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First record of the invasive western conifer seed bug *Leptoglossus occidentalis* (Heteroptera: Coreidae) in Turkey

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Abstract. *Leptoglossus occidentalis* Heidemann 1910 is known as the western conifer seed bug and is an important pest species in North America feeding on seeds of conifers. The overwintering adults enter households and factories and cause nuisance to people. This pest species has been introduced in Europe through transportation and spread rapidly over the continent after its first appearance in northern Italy in 1999. In Turkey it has been found in Edirne and Kırklareli (Lüleburgaz) in Turkish Thrace in October 2009 and in Novomber 2010, respectively, representing the first record of this alien Nearctic genus and species in the country. This study reports identification characters of the species, its host plants, details about its biology and a map of its most recent distribution throughout Europe.

Key words: *Leptoglossus occidentalis*, Coreidae, distribution, invasion, first record, Turkey.

Introduction

The genus *Leptoglossus* Guérin-Méneville, classified in subfamily Coreinae and tribe Anisoscelini, comprises 54 species of large coreids, with leaf-like dilations on the hind tibiae (Brailovsky & Barrera 2004; Schaefer et al. 2008). They are widely distributed in the Nearctic and Neotropical Region from southern Canada, throughout the United States, Mexico, the Antilles, Central America, and South America, including Chile and Argentina (Brailovsky & Barrera 2004). Only one species, *Leptoglossus gonagra* (Fabricius) (= *L. australis* (Fabricius), *L. membranaceus* (Fabricius)) occurs outside the Western Hemisphere, being recorded in Africa, Southeast Asia (including southern China, Taiwan, and Japan), the Pacific Islands, and Australia (Allen 1969; Brailovsky & Barrera 1998; Dolling 2006), and reaching the Canary Islands in Europe (Heiss & Baez 1990; Moulet 1995; Dolling 2006; Aukema et al. 2006). Another species, *Leptoglossus occidentalis* Heidemann, 1910, has been introduced in Europe and Japan only a decade ago, and is recorded for the first time in Turkey by this study. The taxonomy of *Leptoglossus* was recently revised by Packauskas & Schaefer (2001), who recognized 6 species groups within the genus. *Leptoglossus gonagra* is the single species included in the *gonagra* species group, while *L. occidentalis* belongs to the largest *zonatus* species group.

Material examined

Leptoglossus occidentalis Heidemann, 1910: Turkey**:** Edirne province – Balkan Campus of Trakya University, 41° 40' 28" N, 26° 33' 39" E (within a student house), 15.x.2009, 1 male, 1 female, M. Fent leg. et det.; Kırklareli province – Lüleburgaz city center, 41° 24' 24" N, 27° 21'19"E (within a home), 18.xi.2010, 1 female, N. Hacet leg. and M. Fent det. (Trakya University, Science Faculty, Department of Biology, Edirne).

Distribution

Leptoglossus occidentalis is a species native to the western areas of North America, from Mexico and California in the south to British Columbia, Alberta, and Saskatchewan in the north (Heidemann 1910; Torre Bueno 1941; Koerber 1963; Brailovsky & Sánchez 1983; Froeschner 1988; McPherson et al. 1990; Maw et al. 2000). In the 1950s and 1960s it reached the Mid-West (Indiana, Iowa, Montana, Nebraska, Kansas), in the 1970s it was discovered in Wisconsin and Illinois, and in the 1980s it reached Minnesota, Michigan, Ontario, and Connecticut on the Atlantic coast. In the 1990s it further spread in north-eastern USA (Pennsylvania, New York, Massachusetts, Rhode Island, New Hampshire, Maine) and south-eastern Canada (New Brunswick, Quebec) (Schaffner 1967, Allen 1969, Katovich & Kulman 1987, Froeschner 1988, McPherson et al. 1990, Gall 1992, Marshall 1992,

Wheeler 1992, Maw et al. 2000, Ridge-O'Connor 2001, Javahery 2002). Long-distance transport by human means (e.g., with Christmas trees or other shipments of goods) accelerates the spreading of the species (e.g. Gall 1992, Ridge-O'Connor 2001, Wyniger 2007).

