

A Dichotomous Determination Key for Autochthonous Oak Species from Romania

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Abstract Genus *Quercus* is known among specialists especially due its taxonomical complexity that is mainly determined by its high number of taxa and the interspecific hybridization. The aim of this paper was to propose a dichotomous determination key for the autochthonous oak species from Romania. In order to determine the morphological traits that have the highest discriminating power between the oak species, data from several morphological-statistical studies done across Europe and information from specialized manuals were taken into consideration. If in the case of Turkey oak (*Quercus cerris*) and Hungarian oak (*Quercus frainetto*) there is no doubt regarding their correct determination, the situation is more complicated in the case of the pairs pedunculate oak (*Quercus robur*) - grayish oak (*Quercus pedunculiflora*) and pubescent oak (*Quercus pubescens*) - Italian oak (*Quercus virgiliana*). For a correct determination, at least 5 to 10 twigs, leaves and/or cupula peduncles per tree should be taken into consideration. Also, it is indicated to sample the twigs and the leaves from the crown, not from a solitary branch/sprig.

Key words

dichotomous key, oak, Quercus

In general, tree species can be easily identified by means of dichotomous keys based on their morphological characters, such as twig and/or leaf traits. In the case of the oaks (*Quercus* L.), identifying certain species is sometimes extremely difficult due to their high morphological variability. Identification can become more complicated due to the existence of several varieties and interspecific hybridization.

Quercus (*Fagaceae*) is an extremely diverse genus with approximately 300-500 shrub or tree species worldwide [33]. Due to its high number of closely related taxa, the taxonomy of this genus represents a subject of debate among botanists and other specialists.

According to several classifications [12; 25; 36; 37], 7-9 oak species were described in Romania. Amongst them, only in the case of Turkey oak (*Quercus cerris* L.) and Hungarian oak (*Q. frainetto* Ten.) it seems not to be any doubt regarding the possibility to confuse them with the other oaks. On the contrary, small differences in leaf morphology were reported for the pair pedunculate oak (*Q. robur* L.) - grayish oak (*Q. pedunculiflora* K. Koch) [13; 14] or for the couple pubescent oak (*Q. pubescens* Willd.) - Italian oak (*Q. virgiliana* Ten.) [22]. If regarding the taxonomical status of pubescent oak there is no doubt, being a separate species, in the case of Italian oak the situation is more complicated. This taxon is sometimes described as a separate species [4; 12; 16; 24; 25; 34; 36; 37], but sometimes is not [11; 33]. It is also

considered to be the hybrid between pubescent oak and sessile oak [28].

In the case of sessile oak (*Q. petraea* sensu lato – series *Sessiliflorae*), according to some specialists, there are three different species, namely *Q. polycarpa* Schur., *Q. petraea* (Matt.) Liebl. and *Q. dalechampii* Ten. [4]. Others consider them three subspecies, i.e. *Q. petraea* ssp. *polycarpa* (Schur) Soó, *Q. petraea* (Matt.) Liebl. ssp. *petraea* (Liebl.) Soó and *Q. petraea* ssp. *dalechampii* (Ten.) Soó [37].

Across Europe, many morphological-statistical studies were done for the pair pedunculate oak - sessile oak [1; 2; 5; 14; 17; 27], and little was done in the case of the closely related oaks from series *Lanuginosae*, namely pubescent oak and Italian oak.

The aim of this paper was to propose an easy to use determination key for Romanian oak species based on the morphological-statistical studies recently done in Romania and other European countries.

Morphological variability of Romanian oaks; special focus on pubescent oak and Italian oak

In order to determine which morphological traits have the highest discriminating power between the oak species from Romania, the results of several statistical-morphological surveys done in Bulgaria [7], Croatia [24; 35], Denmark [29], France [2; 17], Germany [1], Italy [8; 9; 10; 23; 26], Ireland [31], Republic of Moldova [15], Poland [5], Slovenia [30], Switzerland [27] and Turkey [6] were taken into

consideration. Based on the above-mentioned studies and on the research recently done in Romania aimed to assess the morphological variability of the pair pedunculate oak - grayish oak [13; 14], on one hand, and the pair pubescent oak - Italian oak [19; 20; 21; 22], on another hand, the proposed dichotomous key will take into consideration the existence of seven distinct oak species in Romania.

Since most of morphological similarities were described in the case of the pair pubescent oak - Italian oak, a detailed leaf morphological description based on several studies and specialized manuals was done.

