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BIOECOLOGICAL NOTES ON *XYLOSANDRUS COMPACTUS* (EICHHOFF)
(COLEOPTERA CURCULIONIDAE SCOLYTINAE), A SPECIES RECENTLY
RECORDED INTO ITALY ⁽¹⁾(*) *Consiglio per la ricerca e la sperimentazione in agricoltura, Research Centre for Agrobiology and Pedology, Via Lanciola n. 12/A, 50125 Firenze, Italy; e-mail: fabrizio.pennacchio@entecra.it.*(***) *Via M. Buonarroti, 54 - Lido di Camaiore (Lucca), Italy.*Pennacchio F., Santini L., Francardi V. – Bioecological notes on *Xylosandrus compactus* (Eichhoff) (Coleoptera Curculionidae Scolytinae), a species recently recorded into Italy.

Intense trade flows favour the accidental diffusion of alien plant and animal species harmful to agricultural crops and forest ecosystems in many parts of the world. Particularly prone to such introductions are lignicolous species of wood-boring beetles that attack living plants and can develop in lumber or crating wood, such as many species belonging to the subfamilies Scolytinae and Platypodinae (Coleoptera: Curculionidae). Investigations of marked witherings of laurel twigs (*Laurus nobilis* L.) carried out from autumn 2010 in an area of the Versilia coast (Lucca) revealed that the Black twig borer, *Xylosandrus compactus* (Eichhoff), was involved in this pathological expression. This species was recently recorded for the first time in Italy on ornamental plants in some localities in the Naples's province. Here we report its essential external morphological features, with useful characters for its distinction from *X. germanus* (Blandford), a morphologically similar species, as well as its essential bioecological features, with special reference to what has been observed in the above-mentioned area of Tuscany. This should facilitate the rapid identification and verification of new outbreaks and, where possible, the timely implementation of control strategies.

KEY WORDS: Black twig borer, insect pest introduction, *Laurus nobilis*.

INTRODUCTION

The intense flow of goods affecting today's global market, in particular the intense trade in products from the Far East, has led to an increase in accidental introductions of plant and animal species harmful to crops and forest ecosystems in various parts of the world (PELLIZZARI and DALLA MONTÀ, 1997; HAACK, 2003, 2006). Particularly prone to such introductions are wood-boring beetles that complete their development in the inner parts of trunks, branches and twigs of living plants and in lumber or crating wood. These include lignicolous or xylomycetophagous species belonging to the subfamilies Scolytinae and Platypodinae (Coleoptera Curculionidae) more than corticolous or phloeophagous species which are generally more easy to control through simple debarking of the material. Moreover, during phytosanitary inspections of imported lumber in ports, airports, freight terminals, etc., it is more difficult to identify material infested by lignicolous or xylomycetophagous beetles than that colonized by corticolous beetles (HAACK, 2003; RABAGLIA *et al.*, 2006; KIRKENDALL and FACCOLI, 2010). In North America, 22 of the 45 wood-boring species present were introduced from different parts of the world (RABAGLIA *et al.*, 2006, 2009, 2010; OKINS and THOMAS, 2009). In Europe, 12 of the 19 species of bark beetles of more or less recent introduction, including the two

spermophagous species *Coccotrypes dactyliperda* (Fabricius) and *Dactylotrypes longicollis* (Wollaston), are xylomycetophagous (KIRKENDALL and FACCOLI, 2010). In recent years, several species of exotic bark beetles (largely lignicolous ones) have been identified in Italy, such as *Gnatbotrichus materiarius* (Fitch) (FACCOLI, 1998), *Xylosandrus germanus* (Blandford) (ZANDIGIACOMO *et al.*, 1998; STERGULC *et al.*, 1999), *X. crassiusculus* (Motschulsky) (PENNACCHIO *et al.*, 2003), *Monarthrum mali* (Fitch) (KIRKENDALL *et al.*, 2008), *Ambrosiophilus atratus* (Eichhoff) (FACCOLI, 2008), *Ambrosiodmus rubricollis* (Eichhoff) (FACCOLI *et al.*, 2009) and *Megaplatypus mutatus* (Chapuis) (TREMBLAY *et al.*, 2000). To these we must add two phloeophagous species: *Phloeosinus armatus* Raitter (COVASSI, 1991) and *Phloeotribus liminaris* (Harris) (PENNACCHIO *et al.*, 2004).

