

Quercus ×numidica Trabut (Fagaceae, Quercoideae) and *Cynosuro peltierii-Quercetum afaredis* Laribi ex El Mokni ass. nov. new taxon and syntaxon to Kroumirian oak forests of Tunisia with remarks on their ecology and conservation

Ridha El Mokni^{1,2,3} 

Key words: chorology, conservation, endemism, Kroumiria, *Quercus afares*, Rosids.

Ključne besede: horologija, ohranjanje, endemizem, Kroumiria, *Quercus afares*, Rosids.

Abstract

The very little-known *Quercus ×numidica* Trabut, recently typified and synonymised to *Q. ×kabylica* Trabut, was found within the *Cynosuro peltierii-Quercetum afaredis* Laribi ex El Mokni ass. nov. (*Quercion suberis* Loisel 1971). Both the taxon and the syntaxon are described here for the first time for the oak forests of Kroumiria in Tunisia. The distribution, ecology and field photographs of the new taxon are presented and IUCN Red List assessment is provided in this paper. Threats at the national level are assessed and conservation measures for the taxon are proposed.

Izveček

Manj znani takson *Quercus ×numidica* Trabut, ki so ga pred kratkim tipizirali in hkrati opredelili takson *Q. ×kabylica* Trabut kot njegov sinonim, smo našli v sestojih asociacije *Cynosuro peltierii-Quercetum afaredis* Laribi ex El Mokni ass. nov. (*Quercion suberis* Loisel 1971). Pojavljanje taksona in sintaksona smo prvič opisali v hrastovih gozdovih na območju Kroumiria v Tuniziji. Predstavili smo razširjenost, ekologijo in terenske fotografije novega taksona in podali oceno po IUCN rdečem seznamu. Ocenili smo grožnje na nacionalni ravni in predlagali ukrepe za ohranjanje.

Corresponding author:
Ridha El Mokni
E-mail: ridhaelmokni@yahoo.fr

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1 Department of Pharmaceutical Sciences "A", Laboratory of Botany, Cryptogamy and Plant Biology, Faculty of Pharmacy of Monastir, Monastir, Tunisia.

2 University of Carthage, Laboratory of Forest Ecology, National Research Institute of Rural Engineering, Water and Forests, Ariana, Tunisia.

3 University of Jendouba, Department of Silvo-Pastoral Resources, Laboratory of Silvo-Pastoral Resources, Silvo-Pastoral Institute of Tabarka, Tabarka, Tunisia.

Introduction

Quercus xnumidica was first described by Trabut (1889) as one of several taxa found in Algerian oak forests, referring to ‘faux lièges or pseudo-lièges’ (false cork oaks / *Quercus pseudosuber* var. *castaneaefolia* Wenzig) that he mentioned “*Quercus numidica* Trabut *sp. nov.*” with the parentage *Q. afares* Pomel × *Q. suber* L. Traditionally, this hybrid was thought to be a different taxon than a very close hybrid that referred to *Quercus xkabylica* Trabut (Trabut, 1890). More recently, Coombes & Vázquez (2021) have confirmed that both taxa represent variants resulting from hybridization between *Q. afares* and *Q. suber* and are synonyms, the earliest and correct name being *Q. xnumidica* Trabut.

This taxon has been attributed to a very restricted distribution, limited to the Algerian oak forests mainly of Bouzegza, Yakouren, Akfadou and Guerrouch [A1, K1 and K2 subsector *sensu* Quézel & Santa (1962)] (Coombes & Vázquez, 2021). Therefore, we here report the first locality of this taxon in the oak forests of Kroumiria in Tunisia.

Material and methods

In 2018, during botanical field surveys in the mountains of the Kroumiria region (in northwestern Tunisia) and its surroundings, we discovered for the first time some individuals of “an afares oak like with atypical leaf shape”. Some vouchers were taken for further studies and a phytosociological relevé was made (see Table 1).

