

QUERCUS CASTANEIFOLIA SUBSP. RECURVATUS (FAGACEAE) A NEW SUBSPECIES FROM HYRCANIAN FORESTS, NORTH OF IRAN

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During the study on flora of Hyrcanian forests and collecting specimens in order to plant in Hyrcanian habitat of National Botanical Garden of Iran, among the collected specimens, some specimens of the *Quercus castaneifolia* (Chestnut leaved oak) from south of Sari city in Mazandaran Province in North of Iran seemed to be interesting and were different from the other known subspecies of *Q. castaneifolia*. Results of morphological study of the species showed that there are clear differences between shape of the cupule and some micromorphology traits of the leaf trichomes and pollen. Thus, based on the botanical traits of the new taxon and according to summarised data from the obtained results of the other subspecies and variety of the *Q. castaneifolia*, this taxon was identified as a new subspecies and named: *Quercus castaneifolia* subsp. *recurvatus* Zare et Panahi which is described here. The new taxon is related to *Quercus castaneifolia* subsp. *castaneifolia* var. *castaneifolia* and well characterised by having different shape and arrangement of the involucre bracts on the acorn cupule comparing with the others.

Key words: cupule eminentia, Hyrcanian forest, micromorphology, pollen, *Quercus*, trichome

INTRODUCTION

Quercus L. is the most diverse genus of Fagaceae in Iran (Sabeti 1994). The taxonomy of *Quercus* is extremely complex (Burger 1974) owing to great variability, high species number and the frequent occurrence of introgressive hybridisation (Tucker 1974). *Quercus castaneifolia* C. A. Mey. is one of the most important species of Iran's native oaks, distributed in the Hyrcanian Forests (Sagheb Talebi *et al.* 2014). This species shows morphological variations in leaf and acorn characteristics. The delimitation of *Q. castaneifolia*, number of its subspecies and varieties varies according to different authors (Panahi *et al.* 2011). Meyer (1831) described *Q. castaneifolia* from the Caucasus and Hyrcanian forests of Iran. Schwarz (1935) after studying the herbarium specimens described a new species from Hyrcanian forests namely *Q. sintenisiana* O.

Schwarz, based on trichome characteristics. Camus (1936–1938) reported two subspecies including: *Q. castaneifolia* subsp. *eucastaneifolia* A. Camus and *Q. castaneifolia* subsp. *aitchisoniana* A. Camus from Hyrcanian forests in her monograph of world's oaks. The most complete study of the genus *Quercus* in Iran was done by Djavanchir Khoie (1967) based on leaf and acorn morphology. He treated *Q. sintenisiana* and *Q. castaneifolia* subsp. *eucastaneifolia* as synonyms of the type species, but he accepted *Q. castaneifolia* subsp. *aitchisoniana* as a separate taxon and after survey in Hyrcanian forests, introduced 6 new taxa including: *Q. castaneifolia* subsp. *castaneifolia* var. *ellipsoidalis* Djav.-Khoie; *Q. castaneifolia* subsp. *castaneifolia* var. *minuta* Djav.-Khoie; *Q. castaneifolia* subsp. *incurvata* Djav.-Khoie; *Q. castaneifolia* subsp. *subrotundata* Djav.-Khoie; *Q. castaneifolia* subsp. *triangularis* Djav.-Khoie; *Q. castaneifolia* subsp. *undulata* Djav.-Khoie.

In Flora Iranica only *Q. castaneifolia* subsp. *castaneifolia* is recognised from Hyrcanian forests of Iran (Menitsky 1971). In the newest research on *Q. castaneifolia* in Hyrcanian forests, four infraspecific taxa were confirmed based on micromorphological characteristics of leaf and pollen grain, as follows: *Q. castaneifolia* subsp. *castaneifolia* var. *castaneifolia*, *Q. castaneifolia* subsp. *castaneifolia* var. *minuta*, *Q. castaneifolia* subsp. *aitchisoniana*, *Q. castaneifolia* subsp. *undulata* (Panahi et al. 2011).

Infraspecific taxa of *Quercus castaneifolia*

Quercus castaneifolia C. A. Mey. subsp. *castaneifolia* var. *castaneifolia* – Deciduous large tree, up to 40 m high, with expanded crown, dark grey thick bark and caduceus leaves. Distribution area of this variety is Caucasus and throughout the Hyrcanian forests of Iran. The range of their altitude distribution in Hyrcanian forests is from coast plains to 2,400 m above sea level. The scales of cupule are tough, tomentose, reflexed with grey colour. The scale length gradually increases up to 6 mm at the base of cupule. The shape of gland has partial differences; long fusiform to long cylindrical.

