrow distally,; slightly curved. Fultura pentagonal (Kiriakoff and Talhouk, 1975). Saccus not developed (Doganlar and Avci, 2001; Kiriakoff and Talhouk, 1975).

Female. Wingspan 32 mm. Wing ground color pale and less defined than male. Antennae described as filiforms by

Kiriakoff and Talhouk (1975). Head and thorax grayish; abdomen pale with ochreous hairs and dark fasciae (Kiriakoff & Talhouk, 1975). Scale ratio between length and width near to 2 (Simonato et al., 2013).

Remarks: discal spot is similar to halfmoon-shaped. Fultura as long as wide. Antennae in female shortly bipectinate to apex.

Larva. Mature larva is 25-26 mm long, with a background light gray, almost white color. Abdominal tergites have integumental fields carrying urticating setae bordered with red color and intermixed with bundles of long, white hairs (Kiriakoff and Talhouk, 1975).

Life history: Larvae are social and monophagous on *Cedrus libani*. They were found on young trees at high elevation (1900 m) on Lebanon Mountains, in temperate forests, with an average rainfall of 1200 mm/year (Kiriakoff and Talhouk, 1975). Larvae reach the fifth instar at the end of June and they pupate in soil. Adults emerge in August. This data was collected by Kiriakoff and Talhouk (1975) from a single colony found on a tree and bred in the laboratory (Table 1).

Distribution: was found in the Lebanon forest by Kiriakoff and Talhouk (Kiriakoff and Talhouk) (Figure 1).

3.2.5. *Thaumetopoea pinivora* (Treitschke, 1834): 194; (*Gastropacha pinivora*).

Lectotype: ♂, Northern Germany (probably Sternberg, SW of Rostock according to Schintlmeister, 2013) – Magyar Természettudományi Múzeum, Budapest. Not examined.

Infrasubspecific, according to Schintlmeister (2013):

Th. pinivora ab. *nigromaculata* Peters, 1899: 245.

Th. pinivora ab. *plutonia* Schultz, 1905: 115.

Description (Figure 2): External morphology of *Th. pinivora* is very similar to *Th. pityocampa* although showing significant differences (Agenjo, 1941; De-Gregorio and Redondo, 1994; de Frëina and Witt, 1987).

Male. Antennae short, bipectinate and more grayish than yellow (Agenjo, 1941). Palpus stretched (Doganlar et al., 2005), with first segment longer and thicker than second sharped segment (Agenjo, 1941). Head covered by brownish hairs (de Frëina and Witt, 1987). Canthus notched, not well developed (Agenjo, 1941), with 7 teeth, 6 small and 1 big (de Frëina and Witt, 1987). Leg thin. Foreleg epiphysis present. A pair of spurs in the other legs present. Thorax brown and very hairy; abdomen yellowish (Agenjo, 1941; de Frëina and Witt, 1987). Wingspan 27-37 mm. Forewing ground color ash gray. Forewings with 3 dark fasciae in basal, ante-median and post-median positions. All of them with yellow edge. In the basal fascia, edge yellow on both sides; in the ante-median fascia yellow edge on external side; in the post-median fascia yellow edge on internal sides (Agenjo, 1941; de Frëina and Witt, 1987). These edges often discontinuous. Direction of the dark fasciae slightly different from *Th. pityocampa*, in particularly between ante-median and post-median fascia that converge near dorsum (Agenjo, 1941). Forewing marked from a brown halfmoon-shaped discal spot (de Frëina and Witt, 1987). Fringes alternately brown and white for the entire length of termen. Forewing reverse side pale (Agenjo, 1941; de Frëina and Witt, 1987). Upper side of hindwings white with dark external margin and with whitish-gray fringes. Anal spot sometimes present. Hindwings reverse side pale (Agenjo, 1941; de Frëina & Witt, 1987).

Male genitalia. Up to 3,5 mm when fully stretched (Agenjo, 1941). Uncus small, broad and circular, triangular-shaped with thin and straight tips of lateral appendices. Tegument thin. Valvae distinctive, very short and sharp, with straight bottom edge and rounded at the end; upper edge initially perpendicular to the external margin and turning into convex apically. Inner edge almost straight. Outer end of upper edge produces a process with a right angle and a thicker terminal tip. This joins to the inner margin of the distal end. protuberance present, with many bristles, inserted in well-defined cavities (Agenjo, 1941; de Frëina and Witt, 1987). Fultura pentagonal and very characteristic. Aedeagus not curved (Agenjo, 1941).

Female. Similar to *Th. pityocampa* and *Th. wilkinsoni* (Agenjo, 1941). Wingspan 34-38 mm, with the wing ground color pale and not well defined (de Frëina and Witt, 1987). Antennae wider but shorter than male (Agenjo, 1941). Head and thorax brown with grayish hairs; abdomen lighter with yellow fasciae (Agenjo, 1941). Anal scales that cover egg batches narrow and short, with base, much pointed. Scales pigmented typically, with wide elliptic dark spot near apex bordered on three sides by a lighter line before the terminal edge (Agenjo, 1941); there are no other black regions except this (Doganlar et al., 2005). Moreover scales ratio between length and width near to 2 (Simonato et al., 2013).

Remarks: head with tuft of whitish-gray hairs that cover scapus, and a line of brown hairs between antennae and canthus. Thorax and legs covered with some whitish-gray hairs. On forewings the fasciae with yellow-whitish margin in the upper portion. Light brown spot between the 2 arms of discal spot often present on forewing. Brown pre-apical spot present at costal margin; it can be extended to half of wing. Forewing reverse side pale and with only a dark spot under costal margin of post-median fasciae. Anal spot on hindwing sometimes vague.

Larva. The only description available refers to Démolin (1989) comparison with *Th. bonjeani* (see above). This author considers the larva of *Th. pinivora* not distinguishable from that of *Th. bonjeani*.

Life history: Larvae are highly social (Aimi et al., 2008). In the southern Europe they prefer mountain environments where their host plant growth typically, while in northern Europe, they can be found in the lowland forest (Cassel-Lundhagen et al., 2013). They feed mainly on *Pinus sylvestris* (Cassel-Lundhagen et al., 2013; de Frëina and Witt, 1987) but occasionally they are found on *Pinus nigra* and *Pinus mugo* (Larsson and Battisti, 2014). They prefer slow-growing trees on poor soils (Cassel-Lundhagen et al., 2013). In northern Europe, *Th. pinivora* has a 2 years development cycle. Adults emerge between July and August and mating soon after. Female lays 100-200 eggs on pine needle, from the tip to the base (in contrast to *Th. pityocampa*). Eggs hatch in the early spring. Larvae start to feed on mature needles, mainly during the night, and reach the fifth instar to the end of July. Then they leave the tree in a typical procession to search a suitable site to dig and pupate to a depth of 5-20 cm. Adults emerge in late July of the following year; although a certain proportion of the cocoons have a prolonged diapause (Larsson and Battisti, 2014) (Table 1). Larvae do not build thick tents, in contrast to *Th. pityocampa* and *Th. processionea* (Larsson and Battisti, 2014).

Distribution: *Th. pinivora* was originally known from Northern Europe and later from France and central Spain (Cassel-Lundhagen et al., 2013; Larsson and Battisti, 2014) (Figure 1).

3.2.6. Thaumetopoea sedirica Doganlar et al., 2005: 231; (*Traumatocampa sedirica*)

Holotype: ♂, Turkey, Isparta, Sarkikaragac – m, 38°02' 18"N, 31°22'35"E, ex *Cedrus libani*, 17 August 1968, legit Tosun, Museum of the Agricultural Faculty, Mustafa Kemal University, Hatay, Turkey. Not examined.

Description (Figure 2): External morphology very similar to *Th. ispartaensis.*

Male. Antennae yellow and bipectinate with ramie (Doganlar et al., 2005). Palpus small, with second segment long as the first segment; first segment swollen outwardly (Doganlar et al., 2005). Head dark brown but with lighter hairs in the upper side. tuft with long dark hairs and white broad scales present to cover scapus (Doganlar et al., 2005); the lines of hairs near canthus pale yellow (Doganlar et al., 2005). Canthus notched, with 3-5 broad teeth (Doganlar et al., 2005); Thorax covered by brownish black hairs. Abdomen with golden hair-like setula (Doganlar et al., 2005). Wingspan 30-37 mm. Forewing with dark brown basal, ante-median and post-median fasciae. Apical ends of ante-median and post-median fasciae divergent on anal margin (Doganlar et al., 2005). A typical light brown discal spot present (Doganlar et al., 2005). Hindwing whitish with apical gray fringe, and without anal-spot (Doganlar et al., 2005).

Male genitalia. Uncus large with curved tip. Valvae broad basally, with a short apical projection on ventral margin that becomes thicker towards the tip. Apex of valva turned almost 95°. Internal margin slightly concave while costal one sharply curved apically; the tip of valva narrow (about 1/3 of valvae). Ventral side without tooth (Doganlar et al., 2005).

Female. Wingspan 33-40 mm. Wing ground color paler than male and less defined. Antennae bipectinate with short ramie (Doganlar et al., 2005). Last tergit with many scales and pointed basally with black dots below apical black spot (Doganlar et al., 2005). Moreover scales ratio between length and width near to 2 (Doganlar et al., 2005).

Remarks: hairs dark. Legs thin. Forewing epiphysis present. A pair of spurs in the other legs present. Thorax ventrally covered by lighter hairs. Forewing ground color in whitish-gray; all fasciae with typically yellow edges, like in *Th. pinivora.* Apical ends of ante-median and post-median fasciae parallel on costal margin. Discal spot with halfmoon-shaped present. Fringes brownish-gray. A darker marker can be present in the anal margin of hindwings. Wings reverse sides pale, without any particular ground colors, with only a vague light brown spot in the center of hindwings.

Larva: No information is available.

Life history: Larvae are social and probably monophagous on *Cedrus libani*. The eggs batches are flat, symmetrical and hexagonal on the host bark (Doganlar et al., 2005).

Distribution: Turkey, Isparta region (Doganlar et al., 2005), (Figure 1).

Table 1. Summary of some biological traits of *Thaumetopoea* spp. ? = unknown trait

Species	Life cycle	Diapause	Flight period	Larval period	Host genus
Th. bonjeani	Univoltine	Egg	August - September	March - July	*Cedrus*
Th. cheela	?	?	?	?	*Cedrus* ?
Th. ispartaensis	?	?	?	?	*Cedrus*
Th. libanotica	Univoltine	Egg	August (rearing)	April - June (rearing)	*Cedrus*
Th. pinivora	Univoltine (south) Biannual (north)	Egg (south), Egg + Pupa (north)	July - August	March - July	*Pinus*
Th. sedirica	?	?	?	?	*Cedrus*

3.3. Key to the identification of the moths of Thaumetopoea genus, with special reference to the 'summer' feeding species

1	Canthus convex and smooth	to *solitaria* group
-	Canthus with teeth	2
2	Patter of forewing greyish	3
-	Patter of forewing brownish or whitish	4
3	*Male w*ith dark fasciae on forewings without yellowish edge; *Female w*ith anal scales upper than 2 mm of length or with scales not pointed to proximal part	to *pityocampa* group
-	*Male* with dark fasciae on forewings with yellowish edge; *Female* with anal scales lower than 2 mm of length or with scales pointed to proximal part	to *pinivora* group (5)
4	Forewing with discal spot	*herculeana*
-	Forewing without discal spot	to *jordana* group
5	Ante-median fasciae and post-median of forewing much more converged on termen than costa; Discontinued basal fasciae	*pinivora*
-	Ante-median fasciae and post-median of forewing are equidistant or divergent on termen and costa; Discontinued basal fasciae	6
6	Ante-median fasciae and post- median of forewing are equidistant on termen and costa;	*bonjeani*
-	Ante-median fasciae and post-median of forewing are more divergent on termen than costa;	7
7	With a strong acute angle on ante-median and post-median fasciae on forewing	*libanotica*
-	Without a strong acute angle on ante-median and post-median fasciae on forewing	8
8	Basal fasciae on forewing probably reduced to some point; discal spot with white edge	*cheela*
-	Basal fasciae on forewing well developed; discal spot without white edge	*ispartaensis*/*sedirica*

4. Discussion

The analysis of morphological traits and available data from the literature has identified several similarities between the species considered in this study. Most obvious similarity is based on the wing bands, as all species have 3 thin, dark bands, in basal, ante-median and post-media positions, and they have yellow-whitish edge. Basal fascia is bordered on both internal and external sides; this fascia is discontinuous, often also in *Th. pinivora*. Ante-median fascia is bordered on the external side while the post-median fascia is on the internal site. Moreover a pre-apical spot, more or less marked, is often present. Hindwing has an anal spot, that is visible, although vaguely, also in *Th. ispartaensis*. In fresh specimens probably it could be more marked. Canthus has always teeth, more or less serrated, generally smaller than that of *Th. pityocampa*. Toothed canthus is also present in *Th. cheela*, to give further support to the relatedness of the species to this group. Another important trait could be the shape and pigmentation of the scales used to cover the egg batches; in fact, they are wide and similar in *Th. pinivora*, *Th. ispartaensis* and *Th. sedirica*; while they are narrower and longer in *Th. bonjeani*. Also the analysis of the male genitalia has identified many similarities, especially in the valvae and their apical process but also in fultura that it is pentagonal and similar in *Th. pinivora* and *Th. libanotica*; and it is hexagonal and similar in *Th. ispartaensis* and *Th. bonjeani*. Uncus is small and rounded and aedeagus is generally broader basally and curved, both with a similar shape, although they change in size.

These traits, in addition to those on biology and behavior of larvae, has allowed us to hypothesize that also *Th. cheela* has the same behavior and habits of the other summer *Thaumetopoea*. To further support this hypothesis, we overlapped the collection sites of the specimens and the geographic distribution of *Cedrus deodara* and *Pinus* spp. (*P. gerardiana*, *P. roxburghii* and *P. wallichiana*) (Critchfield and Little, 1966; Vidakovic, 1982), in order to estimate a possible matching with host plant. As both *Cedrus* and *Pinus* occur in the area where the specimens of *Th. cheela* were collected, we cannot conclude about which one is more likely to be the host plant of this species. Unfortunately, micro-scale data about the sites is not available and the issue can be solved only with new collections, possibly of larvae that have to be searched on these host plants.

In addition, the analysis of specimens of *Th. ispartaensis* and *Th. sedirica* has not revealed substantial differences on wing ground color, or on the fasciae inclination. The traits used in the key by Doganlar et al. (2005) did not allow to unambiguously discriminating female scales (Figure 2).

As most of the summer *Thaumetopoea* are associated with *Cedrus*, we compared *Cedrus* phylogeny provided by Qiao et al. (2007) with phylogeny analysis developed by Simonato et al. (2013) for *Thaumetopoea*, to investigate the evolutionary history of this group in relation to their host plants, as suggested by Wahlberg et al. (2013). Qiao et al. (2007) state that *C. deodara* was the first species to diverge from the common ancestor, and then the split concerned *C. atlantica, C. libani*, and *C. brevifolia*. With a molecular clock they estimate that the split between *Cedrus deodara* and the others occurred about 60 Mya (millions years ago); *C. atlantica* from North Africa split about 20 Mya and the separation between *C. libani* and *C. brevifolia* occurred 6-7 Mya. Combining data obtained from Simonato et al. (2013) with sequences available in Genbank, a multiple alignment including the mitochondrial genes *cox1*, *cox2*, and *atp6* was then used for dating the split events among *Thaumetopoea* species. The substitution rate was set to 0.00022 according to (Gaunt and Miles, 2002). Calculations were performed using Beast 1.8.0 software (Drummond et al., 2012). The results obtained from this analysis show that the separation between the summer and the winter *Thaumetopoea* happened about 16.3 Mya (95% HDP interval: 8 to 25). Moreover, the first split in the summer clade between *Th. ispartaensis*/*Th. libanotica* and *Th. bonjeani*/*Th. pinivora* is dated at about 5.5 Mya (95% HPD interval 2.8 to 8.6). The further splits between *Th. pinivora*/*Th. bonjeani* and between *Th. ispartaensis*/*Th. libanotica* occurred about 2.7 Mya (95% HDP interval: 1.2 to 4.4) and about 2.6 Mya (95% HDP interval: 1.2 to 4.2), respectively. As *Th. cheela is* missing from the analysis, we cannot conclude about its possible association with *Cedrus deodara*. Split of the summer clade follows that of *Cedrus atlantica* from the other *Cedrus,* and could be somewhat linked to it. It seems in general that insect species have split later than their host plants, with one of them (*Th. pinivora*) associated with *Pinus* and separated from the sister species *Th. bonjeani* much after the separation of *Cedrus atlantica* from the other *Cedrus*.

Although these results indicate that more studies have to be made, especially for the poorly known species, there are some evidences that *Cedrus* could be the host on which most of speciation in the summer clade has happened. Research should be focused on finding new material on which morphological characters of both adults and larvae have to be tested, together with biological and ecological traits. Moreover, molecular data from this material could complement the evolutionary history and define the phylogenetic relationships within the *Thaumetopoea s.l.*

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Preliminary results of the shape analysis of pine processionary moth scales in Turkey

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Abstract: Larvae of the two pine processionary moth (PPM) sister species, *Thaumetopoea wilkinsoni* and *T. pityocampa*, causes severe allergies in mammals and are dangerous defoliators of Mediterranean pines. While *T. pityocampa* occurs mainly in Europe, *T. wilkinsoni* occurs in Turkey and the Middle East. Recent studies showed that ranges of the two species are in contact in Turkey. Female moths of the two species cover their eggs with scales on their abdomens. These scales are believed to protect eggs from parasitism. Although *T. wilkinsoni* and *T. pityocampa* exhibit highly similar morphologies, few studies have suggested that scale morphology could be used for species identification. However, our field observations in Turkey do not confirm this suggestion. Nevertheless, statistical approaches have never been used on this issue. In this study, we aimed at solving this contradiction by digitizing PPM scale shape photographs taken standardly from 60 individuals collected from different locations in Turkey and Cyprus and by subjecting them to geometric morphometry approaches. We conducted shape analysis by using TPS software and Elliptic Fourier Outline Analysis which is a sensitive method for morphometric computations. Results did not reveal any correlation between scale morphology and species taxonomy. This result could be interpreted as an insufficiency of scale morphology being able to be used as a taxonomic character to separate *T. wilkinsoni* and *T. pityocampa* in Turkey. However, it should be kept in mind that these two species have a contact zone in Turkey, which might cause hybridization. This phenomenon could completely change morphological patterns. In order to reach more accurate results, this study should be repeated with samples from the entire ranges of the two species.

Keywords. *Thaumetopoea wilkinsoni*, *T. pityocampa*, Scale, Shape analysis, Geometric morphometry, Turkey

Türkiye’deki çam kese böceği pullarının şekil analizinin ilk sonuçları

Özet: İki çam kese böceği (ÇKB) türü olan *Thaumetopoea wilkinsoni* ve *T. pityocampa*’nın larvaları memelilerde ciddi alerjik reaksiyonlara neden olmakla kalmaz, aynı zamanda Akdeniz çamlarının da önemli zararlılarıdır. *T. pityocampa* daha ziyade Avrupa’da, *T. wilkinsoni* ise Türkiye ve Orta Doğu’da yayılış gösterir. Yakın zamanlarda yapılan çalışmalar iki türün yayılış alanlarının Türkiye’de kesiştiğini göstermiştir. Dişi güveler yumurtalarını abdomenlerinde bulunan pullarla örter. Bu pulların yumurtaları parazitoidlerden koruduğu düşünülmektedir. Her ne kadar *T. wilkinsoni* ve *T. pityocampa* morfolojik olarak birbirine çok benzese de birkaç çalışmada pul morfolojisinin tür ayrımında kullanabileceği öne sürülmüştür. Ancak arazi gözlemlerimiz bu iddiayı desteklememektedir. Bununla birlikte bu konu ile ilgili olarak şimdiye kadar herhangi bir istatistiksel çalışma yapılmamıştır. Bu çalışmada konuya ilişkin sorulara cevap aramak amacıyla Türkiye ve Kıbrıs’ta farklı alanlardan toplanan 60 bireye ait fotoğraflanmış pullar dijitalleştirilerek geometrik morfometri yaklaşımlarıyla incelenmiştir. TPS yazılımı kullanılarak şekil analizi ve morfometrik hesaplamalarda kullanılan hassas bir yöntem olan Eliptik Fourier Anahat Analizi yapılmıştır. Sonuçlar pul morfolojisi ile tür taksonomisi arasında herhangi bir uyum göstermemiştir. Bu sonuç pul morfolojisinin Türkiye’de yayılış gösteren *T. wilkinsoni* ve *T. pityocampa*’yı birbirinden ayırt etmeye yetecek bir taksonomik karakter olmadığı şeklinde yorumlanabilir. Ancak bu iki türün Türkiye’de melezleşme ile sonuçlanabilecek bir temas kuşağının bulunduğu unutulmamalıdır. Bu durum morfolojik örüntüleri önemli ölçüde değişikliğe uğratmış olabilir. Daha doğru sonuçlara ulaşmak için bu çalışma her iki türün de tüm yayılış alanlarını kapsayacak şekilde genişletilmelidir.

Anahtar kelimeler: *Thaumetopoea wilkinsoni*, *T. pityocampa*, Pul, Şekil analizi, Geometrik morfometri, Türkiye

1. Introduction

The pine processionary moth (hereafter PPM) species, *Thaumetopoea wilkinsoni* (in Turkey and the Middle East) and *T. pityocampa* (Europe and north Africa) (Lepidoptera, Notodontidae) are the most important defoliators of pine in the Mediterranean Basin (Carus, 2004; Masutti and Battisti, 1990) and their larval setae cause severe allergic reactions in mammals (Denis and Schiffermüller, 1776; Rodríguez-Mahillo et al., 2012; Vega et al., 1997). These two species’ ranges contact in northwestern Turkey and studies show

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evidences for hybridization (İpekdal, 2012; İpekdal et al., 2015).