Two years later (2020), more specimens were discovered at the same site and more vouchers were collected. In addition, phytosociological relevé was done in an area where the largest population of *Quercus afares* grows in Tunisia. Many vouchers are housed in the personal collection of the authors (R. El Mokni), deposited in the Herbarium of the University of Monastir (not listed in *Index Herbariorum*) and at PO (codes after Thiers (2021)). The collected specimens were compared with those deposited in the MPU [mainly Lectotype of *Quercus xnumidica*, (MPU barcode MPU-161864) and Lectotype of *Quercus xkabylica* (MPU barcode MPU-010440), MPU-007895, MPU-010435, MPU-010436, MPU-010437, MPU-010438, MPU-010439, MPU-010441, MPU-161863, MPU-271761, MPU-271763, MPU-271764 and MPU-271769] and P [P-05558810, P-06847710, P-06847796, P-06860940, P-06861705, P-06861708, P-06861709 and P-06861730]. The phytosociological relevés were collected following the approach of Braun-Blanquet (1964). The nomenclature of syntaxonomic units follows Laribi

(2000), Laribi et al. (2008), Meddour et al. (2010), Meddour et al. (2017) and Mucina et al. (2016), while the nomenclature of plants is in agreement with Dobignard & Chatelain (2010–2013) and APD (2021). In addition, the relevant literature was analysed and the digital images of the specimens kept in the MPU and P herbaria were examined.

Results and discussion

During field surveys in the oak forests of Kroumiria in Tunisia, specimens corresponding to the morphological characteristics of an hybrid of *Quercus suber* and *Q. afares*, *Q. xnumidica*, were observed and collected.

The comparison of the collected specimens with those deposited in the MPU confirms that the features (especially in the leaves) of the new oak match *Quercus xnumidica* Trabut (syn. *Q. xkabylica* Trabut) and that no such evidence exists for Tunisia so far.

Selected examined specimens

ALGERIA (historical records): Guerrouch, Juillet 88 (MPU-161864). Akfadou, without date, *Trabut* (MPU-007895). Forêt de l’Akkfadou, without date, *l. Trabut s.n.* (MPU-010435). Akfadou, October 1888, *l. Trabut s.n.* (MPU-010435, MPU-010436, MPU-010437, MPU-010438, MPU-010439, MPU-010440, MPU-010441, P-06861705, P-06861708). Forêt de Guerrouch, 1891, *Trabut* (MPU-161863). Chênaies des pentes supérieures du Dj. Goufi, vers 1000 mètres. En revenant Tamesguida, 13 Avril 1955, herbier H. Gillet (P-05558810, PL-05222613). Kabylie de Collo. 24 mai 1944, herbier L. Faurel (P-06847710, PL-05206190, MPU-284133). Chênaies des pentes supérieures du Djebel Goufi, vers 1000 mètres. Kabylie de Collo. 17 mai 1944, herbier L. Faurel (P-06847796, PL-05206678, MPU-284134). Kabylie, without locality, June 1887, *l. Trabut s.n.* (P-06861709). Taourirt Irhil, June 1889, *l. Trabut s.n.* (P-06861730). Yakouren, without date, *l. Trabut s.n.* (MPU-271761). *In quercetis montis* Bouzegza, solo arenaceo, 700–800 m a.s.l., 22-05-1932, *R. Maire s.n.* (P-06860940, MPU-271763). Forêt de Guerrouch, 1891, *l. Trabut s.n.* (MPU-271764). Massif de l’Akkfadou près Yakouren, without date, *Charlemagne s.n.* (MPU-271769). **TUNISIA (new records):** Jendouba; Aïn Draham, Aïn Zana, mixed oak forest on sandstone-clayey soil, approximately 950 m a.s.l., 036°44’12” N, 008°51’34” E, R. El Mokni, 20 March 2018 *El Mokni s.n.* (PO, *Herb. El Mokni*), *ibidem* 16 June 2020, *El Mokni s.n.* (*Herb. El Mokni*).