Quercus castaneifolia C. A. Mey. subsp. *castaneifolia* var. *minuta* Djav.-Khoi – The characteristics of its crown, bark and leaves are similar to the previous variety, but it is smaller in size, so that its tallest trees are 25 m high. Distribution of this variety is restricted to three areas of Hyrcanian forests including Lajim and Veisar forests in Mazandaran Province and the Gorgan forests in Golestan Province. The acorn is characterised by a completely convex hilum with a black-brown ring around it. This is the best discriminative morphological characteristic to distinguish this taxon.

Quercus castaneifolia C. A. Mey. subsp. *aitchisoniana* A. Camus – Deciduous medium size tree, up to 15 m high, with expanded crown, dark grey thick

bark and caduceus leaves. It is observed only in middle and upper altitudes of the Hyrcanian forests. The size of acorn is smaller than that of the type variety. The cupule is semi-spherical with completely erect, triangle shape scales that connect to cupule without any curving.

Quercus castaneifolia C. A. Mey. subsp. *undulata* Djav.-Khoi – Deciduous large tree, up to 30 m high, with expanded crown, dark grey thick bark and caduceus leaves. Its distribution is only restricted to lowland forests of Astara, in Guilan province. This taxon is characterised by big acorns, semi-spherical cupule and cylindrical gland. The cupule scales are thick, long (up to 13 mm) and reflexed.

Quercus castaneifolia C. A. Mey. subsp. *recurvatus* Zare et Panahi – Large trees, up to 35 m, bark in old trees with deep fissured, greyish, leaves narrowed, serrate with large teeth, acorns cupule vasiform, glands fusiform at base, scales short, flat and triangular, layered and overlapping at tip of cupule. The trees distributed in south of sari in central parts of Mazandaran province and there are small population of the taxon in lowland forests and margin of river valley of Sangrizeh.

MATERIAL AND METHODS

Regarding the distribution range of Chestnut leaved oak in the Hyrcanian forests, the new taxon was found and located in the middle region of the Hyrcanian forests. All of collections were performed in North of Iran and the studies were conducted on living specimens of the *Q. castaneifolia* variety and subspecies. These specimens were compared with herbarium specimens of the other taxa and also with some of the most important local herbarium materials. We also had considered variation of the most important characteristics of these species and its subspecies that shows high degree of diversity in shape of the leaves and cupules in the distribution area. Nevertheless, our study was based on morphology of the organs, i.e. shape and traits of cupule's eminentia and micromorphology of trichomes, wax and stomata of the both side of the leaves and pollen characteristics.

For the morphological study, the specimens of the Herbarium of the Research Institute of Forests and Rangelands of Iran (TARI) and Herbarium of Nowshahr were sampled. Measurements were taken from 5 fruits systematically for each examined taxon. A total of 8 quantitative traits (length of gland, diameter of gland, hilum diameter, length, diameter and depth of cupule, inner diameter of cupule and number of cupule spirals) were measured for each taxon.

RESULTS AND DISCUSSION

Quercus castaneifolia C. A. Mey. subsp. *recurvatus* Zare et Panahi,
subsp. nova
(Figs 1–5)

Similar to *Q. castaneifolia* subsp. *castaneifolia* var. *castaneifolia*, but having different shape of cupule involucre bracts. The results of morphological and micro-morphological studies of trichomes and pollens of *Q. castaneifolia* specimens showed that there are clear differences between trees and herbarium specimens of taxa. Based on four mentioned taxa traits, *Q. castaneifolia* subsp. *recurvatus* Zare et Panahi is a new taxon and closest to *Q. castaneifolia* subsp. *castaneifolia* var. *castaneifolia*. In other words, it is similar to type subspecies; therefore, it is compared with the type subspecies. Descriptive statistics of fruit morphological characters are presented in Table 1. The results of morphological along with micro-morphological studies of *Q. castaneifolia* subsp. *recurvatus* are described below.

Typus: Iran, Mazandaran, Sari, Paeen-Sangrizeh village, Margine of Sangdarreh river, 47 m, coll. Zare and Amini 108109 (TARI).

