

BIODIVERSITY OF XYLOPHAGOUS INSECTS AND THEIR ROLE IN THE *Cedrus atlantica* FORESTS DECLINE IN THE NATIONAL PARK OF BELEZMA – BATNA- (ALGERIA)

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RESUME

De tous les ennemis des forêts, les xylophages sont certainement les plus dangereux car la réussite de leur attaque entraîne nécessairement la mort de tout ou partie du sujet atteint. Peu néfastes en temps normal, ils peuvent prendre, à la faveur de circonstances particulières, un développement inquiétant et provoquer de graves dommages. Il n'est pour s'en convaincre, que de rappeler les catastrophes les plus récentes survenues dans les cédraies du Parc National de Belezma.

Dans cette aire protégée, le dépérissement du cèdre de l'Atlas dans le parc national de Belezma (Batna, Algérie), s'est probablement déclenché depuis les années 2000. C'est un phénomène complexe dont les facteurs responsables sont amplement diversifiés. Les quelques observations et études réalisées ont permis de conclure que parmi les causes de ce phénomène ; les insectes xylophages jouent un rôle primordial dans la régression de ces écosystèmes atteignant des cèdres en cours de dépérissement ou déjà dépéris. Cette étude porte sur l'une des plus importantes cédraies du parc national de Belezma, celle du Djebel Boumerzoug situé sur le territoire de la commune de Oued El Chaâba, Condorcet, où l'impact des xylophages et les bouleversements dans le climat est d'autant plus forts que cette essence forestière sensible à la sécheresse ce qui la rend sensible aux attaques des ravageurs.

Nos investigations nous ont permis d'identifier 11 insectes xylophages appartenant à 3 familles : Scolytidae, Buprestidae et Cerambycidae. Les Buprestidae et Cerambycidae sont majoritaires avec des taux total d'apparitions respectivement de 65,94% et 21,47%. La famille restante est celle de Scolytidae représenté par un taux global d'apparition relativement faible; de 12,59%. Ainsi, nous avons observé que les positions de galeries montrent une certaine synchronisation des attaques, où celles des Buprestidae viennent juste après celles de Scolytidae mais en précédant les Cerambycidae.

Cette étude montre qu'un diagnostic des attaques sur l'arbre attaqué même tardif, est indispensable car, au-delà de l'individu, c'est le peuplement qui est menacé. Le diagnostic des attaques sur quelques individus est un des éléments de base de la lutte préventive contre une épidémie.

MOTS CLES: *Cedrus atlantica*, xylophages, dépérissement, Parc National, Belezma, Algérie.

ABSTRACT

Of all of the forests' enemies, xylophagous are certainly the most dangerous because their successful attack necessarily leads to the death of all or part of the affected individual. Not very harmful in normal time, they can take, thanks to special circumstances, a worrying development and cause serious damage. It is to be convinced some, only to recall the most recent disasters which have occurred in the cedar forests of the National Park Belezma.

The dieback of the Atlas cedar in the national park of Belezma (Batna, Algeria), is probably started since the years 2000. It is a complex phenomenon for which the factors responsible are much diversified. The few observations and studies carried out made it possible to conclude that among the causes of this phenomenon; the xylophagous insects play a paramount role in the regression of these ecosystems reaching cedars in the course of decline or already decayed. This study was carried on one of the most famous and largest cedar forests of Algeria, in the national park of Belezma namely that of Boumerzoug located on the territory of the municipality of Wadi El Chaâba, where the impact of xylophagous and the climate changes is probable stronger than this tree species sensitive to drought which then makes them sensitive to pest attacks and pests is close to the southern limit of its distribution area. The method used is that of the diagnosis of the xylophagous insects' attacks through the description of the various galleries dug by them.

Our investigations have allowed us to describe a set of 11 xylophagous insects belonging to three families: Scolytidae, Buprestidae and Cerambycidae. The Buprestidae and Cerambycidae are in a majority with total rates of appearances respectively, of 65.94% and 21.47%. The remaining family is that of Scolytidae represented by a relatively low total rate of appearance; of 12.59%. The observation galleries positions have showed some timing attacks where the Buprestidae come just after those of Scolytidae but before the Cerambycidae.

This study shows that a diagnosis of attacks on the attacked tree even belated is essential because, beyond the individual, it is the population which is threatened. The diagnosis of attacks on some individuals is one of the basic elements of the preventive control against an epidemic.

KEYWORDS: *Cedrus atlantica*, xylophagous dieback, decline, Belezma National Park, Algeria.

1 INTRODUCTION

Dieback is defined like phenomena caused by a whole of factors interacting and following one another in a particular way, and which involve a general deterioration (carrying in particular on the aspect and the growth) and gradual; often ending in the death of the tree [24].

The dieback of the forests, which became a world concern, has been noticed in Algeria especially in the national park of Belezma, on the Atlas cedar since the year 1982, under dispersed spots forms and then became massive about the year 2000 [13]. If other species and areas will touched, the decline of the Atlas cedar would remain in our country the symbol of this worrying problem.