For both species, the leaves are pubescent in the beginning on both sides, but in the fall the abaxial side becomes glabrous [16; 37]. The leaves are very different in shape and size. They are smaller in the case of pubescent oak, usually between 4.5 and 8(12) cm, compared with those of the Italian oak, which are larger (8 - 16 cm) [3; 4; 32; 37]. However, cases where the length of leaves of the two taxa is identical have also been described [16]. As for the number of lobes, there is an overlap. The leaves of pubescent oak have 3 to 6 pairs of lobes, while the leaves of the Italian oak have 4 to 7 pairs of lobes [4; 37]. The petiole of the leaf is longer in the case of Italian oak, usually reaching 3 cm, while the petiole of the pubescent oak is approximately 1 cm long [16; 37], rarely 2 cm long [38].

Proposed dichotomous determination key

Based on the results of the above mentioned studies and morphological descriptions, the following six questions were proposed for the easy to use dichotomous determination key:

Q1: Is the twig glabrous (hairless)?

Q2: Is the petiole 1-3 cm long, the base slightly truncate, but not auricled?

Q3: Is the lower surface of the leaves glabrous (hairless)?

Q4: Do the buds have persistent and long hairy stipules?

Q5: Is the base auricled or heart-shaped and the petiole is short?

Q6: Are the leaves usually no longer than 8 cm, the petiole around 1 cm long and the flower/cupula peduncle no longer than 1 cm?

In order to easily identify the key morphological traits that discriminate between the seven oak species from Romania, the following information and figures are also recommended to be used.

Figure 1 shows the abaxial part of a pedunculate oak leaf, where no hairs are present. It is well known that compared with grayish oak, the abaxial part of the leaf of pedunculate oak has no hairs [14; 18; 37]. The presence of the hairs can be determined through a naked-eye assessment, but it is recommended to use a magnifying glass, with at least 10X magnifying power.



Fig. 1. Abaxial part of a pedunculate oak leaf

Among the autochthonous oak species, only in the case of Turkey oak, the buds have persistent and long hairy stipules (Figure 2) [37]. The stipules persist until the following spring.

Regarding the pair pubescent oak - Italian oak, according to recent research [20; 22], it seems that only the flower/cupula peduncle (Figure 3 and Figure 4) is the only morphological descriptor that differentiate the two species, being visible longer in the case of *Q. virgiliana*.

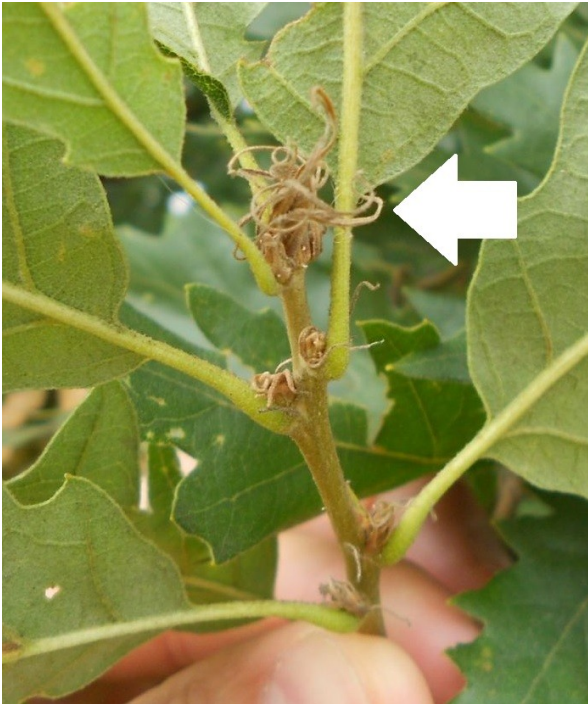


Fig. 2. Buds with persistent and long hairy stipules

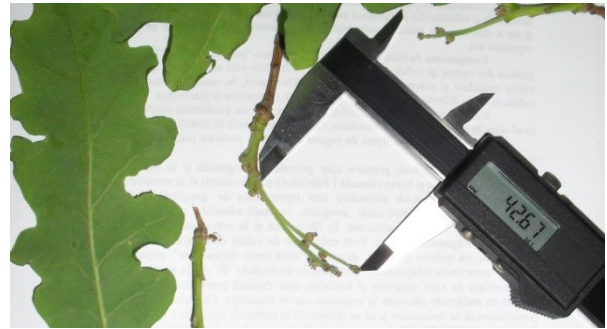


Fig. 3. Flower peduncle of Italian oak



Fig. 4. Cupula peduncle of Italian oak

The proposed dichotomous key is given in Figure 5.

