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BARK BEETLES (COLEOPTERA CURCULIONIDAE SCOLYTINAE) ASSOCIATED WITH *PINUS PINEA* IN LEBANON: NEW RECORDS WITH REMARKS ON THEIR ECOLOGY, DISTRIBUTION AND POTENTIAL THREAT FOR FOREST STANDS

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El Khoury Y., Binazzi F., Nemer N., Noujeim E., Tarasco E., Roversi P.F., Pennachio F. – Bark beetles (Coleoptera Curculionidae Scolytinae) associated with *Pinus pinea* in Lebanon: new records with remarks on their ecology, distribution and potential threat for forest stands.

Five species of Scolytinae new to Lebanon were recorded on *Pinus pinea*: *Hylurgus ligniperda* (Fabricius), *Hylurgus micklitzi* Wachtl, *Hylastes angustatus* (Herbst), *Hylastes attenuates* Erichson, *Carphoborus pini* Eichhoff. Their ecology, distribution and potential phytosanitary risk are discussed in the context of stone pine conservation.

KEY WORDS: Scolytinae, *Pinus pinea*, new records, Lebanon.

INTRODUCTION

Lebanon is situated along the northeastern border of the Mediterranean Sea and it is part of the Middle East and Southwest Asia. The country is divided from South to North by the African-Syrian Rift Valley, which defines the following geographical regions: the coastal Plain, the Lebanon Mountain Range, the Bekaa Valley and the Anti-Lebanon Mountain Range (BEAUMONT *et al.*, 1976). Lebanon has a Mediterranean climate typically characterized by abundant rainfalls during the winter and marked drought conditions in the summer period. The high-altitude regions of the Lebanese Mountain Range are characterized by heavy rainfalls, contrary to the eastern part of the country where a more arid environment is dominant (BIEL, 1944).

These peculiar geomorphological and climatic conditions are ideal for the growth of the stone pine *Pinus pinea* L., a widespread conifer covering more than 12,000 ha in this country (FAO, 2005, 2010; ABOU-FAKHR HAMMAD, 2014).

From an economic and cultural perspective, the most important and emblematic *P. pinea* areas are those situated on Mount Lebanon in the districts: El Metn, Baabda and Aley (7,200 ha). In these sites, the majority of stands belong to private owners and are often located within small properties intensely managed with traditional practices (e.g. pruning and ground clearing) in order to increase cone productivity (NEMER, 2015 FAO). Stone pine is also sparsely spread in the district Chouf, though the second main area is located in the neighboring district Jezzine, South Governorate (about 2,000 ha), where the majority of stands are state-owned properties (ABOU DAHER, 2015; NEMER, 2015). Moreover, other stands are situated in the South, in the inner district Hasbaiya or in the North at Beit Menzer/Hadath El Jebbeh in the district of Bcharré. Furthermore, single trees are present almost everywhere along the coast, including the district of Akkar in the northern part of the country.

Pinus pinea is important for Lebanese rural economy as it is particularly praised by local communities for its nut production and use as fuel wood. In addition, its action against soil erosion in sandy slopes has been well documented in recent literature (NEMER, 2015 FAO). Nonetheless, in the last years, this conifer has increasingly suffered from Dry Cone Syndrome (DCS), a relatively recent disease responsible for the decline of pine nut production in the entire Mediterranean basin. The most relevant damages related to DCS are either a substantial conelet loss in the tree crown before ripening or a marked decline in pine nut yield per harvested cone weight (NEMER, 2015 FAO). This disease, which is still under investigation, could be the ultimate consequence of the combined action of multiple factors resulting in severe damages to stone pine forest vitality. Biotic agents such as pests and diseases, climatic factors, or traditional management of stands such as heavy pruning and clearing practices might play a crucial role in the genesis of this phenomenon.

In the light of the ecological complexity of stone pine ecosystems and because of their delicate equilibrium, there has been a growing emphasis, in the last years, on insects synergistically interacting with this plant (NEMER, 2015

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FAO). Among them, the most relevant in terms of threat to *P. pinea* nuts production is certainly *Leptoglossus occidentalis* Heidemann, a well-known coreid responsible for severe losses to pine nut production (Strong *et al.,* 2001; Strong, 2006; Roversi, 2009; Santini, 2010; Nemer *et al.,* 2019). Biological control agents against this pest are currently under investigation, as an alternative to chemical control (Masner, 1983; Bates and Borden, 2004; Roversi *et al.*, 2011; Sabbatini Peverieri *et al.*, 2012, 2013; Binazzi *et al*., 2013; Paoli *et al*., 2013; El Khoury *et al*., 2018); nonetheless, their efficacy in the field has not been definitively proven and nut production remains endangered in most of the stone pine range. Other potential pests already reported as associated with *P. pinea* in Lebanon are *Tomicus destruens* (Wollaston) and *Orthotomicus erosus* (Wollaston).

