BioInvasions Records (2014) Volume 3, Issue 1: 25–28
doi: http://dx.doi.org/10.3391/bir.2014.3.1.04

Open Access

Rapid Communication

First records of the warm water shipworm *Teredo bartschi* Clapp, 1923 (Bivalvia, Teredinidae) in Mersin, southern Turkey and in Olhão, Portugal

Luísa M. S. Borges[1,2]*, Huseyin Sivrikaya[3] and Simon M. Cragg[1]

[1]*Institute of Marine Sciences, School of Biological Sciences, Portsmouth University, Ferry Road, PO4 9LY, Portsmouth, UK*
[2]*Helmholtz-Zentrum Geesthacht, Centre for Material and Coastal Research, Max-Planck-Straße 1, 21502, Germany*
[3]*Bartin University, Faculty of Forestry, 74100 Bartin, Turkey*

E-mail: luisaborges2000@yahoo.co.uk (LB), h_sivrikaya@yahoo.com (HS), simon.cragg@port.ac.uk (SC)

**Corresponding author*

Received: 22 November 2013 / Accepted: 17 December 2013 / Published online: 17 January 2014

Handling editor: Vadim Panov

Abstract

Bivalves of the family Teredinidae are among the most destructive wood-boring species in the sea. We report the first occurrences of the warm-water shipworm *Teredo bartschi* in Mersin, Turkey, and Olhão, Portugal. The colonisation of the site in Mersin is likely to have occurred by rafting adults originating from the Red Sea, which passed through the Suez Canal (lessepsian migrants). *T. bartschi* might have been introduced in Olhão Harbour, Portugal, either by rafting adults with larvae transported by currents or by larvae transported by ships in ballast water. These seem to be the first published records of established *T. bartschi* populations in the Mediterranean and in northeast Atlantic.

Key words: *Teredo bartschi*, shipworms, teredinids, Mediterranean Sea, northeast Atlantic Ocean

Introduction

The Mollusca is the group with the highest number of alien species in the Mediterranean Sea (Zenetos et al. 2012) and in European waters (Katsanevakis et al. 2013). Among the Mollusca, bivalves of the family Teredinidae (commonly known as shipworms) are probably one of the most economically important groups due to the destruction they inflict in wooden maritime structures. World-wide the damage is estimated to be > one US$ billion dollars annually (Distel et al. 2011). The detection of new invasive teredinid species in European coastal waters is, therefore, of particular importance. Invasive species are in general hard to detect in the early phase of colonisation (Kamburska et al. 2013), this is particularly so in the case of teredinids because their habitat, wood, makes them inconspicuous to most types of surveys. Shipworms enter the wood as larvae, producing minute holes in the wood surface, hardly visible to the naked-eye. Once inside the wood, the tunnels they excavate are not visible from the exterior. Therefore these organisms can go undetected until the wood is heavily colonised (Turner 1966).

Teredo bartschi Clapp, 1923 is a warm water teredinid species (Turner 1966). It was first described from Port Tampa, Florida, but has since been reported widely (Turner 1966; EOL 2007). The wide distribution of *T. bartschi* seems to contradict a number of mechanistic hypotheses that predict a positive correlation between the dispersal ability of a species (the actual or potential distances travelled by migrant species) and its geographic range size (Lester et al. 2007). *T. bartschi* is a long-term larviparous species, brooding the larvae in the gill to the pediveliger stage (Hoagland 1986a). It would be expected, therefore, that this species would have a relatively confined regional distribution because of its short planktonic life stage (Wellington and Victor 1989). However, in many cases, the dispersal ability of species does not correlate with species geographical distribution (Lester et al. 2007). Indeed, in the case of *T. bartschi*, new locations are likely to be colonised by adults (with larvae) rafting in floating wood (Hoagland 1986b; Cragg et al. 2009). Moreover, *T. bartschi* shows a broad physiological tolerance for temperature and salinity, which suits the colonisation of new habitats (Hoagland 1986b).