Morphology (Figure 2)

Tree as tall as that of *Q. afares*, reaching more than 20 m in height in the wild; **trunk** almost single, straight, with diameter nearly always constant; **bark** somewhat corky; young **shoots** tomentose; **leaves** ovate to elliptic, tapered to rounded at the base and tomentose on the under surface, very variable in shape and size, some resembling those of *Q. suber*, others resembling those of *Q. afares* but smaller, sharply toothed to almost entire, late deciduous, overwintering; **petiole** very short to 2 cm long; **cups** to 2 cm across with recurved scales; **acorns** ovoid, about 3 cm long, half enclosed in the cup and ripening in the second year (see more in Trabut (1890) and Coombes & Cameron (2021)).

Distribution of this rare endemic taxon in North Africa

Although *Quercus ×numidica* appears to have a fairly continuous distribution range (in the oak forests of Algeria and Tunisia), its occurrence, although extending from Algiers to Skikda, is scattered (forests of Bouzegza, Yakouren, Akfadou and Guerrouch) and rare, as recently mentioned by Coombes & Vázquez (2021). East of Collo (Skikda) in Algeria has not been reported, even in historical records. Its rarity is mainly due to confusion with *Quercus afares* individuals and may increase in the future due to habitat destruction, hydrological degradation, fires and ongoing global change. To date, *Quercus ×numidica* has been reported from the seven main historical sites of natural populations in Algeria (Bouzegza, Yakouren,

Akfadou, Taourirt Ighil, Guerrouch, Tamesguida, djebel Goufi), with no known actual status. No other sites were published or confirmed after the year 1961.

A recent monitoring of the floristic diversity of the Kroumirian oak forests and their ecological features in northwestern of Tunisia revealed an additional population of *Quercus ×numidica*, as neither historical localities nor specimens preserved in the MPU and P herbaria were found.

The updated occurrence of *Quercus ×numidica* in North Africa is shown here in Figure 1.

Notes on the associated species in Tunisian locality

Quercus ×numidica was found together with many North African/Tunisian-Algerian endemics (see Table 1) within the *Cynosuro peltierii-Quercetum afaredis* Laribi 2000. This association was in fact invalidly described by Laribi (2000) since only a synthetic table has been presented.

Cynosuro peltierii-Quercetum afaredis Laribi 2000 *nom. inval.* (Art. 5 of the Code, 4th edition of the ICPN; Theurillat et al. (2020)). A single relevé is here selected as holotype and validating the name of this association as *Cynosuro peltierii-Quercetum afaredis* Laribi ex El Mokni ass. nov. (*Holotypus*: Table 1, relevé 2).

The syntaxonomic position of the association is as follows: *Quercetia ilicis* Br.-Bl. ex A. Bolós et O. de Bolós in A. Bolós y Vayreda 1950, *Quercetalia ilicis* Br.-Bl. ex Molinier 1934 and *Quercion suberis* Loisel 1971 (see Loisel, 1971; Meddour et al., 2010; Meddour et al., 2017; Mucina et al., 2016).