Tomicus destruens is frequently attracted to pine forests heavily stressed by drought, fire, or root diseases, and in some Mediterranean countries, it has been often reported as a major cause of pine mortality (Lieutier *et al*., 2016). Conversely, *O. erosus*, though being generally a secondary species breeding in logs or trees already colonized by more aggressive beetles, may sometimes attack plants weakened by stress factors such as fire or drought (Robertson, 2008). Moreover, this beetle has been reported as a potential vector of several *Bursaphelenchus* species such as *B. fuchsi* (Braasch and Philis, 2002), *B. fungivorus* (Arias *et al*., 2005), *B. teratospicularis* (Penas *et al.,* 2006), *B. sexdentati* (Carletti *et al*., 2008) and *B. minutus* (Torrini *et al*., 2017).

Bark beetles represent the most economically relevant group of forest pests (Ciesla, 1993). However, despite the increasing attention to their activity, there is still limited knowledge on their interaction with stone pine in Lebanon. The focus of our paper was thus on new records of Scolytinae associated to *P. pinea* with remarks on their ecology, distribution and potential threat for forest stands.

MATERIALS AND METHODS

From August 2014 to October 2018, insects were collected in pure and mixed formations of *P. pinea*. Specimens were sampled from variable-size stands located in diverse habitats. Pine stumps, logs, branches and waste material were manually debarked and inspected for insects. The collected material was then identified based on the keys of Balachowsky (1949), Pfeffer (1995), Schedl (1981), Wood (1986), Wood and Bright (1992). The Scolytinae collections from the Research Centre for Plant Protection and Certification (CREA-DC, Florence, Italy) and the personal collection of Dr. Fabrizio Pennacchio were also used for comparisons. Information concerning current distribution of bark beetles and their association with host plants were mainly obtained from Wood and Bright (1992), Bright and Skidmore (1997), Bright and Skidmore (2002) Knížek (2011), Bright (2014), Lieutier *et al*., (2016) and Alonso-Zarazaga *et al.,* (2017).

RESULTS

During the present study, five species of Scolytinae new to Lebanon were recorded on *P. pinea*: *Hylurgus ligniperda* (Fabricius), *Hylurgus micklitzi* Wachtl, *Hylastes angustatus* (Herbst), *Hylastes attenuates* Erichson, *Carphoborus pini* Eichhoff.

Hylurgus ligniperda Fabricius, 1787

Examined material: El Metn district, Bikfaya, N 33°92'30.28", E 35°67'94.72", 821 m a.s.l. breeding on *P. pinea*, Nabil Nemer leg., n 6 specimens, June 2018; Baabda district, Qsaybeh, N 33°86'74.31", E 35°65'47.38", 627 m a.s.l. breeding in logs of *P. pinea*, Yara El Khoury leg., n 5 specimens, October 2018.

The chorotype of *H. ligniperda* is European. This species had been previously reported in Africa, from Algeria, Azores Islands, Canary Islands, Madeira Island, Morocco, St. Helena Island (introduced), South Africa (introduced), Swaziland (introduced), and Tunisia, (Schedl, 1959; Wood and Bright, 1992; Bright and Skidmore 1997; CABI/EPPO 2010; CABI, 2019); in Asia from Turkey, China (Manchuria), India (likely introduced), Sri Lanka (likely introduced), Japan (introduced), (Serez, 1987; CABI/EPPO, 2010; Sarikaya and Avci, 2011; CABI, 2019); in Europe from Austria, Belarus, Belgium, Bosnia Hercegovina, Bulgaria, Cyprus, Croatia, former Czechoslovakia (Cech Republic and Slovakia) Denmark, Estonia, Finland, French mainland with Corsica, Germany, Greek mainland, Hungary, Italian mainland with Sicily and Sardinia, Latvia, Lithuania, Macedonia, Moldova, Montenegro, Netherlands, Norwegian mainland, Poland, Portugal mainland, Russian Federation (Caucasus, Central European Russia, Crimea, Daghestan and North European Russia) Serbia, Slovenia, Spanish mainland with Balearic islands, Sweden, Switzerland, UK, Ukraine (Schedl, 1967; Leker *et al.,* 1977; Rudnev and Vasechko, 1988; Burakowski *et al.,* 1992; Wood and Bright, 1992; Pfeffer, 1995; Bright and Skidmore 1997; Pileckis and Monsevicius, 1997; Bright and Skidmore 2002; Colonnelli, 2003; CABI/EPPO 2010; Knížek, 2011, 2013; Bright, 2014; Lieutier *et al.,* 2016; CABI 2019); in North and South America (where it is introduced) from United States, Argentina, Brazil, Chile, Paraguay, Uruguay (Shedl, 1959; Wood and Bright, 1992; Bright and Skidmore 1997, 2002; Wood, 2007; Tiranti, 2010; Bright, 2014; Kirkendall, 2018); in Oceania (where it is introduced) from Australia and New Zealand (Hosking, 1979; Wood and Bright, 1992; CABI/EPPO, 2010; Alonso-Zarazaga *et al.,* 2017; CABI, 2018).

