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Research Article

First record of the invasive alien species *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae: Scolytinae) in Turkey

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Abstract

Xylosandrus compactus (Eichhoff), a polyphagous invasive pest native to Asia, was first detected on the European continent in Italy in 2011. It has since been recorded in five additional European countries, France, Spain, Malta, Monaco, and Greece. The present study reports for the first time the presence of the species in Turkey. As a result of our literature review, there is no record of the genera *Lonicera* and *Crataegus* as host plants of *X. compactus*. We identified new host plant species to *X. compactus*: *Lonicera pileata* var. *yunnanensis* (Franch.) Bernd Schulz and *Crataegus monogyna* Hayek. In addition, we determined the black twig borer on *Fagus sylvatica* f. *pendula* (Lodd.) Dippel. *Laurus nobilis* was the host plant infested by *X. compactus* at all localities but one locality.

Key words: Black twig borer, invasive pest, *Laurus nobilis*, *Lonicera*, *Crategus*, new host

Introduction

The genus *Xylosandrus* belongs to the Xyleborini tribe of the weevil subfamily Scolytinae (Coleoptera: Curculionidae) and contains 52 tropical and subtropical species (Wood and Bright 1992). In their catalogue of the Scolytinae, Bright and Skidmore (1997) listed 54 species of *Xylosandrus*. Dole and Cognato (2010) revised the genus and proposed a new classification with only 39 species of *Xylosandrus*. In addition, a recent paper by Smith et al. (2022) proposed restoring *X. declivigranulatus* (Schedl), formerly synonymized with *X. crassiusculus*, which would lead to 40 species of *Xylosandrus*. This clade includes three economically important pests: *X. compactus* (Eichhoff), *X. germanus* (Blandford), and *X. morigerus* (Blandford). *Xylosandrus compactus* is the second species of this genus found in Turkey, after *X. germanus*, which was recorded in hazelnut orchards (*Corylus avellana* L.) in Ordu (Ak et al. 2011).

Xylosandrus compactus (black twig borer) is considered a species native to East Asia (Wood 1982; Chong et al. 2009). Rabaglia et al. (2006) reported that *X. compactus* is distributed in Africa, Asia, Pacific Islands (introduced)

(Hawaii), New Zealand (introduced), South America, and North America (Antilles and the United States; introduced). However, Brockerhoff et al. (2003) reported that the reference about to the establishment of the species in New Zealand is probably incorrect as we have no reports of a breeding population there. Also, EPPO (2022) remarks that the record of this species in New Zealand is unreliable. In Europe, *X. compactus* was detected for the first time on *Quercus ilex* L., *Laurus nobilis* L. and *Viburnum* sp. in Italy (FITOLAB 2011; Garonna et al. 2012). Afterwards, black twig borer was reported with large populations on the Alpes-Maritimes coast in the Botanical Garden of Villa Thuret and the Garoupe Forest near Nice, France (Chapin et al. 2016; Roques et al. 2019). Subsequently, *X. compactus* was detected in Sicilia (Gugliuzzo et al. 2019a), Greece (Spanou et al. 2019), Monaco (Roques et al. 2019), Spain and Islas Baleares (Leza et al. 2020), and lastly in Malta in 2021 (EPPO 2022). European host plant species of *X. compactus* include (in alphabetical order and not by preference) *Acer* spp., *Alnus* spp., *Arbutus unedo* L., *Azalea* spp., *Camelia* spp., *Castanea sativa* Mill., *Celtis australis* L., *Ceratonia siliqua* L., *Cercis siliquastrum* L., *Citrus medica f. aurantifolia* (Christm.), *C. limon* (L.), *Cornus sanguinea* Thunb., *Coryllus avellana, Eucalyptus* spp., *Evonymus* spp., *Fagus* spp., *Ficus* spp., *Fraxinus ornus* L., *Hibiscus* spp., *Gardenia* spp., *L. nobilis*, *Liquidambar styraciflua* L., *Liriodendron tulipifera* L., *Magnolia spp., Morus alba* L., *Olea europea* L., *Phillyrea* spp., *Pistacia lentiscus* L. *Pittosporum* spp., *Platanus* spp., *Prunus laurocerasus* L., *Punica granatum* L., *Q. ilex, Q. robur* Asso, *Rhamnus* sp., *Ostrya* spp., *Rhododendron* spp., *Ruscus aculeatus* L., *Tilia* spp., *Ulmus* spp., *Viburnum tinus* L., and *Vitis* spp. (FITOLAB 2011; Garonna et al. 2012; Pennacchio et al. 2012; Vannini et al. 2017; Spanou et al. 2019; Leza et al. 2020; Faccoli 2021; Riba-Flinch et al. 2021). In addition, Riba-Flinch et al. (2021) reported that the affected hosts in Italy and France are included in 54 genera of forest, agricultural, and ornamental plants.

