Dendrochronologia 70 (2021) 125890

Contents lists available at ScienceDirect

Dendrochronologia

journal homepage: www.elsevier.com/locate/dendro

Q-NET – a new scholarly network on quantitative wood anatomy

Georg von Arx [a,b,*,1], Marco Carrer [c,2], Alan Crivellaro [d,e,3], Veronica De Micco [f,4], Patrick Fonti [a,5], Frederic Lens [g,h,6], Angela Luisa Prendin [i,7], Sabine Rosner [j,8], Ute Sass-Klaassen [k,9]

[a] Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Zuercherstrasse 111, CH-8903 Birmensdorf, Switzerland
[b] Oeschger Centre for Climate Change Research, University of Bern, Hochschulstrasse 4, CH-3012 Bern, Switzerland
[c] Dipartimento Territorio e Sistemi Agro-Forestali – Università degli Studi di Padova, Viale dell'Università 16, 35020 Legnaro, Italy
[d] Department of Geography, University of Cambridge, 20 Downing Place, Cambridge CB2 3EN, UK
[e] Forest Biometrics Laboratory, Faculty of Forestry, "Stefan cel Mare" University of Suceava, Str. Universitatii 13, 720229 Suceava, Romania
[f] Department of Agricultural Sciences, University of Naples Federico II, via Università 100, 80055 Portici (Naples), Italy
[g] Naturalis Biodiversity Center, Research Group Functional Traits, P.O. Box 9517, 2300RA Leiden, The Netherlands
[h] Institute of Biology Leiden, Plant Sciences, Leiden University, Sylviusweg 72, 2333 BE Leiden, The Netherlands
[i] Department of Biology, Ecoinformatics and Biodiversity, Ny Munkegade 116, 8000 Aarhus C, Denmark
[j] Institute of Botany, University of Natural Resources and Life Sciences, Gregor Mendel Strasse 33, 1180 Vienna, Austria
[k] Wageningen University & Research, Forest Ecology and Forest Management, P.O. Box 47, 6700 AA Wageningen, The Netherlands

ARTICLE INFO

Keywords:
Wood anatomical traits
Community network
Virtual networking

ABSTRACT

Quantitative wood anatomy (QWA) is a dynamic research approach of increasing interest that can provide answers to a wide range of research questions across different disciplines. However, the lack of common protocols and knowledge gaps hinder the realisation of the full potential of QWA. Therefore, we established the new community-based network Q-NET to provide an open interdisciplinary platform for exchange and research around QWA. Q-NET (https://qwa-net.com) combines an online knowledge and exchange base with virtual workshops. The first two workshops each attracted more than 125 participants from around the world, demonstrating the community's interest in QWA and this virtual way of networking and collaborating. Indeed, virtual networks such as Q-NET could increase the inclusiveness, efficiency and sustainability of scientific collaboration while providing additional training and teaching opportunities for early career scientists, both of which complement in-person conferences and workshops.

Quantitative wood anatomy (QWA) is the numeric analysis of xylem anatomical traits of trees, shrubs, and herbaceous species and their relationship to plant functioning, growth, environment, wood quality and species identification (De Micco et al., 2019; Lens et al., 2020; von Arx et al., 2016). The xylem anatomical traits include measurable and countable anatomical variables of cells (lumen and cell wall dimensions, counts, position and spatial arrangement; e.g., IAWA Committee, 1989, 2004; Scholz et al., 2013), tissues (area, abundance and counts; e.g., von Arx et al. (2015); Ziemińska et al., 2013), pits (dimensions of aperture, pit border, pit membrane thickness, torus and margo, and counts; e.g., Bouche et al. (2014), Li et al. (2016), Plavcová et al. (2013)), discrete anatomical features such as intra-annual density fluctuations (IADFs; e.

* Corresponding author at: Swiss Federal Institute for Forest, Snow and Landscape Research WSL, Zuercherstrasse 111, CH-8903 Birmensdorf, Switzerland.
E-mail address: georg.vonarx@wsl.ch (G. von Arx).
[1] 0000-0002-8566-4599.
[2] 0000-0003-1581-6259.
[3] 0000-0002-1307-3239.
[4] 0000-0002-4282-9525.
[5] 0000-0002-7070-3292.
[6] 0000-0002-5001-0149.
[7] 0000-0002-5809-7314.
[8] 0000-0003-1708-096X.
[9] 0000-0002-8479-3209.