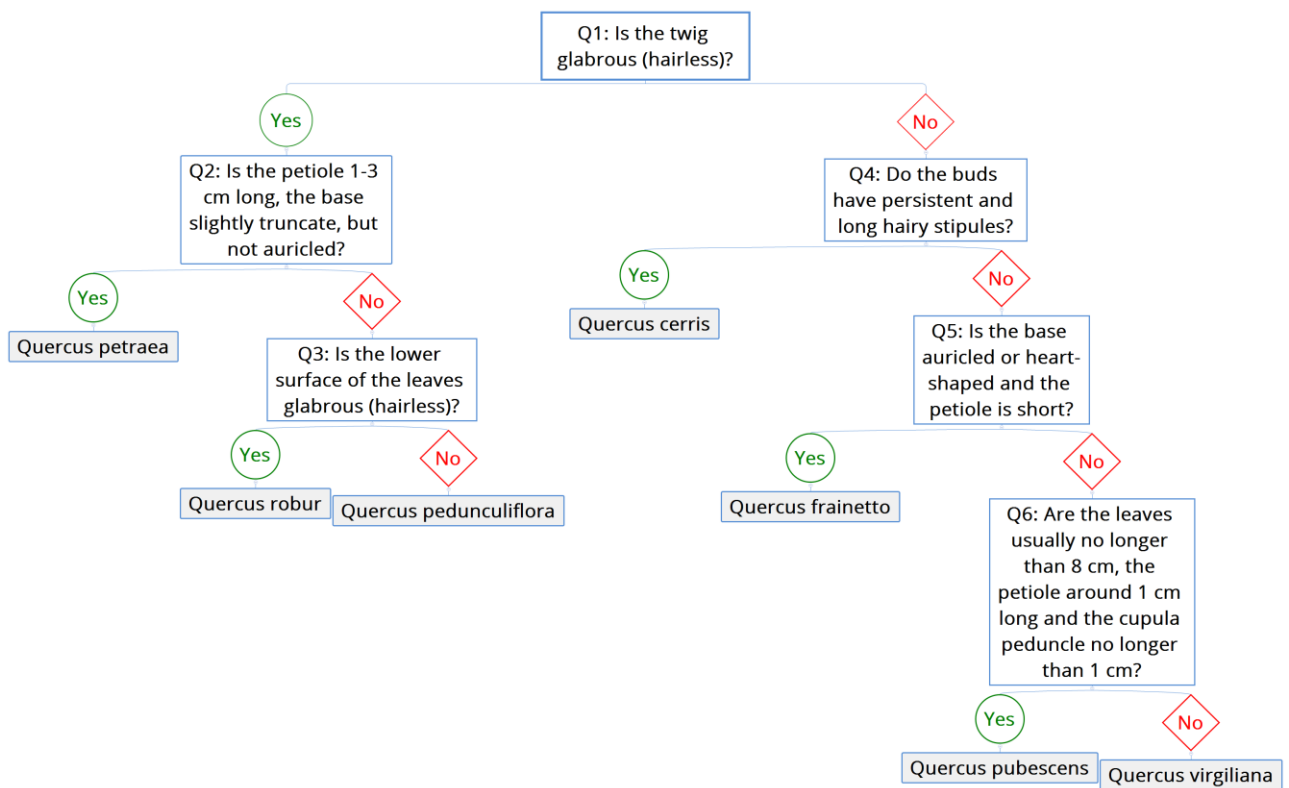


Fig. 5. Dichotomous determination key of Romanian oak species

Conclusions and Recommendations

Even if Genus *Quercus* is regarded as a complicated one from a taxonomical perspective, thanks to the studies recently conducted across Europe, nowadays it is easy to determine the key morphological characters that have the highest discriminating power between closely related oak species. Since, in general, there are small differences between the acorns of the autochthonous oak species, a correct determination of the species based on twig and/or leaf traits is mandatory especially in the case of harvesting the seeds for producing seedlings in nurseries and for breeding programs.

Considering the special situation of grayish oak and Italian oak, in order to reach a final conclusion regarding their status (*i.e.* separate species or subspecies), future research should take also into consideration their genetic diversity assessed by the aid of modern molecular markers, such as microsatellites. Until then, according to the current knowledge in terms of their morphological variability, these taxa could be regarded as separate oak species.