Tree up to 35 m height or more and more than 100 cm diameter, bark of young trees smooth and grey, gradually deep and shallow fissured. Young twigs brown greyish, pannose and often with some prominent longitudinal lines and sparse bright lens, old branches brown reddish along with oligomeric lens. Leaves lanceolate, acute at the base, acuminate at the apex or apiculate, 8–15 cm long and 2.5–5.5 cm broad, leaf margins serrate with 5–8 pair of large, triangular and apiculate teeth. Leaf blade pinnately nerved, on the upper surface pale and dark green, in usual observation (by stereo microscope 10–40×) with very small stellate hair as evenly between subsidiary veins, in lower surface pale green greyish with relatively prominent venation, along with small and dense panniform hairs (10–40×). Petiole 12–17 mm long and hairy. Bud's scales spirally arranged in 5 rows, light brown, hairy and without stalk. Acorn's cupule is relatively vasiform and also more or less narrowed and is different of the other taxa of *Q. castaneifolia*. So that the 2/3 of the cupule length with small and reflected scales, bracts 1/3 of the upper part of cupule is different and bracts shape is wide triangular specially at base and very compressed and layered dense or fused, as spirally with simultaneously undulate and short upright or ± downward forms, edge and margin of cupule covered with ciliate hairs. Acorns narrow, 35–40 mm long and 13–16 mm broad, light brown and becoming dark brown-reddish at the ripening time. This subspecies in lowland forests usually is mixed with the other taxa of *Q. castaneifolia*.

The taxon is relatively related to *Q. castaneifolia* subsp. *castaneifolia* var. *castaneifolia*, but is different due to having different shape of cupule involucre bracts as mentioned or explained above (Figs 1–3).



Fig. 1. *Quercus castaneifolia* C. A. Mey. subsp. *recurvatus* Zare et Panahi ($\times 2/3$)

Table 1
Descriptive statistics of leaf and fruit morphological characters (mean ± SD)

Variables	Lg	Dg	Dh	Lc	Dc	Dec	IDc	Ncs
<i>Q. castaneifolia</i> subsp. <i>castaneifolia</i>	40±2.2	18.1±0.5	9±0.3	17±0.7	24±0.8	15±0.4	19±0.4	20±1.2
<i>Q. castaneifolia</i> subsp. <i>castaneifolia</i> var. <i>minuta</i>	22±1.6	14.1±0.5	9.4±0.4	15.5±0.5	18.3±0.6	13±0.4	15.3±0.3	18±0.6
<i>Q. castaneifolia</i> subsp. <i>aitchisoniana</i>	14±0.7	10.8±0.3	6±0.4	10±0.6	14.8±0.3	7.1±0.3	11.5±0.5	18±0.8
<i>Q. castaneifolia</i> subsp. <i>undulata</i>	27±0.7	16.5±0.5	10±0.4	21±0.8	33.5±0.5	17±0.7	17±0.7	22±0.7
<i>Q. castaneifolia</i> subsp. <i>recurvatus</i>	37±0.8	17.2±0.6	5.5±0.4	23±1.2	25.1±0.9	16.1±0.7	18±0.6	17±0.8

Lg = length of gland; Dg = diameter of gland; Dh = length of hilum; Lc = length of cupule; Dc = diameter of cupule; Dec = depth of cupule; IDc = inner diameter of cupule; Ncs = number of cupule spirals

Micromorphology description
Trichomes, wax and stomata

Trichomes are present on both leaf surfaces, although they are more abundant in terms of density and type on the abaxial leaf surface. The trichomes of the adaxial surface are restricted only to a few stellate ones with 4–10 rays. We identified five different trichome types on the abaxial as follows: Simple-uniseriate type that is thin-walled, multicellular and uniseriate. Solitary type that is single, medium length, usually appressed sometimes straight and unicellular, was observed often on the midrib of studied taxon (Fig. 4C). Stipitate-fasciculate type with 2–4 erect rays, with thick-walled cells, clustered and fused at the base on the midrib (Fig. 4C). Multiradiate type with thick-walled, clustered or tufted, with rays radiating from more than one level, have 6–12 (often 6–10) rays measuring 80–160 µm. The outer erect or more or less horizontal and the inner erect ones (Fig. 4B). Stellate type, usually thick-walled, with a single set of radiating, slender rays, projecting horizontally from a common centre, sessile or stipitate. This trichome is the most abundant type in this taxon, which was found on both sides of leaf. The number of rays in stellate trichomes changes, from 4–12. The ray length of this trichome varies from 60–170 µm (Figs 4A, B). Only one type of epicuticular waxes, with smooth layer, was recognised on the abaxial and adaxial surfaces of leaves. The stomata are elliptical in shape and raised above the epidermal surface (Fig. 4A). The stomata are not seen easily because of high density of trichomes.