It is to be convinced, that only to quote the catastrophe which undergo the Algerian cedar forests and more particularly those of the National Park of Belezma; more than 80% of the total surface of Atlas cedar was devastated between 2003 and 2012, a hundreds of cubic meters of wood destroyed and others damaged at the same time in the mountains of Tuggourt, Bordjem and Boumerzoug. Extreme cases were observed in this region of Batna [13, 20]. The National Park of Belezma recorded the highest level of tree mortality: in Djebel Touggurt, wide areas showed forest decline and mortality and were invaded by *Fraxinus xanthoxyloïdes*, whereas in Djebel Boumerzoug *C. atlantica* almost disappeared and the space has been invaded by another drought-tolerant species, *Quercus ilex* [20].

Among the many studies carried out to try to explain the phenomenon; much concern the national Belezma Park. However, none of them still made it possible to highlight in an unquestionable way the facts in question. Rather widespread assumptions jointly intervene several factors; foremost climate changes, the water deficiency, but also the climatic accidents and especially xylophagous insects.

According to [28] and [27], the xylophagous insects often intervene in the last phase of the decline by accelerating this phenomenon.

When one wishes to understand the reasons for the differences observed in the health status of the various stands of cedar, it faces the difficulty to integrate the many environmental factors which vary at the same time: Altitude, slope, substrate, climate, topography, exposure, without forgetting the stand age and forestry characteristics above.

For this reason, we based ourselves in this study on, the xylophagous insects which are certainly the most dangerous because the success of their attack necessarily causes the death of all or part of the reached subject. Not very harmful in normal time, they can take, with the particular favor circumstances, a worrying development and causing serious damage. When the problems of "xylophagous insects" are known, "it appears worrying» [4]. At the economic level, those xylophagous ones can even generate significant losses for they can consume, the paperboard, paper and thus degrade other materials, like insulators, the plasterboards and the plastics [37].

This work aims firstly to particularly describe the main cedar xylophagous insects, through the description of the cedar entomological population; we try to find some suggestions and direction for sustainable management of this forest heritage.

2 MATERIALS AND METHODS

2.1 Experiment site

The national Park of Belezma, is a protected area covering a surface of 26.250 ha. It is located in the Eastern part of the northern Algeria at the northeastern tip of the Saharan

Atlas mountain range in Belezma which is located at the Western end of the Aures mount [3].The studied Cedar forest is located on the northwest slope of mount Boumerzoug (fig 1). This Cedar plantation covers a surface of 400 ha; within which, four stations were retained for this work. The stations selected; are almost homogeneous from the topography, soil and stands health point of view. They

are considered as repetitions; here to inventory the greatest possible number of xylophagous species. This is particularly interesting, because of the cedar forests altered health status which indicates a rate of decline at this mount of almost 95% compared to the other cedar sites where this rate varies between 50 and 70 % (fig. 2). The table (1) below shows the general characteristics of the study sites.

Table 1: General characteristics of the study plots

Station	Altitude (m)	Coordinates	Health status %	Slope	Dominance
S1	1410	35°35'47.4''N 006°05'43.0''E	Decays 95	≥40%	Cedar- Oak
S2	1419	35°35'45.6''N 006°05'42.6''E			
S3	1419	35°35'44.4''N 006°05'34.7''E			
S4	1413	35°35'43.6''N 006°05'34.6''E			

The climate is characterized by a rigorous winter and a hot and dry summer with a dry period lasting five months from May to September. The average annual rainfall is 328,3 mm. The Cedar is installed on brown calcareous soils, which locating on Marly-limestones substrates [1] and [11], [12]. The Cedar is usually accompanied by the Holm oak by forming mixed forests.

Figure2: Mountain of Boumerzoug view from the East exposure (Photo: H.Boukerker, 2009)

2.2 Material and Method

The method used in our study is that the diagnosis of the xylophagous insect attacks through the description of the different galleries dug by them. This diagnosis is essential because, beyond the individual, it is the population which is threatened. It is one of the basic elements of the preventive control against an epidemic [22]. If the galleries are entirely varied, they have on the other hand a rather constant structure and characteristic of a given species. Thus, it is often possible to simply identify a xylophagous species by the examination of its fresh or old galleries, where the interest to describe; the type of galleries traced by each principal studied species, by using a certain number of measurements, [9].

For this purpose, we have made several trips on the ground during the period 2010 and early 2011 to select the experimental sites and the trees that would be studied. In the absence of any alive trees, in the mountain of Boumerzoug; decayed trees were taken into account. Thus to increase the possibilities of meeting alive xylophagous, the selected harvest period was the summer season (May-August 2011); which represents the intense phase of adult's insect activity.

Four trees were cut in each of the four study sites. The selected trees are almost homogeneous from the age point of view (90-100 years) and dendrometric characteristics (table 2).