https://doi.org/10.1016/j.dendro.2021.125890
Received 28 May 2021; Received in revised form 10 September 2021; Accepted 16 September 2021
Available online 20 September 2021
1125-7865/© 2021 The Authors. Published by Elsevier GmbH. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

g., De Micco et al. (2016)), resin ducts (e.g., Rosner and Hannrup (2004), Vázquez-González et al. (2020)), frost rings (e.g., Payette et al. (2010)), light rings (e.g., Filion et al. (1986)), blue rings (e.g., Piermattei et al. (2015)) and more. The variability is often measured along time series of growth rings, and matching the position within the ring to the sub-seasonal time window in which an anatomical feature was formed (Ziaco, 2020) allows reconstruction of processes (Carrer et al., 2017; Castagneri et al., 2017) and environmental variability (Björklund et al., 2020; Fonti et al., 2010; Hillabrand et al., 2018) at high resolution. Other viewpoints from which variability in anatomical traits is commonly investigated include phylogeny (Lens et al., 2016; Pace et al., 2009), patterns among species (Hietz et al., 2017; Olson et al., 2020), genetics (Davin et al., 2016; Eilmann et al., 2014; Hajek et al., 2016), allometry (Anfodillo et al., 2006; Rosell et al., 2017) and basic understanding of structure-function relationships (Hacke et al., 2015; Lens et al., 2011; Sviderskaya et al., 2020). Time series of QWA data can also be linked to other plant physiological data streams, such as time series of stable isotopes (Martin-Benito et al., 2017), dendrometer (Cocozza et al., 2016), and sap flow data (Tateishi et al., 2008). Altogether, QWA contributes to answering research questions related to ecophysiology, evolution, plant identification, tree biology, forest ecology, wood quality, and is applied in many different disciplines such as dendrosciences, geosciences and forest management. However, as with many dynamically evolving research approaches, there are limitations at many levels, including lack of common protocols and data analysis standards as well as knowledge gaps for proper interpretation.

1. Q-NET is a new community-based QWA network

Awareness of these limitations motivated the creation of the new community-based network Q-NET (https://qwa-net.com). Q-NET brings together scientists using QWA with the goal of providing an open interdisciplinary platform for exchange and research around QWA. Specifically, Q-NET aims to (i) identify key knowledge gaps, (ii) harmonise field and lab methods, and define standards and procedures for sampling, lab methods and data analysis, (iii) integrate QWA data to address large-scale environmental effects on tree growth and functioning, (iv) develop ideas for common projects, research agenda and priorities, and other activities, and (v) integrate with other disciplines to upscale from tree to stand and ecosystem level, e.g. through remote sensing, modelling approaches and artificial intelligence. The ultimate goal of Q-NET is to provide a platform to facilitate synergies among members that advance QWA and promote breakthroughs in the multidisciplinary field of wood science.

2. Q-NET organisation, participation and deliverables

Membership in Q-NET is open to anyone interested in sharing experiences and ideas on QWA. Membership is free and only requires registration (https://qwa-net.com/membership/). Since its launch on October 16th, 2020, Q-NET has grown to more than 390 registered members from 49 countries around the world (as of September 1st, 2021). The network is managed by the Q-NET Coordination Team, a rotating group of researchers in the field who volunteer time and energy to keep the idea alive.

The online member area of Q-NET hosts a directory with research profiles of all members to facilitate the search for scientific partners with specific expertise and lab equipment. The ongoing compilation of online tools and resources such as tutorial videos, books and articles about laboratory methods, online databases, software and hardware, etc. provides an important and growing knowledge platform. In addition, a set of different forums are available to post general questions, announce open positions and seminars, and interact in specific projects and activities.

A key activity of Q-NET is virtual workshops. The Q-NET workshops are “idea markets” that benefit from an interdisciplinary network for developing and elaborating new collaborative ideas, defining standards, advancing methodology, creating synergies from a larger and more diverse network, developing proposals and publications, etc.

3. Q-NET workshops and projects

The first virtual Q-NET workshop on November 30th, 2020, was attended by more than 160 participants and was dedicated to develop ideas for joint activities around the ten topics: (1) knowledge gaps in QWA; (2) protocols and standardised methods for QWA data production; (3) online toolbox for data analysis; (4) identification of structure-function relationships and relevant functional traits; (5) linking QWA with other data and proxies; (6) analysing wood anatomical time series: requirements and guidelines; (7) modelling and QWA: from cell to ecosystem; (8) wood technology and QWA: from dimensional measurements to biomechanics; (9) xylogenesis amd QWA: from counting to measuring; and (10) developing next-generation tools for quantification of anatomical structures. These topics were discussed in parallel breakout rooms prepared and led by experts in the field. The workshop produced ten ideas for common projects. The developed project ideas targeted a diversity of outcomes including perspective and review articles, regular exchange platforms, surveys, analyses scripts and databases.

