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The review of the PhD thesis of Eyob Gebrehiwot Gebregeorgis titled “Annual to Intra-annual Dendroclimatic Studies of *Juniperus procera* at Blue Nile’s basin, Gonder Ethiopia”

In the thesis, the author presents a complex dendrochronological study of the species *Juniperus procera* from Ethiopia. The main aim of the study was to confirm if annual tree rings produced by African pencil cedar in the region of the Blue Nile’s basin can be successfully cross-dated. For this purpose visually identified and cross-dated tree-rings were validated using radiocarbon dating. Another part of the study concerns the analyses of anatomical features of the wood as a potential indicator of environmental factors which influences radial growth. In the tracheids, the lumen diameter, wall thickness and the ratio of both were measured and standardized by their relative position within the tree-ring. Anatomical parameters of the transition between late-wood and early wood were analyzed as well. Obtained variables: tree-ring width chronology and tracheidal chronologies were than tested for their relationship with climatic data - the local record of precipitation. The study was based on 40 core samples extracted from trees growing in four Ethiopian Orthodox Church grounds near the city of Gonder.

As a main result, the author confirmed the annual character of tree-rings produced by *Juniperus procera* in the area of the Blue Nile basin. Preliminary, visual cross-dating corresponded to calendar years obtained with AMS bomb-peak radiocarbon dating. Tree-ring chronology showed a stable response to summer and annual precipitation and negative pointer years overlapped with historical drought in the region. Anatomical analyses of the dimensions of tracheids showed that trees produced cells of small diameter – much smaller than most of the conifer species. However, small dimensions of tracheids were compensated by a higher number of cells. This may indicate, that African pencil cedar invest more on cell division than cell enlargement. The author suggests that parenchyma cells which occur within the xylem can be related with abrupt environmental changes. At the early-wood to late-wood

transition a significant drop in lumen diameter was observed, while the wall thickness was increased. This can be useful in the separation of annual rings.

The dissertation is in the form of a monograph, a traditional and still prevailing way of presentation of doctoral theses in Poland. The manuscript consists of 151 pages written with a 12 point font and lines are double spaced. Such a volume seems to be optimal like for this kind of work. It corresponds roughly to the volume of 2-4 manuscripts of regular research papers. The text is divided into chapters typical for a research paper: introduction, literature review, material and methods, results, discussion, conclusion and references. The text is preceded by acknowledgments, a table of contents, list of tables and figures and an abstract.

The abstract is informative and it summarizes the objectives of the study, methods and results. Key words describe the subject of the study, but maybe a name of the object of the study – the species, and place of the study could be added. Key words should be given in an alphabetical order.

The introduction contains clearly defined objectives of the study and the author raises reasonable questions which inspired him for this work. The short Introduction (4 pages) is followed by a long chapter “Literature review” (20 pages). This part contains 23 numbered subchapters and bold headings. Although it contains a very large portion of literature, in fact it is a little bit chaotic and difficult to read. There is no clear reason to divide the text so much, and subchapters could be merged: like “1.1.1 General objectives” (4 lines) and “1.1.2 Specific objectives and research question” (14 lines). Some information is repeated in consecutive headings. The subchapter “Basic inter-annual dendrochronological techniques and procedures” could be moved to “Materials and Methods”, because in fact, technical issues are repeated again in the next chapter. For instance subchapter “2.5 Radiocarbon dating” contains general information which is supplemented with more details in the subchapter “3.2.3 Radiocarbon dating” in the Methods. There is no need to touch so many topics in this part like climate change, anatomy of woody plants, definition and history of dendrochronology, methodological details etc. This chapter should be focused more particularly, on tropical dendroclimatology. However, this very broad part proves, that the author is familiar with all aspects of his study. These are only technical remarks, because the Introduction and the Literature review contain the most important things: the state of the art and especially the recent progress in tropical dendrochronology.

The methodological part of the study is well described and consecutive steps of this work are illustrated with 10 figures. Methods used in the study follow standard dendrochronological procedures. They are complex and consist of: visual cross-dating

verified with statistics and additionally confirmed by radiocarbon dating, intra annual tracheidal analyzes based on the measurements of the dimensions of cells and finally the climate-growth analyzes conducted for tree-ring widths as well as for tracheidal parameters.