Xylosandrus compactus adults are active between mid-March and late September, even though variations are related to local and seasonal climatic conditions. Only the females can fly and attack potential host plants. The females usually penetrate twigs and small branches, which are 1–3-year-old twigs up to a maximum diameter of 4–6 cm (ANSES 2017). However, cases of infestation in Sicily are also reported on carob trunks over 30 cm in diameter (Gugliuzzo et al. 2019a), although highly unusual. Invasion by the female occurs through a small circular entrance hole with a diameter of 0.7–0.8 mm, usually dug on the lower side of the branch (ANSES 2017). The eggs are laid in the breeding chamber: females will be born from fertilized ones, males from unfertilized ones; here, the larvae develop and finally, the pupae and adults appear. The mating occurs between siblings (Entwistle 1964). The development cycle is completed in about 4–6 weeks depending on the climate and season. In favourable climatic conditions, there are numerous generations a year: in northern Italy, there are at least three

(Faccoli 2021), although, in the central-southern regions, there may be four, and in Sicily, up to five have been reported (Gugliuzzo et al. 2019b, 2020). Wintering is entrusted to the adults of the late-summer generation and takes place inside the host plant in which the insects have developed (Pennacchio et al. 2012; Gugliuzzo et al. 2019b, 2020). The beetles can spread at distances >8 km from the infested area during the previous flying season (Gugliuzzo et al. 2019b).

The black twig borer is a globally invasive ambrosia beetle associated with several fungi species. Despite many studies on this beetle (Brader 1964; Von Arx and Hennebert 1964; Batra 1967; Vannini et al. 2017; Morales-Rodríguez et al. 2021), reports of its primary symbionts are conflicting. Bateman et al. (2016) characterized the fungal symbiont community using dilution series and showed that *X. compactus* was consistently associated with two fungal taxa, *Fusarium* spp. and *Ambrosiella xylebori* Brader ex Arx & Hennebert. *Ambrosiella xylebori*, are considered true mutualists and supply the diet for the larvae in the galleries. However, *Fusarium* spp., often members of the *Fusarium solani* (Mart.) Sacc. complex (FSSC), are considered stable associates and are involved in necrosis development on infested twigs/branches (Bosso et al. 2012; Bateman et al. 2016; Vannini et al. 2017). Benvenuti et al. (2021), in their study, evaluated the differences in fungal communities isolated from the external surface of the two scolytids' bodies and determined that the most abundant fungi in the bodies of *X. compactus* were of genera *Cladosporium* (83%) and *Geosmithia* (76%).

The development of *X. compactus* occurs at the expense of economically important plants. The beetle causes extensive damage to coffee and cocoa throughout tropical Africa, Indonesia, southern India and the West Indies. Lavabre (1958, 1959) reported losses of about 20% of the coffee crop in Cameroon. Ramesh (1987) remarked that losses due to *X. compactus* were 21% on 45-year-old coffee plants and 23.5% on young plants in India. Brown (1954) reported that it attacks the avocado tree in the adult stage. *Xylosandrus compactus* was a significant pest of tea, causing extensive dieback in Japan (Kaneko et al. 1964). Infestation rates of 60–70% in African mahogany were reported in the forest nurseries in Pune, India, by Meshram et al. (1993). Yan et al. (2001) recorded an attack rate of 78% on the main stems of young chestnut trees in the local chestnut plantation in China. In Uganda, Egonyu et al. (2009) remarked that *X. compactus* invaded 35% of coffee farms in the Mukono and Kayunga, while Kagezi et al. (2014) found that it damaged more than 13% of cocoa fields in Bundibugyo, Kibaale and Hoima. Kagezi et al. (2015) revealed that *X. compactus* damage to coffee was valued at US$40 million annually at the current market prices and production volumes in Uganda. Two species native to the Mediterranean with commercial value, *L. nobilis* (Francardi et al. 2012) and *C. siliqua* (Gugliuzzo et al. 2019a) have been reported as preferred host plants.