Methods

Pallets and shells of teredinids were extracted from panels of *Pinus sylvestris* L. exposed at a depth of 3-metres from May 2002 to May 2003 at Olhão, Portugal (N 37.024, W 7.835) and at Mersin, southern Turkey (N 36.563, E 34.254). In the latter site, pallets were also extracted from panels exposed during 2012/2013. Specimens were identified on the basis of the morphology of the pallets, using the keys of Turner (1971) and the illustrations in Turner (1966). In addition, the dimensions of the pallets were measured. The total length of the pallets was measured from the end of the tip to the middle of the line between the tips of the periostracum. The length and width of the blade were also measured.

Environmental conditions of sea surface temperature (SST) and sea surface salinity (SSS) at the two study sites were determined from a global hybrid dataset of temperature and salinity compiled by Borges et al. (2014). This hybrid dataset was based primarily on the global environmental dataset in BIO-ORACLE (Tyberghein et al. 2012), using the long-term variation for salinity provided by the Research Archive (RDA) (Ishii et al. 2005).

Results

The long-term SST and SSS conditions at Olhão ranged from 15.0 to 25.0ºC and 33.0 to 37.0, respectively. These conditions agreed with measured temperatures and salinity in the area (Borges et al. 2014). At Mersin the range SST and SSS varied from 15 to 30.7ºC and 33 to 40, respectively, also agreeing with measured values of temperature and salinity in the area in 2002–2003 (Develi, unpublished data).

The pallets collected were counted and identified. The morphology of the pallets matched the description of *T. bartschi* by Turner (1971).

Diagnosis. Blade of pallets without middle ridge; calcareous portion not extending to tip of blade but visible internally; distal margin of inner face U-shaped, outer face U-V shaped; periostracum light golden to dark brown, extending beyond calcareous portion to form lateral horns. The size of pallets from Olhão varied between 2.68–3.80 mm, while the height and width of the blade varied respectively between 1.0–1.7 mm and 0.9–1.3 mm; the pallets obtained from Mersin had sizes varying from 2.92–3.61mm, whereas the height and width of the blade varied respectively from 1.3–1.9 mm and 0.9–1.3 mm (Figure 1).

Discussion

Teredo bartschi specimens recruited and grew to maturity in wooden panels exposed in Mersin, Turkey in 2002/2003 and 2012/2013 and therefore this species was considered established, according to the definition of Turner (1966). However, in surveys carried out in 2007 and 2010, *T. bartschi* did not recruit to the collecting panels exposed in the area. Therefore, it is not possible to ascertain whether the specimens found in 2013 were descendent of the population sampled in 2003 or whether they are a recent reintroduction. It is also possible that the population found in Mersin is a sink population, originated from a source population in the Red Sea. This species is a long-term larviparous and, therefore, the area was likely to have been colonized by rafting gravid females, which entered the Mediterranean via the Suez Canal (lessepsian migrants). Indeed this species was previously found in the Suez Canal (Clapp and Kenk 1963; Turner 1966: pg 86). Another population of *T. bartschi* present in the Gulf of Aqaba was also thought likely to originate from the Red Sea (Cragg et al. 2009). Furthermore, both the characteristics and the dimensions of the pallets found in the present study were similar to that of the pallets found in the Gulf of Aqaba. Other surveys carried out in southern Turkey by Sen et al. (2010) and Shipway et al. (University of Portsmouth, UK, pers. comm.) did not find this species, which may mean that it has not yet spread to other areas in the Mediterranean.

Teredo bartschi also recruited and matured in wooden panels exposed at Olhão harbour (one year exposure); therefore, the species was considered established. This species did not, however, recruit to collecting wooden panels exposed in 1999, 2000, and 2001 at this site (Praël 2003). Therefore, it seems that *T. bartschi* occurred in Olhão harbour for the first time in 2003 and should be considered an alien cryptogenic species, as there is no evidence of its origin. We cannot ascertain, however, whether or not the population was able to persist in the area, because no additional monitoring was carried out. Although the colonization of the site (Olhão)