PPM is a univoltine organism. Its gregarious larvae feed on the pine host during the winter, descend to the soil in spring for pupation, and adults fly in late summer or early autumn depending mostly to latitude and altitude; and females lay their eggs on pine needles immediately after mating (Avcı and Oğurlu, 2002; Avcı, 2000; Démolin, 1969; Halperin, 1990). Female moth covers its oviposited eggs with the scales on its abdomen. These scales probably protect the eggs from parasitoids and desiccation (Avcı, 2000; Floater, 1998, Mirchev et al., 2004, Özkazanç, 2002, Schmidt, 1990).

T. wilkinsoni and *T. pityocampa* exhibit highly similar morphologies, but few studies have suggested that scale morphology could be used for species identification (Doğanlar et al., 2005; Tsnakov et al., 1991). Although our field observations do not confirm this suggestion (İpekdal, 2012) statistical approaches have never been used so far to solve this ambiguity.

In this study we aimed to quantify shapes of the scales collected from different localities in Turkey and Cyprus. This study is the first attempt to investigate scale morphology statistically and to reveal its suitability as a taxonomic character. Our results did not reveal any correlation between scale morphology and species taxonomy.

2. Material and methods

We collected 60 PPM egg batches from 13 localities in Turkey and one in Cyprus. According to İpekdal (2012) 45 of them were identified as *T. wilkinsoni*, 12 as hybrids, and 3 as *T. pityocampa*. We picked off 20 scales per egg batch and fixed them on microscope glasses by using Entellan (Merck). We took photographs of the fixed scale preparations under a Leica DC300-MZ75 digital dissection microscope at Hacettepe Uni. Dept. of Biology and Ecological Sciences Research Lab. by using a magnification of 0.32 and scaling of 1mm. Then the two-dimensional outline of the scale was digitized. The starting point of the outline was defined at the peak point of the scale (Figure 1).

For each scale, 64 points at equally spaced intervals along the outline were sampled using TpsDig2 (Rohlf, 2010). This set of x, y-coordinates was then analysed using an Elliptical Fourier Analysis (EFA) using the software EFAwin (Ferson et al., 1985). This method is based on separate Fourier decompositions of the incremental changes along x and y as a function of the cumulative length along the outline (Kuhl and Giardina, 1982). The outline is approximated by a sum of trigonometric functions of decreasing wavelength: the harmonics. Any harmonic corresponds to four coefficients: A_n and B_n for x, and C_n and D_n for y, defining an ellipse in the xy-plane.

The first ellipse corresponds to the best-fitting ellipse to the outline. Its major axis was taken as new x-axis to adjust the orientation of the outline (Rohlf, 1990). Its area was used to standardize the Fourier coefficients (FCs) for size differences in order to eliminate isometric size effects and to concentrate on shape information only. Since the coefficients A_1, B_1 and C_1 correspond to residuals after standardization (Crampton, 1995; Renaud et al., 1996) they were not included in the subsequent statistical analysis. The coefficient D_1 still retains information about the elongation of the outline (Michaux et al., 2007). It was thus included in the statistical analyses.

In order to evaluate the adequate threshold harmonic for the analysis of PPM scale, the shape of one UM1 was measured ten times, providing an estimate of the measurement error for each harmonic (Figure 2). Measurement error was estimated as the percentage of error for the amplitude (square root of the sum of the squared FCs). In our case, measurement error was low (<5%) until the fifth harmonics and abruptly increased thereafter (Figure 2). The content of information of each harmonic provided information about the amount of shape information provided by that harmonic (Crampton, 1995). The amplitude of each harmonic wass cumulated over the total range of harmonics, and the information brought by each harmonic wass then estimated as the percentage of this sum represented by its harmonic. Each of the five first harmonics increased significantly the amount of shape information up to 97.07% of the total information (Figure 2). The plateau reached afterwards showed that the subsequent harmonics brought almost no further relevant shape information. Hence, considering the set of the first five harmonics appeared as a good compromise between measurement error, information content, and the number of variables to be considered. A data set of 17 variables (20 FCs minus A_1, B_1 and C_1) was thus retained for subsequent analyses.

Statistical analyses: Principal component analysis (PCA) was performed on the set of 17 FCs in order to test differences between the two species *T. wilkinsoni* and *T. pityocampa*. All statistical analyses were performed by using SYSTAT v.11.

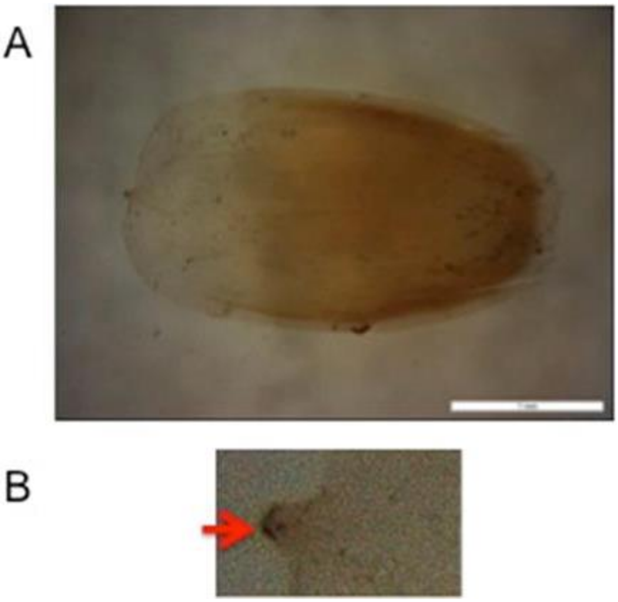

Figure 1. Scale of pine processionary moths (a), starting point of digitization of outline analysis on a scale (b)

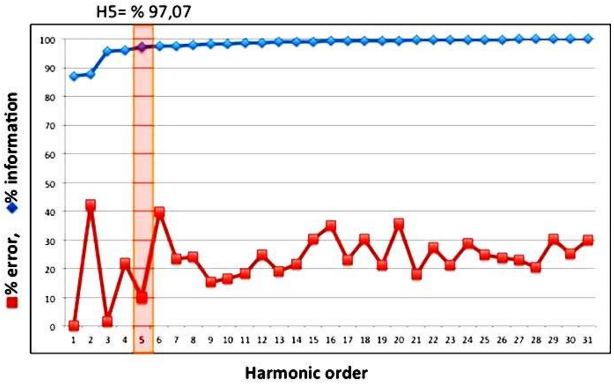

Figure 2. Measurement error (red squares below) and cumulative power (blue diamonds above) as a function of the harmonic order for the elliptic Fourier transform of PPM scale

3. Results and discussion

The first axes of principal component (PC1), based on 17 variables came from elliptic fourier outline analysis of scale measurements, accounted for 94.6% of the total morphometric variation and seemed to express the overall shape of the scale with the populations of *T. wilkinsoni* and *T. pityocampa* and their hybrids.

Our results did not reveal any significant correlation between scale morphology and taxonomy. However, we found a slight differentiation between *T. wilkinsoni* and *T. pityocampa* on the first axis of PCA (Figure 3); yet it is not enough to seperate the two PPM species and their hybrids. Thus we can conclude that scale morphology is an insufficient character to be used for seperating *T. wilkinsoni* and *T. pityocampa* in Turkey. However, it should be kept in mind that these two species have a contact zone in Turkey. Hybridization could completely change morphological patterns. Furthermore, our sampling size could cause biased results. Therefore, in oreder to reach more accurate results, this study should be repeated with a larger sampling size from the entire ranges of the two species.

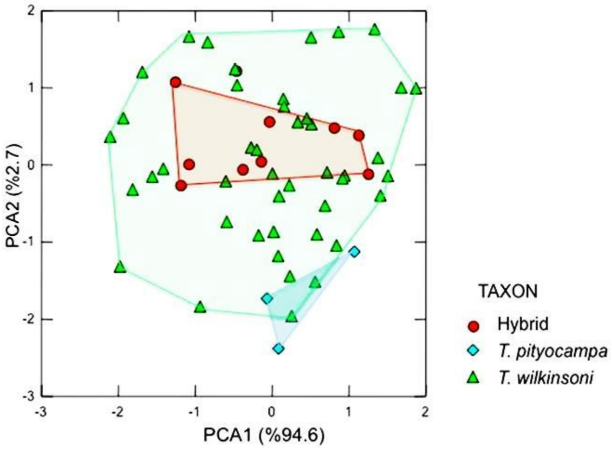

Figure 3. Shape variation of the three different groups of PPM scale in Turkey and Cyprus, displayed on the first two axes of a PCA on the Fourier coefficients

Acknowledgements

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Contribution to the bio-ecology of *Acrobasis consociella* (Hübner, 1813) (Pyralidae, Phycitinae) in Tunisia

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Abstract: *Q. coccifera* is the characteristic species present in the north-eastern forest (Jebel Abderrahmane) and the north-western forest (Sejnane). At the end of April of 2005, a complete defoliation of more than 500 ha of evergreen shrubs of Jebel Abderrahmane caused by larvae of *Orgyia trigotephras* was observed. At the beginning of April 2010, a severe defoliation of a shrub-forest was noted in Sejnane, where about 2500 ha of the forest were defoliated by larvae of *O. trigotephras*. However, on defoliated *Halimium halimifolium* trees we found in addition to larvae and pupae of *O. trigotephras*, larvae and pupae of *Anacampsis scintillella*. In March 2012, pupae of *Acrobasis consociella* were observed on *Q. coccifera* in Jebel Abderrahmane and Sejnane to compete with *O. trigotephras*. Preliminary investigations of bioecology of *A. consociella* were carried out in the two forests. To estimate host plant infestations', a direct counting was carried out on the host plant, yielding a mean number of shelters of 5.80 shelters for *A. consociella* and 0.24 for *O. trigotephras* at the two sites. About 30 shelters of *A. consociella* from *Q. coccifera* were collected to be analyzed in the lab. The mean number of larvae was 0.59 at Sejnane and 0.93 at Jebel Abderrahmane. Results show that the life cycle of *A. consociella* took 10 weeks. First instar larvae were observed in the beginning of February. Pupa was observed in mid-March, and it took about 3 weeks to become adult; the first adult was observed in the beginning of April. Life history of *A. consociella* was poorly studied, so far. In this paper, we present a contribution of its biological cycle, although further investigations must be done to deepen the knowledge of this pest.

Keywords: *Acrobasis consociella, Orgyia trigotephras, Quercus coccifera,* Tunisia

Tunus'ta *Acrobasis consociella* (Hübner, 1813) (Pyralidae, Phycitinae)'in biyo-ekolojisine katkılar

Özet: *Q. coccifera* kuzeydoğu (Jebel Abderrahmane) ve kuzeybatı (Sejnane) ormanlarının mevcut karakteristik bir türüdür. 2005 yılı nisan ayının sonunda Jebel Abderrahmane yöresinde *Orgyia trigotephras* larvaları tarafından 500 hektardan daha fazla herdem yeşil çalılarda yaygın bir zarar gözlenmiştir. Nisan 2010 başlarında Sejnane'de yaklaşık 2500 hektar orman alanında *O. trigotephras* larvalarının neden olduğu ciddi bir zarar kaydedilmiştir. Bununla beraber zarar gören *Halimium halimifolium* ağaçlarnda *O. trigotephras* larva ve pupalarına ek olarak *Anacampsis scintillella*'nın larva ve pupalarına rastlanmıştır. Mart 2012'de *Acrobasis consociella*'nın pupaları *O. trigotephras* ile rekabet içinde olduğu görülmüştür. *A. consociella*'nın biyoekolojisine dair ilk araştırmalar, bu iki ormanda gerçekleştirilmiştir. Konukçu bitki istilalarını tahmin etmek amacıyla, konukçu bitki üzerinde doğrudan sayım yapılmış ve sonuç olarak her iki bölgede *A. consociella* için ortalama 5.80 yuva ve *O. trigotephras* içinse 0.24 yuva tespit edilmiştir. *Q. coccifera* üzerinden yaklaşık 30 adet *A. consociella* yuvası laboratuvarda incelenmek üzere toplanmıştır. Ortalama larva sayısı Sejnane'de 0.59, Jebel Abderrahmane'de ise 0.93 olarak tespit edilmiştir. Sonuçlar, *A. consociella*'nın yaşam döngüsünün 10 hafta sürdüğünü göstermiştir. Birinci dönem larvalar, şubat ayının başlarında gözlenmiştir. Pupa ise mart ayının ortalarında gözlemlenmiş ve yaklaşık 3 hafta içerisinde ergin döneme geçmiştir; ilk ergin böcekler nisan ayının başlarında gözlenmiştir. *A. consociella*'nın yaşam döngüsü şu ana kadar çok fazla araştırılmamıştır. Bu çalışmada, bu türün biyolojik döngüsünün katkısı sunulmaktadır ancak bu zararlı hakkında daha fazla bilgi elde etmek için başka araştırmalar yapılmalıdır

Anahtar kelimeler: *Acrobasis consociella, Orgyia trigotephras, Quercus coccifera,* Tunus

1. Introduction

Mediterranean oak forests are characterized by the presence of deciduous oaks (deciduous oak forests) and evergreen oaks (sclerophyllous oaks) (Hasnaoui, 1992). *Quercus* genus includes 500 species (El Toubi, 1996). In Tunisia, it's represented by five species: *Q. suber*, *Q. ilex*, *Q. canariensis*, *Q. afares* and *Q. coccifera* (Hasnaoui, 1992). *Q. coccifera* is the characteristic species present in the north-eastern forest (Jebel Abderrahmane) and the north-

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western forest (Sejnane). At the end of April of 2005, a complete defoliation of more than 500 ha of evergreen shrubs of Jebel Abderrahmane (2500 ha): *Q. coccifera*, *Pistacia lentiscus*, *Erica arborea* and *E. multiflora* caused by larvae of *Orgyia trigotephras* (Eribidae, Lymantriinae) was observed (Ezzine *et al*., 2010). At the beginning of April 2010, a severe defoliation of a shrub-forest was noted in Sejnane, where about 2500 ha from 3200 ha of the totality of the forest were defoliated by larvae of *O. trigotephras*. Defoliated shrub species were: *Halimium halimifolium*, *Q. coccifera*, *P. lentiscus*, *E. arborea* and *E. multiflora*. However, on defoliated *H. halimifolium* trees we found in addition to larvae and pupae of *O. trigotephras*, larvae and pupae of *Anacampsis scintillella* (Gelechiidae, Anacampsinae) (Ezzine et al., 2015). In March 2012, pupae of *Acrobasis consociella* (Pyralidae, Phycitinae) were observed on *Q. coccifera* in Jebel Abderrahmane and Sejnane to compete with *O. trigotephras*.

A. consociella is known from nearly all the European countries (Karsholt and Razowski, 1996), including Corsica, Sardinia and Sicily in the Mediterranean (Speidel, 1996). In North Africa known from Tunisia, Algeria (Lucas, 1914) and Morocco (Asselbergs, 1998). *A. consociella* feeds on *Quercus* (Capek and van Achterberg, 1992; Shaw *et al*., 2011; Huertas Dionisio, 2009; Mészáros, 1972). On *Q. cerris* and *Quercus petrae* (Csóka, 1991), on *Q. cerris* (Rossnev *et al*., 2009), on *Q. suber* (Huertas Dionisio, 2009). Larvae are gregarious (Perette *et al*., 2009), lives among *Quercus* host leaves spinning and attached with silk, containing 1to 4 larvae (Shaw *et al*., 2011) and build a very characteristic galleries (Huertas Dionisio, 2009). Life history of *A. consociella* has not been studied comprehensively in Tunisia, so far. In this work we aim at (1) investigating the bio-ecology of *A. consociella*, (2) studying competition between *A. consociella* and *O. trigotephras* and (3) determining the influence of infestation on host plant.

2. Material and methods

2.1. Study area

The study area includes Mediterranean maquis, distributed along the coast between north-western (Bizerte, site of Sejnane) and north-eastern Tunisia (Cap Bon, site of Jebel Abderrahmane). Investigations were done in only one infested station in Sejnane: Barrage Ziatine (48 m, 37°11´N, 9°11´E) and four infested stations in Cap Bon-Jebel Abderrahmane: Ftahiz (121 m, 36°.52’ N, 10°.45’ E), Jebel Ben Oulid (432 m, 36°52'N, 10°48'E), Delhiza (401 m, 36°51'N 10°47'E) and Guitoun (136 m, 36°.83’ N, 10°.82’ E) (Figure 1). We opted for a systematic sampling, materialized by two orthogonal transect lines (Nsibi *et al*., 2006). Each transect consisted of 12 plots, about 300 m long each, spaced 50 m. The plot was square shaped ($25\ m^2$) (Wikum and Frederick Shanholtzer, 1978). Vegetation was composed by Mediterranean maquis with shrubby vegetation, about 1-2 m high; main species were *Calicotome villosa* Poiret, *Cistus crispus* L., *Cistus monspeliensis* L, *E. arborea* and *E. multiflora*, *P. lentiscus*, *Phillyrea media* L. and *Q. coccifera*.

Figure 1. Study sites

2.2. Host plant infestation

In March 2014, in each plot, we identified and counted shrubby vegetation species. The plant preference of *A. consociella* and *O. trigotephras* for oviposition was evaluated in a field survey by counting the number of shelters on each *Q. coccifera* tree present in the study site.

2.3. Larvae development

Larvae of *A. consociella* feed gregariously in spun leaves of *Q. Coccifera.* In February, March and April 2014, 30 spun leaves, were collected and placed in plastic boxes (21 × 10 × 10 cm) at a temperature of 25°C. Under a binocular microscope (Leica, S42), 20x magnification, we observed and counted the number of larvae in each spun leaves. Each larva was individually collected, described and measured.

2.4. Statistical analysis

To compare the infestation by *O. trigotephras* and *A. consociella*, and the female fecundity of *A. consociella*, we used ANOVA and Student-Newman-Keuls test (5%). Statistical treatment of the data was performed using the software SPSS (Version 17.0). Body size is reported as mean ± standard deviation.

3. Results

3.1. *A. consociella* and *O. trigotephras* oviposition

The presence and absence of each defoliator on *Q. coccifera* was summarized in table 1. The number of shelters was significantly higher for *A. consociella* at sites ($p < 0.000$). It differed significantly among stations for *A. consociella* ($p < 0.01$) while it did not for *O. trigotephras* ($p < 0.319$). The mean shelters numbers’ of *A. consociella* and *O. trigotephras* at the two sites were 5.80 and 0.24. For *A. consociella*, the mean number was 1.72 at Sejnane and 21.05 at Jebel Abderrahmane. For *O. trigotephras* the mean number was consecutively 0.2 and 0.42 (Figure 2).

Table 1. Presence/absence of *A. consociella* and *O. trigotephras* on *Q. coccifera* from 2010 to 2014

Site	2010/2011/2012		2013/2014	
	O. trigotephras	*A. consociella*	*O. trigotephras*	*A. consociella*
Cap Bon-Jebel Abderrahmane	1	0	1	1
Bizerte-Sejnane	1	1	1	1

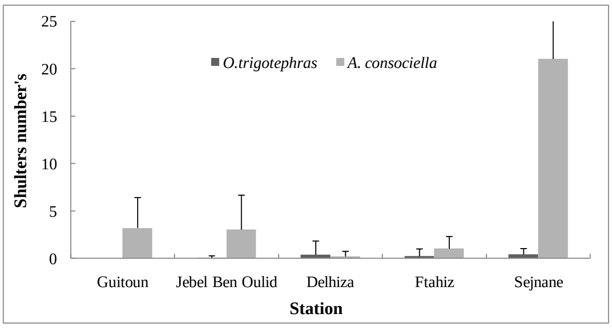

Figure 2. Host plant infestation in each station

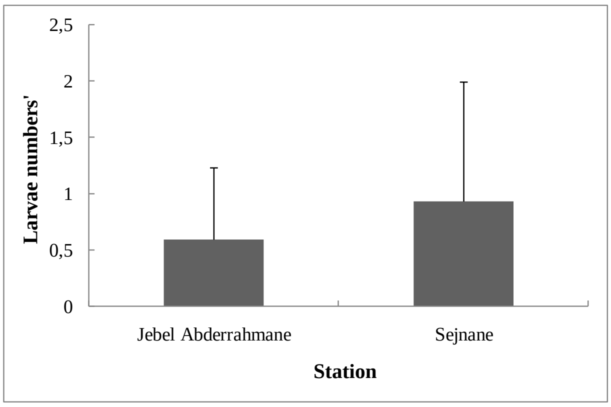

Figure 3. Number of *A. consociella* larvae in spun leaves of *Q. coccifera* at each station

3.2. Larvae and pupae

Figure 4. Larvae of *A. consociella*; a. first instar larvae, b. second instar larvae, c. third instar larvae

3.3. Life cycle of A. consociella

In the study area *A. consociella* had univoltine life cycle (one generation a year), which took 10 weeks. First instar larvae were observed in the beginning of February. Pupa was observed in mid-March, and it took about 3 weeks to become adult; the first adult was observed in the beginning of April.

4. Discussion

In the literature *A. consociella* is reported to have one generation a year, with the larva feeding during February (Huertas Dionisio, 2009), Mai (ISF, 2006), being full fed towards the end of the month or beginning of July, and from the July (Huertas Dionisio, 2009) to August (Perette *et al.*, 2009) the adult appears. In Tunisia, larvae were observed from mid-February to the beginning of April. This period coincides with the emergence of larvae of *O. trigotephras* (Ezzine *et al*., 2010). In 2010, in Sejnane, *O. trigotephras* was found in higher abundance, mainly feeding on shrub species: *H. halimifolium*, *Cistus sp.*, *Q. coccifera*, *P. lentiscus*, *Erica arborea* and *E. multiflora*. In this ecosystem only *A. scintillella* was found to compete in numbers on *H. halimifolium* with *O. trigotephras*. A lack of competitors may have favoured the higher abundance of *O. trigotephras* in this ecosystem (Ezzine *et al*., 2014) and the damage of *A. scintillella* seemed to be weak. From 2012 to 2014, the situation has changed, in addition to *O. trigotephras*, *A. consociella* was observed not only in the North-west but also in the North East and it competed on *Q. coccifera* with *O. trigotephras*. First instar larvae of *O. trigotephras* feeds on fresh foliage of *Q. coccifera* (Ezzine *et al.*, 2010). If fresh foliage is attacked by *A. scintillella*, neonate larvae of *Orgyia* will die by starvation. The competition between *O. trigotephras* and *A. consociella* for the same part of the host plant will influence the dynamic of competitors, and in our case it has negatively affected *Orgyia* dynamics. Infestation by *A. consociella* and larvae numbers' in each shelter were correlated, leading to two groups, one homogenous group of Jebel Abderrahmane (Ftahiz, Jebel Ben Oulid, Delhiza and Guitoun), and a second group in Sejnane. This result confirms that the outbreak site of *A. consociella* is Sejnane, may depend on the quantity of host plant foliage. The presence of *A. scintillella* in Jebel Abderrahmane is lower compared to Sejnane and it can be explained by the decrease of the *O. trigotephras* population in these sites (Ezzine, pers. observ.), due to the cyclic outbreaks of *O. trigotephras* (Ezzine *et al*., 2010).