Hylurgus ligniperda had been previously recorded on the following host plants: *Pinus brutia, P. canariensis, P. contorta*, *P. elliottii, P. halepensis, P. kochiana, P. montezumae*, *P. nigra, P. nigra austriaca, P. nigra nigra, P. nigra pallasiana, P. patula, P. pinaster*, *P. pinea, P. ponderosa, P. radiata, P. sylvestris, P. sylvestris var. hamata* and *P. strobus*; other records were also reported from *Cedrus; Larix*; *Picea; Pseudotsuga* (Wood and Bright, 1992; Bright and Skidmore 1997; Wood, 2007; Bright, 2014; Kirkendall, 2018; CABI, 2018).

Hylurgus micklitzi Wachtl, 1881

Examined material: El Metn district, Broumana, N 33° 88'19.29", E 35°63'94.55", 682 m a.s.l. breeding on *P. pinea*, Nabil Nemer leg., n 12 specimens, May 2018; El Metn district, Bikfaya, N 33°92'30.28", E 35°67'94.72", 821 m a.s.l. breeding on *P. pinea*, Nabil Nemer leg., n 7 specimens, June 2018; El Baabda district, Qsaybeh, N 33°86'74.31", E 35°65'47.38", 627 m a.s.l. breeding on *P. pinea*, Yara El Khoury leg., n 8 specimens, September and October 2018.

The chorotype of *H. micklitzi* is Mediterranean. This species had been already reported in Africa, from Algeria, Egypt, Libya, Morocco, Tunisia; in Asia, from Palestine and Turkey; in Europe, from Spanish mainland, French mainland, Germany, Greek mainland, Malta, Cyprus, Hungary, Italian mainland with Sicily and Sardinia, former W USSR (Russian Federation including Caucasus and Krasnodar) and former Yugoslavia (currently Croatia) (Pfeffer,1995; Shedl, 1967; Wood and Bright, 1992; Bright and Skidmore, 2002; Colonnelli, 2003; Bright, 2014; Knížek, 2013). *Hylurgus micklitzi* had been previously recorded on the following host plants**:** *Pinus halepensis*, *P. pinaster, P. pinea* and *P. nigra pallasiana balcanica* (Wood and Bright, 1992; Bright and Skidmore, 1997; Alonso-Zarazaga *et al.,* 2017).

Hylastes angustatus Herbst, 1793

Examined material: Baadba district, Arsoun, N 33°85'09.31", E 35°70'63.92", 954 m a.s.l. breeding on *P. pinea*, Yara El Khoury leg., n 7 specimens, July 2015, October 2015, and September 2018.

The chorotype of *H. angustatus* is European. This species had been previously reported in Africa from South Africa (where it is introduced); in Asia, from Turkey and Iran; in Europe, from Austria, Belarus, Bulgaria, Croatia, former Czechoslovakia (currently Czech Republic, Slovakia), Danish mainland, England, Estonia, European Turkey, Finland, French mainland, Germany, Greek mainland, Hungary, Italian mainland with Sicily and Sardinia, Latvia, Lithuania, Macedonia, Moldova, Norwegian mainland, Poland, Portuguese mainland, Spanish mainland, Sweden, Belgium, Switzerland, former USSR (currently Central European Russia, Dagestan, Northwest European Russia), UK, Ukraine, former Yugoslavia (currently Croatia, Kossovo, Macedonia, Montenegro Serbia and Slovenia) (Schedl, 1967; Lekander *et al.,* 1977; Wood and Bright, 1992; Bright and Skidmore, 1997; 2002; Colonnelli, 2003; Knížek, 2013; Bright, 2014; Lieutier *et al.,* 2016; Alonso-Zarazaga *et al.,* 2017).

