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Research Article

A New Hybrid Record for The Vascular Flora of Türkiye: *Fagus x taurica* Popl.

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ABSTRACT

The presence of *Fagus x taurica* Popl., a hybrid of two *Fagus* L. taxa known to be naturally distributed in Türkiye, has been detected in the natural deciduous-mixed forests of Bolu. Specimens were collected from Kökez Old Growth Fir Forest Nature Reserve Area, Bolu Kale Fındığı Nature Reserve Area, and Yedigöller National Park in Bolu province, northwest Türkiye. After the identification, specimens were compared with materials in the international herbaria. As a result of the examinations, the morphological features seen to be different from its parents are as follows: Young shoots are grayish-green in color, leaves have 7-13 pairs of lateral veins, are ovate or obovate, and their margins are dentate, and the cupula scales are subulate. It resembles *F. orientalis* Lipsky in terms of leaf characteristics and *F. sylvatica* L. in terms of cupula characteristics. In this article, a botanical description of the taxon, differences from the main species, distribution maps, and photos are given. *Fagus x taurica* is a new hybrid record for the vascular flora of Türkiye. With this new record, the number of *Fagus* sp. taxa in the flora of Türkiye has risen to 3.

Keywords: Crimean beech, Fagaceae, Forest biodiversity, New records, Northern Türkiye

Türkiye Vasküler Florası İçin Yeni Bir Hibrit Kayıt: *Fagus x taurica* Popl.

Öz

Türkiye'de doğal olarak yayılış gösterdiği bilinen iki *Fagus* L. türünün bir melezi olan *Fagus x taurica* Popl.'nin varlığı Bolu'nun doğal geniş yapraklı ormanlarında tespit edilmiştir. Örnekler Kuzeybatı Türkiye'nin Bolu ilindeki Kökez Çok Yaşlı Gökmar Ormanı Tabiatı Koruma Alanı, Bolu Kale Fındığı Tabiatı Koruma Alanı ve Yedigöller Milli Parkı'ndan toplandı. Tanımlamanın ardından örnekler uluslararası herbaryumdaki materyallerle karşılaştırıldı. İncelemeler sonucunda ebeveynlerinden farklı olarak görülen morfolojik özellikler şöyledir: Genç sürgünler grimsi-yeşil renkte, 7-13 çift yan damara sahip yapraklar yumurtamsı veya ters yumurtamsı şekilde ve kenarları dişli, kupula pulları biz şekindedir. Yaprak özellikleri bakımından *F. orientalis* Lipsky'e, kupula özellikleri bakımından ise *F. sylvatica* L.'ya benzemektedir. Bu makalede taksonun botanik tanımı, ana türlerden farklılıkları, yayılış haritaları ve fotoğrafları verilmektedir. *Fagus x taurica* Türkiye vasküler florası için yeni bir hibrit kayıttır. Bu yeni kayıtla birlikte *Fagus* cinsine ait Türkiye florasındaki takson sayısı 3'e yükselmiştir.

Anahtar Kelimeler: Kırım kayını, Fagaceae, Orman biyoçeşitliliği, Yeni kayıt, Kuzey Türkiye

I. INTRODUCTION

The genus *Fagus* L. sp. is one of the 8 genera of the Fagaceae family and is represented by 13 taxa in the world [1, 2, 3]. It is known that two taxa of this genus, *Fagus orientalis* Lipsky and *Fagus sylvatica* L. are distributed in Türkiye [4, 5].

Fagus orientalis (Oriental beech) which naturally spreads in the east of the Balkan Peninsula (Bulgaria, Romania, Greece), Crimea, Caucasus, and Northern Iran, has a wider distribution in Türkiye [4, 6]. It establishes pure or mixed stands with coniferous and other deciduous species in Thrace, Istranca Mountains, Kaz Mountains, Uludağ, and Marmara Region along the Black Sea coast. It also moves to the south and mixes with plants of Mediterranean origin along with some Euro-Siberian origin plants like itself in the Amanos Mountains [7].

Fagus sylvatica (European beech), which naturally spreads in Western-Central Europe, the Balkans, the south of Russia, and the central part of Moldova, enters Türkiye from the Balkans and shows a limited distribution in the Thrace forests [8, 9, 10]. However, there are some local records from Ilgaz Mountains/Kastamonu [11] and Kavaklı Nature Reserve Area/Karabük [12]. A clear delimitation of the area in the Balkans is very difficult, as introgressive hybridization occurs between the Oriental beech and the European beech [6].

Although these two species are phylogenetically very close to each other, Poplawska, in her study on morphological variations of beeches growing in Crimea, proposed a new hybrid species, *Fagus x taurica* Popl., which has common features of *Fagus orientalis* and *Fagus sylvatica* [13]. This hybrid species is also included in the world Fagales checklist published in 1998 [8]. It was indicated that, in the central-east and east regions of the Rhodope Mountains in Bulgaria and Greece, extensive hybridization zones are observed between Oriental and European beeches [14, 15]. In addition, the results obtained in a study comparing the leaf morphologies of *Fagus orientalis* and *Fagus sylvatica* revealed that there was no significant morphological difference in terms of leaves [16].