This work is a contribution to the life history of *A. consociella* in Tunisia and it opens the way to future studies on the influence of temperature on its dynamic.

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2016, 17(Special Issue): 48-50 | Research article (Araştırma makalesi)

Some biological aspects of *Virachola livia* on *Acacia farnesiana* in the South of Tunisia

Rym Mkaouar[a,*], Samir Dhahri[a], Mohamed Lahbib Ben Jamaa[a]

Abstract: The pomegranate butterfly *Virachola livia* constitutes a severe pest to the pomegranate in Tunisia, since its record in 2006. However, *V. livia* was found to breed not only in the pomegranate but also in the pods of *Acacia farnesiana* which is a very common plant in Gabes region (South-East of Tunisia). This study which was carried out in Metwia (the most infested area in Gabes) from April to July 2013, aims to clarify some biological aspects of *V. livia* on *A. farnesiana* such as: fly of adults, egg laying, larva development, pupae and number of generation. Randomized samples of green Acacia pods were collected weekly from different trees of *A. farnesiana*. In the lab, pods were examined under a binocular to detect eggs, after pods were desiccated to count larva stage and pupae. The monitoring of adults activity and emergence were made by experimental apparatus both in the field and the laboratory. The preliminary results show that *A. farnesiana* is the main and primary host plant of *V. livia* in South Tunisia. On *A. farnesiana* this pest develops three annual generations, each one lasts about four weeks. The first generation starts late in April and finished in the end of May. The second one is from the end of May to about the twenty five of the next month; the third is from the last one to the middle of July. Due to the absence of green pods on the tree from July, the butterfly migrates to its alternative host the pomegranate.
Keywords: *Virachola livia*, *Acacia farnesiana*, Bioecology, Tunisia

Güney Tunus'ta *Acacia farnesiana* üzerinde yaşayan *Virachola livia'*nın bazı biyolojik özellikleri

Özet: Nar kelebeği *Virachola livia*, 2006 yılında ilk kez kaydedildiği zamandan bu yana Tunus'ta narlar için çok zararlı bir böcek olmuştur. Ancak, *V. livia'nın* sadece nardan değil aynı zamanda Gabes bölgesinde (Tunus'un Güneydoğusu) çok yaygın bir bitki türü olan *Acacia farnesiana*'nın tohumlarında da beslendiği tespit edilmiştir. Nisan ve Temmuz 2013 arasında Metwia bölgesinde (Gabes'te en çok istila edilen bölge) gerçekleştirilen bu çalışmanın amacı, *A. farnesiana* ile beslenen *V. livia* böceklerinin ergin uçuşu, yumurtlama, larva gelişimi, pupa ve nesil sayısı gibi bazı biyolojik özelliklerini açıklığa kavuşturmaktır. *A. farnesiana* türünde yer alan farklı yeşil Akasya ağaçlarının tohumlarından haftalık olarak rasgele örnekler alınmıştır. Larvaları ve pupa evresini saymak için tohumlar kurutulduktan sonra yumurtaları belirlemek üzere laboratuvarda binoküler ile incelenmiştir. Ergin böceklerin aktivitesi ve çıkışı, hem sahada hem de laboratuvarda deney aleti ile izlenmiştir. İlk sonuçlar, *A. farnesiana*'nın Güney Tunus'ta *V. livia* için ana ve birincil konukçu bitki olduğunu göstermektedir. Bu böcekler *A. farnesiana* üzerinde üç senelik nesil geliştirmektedir ve her senelik nesil yaklaşık dört hafta sürmektedir. İlk nesil nisan ayının sonlarında başlayıp mayıs ayının sonunda ömrünü tamamlamaktadır. İkinci nesil, mayıs sonlarında başlayıp bir sonraki ayın yirmi beşinci gününe kadar sürmektedir. Üçüncü nesil ise en son aydan başlayıp temmuz ortasına kadar devam etmektedir. Temmuz itibariyle ağaçlarda yeşil tohum zarfları olmadığı için, kelebekler alternatif konukçu olan nar bitkilerine göç etmektedir.
Anahtar kelimeler: *Virachola livia*, *Acacia farnesiana*, Biyo-ekoloji, Tunus

1. Introduction

The pomegranate butterfly *Virachola livia* constitutes a severe pest to the pomegranate in Tunisia, since its record in 2006. However, *V. livia* was found to breed not only in the pomegranate but also in the pods of *Acacia farnesiana* which is a very common plant in Gabes region (South-East of Tunisia). The genus *Acacia* is one of the most useful types for the economy because it plays an important role in soil science, agriculture, reforestation and farming. In southern Tunisia, several species of Acacias, including *Acacia farnesiana* have been planted since the 60s as windbreaks around irrigated pomegranate.

However, many questions remain raised, both on the migration of the pest *V. livia* from *Acacia* to the pomegranate, both biology and the understanding of the involvement of Acacias in outbreaks of the pest and the considerable decrease in pomegranate production. In a previous work, we show that *Acacia farnesiana* is considered the secondary host of *V. livia (Mkaouar et al*

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2013). In this work, we aim to clarify some biological aspects of *V. livia* on *A. farnesiana* such as: fly of adults, egg laying, larva development, pupae and number of generation.

2. Material and methods

2.1. Studied localities (Figure 1)

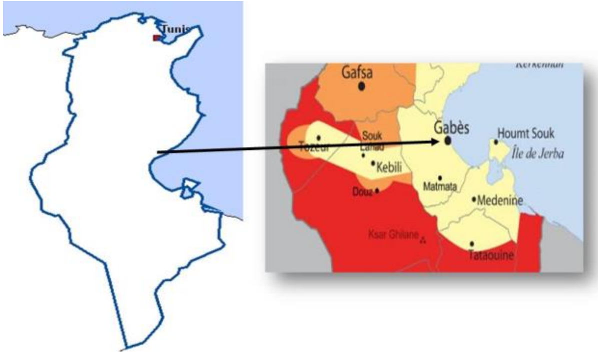

Figure 1. Prospection sites (Gabes region)

2.2. Experimental protocols

Our study was carried out in South of Tunisia, in Metwia (the most infested area in Gabes) from April to July 2013. Green pods from *A. farnesiana* were collected weekly separately placed in plastic bags. In the lab, pods were examined under a binocular to detect eggs, after pods were desiccated to count larva stage and pupae (Figure 2). The monitoring of adults activity and emergence were made by experimental apparatus both in the field and the laboratory. Green pods were carried out at room temperature (20-25°C) for one week and stored until adult emergence. The specimen were stored in alcohol 95% in Eppendorf safe-lock tubes and stored at -4° C.

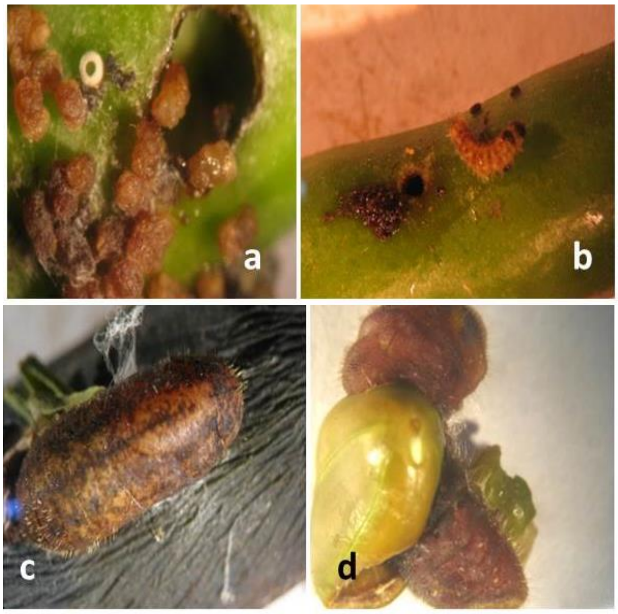

Figure 2. Different development stage of *Virachola livia* on Acacia (a: egs; b: young larvae; c: pupae; d: old larvae)

3. Results and discussion

The occurrence of three distinct peaks of *V. livia* in Acacia pods for both preoviposition period and adult emergence (Figure 3).

In Tunisia, on *A. farnesiana V. livia* develops three annual generations, each one lasts about four weeks (Figure 3). The first generation starts late in April and finished at the end of May. The second one is from the end of May to about the twenty five of the next month; the third is from the last one to the middle of July (Figure 3). However, in the Middle East, on *Acacia* sp., this pest can develop between six and eight generations (Avidov, 1958; Awadallah, 1966). Infestation of pomegranate starts at about the end of the third generation, and owing to the dryness of acacia pods (Figure 4) starting from about the end of July, the butterflies migrate to pomegranate.

No infestation with *Virachola* appeared on promegranate fruit before September. When acacia pods got dry, the butterflies were forced to lay their eggs on pomegranate. Infestation continued till the fruiting season came to the end and the green pods of Acacia showed up and the butterflies moved to the alternative host once again. A similar cycle was mentioned by Hanna (1939) in Egypt and Avidov (1958) in Palestine. Due to the absence of green pods on the tree from July, the butterfly (Figure 5) migrates to its alternative host the pomegranate.

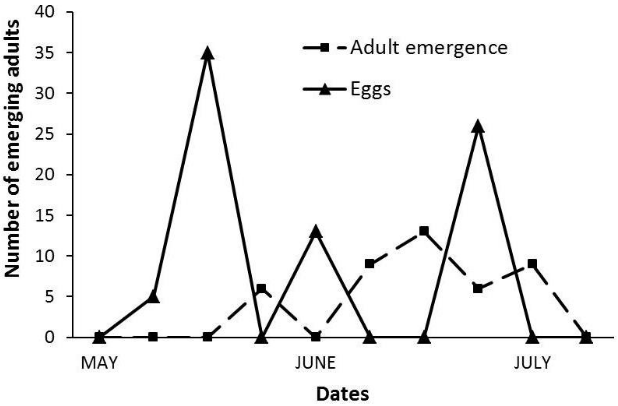

Figure 3. The population dynamics of *Virachola livia* on *Acacia farnesiana*

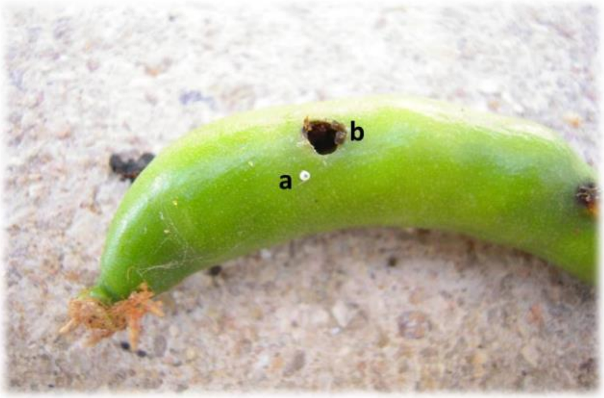

Figure 4. *Virachola livia* egg (a) and entrance hole of larva (b) on Acacia green pod

Figure 5. *Virachola livia* adult

4. Conclusion

In this work, some biological aspects of *V. livia* on *A. farnesiana* were clarified for the first time in North Africa and in Tunisia. Preliminary biological cycle is assessed regarding host plant and peaks of adult emergence in Metwia region. More observations on pomegranate and date palm are planned to fulfill the complete cycle per year and for a better management of the pest in the future.

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2016, 17(Special Issue): 51-57 | Research article (Araştırma makalesi)

Influence de l'attaque des Carpophages sur les métabolites des glands du chêne-liège (*Quercus suber)*

Yasmine Adjami[a], Rym Ghanem[a,*], Hiba Daas[a], Mohamed Laid Ouakid[a], Juli Pujade-Villar[b], Abdelmadjid Bairi[a]

Résumé : La manutention de la régénération naturelle des subéraies reste une préoccupation majeure des forestiers en Algérie. Face à la dégradation de l'état sanitaire des forêts algériennes, il est urgent de la penser autrement. La glandée est affectée par cette dégradation, démontrant un faible rendement et une vulnérabilité marquée, face aux attaques d'insectes Carpophages, qui perturbent la régularité et l'abondance de la glandée. Pour cette étude on a dosé des métabolites (glucides et lipides) sur les différentes catégories des glands (sains et attaqués). Ce dosage est complété par une analyse chimique des différents extraits des glands par chromatographie en phase gazeuse / spectrométrie de masse. Le résultat obtenu indique que l'infestation touche le contenu en métabolites des glands plus au niveau de l'amande qu'au niveau du péricarpe. L'analyse chimique des différents extraits des glands par chromatographie en phase gazeuse / spectrométrie de masse a permis d'identifier 18 de composés majeurs appartenant à différentes classes chimiques (aldéhydes, alcools, cétones, acides, hydrocarbures saturés ou insaturés, terpènes, sesquiterpènes, etc.…). La fraction lourde, non volatile, comprend de nombreux sesquiterpènes et hydrocarbures saturés (C_{22} à C_{29}) et des polyphénols en C_{28} et C_{29}.

Mots clés: *Quercus suber*, glands, Carpophages, métabolites, Chromatographie en phase gazeuse / spectrométrie

Influence of carpophagous attack on metabolites of cork oak (*Quercus suber*) acorns

Abstract: Natural regeneration maintenance of cork oak remains a major concern of forest in Algeria. Faced with the deterioration of the health status of the Algerian forests, it is urgent to think otherwise. Acorn is affected by this degradation, showing a low yield and vulnerability to carpophagous attack that disrupt the regularity and abundance of acorns. In this study, metabolites (carbohydrates and lipids) on the different categories of acorns (healthy and attacked) were measured. This assay is completed by a chemical analysis of different extracts acorns by gas chromatography / mass spectrometry. The result indicates that the infestation key content metabolites acorns more at the almond at the level of the pericarp. Chemical analysis of different extracts acorns by gas chromatography / mass spectrometry identify 18 major compounds belonging to different chemical classes (aldehyds, alcohols, ketones, acids, saturated or unsaturated hydrocarbons , terpen , sesquiterpen , etc ....) . Nonvolatile heavy fraction includes many sesquiterpen and saturated hydrocarbons (C22 to C29) and C28 and C29 polyphenols.

Keywords: *Quercus suber* acorns, Carpophages, metabolites, GC / MS

Karpofaj saldırısının mantar meşesi (*Quercus suber*) palamutlarının metabolitleri üzerinde etkisi

Özet: Mantar meşesinin doğal gençleştirme işlemleri, Cezayir'deki ormanlar açısından önemli bir mesele olmaya devam etmektedir. Cezayir ormanlarının sağlık durumunun bozulması nedeniyle, ivedilikle tedbir alınması gerekmektedir. Palamut, bu bozulmadan etkilenerek düşük verime sahip olmakta ve palamutların düzenliliği ve bolluğunu bozan karpofaj saldırısına karşı savunmasız kalmaktadır. Bu çalışmada, metabolitlerlerin (karbonhidrat ve lipitler) farklı kategorideki (sağlıklı ve saldırıya uğramış) palamutlar üzerine etkisi ölçüldü. Bu deney, farklı palamut özütleri gaz kromatografisi/kitle spektrometrisi ile kimyasal analize tabi tutularak tamamlanmıştır. Analiz sonucu, Sonuç olarak istila önemli içerik metabolitleri perikarp seviyesinde badem daha meşe palamudu olduğunu gösterir. Gaz kromatografisi/kitle spektrometrisi ile farklı palamut özütlerine uygulanan kimyasal analiz sonucunda, farklı kimyasal sınıflara ait (aldehitler, alkoller, ketonlar, asitler, doymuş veya doymamış hidrokarbonlar, terpen, seskiterpen vs.) 18 temel bileşik tespit edilmiştir. Uçucu olmayan ağır fraksiyon, çok miktarda seskiterpen, doymuş hidrokarbon (C22 ila C29 arası) ve C28 ile C29 polifenollerini içermektedir.

Anahtar kelimeler: *Quercus suber* meşe palamudu Carpophages, metabolitler, GC / MS

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1. Introduction

Le chêne-liège, (*Quercus suber L.*), constitue une des richesses forestières de l'Algérie. Ses forêts tenaient et tiennent toujours une place primordiale dans la vie socio-économique de la population riveraine et du pays en général. Elles constituent en effet, un terrain de parcours pour un cheptel varié grâce à leur abondance en sous-bois et en glands. (Peyerimhoff, 1941).

Les subéraies algériens sont les écosystèmes les plus fragiles du fait de la pression chaque année de nombreux facteurs. , La dégradation des sols, les incendies, le surpâturage, les maladies fongiques et les attaques d'insectes ravageurs font disparaître des surfaces considérables de chêne vert (*Quercus ilex L*) et surtout de chêne-liège (*Quercus suberL*) (Messaoudène, 2000).

Cependant, un recours à la régénération serait indispensable pour la réhabilitation de ces forêts. Mais cette régénération dépend fortement non seulement de la régularité et de l'abondance des glandées mais aussi de la taille et de l'état phytosanitaire des glands. (Suszka et al, 1994; Merouani et al, 2001). En effet, les glands sont malheureusement régulièrement attaqués par des champignons et des insectes (Bakry et al., 1999; Anderson, 1992; Fukumoto & Kajimura, 2000).

Les insectes jouent un rôle important dans la diminution de la viabilité des glands ils ont une incidence notable sur le potentiel de reproduction du chêne. Les effets directs sur l'alimentation de l'embryon et sur les cotylédons peuvent empêcher la germination des glands. L'effet direct des insectes c'est la consommation de l'embryon ou de l'endommager, qui rend impossible la germination et le développement des plantules (Hirka et Csóka, 2006). Cela est dû surtout à la diminution de certains composés chimiques des glands. Pour étudier ce phénomène, on a évalué la relation entre l'attaque des carpophages des glands du chêne-liège et le contenu des métabolites de ces derniers (glucide, lipides et protéine), ainsi que le contenu des polyphénols par l'extrait des glands avec différents solvants. Une analyse chimique des glands de chêne-liège a été réalisée par chromatographie en phase liquide couplée à la spectrométrie de masse.

2. Matériels et méthodes

Plus de 500 glands de chêne-liège *(Quercus suber)* ont été récoltés au mois d'octobre 2012dans la subéraie d'El-Kala au Nord Est de l'Algérie.

2.1. Dosage des métabolites

Le dosage des métabolites est réalisé au niveau de l'amande et du péricarpe des glands sains et attaqués (1 à 2 trous), la méthode utilisée pour chaque dosage diffère selon le type de métabolite. Le dosage des glucides totaux à été effectué selon la méthode de Duchateau et Florkin (1959), les lipides totaux par la méthode de Goldsworthy et al (1972) et le dosage des protéines a été réalisé par la méthode de Brad Ford (1976).

2.2. Analyse chimique des extraits de glands

L'analyse chimique des glands de chêne-liège a été réalisée par chromatographie en phase liquide couplée à la spectrométrie de masse. Les glands de chêne-liège ont été divisés en 3 lots de 50 glands: le premier lot contenant le péricarpe du gland découpé finement, le deuxième lot contenant l'amande et le troisième lot tout le gland découpé finement. Les trois lots ont étés extraits en utilisant deux types de solvants de polarité différente : le pentane (solvant apolaire) et l'hexane (solvant polaire). Ces solvants ont permis d'extraire majoritairement les composés apolaires (cas du pentane) ou polaires (cas de l'hexane). L'identification des composés a été réalisée par couplage chromatographie en phase gazeuse / spectrométrie de masse (GC/MS) au Laboratoire de Recherche de l'INRA de Dijon (France). Les spectres de masse obtenus ont étés comparés aux spectres de références publiés dans le EPA-NIH Mass Spectral Data Base (Heller et Milne, 1980) et avec ceux de la bibliothèque de spectres de l'INRA Dijon. Pour le dosage de la teneur des polyphénols totaux dans les différents extraits organiques, on a adopté une technique basée sur l'utilisation du réactif de Folin-Ciocalteau.

3. Résultats

Dosage des lipides

Le contenu en lipides des glands du chêne-liège varient en fonction que le gland soit sain, attaqué ou fortement attaqué. Le gland sain présente au niveau de l'amande une teneur d'environ 50 µg/g.MS, cette concentration diminue quand le gland est attaqué et qu'il présente un trou à 22,61± 3,61 µg/g.MS. Lorsque le gland est fortement attaqué, on enregistre une chute des lipides à 6,18± 3,96 µg/g.MS. Il y a une différence significative entre ces 3 moyennes (F=23,12 p=0,0001). Par contre le contenu en lipides dans le péricarpe des glands sains est faible par rapport à l'amande environ 16 µg/g.MS et malgré une légère augmentation de ces concentrations dans les péricarpes des glands attaqués ces moyennes ne sont pas significativement différentes (F=1.06, p=0.8) (Figure 1).

Dosage des glucides

Quand le gland est sain la teneur en glucides au niveau de l'amande est de 3,11 µg/g.MS alors qu'au niveau du péricarpe elle est de 1, 71 µg/g.MS. Ces valeurs diminuent lorsque le gland est attaqué. Au niveau de l'amande des glands attaqués la diminution est non significative (F=1.71, p=0.1) et elle est de 3,07 µg/g.MS et 3,06 µg/g.MS. Concernant le péricarpe cette diminution est significative (F = 10,35, p=0.0005) puisqu'elle atteint 1,1 µg/g.MS et 1,2 µg/g.MS pour les glands fortement attaqués (Figure 2).