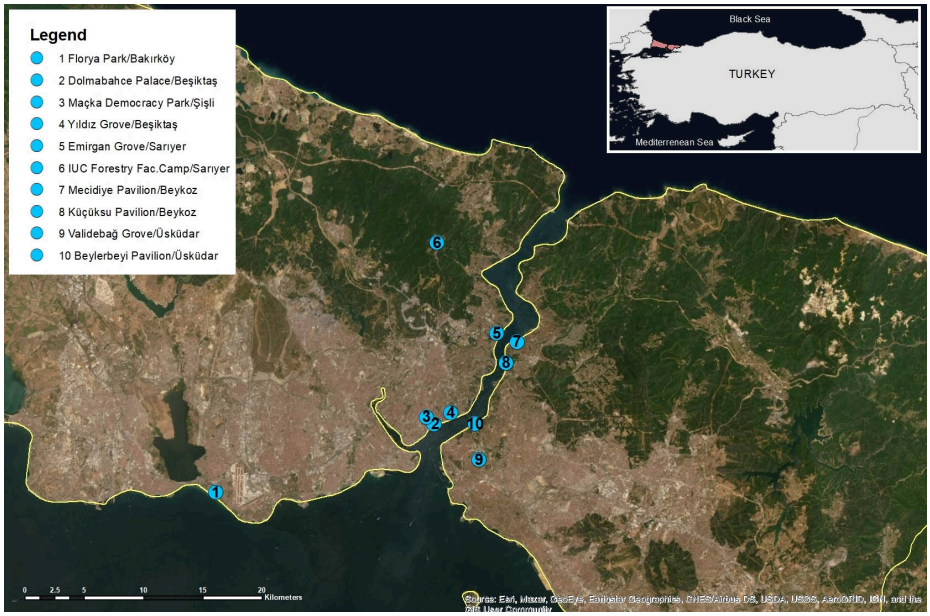

Figure 1. The study area (ESRI 2014).

The present study reports that severe wilting and drying of plants and twigs in Istanbul's parks, gardens, and groves were seen in the summer of 2022. We conducted surveys in these areas and attempted to reveal the causes of the symptoms in plants. The authors reported their findings to the responsible authority of the government, who noted the presence of this invasive alien species.

Materials and methods

In 2021, in Florya, plant protection experts of the Istanbul Metropolitan Municipality Directorate of Parks and Gardens observed wilting, foliar necrosis, twig death, and small insect entrance holes on the twigs of *L. pileata* var. *yunnanensis* (syn: *L. nitida* E.H. Wilson) and found adult beetles.

In 2022, parks, gardens, and groves in Istanbul were surveyed and detected similar symptoms in several species of plants. During field surveys, wilted and dried twigs with insect entrance holes were cut, placed in plastic containers, and brought to the laboratory. These twigs were dissected with a scalpel, and insect larvae, pupae, and adult individuals and their tunnels were exposed. All adult beetles obtained in 2021 and 2022 were examined under the Leica S8APO microscope and Leica DFC camera and identified from the literature. Thirty female adult individuals were measured and turned into biological museum material. These specimens were preserved in the Collection of İstanbul University – Cerrahpaşa, Faculty of Forestry, Department of Forest Entomology and Protection. In addition, a distribution map of the study areas is shown in Figure 1 (ESRI 2014).

