Incidence and severity of marine borer attack at different depths at Mtongwe Jetty Pontoon Mombasa, Kenya

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Abstract

The activity of marine borers was investigated at Mtongwe Jetty Pontoon, Mombasa, Kilindini harbour using untreated panels of *Pinus patula* (Schlecht) submerged to different depths. Twenty test panels replicated over 7 months were each strung in three ladder-like frames using nylon twine and suspended vertically, in such a way that the top most panels were 25 cm below the water surface at low and high tide. Monthly observations were made between January and July for the vertical incidence and extent of marine borer attack following the technique of Bobat (1995). Marine borers were collected from test panels, identified and counted. In addition, the percentage weight loss for panels at different depths was determined at the end of 7 months. *Teredo fulleri (Clapp)* was dominant on panels near water surface while *Martesia striata (Linne)* and *Lyrodus pedicellatus* (Quatrefages) were predominant at the bottom. The results showed that attack began within the first month of exposure and was severest by the seventh month. The vertical incidence and extent of attack decreased with increasing depth of panel exposure and was negatively correlated with depth. This is attributed to changes in hydrographic conditions.

Key words: Kilindini harbour, *Lyrodus pedicellatus*, *Martesia striata*, *Pinus patula*, *Teredo fulleri*

Résumé

L'activité des foreurs marins a été étudiée dans le Ponton de Mtongwe Jetty, Mombasa, dans le port de Kilindini, en utilisant des panneaux de *Pinus patula* (Schlecht) non traités, plongés à différentes profondeurs. Vingt panneaux tests identiques ont été attachés avec des cordes de nylon pour former trois cadres ressemblant à des échelles et suspendus pendant sept mois verticalement de façon à ce que les panneaux supérieurs se trouvent à 25 cm sous la surface à marée basse et haute. L'on a fait des observations mensuelles entre janvier et juillet de l'occurrence verticale et l'étendue de l'attaque des foreurs marins en utilisant la technique de Bobat (1995). Les foreurs marins ont été collectés sur les panneaux tests, identifiés et comptés. De plus, on a déterminé le pourcentage de la perte de poids des panneaux aux différentes profondeurs à la fin des sept mois. *Teredo fulleri* (Clapp) était dominant sur les panneaux situés près de la surface de l'eau alors que *Martesia striata* (Linné) et *Lyrodus pedicellatus* (Quatrefages) étaient prédominants en profondeur. Les résultats ont montré que l'attaque a commencé dès le premier mois et que c'est alors qu'elle fut la plus sévère. L'occurrence verticale et l'étendue de l'attaque diminuaient quand le panneau était plus profond et étaient négativement liées à la profondeur. Cela est attribué aux changements des conditions hydrographiques.

Introduction

The Kenyan coastline stretches over 500 km with numerous fish-landing centres. Preliminary surveys have shown that a considerable proportion of wood is used for marine purposes as harbour pilings, fenders, jetty construction and boat building. *Grewia glandulosa, Grewia bicolor*, *Grewia plagiophylla* and *Azadirachta indica* are the timber species mainly utilized for the fabrication of traditional fishing craft.

Wood used in the marine environment is subject to rapid destruction by marine borers. The mechanical properties, low cost, resistance to corrosion and widespread availability of wood have made it the preferred construction material for use in the sea despite recent efforts to introduce modern materials (Hockman, 1973; Brown *et al.*, 2002). The service life of a wooden structure in seawater is dependent on the borer species as well as the environmental conditions at a geographical location. In general,

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wooden structures deteriorate at a greater rate in tropical waters than in temperate waters (Santhakumaran, 1996; Brown, Eaton & Thorp, 2001; Cragg *et al.*, 2001). For instance, Mccoy-Hill (1962) reported premature failure of fenders in Kilindini Harbour and associated this to the activities of marine boring fauna, which were either molluscs or crustaceans. Wood intended for marine use is generally treated with copper chromium arsenate (CCA), creosote or a combination of the two wood preservatives. However, attack of creosote-treated wood by *Limnoria tripunctata* and *Martesia striata* has been reported (Cragg *et al.*, 2001).