In Europe, the western conifer seed bug was first collected in 1999 in Vicenza in northern Italy (Tescari 2001). The first record was followed by a rapid spread of this species in Italy, where it was found all around the country, including Sicily and Sardinia (Bernardinelli & Zandigiacomo 2001, 2002, Hilpold 2005, Maltese et al. 2009, Olivieri 2004, Pezzi 2003, Taylor et al. 2001, Tescari 2001 2003, Vanin et al. 2005, Villa et al. 2001, Vicidomini & Pignatoro 2007). The species soon crossed Italian boundaries and began spreading in Europe:

2002 – Switzerland: Tessin canton in southern Switzerland (Colombi & Brunetti 2002); first record north of the Alps in 2006 by Wyniger (2007).

2003 – Slovenia (Gogala 2003); further records throughout the country were reported by Jurc & Jurc (2005) and Gogala (2008).

– Spain: Barcelona (Ribes et al. 2004; Ribes & Escolà 2005); later recorded from additional localities in Catalunia (Ribes et al. 2008), in Murcia (Valcárcel & Portillo 2009), Andalucia, and Madrid (Vázquez et al. 2009) in 2008, and finally in Donostia in Basque Country (Pagola Carte 2009) in 2009.

2004 – Croatia: Island of Cres in North Dalmatia (Tescari 2004); further recorded from Dalmatian islands by Rab, Brač & Hvar in 2007 by Kment & Baňař (2008).

– Hungary (Harmat et al. 2006; Földessy 2006).

2005 – Austria: In the autumn of 2005, it was collected in Tyrol, Carinthia, and Vienna (Rabitsch & Heiss 2005). It was later recorded in Salzburg by Novotny (2007).

– France: Collected in nothern Corse in 2005 (Dusoulier et al. 2007). In mainland France it was first collected in 2006 from cca. 17 localities, especially in south-eastern France (Moulet 2006; Dusoulier et al. 2007). Further spreading throughout the territory was documented by Dusoulier et al. (2007), Rahola (2007), Alziar (2008), Seiller (2008), Tamisier (2008), Guérin (2008), Haran & Michel (2009) and Hugel (2009).

2006 – Germany: Berlin (Werner 2006), Baden-Würtemberg (Hoffmann 2008, Rietschel 2009), and Bavaria (Hoffmann 2008, Schmolke & Schulz-Mirbach 2008). It was further recorded in Hesse (Hoffmann 2008), North Rhine-Westphalia (Pérez Vera & Hoffmann 2007), Brandenburg (Landeck 2008), and Saxony (Arnold & Walter 2009).

– Czech Republic: Brno (southern Moravia) (Beránek 2007, Kment et al. 2008); further spreading was documented by Kment et al. (2008) and Hradil et al. (2008).

– Serbia: Novi Sad; collected in Belgrade in 2007 (Protić 2008).

2007 – Great Britain: Weymouth College in Dorset in southern England (Malumphy & Reid 2007). The first record was followed by rapid influx, so Malumphy et al. (2008) already reported 35 confirmed records from 15 vice-counties as far as Kendal in Westmorland in north-western England. Further recordings were given by Bantock & Nau (2009), Bowdrey (2009), Witts & Russell (2009). Anonymus (2010) also mention the species in South Wales (Swansea).

– Belgium: Oostende (Aukema & Libeer 2007); additional localities were reported by Aukema et al. (2009).

– Poland: Wrocław and Miechów near Kraków in southern Poland (Lis et al. 2008).

– Slovakia: Bratislava (Majzlan & Roháčová 2007), further records by Hradil et al. (2008).

– the Netherlands: Bergen op Zoom; in 2008 it was recorded from ten additional localities in various regions of the country, mostly in coastal areas (Aukema 2008).

2008 – Montenegro: Budva (Hradil 2008).

– Bulgaria: Sofia (Simov 2008).

– Channel Islands: Guernsey (Malumphy et al. 2008). Anonymus (2010) also mention the species in Jersey.

2009 – Romania: Cluj-Napoca (Ruicănescu 2009).

– Denmark: Collected in October 2009 in two rather distant localities, Lemvig in NW Jylland and Langø on Falster Island (Buhl & Stephensen 2009).