Still in progress investigation of the causes of marked and widespread witherings of the more or less thin branches of laurel (*Laurus nobilis* L.) carried out from autumn 2010 in a relatively small area of the Versilia coast included in the municipalities of Lido di Camaiore, Pietrasanta, Forte dei Marmi (Province of Lucca) and, only for few isolated locations, in those of Montignoso and Massa (Province of Massa-Carrara) revealed that the black twig borer *X. compactus* (Eichhoff) was involved to some extent in the aforementioned unusual phytopathology. This species was recently recorded for the first time in Italy, by the Phytopathological Laboratory of the Phytosanitary Service of the Campania Region, on ornamental plants in some localities of the province of Naples, such as Gussone Park in Portici and the park of Capodimonte (FITOLAB, 2011a, 2011b). Shortly thereafter, it was recorded by us for the province of Lucca (FRANCARDI *et al.*, 2012).

¹ This study was carried out as part of the Project "Strateco-Phytosanitary Emergences: Containment Strategies" D.M 30290/7303/09.

In the present note, we report the essential features of the external morphology and biology of *X. compactus* on the basis of previous literature data and our investigations carried out in the above-mentioned area of Tuscany in 2010-2012. This should facilitate the rapid identification and verification of new outbreaks and, where possible, allow for the adequate planning and timely implementation of control measures.

SPECIMENS EXAMINED

Many females and a male were found within the maternal galleries in different localities in the municipalities of Lido di Camaio, Marina di Pietrasanta and Forte dei Marmi (Lucca) between October 2010 and October 2012.

DISTRIBUTION

The native distribution area of *X. compactus* is probably tropical and subtropical Southeast Asia (India, Sri Lanka, Indochina, China, Indonesian Archipelago, Micronesia, Philippines, Japan), from where it has been introduced into many parts of the world. To date, its presence is established for much of Africa, where it is widespread, probably introduced several centuries ago during the first trading missions. The species is recorded from Mauritania, Sierra Leone, Liberia, Ivory Coast, Ghana, Nigeria, Cameroon, Equatorial Guinea, Gabon, Republic of Congo, Democratic Republic of Congo, Uganda, Kenya, Tanzania, South Africa, as well as from the Indian Ocean islands (Madagascar, Seychelles, Mauritius, Comoros, Reunion). In North America, to which it was probably introduced in the first half of the 20th century, it is now widespread in the south-eastern states of the USA (Florida, Georgia, Louisiana, Mississippi, Texas, North and South Carolina). In Latin America, it is present in Brazil, Peru and the Caribbean islands (Cuba and the Antilles). It is also recorded from New Caledonia, New Zealand, Hawaii, Samoa and Fiji (SCHEDL, 1962; BEAVER, 1976; WOOD 1977, 1980, 1982; SAMUELSON, 1981; CHAPIN and OLIVER, 1986; DEYRUP and ATKINSON, 1987; WOOD and BRIGHT, 1992; DELGADO and COUTURIER, 2010, 2012).

ADULT MORPHOLOGY

FEMALE – Body stout, cylindrical, dark brown or black, shiny, with a length between 1.4 and 1.9 mm, length/width ratio 2.1. Antennae with funicle consisting of 5 articles and club obliquely truncated. Pronotum with length/width ratio 0.94-0.95. Anterior margin armed with 6-10, most commonly 6-8, rather coarse denticles. Elytra 1.2 times as long as wide. Elytral slope with regularly arcuate profile, striae with short but distinct rows of setolae, interstriae with clearly longer rows of setolae (Fig. I, 1 and 2; Fig. II, 1 and 2).