A considerable number of marine borer studies have been carried out in temperate regions of the world (Cragg *et al.*, 2001; Vishwakiran *et al.*, *2001*). Little comparative research has been carried out in the African tropics where it is predicted that marine borer attack is severe and losses are enormous (Brown & Eaton, 2001). The main objective of the study was to evaluate the vertical incidence and severity of marine borer attack on untreated *Pinus patula* wood panels. A comparison of the results is made with findings from temperate regions.

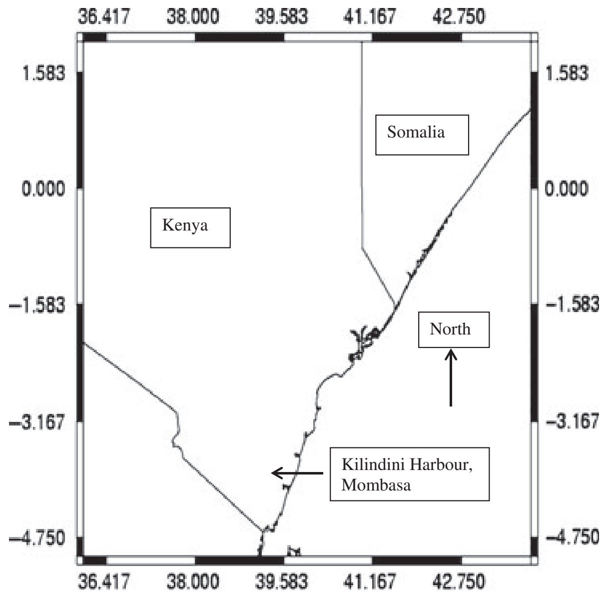

Fig 1 Map of Kenya's coastline

Materials and methods

Study area

The study was carried out at Mtongwe Jetty Pontoon located 5 km from Kilindini harbour, Mombasa between the months of January and July 2006. Figure 1 shows the test site along Kenya's coastline. Water temperature averages 27°C, pH ranges between 8.3 and 8.5 while salinity varies from 29 to 35.5‰.

Preparation of samples

A sixteen-year-old *Pinus patula* plantation at Kaptagat forest was selected to provide test material for the study. The wood species is known to be less durable and shows clearly the distribution of marine borers along the depth. The trees were selected randomly and felled. The logs were converted into three replications of 140 billets each and flat sawn into 150 mm × 100 mm × 25 mm clear sapwood panels. The panels were air-dried to an equilibrium moisture content of about 15% and 6 mm diameter holes drilled at 25 mm from each end and 50 mm from the edge for attachment in a ladder arrangement. The test panels were then sequentially numbered for identification purposes by noting their relative position on the ladder. The initial weight (W_1) of each air-dried board was then determined. Theoretical dry weight (W_t) of test samples was determined by calculating the average per cent (%) moisture content of similar samples dried at 103°C to get the average per cent (%) moisture content (μ).

$$W_t = \frac{100\mathrm{W}_u}{(100 + \mu)}$$

where, W_t is theoretical dry weight of the test samples,

W_u is weight of test samples after conditioning at room temperature,

μ is percentage moisture content measured after oven drying at 103°C.

In this test, the theoretical dry weight of wood was used because in testing for durability, samples should not be dried at 103°C to avoid degradation of the wood components.

Panels were then strung in ladder-like frames using 6-mm diameter nylon twine. Knots were positioned 25 cm apart to separate boards from each other along the ladder. Strings of test panels were suspended vertically below Mtongwe Jetty Pontoon in such a way that the top and the bottom most panel were about 0.25 m and 5 m below the water surface at low tide, respectively. Allowance was made such that the arrays were free to rotate with the prevailing currents. The lower ends of the twines were tied to an anchor stone, while the upper ends were attached to

Fig 2 Strung test panels

a wooden float (Fig. 2). A total of 21 ladders, 10 m apart, each bearing twenty panels were submerged in marine water to expose them to marine borers. Every month without replacement, three ladders were pulled out of the water, scraped free of fouling organisms and examined for the presence of marine-borer attack in the form of borer holes for molluscs and shallow tunnels for crustaceans (Limnoriidae).