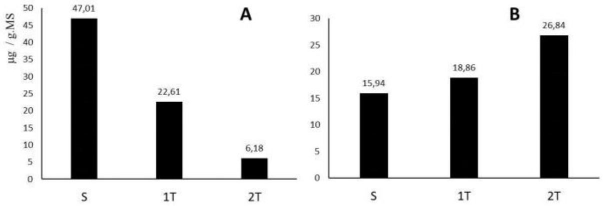

Figure 1. Variations du contenu en lipides des glands sains et attaqués au niveau de l'amande (A) et du péricarpe (B). S : gland sain ; 1T : gland avec 1 trou ; 2T : gland avec 2 trous

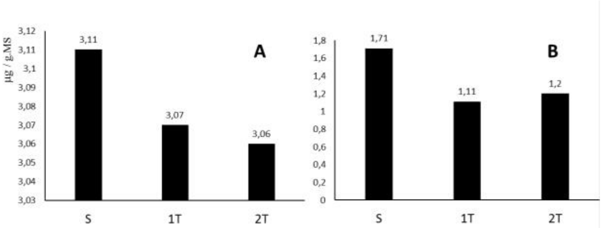

Figure 2. Variations du contenu en glucides des glands sains et attaqués au niveau de l'amande (A) et du péricarpe (B). S : gland sain ; 1T : gland avec 1 trou ; 2T : gland avec 2 trous

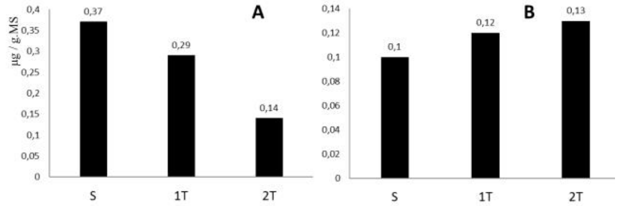

Figure 3. Variations du contenu en protéines des glands sains et attaqués au niveau de l'amande (A) et du péricarpe (B). S : gland sain ; 1T : gland avec 1 trou ; 2T : gland avec 2 trous

Dosage des protéines

Le contenu en protéine de l'amande du gland sain du chêne-liège est de 0,37 ± 0,01 µg/g.MS cette valeur diminue à 0,29 ± 0,03 µg/g.MS quand le gland est attaqué et qu'il présente un seul trou de sortie d'insecte, toutefois cette concentration diminue significativement lorsque le gland est fortement attaqué 0,14 ± 0,05 µg/g.MS (F=16,29 ; p=0,0001). Il semble que l'attaque des insectes n'a pas d'effets sur la teneur en protéines du péricarpe puisque les moyennes enregistrées ne sont pas significativement différentes (Figure 3).

Analyse chimique des extraits

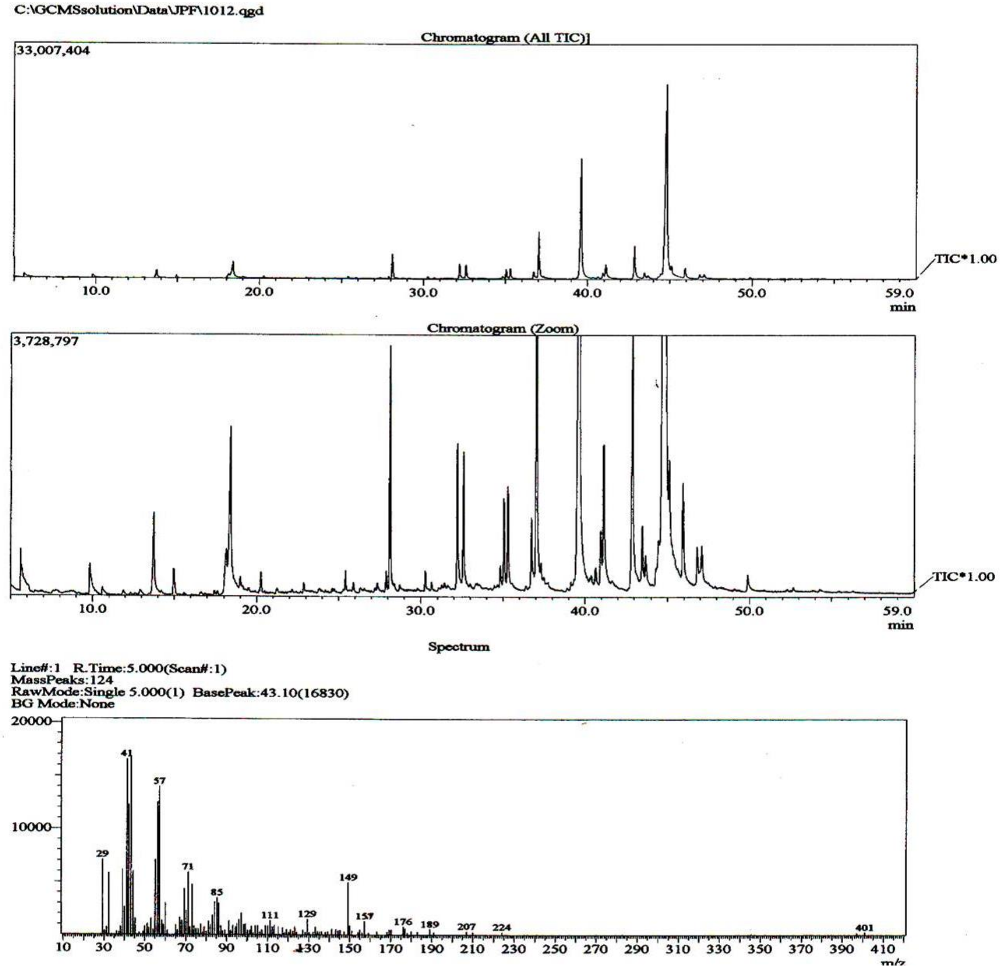

Figure 4. Profil chromatographique et spectre de masse d'un extrait « type » illustrant les composés lourds du péricarpe et des cotylédons des glands du chêne –liège extraits à l'hexane et au pentane

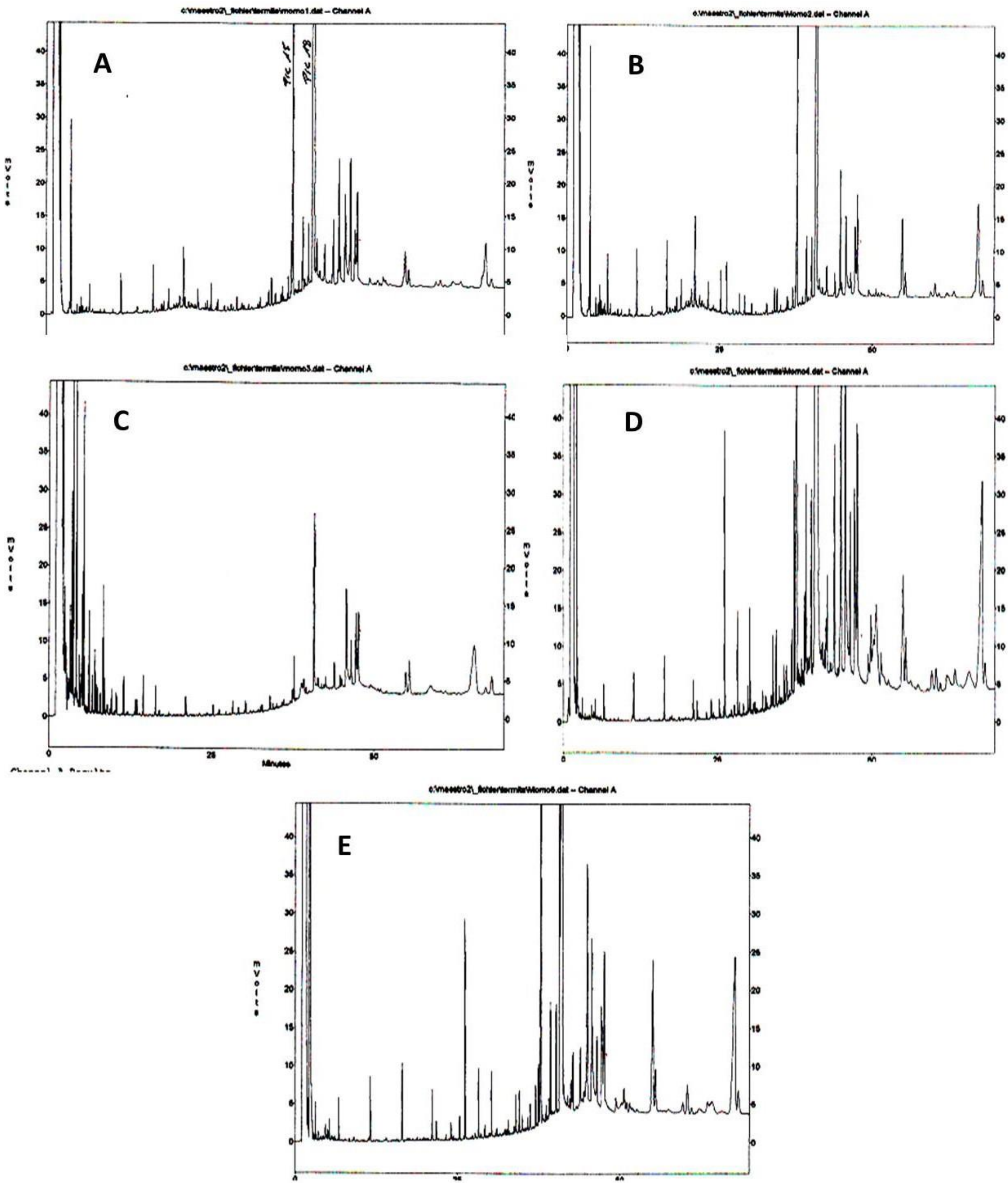

Figure 5. Profil chromatographique du péricarpe et de l'amande d'un gland de chêne-liège extrait par les deux solvants, l'hexane et le pentane. A: Profil chromatographique du péricarpe d'un gland de chêne-liège extrait à l'hexane B: Profil chromatographique d'un gland entier de chêne-liège extrait à l'hexane C: Profil chromatographique de l'amande d'un gland de chêne-liège extrait au pentane D: Profil chromatographique du péricarpe d'un gland de chêne-liège extrait au pentane E: Profil chromatographique d'un gland entier de chêne-liège extrait au pentane

Une cinquantaine de composés divers, en plus ou moins grande concentration, ont pu être détectés dans les différents extraits de glands par les différents types de solvant. Les analyses quantitatives révèlent que l'utilisation du pentane comme solvant permet d'extraire beaucoup plus de composés ces résultats tiennent certainement à la polarité des composés extraits (Figure.4, 5). L'analyse chimique par chromatographie en phase gazeuse / spectrométrie de masse a permis d'identifier 18 composés appartenant à différentes classes chimiques (aldéhydes, alcools, cétones, acides, hydrocarbures saturés ou insaturés, terpènes, sesquiterpènes, etc.…). La fraction lourde, non volatile, comprend de nombreux sesquiterpènes et hydrocarbures saturés (C_{22} à C_{29}) et des polyphénols en C_{28} et C_{29} (Figure. 4 et Tableau. 1). Les extraits au pentane révèlent que les polyphénols sont les composés majoritaires au niveau de l'amande (respectivement 24.37%, 4.78%, 32.67% de la fraction extraite); ces taux diminuent dans le péricarpe et même dans l'extrait du gland entier. En utilisant l'hexane comme solvant, on n'obtient plus que (2.23% et 0.85% et 0.83% au niveau de l'extrait du gland entier). (Tableau 1).

Dosage des polyphénols totaux

La composition phénolique des glands troués de *Quercus suber* extrait par les différents solvants utilisés, est présentée par la Figure 5. La quantité des polyphénols totaux extraite est significativement différente (F= 12.36 p= 0.0001) en fonction du solvant utilisé. C'est l'éthanol qui extrait le plus de polyphénols 154.8 mg GAE/g du poids sec, alors que le chloroforme extrait le moins de polyphénols 44.6 mg GAE/g du poids sec. L'eau et l'acétone extrait environ les mêmes quantités 108 et 111 mg GAE/g du poids sec (Figure. 6).

Tableau 1. Analyse chimique par chromatographie en phase gazeuse / spectrométrie de masse des différents extraits. Concentrations (%) des composés identifiés. HP : Hexane péricarpe ; HGE : Hexane gland entier ; PA : Pentane amande ; PP ; Pentane péricarpe ; PGE ; Pentane gland entier

Composés	Extraits				
	HP	HGE	PA	PP	PGE
Composé C_{18}	0.9	1.95	trace	1.60	Trace
Acide saturé C_{16}	trace	2.48	3.60		0.62
Composé C_{20}	1.80	1.67	trace	0.56	Trace
Acide oleique	trace	2.48	5.74	0.81	3.00
Composé C_{22}	0.8	trace	trace	0.15	Trace
Composé C_{24}	trace	trace	trace	Trace	Trace
Composé C_{25}	3.13	2.10	trace	2.61	Trace
Composé C_{26}	0.8	trace	trace	Trace	Trace
Tetracosanol C_{24}	3.13	2.10	4.64	2.47	1.51
Composé C_{27}	7.70	7.10	2.10	2.97	2.82
Composé C_{28}	1.41	0.90	trace	1.49	1.51
1,2 epoxymonadecane	1.03	12.28	3.18	1.29	8.50
Alcool	3.96	6.45	6.44	0.22	1.13
Composé C_{29}	1.32	1.09	1.23	1.03	1.03
Polyphénol ($C_{28}H_{48}O_2$)	3.37	2.23	24.37	2.77	4.57
Vit E	0.86	0.79	2.15	1.80	1.29
Polyphénol ($C_{28}H_{48}O$)	0.92	0.85	4.78	0.34	9.33
Polyphénol ($C_{29}H_{50}O$)	1.29	0.83	32.67	0.33	1.60

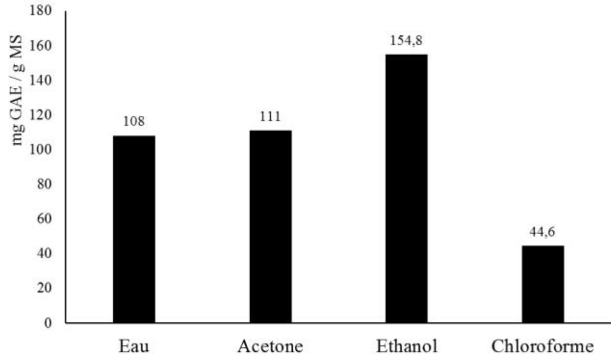

Figure 6. Effet des différents solvants sur le contenu polyphénolique des glands troués de *Quecus suber*. Les valeurs sont exprimées en mg GAE/g du poids sec. (m ± s n=3)

4. Discussion

Le problème de dépérissement dont souffrent actuellement les forêts de chêne-liège dans le pourtour méditerranéen contribue à la régression de l'aire de ces subéraies, ce qui nécessite une régénération de cette essence à partir des glands, mais plusieurs problèmes sont liés à la germination de ces glands tel que l'irrégularité des glandées et les grandes pertes de glands frais, occasionnés avant leur utilisation (desséchement), ainsi que la dormance embryonnaire (Merouani et al., 2001), auxquelles s'ajoutent la déprédation exercée sur les glands par les champignons et les insectes (Crawely et Long, 1995 ; Fuchs et al., 2000). Les dégâts des carpophages des glands peuvent perturber et diminuer la régularité et l'abondance de la glandée, avec des incidences directes sur la capacité germinative et par conséquence sur la régénération naturelle. Ce sont les glands tombés au sol qui sont les plus attaqués comparativement aux glands de l'arbre (Adjami, 2009). Les glands attaqués peuvent germer si l'embryon n'est pas consommé, ils peuvent même donner des plantules qui se développent moins bien que ceux issues des glands sains. (Hirka, 2003). L'importance des attaques des glands par les insectes explique en partie la déficience de la régénération naturelle du chêne-liège observée dans nos forêts. Les insectes évoluant à l'intérieur des glands du Nord Est algérien dans la région d'El-Kala sont des Lépidopères de la famille des Tortricidae (*Cydia fagiglandana* et *Cydia splendana*), et un coléoptère de la famille des Curculionidae *Curculio* sp.**,** ce dernier est un important ravageur des glands de *Quercus* (Bovey et al., 1975, Bellal, 2008, Adjami,2009).

Les glands de chêne-liège sont riches en métabolites surtout quand ils ne sont pas attaqués. Le contenu lipidique est très important surtout au niveau de l'amande, ce contenu diminue de huit fois lorsque les glands sont fortement attaqués. Le péricarpe contient aussi de grandes quantités de lipides qui varient en fonction de l'attaque. A côté d'une richesse en lipides des glands de chêne-liège, les quantités de sucres ne sont pas négligeables, surtout au niveau de l'amande, mais il semble que l'attaque des glands ne perturbe pas le métabolisme glucidique. Les glands sont une source riche d'hydrates de carbone, des acides aminés, des protéines, des lipides et stérols divers. A côté des composants alimentaires, ils contiennent divers composés biologiquement actifs (des tanins, l'acide gallique et ellagique et différents dérivés hexahydroxydiphenoyl) qui possèdent une activité antioxydante. (Cantos et al., 2003; Chiou, 1989; Lee et al.,1992; Rakic´, 2000; Rakic´ et al., 2004; 2006).

Un gland comprend une enveloppe externe ou péricarpe constituée de 5 couches dont la plus importante est la couche ligno-cellulosique, résistante et pouvant atteindre 3,5mm d'épaisseur. A l'intérieur se trouve l'embryon formé par la plantule et les deux cotylédons. L'attaque des glands commence par la destruction de l'embryon par des insectes dont le plus important est le charançon *Balaninus rectus*. En pénétrant dans le gland les insectes y introduisent des micro-organismes qui contribuent à sa décomposition, des champignons en particulier. Au stade suivant l'embryon est totalement détruit par le charançon et par les chenilles des Lépidoptères. (Dajoz, 1980).

L'analyse chimique des glands de chêne-liège par chromatographie en phase gazeuse a permis de mettre en évidence une cinquantaine de composés divers, en plus ou moins grande concentration, détectés dans les différents extraits. Le pourcentage et la concentration de chacun des composés sont variables, non seulement en fonction de la partie du gland extrait, mais également du type de solvant utilisé. Le pentane comme solvant permet d'extraire beaucoup plus de composés appartenant à différentes classes chimiques (aldéhydes, alcools, cétones, acides, hydrocarbures saturés ou insaturés, terpènes, sesquiterpènes, etc.…). Les polyphénols sont les composés majoritaires au niveau de l'amande et diminuent dans le péricarpe et même dans l'extrait du gland entier. Différents solvants ont été employés pour l'extraction de polyphénols des plantes (Pinelo et al., 2004; Hayouni et al., 2007). Le rendement d'extraction dépend du solvant et la méthode d'extraction (Goli *et al* 2004). La méthode d'extraction doit permettre l'extraction complète des composés d'intérêt et doit éviter leur modification chimique (Zuo et al., 2002). Les mélanges aqueux d'ethanol, le méthanol et l'acétone sont généralement employés dans l'extraction des plantes (Sun & Ho, 2005).

Le dosage de la composition phénolique des glands troués de *Q. suber* a permis d'extraire de grandes quantités de polyphénols surtout avec l'éthanol comme solvant, l'eau et l'acétone peuvent aussi extraire des quantités appréciables. Les polyphénols naturels regroupent un vaste ensemble de substances chimiques comprenant au moins un noyau aromatique, et un ou plusieurs groupes hydroxyles, en plus d'autres constituants. Ils peuvent être de simples molécules, comme les acides phénoliques, ou des composés hautement polymérisés comme les tanins. Ces squelettes carbonés de bases sont issus du métabolisme secondaire des plantes, ce qui signifie qu'ils n'exercent pas de fonction directe au niveau des activités fondamentales de l'organisme végétal, comme la croissance ou la reproduction (Goli *et al* 2004).

Le règne végétal offre une large gamme de composés polyphénoliques polaires et apolaires qui sont des antioxydants avec des propriétés redox, leur permettant d'agir comme des donateurs d'hydrogènes (Pietta, 2000). Les nouvelles découvertes de leurs activités biologiques fournissent la base à l'intérêt d'utilisation d'antioxydants naturels et antimicrobiens, comme des outils de lutte biologique contre les insectes nuisibles. Les tanins, un groupe de composés de phenoliques sont connus pour être responsables de la défense des glands contre les insectes et le vertébrés prédateurs (Renard, 1982; Weckerly *et al*, 1989; Steele et al., 1993; Smallwood et al., 2001; Vander le Mur, 2001).

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Natural enemies of *Orgyia trigotephras* (Boisduval 1829) (Lepidoptera, Erebidae, Lymantriinae) in Tunisia

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Abstract: Phytophagous insects may select plants or plant parts not only based upon nutritional content, but also on the intensity of predation and parasitism. This observation leads to the enemy free space hypothesis, which suggests that herbivores select host plants for which the mortality from natural enemies is minimized, by preferring host plants on which the herbivores would be less vulnerable to their natural enemies. In Tunisia, *Orgyia trigotephras* is a polyphagous moth, bivoltine with a spring (SG) and an autumnal (AG) generation. This work was carried out in two sites: Jebel Abderrahmane (Ftahiz, Delhiza and Guitoun) and Bizerte (Sejnane). The aim is to compare the importance of predation by moth larvae (*Coccidiphila rungsella*) and parasitism by egg parasitoids (*Aprostocetus sp.*) on *O. trigotephras* on two host species, *Quercus coccifera* and *Pistacia lentiscus*.