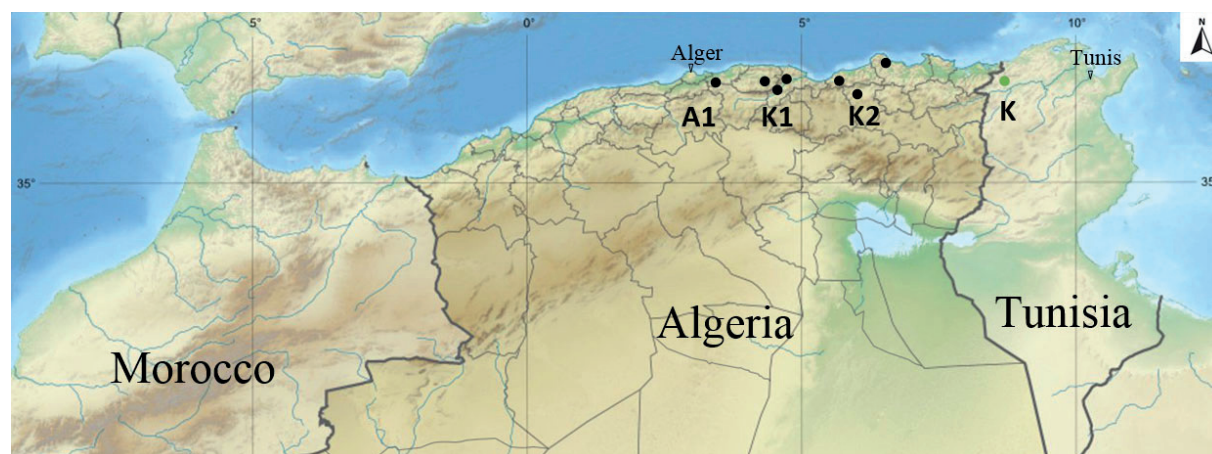


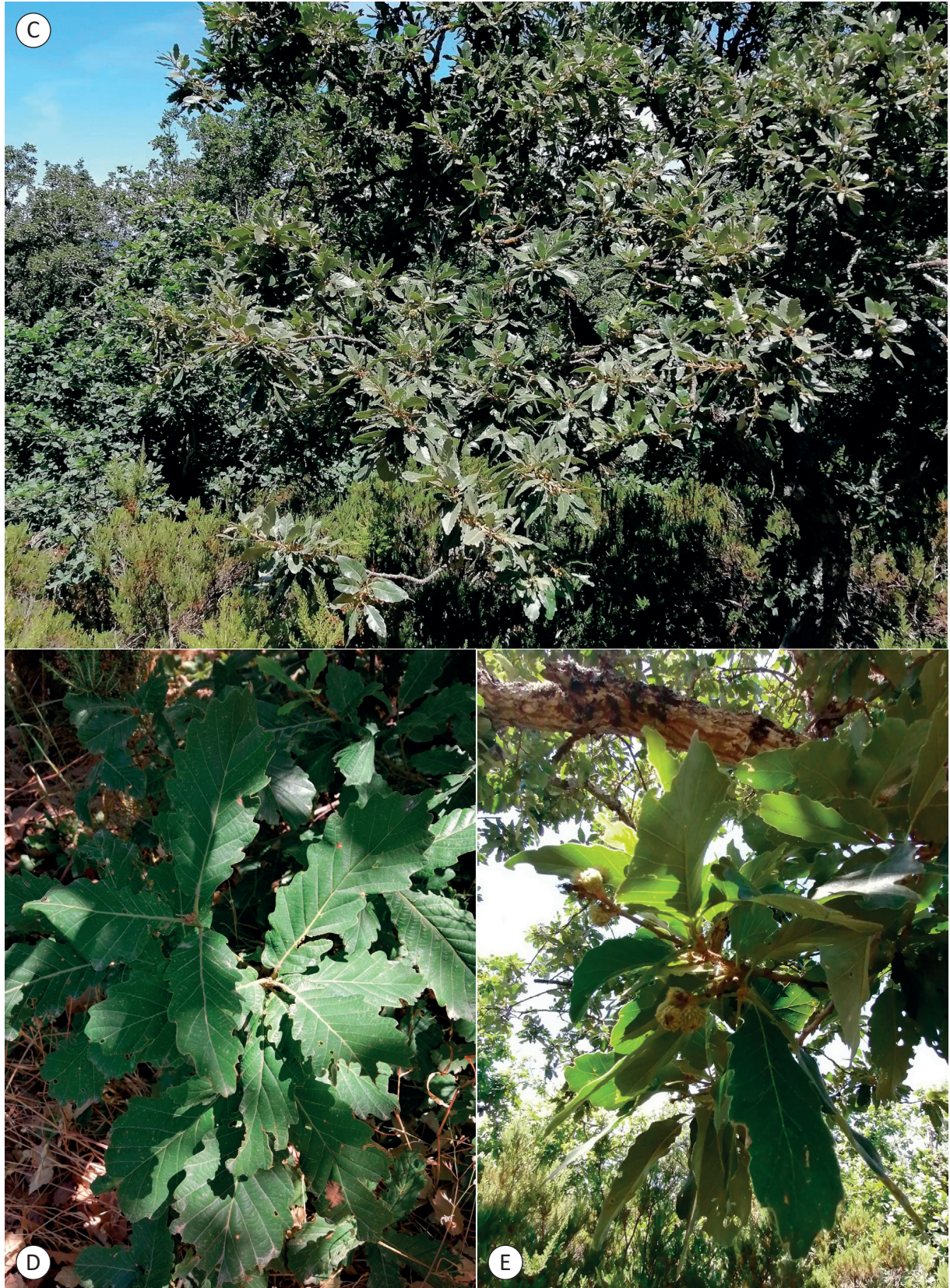
Figure 1: Distribution of *Quercus ×numidica* in North Africa; the green point corresponds to the new record and the extreme eastern population (8. Jendouba/Ain Draham/Ain zana, NW Tunisia) and the black points to historical records, as follows from the west to the east: 1. Bouzegza, 2. Yakouren, 3. Akfadou, 4. Taourirt Ighil, 5. Guerrouch, 6. Tamesguida, 7. djebel Goufi (cf. Coombes & Vázquez 2021; GBIF 2021).