Determination of the extent of attack

After 7 months of exposure, test panels from the last three ladders were oven dried to constant final weight (W_f). The difference between theoretical dry weight (W_t) and final oven dry weight (W_f) was expressed as a percentage to estimate the total weight loss, which may have incorporated salts and calcareous deposits left by teredinids. Test panels were rated using the technique described by Bobat (1995) in which severity of attack is rated using a nominal scale of 0 to 10, representing no attack and complete attack, respectively. The extent of attack was also determined visually by examining the intensity of attack based on the type of borer and the relative size and number of holes. Statistical tests were carried out to test for any differences between the incidence of marine borers over the 7 months as well as at different depths.

Collection and identification of marine borer specimens

Fouling organisms such as barnacles and bivalves were removed monthly from test panels to uncover the panels. Teredinids and Pholads were carefully removed from the panels with a mallet and chisel, ensuring that the pallets were not damaged, and transferred with the aid of a fine paintbrush into storage bottles containing formalin. Marine borer specimens were extracted from test panels by removing the surface layers of the wood to expose them. The wood chippings and splinters removed during the extraction of the borers were collected and used in determination of final weight of the panel. Marine borers collected were identified using the taxonomic key by Turner (1971) and the facilities at the National Museums of Kenya and Kenya Marine and Fisheries Research Institute.

Hydrographic conditions at the test site

To minimize the effects of external factors, temperature, pH and salinity were monitored on a weekly basis. An ordinary mercury thermometer graduated to 0.5°C was used to determine the surface water temperature at the test site. Water was drawn in a plastic container and temperature measurements were taken within 30 s by dipping the thermometer in the water.

Seawater samples were collected in 50-ml bottles for the determination of pH. These bottles were taken to the laboratory, shaken well and allowed to stand for 2 min before taking the measurements using a pH meter. Water salinity readings were made using a simple refractometer calibrated for salinity range from 0% to 100%.

Data analysis

The ordinal data for number of marine borers within the 7-month period were analyzed using Kruskal–Wallis test. This test is more powerful than other appropriate tests and hence is sensitive against differences among means in the populations. It tests the hypothesis.

H_o: The three population distribution functions are identical.

H_1: The three populations do not all have identical distributions.

Linear regression was used to derive an empirical model for predicting weight loss at different depths.

Results

Hydrographic conditions

The mud line during low tide was approximately 5 m, allowing contact with the lowest panel. Water temperature ranged from 26°C to 29°C, pH 8.1 to 8.4, while salinity varied from 29 to 34‰ during the study period.

Vertical incidence of marine borers

Lyrodus pedicellatus, Teredo fulleri and *Martesia striata* were identified as the active borers at Mtongwe Jetty (Fig. 3). *Teredo fulleri* was more active in the upper reaches of the water column while the remaining two species *Lyrodus pedicellatus* and *Martesia striata* preferred deeper layers of the water column.

The marine borers attacked all the test panels within the first month of exposure and during the 7-month study period, all test panels were fully infested (Fig. 4). The highest number of marine borers was observed on the panels closest to the water surface with numbers generally decreasing steadily with increasing depth of exposure (Fig. 5). Intense activity by fouling organisms was also observed at the test site, being more prevalent on the panels closest to the water surface and decreasing with depth. Further, it was observed that the severity of panel

