

*Short Communication***A simple and inexpensive method for sharpening permanent steel knives with sandpaper**

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ABSTRACT

Good anatomical sections can only be obtained with a perfectly sharp knife. Permanent steel microtome knives are present in numerous plant anatomy labs and they yield excellent results, with the only caveat that they need to be re-sharpened after use. Automatic knife sharpeners have been especially designed for this purpose, but they require abrasives in their use, which may be expensive and hard to obtain. Here we describe and illustrate in detail an inexpensive, fast, widely accessible technique to sharpen permanent microtome knives using different sandpaper grits. Knives sharpened with this technique have already been in use for over a decade and are suitable for all types of botanical specimens both embedded and unembedded.

Keywords: Plant anatomy, sectioning, sliding microtome, knife sharpening, plant preparation.

INTRODUCTION

A profusion of articles and books exist in the literature with methods for obtaining good anatomical sections from woods and barks for anatomical descriptions (Chamberlain 1935; Johansen 1940; Sass 1958; Berlyn & Miksche 1976; Kukachka 1977; Gerlach 1984; Kraus & Arduin 1997; Khasim 2002; Barbosa *et al.* 2010; Angyalossy *et al.* 2016). In all of these important contributions, the authors unanimously agree that a sharp knife is the first and foremost requirement to obtain good anatomical sections. Berlyn and Miksche (1976, page 55) state that “for critical work there is no substitute for the heavy and properly sharpened microtome knife”, which is in the lines of what

their mentor, Sass (1958, page 42), had written two decades earlier: “For cutting very thin sections, uncommonly thick or large sections, or for tough materials, the heavy microtome knife is indispensable. The greater rigidity of a knife permits sectioning of material with which a flexible razor blade would chatter, cutting sections of uneven thickness.”

It is clear that these authors made use of heavy, permanent steel microtome knives. These knives were gradually substituted by disposable microtome knives, which are placed in a knife holder. There is no doubt that good anatomical sections of rigid materials can indeed be obtained with disposable knives, and that they may match the work of heavy knives (Sass 1958; Fujii 2003; Schweingruber 2012). However, several of our institutions, and this is the case of the Institute of Technological Researches of São Paulo (IPT), the Smithsonian Institution, the Forest Products Laboratory (Madison, WI), the Botany Department of the University of São Paulo (USP, São Paulo) and many other Institutions, still have the heavy steel microtome knives, perhaps as a legacy from the early days. In others, especially in developing or newly industrialized countries in Latin America and Asia, the price of buying disposable knives can be a limiting factor.

As good as these permanent knives are, the caveat is that they need to be re-sharpened periodically, especially when sectioning hard materials. In the old days, sharpening of microtome knives was a laborious and skillful job that took hours and involved a honing back and a stiff leather strop (Malone 1922; Johansen 1940). Later, companies created microtome automatic knife sharpeners (Fig. 1A), which would do the same job in a matter of minutes, by using glass plates and coarse and fine abrasive substances (Hillier 1951). These abrasives are, however, quite expensive; many manufacturers stopped producing them, and they may be sold only in some countries, which are limiting factors for many labs. Here we suggest a simple, straightforward and inexpensive technique for perfectly sharpening microtome permanent steel knives using different grits of sandpaper. This has been used by us in São Paulo for the past 10 years with success both to section fragile and rigid plant parts, infiltrated in all different types of embedding media. This technique has already been implemented in large Plant Anatomy Labs such as those at the Research Institute of São Paulo (IPT, Brazil), University of São Paulo (USP, Brazil), Botany Institutes of the Rio de Janeiro and São Paulo Botanical Garden (Brazil), Forest Products Laboratory (Madison, U.S.A.), São Paulo State University (UNESP, Brazil), CITEmadera (Lima, Peru), and the Smithsonian Institution (Washington DC, U.S.A.), among others. The technique proposed here has proven to be adequate to section not only plant parts, but also bones, other types of animal tissues, and even synthetic materials.