In the results the author admits that cross-dating was a challenging task. The verification of the quality of the visual identification of tree-rings is possible by bomb-peak radiocarbon dating only in a time scale of the last ca. 60 years and such a calibration was done for 7 samples. The cross-dating of tree-rings prior to this period could be doubtful due to the presence of missing, false rings and micro rings. How can the author be sure if the whole samples were cross-dated correctly? This issue needs some critical discussion. Maybe, some portions of cores with visually identified and cross-dated rings could be shown (e.g. where are the annual rings in figure 15?). The raw data of the measurements would give the picture of the year to year variability of ring-widths as it is presented for early wood percentage (Figure 25) and the number of tracheids (Figure 26). Why the index chronologies in Figure 18 are not shown in one graph (and in better quality)? The small distance among sampling sites doesn't seem to explain the different patterns of local chronologies. This also raises a question about the correctness of the cross-dating.

The author mentions missing rings and false rings as a source of trouble in the study – how many such troublesome rings was identified in the cores e.g. per century per sample? Figure 3 presents historical droughts and observed negative pointer years. In the “Results” and in the “Discussion” the author admits that not all narrow rings were induced by droughts and he explains that trees may not necessarily respond to an abrupt climate change. Is this the only explanation? Here, in my opinion, is the weak point of the discussion. Radial growth does not depend exclusively on climate. There might be many other factors which influence growth depression like defoliation by animals, grazing, trampling (spiritual gatherings during masses near churches), cutting branches (sampled trees were high-pruned), perhaps the possibility of historical fires. Sampled trees might have been affected by bio-social interaction in the past e.g. periods of competition and releases due to the death of neighboring trees can cause very strong changes in ring-width pattern. Nowadays the woodlands around the churches may look like a well preserved arboreta (page 27), but most likely these places were exploited in the past for fire wood, construction wood etc. This may matter in this work, because the sample is very small (3, 4, 6 and 18 trees per plot).

*Juniperus procera*, like the other trees representing this genus, is a dioecious plant. Tree-ring patterns of male and female individuals can be different due to the higher costs of reproduction in the case of female trees. This effect can be enhanced in poor environmental

conditions. Did the author distinguish the sex structure of the sampled population? All these factors can affect tree-ring growth, and should be discussed.

The “blue column” – parenchyma cells located in the xylem were formed due to “some sudden abiotic stress during the growing season”. I would be interested what precisely, does the author mean by such a stress?

## **Conclusion**

Dendrochronology as a scientific discipline was established and successfully developed based on the model of tree growth in temperate and boreal zone, where cambial activity is distinctively seasonal. In effect, trees produce a clear pattern of annual tree-rings which can be easily identified even by macroscopic observation and their exact time of formation can be assigned to certain calendar years. Thus, dendrochronology has been broadly applied in climatic studies, forest ecology, archeological cross-dating etc. This problem occurs when period of dormant and vegetation season is not so clear. Tree-ring studies in the Mediterranean and tropical zone are much more difficult due to a complicated pattern of cambial activity. The author accepted the challenge of ambitious task. Although the study is based on a small number of trees like for a dendrochronological work, the dataset has been thoughtfully analyzed. The anatomical part is especially impressive. The work is supported by a high number of references. The large body of literature is correctly cited and the author demonstrates a good knowledge of the state of the art. This monograph is definitely a valuable work, which deepens our view of tree growth in the tropics as well as the biology of the *Juniperus procera*. The author demonstrated a competence to analyze data properly, to present results and he manifested a patience during time-consuming and laborious work in the laboratory. His work constitutes a significant contribution to science.

In my opinion, the PhD dissertation of Eyob Gebrehiwot Gebregeorgis meets the formal requirements set for PhD theses in Poland. I hereby request that Eyob Gebrehiwot Gebregeorgis’ doctoral dissertation be admitted to the further steps of the procedure, including the public defense.



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