Slika 1: Razširjenost *Quercus ×numidica* v Severni Afriki; zelena točka predstavlja novo lokacijo in najbolj vzhodno populacijo (8. Jendouba /Ain Draham/Ain zana, SZ Tunizija), črna pa zgodovinske podatke od zahoda proti vzhodu: 1. Bouzegza, 2. Yakouren, 3. Akfadou, 4. Taourirt Ighil, 5. Guerrouch, 6. Tamesguida, 7. djebel Goufi (cf. Coombes & Vázquez 2021; GBIF 2021).



Figure 2: *Quercus ×numidica* (syn. *Q. ×kabylica* by Trabut 1890) in Kroumirian oak forests; A: habit of a tree in its natural habitat; B: part of the trunk with somewhat corky bark; C: crown; D: typical leaves; E: cups. (Jendouba, NW Tunisia, North Africa; 16.6.2020). Photos by Ridha El Mokni.

Slika 2: *Quercus ×numidica* (syn. *Q. ×kabylica* Trabut 1890) v hrastovih gozdovih na območju Kroumiria; A: drevesa na naravnem rastišču; B: del debla z nekoliko oplutenelim lubjem; C: krošnja; D: značilni listi; E: plod. (Jendouba, SZ Tunizija, Severna Afrika; 16. 6. 2020). Fotografije: Ridha El Mokni.



The association was defined in Algeria within the Great Kabylia biogeographic subsector [K1 *sensu* Quézel & Santa (1962)], where the characteristic combination of this syntaxon includes *Quercus afares* Pomel, *Cynosurus peltieri* Maire (both endemic to northeastern Algeria and northwestern Tunisia), *Galium tunetanum* Poir. (an endemic of the Maghreb), *Phlomis bovei* de Noé subsp. *bovei* (a subspecies endemic to northeastern Algeria and northwestern Tunisia), and other taxa that are indicators of the temporary hydromorphic of clay soils (sub-numidian clays outcrop) occupied by the afares oak forest. These forests are determined, at least in part, by an edaphic determinism and are located almost between 1,000 and 1,300 m a.s.l. in a cool, humid bioclimate (as almost in Tunisia), in the upper Mesomediterranean, on the driest slopes facing west, southwest and south, mainly in the Akfadou forests (Laribi, 2000).