– Norway: Collected in October 2009 in Rogland County (Klepp, 58°46′36″N, 5°38′20″E) and in November 2009 in Vest-Agder County (Jørgenstadt near Stusvik), both situated in south-west of the country (Mjøs et al. 2010).

– European Turkey: Edirne (in October 2009) and Kırklareli–Lüleburgaz (in Novomber 2010) (see above).

2010 – Portugal; north-western part of the country (Auroca, Caminha, Matosinhos, Mondim de

Basto, Porto, Trofa and Vila nova de Gaia) (Grosso-Silva 2010).

Considering the rapid spreading of the species, we may expect that *L. occidentalis* already reached Transcarpathian Ukraine and all the remaining countries of the Balkan Peninsula, but records are missing due to lack of collecting effort in those areas.

The big spreading potential of *Leptoglossus occidentalis* is supported by its recent finding in Japan, where three specimens were collected in Tokyo in 2008 (Ishikawa & Kikuhara 2009). Zhu (2010) reported one specimen intercepted by Tianjin Entry-Exit Inpection and Quarantine Bureau in north-eastern China.

The distribution of *Leptoglossus occidentalis* in Europe is shown in Fig. 1.

Morphology and Identification

The genus *Leptoglossus* can be easily distinguished from all other Palaearctic Coreidae by the denticulate hind femora and leaf-like dilations on hind tibiae (Moulet 1995). Both *Leptoglossus* species occurring in the Palaearctic region can be identified as follows (cf. Jurberg et al. 1971; McPherson et al. 1990; Moulet 1995; Villa et al. 2001):

1. Humeral angles of pronotum not produced, widely rounded, disc of pronotum brown with several black round spots, without any pale transverse stripe; leaf-shaped dilations of hind tibiae smaller and narrower, both outer and inner part of the dilation are nearly symmetrical, without teeth. 15.0–20.0 mm. (Fig. 2) ..... *Leptoglossus occidentalis* Heidemann
– Humeral angles of pronotum produced into spine, disc of pronotum with orange, transverse, slightly sinuate stripe on anterior half; leaf-shaped dilations of hind tibiae larger and wider, outer part distictly larger and bearing distinct teeth comparing with the small and inerme inner part of dilation. 17.0–24.0 mm. (Fig. 3) ..... *Leptoglossus gonagra* (Fabricius)

The body of *Leptoglossus occidentalis* is dorsally reddish-brown to brown, with white, short, erect pubescence, hairs on dorsal side of head, anterior part of pronotum, scutellum and legs distinctly longer. Head above black, medially with narrow longitudinal reddish-brown stripe and two shorter stripes behind eyes. Antennae long, antennomere 1 thicker than the remaining ones, slightly curved laterad, yellowish-brown with a wide black longitudinal stripe dorso-laterally, antennomeres 1 to 3 yellowish-brown, antennomere 4 blackish. Pronotum brown, medially with scattered small black spots, its posterior part bearing a low transverse ridge in front of scutellum. Scutellum black, medially brown, its apex is whitish. Corium reddish-brown, basally paler, with whitish zigzag transverse line medially; membrane dark brown. Segments of connexivum anteriorly whitish, posteriorly black. Body reddish-brown ventrally, with scattered black punctures and spots. Rostrum yellowish-brown, long, reaching middle of sternite IV. Legs yellowish-brown, femora dorsally (except of bases), apices of tibiae and tarsi blackish; distal halves of femora with distinct short spines on its inner surface, most prominent on hind femora; the hind tibiae medially flattened, the dilation rather narrow, lanceolate, both parts rather symmetrical, without teeth.

The structure of the female reproductive system and its function was recently described in detail by Chiang (2010a,b). The eggs were described by Koerber (1963) and Chiang (2010a). For description of larval instars see Koerber (1963), a photograph of a larva was provided e.g. by Beránek (2007).