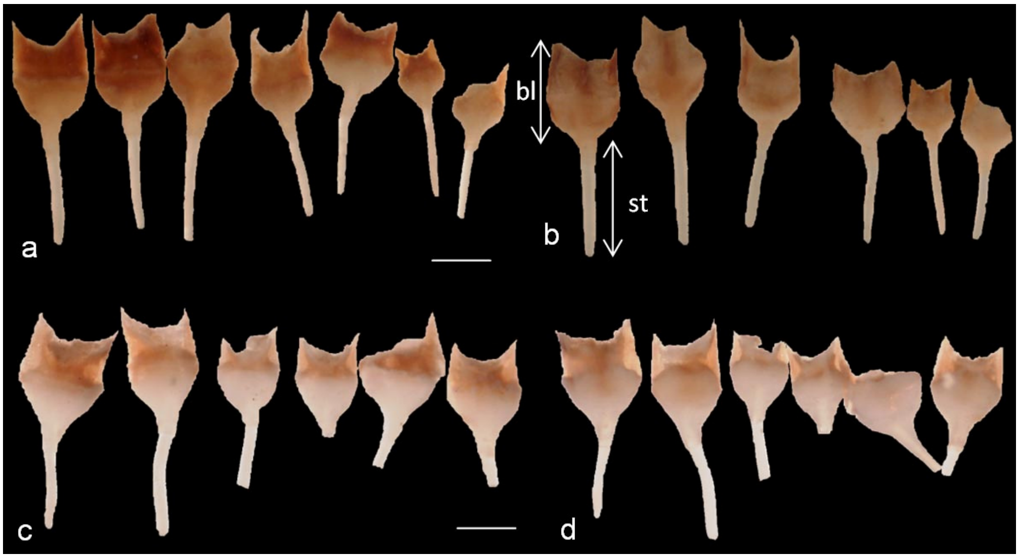

Figure 1. Outer and inner face of pallets of *Teredo bartschi* collected from experimental panels at Mersin Bay Turkey (a and b) and Olhão Harbour Portugal (c and d). Scale bar= 1mm; bl- blade; st- stalk. Photomicrograph by Luísa Borges.

by larvae transported in ballast water cannot be ruled out, the short duration of the larvae in the plankton before settlement (Hoagland 1986a) makes it less likely than colonization by adults (with larvae) carried in driftwood, either from the Mediterranean or from western Atlantic. The environmental conditions of temperature and salinity at Olhão and at Mersin are probably not limiting factors for *Teredo bartschi*, even at the most critical life stage. Indeed, the reported limits of temperature (16–32ºC) for larval *T. bartschi* (Hoagland, 1986b) are close to the range of temperature and salinity observed at Olhão (15–25ºC) and Mersin (15–30ºC) (Borges, unpubl. data). Similarly, this species occurs in estuarine areas (Hoagland 1986b) and also in hyperhaline areas as in the Gulf of Aqaba with salinity > 40 (Cragg et al. 2009). Therefore, the shipworms are not likely to be stressed by the range of salinity either at Olhão (33–35) or at Mersin (33–40). Favourable conditions of temperature and salinity for this species can be found in other areas in the Atlantic and along the Mediterranean coasts of Europe (Borges et al. 2014) and additional surveys are warranted to monitor for possible range extensions of this destructive species.

Teredo bartschi was previously reported occurring in European waters (Gofas et al. 2001; Coll et al. 2010). In both publications, the occurrence of *T. bartschi* in the Mediterranean is cited from Sabelli et al. (1990). However, the latter refers to the publication of Clapp (1923), who mentions the distribution of the species but not in Europe (Tagliapietra, Consiglio Nazionale delle Ricerche, Instituto di Scienze Marine, Venice, Italy, pers. comm.). We also searched online databases such as World Register of Marine species (WoRMS), Integrated Taxonomic Information System (ITIS) and Encyclopedia of Life (EOL). The map of point data provided by EOL (2007) shows three locations for *T. bartschi* in Europe, one of which is misplaced (specimens collected in New Jersey, USA).The other two points refer to the occurrence of the species in the east Atlantic, off Nazaré, Portugal (1978) and in the Mediterranean at Rota, Spain. The information provided by the Global Biodiversity Information Facility (GBIF), on the point data in EOL, and other records of *T. bartschi* in Israel and Egypt, does not mention the type of wood from which the specimens where collected (driftwood, local wooden structures or wooden test panels). Therefore, it is not possible to ascertain whether or not *T. bartschi* was found established in the sites listed in GBIF. This might be the reason why *T. bartschi* was not included in some of the most recent lists of alien species in the Mediterranean and Europe (Zenetos et al. 2005; Zenetos et al. 2010; Zenetos et al. 2012; Katsanevakis et al. 2013). Therefore, ours seem to be the first record of established *Teredo bartschi* populations in the Mediterranean and east Atlantic coast of Europe.