Keywords: *Orgyia trigotephras, Aprostocetus* sp.*, Coccidiphila rungsella, Quercus coccifera, Pistacia lentiscus,* Tunisia

Tunus'ta *Orgyia trigotephras* (Boisduval 1829) (Lepidoptera, Erebidae, Lymantriinae)'ın doğal düşmanları

Özet: Bitki ile beslenen böcekler, sadece besin içeriğine göre değil aynı zamanda avcılık ve parazitlik yoğunluğuna göre bitkileri veya bitkilerin belirli kısımlarını seçebilir. Bu gözlem sonucunda, düşmansız alan hipotezi ortaya atılmıştır. Bu hipoteze göre, otoburlar doğal düşmanlarına karşı daha az savunmasız olabilecekleri konukçu bitkileri tercih ederek doğal düşmanlardan kaynaklanan ölümlerin en az düzeyde olacağı bitkileri seçmektedir. Tunus'ta *Orgyia trigotephras,* ilkbahar nesli (İN) ve sonbahar nesli (SN) ile bivoltin ve polifag bir böcek türüdür. Bu çalışma, iki bölgede gerçekleştirilmiştir: Jebel Abderrahmane (Ftahiz, Delhiza ve Guitoun) ve Bizerte (Sejnane). Bu çalışmanın amacı, Tunus'ta her neslin *Quercus coccifera* ve *Pistacia lentiscus* üzerinde böceğin larvalarının (*Coccidiphila rungsella*) avcılık düzeyi ve *O. trigotephras* yumurta parzitoidlerinin (*Aprostocetus sp.*) parazitlik düzeyinin önemini karşılaştırmaktır.

Anahtar kelimeler: *Orgyia trigotephras, Aprostocetus* sp.*, Coccidiphila rungsella, Quercus coccifera, Pistacia lentiscus,* Tunus

1. Introduction

Phytophagous insects may select plants or plant parts not only based upon nutritional content, but also on the intensity of predation and parasitism. This observation lead to the enemy free space hypothesis, which suggests that herbivores will select host plants for which the mortality from natural enemies will be minimized, by preferring host plants on which the herbivores would be less vulnerable to their natural enemies. *O. trigotephras* is a polyphagous insect. Its abundance varies strongly across regions, from rare and endangered (Dionisio, 2002) to a common defoliator or even to pest status (Villemant and Fraval, 1993; Chakali et al., 2002; Ezzine et al., 2010). *O. trigotephras* is bivoltine, with a spring generation, from April to June and an autumn generation, from October to December (Ezzine et al., 2014). An outbreak of *O. trigotephras* occurred in Tunisia in 2005 and lead to the complete defoliation of more than 500 ha of Jebel Abderrahmane forest (2000 ha) (Ezzine et al., 2010). Egg masses including about 140 eggs are laid in a loose silk net spun between two or three leaves of the host tree (Ezzine et al., 2010).

During the outbreaks, Lepidoptera defoliators cause considerable damage leading to complete defoliation of oak, from which it results in adverse effects on their production and regeneration. Dynamics of these lepidopteran pests is limited by the effect of parasitoids. Each development phase of the life cycle of the insect is preyed by a number of parasitoids or predators (Villemant, 2003), which may be either Hymenoptera or Diptera (Elouard, 2009). In 1989, Villemant reported the presence of four species of Hymenoptera antagonists of *O. trigotephras*: *Cotesia melanoscela* (Ratzeburg) and *Meteorus pulchricorni* (Wesmael), larval parasitoids (Bastaoui, 1983; Dahou, 1984), *Coccygomimus maraguesi* (Schmiedecknecht) and

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Coccygomimus instigator (F.), pupal parasitoids (Villemant, 1989).

No work has been done on the auxiliary fauna of *O. trigotephras* in Tunisia and the Mediterranean basin. In this context, this work aims to study the importance of predation and parasitism of *O. trigotephras* and to better understand the relationship between pest/parasitoid and host plant in the North-east (Jebel Abderrahamane) and the North-west (Sejnane) of Tunisia in 2013.

2. Material and methods

2.1. Study area

This work took place in the north-eastern part of Tunisia (Jebel Abderrahmane, Cap Bon) and the north-western (Sejnane). One infested station in Sejnane (Barrage Ziatine) and four infested stations in Jebel Abderrahmane: Ftahiz, Delhiza and Guitoun (Tableau 1). The vegetation consists of Mediterranean maquis with shrubby vegetation, about 1-2m high. The predominant plant species are *Calicotome villosa* Poiret, *Cistus crispus* L., *Cistus monspeliensis* L, *Erica arborea* and *E. multiflora*, *P. lentiscus*, *Phillyrea media* L. and *Q. coccifera*.

Table 1. Study area

Stations	Altitude	Latitude (N)	Longitude (E)
Ftahiz	121m	36°.52’	10°.45’
Delhiza	401m	36°51'	10°47’
Guitoun	136m	36°,83’	10°,82’
Sejnane	48m	37°11′	9°11’

2.2. Sampling

A total of 30 egg masses were collected from each host species: *Q. coccifera* and *P. lentiscus* on each station and at the end of each generation during 2012 and 2013. Eggs masses were collected by cutting branches with scissors. In the laboratory, each egg mass was placed separately in a tube and was surveyed daily to follow-up the emergence of the natural enemies (parasitoids and predators) and to establish their density. The emerging insects were removed carefully using a brush of fine hair and after a relaxation time of 2 min in the refrigerator they were stored in an Eppendorf tube filled with ethanol (96%).

To identify viable, hatched, preyed, dried and unfertilized eggs we used the method described by Villemant (1993). Firstly, we removed the silky cocoon and then separate the eggs by brushing the egg mass inside a 1 mm mesh sieve to remove the scale layer that separate the eggs. Eggs were then placed in a 9 cm Petri dish and observed under a binocular microscope (Leica, S42). Total number of eggs per egg mass was counted as an estimate of the realized fecundity. Analysis of batches allowed the estimation of the average fertility of the female (the total number of eggs per batch), the rate of parasitism and predation for each batches during both spring and autumnal generations.

2.3. Statistical analysis

The statistical treatment of the data was performed using SPSS (version 17.0) software. For the analysis of female fecundity and the different categories of eggs ANOVA and Student-Newman-Keuls test were used to compare variables at 5%.

3. Results

3.1. Females fecundity

There is a high significant difference of fecundity between generations in each site ($p < 0.01$). Female fecundity is higher in the SG than the AG (Figure 1). A high significant difference was observed between Ftahiz, Delhiza, Guitoun and Sejnane for the SG and the AG ($p < 0.01$). Mean fecundity observed in Sejnane for both generations is more important than Jebel Abderrahmane (Figure 2).

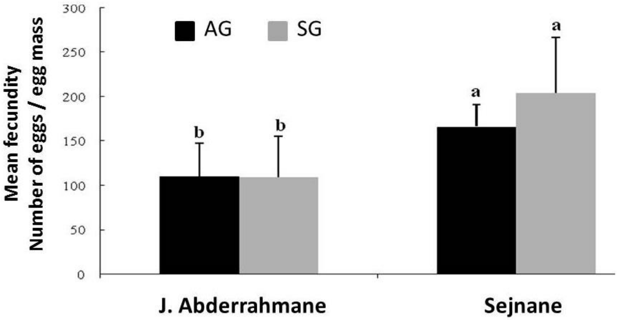

Figure 1. Mean fecundity of *O. trigotephras* for the two generations in both sites.
SG: spring generation; AG: autumnal generation

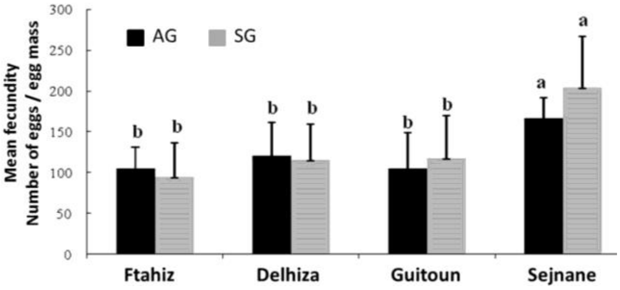

Figure 2. Mean fecundity of *O. trigotephras* for the two generations in the different stations
SG: spring generation; AG: autumnal generation

3.2. Egg mortality

Statistical analysis showed a significant difference ($p<0.01$) between hatched, predated and dried eggs in the two study sites and during the AG and the SG. No significant difference for the parasitized eggs (SG: $p<0.73$ and AG: $p<0.68$) and the unfertilized eggs (AG: $p<0.193$ and SG: $p<0.71$) between the two sites.

3.3. Parasitized and predated eggs

Ezzine et al. (not published) identified only one parasitoid of the genus *Aprostocetus* (Hymenoptera, Eulophidae) and only one predator, the moth *Coccidiphila rungsella* Nel & Brusseaux, 1997 (Cosmopterigidae) from eggs in 2005 and 2009. In this study, we confirmed the occurrence of both species for both spring and autumnal generations. *C. rungsella* was observed in Jebel Abderrahmane and in Sejnane, on *Q. coccifera* and *P. lentiscus* while *Aprostocetus* sp. was observed only in Jebel Abderrahmane, on the two host species.

Predation differed between generations (p<0.000), while parasitism did not (p=0.786). Between all the studied stations, predation and parasitism differed significantly (p<0.000). Although, between host plants, the difference was not significant with p=0.527 for predated eggs and p=0.338 for parasited eggs. Parasitism and predation in Jebel Abderrahmane were higher for both host plants in AG. For the SG, parasitism was important only on *P. lentiscus* (Table 2). However, in Sejnane parasitism was very low on both host plants for the AG, while for the SG, it was observed only on *Q. coccifera* (Table 2). In Ftahiz (AG), *Q. coccifera* was more parasitized than *P. lentiscus*. Whereas, predation was important on both host plants (Table 3). Although in SG, parasitoid and predator were observed only on *P. lentiscus* (Table 3). In Delhiza and Guitoun, parasitism was lower for both generations and both host plants. Yet, predation was important on both stations and host plants (Table 3).

4. Discussion

The difference of the female fecundity between the two generations can be due to the host plant and to the quality of the foliage of the host plant that can affect insect performance. *O.trigotephras* is a oak defoliator (Villemant & Fraval, 1993), young larvae (first and second instars larvae) of the SG feed on the fresh foliage of *Q. coccifera*. Older larvae feed on *P. lentiscus* and other shrub species (Ezzine *et al*, 2010). Young larvae of the AG feed on the fresh foliage of *E. arborea* and *P. lentiscus*. Older larvae feed on *Q. coccifera* (Ezzine *et al*, 2012). In 2005 and 2009, egg batches were found more frequently on *P. lentiscus*. Yet, larval survival, development and adult fecundity were higher when larvae could feed on *Q. coccifera* leaves (Ezzine et al., not published).

Parasitism and predation differs between the two generations, sites, stations and host plants. This difference is may be due the interaction between enemies, eggs and host plants. Ezzine et al. (2010) showed that there's a highly significant difference of parasitized eggs on different host plants: 1.2% on *Q. coccifera* and 0.2% *P. lentiscus*. In fact, some parasitoids or insects are able to attack their host plant at a specific stage of development thereof, usually during the bud break, so they must be present at the phonological stage of the host plant forward or lags behind its development, resulting in a reduced attack in duration or, in extreme cases, impossible (Marçais et al., 2000). While, when insects are specific to one or more host plants, they must develop a system that allows them to quickly find their site of feeding or breeding. At the location of their host plant, insects especially using vision, olfaction and taste for the oviposition (Claude Nicole, 2002). The epidemic development of many parasitoids is strongly influenced by the conditions of temperature and humidity, infection or multiplication (Marçais et al., 2000). The increase in temperature also plays on parasitoids and predators of processions pests (Mattson and Haack, 1987).Their thermal optimum may be different, global warming would sometimes be favorable to insect pests (Fleming and Volney, 1995), sometimes favorable to their natural enemies (Skirvin et al., 1997). The absence of *C. rungsella* in Guitoun can be explained by the difference of the altitude. It is likely that this predator prefers high altitudes (Delhiza) and the exposure to the sun and the sea (Sejnane). Qualitative and quantitative changes in host plants, climatic conditions for each station and even the biology of *O. trigotephras* can influence the success of the enemies. A study done in Morocco by Villemant and Fraval (1992) showed that climate and certain biological characteristics of the species (larval development, larval quiescence or prolonged imaginal) allow egg parasitoids to act during the egg stage of *Lymantria dispar*.

Natural enemy abundance differed between generations, sites and stations. These variations are due primarily to the nature of the host plant which is necessarily correlated to the climatic conditions. In this case, it is important to study the effects of climatic factors on the dynamics of the natural enemies in relation to the outbreak phase of the pest.

Table 2. Parasitism and predation between sites (mean ± SE). SG: spring generation; AG: autumnal generation

Generation	Eggs categories	Host plant	Sites	
			J. Abderrahmane	Sejnane
AG	predated eggs	*Pistacia lentiscus*	9,91±1,71	4,63±1,42
		Quercus coccifera	9,5±2,65	5,4±1,78
	parazited egg	*Pistacia lentiscus*	2,25±0,58	0,34±0,23
		Quercus coccifera	4,56±1,53	0,12±0,11
SG	predated eggs	*Pistacia lentiscus*	4,05±1,01	0
		Quercus coccifera	0,57±0,23	1,53±0,51
	parazited egg	*Pistacia lentiscus*	3,42±0,86	0
		Quercus coccifera	0,84±0,57	0,57±0,37

Table 3. Parasitism and predation among stations (mean ± SE). SG: spring generation; AG: autumnal generation

Generation	Egg categories	Host plant	Stations			
			Ftahiz	Delhiza	Guitoun	Sejnane
AG	predated eggs	*Pistacia lentiscus*	13,42±1,10	9,18±2,35	7,13±1,68	4,63±1,42
		Quercus coccifera	15,22±3,42	5,99±1,69	7,3±2,84	5,4±1,78
	parazited egg	*Pistacia lentiscus*	5,91±0,98	1,55±0,40	0,7±0,37	0,34±0,23
		Quercus coccifera	8,94±2,30	1,76±0,56	2,98±1,74	0,12±0,11
SG	predated eggs	*Pistacia lentiscus*	10,57±2,42	0,78±0,23	0,81±0,37	0
		Quercus coccifera	0	0	1,71±0,69	1,53±0,51
	parazited egg	*Pistacia lentiscus*	7,11±1,46	1,1±0,31	2,07±0,81	0
		Quercus coccifera	0	0	2,54±1,73	0,57±0,37

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The spatial distribution of trees outside forests in a large open-field region and its potential impact on habitat connectivity for forest insects

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Abstract: Forest trees are commonly used for ornamental purposes and are thus frequently encountered in non-forest landscapes where they represent an important component of the so-called trees outside forests (TOF). Little is known about the role of these trees in the connectivity between forest patches and their potential impact upon forest organisms' dispersal. We focused on the tree species belonging to genera *Pinus*, *Cedrus* and *Pseudotsuga*, the potential hosts of the pine processionary moth *Thaumetopoea pityocampa*, a common defoliator in the western Mediterranean basin. We carried out an exhaustive inventory of trees in a 22 × 22 km sampling window located in the Beauce region (France) an agricultural territory where landscapes consist of intensively managed open-fields (mainly dedicated to cereal crops). The results showed that host trees suitable for the PPM are much more numerous than expected, and form small patches scattered across the study area. They are mostly ornamental trees planted in populated places such as villages. We conclude that hosts suitable for the PPM are available throughout agricultural landscapes. Various forest pests may benefit from TOF coverage that forms consistent ecological continuities linking forest areas. It appears that forest health should be addressed in a large context, encompassing non-forested areas, either agricultural lands or urbanized territories that play an overlooked role in large-scale spatial dynamics of forest pests and diseases.
Keywords: Trees outside forest, Spatial point pattern, Landscape connectivity, Pine processionary moth

Orman dışında geniş bir açık tarlada yer alan ağaçların uzamsal dağılımı ve orman böceklerinin habitat bağlantıları üzerindeki etkisi

Özet: Orman ağaçları genellikle süs bitkileri olarak kullanılmaktadır ve dolayısıyla orman dışındaki arazilerde sıklıkla karşılaşılmaktadır. Bu ağaçlar söz konusu arazilerde orman dışındaki ağaçların önemli bir bileşenini temsil etmektedir. Bu ağaçların orman parçaları arasındaki bağlantıdaki rolü ve orman canlılarının dağılımı üzerindeki potansiyel etkileri hakkında çok az bilgi mevcuttur. Batı Akdeniz havzasında yaygın olan yaprak zararlısı tür çam kese böceği *Thaumetopoea pityocampa*'nın potansiyel konukçuları olan *Pinus*, *Cedrus* ve *Pseudotsuga* cinsine ait üç türe odaklandık. Yoğun amenajman çalışmaları yapılan açık tarlaların (ağırlıklı olarak tahıl üretimi yapılan) yer aldığı arazilerden oluşan bir tarımsal bölge olan Beauce bölgesinde (Fransa) 22 x 22 km örneklem penceresinde kapsamlı bir ağaç envanteri hazırladık. Çalışmanın sonuçları, çam kese böceği için uygun olan konukçu ağaçların beklenenden daha fazla sayıda olduğunu ve çalışma alanının tamamına yayılmış küçük parçalar oluşturduğunu göstermiştir. Bu ağaçlar ağırlıklı olarak köy gibi yerleşim yerlerinde dikilen süs ağaçlarıdır. Çam kese böceği için uygun konukçu ağaçların tarımsal arazilerin tamamında mevcut olduğu sonucuna vardık. Çeşitli orman zararlıları, orman alanlarıyla bağlantı sağlayan tutarlı ekolojik devamlılıklar teşkil eden orman dışı ağaçların kapladığı alanlardan faydalanabilir. İster tarım arazisi olsun isterse kentsel bölgeler olsun orman dışı alanların, orman zararlıları ve hastalıklarının geniş ölçekli uzamsal dinamiklerinde oynadığı rol göz ardı edilmiştir, dolayısıyla orman sağlığının orman dışı alanları da kapsayacak şekilde daha geniş bir bağlamda değerlendirilmesi gerekmektedir.
Anahtar kelimeler: Orman dışı ağaçlar, Uzaysal nokta deseni, Arazi bağlantısı, Çam kese böceği

1. Introduction

Forest trees are commonly used for ornamental purposes and are thus frequently encountered in non-forest landscapes where they represent an important component of the so-called trees outside forests (TOF). TOF are defined as "trees on land not defined as forest and other wooded land" (Kleinn, 2000). There is a growing recognition that TOF provide various valuable benefits and services such as their contribution to biodiversity conservation or their recreational value in urban and peri-urban landscapes (Manning et al., 2006; Roy et al., 2012). Nevertheless, TOFs may also play a key-role in pest dissemination and expansion by creating ecological continuities between forest patches. This phenomenon may be of importance since urban areas are major points of entry for invasive species

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whilst urban forests and TOF connect these areas to natural or planted forests. Ludicrously, TOF role as element of ecological continuities with regard to forest pest dispersal has not received much attention so far, possibly because they are generally absent from forest inventories. The present study was designed to finely assess the spatial distribution of TOF across agricultural landscapes and to determine if they constitute ecological continuities for a forest insect, the pine processionary moth (PPM) *Thaumetopoea pityocampa.* The PPM is one of the main defoliating forest pests in the Mediterranean area. Recent studies showed that its range is currently expanding northward due to climate warming. This recent expansion did not appear to be affected by the presence of very large open-field areas such as the Beauce region one of France's most productive agricultural areas, where trees are considered relictual. We designed a field survey with the aim of mapping all the TOF that could be suitable host for the PPM and evaluating their impact in terms of ecological continuities with regard to the pest dispersal.

2. Material and methods

2.1. Study site and field sampling

The survey was carried out in a 22 × 22 km = 484 km^2 area located in the north of the Centre region of France (Figure 1). The landscape mostly comprised wide arable lands (cereal) (Rousselet et al., 2013). All TOF belonging to the genera *Pinus*, *Cedrus* and *Pseudotsuga* were considered as potential hosts of the PPM and are thereafter referred to as HTOF. We conducted an exhaustive sampling by visiting all carriageable paths and roads in autumn and winter 2009–2010, a period during which sighting and identification of PPM host trees (coniferous species) is easier because deciduous trees have lost their leaves. We observed and geolocalized every individual or small group of host trees (single trees, linear groups of trees, trees in linear features or along roads and small woodlands). Observation was done from the public space by eye and with binoculars when necessary.

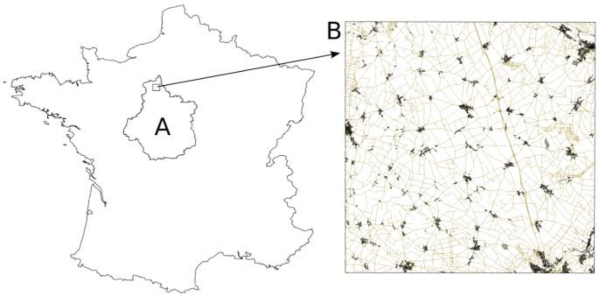

Figure 1. Sampling plot. A. The survey was carried out in the Région Centre in France. B. The sampling plot consisted in a 22 × 22 km window where an exhaustive inventory of HTOF was performed. The landscape mostly comprised wide arable lands (cereal) with scattered villages. The figure illustration shows the distribution of the buildings and the roads in the sampling area

2.2. Data analyses

The field data formed a spatial point pattern. We performed exploratory analysis using the Ripley's reduced second moment function K(r) (Ripley, 1981). A test based on 1000 simulations of complete spatial randomness (CSR) was carried out in order to discriminate between random, aggregated and regular point patterns.

A map of HTOF density was derived from the kernel smoothed intensity function of the observed point pattern (Diggle, 2003) and expressed in tree per ha. All computations were carried out using the R language (R Core Team, 2014) and the R package spatstat (Baddeley and Turner, 2005).