Hylastes angustatus had been previously recorded on the following host plants: *Pinus elliottii, P. kochiana, P. laricio, P. montezumae, P. mugo* (sub. *P. montana*), *P. nigra var. austriaca, P. nigra nigra, P. nigra pallasiana, P. pinaster, P. pinea, P. pumila; P. sylvestris; Larix decidua, L. europea; Picea abies* and *P. orientalis* (Schedl, 1981; Wood and Bright, 1992; Bright and Skidmore, 1997; Bright, 2014; Lieutier *et al.,* 2016).

Hylastes attenuatus Erichson, 1836

Examined material: El Metn district, Qsaybeh, N 33°92'30.28", E 35°67'94.72", 627 m a.s.l. breeding on *P. pinea*, Yara El Khoury leg., n 3 specimens, October 2018.

The chorotype of *H. attenuatus* is European. This species had been previously reported in Africa from Azores Islands and Madeira island; in Asia from China "Manchuria", Iran, Japan, Korea, Taiwan (probably introduced) and North European territories (Russian Federation); in Europe from Austria, Belarus, Belgium, former Czechoslovakia (Czech Republic and Slovakia), Cyprus, England, Estonia, Finland, French mainland and Corsica, Germany, Greek mainland, Hungary, Italian mainland and Sicily, Latvia, Lithuania, Norwegian mainland, Poland, Portugese mainland, Spanish mainland, Sweden, Switzerland, Turkey, Ukraine, former Yugoslavia (Bosnia Herzegovina, Croatia, Kossovo, Macedonia, Montenegro, Serbia, Slovenia), former USSR (Daghestan, Central European Russia and Northwest European Russia) (Schedl, 1967; Lekander *et al.,* 1977; Wood and Bright, 1992; Pfeffer, 1995; Bright and Skidmore, 1997; 2002; Colonnelli, 2003; Mandelhstam *et al.,* 2006; Knížek, 2013; Bright, 2014; Lieutier *et al.,* 2016; Alonso-Zarazaga *et al.,* 2017).

Hylastes attenuatus had been previously recorded on the following host plants: *Pinus densiflora, P. halepensis, P. kochiana, P. nigra nigra, P. nigra austriaca, P. nigra laricio, P. pentaphylla, P. pinaster, P. pinea, P. radiata* and *P. sylvestris*; *Picea excelsa* (Wood and Bright, 1992; Bright and Skidmore, 1997; Bright, 2014).

Carphoborus pini Eichhoff, 1881

Examined material: Baadba district, Arsoun N 33°85'09.31", E 35°70'63.92", 954 m a.s.l. breeding on *P. pinea*, Yara El Khoury leg., n 1 specimens, September 2018.

The chorotype of *C. pini* is Mediterranean. This species had been previously reported in Africa from Algeria and Tunisia; in Asia from Cyprus and Turkey, and Iran; in Europe from French mainland with Corsica, Greek mainland, Hungary, Italian mainland with Sicily, Sardinia and Tuscany Islands, Spain, former Yugoslavia (current Bosnia Herzegovina and Croatia) (Wood and Bright, 1992; Pfeffer, 1995; Bright and Skidmore, 1997; Colonnelli, 2003; Bright, 2014; Lieutier *et al.,* 2016; Alonso-Zarazaga *et al.,* 2017).

Carphoborus pini had been previously recorded on the following host plants: *Pinus brutia, P. halepensis, P. nigra, P. pinaster* and *P. pinea* (Schedl, 1967*;* Wood and Bright, 1992; Bright and Skidmore, 1997).