Fig. 2. *Quercus castaneifolia* C. A. Mey. subsp. *recurvatus* Zare et Panahi



Fig. 3. Cupule of *Quercus castaneifolia* C. A. Mey. subsp. *recurvatus* Zare et Panahi

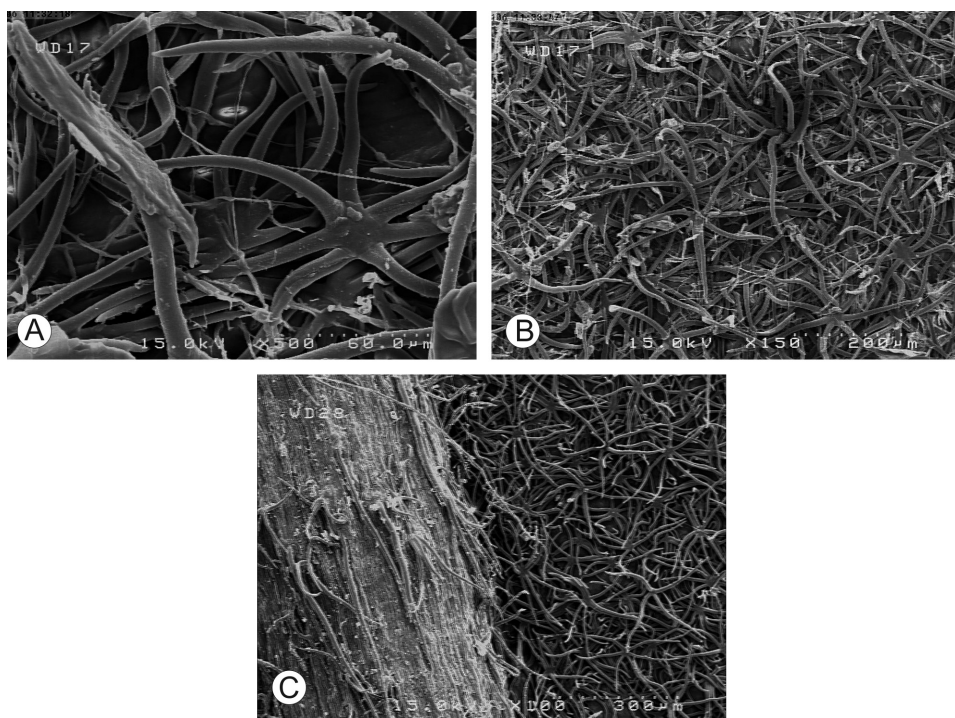


Fig. 4. SEM micrographs of trichomes and midrib of *Quercus castaneifolia* subsp. *recurvatus*. A–C = abaxial surface. Scale bar: A – 60 μ m, B – 200 μ m, C – 300 μ m

Pollen

The pollen size is categorised in medium class (26–50 μm). The morphology of pollen grains is tricolporate; with medium length colpi (Fig. 5B), pores sometimes indistinct, geniculus sometimes present; oblate-spheroidal shape. The pollen grains are isopolar (Figs 5D–F). The length of polar axis varies from

