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Full Length Research Paper

Fouling and boring organisms that deteriorate various European and tropical woods at Turkish seas

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This study aims to investigate the diversity of fouling and boring organisms damaging wood material at Turkish coasts. Trials were carried out at six harbour sites throughout the seas surrounding Turkey. Various Euopean and tropical wood samples were hanged down at a depth of six meters in the sea for a period of one year. Identification of the organisms obtained from wood panels revealed the presence of five wood borer and 26 fouling species. İskenderun harbour had the highest boring organism diversity (five species) and it was followed by Trabzon and Finike harbours (three species) and Bandirma, Eregli and Alacati harbours (two species). The two molluscan boring species, *Teredo navalis* and *Lyrodus pedicellatus* were observed at all harbour sites, but *Nototeredo norvegica* was at Trabzon and İskenderun harbours only. *Bankia carinata* was obtained only at İskenderun harbour and the crustacean wood borer *Limnoria tripunctata* was found at Finike and İskenderun harbours. All native tree species, except for the olive, were significantly damaged by fouling and boring organisms.

Key words: Wood destroyer organism, mollusca, crustacea, Turkey coasts.

INTRODUCTION

Wood material is under significant exposure of physical and biological factors in the marine environment (Mouzouras et al., 1990; Johnson et al., 1992). Damage caused by marine borers to wood structures has been subjected to several scientific researches beginning from the early 18th century. Among the pioneering studies, Sellius (1733) investigated species of the family Teredinidae and Linnaeus (1758) gave detailed species accounts of boring organisms in “Systemae Nature”. These researches were followed by Adams and Adams (1854 - 1858) and Jeffreys (1860). The boring organisms are classified to the families Teredinidae and Pholadidae (Mollusca), Limnoridae, Sphaeromatidae and Cheluridae (Crustacea), respectively. The first two families are abundant in the marine environment and have a strong influence on wood structures (Ryabchikov, 1957).

Wooden material is being widely used in the sea due to its abundance that means renewable material, elastic properties, low production costs and easy plantation (Eaton, 1985; Cragg et al., 1999). Moreover, mechanical properties of wood make it an ideal structure for marine constructions. Hard wood material is preferred in localities exposed to high levels of physical damage, because of their natural durability and dense formation. In some other applications, preservative treated soft wood may also be used (Oliver, 1974; Plaster and Sawyer, 1998).

Limited number of studies have been conducted with regard to durability of wood as well as biodiversity of boring organisms in Turkey waters. Demir (1954) detected *Teredo navalis* in deep waters of the Marmara Sea. Berkel (1961) reported that several woods used in waters around Istanbul were rapidly destroyed by boring organisms. Sekendiz (1981) examined *T. navalis* in the East Black Sea region and found boring organisms in the Turkish waters. Pinar (1977) carried out ecological experiments on fouling and boring organisms and investigated the effectiveness of antifouling paints on wood, metal and glass panels in the harbors of the Amasra, İstanbul, Canakkale, İzmir and Mersin for 12 months. At these stations, *T. navalis*, *Limnoria tripunctata* and *Chelura terebrans* were identified in untreated black pine (*Pinus nigra*). The boring activity was severe in all harbors except İzmir. Bobat (1994) studied durability of treated wood species (Scots pine, fir, oak and beech)

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with creosote and chromated copper borate (CCB) over 14 months in the harbors of İzmir, Mersin and Trabzon. He found that samples exposed in the Marmara Sea were not degraded, whereas untreated samples, except for oak, were almost destroyed in the Mediterranean and Black Seas. Two mollusks were found in Scots pine and oak treated with CCB (chromated copper borate) and exposed in the Mediterranean and Black Seas. Bobat (2002) studied marine wood-boring organisms in Turkish Eastern Mediterranean and Black Sea Coastal Waters. Sivrikaya (2003) investigated marine borers in samples of both sapwood and heartwood of Scots pine, oak and chestnut in Amasra on the Black Sea coast. During the 12-month trial, only *T. navalis* was identified in the wood samples. In Scots pine samples, sapwood suffered slightly more attack than heartwood.