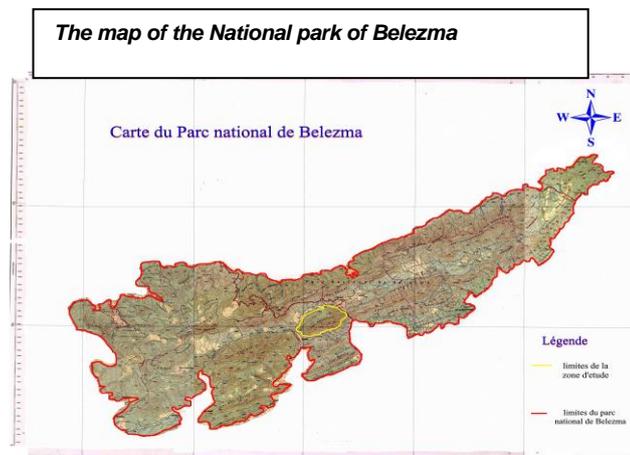


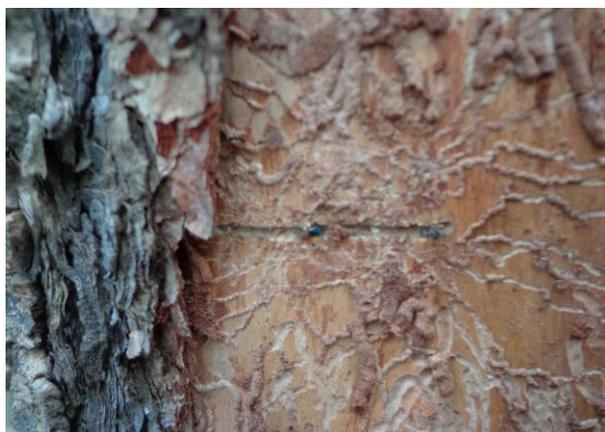
Figure 1: The location of the study area Within park the national of Belezma



Table 2: Dendrometric characteristics of the cut down trees of Atlas cedar studied in the National park of Belezma

Station	N° Tree	Height (m)	Diameter (m)	Age (years)	Station	N° Tree	Height (m)	Diameter (m)	Age (years)
1	T 1	10.63	0.24	90	3	T 1	12.00	0.18	100
	T 2	09.85	0.14	100		T 2	11.04	0.20	90
	T 3	10.42	0.17	95		T 3	09.95	0.19	99
	T 4	11.12	0.21	92		T 4	09.12	0.32	95
2	T 1	09.45	0.15	95	4	T 1	10.13	0.21	93
	T 2	08.99	0.21	93		T 2	11.12	0.22	91
	T 3	10.56	0.22	100		T 3	09.17	0.23	95
	T 4	11.10	0.19	97		T 4	08.86	0.25	100

The part of the tree concerned with the study extends from 0.5 m above ground to 7.5 meters high. These trees were carefully barked at the laboratory after their softening with water, and then these have been carefully examined with the naked eye and under a binocular magnifying glass (X10 and X16) in order to extract the remaining dead adults' insects or their nymphs and to characterize the extent damage caused by the insects incriminated; by measuring the dimensions of the devastated areas. These areas are characterized by the reaction of the tree (resin flow) and the presence of xylophagous insect traces (sawdust, galleries, lodges pupation...). The galleries dimensions were measured by using an electronic caliper and a graduate rule (mm). By using a moistened brush all the encountered invertebrates during the examination of the galleries or barks, were preserved in alcohol (ethanol) to be identified later. The confirmation of the corresponding species galleries described in this article was made, by identifying remaining in the galleries of living species or dead ones (figure 3) by using suitable keys of determination [5], [30] and [32].

**Figure3: A remaining in the gallery of dead insect**

For the descriptive evaluation of the damage extent caused by insects, and in addition to the description of the different galleries using a certain number of measurements; we opted for the parameters:

- Global rate appearance per family for all the stations in %.
- Global rate appearance per species for all the stations in %.

For statistical analysis we have used:

- D: Overall density attack (Total number of galleries for each species per station) [23] and [10], [7], [33].
- D: Overall density attack (Total number of galleries for each family per tree) [23] and [10], [7], [33].

STATISTICAL ANALYSIS

The average rates of trees attacks per family and per xylophagous species were identified and subjected to ANOVA and variance analyses with two factor station / tree were made for the variables related to measured parameters; number of galleries (overall density of attack by insect species or xylophagous family) and the comparison of the averages for the four stations was conducted using the Newman-Keuls test at 5% significance threshold using the XLSTAT version 2009.3.02 software.

3 RESULTS

3.1 Composition of the xylophagous settlements (total Abundance)

The process that we set up in the cedar plantation has allowed us to gather the specimens collected on 11 species, represented by 3 families belonging to the order of Coleoptera (fig. 4 and 5).