3. Results and discussion

A total of 3831 HTOF were recorded corresponding to 0.078 occurrences per ha. The observed point pattern is shown in Figure 2. HTOF appeared to be distributed in the form of small patches scattered across the sampling window. The Ripley’s K function (Figure 3) indicated a patchy distribution with Ripley’s K index well above the 97.5% quantile computed from the CSR simulations. The map derived from the kernel smoothed intensity is given in Figure 4. It strongly conveyed the spatial distribution of HTOF patches. Small patches of HTOF are scattered across the whole survey window and comparing Fig 1B, Figure 2 and Figure 4 indicated that HTOF were located close to buildings. Our results clearly indicated that HTOF were distributed in the form of small spatial aggregates. These structures appeared to be associated with the buildings where people plant ornamental trees. Although this pattern is not surprising, the virtue of our survey is to provide a quantitative overview of the phenomenon. Interestingly, there were patches of HTOF scattered throughout the study plot and the consequence in terms of PPM dispersal is very important. Even in an open-field agricultural landscape, ornamental trees form a dense network of small patches covering fairly homogeneously the whole area. Such network thus constitutes an important element of ecological continuity with regard to the PPM as well as other forest pests, either vertebrate, invertebrate or plant disease. More research is needed to explore the potential implications of these findings in terms of management. These could imply recommendations regarding the ornamental species to be used and ultimately policies. The idea that emerges is that forest health should be addressed in a large context encompassing non-forested areas, either agricultural lands or urbanized territories because they play an overlooked role in large-scale spatial dynamics of forest pests and diseases.

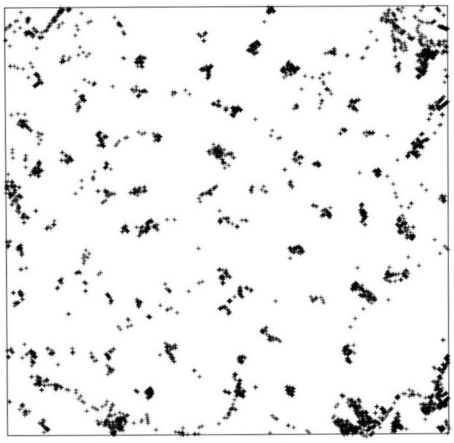

Figure 2. Observed spatial point pattern of HTOF in the Beauce region. A total of 3831 trees were georeferenced

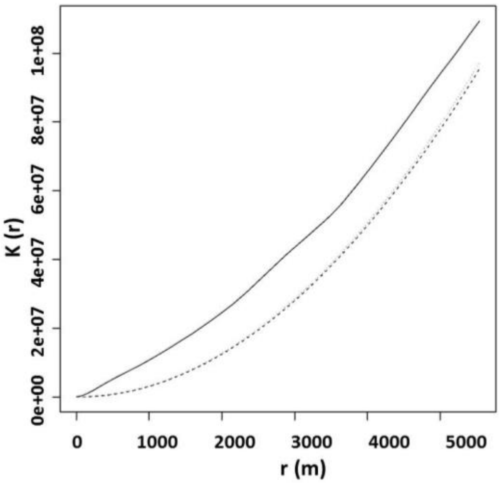

Figure 3. Ripley's K function for the observed HTOF. Dotted and dashed lines stand for 97.5% and 2.5% envelopes corresponding to complete spatial random point patterns

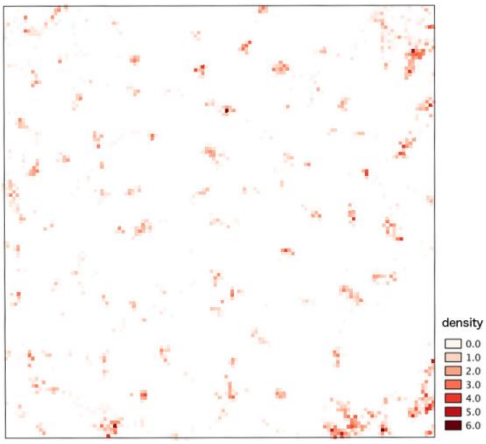

Figure 4. Kernel smoothed density for HTOF. The values are expressed in number of HTOF per ha

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Monochamus galloprovincialis distribution in Aleppo pine forests in Tunisia

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Abstract: The pine wilt disease, caused by the pine wood nematode (PWN) *Bursaphelenchus xylophilus*, was detected in Europe in 1999 in Portugal and the longhorn beetle *Monochamus galloprovincialis* reported as the only vector since 2001. Although not present in northern Africa, it is feared that the PWN may cause significant damage if introduced into the Maghreb region, where several susceptible pine species which can serve as hosts are found, along with insects of the *Monochamus* genus which can act as vectors. In order to assess the risk of propagation of the wilt disease, we surveyed for the presence of possible vectors of the *Monochamus* genus in Tunisia, characterizing the distribution and emergence pattern. Studies were carried in nine locations with Aleppo pine (*Pinus halepensis*) forests. Sampling for insects was based on the trap tree technique, allowing beetles to lay eggs in the field and subsequently emerging. We confirmed the presence of *Monochamus* beetles in Tunisia, with only one species detected, *M. galloprovincialis*, which was widespread in the Aleppo pine forests. Our results show that this specie can develop and emerge from the basal, median and the upper part of the Aleppo pines with similar success. The larval development took nearly one year and adult emergences occurred from May to August during 2012. Results are discussed in view of similar biological studies conducted in other Mediterranean countries and the implications for the risk assessment of pine wilt disease in Tunisia.

Keywords: Pine sawyer, *Pinus halepensis*, Emergence, Xylophagous beetle, Pine wilt disease

Monochamus galloprovincialis'in Tunus'taki Halep çamı ormanlarında yayılışı

Özet: Çam odun nematodu *Bursaphelenchus xylophilus*'un yol açtığı çam solgunluk hastalığı, Avrupa'da 1999 yılında Portekiz'de tespit edildi ve teke böceği *Monochamus galloprovincialis* 2001 yılından bu yana tek vektör olarak bildirildi. Kuzey Afrika'da var olmasa da nematodun, konukçu olarak kullanılabilecek çeşitli hassas çam türlerinin yer aldığı Mağreb bölgesine girmesi halinde, *Monochamus* cinsinin vektör olarak hareket edebilecek böcekleriyle birlikte önemli bir hasara yol açmasından korkulmaktadır. Solgunluk hastalığının yayılma riskini değerlendirmek amacıyla, Tunus'ta yayılış ve çıkış özelliklerini belirleyerek *Monochamus* cinsindeki olası vektörlerin varlığını araştırdık. Çalışmalar Halep çamı (*Pinus halepensis*) ormanlarında dokuz bölgede gerçekleştirilmiştir. Tuzak ağaç tekniğiyle böcek örnekleri toplanmıştır ve böylelikle böcekler bu sahada yumurtlamış ve ardından çıkmıştır. Tunus'ta *Monochamus* cinsinden sadece tek bir türün varlığını, Halep çamı ormanlarında yaygın olan *M. galloprovincialis* türünü tespit ettik. Sonuçlarımız, bu türün Halep çamlarının taban, orta ve üst kısımlarında benzer başarı oranlarıyla gelişebileceğini ve çıkabileceğini göstermektedir. Larva gelişimi yaklaşık bir yıl sürmektedir ve erginlerin çıkışı 2010 yılında Mayıs ve Ağustos ayları arasında gerçekleşmiştir. Sonuçlar, diğer Akdeniz ülkelerinde yürütülen benzer biyolojik çalışmalar ışığında ve Tunus'ta çam solgunluk hastalığının risk değerlendirmesinin olası sonuçları açısından değerlendirilmiştir.

Anahtar kelimeler: Çam odun zararlısı, *Pinus halepensis*, Çıkış, Oduncul böcek, Çam solgunluk hastalığı

1. Introduction

In Tunisia, Aleppo pine (*Pinus halepensis*) is the most common pine specie, covering almost 54% of the forested area (DGF, 2010). Despite its importance, it is characterised by serious regeneration constrains, mainly because of anthropic pressure and over-exploitation. It is also suffering from attacks by various insect pests, namely bark and wood borers such as *Tomicus destruens*, *Orthotomicus erosus* and *Pityogenes calcaratus* (Ben Jamâa, 2007), but also from new invasive pests (Ben Jamâa et al., 2013), which are implicated explicitly or implicitly in the pine forests decline. The pine wood nematode (PWN) *Bursaphelenchus xylophilus*, and its vectors of *Monochamus* genus are nowadays among the most feared invasive pests in Europe and northern Africa, as these two agents are able to wilt and kill several susceptible species of pines (Mota et Vieira, 2010). In Europe, the nematode and its vector have been

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studied in detail since the introduction of the PWN in 1999, and the most important features of the insect's bio-ecology and its interaction with the nematode are now well known (Naves et al., 2006, 2007, 2008; Akbulut et Stamps, 2011). The same cannot be said for the southern side of the Mediterranean sea, as with the exception of isolated notes on the presence of *M. galloprovincialis* in Northern Africa, including Tunisia (Hellrigl, 1971), no detailed studies have been conducted until now, despite the serious risk to this area due to the widespread presence of pine hosts, vectors and significant commercial trade of wood with countries where the nematode is already present. In this paper we begin to characterize the presence of the pine sawyer *M. galloprovincialis* in Tunisia, its distribution in the Aleppo pine forests and its emergence pattern.

2. Materials and methods

The study was carried out in nine representative Aleppo pine (*Pinus halepensis*) forests in Tunisia (Table 1), belonging to the humid, subhumid, semi arid and arid superior bioclimate. The survey of *Monochamus* was conducted with the trap tree technique. Two healthy pine trees were cut at 20 cm from its base in each site from July to august 2011 and left in the field to allow the oviposition of beetles. The whole trees were kept on the soil at a shaded place. The two trees are distant with about 10 m in each forest.

After 43 days, three logs of 1m of length were taken from each tree in each forest. One log from the base, one from the medium and the last one's from the upper part of each tree (N= 54 logs), and taken to the INRGREF Entomological Laboratory in Tunis, where they were kept separately in an insect-proof bags under natural conditions. Indeed, the INRGREF station is belonging to the semi arid bio-climate. In this station, the average of the annual temperature reach the 18.1°C (T° min: 4.9°C; T° max: 36.5°C) and the precipitation didn't exceed the 500 mm (Auge et Francelet, 1970).

All the logs stored in the INRGREF station were weekly monitored until September 2012. Emerging adult insects were collected, counted, identified and conserved in alcohol (95%). Insect identification was made at the Entomological Laboratories of INRGREF in Tunisia and of INIAV in Portugal, using several keys (Picard, 1929; Vives, 2000). Voucher specimens are kept in the INRGREF entomological collection in Tunis, Tunisia.

Kruskal–Wallis nonparametric analysis of variance test was used to compare the mean number of emerged beetles between localities, bioclimates and tree sections, with $\alpha = 0,05$. Statistical procedures were performed using the SPSS software.

Table 1. Location of the Aleppo pine (Ap) forests studied in Tunisia. Sp – Stone pine (*Pinus pinea*), Mp – Maritime pine (*Pinus pinaster*)

Districts	Forests	GPS coordinates	Bioclimate Classification (CNEA, 2007)	Stands nature	Pines species
Bizerte	Azib	N37°12,862'; E09°58,332'	Humid	Mixed	Ap, Sp , Mp
Jendouba	Dar fatma	N36°49,090'; E08°44,795'	Humid	Mixed	Ap, Sp , Mp
Nabeul	Oued Bir	N36°53,354'; E10°47,896'	Subhumid	Mixed	Ap, Sp
	Darchichou	N36°57,725'; E10°59,514'	Subhumid	Mixed	Ap, Sp
Zaghouan	Sidi Aouidet	N36°22,69'; E09°76,450'	Semi-arid	Pure	Ap
Siliana	Sidi Said	N36°11,623'; E09°39,140'	Semi-arid	Pure	Ap
Kef	Kebouche	N36°12,773'; E08°54,566'	Semi-arid	Pure	Ap
Kasserine	Samama	N35°20, 14'; E08°48,320'	Arid superior	Pure	Ap
	Ain Amara	N35°16,41'; E08°30,000'	Arid superior	Pure	Ap

3. Results

3.1. Presence and distribution of the pine sawyer beetles

Figure 1. Adult male of *Monochamus galloprovincialis.* Scale bar = 1 cm

During this study, the presence of *Monochamus galloprovincialis* Olivier 1795 in the Tunisian Aleppo pine (Ap) forests was confirmed (Figure 1), this being the only species of its genus detected. This pine sawyer was found in all sampled localities, from central to northern Tunisia (Figure 2).

The symptoms of the feeding and oviposition of the longhorn beetles on the bark or wood of the felled pines were very conspicuous and clearly noticeable in the field (Figure 3).

Logs of trap-trees from Samama, Central Tunisia, where the most colonized by *M. galloprovincialis*. Indeed, these logs contain almost 39% of the total number of the emerged beetles, followed by Oued Bir and Kebouche forests, each with 16% of the total. Inversely, logs from the Azib and Dar Fatma forests (Northern Tunisia), and belonging to the humid bioclimatic area, had the lowest number of emergences, with just 4% each (Table 2). These variations resulted in significant differences for the mean number of emerged beetles between localities (Kruskal–Wallis test: χ2 =22.2, d.f. =8, p =0.045), and also between the different bioclimatic area (Kruskal–Wallis test: χ2 =6.8, d.f. =3, p =0.077).

The mean number of *M. galloprovincialis* emerging per pine log was 19 adults, with a maximum of 62 in Oued Bir region (Nabeul: Northern Tunisia) and a minimum of 2 in Azib region (Bizerte: Northern Tunisia) (Table 2). Comparing the emergence by tree sections, no significant differences were found on the number of *M. galloprovincialis* from the upper, medium and basal parts of the trap-trees (Kruskal–Wallis test: χ2 =3.31, d.f. =2, p =0.1915), although a slightly higher number of beetles emerged from the middle section of the trees

Figure 2. Tunisian localities were *M. galloprovincialis* was detected (1: Azib; 2: Darchichou; 3: Oued Bir; 4: Dar fatma; 5: Kebouche; 6: Sidi Aouidet; 7: Sidi Said; 8: Samama; 9: Ain Amara)

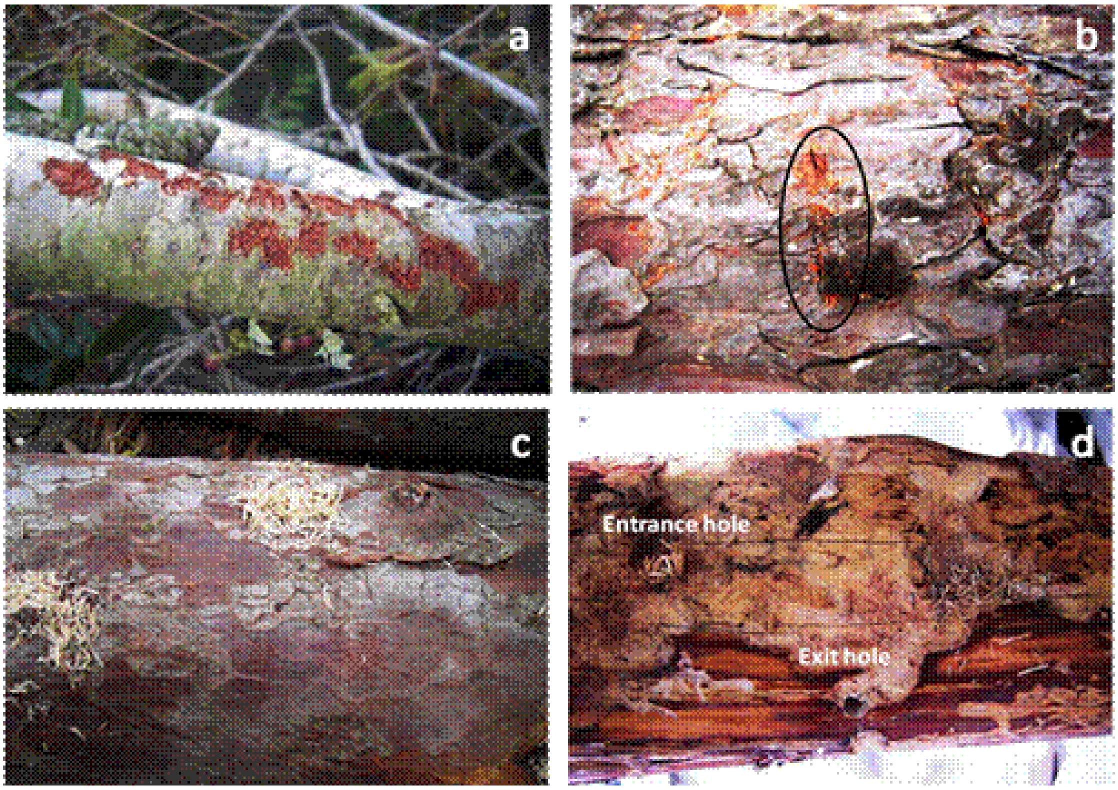

Figure 3. Evidence of *M. galloprovincialis* presence on Aleppo pine (a: nutritional wounds on the bark, b: eggs notches, c: sawdust of larval stages; d: larval galleries in the wood)

Table 2. Emerged beetles from localities in Tunisia (mean ± SE). * Means in the column with the same letter do not differ significantly, Multiple Comparison test

Forests	Location in Tunisia	Bioclimatic Area	Trap tree diameter at 1.30 m (cm)	Emerged beetles		
				Number	%	Insects per log*
Azib	North	Humid	6.05	41	4.07	6.8±1.7a
Dar Fatma	North	Humid	5.57	38	3.77	12.7±4.7a
Darchichou	North East	SubHumid	8.99	93	9.24	15.5±2.4ab
Oued Bir	North East	SubHumid	5.81	164	16.30	27.3±8.7ab
Sidi Aouidet	Center	SemiArid	7.24	129	12.82	21.5±4.3ab
Sidi Said	Center	Semi arid	6.44	66	6.56	11.0±3.0a
Kebouche	Center	Semi Arid	5.33	165	16,40	27.5±3.9ab
Ain amara	Center	Arid superior	7.88	74	7.35	12,3±3.7a
Samama	Center	Arid superior	8.28	236	23.46	39.3±2.3b
			Total number of emerged beetles	1006	100	18.62±3.8

3.2. Emergence pattern

No cerambycid emerged during 2011. Emergencies only occurred during the subsequent year, 2012, and therefore *M. galloprovincialis* required one year completing its life cycle in Tunisia. The 1006 adults, obtained from the stored logs in the INRGREF, emerged during the spring-summer period (Figure 4), with the earliest beetle emerging in mid–May (from Samama), while the latest beetles appeared in august from Oued Bir logs. This emergence seems to be correlated to the temperature (R^2= 0.594). According to our observations, and considering the origin of each log, the peak of emergence of *M. galloprovincialis* in Tunisia occurs during the June- July period (Figure 5).

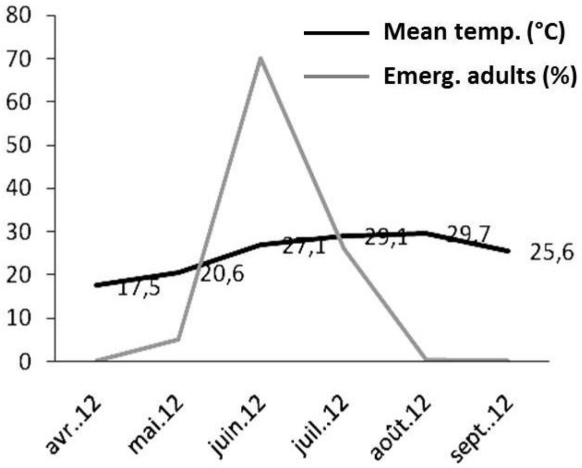

Figure 4. Emergence pattern of M. galloprovincialis from stored Aleppo pine logs at the INRGREF station

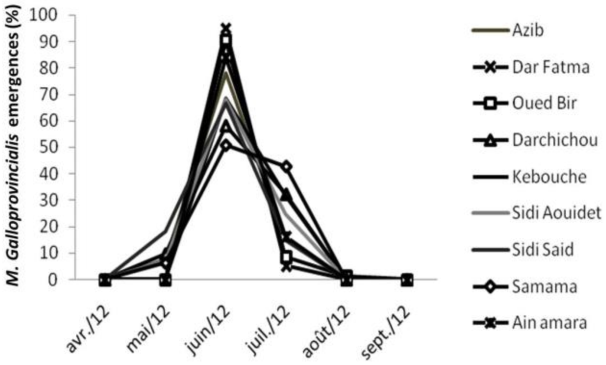

Figure 5. Emergence pattern of M. galloprovincialis from logs of each localities.

4. Discussion

Despite the recognized importance of *M. galloprovincialis* as one of the main vector's of PWN in Europe (Naves et al., 2007, Akbulut and Stamps, 2010), no previous study had been done on its presence and distribution in the Maghreb region in North Africa, with the expectation of scattered records on its presence (Hellrigl, 1971; Kerris and Guerroudj, 1991). In Tunisia, both the *Monochamus* species and *B. xylophilus* were classified as quarantine pests (Jort, 2012).

Our results confirm the presence of *M. galloprovincialis* on Aleppo pine on Tunisia, in accordance to previous references by Hellrigl in 1971. The pine sawyer is native to Tunisia and is the only *Monochamus* species found in the country (Mejri et al., 2014: in press), as well as in northern Africa (Hellrigl, 1971). Our results confirm that it is widely distributed in Tunisia, following the distribution of its main host plant, Aleppo pine. If we assume that the number of eggs laid in the trap-trees is related to the abundance of insects in the forest, we can conclude that the insect´s abundance differs between localities, with contrasting patterns between the arid (more abundant insect populations) and semi-arid (less abundant) locations. Nevertheless, other factors beside the climatic conditions of each location might be involved, because in the arid zones the forests consist on monocultures of just one pine species (Aleppo pine), while in the humid locations other pines, such as maritime pine *P. pinaster*, can also be found in abundance, and can serve as alternative host for the insects and attract egg-laying female beetles.