MATERIALS AND METHODS

The study was carried out at six harbours (Trabzon, Eregli, Bandirma, Alacati, Finike, and İskenderun) along the Turkish coasts. Wood samples of 33 tree species (18 European and 15 tropical originated) were located at each sampling station. The European species were Juniper, Walnut, Ash, Mulberry, Fir, Hornbeam, Elm, Austrian pine, Beech, Chestnut, Alder, Cherry, Oak, Scots pine, Cedar, Cypress, Black locust and Olive. The Tropic African Species were Afrormosia, Akajou, Azobe, Bilinga, Bubinga, Douka, Dousse, Gombe, Iroko, Limba, Movingui, Ovengkol, Padauk, Sapelli and Wenge. The wood materials used were 200x75x25 mm in dimensions, prepared according to TS EN 275/2000 standards. Woods were drilled at both ends and lined up over a steel wire with 25 mm of space in between. The wooden panels were then hanged down to a depth of 6 m, during 15 - 30 September 2006 at all study stations. After the panels stayed for one year in the marine environment, they were removed from the sea during 1 - 10 November 2007 and transported to the laboratory of Ege University Faculty of Fisheries for examination. The fouling and boring organisms associated with wooden panels were sorted and identified using a stereomicroscope, following keys of Turner (1966), Schultz (1969), Parenzan (1974) and Cachia et al. (2004).

Evaluation of marine organism attacked on treated and untreated wood samples was evaluated by visual inspection follow the instructions given the standard TS EN 275/2000. Destruction points according to standard are 0 point: no destruction, 1 point: little destruction, 2 point: moderate destruction, 3 point: violent destruction and 4 point: fully destruction.

RESULTS AND DISCUSSION

Fouling organisms

The examination of fouling organisms obtained from wooden panels revealed the presence of 26 species belonging to Porifera, Bryozoa, Polychaeta, Cirripedia, Mollusca and Tunicata (Table 1). The most diverse group was Mollusca with 17 species, followed by Polychaeta (4 species) and Porifera (2 species). The rest of the systematic groups (Bryozoa, Cirripedia and Tunicata) was represented by only one species for each (Figure 1).

According to species distribution among the studied harbour sites, Iskenderun Bay had the highest number of fouling organisms; a total of 18 species mostly belonging to Mollusca (14 species) were determined. The diversity at other harbours were significantly lower; six species were identified from Alacati and Finike harbours, followed by Bandirma harbour (5 species) and Trabzon and Eregli harbours (4 species) (Figure 2).

Boring organisms

Identification of boring organisms obtained from wood panels resulted in the presence of a total of five species belonging to Mollusca and Crustacea was shown in Table 2. Proportion of boring organisms according to harbour sites was shown in Figure 4. Marine wood borers determined at Trabzon harbour were *T. navalis* Linné 1758, *Lyrodus pedicellatus* Quatrefages 1849 and *Nototeredo norvagica* Spengler 1792. The severity of two marine wood borers, *T. navalis* and *L. pedicellatus*, were lower in Eregli harbour, compared to Trabzon harbour (Figure 3). Only two molluscan wood borers, *L. pedicellatus* and *Teredo navalis* were deter-mined in Bandirma harbour, the latter causing higher damage. The proportion of damaged wood panels was the lowest in Alacati harbour. The two wood boring species identified in Alacati harbour were *T. navalis* and *L. pedicellatus*. Wood boring organisms identified at Finike harbour were *Teredo navalis, L. pedicellatus* (Mollusca) and *L. tripunctata* (Crustacea). Highest damage was caused by *T. navalis* at this site. Boring organisms identified from Iskenderun harbour were *L. tripunctata* (Crustacea), *T. navalis* (Figure 5a), *L. pedicellatus* (Figure 5b), *N. norvagica* (Figure 5c) and *Bankia carinata* (Mollusca).

Marine durability of the wood species

Boring organisms identified on the wood samples and natural durability classification of the tree species were shown in Table 4. Marine durability classification of the tree species was determined according to standard TS EN 275/2000 and that study was published at the previous issue (Sen et al., 2009). After the ratings were determined for the Duncan test, 33 wood species were arranged in 9 natural durability categories in Table 3. The wood species with similar durability are indicated by the same letter in homogenous groups. None attack was observed in test samples treated with chromated copper arsenat (CCA) and copper-chrom-boron (CCB) in the control groups. Table 3 also shows the natural durability of the wood species from the highest to the lowest.