Conservation status

In total, we can name all included (historical and current records) eight populations/subpopulations of *Quercus ×numidica* currently known in North Africa (Algeria and Tunisia). All populations are scattered with a limited number of individuals, not exceeding 20 for the Tunisian subpopulation. Their occurrence is still linked to oak forests dominated by afares oak.

Based on the IUCN Threats Classification Scheme (IUCN, 2021), we can highlight the following:

2. agriculture (2.3 Livestock farming, 2.3.1 Nomadic grazing): continuous overgrazing, whether in Tunisia with high numbers of goats or in Algeria with intensive frequentation by cattle (Meddour, 1993; Laribi, 2000), remains the most obvious threat to these communities and to the native biodiversity they host in these ecosystems. Persistent overgrazing leads to retrogression, encourages the growth and spread of weeds and plants of the pastoral rangelands (see Table 1), and leads to the depletion and even loss of native and endemic plant species;
3. energy production and mining (coal mining): the constant aggressive cutting of oak branches for heating coal can only reduce the performance of the trees, limiting their productivity and reducing their acorn production;
5. biological resource use (5.3 Logging and wood harvesting, 5.3.3 Unintentional effects: subsistence/small scale (species being assessed is not the target) [harvest]): illegal logging of oak trees has always continued and has become more frequent mainly in the last decade. Such behavior can only harm and deeply disturb any type of ecosystem balance and evolution;
7. changes in the natural system (7.1 Fire, 7.1.1 Increase in frequency/intensity of fires): the increase in the

frequency of fires especially in the last decade (about 392 fires that burned more than 1300 ha of forest area within Aïn Draham delegation, Comm. Pers. L. Hamdi, forestry engineer in the Aïn Draham forestry delegation) facilitates the fragmentation to irreversible habitat destruction and disrupts important processes such as gene flow; (7.3 Other ecosystem changes): the improper, excessive and continuous collection of litter under oaks by nurserymen can only destroy any soil process that favours the formation of a humus soil suitable sustaining this biodiversity;

12. other options (12.1 Other threats): the lack of effective habitat conservation strategies by governments, rehabilitation of burnt areas, and increasing the resilience of species populations to fire damage, compounded by the negative effects of very high visitation by non-target hikers and heavy trampling during the beatings of wild boars.

The eight reported populations at eight sites (historical and new records, Figure 1) have an AOO (Area Of Occupancy) of 40 km² (<< 500 km²) and an EOO (Extend Of Occurrence) of 12,011 km². Given a decline in the habitat quality (fragmentation, overgrazing and illegal continuous and excessive logging), *Quercus ×numidica* may be classified as Endangered [B2b(i,ii,iii,iv)c(i,ii,iii)] in North Africa, according to IUCN (2021) criteria.

Conservation measures

Despite the great efforts made for more than two decades in monitoring deciduous oaks (*Quercus afares* and *Q. canariensis*) and their high biodiversity, the work is still in its infancy and several conservation measures should be carried out urgently and more seriously. The conservation strategy for these endangered oaks (including the newly reported endangered deciduous oak *Quercus ×numidica*) requires at least: (i) *in situ*, putting an end to excessive and massive overgrazing, by including especially the areas where the newly discovered taxon (*Quercus ×numidica*) is rampant, and declaring these oak forests prohibited by law from grazing, in order to save what is left of the surviving populations and monitor their status and habitat quality, (ii) *ex situ*, acorns of these oak species (especially *Quercus afares* and *Q. ×numidica*) previously collected from surroundings than planted in the forest nursery of Aïn Sultan (located within Kroumiria under almost identical conditions and at the same altitude), where a test with more than 900 acorns of zeen oak in recent years showed a success rate of more than 90% (pers. comm. S. Hamzaoui, forestry technician of Aïn Sultan area). The plant material obtained (about three to five years old plants) will be used later to strengthen existing sporadic wild populations and

to restore sites where wild populations have been severely damaged, especially in the last decade, following efficient and known guidelines for reintroduction.