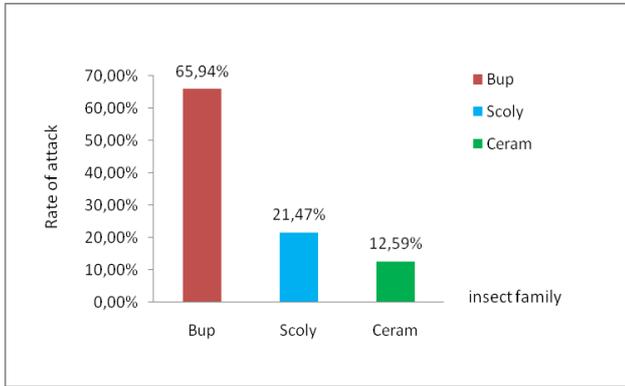


Figure4: *Xylophagous global rate appearance (%) of the Atlas cedar in the National park of Belezma*

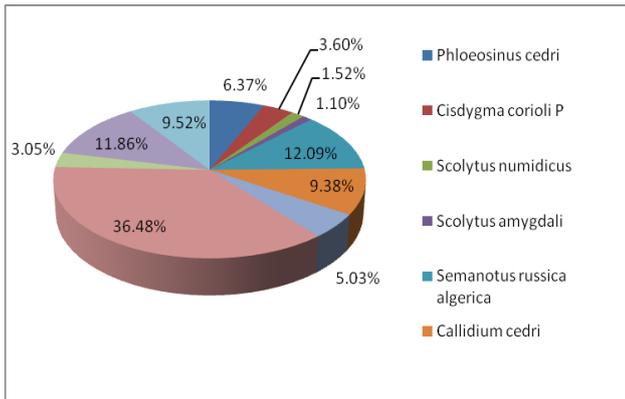


Figure5: *Xylophagous rate appearance per species (%) of the Atlas cedar in the National park of Belezma*

Reading of the different recorded rate values of species (fig.4) and families (fig.5), show that the majority families are Buprestidae followed by Cerambycidae and lastly Scolytidae. They are represented by Global rate appearance respectively by 65.94 %, 21.47 % and 12.59 %. Scolytidae are represented by *Phloeosinus cedri*, *Cisdygma corioli P*, *Scolytus numidicus* and *Scolytus amygdali*. Cerambycidae is represented by *Semanotus russica algerica* and *Callidium cedri*. Whereas the 5 species are classified among Buprestidae; it concerns *Anthaxia chobauti*, *Melanophila marmottani boudyi*, *Anthaxia crostica maroccana*, *Anthaxia ludoviccae* and *Anthaxia marmottani*

3.2 Distribution of the specimens by systematic order

Buprestidae and Cerambycidae are in a majority with total

rates of appearances respectively of 65.94% and 21.47% (fig.4). The first are present with species rates of appearances of 5.03 %, 36.48 %, 3.05 %, 11.86 % and 9.52 % respectively of *Anthaxia chobauti*, *Melanophila marmottani boudyi*, *Anthaxia crostica maroccana*, *Anthaxia ludoviccae* and *Anthaxia marmottani*. On the other hand *Semanotus russica algerica* and *Callidium cedri* are present with species rates of appearance of 12.09 % for the first and 9.38 % for the second one. The remaining family is that of Scolytidae represented by a relatively low total rate of appearance; of 12.59%. Thus, this family is represented by four species *Phloeosinus cedri*, *Cisdygma corioli P*, *Scolytus numidicus* and *Scolytus amygdali*, (fig.5).

Statistical analysis of the variable “overall density attack” corresponding to each family per tree showed that the family of Buprestidae is significantly higher than those of Cerambycidae and Scolytidae (Table 3).

All Atlas cedar trees were attacked by all species of xylophagous, so the three families are present in the four stations, but at different rates. Atlas cedar seems more often attacked by xylophagous belonging to the family Buprestidae with an estimated average per tree of about 16.5. The family of Cerambycidae is classified in second place with an average of 5.37. And finally the family of Scolytidae with an estimated average of 3.18 (Table 3).

Table 3: *Family / Newman-Keuls (SNK) / Analysis of the differences between the terms with a confidence interval of 95%*

Modality	Estimated average per tree	Groups
<i>Buprestidae</i>	16,5	A
<i>Cerambycidae</i>	5,37	B
<i>Scolytidae</i>	3,18	C

These results show that *Melanophila marmottani boudyi* attends much the cedar with an estimated average per station of 36.25 followed by by *Semanotus russica algerica* and *Anthaxia ludoviccae* with an average of 12. Same tendencies that previously with significant differences are observed for the two homogeneous groups *Callidium cedri*, *Anthaxia marmottani* and *Phloeosinus cedri*, *Anthaxia chobauti* (table 4).

The two species *Cisdygma corioli P* and *Anthaxia crostica maroccana* do not differ significantly between them (respectively averages of 3.5 and 3.25) and is classified right before the last group constitutes of both scolytides; *Scolytus numidicus* and *Scolytus amygdali* with smallest estimated average of 1.5. (Table 4).