Millettia laurentii and *Tieghemella heckelii* showed the best performance followed by *Lophira alata*, *Pterocarpus soyauxi* and *Olea europaea*. Olivewood had surprisingly showed high durability in the range of 5. These five species were degraded less than other tropic species. Slightly lower durability was observed by *Guibourtia ehie* and *Nauclea diderichii* (group 3), *Distemonanthus*

Table 1. Fouling organisms found on wood samples exposed at six harbour sites.

Organism	Trabzon	Bandirma	Eregli	Alacati	Finike	İskenderun
Porifera						
Sycon raphanus Schmidt, 1862				*		
Porifera (sp.)		*		*	*	*
Bryozoa						
Bryozoa (sp.)	*	*	*	*	*	*
Polychaeta						
Filograna sp.			*			
Pomatoceros triqueter (Linnaeus, 1767)				*		
Spiobranchus tetrocerus (Schmarda, 1861)						*
Serpulidae (sp.)	*	*			*	
Cirripedia						
Balanus amphitrite Darwin, 1854	*	*	*		*	*
Mollusca						
Vermetus triquetrus Bivona Ant., 1832						*
Mytilaster lineatus (Gmelin, 1791)	*				*	*
Brachidontes pharaonis (Fischer, 1870)						*
Mytilus galloprovincialis Lamarck, 1819		*	*			
Septifer forskali Dunker, 1855						*
Pinctada radiata (Leach, 1814)						*
Mimachlamys varia (Linnaeus, 1758)						*
Spondylus gaederopus Linne, 1758						*
Spondylus cf. s*pinosus* Schreibers, 1793						*
Spondylus sp.						*
Anomia epiphium Linne, 1758				*		*
Ostrea edulis Linnaeus, 1758						*
Ostreola stentina (Payraudeau, 1826)					*	*
Ostrea sp.						*
Chama gryphoides Linne, 1758						*
Chama pacifica Broderip 1834						*
Petricola lithophaga (Philippson, 1788)						*
Tunicata						
Tunicata (sp.)				*		*

*Present in the location.

benthamianus and *Chlorophora excelsa* (group 4) and *Afzelia bipindensis*, *Pericopsis elata* and *Entandropra gma cylindiricum* (group 5). *Juniperus foetidissima* showed the highest resistance against marine borers and similar results were also observed with *Didelotia africana* (group 6). *Terminalia superba*, *Guibourtia tessmannii*, *Castanea sativa*, *Juglans nigra*, *Robinia pseudoacacia*, *Cupressus sempervirens*, *Morus alba* and *Quercus petraea* performed moderate durability against marine borers (group 7) with ratings of 2.58 - 3.17. *Cedrus libani*, *Carpinus betulus* and *Khaya anthotheca* showed high degradation (group 8) like *Ulmus minor, P. nigra*, *Pinus sylvestris*, *Fraxinus excelsior, Prunus avium*, *Fagus orientalis, Alnus glutinosa and Abies nordmanniana* had the same degradation respectively (group 9).

Conclusion

This study was conducted to determine the influence of fouling and boring organisms to wood material of various tree species at six harbour sites along Turkish coasts. From a total of five marine wood borers identified, all species were found at İskenderun harbour. Three species were observed at Trabzon and Finike harbours and only two species were identified in Bandirma, Eregli and Alacati harbours. The marine wood borer crustacean, *L. tripunctata*, was observed only at two harbours (Finike and Iskenderun) located at the Mediterranean coast of Turkey. Among the molluscan boring species, *T. navalis* and *L. pedicellatus* were the organisms most occurring at all the harbour sites. *B. carinata* specimens were obtain-