We recommend using not only a twig, leaf or cupula peduncle per tree in order to determine the species but more, at least 5 to 10 from the same tree. It is also indicated to sample the twigs and the leaves from the crown, not from a solitary branch or sprig, situated in the lower part of the trunk.

This dichotomous key should be used with caution in mixed-oak stands, where two or more species occur and the possibility to sample a hybrid is high. In this case several other morphological descriptors should be taken into account. The only exception is Turkey oak that is not hybridizing with the rest of the autochthonous oak species from Romania.

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References

1. Aas G. 1993. *Taxonomical Impact of Morphological Variation in Quercus robur and Q. petraea: A Contribution to the Hybrid Controversy*. Annals of Forest Sciences 50(1): 107s-113s.
2. Bacilieri R., Ducousso A. & Kremer A. 1995. *Genetic, Morphological, Ecological and Phenological Differentiation between Quercus petraea (Matt.) Liebl. and Quercus robur L. in a Mixed Stand of Northwest of France*. Silvae Genetica 44: 1-10.
3. Bartha D. 2009. *Quercus virgiliana Ten.*, 1836, Enzyklopädie der Holzgewächse 25, Erg. Lfg. 9/01.
4. Beldie Al. 1952. *Genul Quercus*. pp. 224-226. In Nyarady, E. (ed.): Flora R.P.R. Vol. I. Editura Academiei R.P.R.
5. Boratynski A., Marcysiak K., Lewandowska A., Jasinska A., Iszkulo G. & Burczyk J. 2008. *Differences in leaf morphology between Quercus petraea and Q. robur adult and young individuals*. Silva Fennica 42(1): 115-123.
6. Borazan A. & Babaç M.T. 2003. *Morphometric leaf variation in oaks (Quercus) of Bolu, Turkey*. Annales Botanici Fennici 40: 233-242.
7. Broshtilov K. 2006. *Quercus robur L. leaf variability in Bulgaria*. Plant Genetic Resources Newsletter 147: 64-71.
8. Bruschi P., Vendramin G.G., Bussotti F. & Grossoni P. 2000. *Morphological and molecular differentiation between Quercus petraea (Matt.) Liebl. and Quercus pubescens Willd. (Fagaceae) in Northern and Central Italy*. Annals of Botany 85: 325-333.
9. Bruschi P., Vendramin G.G., Bussotti F. & Grossoni P. 2003a. *Morphological and molecular diversity among Italian populations of Quercus petraea (Fagaceae)*. Annals of Botany 91: 707-716.
10. Bruschi P., Grossoni P. & Bussotti F. 2003b. *Within- and among-tree variation in leaf morphology of Quercus petraea (Matt.) Liebl. natural populations*. Trees 7: 164-172.
11. Camus A. 1936-1954. *Les chênes. Monographie du genre Quercus*, Paris, Lechevalier Publishing House.
12. Coldea G., Fărcaș S., Filipaș L., Ursu T.M. & Stoica I.A. 2010. *Syntaxonomic revision of Quercus virgiliana Ten. and Quercus pedunculiflora K. Koch Forests from Romania*. Studia UBB Biologia LV 2: 39-50.
13. Curtu A.L., Șofletea N., Toader A.V., Enescu C.M., Moldovan I.C. & Chesnoiu E.N. 2009. *Stejarul brumăriu: specie sau unitate intraspecifică a stejarului pedunculat?* Revista Pădurilor 5: 24-30.
14. Curtu A.L., Șofletea N., Toader A.V. & Enescu C.M. 2011. *Leaf morphological and genetic differentiation between Quercus robur L. and its closest relative, the drought-tolerant Quercus pedunculiflora K. Koch*. Annals of Forest Science 68(7): 1163-1172.
15. Cuza P. 2010. *Variabilitatea frunzelor stejarului pufos (Quercus pubescens Willd.) în Republica Moldova*. Mediul Ambient 5(53): 7-14.
16. Doniță N. 2008. *Quercus virgiliana Ten., un arbore de interes pentru silvicultura din zonele aride*. Revista Pădurilor 4: 18-19.
17. Dupouey J-L & Badeau V. 1993. *Morphological variability of oaks (Quercus robur L, Quercus petraea (Matt) Liebl, Quercus pubescens Willd) in northeastern France: preliminary results*. Annals of Forest Science 50: 35-40.
18. Enescu C.M., Chesnoiu E.N., Șofletea N. & Curtu A.L. 2010. *Leaf morphology in Quercus robur genetic resources from Romania*. Bulletin of the Transilvania University of Brașov, Series II, 52: 47-54.