Modality	Estimated average per station	Groups
<i>Melanophila marmottani boudyi</i>	36,250	A
<i>Semanotus russica algerica</i>	12,000	B
<i>Anthaxia ludovicæ</i>	12,000	B
<i>Callidium cedri</i>	9,500	C
<i>Anthaxia marmottani</i>	9,250	C
<i>Phloeosinus cedri</i>	6,250	D
<i>Anthaxia chobauti</i>	5,250	D
<i>Cisdygma corioli P</i>	3,500	E
<i>Anthaxia crosica maroccana</i>	3,250	E F
<i>Scolytus numidicus</i>	1,500	F
<i>Scolytus amygdali</i>	1,500	F

Table 4: Species / Newman-Keuls (SNK) / Analysis of the differences between the terms with a confidence interval of 95%

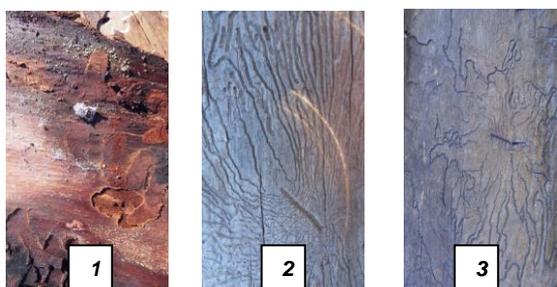
3.3 Presentation of the galleries characteristics systems of the principal xylophagous species

3.3.1 Family of Scolytidae

Phloeosinus cedri species seem to have a preference on the relatively young subjects of cedar. According to various measurements made in the galleries of this family (figure 6), *Phloeosinus cedri* proved to be the species which digs a system of galleries, of which the lengths present significant variations; and which seems according to [16]; depend on the duration of development of the larva or its survival, which in their turn can depend on the climatic conditions like capacities of the reactions of the plant-host. The system is of type under cortical with variable lengths and constant widths of the larval galleries and maternal gallery. The latter is laid out according to the longitudinal axis of the tree. On the other hand the larval galleries are perpendicular to the maternal gallery. The number of oviposition is of 14 ± 3 on average. As a whole the system of gallery seems present in wood a sculpture in the shape of millipede



Figure6 : Galeries systèmes of the principale xylophagous species (source : The author 's work out) : 1) *Cisdygma corioli P*, 2) *Scolytus numidicus*, 3) *Scolytus amygdali*, 4) *Semanotus russica algerica*, 5) *Callidium cedri*, 6) *Anthaxia chobauti* , 7) *Melanophila marmottani boudyi*, 8) *Anthaxia ludovicæ*, 9) *Anthaxia marmottani + Scolytus numidicus*



However, for *Scolytus amygdale*, this one presents a system of simple longitudinal gallery (figure 6), generally parallel with the axis of the tree; the female practices an opening of entry not exceeding 1.5 mm of circumference. At the beginning, the larval galleries are perpendicular to the maternal gallery then they become sinuous has their termination and inflect to the top or bottom to become at least parallel to the corridor of laying. These later

measured between 3.7 and 4.6 cm of length and 1.6 mm of width. With an orientation generally parallel with the axis of the trunk or directed perpendicularly especially in the branches. The galleries sculpture of approximately 0.4 mm of depth; clearly impress the sapwood on which are laid out on both sides of the maternal corridor; notches of laying.

Concerning *Cisdygma corioli* P, its system of gallery is under cortical impressing sapwood slightly (figure 6). The observations showed that the mushrooms inoculated by this insect erase in the major part of the observed cases any trace of galleries. This species presents a system laying of the «transverse» type; the corridor of laying practiced by the female, measures 5mm length and 0.6mm width. From this last and parallel to the tree axis, the various larval galleries start, with a variable length of 19 mm to 127 mm. The galleries have sizes variable which seem function of the lifespan of the larva and dimensions that offers the attacked organ; whereas the width is relatively constant (meadows of 0.5mm).

A longitudinal, parallel gallery system to the axis of the trunk or branches (in the major part of the case) was observed for *Scolytus numidicus* species. But is directed sometimes obliquely or perpendicular to these axes (figure 6). The longitudinal maternal corridor is furnished with well marked side notches of laying and larval gallery. These species practices only one laying oviposition corridor of an average length and width respectively, of 39 mm and 1,4 mm, which works sapwood clearly. This gallery is characterized by its starter in the shape of hook [6]. The larval galleries impress wood slightly. These last present numbers some which differs from one to another of the same maternal gallery. They are very tight, fine and long. With their starting point, they work wood slightly, and then they become large and deep while being inserted in sapwood as they move away from the maternal gallery. These larval galleries are initially perpendicular to the oviposition laying gallery then are directed at least to the top or the bottom of the system to become at least parallel to the maternal gallery. The holes of nymphose in bottom of bag appear at the final end of the larval gallery.