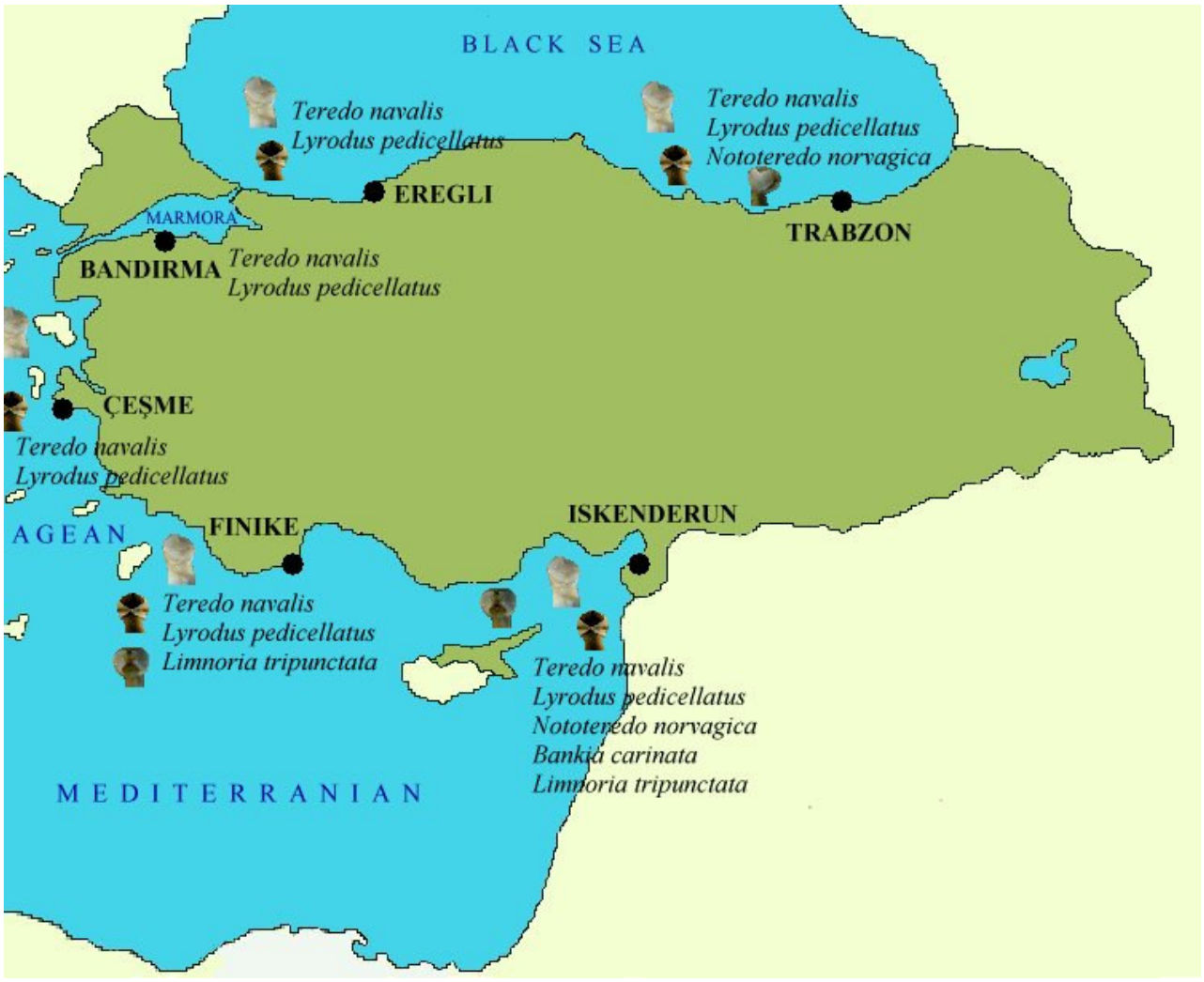

Figure 1. Distribution of boring organisms identified in the wood panels at the test areas

Table 2. Boring organisms identified at each harbour site.

Organism	Trabzon	Bandirma	Eregli	Alacati	Finike	İskenderun
Crustacea						
Limnoria tripunctata Menzies, 1951					*	*
Molluca						
Teredo navalis Linné, 1758	*	*	*	*	*	*
Lyrodus pedicellatus Quatrefages, 1849	*	*	*	*	*	*
Nototeredo norvagica (Spengler, 1792)	*					*
Bankia carinata (Gray J.E., 1827)						*

*Present in the location.

ed only from Iskenderun harbour, whereas, *N. norvegica* only found at Trabzon and Iskenderun harbours The finding of the this study indicated that tree species with nondurable heartwood having low natural durability were mostly damaged by *Teredo navalis*, which is the dominant marine wood borer in all harbour sites excluding Iskenderun harbour. An opposing situation was observed in the naturally dense and durable heartwoods, where the damage of *L. pedicallatus* was much more pronounced than *T. navalis*. Despite the fact that only five