MALE – very rare, apterous and haploid, much smaller than the female (0.8-1.1 mm), twice as long as wide. Pronotum narrowly rounded, flattened or slightly concave in the median part, anteriorly lacking projecting denticles. Spicules barely appreciable, almost obsolete. Elytral striae and interstriae with irregular spotting.

Morphologically, *X. compactus* presents marked similarities to *X. germanus* (Blandford). Nevertheless, it can be distinguished from the latter by its smaller size (the

females of *X. germanus* measure 2.0-2.3 mm); by the presence of rows of setolae on both the striae and the interstriae of the elytral slope (in *X. germanus* the setolae along the striae are obsolete or completely absent) and by the flat interstriae (in *X. germanus* they are weakly convex) (Fig. I, 3).

BIOLOGICAL NOTES

Like all representatives of the tribe Xyleborini, *X. compactus* is a xylomycetophagous bark beetle (WOOD, 1982). Its preimaginal development occurs in the pith tissue of thin twigs of 1-2 years and of the current year with a diameter between 2.5 and 12 mm; its feeding is almost exclusively on an ambrosia-type fungus.

The adult female digs the maternal galleries, normally on the side of the twig facing the ground or in any case on the less exposed side, starting from an entrance hole of ca. 0.8 mm diameter around which, as also observed by DIXON *et al.* (2003), there may be a small amount of loose frass that tends to disperse in a short time. During the early excavation phases, the female proceeds orthogonally to the major axis of the twig, crossing the cortical tissue, the phloem and xylem, until she reaches the pith. Within the pith, she digs and later expands (proceeding in the direction of the twig's major axis) the true maternal gallery, the one reserved for larval development, whose diameter generally corresponds to that of the pith (Fig. III, 1 and 2). This gallery extends partly beneath but mainly above the entrance tunnel (see Figs. IV and V). In this micro-environment, the female releases the spores of the symbiotic ambrosia fungus carried by her in a special structure of the pronotum called the *mycangium* (LHOSTE and ROCHE, 1959). After the fungal mycelium has begun to develop, the female will release a more or less large group of eggs. According to ENTWISTLE (1964), unfertilized females and those that have exhausted the sperm reserve lay eggs that only produce haploid males by means of facultative arrhenotokous parthenogenesis.

Egg hatching, occurring 4-6 days after deposition, is followed by three larval stages and the pupal stage. The entire cycle lasts from 27 to 40 days depending on the physical and chemical conditions of the host tree and the climatic conditions (BRADER, 1964; HARA and BRADSLY, 1979). Throughout this developmental period, the mother remains with her brood.

The newly emerged adults, whose sex ratio is strongly biased in favour of females, are initially light brown. With progressive consolidation of the integumental structures and maturation of the gonads, the colour turns into a definitive intense dark brown in 4-5 days (see Fig. III, 3). Mating can occur from this moment on, taking place inside the maternal gallery before the young females leave the twig and disperse. In view of the above-mentioned values, taken from the literature and based on regular surveys carried out in Versilia on laurel plants in the period 2010-2012, it is reasonable to assume that, in this area of recent introduction, the species can complete at least two generations and the more or less protracted beginning of a third between the end of April and late November. Moreover, in this area, the species normally overwinters as adults, sheltered and inactive inside the maternal galleries in more or less numerous groups. When young females leave the maternal gallery and disperse, their active flight is certainly supported by the wind. Nevertheless, it seems likely that when they develop on a particularly receptive