Host Plants

Leptoglossus occidentalis is specialised to conifers. It has been recorded from about 40 species of conifers, mostly from pines (e.g., *Pinus attenuata, P. banksiana, P. contorta, P. coulteri, P. flexilis, P. halepensis, P. jeffreyi, P. lambertiana, P. laricio, P. monticola, P. mugo, P. nigra, P. pinea, P. ponderosa, P. radiata, P. resinosa, P. sabiniana, P. strobus, P. sylvestris*), but also on *Pseudotsuga menziesii, P. macrocarpa, Tsuga canadensis, T. mertensiana, Calocedrus* (= *Libocedrus*) *decurrens, Abies concolor, A. magnifica, Picea glauca* (Pinaceae) and *Cupressus sempervirens* (Cupressaceae) (e.g., Koerber 1963; Schaffner 1967; Krugman & Koerber 1969; Katovich & Kulman 1987; McPherson et al. 1990; Gall 1992; Maltese et al. 2003; Vanin et al. 2005; Kment & Baňař 2008; Protić 2008). In Sicily, *L. occidentalis* was recorded on *Pinus halepensis, P. laricio, P. pinea, P. nigra, Pseudotsuga menziesii* in mountains in Sicily up to 1430 meters of altitude (Maltese et al. 2009). They were collected in northern Italy on *Pinus strobus, P. sylvestris, P. nigra, Pseudotsuga* sp. without impor-

tant harm to the host trees (Hellrigl 2006). In Croatia, Tescari (2004) recorded an adult and a nymph at the base of *Pinus nigra*, and Kment and Baňař (2008) on *P. halepensis*. Protić (2008) reported a specimen collected on *Calocedrus decurrens* in a park in Serbia.

Besides conifers, Rice et al. (1985) observed damage caused by *L. occidentalis* feeding on fruits

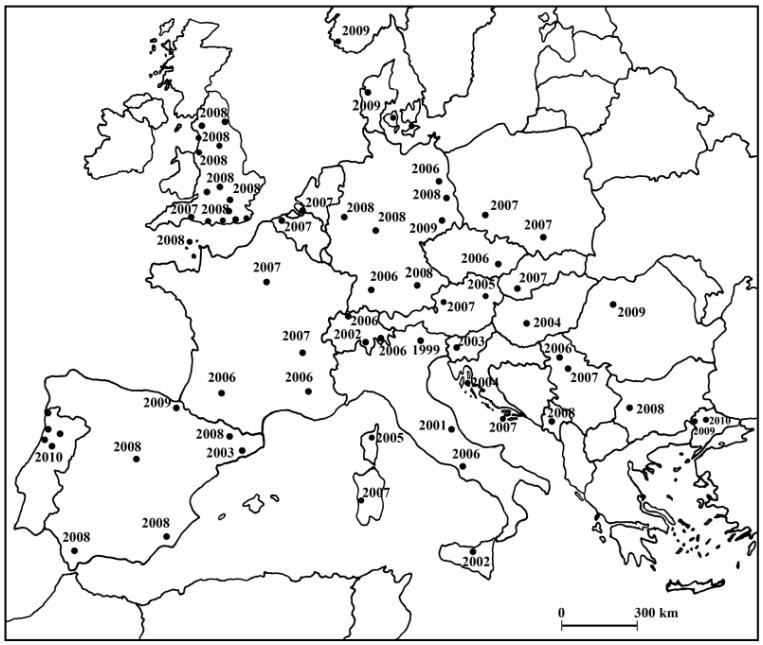

Figure 1. The distribution of *Leptoglossus occidentalis* Heidemann, 1910 in Europe.

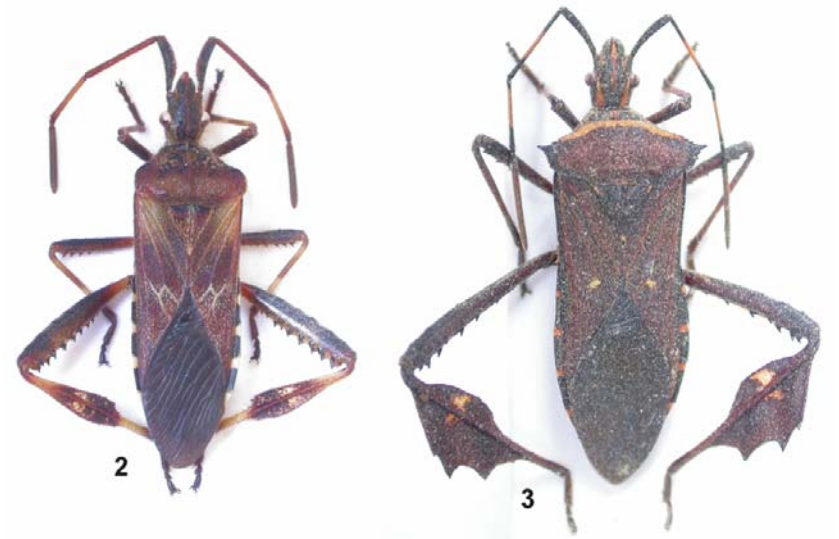

Figure 2. *Leptoglossus occidentalis* Heidemann 1910, habitus in dorsal view (Czech Republic, Brno, coll. National Museum, Prague).