Acknowledgements

This study was supported by a grant provided by Foundation for Science and Technology (FCT), Portugal to LB (SFHR/BD/ 17915/2004).The authors thank Dr Ferit Bingel at the Middle East Technical University, Turkey, for deploying the test panels and for supplying information related to the environmental conditions at the test site. We thank Davide Tagliapietra at Consiglio Nazionale delle Ricerche, Instituto di Scienze Marine (ISMAR CNR), Venice, Italy and his colleagues in Bologna for checking the reference of *Teredo bartschi* in Sabelli et al. (1990). The manuscript benefited from constructive comments of two anonymous referees.

References

Borges LMS, Merckelbach LM, Sampaio Í, Cragg SM (2014) Diversity, environmental requirements, and biogeography of bivalve wood-borers (Teredinidae) in European coastal waters. *Frontiers in Zoology* 11: 13, http://dx.doi.org/10.1186/1742-9994-11-13

Clapp WF (1923) New species of Teredo from Florida. *Proceedings of the Boston Society of Natural History* 37: 31–38

Clapp WF, Kenk R (1963) Marine borers an annotated bibliography. Washington DC: Office of Naval Research Department of the Navy, pp 1136

Coll M, Piroddi C, Steenbeek J, Kaschner K, Lasram FBR, Aguzzi J, Ballesteros E, Bianchi CN, Corbera J, Dailianis T, Danovaro R, Estrada M, Froglia C, Galil BS, Gasol JM, Gertwagen R, Gil J, Guilhaumon F, Kesner-Reyes K, Kitsos M-S, Koukouras A, Lampadariou N, Laxamana E, Cuadra CML-F, Lotze HK, Martin D, Mouillot D, Oro D, Raicevich S, Rius-Barile J, Saiz-Salinas JI, Vicente CS, Somot S, Templado J, Turon X, Vadfidis D, Villanueva R, Voultsiadou E (2010) The biodiversity of the Mediterranean Sea: estimates, patterns, and threats. *PloS One* 5(8): e11842, http://dx.doi.org/10.1371/journal.pone.0011842

Cragg SM, Jumel M-C, Al-Horani FA, Hendy IW (2009) The life history characteristics of the wood-boring bivalve *Teredo bartschi* are suited to the elevated salinity, oligotrophic circulation in the Gulf of Aqaba, Red Sea. *Journal of Experimental Marine Biology and Ecology* 375: 99–105, http://dx.doi.org/10.1016/j.jembe.2009.05.014

Distel DL, Amim M, Burgoyne A, Linton E, Mamangkey G, Morrill W, Nove J, Wood N, Yang J (2011) Molecular phylogeny of Pholadoidea Lamarck, 1809 supports a single origin for xylotrophy (wood feeding) and xylotrophic bacterial endosymbiosis in Bivalvia. *Molecular Phylogenetics and Evolution* 61: 245–254, http://dx.doi.org/10.1016/j.ympev.2011.05.019

EOL (2007) Encyclopedia of Life "*Teredo bartschi* Clapp, 1923" Encyclopedia of life. http://eol.org/pages/439960 (Accessed 1 October 2013)

Gofas S, Le Renard J, Bouchet P (2001) Molluscca. In: Costello MJ (ed), European register of marine species: a check-list of the marine species in Europe and a bibliography of guides to their identification. Collection Patrimoines Naturels, France, pp 108–213

Hoagland KE (1986a) Genetic variation in 7 wood boring teredinid and pholadid bivalves with different patterns of life-history and dispersal. *Malacologia* 27: 323–339

Hoagland KE (1986b) Effects of temperature, salinity and substratum on larvae of the shipworm *Teredo bartschi* Clapp and *Teredo navalis* Linnaeus (Bivalvia: Teredinidae). *American Malacological Bulletin* 4: 89–99