3.3.2 Family of Cerambycidae

The *Semanotus russica algerica* species digs very variable orientation galleries compared to the tree axis (figure 6). They can be parallel, perpendicular or oblique compared to this last. The branches of smaller diameter are preferred by the larvae. The galleries dug in wood by these larvae, have a few specific form. Generally parallel to surface, mouthful at its base by a remains cluster woody and bent of the length dimension of 1.9 and of 2,7 cm.

For *Callidium cedri*, its presence is generally marked on deadwood or in decomposition, on either branches or trunks. It digs galleries which strongly impress the liber (figure 5). The galleries dug by the larvae are subcortical and parallel to the axis of the trunk, but penetrate then in the external part of sapwood where the nymphs takes place. The adults holes exit, that observed on the infected or

attacked trunks surface, have an oval form length and width respectively of $7,9 \pm 1,7$ mm and $4,1 \pm 1,5$ mm.

3.3.3 Family of Buprestidae

General observations can be allotted to the species belonging to this family. The small boxes nymphos are proportional to size species, while the lengths of the larval galleries are likely significant individual variations. The openings dug by the various larvae for the exit of the future adults are generally oval, of variable dimension according to the size of the species and in the major part of the cases are directed parallel to the branches or to the tree trunk (figure 6). Smallest buprestae, *A. corsica maroccana* and *A. martini* thus dig the smallest galleries in branches of low diameter. Conversely, *M. marmottani boudyi*, the largest cedar Buprestidae, digs the biggest galleries in trees parts of large diameter and does not make damage on the summit and the branches. Lastly; *A. chobauti*, *A. marmottani* and *A. ludovicae* whose sizes are practically similar; dig galleries of almost equivalent surface. Generally, the galleries dug by the species of this family are very deep in the phloem and the phelloderm.

For the five species of Buprestes, namely *Anthaxia martini*, *A. corsica maroccana*, *A. ludovicae*, *A. chobauti* and *A. marmottani* our results agree with those of [19]. Thus *Anthaxia martini* and *A. corsica maroccana* prefer to attack the summit parts of the tree and the small branches, *A. ludovicae*, *A. chobauti* and *A. marmottani* go on the average dimension such as the trunk and the big branches, while *Melanophila marmottani* seems to prefer the large gauges, in particular the base of the tree.

The *Melanophila marmottani boudyi* (Fairmaire, 1868) species has the characteristic to have a larger size compared to the other species of Buprestae. On the contrary of other species of the *Anthaxia* kind, this species digs penetrating and sinuous galleries with an average width of 6.9 cm, but also of the different lengths, on average 27 cm length. The larva starts and digs a gallery slightly marking wood compared to the bark (figure 6). The nymphose holes of ovals form are arranged deeply in wood. The cabins nymphales, are generally carried out on the level of woody tissues. They measure on average 6mm of length, 2,5 mm of width and 10 mm of depth.

Concerning *Anthaxia marmottani*, The larva digs sinuous galleries of variable length (103.05mm to 135.19mm). They dig corridors comparatively to *Anthaxia corsica maroccana* and *Anthaxia ludovicae*; impress less the xylem. It drills in sapwood deep nymphose holes which are oval and measure 6 mm in diameter (figure 6).

For *Anthaxia chobauti*, this species seems much as *Anthaxia marmottani*, concerning the nypal holes which are deep and oval and dimensions of the galleries which are sinuous and impressing well the xylem with variable lengths, on average varies between 9 and 11cm (figure 6).

However *Anthaxia corsica maroccana*, with the reverse of *Anthaxia marmottani* the larvae of this species deeply dig

in the xylem sinuous galleries of an approximate length of $(80.25 \pm 19 \text{ mm})$ (figure 5).

Lastly the galleries dug by the larvae of *Anthaxia ludovicæ* in sapwood are sinuous and compared to the preceding species of Buprestidae; are relatively big from the width and depth point of view. The nymal cabin has an average depth (figure 6).

4 DISCUSSIONS

The observation of the galleries positions show that the Buprestidae attacks come after those of Scolytidae but precede those of Cerambycidae. Concerning the species *Melanophila marmottani*; it has been described by [15] as the species most attached to the Atlas cedar that it is almost impossible to find a dead or dying branch or a trunk which does not carry its traces. This may be the reason for which we recorded a relatively high rate of appearance of 36.48 % compared to the other species belonging to the same family.

The genus anthaxia is represented in our results by four species with rates of appearance per species which do not differ much. It varied between 3.05 % for *Anthaxia crosica maroccana* and 11.86 % for *Anthaxia ludovicæ*. This kind has already been reported on *Cedrus atlantica* in Algeria by [18] and by [8]; [9] and [25] in Morocco. According to same authors', this genus is always implicated in the attacks affecting the coniferous trees of the North of Africa. The five species of Buprestes quoted previously seem more abundant in the massive forest of Boumerzoug, hastening cedar decline. They represent 65.94% of the total xylophagous in our study sites.

Regarding Cerambycidae subservient to the Atlas cedar, they are classified in second position after Buprestes by an appearance total rate of 21.47%.