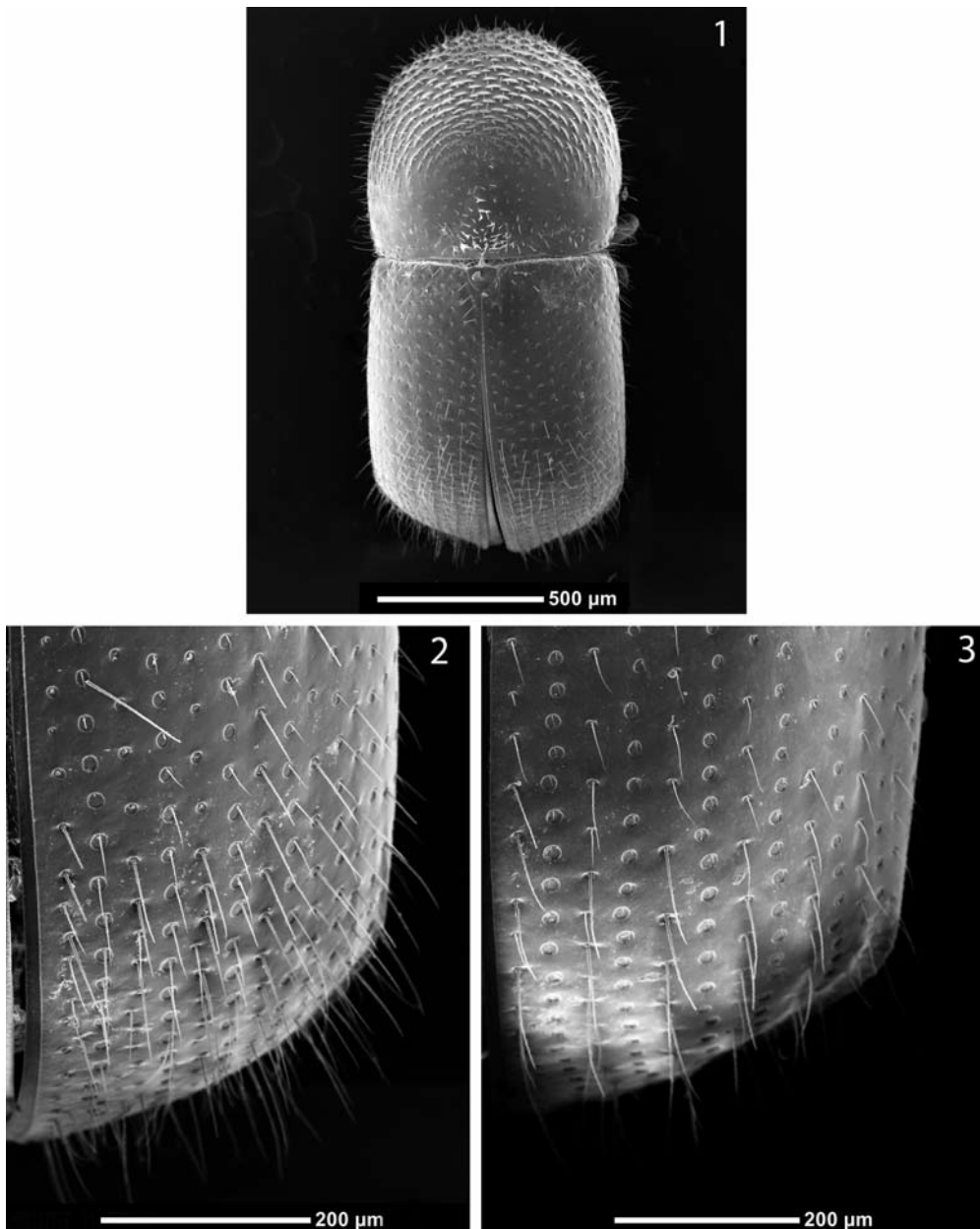


Fig. I – Scanning electron microscope (SEM) photos. 1. *Xylosandrus compactus* (Eichhoff) adult female: overall appearance. 2. *X. compactus*: detail of elitral declivity. 3. *Xylosandrus germanus* (Blandford): detail of elitral declivity (photo C. Benvenuti).

host plant (which we found to be laurel in our study area) they largely tend not to disperse in the air but rather to remain on the original or nearby host plants and to dig their own egg galleries in them. This could explain the massive attacks during a single season which progressively affect the same plant or the same laurel hedge, as well as the relative slowness with which outbreaks expand, even in areas such as Versilia where laurel is very widespread.