MATERIALS

The materials here are a Type C Microtome Steel Knife (Fig. 1B,C), different grits of waterproof sandpaper, an automatic knife sharpener, and mineral oil as a lubricant. The type C microtome knife can be either 16 or 12 cm long. Type C knives have a wedge-shaped blade and are among the hardest available (check Mohammed *et al.* 2012 for a description of all types of knives) and are adequate to section both hard and soft materials (Kraus & Arduin 1997). Waterproof sandpaper with four different grit types

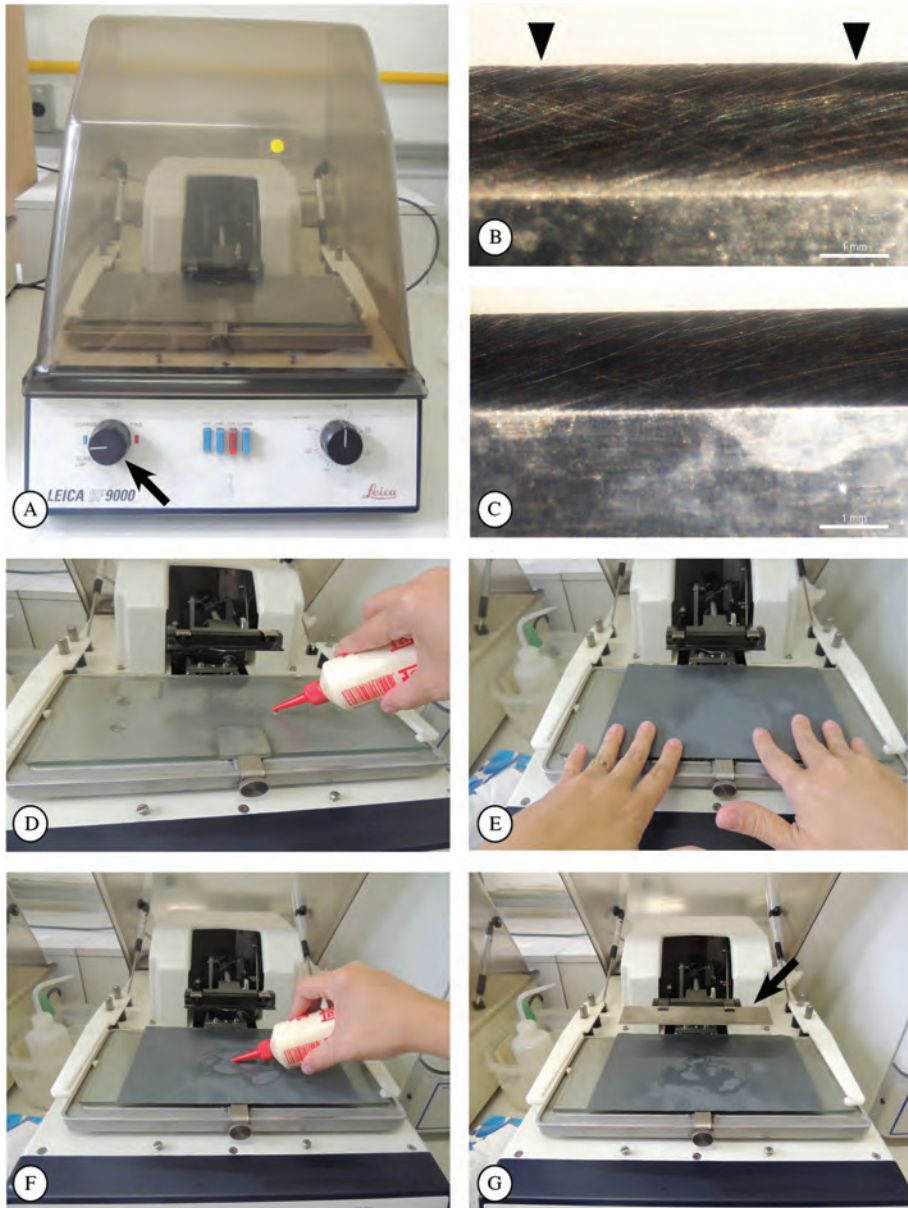


Figure 1. Materials and steps to sharpen steel knives with sandpaper. – A: Automatic knife sharpener. Note the coarse and fine button (arrow). – B: Example of an unsharp knife, with imperfections and nicks (arrowheads) under the dissecting microscope. – C: Example of a sharp knife under the dissecting microscope. – D: Mineral oil being applied on top of the glass place. – E: Sandpaper being adhered to the glassplate with the use of oil. – F: Mineral oil being applied upon the sandpaper to act as a lubricant between the sandpaper and the knife. – G: Knife centrally placed. Note that the sandpaper is slightly wider than the knife.