19. Enescu C.M. & Șofletea N. 2011. *Leaf and fruit morphology in pubescent oak Natura 2000 sites across Central Transilvania*. Forest and Sustainable Development: 29-34.
20. Enescu C.M., Șofletea N. & Curtu A.L. 2012a. *Cluster analysis in pubescent oak taxa from series Lanuginosae: a case study*. Bulletin of the Transilvania University of Brașov, Series II 54(1): 79-84.
21. Enescu C.M., Șofletea N. & Curtu A.L. 2012b. *Fruit morphological variability of pubescent oak (Quercus pubescens Willd.) in two geographical regions of Romania*. Revista Pădurilor 6: 19-23.
22. Enescu C.M., Curtu A.L. & Șofletea N. 2013. *Is Quercus virgiliana a distinct morphological and genetic entity among European white oaks?* Turkish Journal of Agriculture and Forestry 37: 632-641.
23. Fortini P., Viscosi V., Maiuro L., Fineschi S. & Vendramin G.G. 2009. *Comparative leaf surface morphology and molecular data of five oaks of the subgenus Quercus Oerst (Fagaceae)*. Plant Biosystems 143(3): 543-554.
24. Franjić J., Liber Z., Škvorc Ž., Idžojtić M., Šoštarić R. & Stančić Z. 2006. *Morphological and molecular differentiation of the Croatian populations of Quercus pubescens Willd.* Acta Societatis Botanicorum Poloniae 75(2): 123-130.
25. Georgescu C.C. & Morariu I. 1948. *Monografia stejarilor din România*. București. Universul Publishing House.
26. Grossoni P., Bettini D., Bruschi P., Bussotti F. & Lumini M.B. 1998. *Studio macro e micromorfologico di Quercus petraea (Matt.) Liebl. e di Quercus pubescens Willd. della macchia di Berignone-Tatti (Volterra, Italia Centrale) [Toscana]*. Monti e Boschi 49(2): 25-30.
27. Gugerli F., Walser J.C., Dounavi K., Holderengger R. & Finkeldey R. 2007. *Coincidence of small-scale spatial discontinuities in leaf morphology and nuclear microsatellite variation of Quercus petraea and Q. robur in a mixed forest*. Annals of Botany 99: 713-722.
28. Hedge I.C. & Yaltirik F. 1982. *Quercus L.* pp. 659-683. In Davis, P. H. (ed.): Flora of Turkey and the East Aegean Islands. Edinburgh University Press.
29. Jensen J., Larsen A., Nielsen L.R. & Cottrell J. 2009. *Hybridization between Quercus robur and Q. petraea in a mixed stand in Denmark*. Annals of Forest Science 66: 706.
30. Jerše M. & Batič M. 2007. *Morphological analysis of pubescent oak (Quercus pubescens Willd.) in Slovenia*. Zborik gazdarstva in lesarstva 83: 35-45.
31. Kelleher C.T., Kelly D.L. & Hodkinson T.R. 2004. *Species status, hybridization and geographic distribution of Irish populations of Quercus petraea (Matt.) Liebl. and Q. robur L.* Watsonia 25: 83-97.
32. Negulescu E.G. & Stănescu V. 1964. *Dendrologia, cultura și protecția pădurilor*. București, Didactică și Pedagogică Publishing House.
33. Nixon K.C. 1993. *Infrageneric classification of Quercus (Fagaceae) and typification of sectional names*. Annals of Forest Science 50: 25 -34.
34. Schwarz O. 1993. *Quercus L.* pp. 72-76. In Tutin, T.G. (eds.) Flora Europaea. Cambridge University Press.
35. Škvorc Ž., Franjić J. & Idžojtić M. 2005. *Population structure of Quercus pubescens Willd. (Fagaceae) in Croatia according to morphology of leaves*. Acta Botanica Hungarica 47(1-2): 183-196.
36. Stănescu V., Șofletea N. & Popescu O. 1997. *Flora forestieră lemnoasă a României*. București, Ceres Publishing House.
37. Șofletea N. & Curtu L. 2007. *Dendrology (in Romanian)*. Brașov, Transilvania University Publishing House, 418 pp.
38. Trinajstić I. 2007. *About the problem of differentiation between the oaks Quercus pubescens Willd. and Quercus virgiliana Ten.* Pregledni Članci – Rewievs UDK 630 * 164. Šumarski list br. 1- 2: 57 -60.