A survey after the workshop revealed that two-thirds of the workshop participants considered themselves as juniors, which reflects the membership structure well. Slightly less than two-thirds indicated that such workshops should be organised twice per year. The workshop was rated very positively overall by participants, which shows that such virtual workshops can be a welcome complement to physical conferences and workshops.

A second workshop took place on May 19th, 2021, and was titled “A journey through QWA with stopovers”. Different from the concept of the first workshop, questions and suggested topics were collected previously and then answered and discussed by experts in five sequential sessions grouped into: (1) study design and field work, (2) sample preparation, (3) measuring techniques, (4) data analysis, and (5) xylogenesis. This second workshop was attended by more than 125 participants.

4. Conclusions

Quantitative wood anatomy (QWA) is a dynamically developing research approach that can contribute to providing answers to research questions on a wide range of environmental topics. However, there is a lack of consolidated common protocols. Furthermore, informed use and interpretation of QWA data requires an understanding of the complexity of the drivers behind the measured characteristics, which in turn requires multidisciplinary expertise. The newly established, community-based network Q-NET combines online and virtual tools to address these challenges and create synergies that advance QWA and its application in research.

Our experience to date suggests that Q-NET could be a model for a new, complementary channel of scientific exchange and collaboration in a relatively small research community. The benefits of this virtual networking include (i) greater inclusiveness, as there are no fees, making it easier for many members with small budgets to participate, (ii) a reduced time commitment to participate, as no travel is required, which could attract additional participants with time constraints, and (iii) a smaller carbon footprint. However, virtual meetings also bring challenges, such as different time zones that make it impossible for a global community to meet at the same time. Moreover, the social aspect of in-person conferences and workshops, which is often seen as equally important for networking and developing creative ideas, has no real equivalent in the virtual world. Altogether, virtual events offer the opportunity for a more inclusive group of researchers to interact with each other and provide additional training and teaching opportunities for early career scientists. This could help establish more consolidated

common standards, protocols and knowledge bases, which is particularly important for dynamically evolving research approaches such as QWA.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We would like to thank the many colleagues who were involved in the development of the Q-NET concept in three workshops on September 18th, 2019, June 12th, 2020 and July 9th, 2020: A. Arzac, G. Battipaglia, A. Bräuning, A. Buras, F. Campelo, D. Castagneri, J. Dolezal, I. Garcia-Gonzalez, H. Gärtner, J. Gricar, I. Heinrich, S. Jansen, E. Liang, J. M. Olano, L. Plavkova, P. Prislan, C. Rathgeber, B. Schuldt, M. Wilmking, E. Ziaco. We would also like to express our gratitude to the numerous colleagues who actively contributed to the first two Q-NET workshops on November 30th, 2020, and May 19th, 2021, and thus contributed to a successful launch of this initiative: A. Arzac, G. Battipaglia, J. Björklund, A. Cabon, D. Castagneri, A. Crivellaro, K. Cufar, T. De Mil, M. Fonti, H. Gärtner, J. Gricar, A. Hurley, S. Jansen, S. Klesse, S. Mayr, J.M. Olano, R. Peters, L. Plavkova, P. Prislan, C. Rathgeber, G. Resente, J. Van den Bulcke, E. van der Maaten, M. Wilmking, E. Ziaco. We further acknowledge stimulation of the Q-NET idea by the COST Action STReESS (COST-FP1106). GvA was supported by the Swiss National Science Foundation SNSF (grant no. 200021_182398, XELLCLIM). AC received funding from the Fritz H. and Elisabeth Schweingruber Foundation. ALP was supported by a Marie Sklodowska-Curie Individual fellowship (IF) under contract number 895233. Q-NET is currently supported by the following scientific associations: Association for Tree-Ring Research (ATR), International Association of Wood Anatomists (IAWA) and Tree-Ring Society (TRS).

Declaration of Competing Interests

None.