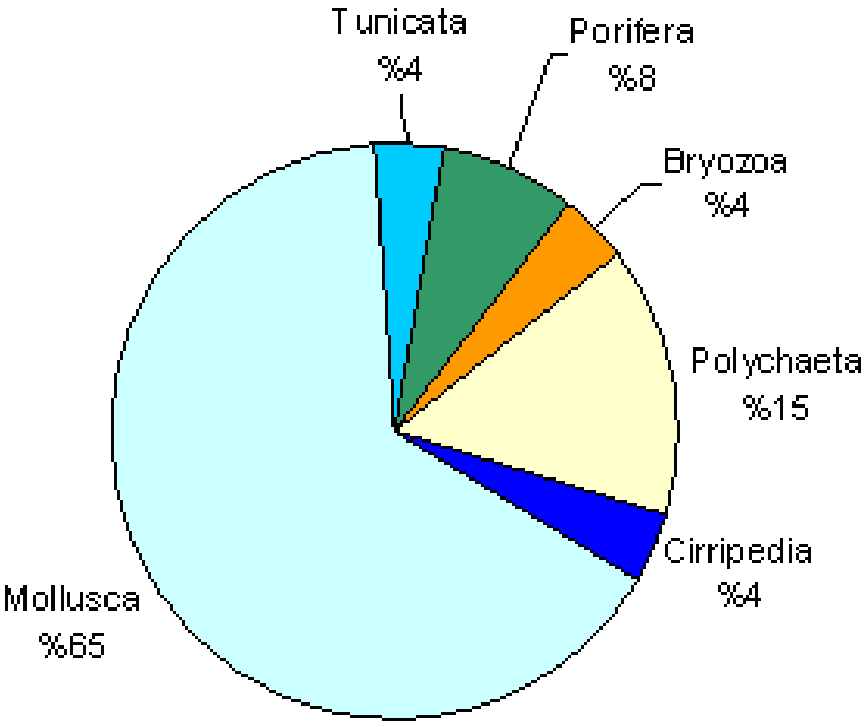

Figure 2. Percentage distribution of fouling organisms according to main systematic groups.

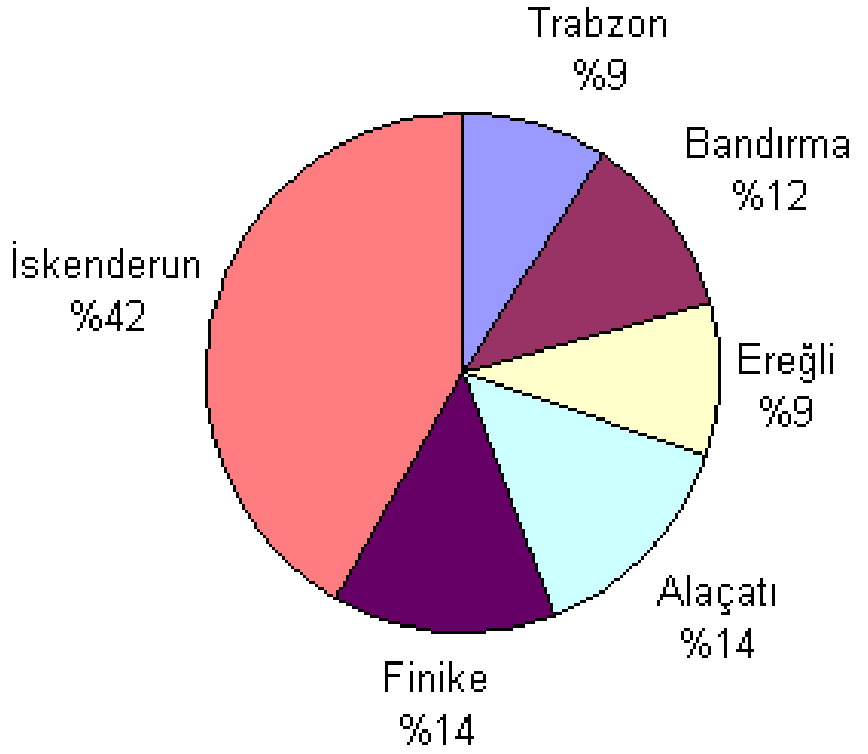

Figure 3. Proportion of fouling species according to harbour sites.