Conclusions

According to the available literature, this is the first record of *Quercus xnumidica* in the oak forests of Tunisia, and thus its new eastern limit in North Africa. This finding belongs to the plant association *Cynosuro peltierii-Quercetum afaredis* Laribi ex El Mokni ass. nov. which was also reported for the first time for the Kroumirian Mountains. Both the taxon and the syntaxon contribute to improve and update the knowledge of the chorology and ecology of Tunisian deciduous oaks, the floristic and vegetation richness of Kroumiria, but also underline the urgent need to protect the diversity of ecosystems in these highly disturbed habitats before reaching a stage of no return.

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Ridha El Mokni  <https://orcid.org/0000-0003-3849-1039>

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Table 1: Floristic relevés for *Quercus xnumidica* Trabut plant community (2018–2020) within Tunisian oak forests (Jendouba/Aïn Draham/Aïn zana, NW of Tunisia), (-, no report; +, present with more than 10 spontaneous individuals within the reported population of *Quercus afares* Pomel; 1, 2, 3 and 4 are following the Braun-Blanquet cover-abundance scale; *indicates endemic taxa to Tunisia and its very close neighboring countries; ♣ indicates pastoral plants).

Tabela 1: Popisi združbe z *Quercus xnumidica* Trabut, narejeni v zadnjih nekaj letih (2018–2020) v hrastovih gozdovih v Tuniziji (Jendouba/Aïn Draham/Aïn zana, SZ Tunizije), (-, ni prisotna; +, prisotnih več kot 10 spontano rastočih osebkov populaciji vrste *Quercus afares* Pomel; 1, 2, 3 in 4 ustrezajo lestvici pokrovnosti in številčnosti po Braun-Blanquetu; *označuje endemične taksone v Tuniziji in sosednjih državah; ♣označuje rastline, značilne za pašne površine).

Relevé number	1	2 (Holotypus)
Biogeographical entity	Kroumiria	Kroumiria
Site	Oak forests of Kroumiria (Jendouba/Aïn Draham/Aïn Zana)	Oak forests of Kroumiria (Jendouba/Aïn Draham/Aïn Zana)
Date	12.07.2018	16.06.2020
Vegetation coverage (%)	85–90	90–95
Surface area (m ²)	256	256
Altitude (m a.s.l.)	886.6 – 954.8	886.6 – 954.8
Coordinates	036°44'12" N 008°51'34" E	036°44'12" N 008°51'34" E

Diagnostic species of the *Cynosuro peltierii-Quercetum afaredis* association

* <i>Quercus afares</i> Pomel	3	4
* <i>Cynosurus peltieri</i> Maire	1	2
* <i>Galium tunetanum</i> Lam.	1	1
* <i>Quercus xnumidica</i> Trab.	+	+
* <i>Phlomis bovei</i> de Noé subsp. <i>bovei</i>	+	+

Diagnostic species of the *Quercion suberis* alliance

<i>Quercus suber</i> L.	2	2
* <i>Teucrium atratum</i> Pomel	1	2
<i>Cytisus villosus</i> Pourr.	1	1
<i>Melica minuta</i> L.	1	1
<i>Pulicaria odora</i> (L.) Rchb.	1	1
<i>Genista ulicina</i> Spach	1	1

Diagnostic species of the *Quercetalia ilicis* order

* <i>Quercus canariensis</i> Willd.	3	3
<i>Erica arborea</i> L.	2	2
<i>Galium rotundifolium</i> L.	1	1
<i>Geranium purpureum</i> Vill.	1	1
* <i>Cyclamen africanum</i> Boiss. & Reut.	1	1
<i>Luzula forsteri</i> (Sm.) DC.	1	+
<i>Phillyrea latifolia</i> L.	2	-
<i>Asplenium adiantum-nigrum</i> L.	1	1
<i>Cytisus villosus</i> Pourr.	1	1