X. compactus is a primary phytophagous which, like many other xylomycetophagous bark beetles, is largely polyphagous. Hence, it can cause severe phytosanitary problems in areas of recent introduction. At present, more than 220 host plants, belonging to 62 families, are known. In the presumed native tropical regions and in those of new introduction, the development of *X. compactus* occurs

at the expense of economically important plants such as coffee, tea, mango, avocado, cacao and lychee. Several other species of economic, ecological and ornamental importance can be attacked, including those belonging to the genera *Acacia*, *Acer*, *Azalea*, *Celtis*, *Cornus*, *Eucalyptus*, *Ficus*, *Hibiscus*, *Khaya*, *Liquidambar*, *Magnolia*, *Malus*, *Ostrya*, *Platanus*, *Swietenia* and *Vitis* (NGOAN *et al.*, 1976; WOOD, 1982; DIXON and WOODRUFF, 1982; MESHAM *et al.*, 1993; INTACHAT and KIRTON, 1997; DAEHLER and DUDLEY, 2002; MATSUMOTO, 2002). Other recorded host plants in the same environments include perennial herbaceous species belonging to the families Orchideaceae, Araceae and Zingiberaceae (HARA and BRADSLEY, 1979; HARA and SEWAKE, 1990). Additional lists of host plants for this bark beetle are reported in



Fig. II – *Xylosandrus compactus* (Eichhoff). 1. Overall appearance of an adult female. 2. Group of adults in a maternal gallery (photo P. Giannotti).

SCHEDL (1962), BRADER (1964), SAMUELSON (1981), and WOOD and BRIGHT (1992).

In Italy, *X. compactus* attacks have been recorded on laurel, holm oak and viburnum in Campania (cf. FITOLAB, 2011a). To this can be added the host plants we recently recorded in Versilia where, in addition to the greatly preferred laurel, *X. compactus* also attacks and develops on many other trees and shrubs such as cherry laurel, pittosporum, spindle, strawberry tree, hazelnut, holm oak, English oak, maple, alder, beech, elm, lime, sweetgum, tulip tree, magnolia, common dogwood, pomegranate, azalea, rhododendron, camellia, gardenia, lemon and olive.

However, despite such a large number of potential hosts, it seems that only a few of them have the particular physical and chemical characteristics to support the development of large *X. compactus* populations. According to BRADER (1964), we can state on the basis of our findings that the different hosts of this bark beetle share the following characters: small diameter of the woody twigs in which the maternal gallery is dug, absence of pubescence of the outer surface of the twigs and no emission of gum,

latex or other liquids from the wound produced by the bark beetle when digging the gallery.

DAMAGES

In many areas of new introduction, *X. compactus* has shown marked aggressiveness towards plants in apparently good vegetative conditions, often leading to significant economic losses (LAVABRE, 1958, 1959; SAMUELSON, 1981; RAMESH 1987; EGONYU *et al.*, 2009). Among the many described cases, it should be noted that very intense attacks on even young plants of *Castanea* sp. were observed in China (Yan *et al.*, 2001), while in Hawaii (ZIEGLER, 2001, 2002) there have been *X. compactus* attacks against rare native species threatened with extinction (*Colubrina oppositifolia* and *Caesalpinia kavaensis*); hence, this beetle is now a serious threat to the survival and biodiversity of the natural ecosystems of these islands.

The attacks cause the desiccation of a more or less conspicuous part of the thinner branches of the canopy, with consequent physiological damage for the entire plant. As a



Fig. III – *Xylosandrus compactus* (Eichhoff). 1. Group of larvae and pupae in the maternal gallery. 2. Pupa. 3. Newly emerged adult (photo P. Giannotti).

result production losses may occur in both agricultural and forest ecosystems, as well as significant aesthetic damage of many ornamental plants (Fig. VI, 1 and 2) (NELSON and DAVIS, 1972; RAMESH, 1987; WATERHOUSE, 1997; DELGADO and COUTURIER, 2010, 2012).

In laurel (in which the symptoms of the attack are always particularly evident) and in all other host plants examined by us, the damage appeared within 7-10 days, according to the following successive stages. A blackish colouration appeared rapidly on the outer surface of the twig in the area closely adjacent to the entrance tunnel. Within a few days, the blackening of the external tissues involved not only a short inferior tract but also the entire part of the twig superior to the entrance hole with contemporary rapid necrosis and desiccation of the same sprig (Fig. VI, 1).