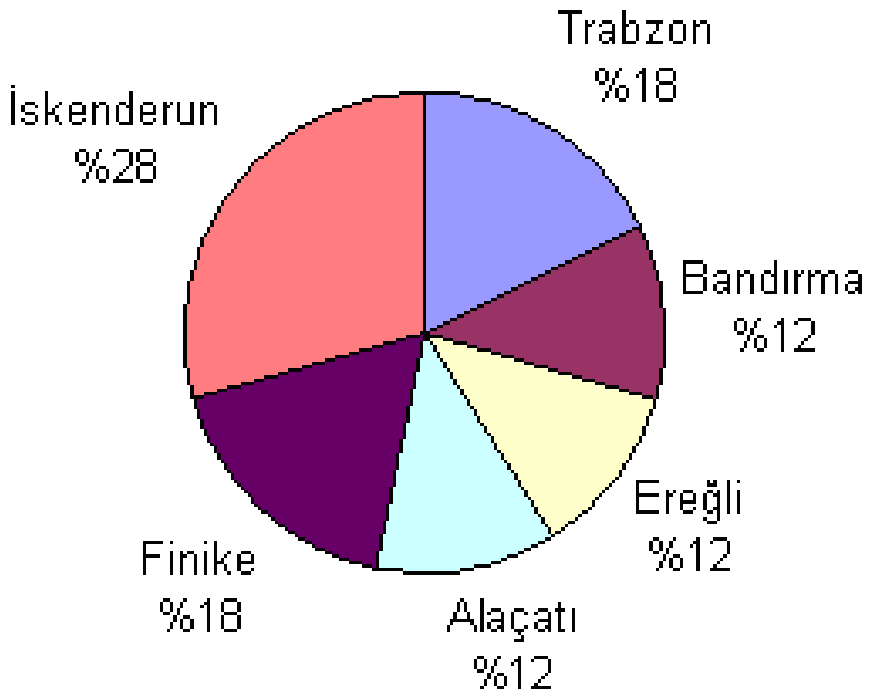

Figure 4. Proportion of boring organisms according to harbour sites.

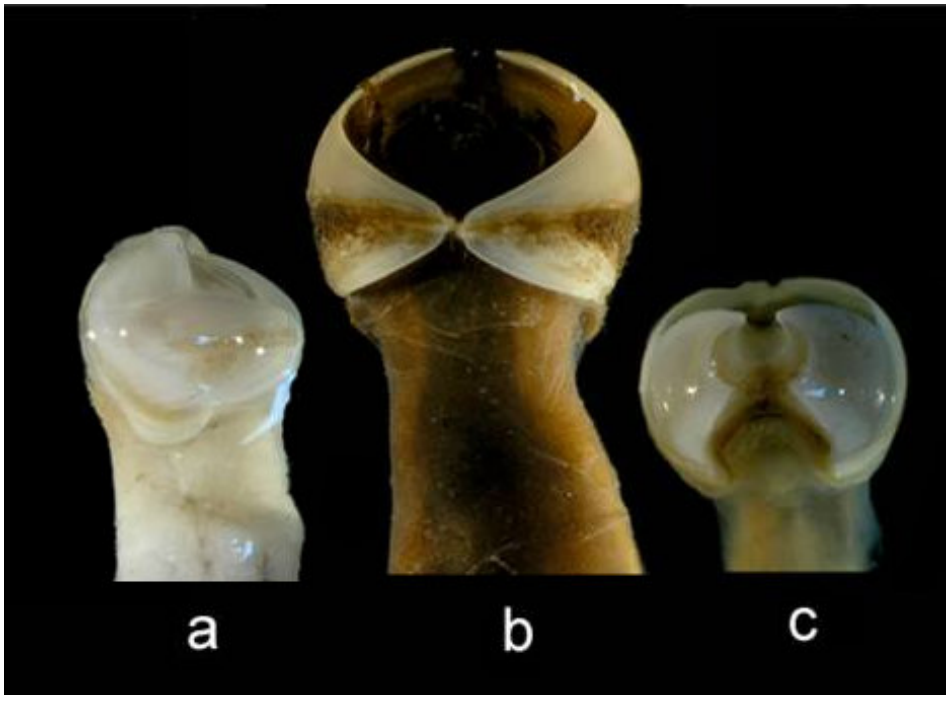

Figure 5. a.) *Teredo navalis* **b.)** *Lyrodus pedicellatus* **c.)** *Nototeredo norvegica*

boring species was identified within the framework of this study, a higher number of wood detoriating organism probably occur throughout the study area. An improved methodology and the examination of wood panels that were exposed to marine environment within shorter periods may reveal a more diverse boring organism fauna.