References

Anfodillo, T., Carraro, V., Carrer, M., Fior, C., Rossi, S., 2006. Convergent tapering of xylem conduits in different woody species. New Phytol. 169, 279–290.
Björklund, J., Seftigen, K., Fonti, P., Nievergelt, D., von Arx, G., 2020. Dendroclimatic potential of dendroanatomy in temperature-sensitive Pinus sylvestris. Dendrochronologia 60, 125673.
Bouche, P.S., Larter, M., Domec, J.-C., Burlett, R., Gasson, P., Jansen, S., Delzon, S., 2014. A broad survey of hydraulic and mechanical safety in the xylem of conifers. J. Exp. Bot. 65, 4419–4431.
Carrer, M., Castagneri, D., Prendin, A.L., Petit, G., von Arx, G., 2017. Retrospective analysis of wood anatomical traits reveals a recent extension in tree cambial activity in two high-elevation conifers. Front. Plant Sci. 8, 737.
Castagneri, D., Fonti, P., von Arx, G., Carrer, M., 2017. How does climate influence xylem morphogenesis over the growing season? Insights from long-term intra-ring anatomy in Picea abies. Ann. Bot. 119, 1011–1020.
Cocozza, C., Palombo, C., Tognetti, R., La Porta, N., Anichini, M., Giovannelli, A., Emiliani, G., 2016. Monitoring intra-annual dynamics of wood formation with microcores and dendrometers in Picea abies at two different altitudes. Tree Physiol. 36, 832–846.
Davin, N., Edger, P.P., Hefer, C.A., Mizrachi, E., Schuetz, M., Smets, E., Myburg, A.A., Douglas, C.J., Schranz, M.E., Lens, F., 2016. Functional network analysis of genes differentially expressed during xylogenesis in soc1ful woody Arabidopsis plants. Plant J. 86, 376–390.
De Micco, V., Campelo, F., De Luis, M., Bräuning, A., Grabner, M., Battipaglia, G., Cherubini, P., 2016. Intra-annual density fluctuations in tree rings: how, when, where, and why? IAWA J. 37, 232–259.
De Micco, V., Carrer, M., Rathgeber, C.B.K., Julio Camarero, J., Voltas, J., Cherubini, P., Battipaglia, G., 2019. From xylogenesis to tree rings: wood traits to investigate tree response to environmental changes. IAWA J. 40, 155–182.
Eilmann, B., Sterck, F., Wegner, L., de Vries, S.M.G., von Arx, G., Mohren, G.M.J., den Ouden, J., Sass-Klaassen, U., 2014. Wood structural differences between northern and southern beech provenances growing at a moderate site. Tree Physiol. 34, 882–893.
Filion, L., Payette, S., Gauthier, L., Boutin, Y., 1986. Light rings in subarctic conifers as a dendrochronological tool. Quat. Res. 26, 272–279.
Fonti, P., von Arx, G., García-González, I., Eilmann, B., Sass-Klaassen, U., Gärtner, H., Eckstein, D., 2010. Studying global change through investigation of the plastic responses of xylem anatomy in tree rings. New Phytol. 185, 42–53.
Hacke, U.G., Lachenbruch, B., Pittermann, J., Mayr, S., Domec, J.-C., Schulte, P., 2015. The hydraulic architecture of conifers. In: Hacke, U. (Ed.), Functional and Ecological Xylem Anatomy. Springer International Publishing, pp. 39–75.
Hajek, P., Kurjak, D., von Wühlisch, G., Delzon, S., Schuldt, B., 2016. Intraspecific variation in wood anatomical, hydraulic, and foliar traits in ten European beech provenances differing in growth yield. Front. Plant Sci. 7, 791.
Hietz, P., Rosner, S., Hietz-Seifert, U., Wright, S.J., 2017. Wood traits related to size and life history of trees in a Panamanian rainforest. New Phytol. 213, 170–180.
Hillabrand, R.M., Lieffers, V.J., Hogg, E.H., Martínez-Sancho, E., Menzel, A., Hacke, U. G., 2018. Functional xylem anatomy of aspen exhibits greater change due to insect defoliation than to drought. Tree Physiol. 39, 45–54.
IAWA Committee, 1989. IAWA list of microscopic features for hardwood identification. IAWA Bull. 10, 219–332.
IAWA Committee, 2004. IAWA list of microscopic features for softwood identification. IAWA J. 25, 1–70.
Lens, F., Liang, C., Guo, Y., Tang, X., Jahanbanifard, M., da Silva, F.S.C., Ceccantini, G., Verbeek, F.J., 2020. Computer-assisted timber identification based on features extracted from microscopic wood sections. IAWA J. 41, 660–680.