DISCUSSION

The extensive investigation of mixed and pure stands of *P. pinea* allowed the identification of five species new to Lebanon, all belonging to three genera: *Hylurgus, Hylastes* and *Carphoborus.* In the genus *Hylurgus*, two species were recorded in the survey: *H. ligniperda* and *H. micklitzi.*

Hylurgus ligniperda, though native to central and southern Europe, Algeria, Asia Minor, Crimea (Ukraine) and Caucasus, successfully established in Japan, Australia, New Zealand, Brazil, Uruguay, Chile and South Africa (Bain, 1977; Neumann, 1987; Ciesla, 1988; Tribe, 1991; Pfeffer, 1995; Pawson *et al.,* 2014; Romo *et al.,* 2015). The patterns of spread clearly show that this beetle has currently a sub-cosmoplitan distribution; in fact, it has not only colonized all the available natural populations of pines but has also followed their extensive artificial introductions around the world.

In Europe, this species is widespread in all Mediterranean forests and its infestations generally affect only heavily weakened pines (Lieutier *et al.,* 2016). The lower part of trunks is the most subjected to the attack even though root collars and emerging roots of recently dead, stressed, unhealthy or fallen trees can be equally attractive (Brown and Laurie, 1968; Gil and Pajares, 1986; CABI, 2019).

Moreover, fresh stumps or bark portions of log piles in direct contact with the soil can be also colonized while slash and logging debris represent suitable breeding sites (CIESLA, 1988, 1993; CABI, 2019). Even though regarded as a minor pest with little economic importance, infestations have been observed in declining or dying stands weakened by diseases, nutrient deficiencies, mechanical injury or previous insect attacks (VIEDMA 1964; LIEUTIER *et al.,* 2016; CABI, 2018). In these conditions infestations are often heavy (BROWN and LAURIE, 1968) and areas involved in reforestation are particularly at risk (BROWNE, 1986; ROBERTSON *et al*., 2008). In southeastern France, FABRE and CARLE (1975) reported it as a secondary pest of *Pinus pinaster* severely weakened by the scale insect *Matsucoccus feytaudi* Duc**.** while CIESLA (1988), in Chile, observed secondary attacks in the root zone of pines infested by the pathogen *Verticicladiella* sp.

As many other scolytinae, *H. ligniperda*, in some circumstances, may be a significant pest not only directly, for its activity on host plants, but also indirectly as vector of nematodes carried under the elytrae (ROBERTSON *et al*., 2008). Associations have been observed with *Bursaphelenchus sexdentati* in Greece and Portugal (SKARMOUTSOS and SKARMOUTSOS, 1999; PENAS *et al.,* 2006)**,** *B. tusciae* in Portugal and Tunisia (PENAS *et al*., 2006; MEJRI *et al.,* 2016), *B. hellenicus* in Italy and Portugal (PENAS *et al*., 2006; CARLETTI *et al*., 2008; D'ERRICO *et al*., 2015). Furthermore, several associations with fungi have been also reported. In particular, there is evidence that many *Grossmania* and *Leptographium* species causing root diseases are vectored by *H. ligniperda.* Though normally regarded as weak pathogens, these fungi may significantly contribute to the decline of already stressed conifers when their action is combined with bark beetle attacks. This phenomenon might be amplified by fungal cross contamination between insects overwintering in galleries (CABI 2019) (ZHOU *et al*., 2001, 2004; KIRISITS, 2004; REAY *et al*., 2006; KIM, 2010; KIM *et al*., 2011; LINNAKOSKI, 2011; JANKOWIAK and BILAŃSKI, 2013; DAVYDENKO *et al*., 2014; CABI, 2019). *H. ligniperda* is also known to be associated with many *Ophiostoma* species, often responsible for reduced growth, chlorosis, crown thinning and ultimately plant death (KIRISITS, 2004; KIM, 2010; DAVYDENKO *et al*., 2014). In South Africa this beetle has been sometimes reported to introduce blue stain fungi into the wood and to vector the root pathogens *Leptographium* spp. (WINGFIELD *et al.,* 1985; 1988; TRIBE, 1991). In the same country, ZHOU XUDONG *et al*. (2001) investigated Ophiostomatoid fungi associated with *H. ligniperda* in artificial stands of *Pinus patula* and *Pinus elliottii* observing that the most commonly recorded species were *Leptographium serpens, L. lundbergii, Ophiostoma ips* and *O. serpens* (ZHOU XUDONG *et al*., 2001; CABI, 2019). More recently, in Ukraine, Davydenko *et al*., (2014) examined fungal communities associated with *H. ligniperda* colonizing *Pinus sylvestris*. Among the isolated taxa, those belonging to the genus *Ophiostoma* were the most frequent and included five species: *O. piceae*, *O. bicolor*, *O. ips*, *O. canum* and *O. rectangulosporium*, all of which are reported in literature as weak tree pathogens.