Most Authors attribute the damage caused by *X. compactus* to the mechanical action of digging the maternal galleries by the females in the tissues of living twigs and shortly thereafter to the presumed pathogenicity of the symbiotic ambrosia fungi brought in by the bark beetle. There is no complete agreement on the identity of these fungi: some Authors argue that it is *Fusarium solani* (Mart.) Sacc (NGOAN *et al.*, 1976; HARA and BEARDSLEY, 1979; DAEHLER and DUDLEY, 2002; BAMBARA, 2003;

DIXON *et al.*, 2003), while others report it to be *Ambrosiella xylebori* Brader (BRADER, 1964; BHAT and SREEDHARAN, 1988) or *Ambrosiella macrospora* (Fr.-Grossman) Batra (MUTHAPPA and VENKATASUBBAIAH, 1981). Other Authors considered this last fungus fundamental for the larval feeding but not pathogenic for the plant (FRANCKE-GROSSMAN, 1952). In any case, it cannot be excluded that the pathogenicity of the ambrosia fungus is supported by that of other parasitic fungi (agents of anthracnose) that penetrate into the tissues through the wound produced by the bark beetle (BRADER, 1964).

With regard to this issue, preliminary results have been recently obtained at the Micology lab of the Department of Agriculture, Food and Environment of the University of Pisa. Tissues of *Laurus nobilis*, *Acer pseudoplatanus* and *Magnolia grandiflora* with gellery systems, preovipositional females and mature larvae of *X. compactus*, plated on Potato Dextrose Agar gave rise to colonies of at least six different sporulating fungi and two mycelia sterilia. Among the sporulating fungi, *Verticillium* and *Pestalotiopsis* have been recorded, and these two genera include pathogenic species able to induce symptoms (tracheomycoses and twig blight) similar to those observed in field samples (VANNACCI, 2012, pers. comm.).



Fig. IV – *Xylosandrus compactus* (Eichhoff). 1. Laurel twigs (*Laurus* sp.) with the entrance hole leading to a maternal gallery. 2. Section showing the development of the same gallery (photo P. Giannotti).

CONTROL STRATEGIES

Since *X. compactus* spends much of its life cycle well protected inside the maternal galleries dug in the most internal tissues of the host twigs, the application of control strategies based on synthetic chemical insecticides normally encounters considerable difficulties, beyond the limitations due to environmental, ecological and regulatory concerns. Indeed, results of previous trials from which to draw useful information to plan rapid, effective control interventions are scarce and often contradictory (MANGOLD *et al.*, 1977; MIZELL *et al.*, 1998).

Anyway rational approach to the use of insecticides is to use molecules able to ensure a good contact action and with good residual power to kill newly emerged females when they move in the crown of the host plant in search of suitable points in which to dig their galleries (see: MANGOLD *et al.*, 1977; YAN *et al.*, 2001; BAMBARA, 2003). However, to make this type of intervention more effective, it seems essential to conduct careful monitoring, which can

be carried out with multifunnel traps baited with ethanol (BURBANO *et al.*, 2012). This can be very useful not only for rapid assessment of the spread of the insect into new settlement areas but also to precisely identify the periods of flight of the females in order to plan the place and timing of interventions to contain the species (ABREU *et al.*, 1997, 2012; OLIVER and MANNION, 2001). Although the use of systemic insecticides might appear to be an effective technique against such well protected insects, there are still many doubts about their true usefulness (PEÑA *et al.*, 2011). This is primarily because the location of the preimaginal stages and adults means that they are separated from the surrounding tissues of the host plant by a more or less substantial layer of mycelium of the symbiotic fungus on which they feed, and there is no certainty that it can incorporate lethal doses of the administered active principle. Moreover, these forms of the bark beetle are located, from the beginning of their development, inside tissues whose normal function might be compromised and have begun to wither. This withering adversely affects the



Fig. V – *Xylosandrus compactus* (Eichhoff). 1. Olive twigs (*Olea* sp.) with the entrance hole leading to a maternal gallery. 2. Development of these galleries (photo P. Giannotti).

translocation of the active principle from the sites of application and absorption.