Table 3. Boring organisms identified at each harbour site

	Black sea		Marmara	Agean	Mediterranean	
	Trabzon	Ereğli	Bandırma	Alaçatı	Finike	İskenderun
Crustacea						
Limnoria tripunctata (Menzies, 1951)					*	*
Mollusca						
Teredo navalis (Linné, 1758)	*	*	*	*	*	*
Lyrodus pedicellatus (Quatrefages, 1849)	*	*	*	*	*	*
Nototeredo norvagica (Spengler, 1792)	*					*
Bankia carinata (Gray J.E., 1827)						*

Table 4. Natural durability classification of European and tropical African tree species in view of destruction points obtained from Duncan test results.

Durability Groups		Tree Species used test	DP	HG	Tn	Lp	Nn	Lt	Bc
	Scots pine	treated with CCA	0,00	s	-	-	-	-	-
	Control Samples	treated with CCB	0,00	s	-	-	-	-	-
1	Wenge	*Millettia laurentii*	0,29	a		+	+		
	Douka	*Tieghemella heckelii*	0,33	a		+		+	
	Azobe	*Lophira alata*	0,58	b		+	+		
2	Paduk	*Pterocarpus soyauxii*	0,71	b			+	+	
	Olive	*Olea europaea*	0,79	b	+	+			
3	Ovangkol	*Guibourtia ehie*	1,00	c	+	+			
	Bilinga	*Nauclea diderichii*	1,00	c		+	+		
4	Movingui	*D. benthamianus*	1,42	d	+	+		+	
	Iroko	*Chlorophora excelsa*	1,75	d		+	+		
	Dousse	*Afzelia bipindensis*	1,92	e	+	+	+	+	
5	Afrormosia	*Pericopsis elata*	1,96	e	+	+			
	Sapelli	*E. cylindiricum*	2,00	e	+	+	+	+	
6	Juniper	*Juniperus foetidissima*	2,21	f	+	+		+	
	Gombe	*Didelotia africana*	2,38	f	+	+		+	
	Limba	*Terminalia superba*	2,58	g	+	+		+	
	Bubinga	*Guibourtia tessmannii*	2,63	g	+	+		+	
	Chestnut	*Castanea sativa*	2,67	g	+	+			
7	Walnut	*Juglans nigra*	2,88	g	+	+		+	
	Black locust	*R. pseudoacacia*	2,94	g					
	Cypress	*Cupressus sempervirens*	3,04	g	+	+		+	
	Mulberry	*Morus alba*	3,08	g		+		+	
	Oak	*Quercus petraea*	3,17	g	+	+			
	Cedar	*Cedrus libani*	3,29	h	+	+			
8	Hornbeam	*Carpinus betulus*	3,46	h	+	+			
	Akajou	*Khaya anthotheca*	3,50	h	+	+	+	+	
	Elm	*Ulmus minor*	3,71	i	+	+		+	+*
	Austrian pine	*Pinus nigra*	3,75	i	+	+		+	
	Scots pine	*Pinus sylvestris*	3,75	i					
9	Ash	*Fraxinus excelsior*	3,75	i	+	+		+	
	Cherry	*Prunus avium*	3,75	i	+	+		+	
	Beech	*Fagus orientalis*	3,88	i	+	+		+	
	Alder	*Alnus glutinosa*	3,92	i					
	Fir	*Abies nordmanniana*	3,96	i	+	+		+	

HG: Homogeneous groups DP: Destruction Point Results is based on destruction degrades. α=0.05
On: Organism number, Tn: *Teredo navalis* , Lp: *Lyrodus pedicallatus*, Nn: *Nototeredo norvagica*, Lt: *Limnoria tripunctata*, Bc: *Bankia carinata*
* İt was shown only İskenderun harbour in Mediterranean

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