The second *Hylurgus* recorded in the survey is *H. micklitzi.* There is still controversy on the taxonomic status of this beetle: many Authors still consider this species as a valid taxon (BALACHOWSKY, 1949; PFEFFER, 1995; SCHEDL, 1981; WOOD and BRIGHT, 1992; WOOD, 2007), though others recently suggested that it could be simply a southern form of *H. ligniperda* differing from northern populations for its smaller size (LIEUTIER *et al*., 2016). This scolytid, whose behavior and biology are very similar to those of *H. ligniperda,* has been often reported as a secondary species attacking plants already colonized by more aggressive pests such as *T. destruens* (LIEUTIER *et al*., 2016). Nonetheless, there is very limited knowledge on its potential associations with pathogens such as fungi or nematodes and on its ecological role in forest stands.

In the current survey, two species of *Hylastes* were also recorded: *H. angustatus* and *H. attenuatus*. The genus *Hylastes* comprises bark beetles colonizing base of trunks, root collars or emerging roots of coniferous trees such as pine, spruce and occasionally larch. Moreover, stumps or humid parts of logs in direct contact with the soil can be equally attractive. Once new adults emerge after the winter, they disperse searching for conifer roots of young plants (3-10 years) where they feed in order to reach sexual maturation. This maturation process can be long (often up to several weeks) and represents the most critical phase of the life cycle in terms of potential phytosanitary risk.

*Hylastes angustatus***,** is native to Europe, Mediterranean Basin and Southern Russia where it feeds on conifer cambium and inner bark (SCHEDL, 1959; SCHWENKE, 1974; TRIBE, 1990; 1992). In its native range, it is generally regarded as a secondary species colonizing mainly stressed or declining trees, though damages to pine bark and crown have been often reported in reforestation areas, where sexually immature adults may feed on young seedlings. In South Africa, where it was introduced through trade of plant material since 1930, it breeds almost exclusively on roots and stumps of dead or ailing conifers (TRIBE, 1990). Nonetheless, in artificial monocultural pine plantations, newly emerged adults have been sometimes reported to be more aggressive infesting even healthy trees (TRIBE, 1990; 1992). More recently, some authors reported, in the forest-steppe zone of eastern Ukraine, a consistent increase in diversity and population density of bark beetles; *H. angustatus* together with scolytids belonging to the genera *Orthotomicus, Hylurgus* and *Hylastes* became more frequent damaging forest stands, young plantations and timber of *Pinus sylvestris* (MESHKOVA and SOKOLOVA, 2007).

The second species, *H. attenuates*, is very similar to *H. angustatus* in terms of biology and ecology, though it differs from the congeneric species for its smaller size and dark brown colour. It is mainly associated with pines, though records were also reported from *Picea abies*. This species is widespread in Europe and Asia where it is reported as an unaggressive beetle colonizing mainly roots of stumps and fallen trees.

Carphoborus pini is native to South-Western Mediterranean regions where it is associated with *Pinus* spp. (PFEFFER, 1995). Despite being able to withstand bark drying and phloem degradation, it is only a secondary species breeding primarily in small pine branches and tiny twigs even smaller than 1 cm. It poses no threat to forest stands as plants selected for colonization are only those already declining for adverse environmental or climatic factors such as drought, fire, winter winds or previous attacks by more virulent species (LIEUTIER *et al*., 2016).

Successful colonization of bark beetles depends on the interaction of two essential elements: tree resistance and insect density. If breeding material increases, population may shift from a latent phase (i.e. low population levels) to an outbreak phase (i.e. high population levels) (BERRYMAN, 1982). The threshold between the two conditions may vary according to three factors: tree species, plant susceptibility and bark beetle aggressiveness. Moreover, in the initial phase of the attack, insects may adopt two strategies for neutralizing host resistance: exhausting tree defenses or avoiding tree defenses (LIEUTIER *et al*., 2016). The first one is the most common and anything stimulating energy expenditure in plants, may facilitate this type of approach (LIEUTIER *et al*., 2004; LIEUTIER *et al.,* 2009). Therefore, aggregation pheromones stimulating mass attacks as well as associations with pathogens such as fungi (e.g. some Ophiostomatoid fungi) may benefit beetles in their acticity. When populations of bark beetles reach the critical attack density threshold, tree death is often the ultimate and unavoidable consequence of this plant/insect interaction (BERRYMAN, 1972; 1976; RAFFA and BERRYMAN 1983; LIEUTIER *et al*., 2002; LIEUTIER *et al.,* 2009; 2016).

