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Technical note

A power-driven increment borer for sampling high-density tropical wood

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ABSTRACT

High-density hardwood trees with large diameters have been found to damage manually operated increment borers, thus limiting their use in the tropics. Therefore, we herein report a new, low-cost gasoline-powered sampling system for high-density tropical hardwood trees with large diameters. This system provides increment cores 15 mm in diameter and up to 1.35 m in length, allowing minimally invasive sampling of tropical hardwood tree species, which, up to the present, could not be collected by conventional 5 or 10 mm increment borers. This system provides a single core sample with ample amount of wood for multidisciplinary analyses, including ring width, stable isotope and wood anatomical measurements. The borer never gets stuck inside stems, even in hollowed trees, cores will never twist during coring, and the gasoline drill gives ample flexibility in the field. It is anticipated that the dendrochronological community will find our technique very useful in the pursuit of tropical tree ring research.

1. Introduction

Tree ring studies are relatively scarce in tropical and subtropical regions (Rozendaal and Zuideman, 2011). This is understandable, given that tropical dendrochronology is challenging because (1) many tropical and subtropical tree species show poorly distinct or indistinct tree ring boundaries (Lisi et al., 2008; Pons and Helle, 2011) and (2) sampling tools were developed for softwoods of the Northern Hemisphere or low-density hardwoods. However, such tools are unsuited to tropical tree species of high wood density. Chave et al. (2009) investigated worldwide density of tree species, and in the tropics, maximum values of density achieved 1.35 (g/cm^3) compared to 0.85 (g/cm^3) in Europe. Consequently, common increment borers are seldom appropriate for trees with very high wood density (>0.8 g/cm^3).

Generally, the increment borer is the most common tool to obtain tree cores. As described by Grissono-Mayer (2003) manual increment borers use a tapered cutting thread with 2- or 3-threading at one end, which draws the borer into the tree when turned. It also has a shallow extraction spoon to remove the increment core. The most frequently used increment borers extract cores 4.35–5.15 mm in diameter. However, diameters of 8 mm, 10 mm and 12 mm are also required for studies needing a higher amount of wood sample, such as isotope analysis or wood anatomy studies. Small-diameter corers tend to break easily and can often exhibit significant distortions as a consequence of the coring process. Classical increment borers employ an auger such that the threaded bit works by expulsion, resulting in high friction forces. Consequently, borers with larger diameters often get stuck or even break in hardwoods, owing to higher contact surface with the wood. An example

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Fig. 1. Commercially available tenon plug cutter (photos by FAMAG©).

is the Haglöfã Mora-Cortax increment borer with an inner diameter of 12 mm and outer diameter of 19 mm. This borer has to displace 7 mm of wood. With higher wood densities and rising diameter, the possibility increases that these borers will become irreversibly stuck or even break.

Based on these limitations, dendrochronological laboratories around the world developed several types of borers with different purposes (Schweingruber, 1983). To make the sampling process easier and faster, battery- or gasoline-driven drills have been used (Speer, 2010). Hall and Bloomberg (1984) developed a power borer relying on a chainsaw whose power is converted into rotation by an Atom Drilling Attachment. Publications about those borers and their working principles are rare (Bowers, 1960). In addition, the possibility of acquiring custom-made devices is quite small, and as demand decreased, the manufacture of these tools also decreased. One example is the gasoline-driven CSIRO Trecor system, which was primarily designed to core plantation eucalypts, typically less than 300 mm in diameter. This device allowed a single operator to comfortably collect 100–120 cores per day. The production of a 500 mm borer that provides 13 mm cores ceased in 2010 (Downes, com.per.). The custom-made dendrochronological borer with a length up to 390 mm (core lengths up to 250 mm) offered by Pressler© GmbH (Gestern, Germany; http://www.pressler.com.de/), which relies on principles similar to those of CISRO Trecor, is still available on demand. However, neither borer is suitable for high-diameter tropical hardwood trees.

Taking the limitations described above into account, we developed a portable gasoline-powered sampling system for tropical high-diameter hardwoods. The system has been tested in tropical forests in Brazil and Cameroon for the last two years by sampling a wide range of species of various tree sizes and with different wood properties.

2. Description of the coring system

The coring system consists of 4 major parts: borer, extractor, engine and support frame.

Our drill bit is functionally different from that of manual increment borers. Specifically, we chose a commercially available milling cutter used by carpenters. It is called a tenon plug cutter (Fig. 1). Several manufacturers produce this type of cutter, and the inner diameter can range from 6 to 80 mm. In general, they are made out of high alloy chromium steel and have between four and nine cutting teeth, depending on their respective diameters. We decided on an inner diameter of 15 mm. This respective model is manufactured by FAMAG® (Remscheid, Germany; http://www.famag.com) and has an outer diameter of 26 mm, a shaft length of 18 mm and four cutting teeth.

Two different methods of connecting the tenon plug cutter to the tube were tested in the field. Fig. 2(1a) shows the original tool modified by cutting off the attachment just at the shaft. Afterwards, we bevelled it conically, followed by welding the cutter head to a stainless steel tube. In Fig. 2(1b), the bit is welded at the legs of the attachment. This generates an opening between the tube and the tip. This machining is well suited to species that produce longer wood shavings during the drilling process. The excess of splits is easily removed from the tube, preventing the core from getting stuck inside of it. In addition, it allows the operator to see the material removed when pushing and pulling the borer, recognizing when the core breaks, liquids leak or if any abnormality happens during the drilling process.

The wrought tubes have an inner diameter of 19 mm and wall thickness of 1.5 mm. The resulting outer diameter of 22 mm gives the borer 2 mm of free space in relation to the borehole. This space reduces friction between the stainless steel tube and the wood borehole, thus avoiding overheating. We have produced several borers with different lengths between 55 cm and 135 cm. Short borers are somewhat easier to handle, and selection can be made according to the diameter of the specific trees to be sampled.

The borer is connected to the drill by an adapter (Fig. 2(2)), also made out of stainless steel. On the side where the tube is connected, the diameter is 18.8 mm, which is slightly smaller than the tube's inner diameter. The side of the adapter, which is inserted in the borer socket of the engine, is milled hexagonally to avoid slippage during the coring. A bolt (Fig. 2(3)) locks adapter and tube. The bolt head fits flush with the tube.

To extract the wood core, we use a torsion-stable wire 3 mm in diameter, which is bent to 90° at both ends in different lengths. One end (Fig. 2(4)) has a length of about 7 cm, which is used as a handlebar for turning. The other end has a section 4 to 6 mm long that is filed like a sharp blade (Fig. 2(5)). To release the core, the extractor has to be inserted into the free space of 4 mm around the core milled by the bit. This requires some circular turns and small cuts until the core gets detached. The blade is subjected to high torsion forces, with a corresponding tendency to twist and break. Therefore, we highly recommend providing several extrac-

Fig. 2. (1–5) Schematic illustration of the borer and extractor components: 1a and b modifications of the tenon plug cutter, 2 adapter, 3 locking bolt, 4 handlebar, 5 cutting blade.