Furthermore it can not be excluded that the damage can be determined by the combined presence of exceptional or abnormal climatic and/or edaphic conditions reasonable to induce latent suffering in plants. For this reason all cultivation practices that promote vigor of plants (above all, land ploughing, balanced fertilization strategies and emergency irrigation) can be still useful integrative interventions, not only in order to mitigate the attacks of this species, but also to promote a good vegetative recovery of heavily attacked plants (DIXON e WOODRUFF, 1982; BAMBARA, 2003).

Literature reports suggest a generally low importance of natural enemies in limiting *X. compactus* populations, especially in areas of new introduction. Studies conducted in Indonesia by LE PELLEY (1968) on the activity of some parasitoids showed an inconstant efficacy. However, some positive results were reported by KEUCHENIUS (1931) for the island of Sumatra regarding the effects of a eulophid wasp (*Tetrastichus* sp.) and a bethylid wasp. With

regard to our Tuscan study area, a larva of *X. compactus* with a closely associated larva of a parasitoid was isolated from a laurel twig from Marina di Pietrasanta in September 2011. After 12 days, the parasitoid larva produced a female of the braconid wasp *Heterospilus leptostoma* Fischer. This species, not previously recorded for Italy, belongs to the subfamily Doryctinae, whose members are known as idiobiotic ectoparasitoids of endophytic larvae of Lepidoptera, Hymenoptera Tenthredinidae and Coleoptera, especially bark beetles (SHAW, 1997; WHARTON *et al.*, 1997) (Fig. VII, 1 and 2). Despite the faunistic importance of this parasitoids, our exiguous finding not allow us to make any conclusion of an applied nature.

CONCLUSIONS

The results of our investigation indicate that wherever *X. compactus* has been accidentally introduced it has become a serious phytosanitary problem in a relatively



Fig. VI – *Xylosandrus compactus* (Eichhoff). Evident signs of an attack. 1. On a laurel hedge. 2. On the crown of a lime tree (photo L. Santini).

short time because of the variety of plants it can attack. The effects can be negative and economically disastrous for agricultural and forestry production, especially in the nursery sector and in the international and inland plant trade. This is even more worrying on account of the objective difficulty in adequately controlling the species with the currently available materials and techniques and the almost complete absence of previous studies to help plan truly effective and environmentally friendly containment measures. Therefore, it is necessary to conduct further, more extensive studies on the bioecology of this species and the development of effective techniques to monitor its infestations.

ACKNOWLEDGEMENTS

The Authors would like to thank Prof. Giovanni Vannacci of the Section Patologia Vegetale of the Department of Scienze Agrarie, Ambientali e Agroalimentari of the

University of Pisa, well as Dr. Augusto Loni and Mr. Paolo Giannotti of the Section Entomologia Agraria of the same Department, respectively for the identification of the complex of fungi associated in dieback of twigs attacked by bark beetle, for identification of the parasitoid *Heterospilus leptostoma* Fischer and for the realization of most of the photographs. The Authors are also grateful to the Technical Assistant Claudia Benvenuti of the CRA ABP of Florence for the realization of the SEM images and Dr. Alberto Inghilesi of the Department of di Biologia evolucionistica “Leo Pardi” of the University of Florence, for providing some specimens of *X. germanus* for comparative morphological observations. We wish to thank the Plant Protection Service of Tuscany, seat of Pisa, for reporting some sites infested by *X. compactus* and provided some samples for its determination, and Mr. Mario Pardini of the “Agraria Pardini Giuseppe s.r.l.” of Lido di Camaiore for the continued cooperation provided during the data collection in the field.



Fig. VII – *Heterospilus leptostoma* Fischer (Braconidae Doryctinae), idiobiontic ectoparasite of *Xylosandrus compactus* (Eichhoff). 1. Overall view of an adult female. 2. Larva (right) in close contact with the host larva (left) (photo P. Giannotti).

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