Concerning the biology of the insect, ours results illustrate that in Tunisia, like in similar Mediterranean countries, *M. galloprovincialis* presents one generation per year (Tomminen, 1993; Francardi and Pennachio, 1996; Koutroumpa, 2007; Naves et al., 2008, Akbulut et al., 2008). Unfortunately, we couldn't study the biological traits of the insect and its larval development in each locality and in each bioclimatic area because of some field constraints. However, the only difference will be in the duration of the larval development in the localities belonging to the arid superior bioclimatic area. Indeed, *M. galloprovincialis* will emerge earlier in those localities comparing to the semi arid, subhumid and humid ones. The pattern of adult emergence is also quite similar to other locations from Europe, namely from Italy (Francardi and Pennachio, 1996) and Portugal (Naves et al., 2008), with extended emergence periods during several months in late spring/summer, but with emergence peaks in June and July. This is a preliminary assessment on the distribution and basic biological parameters of the pine sawyer *M. galloprovincialis* associated with Aleppo pine in Tunisia. Future studies should address the insect´s association with other possible host available in the country, such as *Pinus pinaster* and *Pinus pinea*, and its biology in these pines and on other locations. Additionally, research on the association of the pine sawyer with nematodes in Tunisia is also being conducted, and will constitute a valuable tool in assessing the risk of introduction of the Pine wood nematode into this northern Africa country.

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Cedar forests under threat of new pests

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Abtract: 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 connaitre 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, örnekleme ve kültüre alma dâhil olmak üzere sedir ağaçlarındaki böceklerle ilgili çalışmalarımızda, genellikle ağaçlarda bilinenlerin yanısıra 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 salgınların 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, Oduncul, 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[1] 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[2]. 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).

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[1] *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.

[2] *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 vaulogeri*, *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 pruinosus*, *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.

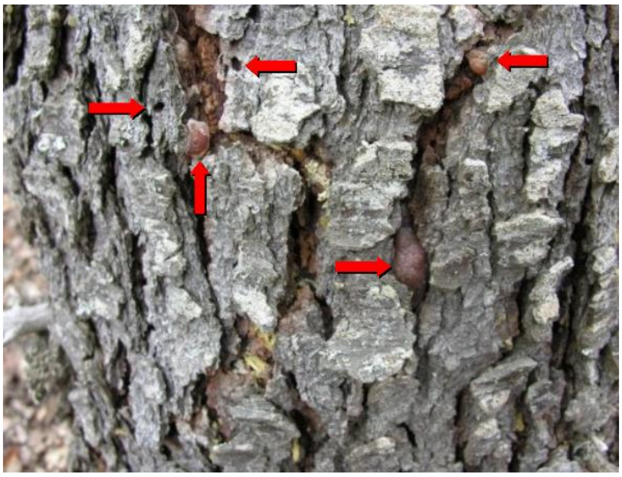

Figure 3. External symptoms of *Phaenops marmottani* (exit holes and resin exudation: arrows) on a cedar trunks in the process of dying back (Photo Mouna).

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)[3].

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,

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[3] 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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Immediate and delayed mortality of the pine processionary moth treated by *Bacillus thuringiensis* var. *kurstaki* 3a 3b in the sub-Saharian pine reforestations

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Abstract: In the reforestations of *Pinus halepensis*, situated in the Algerian sub-Saharian region, 1 500 hectares were treated by an aerial application against the third and fourth larval stage of the pine processionary moth. The microbiological insecticide used contained *Bacillus thuringiensis* var. *kurstaki* 3a 3b. The immediate mortality was evaluated by sampling colonies of caterpillars 7 and 14 days after the application of the treatment, and the delayed mortality was determined firstly for caterpillars after 80 and 100 days in the field and secondly for pupae by collecting and rearing surviving caterpillars to *Btk* at the end of the larval cycle during the nomadic period. The mortality rate of the caterpillars increased between 7 and 100 days and averaged 93 % in the treated zone. The caterpillars exposed to the treatment were more contaminated by *Beauveria bassiana* and infested by the larval-pupal parasitoïds *Erigorgus femorator* Aub. (Hym, Ichneumonidae) and *Phryxe caudata* Rond. (Dip., Tachninidae). The sex ratio of surviving moths was 1.7 in favour of males which suggests that female caterpillars are more vulnerable to *Btk*.

Keywords: *Thaumetopoea pityocampa*, Parasitism, Insect control, *Pinus halepensis*

Aşağı Sahra'da çam ağaçlandırma sahalarında *Bacillus thuringiensis* var. *kurstaki* 3a 3b ile ilaçlanan çam kese böceklerinin anında ve geç ölümü

Özet: Cezayir'de Aşağı Sahra bölgesinde bulunan ağaçlandırılmış *Pinus halepensis* ormanında 1500 hektarlık alana çam kese böceğinin üçüncü ve dördüncü larva evresine karşı havadan ilaçlama uygulaması yapılmıştır. Kullanılan mikrobiyolojik insektisit, *Bacillus thuringiensis* var. *kurstaki* 3a 3b içeriyordu. İlaç uygulamasından sonra 7. ve 14. günde tırtıl kolonilerinden örnekler toplanarak anında ölüm değerlendirilmiştir. Geç ölüm ise, ilk olarak tırtıllar için 80 ve 100 gün sonra sahada belirlenmiş, ikinci olarak ise pupalar için Btk uygulamasına rağmen sağ kalan tırtılları göç döneminde larva döngüsünün sonunda toplayıp büyüterek belirlenmiştir. Tırtılların ölüm hızı, 7 ila 100 gün arasında artış gösterirken ilaçlama yapılan bölgede ortalama %93 olarak belirlenmiştir. İlaçlamaya maruz kalan tırtıllar *Beauveria bassiana* ile daha fazla kontamine olmuş ve *Erigorgus femorator* Aub. (Hym, Ichneumonidae) ve *Phryxe caudata* Rond. (Dipt. Tachninidae) tarafından istila edilmiş durumdaydı. Sağ kalan böceklerin cinsiyet oranı, erkeklerin lehine olacak şekilde 1,7 idi. Bu durum dişi tırtılların *Btk*'ya karşı daha duyarlı olduğunu düşündürmektedir.

Anahtar kelimeler: *Thaumetopoea pityocampa*, Parazitlik, Zararlı kontrolü, *Pinus halepensis*

1. Introduction

The pine processionary moth, *Thaumetopoea pityocampa* (Denis and Schiffermüller, 1775). (Lepidoptera: Notodontidae), is well known for its defoliation of different species of pines and cedars all over the Mediterranean Basin. The larvae are gregarious, inhabit silk nests and pupate below ground. Adults mostly emerge during summer, reproduce and die within a few days. In Algeria the success of the reforestations with *Pinus halepensis* Mill. in the "green barrier" located in the sub-Saharan region is limited by the permanent damage of this insect pest. To control the populations of this insect, and to preserve the progressive installation of its complex of natural enemies in these artificial forests, a biological insecticide using *Bacillus thuringiensis* var. *kurstaki* 3a 3b (*Btk*) have been used since 1980 (Zamoum and Demolin, 2004). Until now, these treatments are the only way to ensure a normal increase of the foliar biomass of the young pines (Zamoum *et al.*, 2007).

The aim of this study was to evaluate the immediate and delayed efficiency of a recent formulation of *Btk* spread during the third and fourth larval stage of the pine processionary moth. The delayed mortality by *Btk* was estimated firstly during the larval stage in the field and secondly for pupae by collecting and rearing surviving

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caterpillars to *Btk* at the end of the larval cycle during the nomadic period were the caterpillars migrate from the host tree to select a habitat underground to pupate. Based on the results obtained we propose an integrate strategy to control this insect pest all over the "green barrier".

2. Material and Methods

2.1. Study site and treatments

The study was carried out at Djelfa in the reforestation of Moudjebara, situated at an altitude of 1 100 m and characterized by a semi-arid bio-climate. The *P. halepensis* plantations have been realized since 1970 on 13 000 ha and the level of the infestation of pine processionary moth was high and permanent.

Btk was sprayed in winter (20-24 December) over 1 500 ha using an aircraft - type Gruman 600 with 8 micronairs AU 5000. *Btk*, serotype 3a 3b, commercialized under the name Foray 48B was used. The dose used was 3 L/ha with 1 litre of water as support; representing a concentration of 39 x 109 International Biological Units/L on the basis of a density of 1.15. At the day of the aerial application (J), 15.3% of the caterpillars were at the third larval instar and 72.7% at the fourth larval instar.

2.2. Treatment efficiency estimation

In addition to an untreated control plot which is located about 500 m far from the treated zone where four plots are delimited. For each plots, the mortality was evaluated by a random sampling of 30 infested trees per plot. The trees were chosen according to a perpendicular transect to the flight of the aircraft. For each tree in the treated and untreated plots, all the egg batches and nests were collected. The number of surviving and dead caterpillars was recorded. For the egg batches, the total number of eggs laid and the number of hatched eggs was recorded to estimate the initial population of caterpillars for each plot. Larval survival to *Btk* was estimated by the difference between averages number of the caterpillars hatched and those recorded into the nests. To evaluate the immediate efficiency of *Btk,* two sampling were carried out at 7 and 14 days after the date of the treatment. In a first step, delayed mortality was determined at 80 and at 100 days after the date of the treatment, to evaluate the survival rate of the caterpillars before the end of the winter season and the migration of the caterpillars from the host tree to the ground for pupation.

2.3. Trapping and rearing of surviving caterpillars

In a second step, the delayed mortality to the *Btk* was also estimated for the pupal stage. At the end of the larval stage and beginning of the nomadic period, 10 nests were randomly sampled in each of the treated and untreated plots. The nests were grafted in the same ecological conditions on two trees in each of the plot. The caterpillars at the end of the larval cycle leave their winter nests to pupation under the soil. To collect these caterpillars, two traps were placed on the trunks and visited daily.

The captured caterpillars were kept separately in a glass tube (8 x 1 cm) and all the treated (N = 535) and untreated (N = 771) caterpillars were placed under semi-natural conditions at Djelfa. We noted mortality of pupae and caterpillars and the emergences of all the larval-pupal parasitoïds and the pine processionary adults. The mycosis mortality was identified by the Professor E. Tarasco (Laboratory of Pathology - University of Bari, Italy).

2.4. Statistical analysis

The data related to the larval survival during the four samples in the treated and untreated plots were analyzed using the Newman-Keuls test to compare all pairs of means following one-way analysis of variance (ANOVA). Means are presented ± 1 S.E. Survival in plots was also expressed as a percentage of the total number average of eggs in the egg batches collected in each plot and period of sampling nests. Incidence of the different species of natural enemies was expressed as a percentage of the total number of caterpillars collected during the end of the larval cycle.

3. Results and discussion

3.1. Immediate and deferred mortality rate of caterpillars

Incidence to *Btk* vary significantly among plots notably for -the two first sampling (Table 1) and among the date of collect at J + 7, 14, 80 and 100 (ANOVA: $F(_{4,335}) = 76.02$, $P < 0.001$ - $F(_{4,339}) = 33.35$, $P < 0.001$ - $F(_{4,191}) = 160.54$, $P < 0.001$ - $F(_{4,224}) = 131.18$, $P < 0.001$) respectively. The average mortality rate observed for the four treated plots was 93 % (Figure 1). This is relatively low compared to a previous mortality assessment performed after an autumn treatment against larvae at the first, second and third larval stages (Zamoum et al., 1997).

Table 1. Larval survival to *Btk* treatement with comparison between untreated and treated plots, for each date of sampling. * Different letters indicate significant differences amonf plots comparison of larval survival means (± S.E.) (Newman and Keuls test, $P < 0.05$)

Plots / date of collect	J + 7	J + 14	J + 80	J + 100
Untreated	$86.8 \pm 3.6^{a*}$	$45,4 \pm 2.3^{a}$	$85,6 \pm 3.9^{a}$	$75,3 \pm 3.0^{a}$
I	25.7 ± 2.4^{d}	$14,1 \pm 2.1^{c}$	$7,5 \pm 2.3^{b}$	$5,3 \pm 2.8^{b}$
II	$40,3 \pm 2.6^{c}$	$7,4 \pm 2.0^{c}$	$13,0 \pm 2.4^{b}$	$10,4 \pm 2.1^{b}$
III	$40,1 \pm 2.2^{c}$	$26,6 \pm 2.2^{b}$	$11,0 \pm 1.6^{b}$	$5,7 \pm 1.4^{b}$
IV	$59,2 \pm 2.2^{b}$	$27,7 \pm 2.4^{b}$	$11,2 \pm 2.6^{b}$	$6,3 \pm 2.6^{b}$

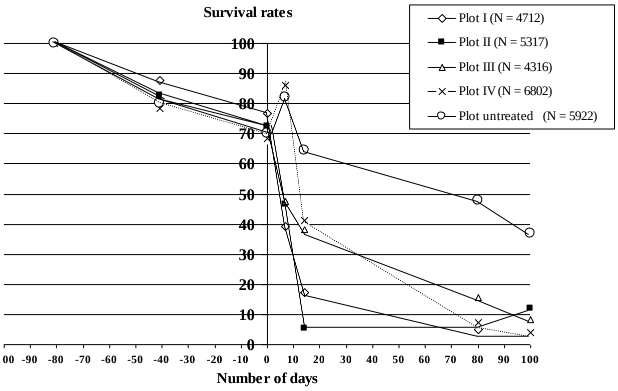

Figure 1. Evolution of larval survival rates in the treated and untreated plots, calculated from the average number of eggs collected and those hatched, the number of larvae recorded at the day of treatment *Btk* (0) and after 7, 14, 80 and 100 days

The immediate mortality rate evaluated at 7 and at 14 days after the treatment exceeded 80 % in plots I and II but it was only 62 and 59% in plots III and IV. Several causes can explain this weak *Btk* performance: firstly, four days after the treatment, rainfalls were registered in Djelfa. Consequently the insecticide might have been washed off in plots III and IV which were the last plots to be treated. Furthermore, the low temperatures during this winter season slowed down the feeding process of the caterpillars and consequently the ingestion of *Btk*.

Treated caterpillars were more vulnerable to the winter conditions than caterpillars from the untreated plot. Winter mortality has been observed by different authors in all the distribution area of this insect pest (Demolin, 1974; Geri, 1980; Battisti, 1988; Zamoum, 1998; Pimentel et al. 2010). In fact at J + 80 and J + 100 days we noted a clear increase in average mortality rates, which reached more than 90% compared to the mortality rates obtained in the untreated plot. This represents an average mortality rate of 19% compared to those obtained at J + 14 days in the four plots treated.

The phenological structure of the caterpillars surviving population at J + 100 days showed a clear abundance of the fourth larval instar in the treated plots compared to the untreated plot where a majority of the caterpillars are at the fifth larval instar (Table 2). This low development is certainly due to the *Btk* treatment; a similar situation was observed with *Euproctis chryssorrhoea* (Lep. Lymantriidae) by Ruelle et al. (1977).

Table 2. Comparison between larval phenology rates observed at the date of treatment *Btk* (J) and that observed during the different sampling periods from J + 7 to J + 100, in the untreated (UP) and treated plots (P I to P IV). C(1): Number of collected colonies; N(2): Number of caterpillars; L(3): Survival larval phenology at third, fourth and fifth larval instars

Plots / Sampling periods	C(1)	N(2)	L3(3)	L4(3)	L5(3)
UP / J	10	544	19,1	80,9	0,0
P I / J	10	429	15,8	2,3	0,0
P II / J	10	762	21,2	18,9	0,0
P III / J	10	378	17,5	25,4	0,0
P IV / J	10	543	10,3	39,4	0,0
			$F_{(2,12)} = 4.64$, $P = 0.03$		
UP / J + 7	56	4863	17,3	82,7	0,0
P I/ J + 7	72	1851	22,3	7,3	0,0
P II / J + 7	62	2499	17,4	29,0	0,0
P III / J + 7	51	2046	7,3	38,9	0,0
P IV / J + 7	99	5859	11,9	56,3	0,0
			$F_{(2,12)} = 8.40$, $P = 0.0005$		
UP / J + 14	84	3815	0,1	52,2	0,0
P I / J + 14	58	818	1,6	14,7	0,0
P II / J + 14	44	288	0,3	7,3	0,0
P III / J + 14	62	1649	0,5	30,1	0,0
P IV / J + 14	101	2795	1,6	30,3	0,0
			$F_{(2,12)} = 11.7$, $P = 0.002$		
UP / J + 80	37	2826	0,0	9,3	78,6
P I / J + 80	32	240	0,0	4,6	4,1
P II / J + 80	31	317	0,0	2,0	9,8
P III / J + 80	61	672	0,0	1,5	17,4
P IV / J + 80	44	491	0,0	1,7	5,5
			$F_{(2,12)} = 2.3$, $P = 0.14$		
UP / J + 100	29	2184	0,0	0,0	86,7
P I / J + 100	32	169	0,0	5,9	0,2
P II / J + 100	62	645	0,0	11,6	0,4
P III / J + 100	62	352	0,0	9,4	0,3
P IV / J + 100	44	277	0,0	12,9	0,0
			$F_{(2,12)} = 0.8$, $P = 0.49$		

3.2. Numerical change in the surviving caterpillars

The surviving caterpillars were much more vulnerable to their natural enemies, especially the entomycosis *Beauveria bassiana* (Bols-Criv. Vuillemin, 1912) and to the specific larval-pupal parasitoïds *Erigorgus femorator* (Aubert, 1960) (Hym. Ichneumonidae) and *Phryxe caudata* (Rondani, 1859) (Dip., Tachnidae) (Figure 2). This could result from a higher number of badly or unstructured nests in the treated plots. The caterpillars cannot escape easily to the attacks of the different species of parasitoïds, as already mentioned by Ruelle et al. (1977) in the case of *E. chryssorhoea.* The sex ratio was 1.7 in favour of male adults. This could be due to the fact that female caterpillars are more affected by natural enemies. The decline in female number could lead to a decrease of the pine processionary moth population for the next generation.

No prolonged diapause was recorded for caterpillars collected in the treated zone (Table 3). It would be necessary to perform additional experiments to study the physiological incidence of *Btk* on the breaking or induction of diapause.

3.3. Possibility of winter treatment

The efficiency of the microbiological preparations with *Btk* against the pine processionary caterpillars from the third and fourth larval stages (Demolin et al., 1993) opens a new opportunity to control the populations of this insect pest. The possibility to delimitate easily the infected zones during the winter season allows targeting precisely the infected zones during aerial applications, and thus avoid the large scale application in autumn on the young caterpillars at the first and second larval stages. Furthermore, in the case of the "Green barrier" reforestation the winter treatments have the advantage to preserve an important zoocenosis which is inactive at this season, and to have a reasonable control by treating when and where it is necessary, as suggested by Delorme (1991).

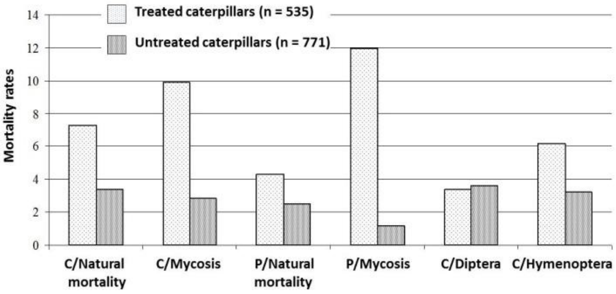

Figure 2. Comparison of mortality due by natural enemies between the caterpillars (C) and pupal stage (P) which survived to *Btk* treatment and those untreated

Table 3. Percentage of male and female adults emerging in year n and n+1 from caterpillars collected in the treated and untreated zones

	Treated plots (N = 305)		Untreated plot (N = 642)	
	Year n	Year n+1	Year n	Year n+1
Adult male (%)	35.9	0.0	38.3	3.4
Adult female (%)	21.1	0.0	38.5	3.1
Sex-ratio	1.7	—	0.9	1.1

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Turkish Journal of Forestry | Türkiye Ormancılık Dergisi
2016, 17(Special Issue): 80-84 | Research article (Araştırma makalesi)

Evaluation du pouvoir insecticide de deux mimétiques de l'hormone de mue (Halofénozide et Méthoxyfénozide) sur les stades immatures de *Lymantria dispar*, principal défoliateur du chêne-liège

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Résumé : La spongieuse *Lymantria dispar* (Lepidoptera, Lymantriidae) est l'un des plus importants ravageurs des subéraies. Il apparaît de manière cyclique et provoque de graves défoliations du chêne-liège. En Algérie, *L. dispar* a été signalé depuis 1925 et la lutte contre ce défoliateur majeur s'appuie essentiellement sur des insecticides chimiques. Dans cette étude, nous avons évalué l'effet insecticide du halofenozide et du methoxyfenozide contre les larves de *L. dispar*. Ces deux molécules appartiennent à une nouvelle génération de régulateurs de croissance des insectes qui imitent les hormones de mue ou ecdystéroïdes. Le Halofenozide est actif contre les Lépidoptères et les Coléoptères, le méthoxyfénozide est spécifique aux Lépidoptères. Le traitement des larves de *L. dispar* nous a permis de déterminer la toxicité et le mode d'action de ces deux insecticides et d'examiner son action différée sur la fécondité des adultes issus du traitement des larves. Nous avons calculé aussi les paramètres toxicologiques, comme on a mis en évidence un effet différé sur la fécondité et la fertilité, avec apparition de formes aberrantes de larve et d'adulte.
Mots-clés : *Lymantria dispar,* Algérie, Halofenozide, Methoxyfenozide, Toxicité, Développement

Insecticidal effect of halofenozide and methoxyfenozide in different stages of *Lymantria dispar*, an important cork oak defoliator

Abstract: The gypsy moth *Lymantria dispar* (Lepidoptera, Lymantriidae) is one of the most notorious pests of hardwood trees. It appears in cyclic way and provokes serious defoliations of the cork oak. In Algeria, *L. dispar* is reported since 1925 and the control of this defoliator consists of chemical insecticides and/or biological control tools. In this project we evaluated halofenozide and methoxyfenozide against larvae of *L. dispar.* These two molecules are member of a new generation of insect growth regulators that mimic the natural insect moulting hormones or ecdysteroids. Halofenozide is active against Lepidoptera and Coleoptera, while methoxyfenozide is more specific for Lepidoptera. We determined the toxicity and mode of action of these two insecticides by treatment of the larvae of *L.dispar*. In intoxicated larvae typical morphological aberrations during moulting/ metamorphosis were observed leading to death. In addition, we noted in the surviving adults a strong negative effect on the fecundity and fertility. The results are discussed in relation to the susceptibility of the different stages of *L. dispar*.
Keywords: *Lymantria dispar,* Algeria, Halofenozide, Methoxyfenozide, Toxicity, Development

Halofenozid ve metoksifenozidin önemli bir mantar meşesi yaprak zararlısı olan *Lymantria dispar*'ın farklı evrelerinde insektisidal etkisi

Özet: Ağaç zararlısı *Lymantria dispar* (Lepidoptera, Lymantriidae), set ağaçlar için en zararlı böceklerden biridir. Bu zararlı, periyodik olarak ortaya çıkmakta ve mantar meşesinin yapraklarına ciddi zararlar vermektedir. Cezayir'de, *L. dispar* 1925 yılından bu yana bildirilmektedir ve bu yaprak zararlısıyla mücadele kapsamında kimyasal insektisitler ve/veya biyolojik mücadele araçları kullanılmaktadır. Bu projede, *L. dispar* larvalarına karşı halofenozid ve metoksifenozid kullanımını değerlendirdik. Bu iki molekül, doğal böcek tüy değiştirme hormonları veya ekdisteroidleri taklit eden yeni nesil böcek büyüme düzenleyicileri arasında yer almaktadır. Halofenozid Lepidoptera ve Coleoptera türlerine karşı etki gösterirken, metoksifenozid Lepidoptra'ya karşı daha etkilidir. *L.dispar* larvalarına bu iki insektisidi uygulayarak toksisitesi ve etki mekanizmasını belirledik. İnsektisid uygulanan larvalar tipik olarak tüy değiştirme esnasında ölümle sonuçlanan morfolojik sapmalar/ metamorfoz

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gözlemlenmektedir. Ayrıca, hayatta kalan erişkinlerin doğurganlığı ve fertilitesi üzerinde güçlü bir negatif etki tespit ettik. Sonuçlar, *L. dispar*'ın farklı evrelerde duyarlılığı açısından irdelenmektedir.