Figure 3. *Leptoglossus gonagra* (Fabricius 1775), habitus in dorsal view (Senegal, Niokolo Koba NP, coll. National Museum, Prague).

of *Pistacia vera* in California. A subsequent experiment confirmed that *L. occidentalis* may develop on pistachio (Uyemoto et al. 1986). Valcárcel & Portillo (2009) found an adult sitting on *Pistacia lentiscus* in southern Spain. Uyemoto et al. (1986) also mentioned capturing adult *L. occidentalis* on almond trees (*Amygdalus communis*) in California.

Ecology and Biology

Leptoglossus occidentalis is univoltine in North America but multivoltine in Mexico (three generations per year) (Koerber 1963, Mitchell 2000). Maltese et al. (2009) estimated no more than two generations per year in Sicily. In North America, overwintering adults leave their shelters in mid-May to early June and seek for coniferous trees to feed on developing seeds and fresh flowers. Females deposit their barrel shaped eggs on needles of the host tree starting from middle to end of spring and eggs hatch in 10–15 days. The first instars feed on the needles and the developing cones a few days before transforming to the second instar. The second instar nymphs are already capable of reaching immature seeds in the cone. The seeds are essential for the bugs development as they are not able to survive when feeding on foliage only. There are five larval instars, the entire development lasting 35–40 days. First generation adults can be found in late July. All life stages feed on the cones causing damage observed at the end of the season (Koerber 1963; Krugman & Koerber 1969; Blatt & Borden 1996a; Mitchell 2000). During autumn the adults seek a variety of overwintering sites. They have been collected under loose bark (Downes 1927), in holes of dead trunks (Dennys 1927), from a hawk and rodent nests (Hussey 1953), and inside buildings (e.g., Spencer 1942; Schaffner 1967; McPherson et al. 1990; Gall 1992; Villa et al. 2001). The aggregation behaviour during autumn is induced by a pheromone (Blatt & Borden 1996b).

Damage and Nuisance

In several US states and Canadian provinces, *L. occidentalis* is recognized as a relatively serious pest of conifer seed orchards, especially on *Pinus* spp. and *Pseudotsuga menziesii*. The bugs suck on young developing cones and may cause abortion of young conelets, fusion of seeds to cone scales as well as direct damage (in various degree) by depletion of the lipid and protein content of the seed up to its complete emptying (Bates et al. 2000a,b, 2002). For example, *Leptoglossus occidentalis* can damage up to 70–80 % of seeds on *Pinus monticola* and 50 % of seeds on *Pseudotsuga menziesii* under natural conditions (Connelly & Schowalter 1991). No study has been conducted to assess the potential damage of *L. occidentalis* to native conifers in European countries, but this species certainly must be considered a potential pest to commercial forestry. Tiberi (2007) listed *L. occidentalis* among pests of *Pinus pinea* cultivated in Italy for the edible seeds. Rice et al. (1985) and Uyemoto et al. (1986) reported damage caused by *L. occidentalis* on cultivated pistachio.

Another impact of *L. occidentalis* is the nuisance to houshold owners by adults aggregating in houses and other buildings while seeking a suitable overwintering place (Gall 1992, Wheeler 1992, Blatt 1994). A case of mass occurrence (over 2000 specimens) in a factory in British Columbia (Canada) was reported by Blatt (1994). The majority of records from European countries so far represent such autumn indoor records (e.g., Villa et al. 2001; Aukema 2008; Kment et al. 2008, Aukema et al. 2009; Maltese et al. 2009). Beside the simple nuisance caused by the bugs presence and their smelly defensive secretion from the metathoracic glands, Bates (2005) also reported damage on cross-linked polyethylene (PEX) pipes commonly used in plumbing and radiant heating systems in the USA; the pipes started to leak after being pierced by the bugs.