Our observations made it possible to notice the presence of only two species *Semanotus russica algerica* and *Callidium cedri*. The Analysis of the positioning sculptures galleries of both species has shown that these are secondary insects and come after the scolytes. Their massive abundance was recorded on wood of relatively large dimensions. These two species, compared to other xylophagous present longer, wider and deeper galleries. They were observed on decaying trees. These results found were confirmed by [26], indicating that they are species that attack deadwood or in decomposition.

Thus, [9], presents *Semanotus russica algerica* whose larva develops exclusively on cedar under branches barks of small diameter [36] and *callidium cedri* Peyerimhoff develops on the side of the previous on branches or cedar logs.

Scolytidae family is represented with an overall appearance of 12.59 % rate. *Phloeosinus cedri* seems prefers branches or trunks of young trees and shows a predilection for the zones with thin bark. Its small presence in mount Boumerzoug, may be due to the fact that the dieback cedar has this place; is so old that the trees are dry and almost devoid of sap. That is what was reported by [14] on this

primary pest; which requires a high carbohydrate nutrient medium and prefers branches sap with only slight physiological deficiency. Young adults primary cause damage by their bites usually at the expense of nutrition stems and shoots of young cedars.

Cisdygma corioli settles in the wood in an advanced state of decay. In spite of its density of recorded attack which is relatively low (3.6 %); the damage caused on the cedar trees touched by this species is important, and this may be due to the inoculation to cedars of phytopathogenic fungi responsible for certain diseases. According to [22] the success of an attack of bark beetles leaves visible traces of galleries on the trunk, accompanied sometimes with black zones corresponding to the development of associated mushrooms (xylo-mycophage species). According to the same author, these fungi are involved in the blue stain. [29] Affirms that some bark beetles are associated with another organism (fungi conveyed in the form of spores on the cuticle), which allows them to bypass the defense reaction of the tree (resin). For example, the fungus grows rapidly and enters the cambium, where it stimulates the formation of new compounds that weaken the trees, causing a stoppage of water supply (loss of hydraulic conductivity) and the rapid death of trees after the attack of bark beetles.

This is what was confirmed in the field by the recognition of a significant presence of these fungi on the cedar trees in decline, and even begin to remove traces of sculpture galleries by breaking them down. For the species, *Scolytus numidicus*, it preferably digs its galleries in the branches of small diameter from 3 to 4 cm, on decaying trees. According to [29]; [21]; [15], is the only species of the genus living exclusively at the expense of *Cedrus atlantica*. It is met, in Morocco (Middle Atlas and Rif) and Algeria (Chr ea in the Blid en Atlas and Djurdjura). This bark beetle is not a primary pest as *C piceae* and *Phloeosinus cedri* but it can become in the event of epidemic invasion [6]. It is what we have observed in our sites of study, at the mount of Boumerzoug where the rate of dieback exceed the 95%.

Scolytus amygdale: Generally, the relatively low rates of Scolytidae and C erambycidae appearance (compared to Buprestidae) with respectively estimated values of 12.59 % and 21.47%, can be due to the probable presence of its natural enemies that are composed mainly of the coleopteran order predatory like it has been reported by [17] and [18], on *Nemosoma breviatum* as the most important under cortical lignivores, that attack the scolytae as well as cerambycidae. Contrary to *Thanasimodes dorsalis* and *Trichodes sp* which attack only the scolytae, while *Temnochila coerulea*, *Malachius lusitanicus* and *Clanoptilus rufus* attack Cerambycidae.

An American dendrochronology specialists team of the Arizona university, that have visited the cedar forests of this protected area; have shown the effect of the climate change on the cedar which would have badly supported the climatic upheavals dominated by persistent periods of heat wave [35]. They showed for the period going of 1148 up to 2006, two periods of long duration consecutive dryness.

The first is spread out between 1557 -1561 and the second of 1998-2002.

According to [35], the hydrous stress, therefore, is suspected to be the potential source of the cedar die-back. The more limiting conditions with frequent and severe droughts that was recorded in the region of the Aures during the last decades, has generated a higher common response of tree growth towards climatic signals [31].

In addition as regards precipitations, the comparative study of the climate in Belezma between the two periods (1975-1993) and (2000-2008), has shown a fall between these periods of 107,2 mm corresponding to a deficit of approximately 23% [33]. Thus, the dryness period and intensity is spread out over a long 10 months period which begins mid-May and hard until September.

These factors have disturbed the physiology of the cedar plantations; making them sensitive to the xylophagous attacks. In the same way, the decay caused by the acuminate one (*Ips acuminatus* Gyll) in all the area of Alps-Provence in Azure's Coast of 1987 to 1989; has followed upon several years of water deficiency deficit [33]. Thus dendroclimatology and dendroecology analyzes results, confirm the hypothesis of climate impacts on the decline, highlighting the problem facing the cedar to manage the water reserves of the Belezma soil, especially from 1980 to 2005 (MESSAOUDENE et al ., TOUCHAN et al.in [2]). The proven lack of forestry policy as regards sylviculture in the forest formations of Belezma, can undoubtedly explain the proliferation of the degradation's factors in the cedar forests [2].