Anahtar kelimeler: *Lymantria dispar*, Cezayir, Halofenozid, Kromafenozid klorofenapir fenisobromolat, Toksisite, Geliştirme

1. Introduction

L. dispar est un insecte aux facultés de survie et au potentiel biotique tout à fait remarquables. Ces propriétés lui permettent de s'adapter rapidement à des environnements très variés, et expliquent le succès de son expansion. Du fait même de ces adaptations, les modes de vie et les facteurs de régulation des populations diffèrent d'un endroit à l'autre, voire d'une forêt à l'autre. Les généralisations ne sont pas possibles et les recherches originales restent indispensables (Fraval, 1989).

C'est aux U.S.A que l'effort de recherche a été le plus important. Doane et McManus (1981), indiquent que *L. dispar* n'est pas du tout maîtrisé, que son expansion géographique se poursuit, que ses pullulations sont imprévisibles et surtout que les modifications que l'homme apporte à la forêt sont favorables au ravageur, aucun aspect ne peut être considéré comme connu.

Le siècle dernier a enregistré des progrès significatifs dans la synthèse des pesticides. Cependant, les insecticides synthétiques ont vite montré leur agressivité envers des organismes non visés dont les insectes utiles, les mammifères et l'homme, en plus de leur persistance dans la nature qui perturbe les équilibres écologiques. Ces dernières années de nouveaux insecticides sélectifs agissants sur les processus physiologiques ou sur des sites biochimiques d'insectes cibles sont apparu.

Cette nouvelle approche a permis l'apparition de composés qui affectent le processus de la régulation hormonale de la mue et du développement chez les insectes comme les agonistes de l'ecdysone, les mimétiques de l'hormone juvénile et les inhibiteurs de la synthèse de la cuticule (Ishaaya et al., 1994, Dhadialla et al., 1998, Oberlander & Silhacek, 1998). Tous ces nouveaux composés sont utilisés contre les déprédateurs des forêts (Retnakaran, 1976), et contre les Lépidoptères (Ishaaya, 1990). Ils sont utilisés avec succès sur les larves de *L. dispar*, dans les programmes de lutte contre ce défoliateur majeur (Berry et al., 1993).

Le présent travail a pour but d'évaluer l'activité insecticide du halofenozide et du methoxyfenozide contre les larves de *L. dispar*. Ces deux molécules appartiennent à une nouvelle génération de régulateurs de croissance des insectes qui imitent les hormones de mue ou ecdystéroïdes et d'examiner leur action différée sur la fécondité des adultes.

2. Matériel et méthodes

2.1. Elevage des chenilles

Un élevage de masse a été réalisé au laboratoire à partir des pontes prélevées dans les subéraies de l'Est Algérien en 2011. Les chenilles, placées dans des boîtes d'élevage de (30 x 20 x 15 cm) sont maintenues à une température de 26°C et une humidité relative de 75%, et nourries quotidiennement de feuilles fraîches de chêne-liège.

2.2. Les produits testés

Le méthoxyfénozide RH-2485 : Le méthoxyfénozide appartient à une classe chimique nouvelle d'insecticides. Cet insecticide est un agoniste de l'ecdysone qui contrôle une large gamme de larves des Lépidoptères à faible dose, il agit par ingestion, par contact et il peut agir aussi comme ovicide.

Le halofénozide RH 0345: Le RH-0345 est le nom commun du N-butyl-N'-(4-chlorobenzoyl benzohydrazide) ; c'est un insecticide de nouvelle génération, de la classe des dibenzohydrazines ; agoniste des ecdystéroïdes qui perturbe le processus normal de la mue, il exerce une action active contre les Lépidoptères, Coléoptères, Homoptères et les Diptères (Smagghe & Degheele, 1995).

2.3. Protocole expérimental

Après des essais préliminaires, et à partir d'un produit commercial, nous avons retenus quatre concentrations pour nos expérimentations : 25 mg/l, 50 mg/l, 75 mg/l et 100 mg/l pour le halofénozide et le méthoxyfénozide. Chaque concentration est appliquée séparément à 3 séries de 15 larves (L2, L3, L4, L5) dans les 24h qui suivent la mue larvaire. Les larves du stade L1 n'ont pas fait l'objet de traitement du fait de leur extrême fragilité.

Le traitement est réalisé par pulvérisation jusqu'à ruissellement du produit sur des feuilles fraîches de chêne-liège. Des feuilles non traitées (aspergées d'eau) sont distribuées à une série de 15 larves servant de témoin. Après 24 heures, les feuilles traitées sont remplacées par des feuilles non traitées. La variable mesurée étant la mortalité journalière des chenilles. Les chenilles ont été maintenues en élevage jusqu'à la formation des chrysalides qui seront sexées et pesées, l'envol des adultes et la ponte. Les pontes feront mesurées dans leur plus grand diamètre et le nombre total d'œufs par ponte compté. On détermine aussi le nombre d'œufs viables par ponte, les œufs viables sont sphériques, turgescents, bien arrondis et l'embryon de la larve peut être visible à travers la coquille.

2.4. Analyse statistique

Le taux de mortalité larvaire corrigé selon Abbott (1925) donne une bonne indication de la toxicité réelle de la solution testée. Les taux de mortalité enregistrés pour les deux molécules des différentes concentrations utilisées sont normalisés par transformation angulaire, d'après les tables établies par Bliss (Fischer & Yates, 1957), font l'objet d'une analyse de la variance à un seul critère de classification. Le calcul de la plus petite différence significative (p.p.d.s) permet le classement des concentrations testées. Afin de caractériser le pouvoir insecticide de la molécule testée, nous avons déterminé la concentration létale 50% et 90% (DL 50, DL 90) selon le procédé mathématique de Finney (1971).

3. Résultats

3.1. Effet toxique direct

Activité insecticide du RH-0345 sur les larves de L. dispar

Les résultats du traitement des larves de tous les stades larvaires de *L. dispar* par le RH-0345 montrent un effet insecticide de cette molécule, les taux de mortalité peuvent atteindre 81% pour la concentration la plus élevée (Tableau 1). La mortalité des différents stades larvaires de *L. dispar* exposées au RH-0345 pendant 10 jours est significativement corrélée aux concentrations utilisées. Les paramètres toxicologiques sont consignés dans le tableau 2.

Activité insecticide du RH-2485 sur les larves de L. dispar

Les larves de tous les stades larvaires sont sensibles au RH-2485. Nous enregistrons des taux de mortalité pour les 4 concentrations utilisées, cette mortalité atteint 92% pour la concentration la plus élevée ce qui traduit un effet insecticide du produit utilisé (Tableau 3). La mortalité des différents stades larvaires de *L. dispar* exposées au RH-2485, pendant 10 jours, est significativement corrélée aux concentrations utilisées. Les paramètres toxicologiques sont consignés dans le tableau 4.

3.2. Effet toxique différé

Parallèlement à son action larvicide sur *L. dispar,* le RH-0345 agit sur certains paramètres du développement de l'insecte, comme le poids des chrysalides mâles et femelles, la taille de la ponte et le nombre d'œufs par ponte. Le taux d'œufs arrivant à maturité peut également être affecté. Chez les chrysalides femelles issues de larves traitées, on note également une diminution importante du poids corporel par rapport aux témoins (t = 17,88 ; *p* : < 0,0001) (Tableau 5). La taille de la ponte, le nombre d'œufs par ponte et le nombre d'œufs non viables sont affectés dans le même sens. Les femelles adultes issues des larves traitées donnent des pontes significativement plus petites que celles issues des larves témoins (t= 13,32 ; *p* : < 0,0001) et un nombre d'œufs significativement plus faible (t = 12,08 ; *p* : < 0,0001). De plus, le nombre des œufs qui n'arrivant pas à maturité est significativement plus élevé que chez ceux pondus par des insectes non traités (t= 17,49 ; *p* : < 0,0001) (Tableau 5). Nous n'enregistrons aucun effet toxique différé du méthoxyfénozide.

Tableau 1. Activité insecticide du RH-0345 en fonction de la concentration sur la mortalité corrigée (%) des différents stades larvaires de *L. dispar* après 10 jours de traitement

Stades	Doses testées				ANOVA	
	25 mg/l	50mg/	75mg/l	100mg/l	F	P
L2	30	44	72	81	6.77	0.0020
L3	27	39	66	69	27.21	0.0007
L4	21	34	61	63	21.13	0.0007
L5	19	29	54	51	9.71	0.0078

Tableau 2. Paramètres toxicologiques du RH-0345 à l'égard des larves de *L. dispar*

Stades	Droites de régression	DL 50	Slope	IC 95%
L2	Y = 0,72X + 0,23 (r = 0,71)	$0,49.10^3$	2,78	(0,12 - 16.12) 10^3
L3	Y = 0,38X – 0,34 (r = 0,78)	$1,12.10^3$	4,26	(0,49 – 34.11) 10^3
L4	Y = 0,90X + 1,12 (r = 0,81)	$2,16.10^3$	12,59	(1,01 – 43.54) 10^3
L5	Y = 0,17X+ 0,94 (r = 0,70)	$7,59.10^3$	16,32	(2,98 – 2.98) 10^3

Tableau 3: Effet insecticide du RH-2485 en fonction de la concentration sur la mortalité corrigée (%) des différents stades larvaires de *L. dispar* après 10 jours de traitement.

Stade	Doses testées				ANOVA	
	25mg/l	50mg/l	75mg/l	100mg/l	F	*p*
L2	42%	68%	81%	92%	15.75	0.0079
L3	37%	56%	73%	80%	40.72	0.0001
L4	31%	47%	66%	75%	53.51	0.0001
L5	24%	36%	48%	53%	29.26	0.0007

Tableau 4. Paramètres toxicologiques du RH-2485 à l'égard des larves de *L. dispar*

Stades	Droites de régression	DL 50	Slope	IC 95%
L 2	Y=2,35x + 1,52 (r = 0,81)	$0,52.10^2$	6,31	(0,34 – 8.53) 10^2
L 3	Y=1,58x + 0,26 (r = 0,89)	$0,99.10^2$	13,29	(0,48 – 14.76) 10^2
L 4	Y=3,06x – 2,41 (r = 0,72)	$2,51.10^2$	14,12	(0,98 – 21.1) 10^2
L 5	Y=2,75x–0,83 (r = 0,70)	$5,26.10^2$	20,43	(1,95 – 26.59) 10^2

Tableau 5. Acticité différée du RH 0345 sur le développement de *L. dispar*

Traitement	Poids des chrysalides mâles (mg)	Poids des chrysalides femelles (mg)	Taille des pontes (cm)	Nombre total d'œufs/ ponte	Nombre d'œufs non viables/ ponte
Témoin	350,00±25,00	1210,00±70,00	3,53±0,75	225,67±92,15	30,42±4,52
Traité L3	120,00±18.00	270,00±40,00	1,11± 0,37	62,00±23,30	56,00±12,12
Traité L4	192,00±15,00	587.00±21.00	2,14±0,3	122,8±37,10	102,8±31,53

4. Discussion

Nos résultats montrent qu'il existe un effet insecticide des deux produits halofénozide (RH- 0345) et methoxyfenozide (RH2485) à l'égard des larves du deuxième et du troisième stade de *L. dispar*, qui se traduit par une mortalité en fonction des concentrations utilisées. Cette mortalité peut atteindre 80 % des larves traitées par les deux molécules. Cet effet persiste au quatrième stade où nous enregistrons un taux de mortalité maximal de 100 % pour toutes les concentrations élevées. Les larves du cinquième stade traitées avec les insecticides présentent une mortalité moyenne assez élevée.

Pendant la dernière décennie, RH-5849, RH-5992 (tébufenozide) et RH-2485 (méthoxyfénozide) ont été découverts et considérés comme les premiers ecdystéroïdes agonistes non stéroïdaux menant à une nouvelle classe de régulateurs de croissance d'insecte, à savoir les benzoylhydrazines, qui incitent la mue précoce et incomplète dans plusieurs ordres d'insecte, particulièrement chez les Lépidoptères (Soltani et al., 2001). Ces composés augmentent l'activité contre les Lépidoptères et les Coléoptères, principalement par l'induction de mue précoce mortelle (Smagghe et al., 1994 ; Dhadialla et al., 2005). Le RH0345 (halofénozide), nouveau ecdystéroïde agoniste non stéroïdal qui développé par la compagnie « Rohm et Haas » (Smagghe *et al*, 1994), a été considéré comme le plus sélectif de sa classe d'insecticides chez les Coléoptères (Darvas et al., 1992).

Les larves (L_3 et L_4) de *Culex pipiens* traitées au RH 0345 présentent une mortalité importante bien que les larves L_3 soient plus résistantes à l'action du RH 0345 que les larves L_4. L'effet du RH 0345 sur les larves du $4^{ème}$ stade de *Culex pipiens* montre un taux de mortalité de 65% à une dose de 26 µg/l (Boudjelida et al., 2005).

Notre étude montre aussi qu'il existe des papillons malformés issus des larves L_4 et L_5 de *L. dispar* traitées au RH -0345. Les mâles se présentent avec des ailes réduites et sont incapable de voler. Pour les femelles, elles sont soit complètement exuviées mais présentant des ailes réduites qui paraissent comme des demi – ailes, soit complètement exuviées ayant des ailes très réduites (ébauches d'ailes) ce qui leur donne l'aspect d'une femelle presque aptère. Le développement nymphal est bloqué, les individus mi larve mi chrysalide sont de couleur noire avec une consistance dure du corps et partiellement exuvié. La partie antérieure est nymphale tandis que la partie postérieure reste larvaire (chenilles incapables de se chrysalider et meurent à ce stade).

Chez les individus d'*Ephestia kuehniella* (Zeller) traités au RH-0345, on a observé des malformations chez les adultes notamment au niveau des ailes qui sont soit incomplètement exuviées, soit malformées (Ouadi & Nencib, 1998). Des anomalies similaires ont été rapportées dans d'autres travaux chez de nombreuses espèces d'insectes (Oberlander et al., 1995; Smagghe et al., 1996). Le RH 0345 affecte, aussi, la croissance et le développement des larves *Culex pipiens* (Boudjelida et al., 2005). L'effet insecticide du RH-0345 étant établi, il semble que c'est l'effet différé sur la reproduction, la fertilité et le développement en général de *L. dispar* qui mérite une étude approfondie.

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Footnotes: Use of footnotes within the text should be avoided as much as possible. If necessary, it can be used below tables and figures.

Symbols and abbreviations: Unit symbols should comply with The International System of Units. Abbreviations should be explained briefly within a parenthesis where it appears first.

References: In the text, literature should be given with the last name of the author and year of the publication (For example: Oliver et al., 1996; Geray, 1998). At the end of the paper, references should be ordered first alphabetically and then chronologically. If there is more than one paper from the same author for a given year, these references should be identified by the letters a, b, c…, after the year of publication (For example: Jensen, 1998a; 1998b; 1999). See Appendix 1 for details on references.

Tables and figures: All tables and figures (graphs, photographs, maps etc.) should be numbered in the order of their citation in the text, and they should be given at the end of the manuscript. Titles of the tables should be located above, and titles of the figures should be located below the related table or figure. Tables and figures should be simple, and their text, number and symbol components should be easily visible and understandable both in print and electronic versions. Figures should be prepared in at least 300 dpi resolution and 8, 15 or 17 cm width. Characters within the figures should be in Times New Roman font type and 8 pt font size.

Submission of a manuscript: In our journal, all review and publishing processes are conducted within an electronic system. Authors who want to submit their manuscript to our journal should first visit our "web page" and "register" as an author. Our registered members can "log in" to the system and then upload their manuscript and "cover letter and copyright transfer form" as an appendix, containing their suggested referees.

Yazar rehberi

Makale A4 sayfa boyutunda, 12 punto Times New Roman yazı tipinde ve düz metin şeklinde hazırlanmalıdır. Zorunlu olmadıkça hiçbir özel format kullanılmamalıdır. Makaleye sayfa ve satır numarası eklenmelidir. Diğer hususlar için lütfen aşağıdaki açıklamalara bakınız:

Kapak sayfası: Kapak sayfasında sırasıyla makale başlığı, yazar adı soyadı, yazar iletişim bilgileri yer almalıdır.

Başlık ve özet (Türkçe ve İngilizce): Özet, 250 kelimeyi geçmeyecek şekilde yazılmalı, kısaca araştırmanın gerekçesini, amaçlarını, uygulanan yöntemi, sonuç ve önerileri içermelidir. Özet sonuna 3-6 kelimeden oluşan anahtar kelimeler eklenmelidir.

Ana metin: Makale ana metni tek satır aralıklı olarak yazılmalı, çizelge ve şekillerle birlikte toplam 15 sayfayı geçmemelidir. Konu başlıkları 1., 1.1., 1.1.1., şeklinde numaralandırılmalıdır.

Dipnotlar: Metin içerisinde dipnotlardan olabildiğince kaçınılmalıdır. Çizelge ve şekillerde ise gerekli olması halinde ilgili objenin altında kullanılabilir.

Semboller ve kısaltmalar: Birim sembolleri Uluslararası Birimler Sistemine (The International System of Units; SI) uygun olmalıdır. Kısaltmalar ise metin içerisinde ilk geçtiği yerde parantez içinde açıklanmalıdır.

Kaynaklar: Metin içinde geçen kaynaklar yazarların soyadları ve yayın yılı ile birlikte verilmelidir (Örnek: Oliver vd., 1996; Geray, 1998). Metin sonundaki kaynaklar önce alfabetik sonra kronolojik sıraya göre sıralanmalıdır. Bir yazarın aynı yılda birden fazla yayınına atıf yapılmışsa, bu kaynaklar yayın yılından sonra gelecek a, b, c… harfleriyle ayrılmalıdır (Örnek: Jensen, 1998a; 1998b; 1999). Kaynaklar hakkında detaylar için Ek 1'e bakınız.

Çizelgeler ve şekiller: Bütün çizelge ve şekiller (grafik, fotoğraf, harita vb.) metin içerisinde atıf sıralarına göre ardışık olarak numaralandırılmalı ve metnin sonuna eklenmelidir. Çizelgelerin üzerinde ve şekillerin altında başlıkları yer almalıdır. Çizelge ve şekiller mümkün olduğu kadar sade olmalı, içerilerindeki metin, rakam, sembol vb. unsurlar hem elektronik ortamda hem de kağıt baskıda net olarak görünür ve anlaşılabilir olmalıdır. Şekiller en az 300 dpi çözünürlüğünde ve 8, 15 ya da 17 cm genişliğinde hazırlanmalıdır. Şekillerde kullanılan karakterler Times New Roman yazı tipinde ve 8 punto büyüklüğünde olmalıdır.

Makalenin gönderilmesi: Dergimizin bütün hakemlik ve yayıncılık işlemleri elektronik sistem üzerinden yürütülmektedir. Dergimize yayın göndermek isteyen yazarların öncelikle dergimizin "web sitesine" girerek "kayıt" ekranından üye olmaları gerekmektedir. Kayıtlı yazarlarımız sisteme "giriş" yaptıktan sonra, makaleleri ile birlikte ve hakem önerilerini de içeren "üst yazı ve telif devir" formunu sisteme ek belge olarak yüklemelidirler.

Appendix 1. References

In accordance with generally accepted principles; author, publication year, title, publisher, page numbers and other appropriate information should be given for each reference.

Electronic references: Ordinary internet sites sources with limited credibility and permanence should not be used as an electronic reference. If a publication exists in both print and electronic versions, the print version should be preferred as a reference.

If used, electronic sources should be treated as printed sources; author, year of publication, title of the article or web page, publisher's name and place should be given. DOI numbers should be included at the end if an online-only publication is used as reference.

Ek 1. Kaynaklar

Genel kabul görmüş ilkelere uygun olarak, her bir yayının yazarı, yayın yılı, başlığı, yayıncısı, sayfa numarası ve gerekli diğer bilgileri verilmelidir.

Elektronik kaynaklar: Sıradan bir internet sitesi gibi güvenilirliği ve devamlılığı şüpheli olan elektronik kaynaklar tercih edilmemelidir. Eğer bir kaynağın hem elektronik hem de basılı hali mevcutsa, basılı olanı referans gösterilmelidir.

Eğer kullanılacaksa, elektronik kaynaklar da basılı kaynaklar gibi düşünülmeli; yazar, yayın yılı, makale veya internet sayfasının başlığı, yayıncı adı ve yeri verilmelidir. Sadece çevrimiçi yayın yapan dergilerde DOI numarası da kaynağın sonuna eklenmelidir.

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