Results and discussion

As a result of our study, we determined that the agent causing the symptoms on the plant twigs was *X. compactus*. Two *Xylosandrus* species have been

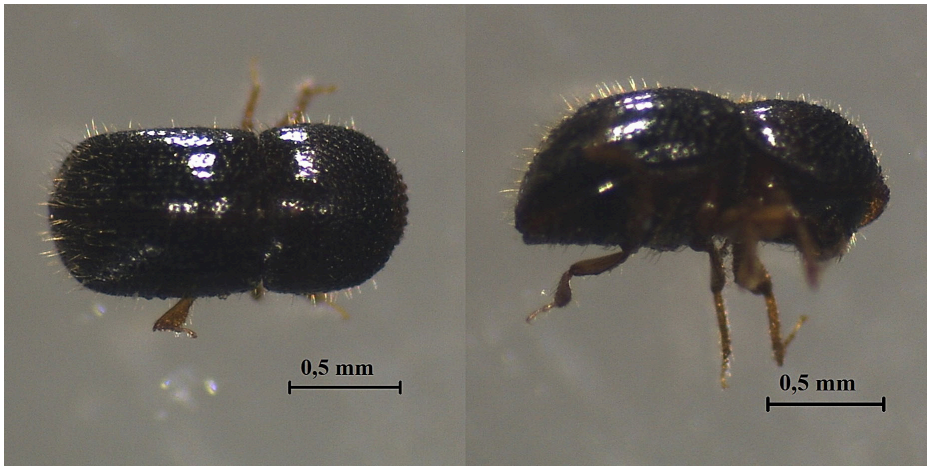

Figure 2. Adult female of *Xylosandrus compactus* (Eichhoff). Photographs by Erdem Hızal.

recorded so far in Turkey, *X. compactus* and *X. germanus,* and the two species have marked morphological similarities. They can be distinguished according to the following identification key:

1. Body 2.3 times as long as wide; declivital striae weakly convex; strial punctures small, shallow; the setolae along the striae neglected or completely absent; body colour dark brown; 2.0 to 2.4 mm (Ak et al. 2011) ..... *X. germanus*

–. Body 2.1 times as long as wide; declivital striae setose, rows of setae on both the striae and the interstriae of the elytral slope, the flat interstriae; body colour dark brown to black; 1.2 to 1.5 mm (Figure 2)..... ..... *X. compactus*

In this study, we found that the dieback caused by *X. compactus* was not restricted to *L. pileata* var *yunnanensis*. A total of 7 tree species belonging to different genera were attacked by *X. compactus* in the study area. The sampling date, plant species, and locations are presented in Table 1. *Laurus nobilis* was the host plant infested by *X. compactus* at 9 out of 10 localities in our study. We collected all adult beetle specimens on lateral twigs of 1–3 cm in diameter from host plants of *X. compactus*. We did not observe any indication of this species on thick branches or young trunks. When the twigs were dissected, long, dark, and necrotic walled tunnels of 2 to 5 cm were observed to have been formed by females (Figure 3). The white larvae and the pupae were found in the tunnels. The dark brown to black female adult *X. compactus* individuals were between 1.2 and 1.5 (± 0.05) mm long (see Figure 2).

Visible symptoms such as dried leaves and twigs, entrance holes on the twigs, and necrotic tunnels in the wood tissue found in our study area were like those found in other studies in the literature (Delgado and Couturier 2017; Vannini et al. 2017; Leza et al. 2020).

The black twig borer is a primary phytophagous pest in about 340 plants of approximately 77 families that severely infest domestic and natural

Table 1. Locations where *Xylosansdrus compactus* and its host plants were found.

	Location	Dates	Host Plants
Istanbul (European Part)	Florya Parks-Bakırköy 40°58′39.33″N; 48°47′14.52″E	17.07.2021	*Lonicera pileata* var. *yunnanensis*
	Dolmabahçe Palace garden-Beşiktaş 41°02′24.51″N; 29°00′00.76″E	25.04.2022	*Cercis siliquastrum* *Laurus nobilis* *Magnolia grandiflora*
	Maçka Democracy Park-Şişli 40°58′39.33″N; 48°47′14.52″E	25.04.2022	*Cercis siliquastrum* *Laurus nobilis*
	Yıldız Grove-Beşiktaş 41°03′01.32″N; 29°00′57.62″E	25.04.2022 17.05.2022	*Cercis siliquastrum* *Crataegus monogyna* *Laurus nobilis* *Magnolia grandiflora* *Quercus ilex*
	Emirgan Grove-Sarıyer 41°06′43.42″N; 29°03′24.63″E	28.04.2022	*Cercis siliquastrum* *Lonicera pileata* var. *yunnanensis* *Laurus nobilis*
	IUC Bahçeköy Forestry Faculty Campus-Sarıyer 41°10′39.91″N; 28°59′28.62″E	30.04.2022	*Cercis siliquastrum* *Laurus nobilis*
Istanbul (Asian Part)	Beykoz Mecidiye Pavilion 41°06′24.21″N; 29°04′39.37″E	21.04.2022	*Cercis siliquastrum* *Laurus nobilis* *Magnolia grandiflora*
	Küçüksu Pavillion-Beykoz 41°05′28.30″N; 29°04′04.13″E	21.04.2022	*Cercis siliquastrum* *Laurus nobilis* *Magnolia grandiflora*
	Validebağ Grove-Üsküdar 41°00′55.96″N; 29°02′47.88″E	30.06.2022	*Laurus nobilis*
	Beylerbeyi Pavilions-Üsküdar 41°02′30.27″N; 29°02′27.99″E	06.07.2022	*Fagus sylvatica* f. *pendula* *Laurus nobilis* *Magnolia grandiflora*