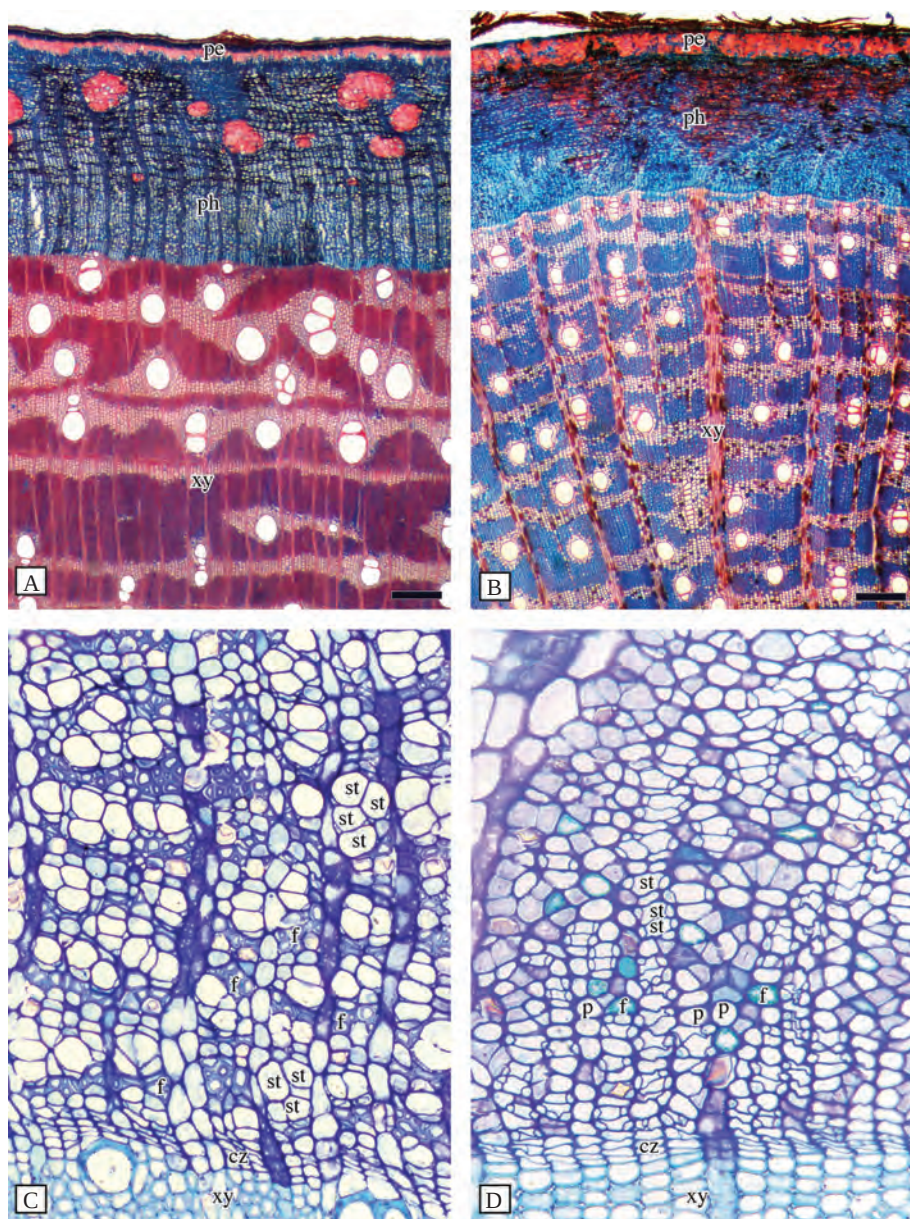
were used: 600- and 1200-grit waterproof sandpapers are used as substitutes of coarse abrasive substances, and the 1500- and 2000-grit sandpapers are used as substitutes of the fine abrasive substances. Waterproof sandpapers of different grits are normally found in any hardware store.

Automatic Knife Sharpener: we have tested the brands Blunt, American Optical Company, Spencer, and Leica (Fig. 1). As lubricant we use any mineral oil (refined petroleum mineral oil).

METHODS

- 1) Cut the waterproof sandpaper to a size wider than the knife, or to the same size as the glass plate.
- 2) Put some drops of mineral oil on the plate (Fig. 1D) and then place the 600-grit sandpaper making sure it adheres to the plate tightly (Fig. 1E). The oil should make the sandpaper attach to the glass plate and not move with the force imposed by the knife sharpener and the knife. If the knife does not have nicks, but it is simply not sharp enough, one can start directly from the 1200-grit sandpaper. If the knife is too blunt, allow 30 minutes with the 600-grit sandpaper.
- 3) Put some drops of mineral oil on the surface of the sandpaper until it is spread all over the area (Fig. 1F). Place the knife centrally in the knife holder (Fig. 1G). Some microtome knife sharpeners (*e.g.*, Leica) have a button that says coarse and another that says fine (Fig. 1A). If your microtome knife sharpener is of this type, leave it on coarse for the entire procedure. Put the sharpener to work for 10–15 minutes. If your microtome knife sharpener does not have this button, just choose the same amount of time.
- 4) By the end of the selected time, verify under a dissecting microscope if there are still nicks on the blade (Fig. 1B). If that is the case, allow more time of sharpening. If the nick is too deep, it is not recommended to insist too long in the sharpening process, otherwise the lifespan of the blade will be considerably reduced. Simply mark the region where the nick is present and use the rest of the knife. The deep nick will automatically disappear in subsequent sharpening sessions.
- 5) By the end of every step, clean the excess of oil in the blade with a delicate paper to remove any grit from the sandpapers, which could cause new nicks.
- 6) Change to the next, more delicate sandpaper grit (1200 in case the 600 was used initially) and repeat step 3, putting the knife sharpener to work for 10–15 minutes. Then progress to 1500-grit sandpaper for another 10–15 minutes.