In Lebanon, *P. pinea* grows mainly in homogeneous, pure, and even-aged stands originating from extensive plantations established from the mid of the 18th century, during the late Ottoman Empire, to the French Mandate period before 1943. As a result, current stands are often highly fragmented and form unbalanced ecosystems consisting of mature single-layer stands with limited or no understory (FAO, 2010; NEMER, 2015). These formations are thus intrinsically vulnerable as they are approaching their final stage of over-maturity and their biological maximum age (PIQUÉ and MUTKE, 2015). Only in few circumstances, such as in more fertile sites and intensely pruned stands with incomplete tree crown cover (e.g. Falaise de Jezzine), a second pine layer may develop. In the latter context, *P. pinea* is often part of a typical mixed formation characterized by *Pinus brutia, Quercus infectoria* (on sandy soils), *Q. calliprinos* (on calcareous soils), *Q. cerris*, *Juniperus excelsa* and other shrubs (NEMER, 2015). However, even in these conducive conditions, natural regeneration cannot often develop under the old stands, and no significant regrowth has been observed. Forest ecosystems are hence extremely simplified, lacking adequate age class equilibrium and constant renovation over time (NEMER, 2015). It is worth noting that regular heavy pruning (each 5-10 years) of *P. pinea* is a widespread practice aimed at facilitating cone harvesting and improving yield. However negative side effects for pine ecosystems have been often reported, particularly when this practice is associated with clearing of understory vegetation performed to accelerate cone cropping. Moreover, since burning is less expensive than manual cutting, light controlled fires often represent a negative standard management practice resulting sometimes in accidentally provoked fires that lead to additional degradation of forest stands. Clearing and burning are particularly deleterious activities in terms of soil conservation as they rapidly deplete forest nutrients and natural organic matter in the highly permeable steep slopes characterized by poor sandy soils. Moreover, prolonged extraction of pruned branch biomass as well as excessive cone yields are equally hazardous procedures that may further endanger the fragile pine ecosystems. In Lebanon, these management practices have been intensively performed for many decades, though little is known on their impact on soil nutrient status as well as on pine resistence/resilience in a context of evolving climate change. In addition, other abiotic factors such as fluctuating precipitations or biotic agents such as pests or diseases might also have a long-term negative impact on pine conservation (NEMER, 2015).

In their native range, the five species of scolytinae newly recorded for Lebanon are minor pests deserving little attention in terms of phytosanitary risk. However, predicting their potential behaviour in the next future appears complex. In fact, not only Lebanese pine stands appear extremely vulnerable and progressively weakened by a wide range of factors, but climatic simulations predict that global change may affect Mediterranean ecosystems more than temperate and boreal ones. That would make their flora and fauna susceptible to temperature increase that might directly influence insect life cycles accelerating larval development and hence the occurrence of earlier spring flights (NEMER, 2015; LIEUTIER *et al*., 2016). That would cause, in turn, an increased voltinism and a potentially higher annual progeny production. Plant critical attack density thresholds might be reached more easily leading to recurrent and extended outbreaks enadangering local tree species. Moreover, temperature could severely influence the interactions between bark beetles and their associated pathogens even though long-term effets on plants remain substantially uknown. Changes in environmental conditions and interactions between organisms might also turn naïve species into actual pests, while an increment in storm frequency and intensity could produce more food sources and breeding sites for bark beetles (LIEUTIER *et al*., 2016).

Among the newly recorded taxa, *Carphoborus pini* is only a secondary species representing no threat for forest stands. Conversely, there is evidence that *Hylurgus* and *Hylastes* might turn, in some cases, into more relevant pests as their recent patterns of spread have clearly shown. In particular, trade in plant material should be carefully evaluated as, in the last decades, *H. ligniperda* and, to a lesser extent, *H. angustatus*, showed a strong ability to spread and establish in a wide variety of environments (CABI, 2019). Furthermore, the already established species *Tomicus destruens* and *Orthotomicus erosus* are known to cause economic damages as they experience rapid population shifts due to global warming (HORN *et al*., 2012). In a climate change scenario, associations of the recorded species with pathogens and phytoparasites such as fungi and nematodes represent a further potential threat, which should be carefully monitored over time. Additional research is thus needed to fully assess the long-term impact of these species on stone pine in Lebanon.

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