Control

The parasitoids of *L. occidentalis* were only marginally studied. Ridge-O'Conner (2001) reported a tachinid fly, *Trichopoda pennipes* (Fabricius 1781), developing in adult *L. occidentalis* in Connecticut (USA) (prevalence 1.5% to 16%). Bates & Borden (2004, 2005) reported three hymenopteran egg parasitoids bred in the seed orchards in British Columbia – *Gryon pennsylvanicum* (Ashmead) (Scelionidae), *Anastatus pearsalli* Ashmead (Eupelmidae) and an unidentified *Ooencyrtus* spp. (Encyrtidae). Camponogara et al. (2003) reported another generalist egg parasitoid, *Anastatus bifasciatus* (Geoffroy) from *L. occidentalis* egg masses in Italy. Parasitoids should certainly play an important role in the integrated pest management of *L.*

occidentalis in the future. Concerning chemical control measures, the effectiveness of several pesticides on *L. occidentalis* was tested in both laboratory and field conditions by Summers & Ruth (1987).

Discussion

Resulting from the fast transportation systems used nowadays, humans carry some species from one ecosystem to another even across countries and continents, either intentionally or not. As far as we know, many of the species introduced in a new environment generally do not survive as it is hard for them to adapt to a new ecosystem. Only a small number of the introduced foreign species adapt to the new environment, establish numerous populations and start spreading. These successful alien species constitute a great potential threat for the new environment because they not only replace the native species in that ecosystem but they may sometimes cause a serious damage to the habitat. Usually it takes a certain time for an alien species to show its impact on the new habitat because the invasion period takes place before the population densities increase to a critical level causing apparent harm (e.g. Lis et al. 2007, Rabitsch 2008, DAISIE 2009). The studies performed so far reported that in Europe *Leptoglossus occidentalis* has not yet reached a critical level to cause economic harm (Hellrigl 2006, Beránek 2007, Steyrer & Perny 2007). However, Lis et al. (2007) concluded that further detailed studies should be carried out on biology and population dynamics of the species in the future.

The records of *L. occidentalis* following its first presence in northern Italy (Vicenza) in 1999 showed that the species rapidly dispersed to western, central, southern and northern Europe. During the first decade of spreading in Europe (1999–2010), *L. occidentalis* reached from Vicenza in northern Italy (Tescari 2001) as far west as Caminha in Portugal (1671 km in bee-line from Vicenza) (Grosso-Silva 2010), Westmoreland (north-western England) in north-west (1411 km) (Malumphy et al. 2008), Klepp in south-western Norway in the north (1526 km) (Mjøs et al. 2010) and in Kırklareli–Lüleburgaz (Turkish Thrace) in the east (1331 km from Vicenza) (this paper). These data indicate that the species was fairly successful in its new habitat. The dispersion rate of the species is greatly correlated with its strong flight ability. The ability to develop successfully on various conifers, the aggregation of specimens during hibernation, and the shift to the usage of man-made structures as overwintering shelters seem to be the key factors enabling the successful spreading and high survival rate of the species in new environments. The development on native European pines already in North America (Schaffner 1967, McPherson et al. 1990) as well as the plantations of native Nearctic conifers in Europe (e.g., *Pinus strobus*, *Pseudotsuga menziesii*), and the possibility of long-distance transportation of entire overwintering aggregations with goods or transportation containers represent very good preconditions for the rapid spreading in Europe and Japan.

Leptoglossus occidentalis was recently recorded in Montenegro, Serbia and Bulgaria in the Balkan Peninsula and these findings show that the species disperses towards east of the continent. The present record of the species in Turkish Thrace can be considered as an indicator of the presence of the species in a wider area of the Balkan Peninsula, which certainly represents an undersampled area for *L. occidentalis* compared with other parts of Europe (e.g., Great Britain, the Netherlands, Czech Republic). Turkish Thrace constitutes today the easternmost distributional border of the species in Europe. It remains to be observed with great concern how quickly the species passes from Europe to Asia across the Çanakkale (Dardanelles) and İstanbul Straits (Bosphorus) to Anatolia.

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