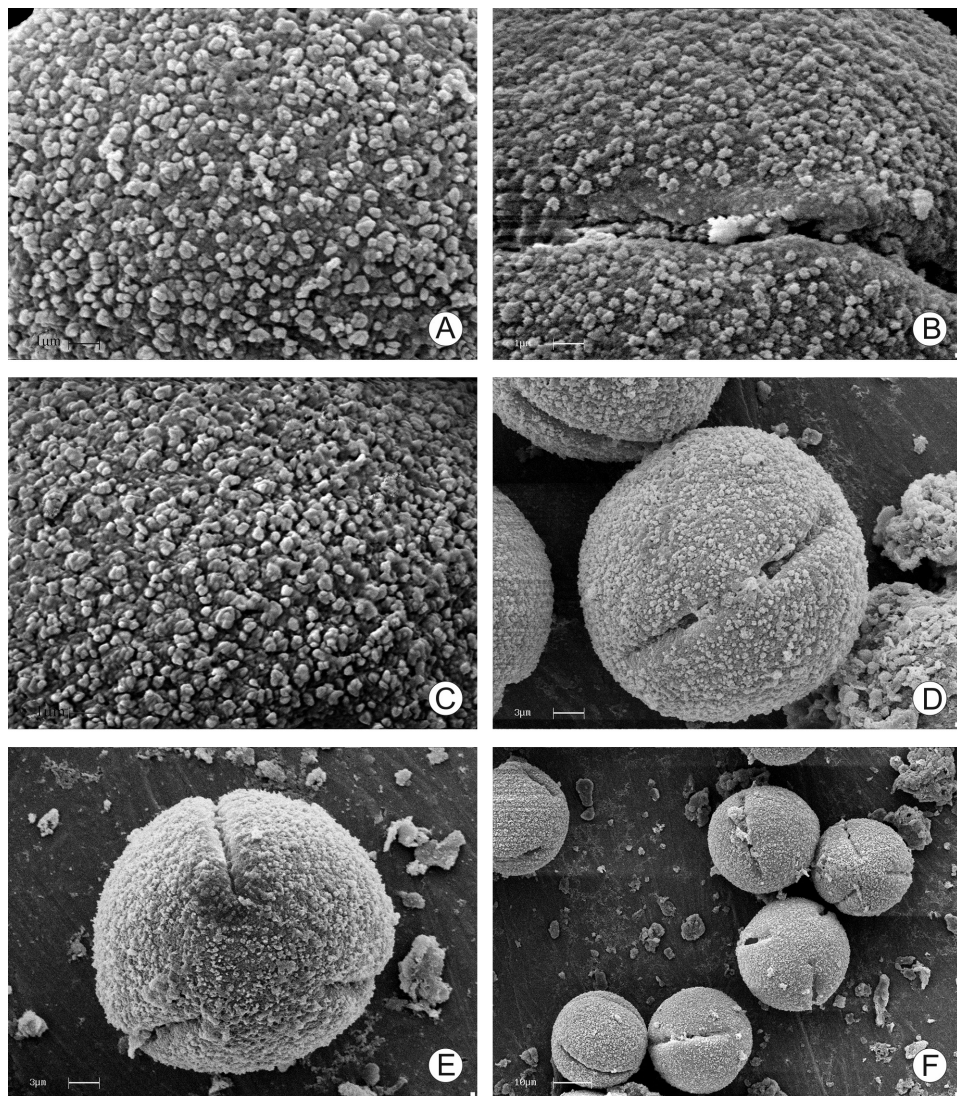


Fig. 5. SEM micrographs of pollen grains of *Quercus castaneifolia* subsp. *recurvatus*. A = mesocolpium, B = colpus membrane, C = apocolpium, D = equatorial view, E = polar view, F = pollen grains. Scale bar: A–C – 1 μm , D–E – 3 μm , F – 10 μm

28–33 μm . The length of equatorial diameter ranges from 30–35 μm . The P/E ratio is 0.93 and the exine thickness is 1 μm . Exine ornamentation in apocolpium and mesocolpium is mostly similar (Figs 5A, C). The pollen surface features of the investigated pollen grains are subdivided into structural characteristics (tectum surface) and sculptural characteristics (projections superimposed upon the tectum surface). The tectum surface is scabrate to rugulate with sparse perfora. Suprasculpture is micro-psilate to micro-scabrate (Figs 5A–C).

Identification key

Based on morphological characteristics, an identification key to the *Quercus castaneifolia* taxa in Iran is presented below.

- 1a Size of gland is small 2
- 1b Size of gland is large 3
- 2a Gland with ± 22 mm long, cupule scale short ± 5 mm long, hilum convex with black brown ring subsp. *castaneifolia* var. *minuta*
- 2b Very short gland ± 14 mm long, cupule with completely erect, triangle scale without any curving, hilum plane without black brown ring subsp. *aitchisoniana*
- 3a Cupule vasiform, glands fusiform at base, scales short, flat and triangular, layered and overlapping subsp. *recurvatus*
- 3b Cupule hemisphere and non-vasiform, glands round and non-fusiform, scales long and non-flatted, often reflexed and not overlapping 4
- 4a Cupule scales long and up to 14 mm long subsp. *undulata*
- 4b Cupule scales shorter and up to 6 mm long subsp. *castaneifolia* var. *castaneifolia*

CONCLUSIONS

Diversity of morphological traits of *Quercus castaneifolia* population in Hyrcanian forests showed that the related taxon of the species has stable and acceptable characteristics for separation and in new subspecies of the *Quercus castaneifolia*; acorn's cupule is relatively vasiform and its scales are flatted, triangular, multi-layered and overlapping at the edge of the cupule. So, these characteristics for the species are important and different from the other subspecies and variety as we known them before (Djavanchir Khoie 1967).

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