environments (Brader 1964; Ngoan et al. 1976; Hara and Beardsley 1979; Oliveira et al. 2008; Pennacchio et al. 2012; ANSES 2017; Vannini et al. 2017; Spanou et al. 2019; CABI 2022; EPPO 2022). Riba-Flinch et al. (2021) recorded that *X. compactus* affects hosts plant in 54 species in Italy and France, but we could not reach this count for Europe. We determined that genera *Lonicera* and *Crataegus* are not included among the hosts of *X. compactus*. *Fagus sylvatica* f. *pendula*, another host we identified, is considered a synonym for *F. sylvatica.* (GBIF 2021). Masuya (2007) identified *X. compactus* on *F. sylvatica* in Japan, while Pennacchio et al. (2012) reported that it attacks and develops on many other trees, including beech in Italy.

In Vannini et al. (2017), 18 different fungal taxa, including *A. xylebori*, *Geosmithia pallida* (G. Sm.) M. Kolařík, Kubátová & Pažoutová, *Fusarium* spp., were found to be associated with *X. compactus* in Italy. Morales-Rodríguez et al. (2021) defined fungal taxa to species level, identifying 60 different fungal species associated with this ambrosia beetle in central Italy. The combined effect due to both activities of colonizing insects and pathogenic fungi might represent a further stress factor in attacked plants and, consequently, a substantial concern from a phytosanitary perspective. This combined effect should be considered a real threat to the natural ecosystems in Europe (Vannini et al. 2017; Benvenuti et al. 2021). The black twig borer, which can have severe damage, was added to the European and Mediterranean Plant Protection Organization (EPPO) Alert List in 2017 and later deleted in 2020. In the EPPO region, it is considered a quarantine

Figure 3. a) Symptoms of *X. compactus* on *Magnolia grandiflora*. (b) Entrance holes. (c) Larvae of *Xylosansdrus compactus* in a tunnel. (d) Discoloration of wood in tunnels. Photographs by Süreyya Altunışık.

pest for Israel and Morocco (EPPO 2022). *Xylosandrus compactus* is not inside the List of Agricultural Quarantine Species, Republic of Turkey, Ministry of Agriculture and Forestry (TCTOB 2022).

The black twig borer has multiple generations, up to five per year. Female adults can fly up to 8 km from the previously infested area. Therefore, *X. compactus* is a primary phytophagous that can find favourable conditions for diffusion and breeding in our environment. In addition to the direct damage to plants due to the digging activity of the females, the transport to the host plant of fungi can cause peripheral desiccation on the colonized twigs. In the present study, we investigated the severe wilting and drying of the twigs of the plants in the parks, gardens and groves of Istanbul. We

detected for the first time the presence of *X. compactus* in Turkey. In addition, two new host plant species belonging to two different genera, *L. pileata* var. *yunnanensis* and *C. monogyna*, have been introduced to the world literature as new hosts of this ambrosia beetle. Considering *X. compactus*' ability to spread and reproduce, this species should be considered a potential damage agent and threat to agro-forestry plants, ornamental trees and maquis in Turkey.

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Authors' contribution

EH: managed the survey planning and design, analysis and beetle identification of the specimen and wrote the draft manuscript and reviewed the original manuscript. SA*: undertook sample collection, contributed to the methodology, and wrote and reviewed the original manuscript. SA: undertook sample collection and logistics and took the field photos.

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