Diagnostic species of the *Quercetea ilicis* class

<i>Arbutus unedo</i> L.	2	2
<i>Erica arborea</i> L.	2	2
<i>Geranium purpureum</i> Vill.	1	1
* <i>Plagius maghrebinus</i> Vogt & Greuter	1	+
<i>Daphne gnidium</i> L. subsp. <i>gnidium</i>	1	+
<i>Selaginella denticulata</i> (L.) Spring	1	1
<i>Smilax aspera</i> L.	1	-
* <i>Eryngium tricuspdatum</i> subsp. <i>bovei</i> (Boiss.) Breton	1	1

Relevé number	1	2 (Holotypus)
Companion species		
<i>Aira tenorei</i> Guss.	1	1
* <i>Andryala integrifolia</i> L.	1	+
* <i>Asphodelus ramosus</i> L.	1	1
<i>Asplenium trichomanes</i> L.	1	1
<i>Briza maxima</i> L.	1	1
<i>Bromus hordeaceus</i> L. subsp. <i>hordeaceus</i>	1	1
<i>Campanula rapunculus</i> L.	1	1
<i>Catapodium rigidum</i> (L.) C.E. Hubb.	1	1
<i>Clinopodium vulgare</i> L.	1	1
<i>Cynosurus echinatus</i> L.	1	1
<i>Dactylis glomerata</i> L. subsp. <i>glomerata</i>	1	+
<i>Diatelia tuberaria</i> (L.) Demoly	1	-
<i>Elaeoselinum asclepium</i> subsp. <i>meoides</i> (Desf.) Fiori	1	1
<i>Ficaria verna</i> Huds.	1	+
<i>Filago asterisciflora</i> (Lam.) Sweet	1	1
<i>Filago pyramidata</i> L.	1	1
<i>Fumana juniperina</i> (Lag. ex Dunal) Pau	1	+
* <i>Galactites mutabilis</i> Durieu	1	2
<i>Gaudinia fragilis</i> (L.) P. Beauv.	1	1
<i>Geranium atlanticum</i> Boiss.	1	1
<i>Geranium lucidum</i> L.	1	+
<i>Geranium robertianum</i> L.	1	1
<i>Holcus lanatus</i> L.	1	1
<i>Hordeum bulbosum</i> L.	1	1
* <i>Hyacinthoides aristidis</i> (Coss.) Rothm.	1	1
<i>Klasea flavescens</i> subsp. <i>mucronata</i> (Desf.) Cantó & Rivas Mart.	+	+
<i>Lagurus ovatus</i> L. subsp. <i>ovatus</i>	1	1
<i>Legousia falcata</i> (Ten.) Janch.	1	1
<i>Lens</i> sp.	+	+
<i>Lens nigricans</i> (M. Bieb.) Godr.	+	1
* <i>Ophrys tenthredinifera</i> subsp. <i>ficalthoana</i> (J.A. Guim.) M.R. Lowe & D. Tyteca	+	-
* <i>Plantago lagopus</i> L.	+	-
* <i>Platanthera bifolia</i> subsp. <i>kuenkelei</i> (H. Baumann) Kreutz	-	+
<i>Polypodium cambricum</i> L.	1	1
<i>Rubus ulmifolius</i> Schott	1	+
<i>Rumex tuberosus</i> L.	+	+
<i>Sedum cepaea</i> L.	1	1
<i>Sherardia arvensis</i> L.	1	1
<i>Stachys arvensis</i> L.	1	+
* <i>Trifolium campestre</i> Schreb.	1	1
* <i>Trifolium cherleri</i> L.	1	1
<i>Trifolium pratense</i> L.	1	1
* <i>Trifolium stellatum</i> L.	1	1
<i>Vicia bithynica</i> (L.) L.	1	+