Ishii M, Kimoto M, Sakamoto K, Iwasaki SI (2005) Frontier Research System for Global Change, Japan Marine Science and Technology Center, Japan: Subsurface Temperature and Salinity. Research Data Archive at the National Center for Atmospheric Research, Computational and Information Systems Laboratory, Boulder, CO, http://rda.ucar.edu/datasets/ds285.3 (Accessed 15 May 2013)

Kamburska L, Lauceri R, Beltrami M, Boggero A, Cardeccia A, Guarneri I., Manca M, Riccardi N (2013) Establishment of *Corbicula fluminea* (O.F. Müller, 1774) in Lake Maggiore : a spatial approach to trace the invasion dynamics. *BioInvasions Records* 2(2): 105–117, http://dx.doi.org/10.3391/bir.2013.2.2.03

Katsanevakis S, Gatto F, Zenetos A, Cardoso AC (2013) How many marine aliens in Europe? *Management of Biological Invasions* 4(1): 37–42, http://dx.doi.org/10.3391/mbi.2013.4.1.05

Lester SE, Ruttenberg BI, Gaines SD, Kinlan BP (2007) The relationship between dispersal ability and geographic range size. *Ecology Letters* 10(8): 745–58, http://dx.doi.org/10.1111/j.1461-0248.2007.01070.x

Praël A (2003) Evaluation of the efficacy and environmental impact of RH287 used as an anti-marine wood boring agent. PhD Thesis, University of Portsmouth, Portsmouth, UK

Sabelli B, Giannuzzi-Savelli R, Bedulli D (1990) Catalogo annotato dei molluschi marini del Mediterraneo. Libreria Naturalistica Bolognese, Bologna, 348 pp

Sen S, Sivrikaya H, Yalcin M, Bakir AK, Ozturk B (2010) Fouling and boring organisms that deteriorate various European and tropical woods at Turkish seas. *African Journal of Biotechnology* 9(17): 2566–2573

Turner RD (1966) A survey and illustrated catalogue of the Teredinidae. The Museum of Comparative Zoology, Harvard University, 265 pp

Turner RD (1971) Methods of identification of marine borers and fungi. In: Marine borers, fungi and fouling organisms of wood. Jones SK, Eltringham GEB (eds), Organisaion for Economic Co-operation and Development, France, pp 18–63

Tyberghein L, Verbruggen H, Pauly K, Troupin C, Mineur F, De Clerck O (2012) Bio-ORACLE: a global environmental dataset for marine species distribution modelling. *Global Ecology and Biogeography* 21(2): 272–281, http://dx.doi.org/10.1111/j.1466-8238.2011.00656.x

Wellington GM, Victor BC (1989) Planktonic larval duration of one hundred species of Pacific and Atlantic damselfishes (Pomacentridae). *Marine Biology* 101: 557–567, http://dx.doi.org/10.1007/BF00541659

Zenetos A, Çinar ME, Pancucci-Papadopoulou MA, Harmelin JG, Funari G, Bellou N, Streftaris N, Zibrowius H (2005) Annotated list of marine alien species in the Mediterranean with records of the worst invasive species. *Mediterranean Marine Sciences* 6(2): 63–118

Zenetos A, Gofas S, Verlaque M, Çinar ME, Raso JEG, Bianchi CN, Morri C, Azzurro E, Bilecenoglu M, Froglia C, Siokou I, Violanti D, Sfriso A, Martín GS, Giangrande A, Katagan T, Ballesteros E, Ramos-Esplá A, Mastrototaro F, Ocaña O, Zingone A, Gambi MC, Streftaris N (2010) Alien species in the Mediterranean Sea by 2010. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part I. Spatial distribution. *Mediterranean Marine Science* 11(2): 381–493

Zenetos A, Gofas S, Morri C, Rosso A, Violanti D, Raso JEG, Çinar ME (2012) Alien species in the Mediterranean Sea by 2012. A contribution to the application of European Union's Marine Strategy Framework Directive (MSFD). Part 2. Introduction trends and pathways. *Mediterranean Marine Science* 13(2): 328–352