Figure 2. Plant samples sectioned with sandpaper-sharpened knives, transverse sections. →
 A: Brazilian ironwood *Libidibia ferrea* (Mart. ex Tul.) L.P. Queiroz, embedded in Polyethylene glycol 1500 (PEG). Secondary xylem (xy) with thick-walled fibers, wide vessels, aliform confluent parenchyma and marginal parenchyma. The phloem (ph) and periderm (pe) well preserved, phloem with large sclereid clusters and periderm with a layer of lignified cells. –
 B: Creeping fig *Ficus pumila* L., embedded in PEG. Secondary xylem (xy) with bands and paratracheal parenchyma alternating with fibers. Phloem (ph) and periderm (pe) well preserved.



Note layer of lignified cells in the periderm. – C: The secondary phloem of the tree “Açoita-cavalo” *Luehea divaricata* Mart., embedded in glycol methacrylate. Cambial zone (cz) well preserved, sieve-tube elements (st) and fibers (f) in clusters, intermingled by parenchyma. – D: The secondary phloem of the creeping fig *Ficus pumila*, embedded in glycol methacrylate. Cambial zone (cz) well preserved. Secondary phloem with sieve tubes (st) accompanied by two companion cells lying on each opposite side, scattered gelatinous fibers (f), intermingled with parenchyma cells (p). — Scale bars: A & B: 300 μ m.

- 7) With the last, 2000-grit sandpaper, repeat step 3 putting the knife sharpener to work for 4–10 minutes (attention: more time will make the blade rounded).
- 8) Clean the knife with absolute ethyl alcohol and check under the dissecting microscope if the blade is well sharpened (Fig. 1C for a well sharpened knife).
- 9) The knife is ready to be used. If it is to be used later, it is a good idea, especially in tropical, humid countries, to apply vaseline or mineral oil to the blade, to prevent it from rusting. The vaseline or the oil should be removed with absolute ethyl alcohol prior to use.

DISCUSSION AND CONCLUSION

The technique presented here involves using different sandpapers for sharpening microtome knives in an automatic knife sharpener, and represents an alternative to the use of abrasive solutions. Abrasive solutions are getting harder to find on the market and their cost surpasses that of sandpaper by a magnitude of hundreds. Sandpapers are furthermore readily available in hardware stores virtually everywhere. Another nuisance avoided by the use of sandpaper is the constant need to resurface the glass plates, which with the use of abrasives need to be reconditioned periodically to be coarse. This step is not needed when sandpaper is used. Each sandpaper can be used to sharpen a knife up to 4 times, after which it should be replaced.

With this technique, it is possible to section perfectly even very hard materials, like the Brazilian ironwood *Libidibia ferrea* (Mart. ex Tul.) L. P. Queiroz (Fig. 2A), which has wood with thick-walled fibers and the more delicate, aliform-confluent and marginal parenchyma side by side. In addition, the blade is good enough to preserve the delicate phloem and periderm (Fig. 2A) when combined with the use of a polystyrene resin (Barbosa *et al.* 2010). It is also adequate for samples with an alternation of soft and hard cells, like in the creeping fig *Ficus pumila* L. (Fig. 2B). Very thin sections can also be obtained with knives sharpened with this technique of plants embedded in glycol methacrylate (Historesin), like seen in “Açoita-cavalo” *Luehea divaricata* Mart. and *Ficus pumila* (Fig. 2C, D), where details of the secondary phloem such as sieve tube and fiber arrangement can be perfectly visualized. All different infiltration and embedding media can also be used, such as paraffin, polyethylene glycol (PEG; Fig. 2A, B) or glycol methacrylate (Historesin, Fig. 2C, D). We highly recommend this convenient method as an option for sharpening steel microtome knives based on our success after rigorous testing on a variety of refractory botanical samples.

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