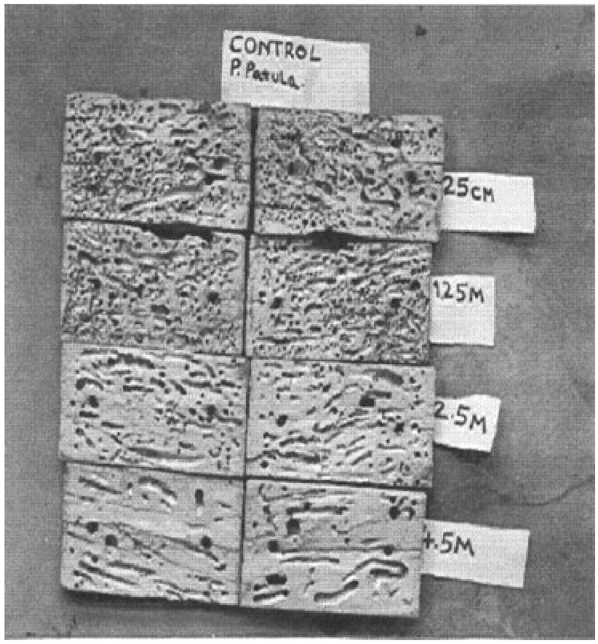

Fig 4 Vertical incidence of marine borer attack on selected *Pinus patula* panels

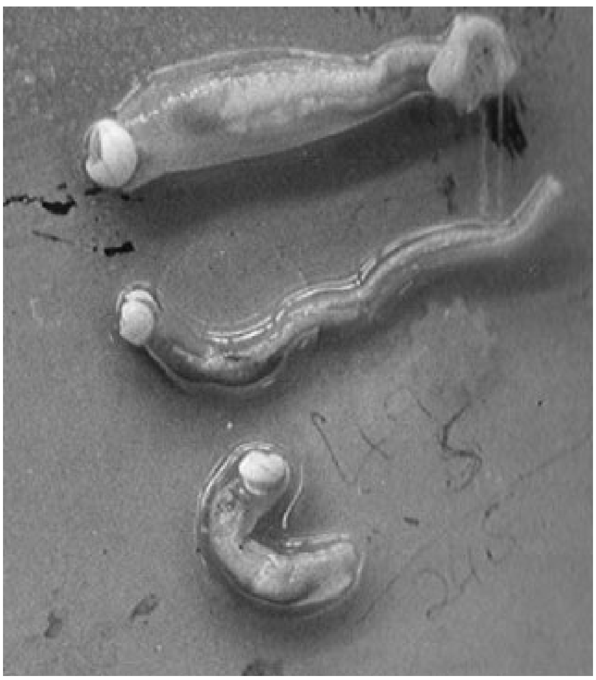

Fig 3 Marine borer species with intact pallets at Mtongwe Jetty Pontoon, Mombasa

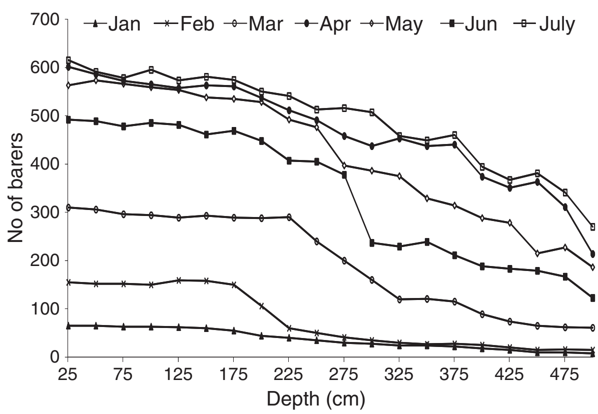

Fig 5 Vertical incidence of marine borers on *Pinus patula* panels at different depths