Lens, F., Sperry, J.S., Christman, M.A., Choat, B., Rabaey, D., Jansen, S., 2011. Testing hypotheses that link wood anatomy to cavitation resistance and hydraulic conductivity in the genus Acer. New Phytol. 190, 709–723.
Lens, F., Vos, R.A., Charrier, G., van der Niet, T., Merckx, V., Baas, P., Aguirre Gutierrez, J., Jacobs, B., Chacon Dória, L., Smets, E., Delzon, S., Janssens, S.B., 2016. Scalariform-to-simple transition in vessel perforation plates triggered by differences in climate during the evolution of Adoxaceae. Ann. Bot. 118, 1043–1056.
Li, S., Lens, F., Espino, S., Karimi, Z., Klepsch, M., Schenk, H.J., Schmitt, M., Schuldt, B., Jansen, S., 2016. Intervessel pit membrane thickness as a key determinant of embolism resistance in angiosperm xylem. IAWA J. 37, 152–171.
Martin-Benito, D., Anchukaitis, K.J., Evans, M.N., Del Río, M., Beeckman, H., Cañellas, I., 2017. Effects of drought on xylem anatomy and water-use efficiency of two co-occurring pine species. Forests 8, 332.
Olson, M., Rosell, J.A., Martínez-Pérez, C., León-Gómez, C., Fajardo, A., Isnard, S., Cervantes-Alcayde, M.A., Echeverría, A., Figueroa-Abundiz, V.A., Segovia-Rivas, A., Trueba, S., Vázquez-Segovia, K., 2020. Xylem vessel-diameter–shoot-length scaling: ecological significance of porosity types and other traits. Ecol. Monogr. 90, e01410.
Pace, M.R., Lohmann, L.G., Angyalossy, V., 2009. The rise and evolution of the cambial variant in Bignonieae (Bignoniaceae). Evol. Dev. 11, 465–479.
Payette, S., Delwaide, A., Simard, M., 2010. Frost-ring chronologies as dendroclimatic proxies of boreal environments. Geophys. Res. Lett. 37, L02711.
Piermattei, A., Crivellaro, A., Carrer, M., Urbinati, C., 2015. The "blue ring": anatomy and formation hypothesis of a new tree-ring anomaly in conifers. Trees 29, 613–620.
Plavcová, L., Jansen, S., Klepsch, M., Hacke, U., 2013. Nobody's perfect: can irregularities in pit structure influence vulnerability to cavitation? Front. Plant Sci. 4, 453.
Rosell, J.A., Olson, M.E., Anfodillo, T., 2017. Scaling of xylem vessel diameter with plant size: causes, predictions, and outstanding questions. Curr. For. Rep. 3, 46–59.
Rosner, S., Hannrup, B., 2004. Resin canal traits relevant for constitutive resistance of Norway spruce against bark beetles: environmental and genetic variability. For. Ecol. Manag. 200, 77–87.
Scholz, A., Klepsch, M., Karimi, Z., Jansen, S., 2013. How to quantify conduits in wood? Front. Plant Sci. 4, 56.
Sviderskaya, I.V., Vaganov, E.A., Fonti, M.V., Fonti, P., 2020. Isometric scaling to model water transport in conifer tree rings across time and environments. J. Exp. Bot. 72, 2672–2685.
Tateishi, M., Kumagai, To, Utsumi, Y., Umebayashi, T., Shiiba, Y., Inoue, K., Kaji, K., Cho, K., Otsuki, K., 2008. Spatial variations in xylem sap flux density in evergreen oak trees with radial-porous wood: comparisons with anatomical observations. Trees 22, 23–30.
Vázquez-González, C., Zas, R., Erbilgin, N., Ferrenberg, S., Rozas, V., Sampedro, L., 2020. Resin ducts as resistance traits in conifers: linking dendrochronology and resin-based defences. Tree Physiol. 40, 1313–1326.
von Arx, G., Arzac, A., Olano, J.M., Fonti, P., 2015. Assessing conifer ray parenchyma for ecological studies: pitfalls and guidelines. Front. Plant Sci. 6, 1016.
von Arx, G., Crivellaro, A., Prendin, A.L., Cufar, K., Carrer, M., 2016. Quantitative wood anatomy – practical guidelines. Front. Plant Sci. 7, 781.
Ziaco, E., 2020. A phenology-based approach to the analysis of conifers intra-annual xylem anatomy in water-limited environments. Dendrochronologia 59, 125662.
Ziemińska, K., Butler, D.W., Gleason, S.M., Wright, I.J., Westoby, M., 2013. Fibre wall and lumen fractions drive wood density variation across 24 Australian angiosperms. AoB Plants 5, plt046.