5 CONCLUSION

This modest study has allowed us firstly to know the role of cedar xylophagous insects in the decline and secondly, to identify, inventory and describe the entomological stands associated with cedar dieback in the Belezma national park area, especially at the level of the Boumerzoug mount. Thus it makes it possible to appreciate the state of the trees infestation by these pests while evaluating their harmfulness. The subcortical examination thus informs us, about the success of the attack and on the precise nature of the aggressor.

The trees barking have allowed us to highlight 11 species of xylophagous belonging to the order of the Coleoptera. These species that are represented by three families; Scolytidae, Buprestidae and Cerambycidae, are at the origin of the massive dieback observed on the cedar. These xylophagous insects are agents of forests weakening and seem to be an apparent symptom of decay. The used protocol; decortications, observations, measurements and comparison of the various observed galleries systems, allowed us to identify and specify the specific xylophagous species corresponding to the various galleries. It was also possible to reconstitute the xylophagous attacks succession which infested trees and thus to define their characteristics through the visual analysis of the galleries sculptures positioning. Indeed; Scolytidae settle in first, Buprestidae

arrive then and finally, Cerambycidae lastly. This information constitutes for the entomologist a tool of assistance to diagnose the damage and to identify the xylophagous species in the field.

To our knowledge, several species of xylophagous are reported for the first time in this study on the cedar forests of Belezma. It is in particular about *Phloeosinus cedri*, *Cisdygma corioli* P and *Scolytus numidicus* for Scolytidae; *Semanotus russica algerica* and *Callidium cedri* for Cerambycidae and finally *Anthaxia chobauti* *Anthaxia crosica maroccana*, *Anthaxia ludovicae* and *Anthaxia marmottani* for Buprestidae.

It also appears obvious through this modest contribution that these last species seem to have a dependent spatial distribution of the choice and the requirements of each species with respect to the medium, cedar's dimensions and the richness of this species in water and nutrients. Thus the sometimes significant differences recorded of the presence rates of certain species compared to others; can be allotted to the non requirement of these last. By counter, the others which present a more restricted distribution are more demanding. In mountain Boumerzoug, this protocol has formally demonstrated that Cerambycidae and especially the Buprestidae, make the majority of the xylophagous fauna of the cedar forests.

The high percentages of insects attack belonging to these families, on the Atlas cedar trees, may be due to the low number of the natural enemies (parasitic and predatory) of these xylophagous or related to the bad health state of the station compared to those of Touggurt and Bordjem. The strong presence of these xylophagous species at the level of forests' cedar can be explained by the deteriorated state of the Belezma forest, which contains a large number of privileged trees, therefore constituting consequently a very hostile biotope to their outbreak. [34].

The mountain of Boumerzoug is characterized by skeletal grounds, with a low thickness exploitable soil by the roots and with a strong slope exceeding the 50%, which has caused significant hydrous erosion at the expense of the water needs of cedar (low useful soil reserve). A more detailed study of these pests is needed in this area of Algeria severely affected by the decline (more than 70%). It would be also desirable to study the impact of mushrooms associated with xylophagous to estimate the economic repercussions of their damage.

The study of the xylophagous attacks can made up an effective means for the diagnosis of a physiological imbalance which probably (considering the small number of the observed insects during our study) can be related to other medium factors such as pathogenic mushrooms (Armilaire.etc), topography (slope, exposure and altitude), type of forests (monospecific or mixed) and the soil by its hydrous characteristics especially (useful reserve, surface quality, exploitable thickness by the roots). The xylophagous ones constitute a significant element of cedar forest degradation in Algeria.

A multidisciplinary study is recommended in the cedar

forests of this protected area, in order to highlight, the role of the other biotic and abiotic factors (climate, soil and mycologic) in the course of the phenomenon of decay.

View the massive decline that the cedar undergo; a quantitative analysis of the space distribution of the various xylophagous species is necessary and can be carried out in order to put in relation with the mortality rate, which according to our observations differs largely from one site to another. Each insect species is recognizable by its form and the shape of the galleries which has dug, thus it is possible to study their distribution by trapping or at least a posteriori by analyzing the galleries under the bark of the dead trees.

It is also desirable to carry out comparative studies on the xylophagous fauna of the other Algerian cedar plantations; to highlight the typical subservient species with the Atlas cedar, because in Algeria the listing of these species remains incomplete.

Moreover, as reported by [22], even when the diagnosis is very early, there are not often remedies to save the tree and one can then count only on the intrinsic defense capacities of this one. However, even late, a diagnosis attacks on the infested trees is essential because, beyond the individual, it is the population which is threatened. The diagnosis of the attacks on some individuals is one of the basic elements of a preventive control fight against an epidemic.

In the end, it should be appropriate to recall; that the experimentation was led in a particular area with only four stations, and that the possibilities of generalization of the results are necessarily limited.

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