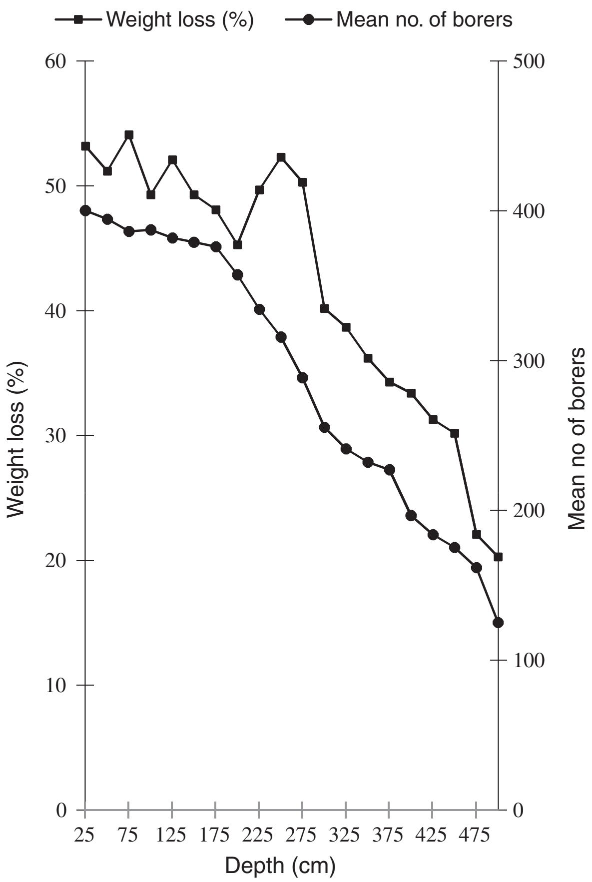

Fig 6 Severity of attack by marine borers on *Pinus patula* panels at different depths

attack by marine borers decreased with increasing depth and increased with time (Fig. 6). Kruskal–Wallis test statistics indicated that the severity of attack was significantly different between months and at the various depths. The ranked means of borer occurrence show that January had the lowest and July the highest rank corresponding with the lowest and highest cumulative degree of attack, respectively (Table 1).

No variation amongst the three ladder replicates was observed ($P \geq 0.05$) indicating that blocking using ladders was effective and that ladders did not contribute to any variation. Linear regression analysis indicated a strong negative correlation between the incidence of marine borers and depth ($R = -0.96$). A similar correlation was observed between depth and extent of attack ($R = -0.92$). The linear relationship between the depth and severity of attack represented by weight loss is shown in equation 1.

Table 1 Ranked means for incidence of marine borer attack for ladder replicates in different months

Month	Sample	Ranked mean score
Jan	60	80
Feb	60	92
March	60	137
April	60	203
May	60	272
June	60	322
July	60	368
Total	420	

$$\text{Weight loss}(\%) = 59.447 - 0.06616 \times \text{Depth} \qquad (1)$$

This estimates the amount of wood loss after a reasonable exposure to marine borers, which provides an insight into the potential destructive effects.

Discussion

Tidal movement and surface runoff influence the hydrographic conditions at Mtongwe jetty during the rainy season. These conditions were similar to those of Mccoy-Hill (1962) who carried out the studies at Kilindini harbour. Marine borers were observed to have settled in large numbers on the wood panels near the water surface. Shipworms extracted from test panels near the water surface were very small indicating retarded growth because of the high intensity of settlement. Observations made by Santhakumaran (1982); Brown & Eaton (2001) and Boaz (2002) show that Pholads prefer panels towards the sea bottom, close to the mud line.

All the test panels were severely damaged within the 7-month test period with percentage weight loss of 20.3% at 5 m to 53.2% at 0.25 m depth. The results illustrate the severity of attack, which teredinids can inflict on untreated timber in Kilindini harbour, Mombasa and conform to those of Santhakumaran (1996) and Kaehler (1999). Complete destruction of pine boards at Kilindini harbour within 6 months by marine borers has been reported before (Mccoy-Hill, 1962). The severest attack at the surface is because of the extremely prolific nature of Teredinidae and Pholadidae species producing vast numbers of free swimming larvae, which start boring upon encountering a suitable surface for settlement (Mccoy-Hill, 1962).

Conclusion

The vertical incidence of borers and severity of attack were the highest in the test panels closest to the water surface and decreased with increasing depth of exposure towards the sea bottom. A strong negative correlation between the severity of *Pinus patula* attack and depth was established. This indicates that the optimal place to fix any physical barrier such as polyvinyl chloride (PVC) liners to retard attack is in the upper rather than lower water column. The three borer species active at Kilindini harbour were identified as *Martesia striata, Teredo fulleri* and *Lyrodus pedicellatus*.

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