The taxonomic position of the species resulting from this hybridization has long been controversial. While the Balkan beech (*Fagus moesiaca* (K.Malý) Czeczott) is considered by some scientists as a hybrid between *Fagus orientalis* and *Fagus sylvatica*, which is close to *Fagus sylvatica*; some consider it to be a transitional form in which one of the two species is dominant. While some consider it an ecotype, others consider it the same species as the Crimean beech (*Fagus x taurica*). Considered a subspecies of *Fagus sylvatica* in some articles, *Fagus moesiaca* now is a synonym of *Fagus x taurica* [1, 6, 14, 16, 17, 18, 19, 20].

In this study, we report the presence in Türkiye of *Fagus x taurica*, a hybrid species between *Fagus orientalis* and *Fagus sylvatica*, which is common in Europe and Crimea.

II. MATERIAL AND METHODS

Fagus x taurica samples were collected during the floristic investigations in Kökez Old Growth Fir Forest Nature Reserve Area, Bolu Kale Fındığı Nature Reserve Area, and Yedigöller National Park in Bolu province, in July–October 2020. The collected samples were dried in accordance with the herbarium rules and turned into herbarium samples.

Herbarium specimens of *F. orientalis*, *F. sylvatica*, and *F. x taurica* (listed in the examined specimens part) were used for comparative investigation. After identification by using literature about the taxon [6, 8, 13], specimens were compared with materials in the herbaria of B (Botanical Garden and Botanical Museum in Berlin), BR (Meise Botanic Garden Herbarium), DUOF (Düzce Üniversitesi Orman Fakültesi Herbaryumu), E (Herbarium of Royal Botanic Garden of Edinburgh), L (Leiden Herbarium),

MW (Herbarium Universitatis Mosquensis), NEU (Susse Herbar, Universite De Neuchatel). After that specimens were deposited in the Herbarium of the Düzce University Forestry Faculty (DUOF).

The morphological features of the plant samples were examined and compared with each other. Leaf, fruit, and bark features were photographed. The morphological differences between the three taxa were defined by both measurements and literature and an identification key was created.

III. RESULTS AND DISCUSSION

A hybrid of *Fagus* sp. has been recorded for Türkiye. Therefore, it is necessary to present a new identification key for these 3 taxa that naturally spread in Türkiye.

Fagus x taurica Popl., Trudy Izuch. Zapov. Otdela Okhr. Prir. Glavnauki 2: 84 (1925) [19], (Fig. 1).

Hybrid Formula: *F. orientalis* x *F. sylvatica*

Lectotype: Described from the Crimean National Forest. Type in the Herbarium of the National Forest.

Synonyms: *Fagus sylvatica* f. *moesiaca* K.Malý in P.F.A.Ascherson & K.O.R.Graebner, Syn. Mitteleur. Fl. 4: 438 (1911), *Fagus sylvatica* f. *dawycki* Hesse, Mitt. Deutsch. Dendrol. Ges. 21: 366 (1912), *Fagus x moesiaca* (K.Malý) Czeczott, Ann. Soc. Dendrol. Pologne 5: 52 (1933), *Fagus sylvatica* subsp. *moesiaca* (K.Malý) Szafer, Polska Akad. Umiejtn. Rozpr., Wydz. Mat–Przyr., B, Nauki Biol. 71: 69 (1935), *Fagus x moesiaca* f. *leucodermis* Korac, Nau?ni Skup. Od. Prir.–Mat. Nauka 1(1), 33 (1974). *Fagus x moesiaca* var. *dawycki* (Hesse) P.D.Sell, Fl. Gr. Brit. Ireland 1: 685 (2018).



Figure 1. General appearance of *Fagus x taurica*: (a) habitus, (b) bark (c) young shoot, (d) leaf

Description: Bark smooth and darker grey from *F. orientalis*. Pseudo-terminal buds to 1.7–2.2 cm. Young shoots greyish–green, pubescent. Leaves broadly elliptic to obovate or ovate, acuminate, 8.1–11.7x4.2–7.3 cm, with (–7) 9–11 (–13) pairs of veins, cuneate or rounded at base, margin prominently dentate, glabrous on both surfaces except for midrib and primary veins of the lower surface, which are long silky–pilose; petiole pubescent, 0.3–1.1 cm, stipules 2.3– 3.5 mm, caducous. Involucral scales subulate; peduncles to 3.5 cm, pubescent. Nuts 1.2–2.2 cm (Morphological values were measured by the authors on herbarium samples DUOF 9546!, 9547!, 9548!, 9549! 9550!).

A deciduous, natural hybrid tree taxon between *F. orientalis* and *F. sylvatica*. The leaves are closer to the ancestor *F. orientalis*, but they are closer to the ancestor *F. sylvatica* in terms of fruit status. They lack the spatulate bracts on the lower part of the cupula, which are specific to *F. orientalis* [21]. The differences of this taxon from the main species are given in Table 1 and Figure 2.

Table 1. Morphological differences between *Fagus x taurica* and its parents.

Character / Trees	<i>Fagus orientalis</i>	<i>Fagus sylvatica</i>	<i>Fagus x taurica</i>
Young shoot	reddish–brown	reddish–brown	greyish–green
Leaves	obovate	ovate	has both ovate and obovate leaves
Lateral veins	8–13 pairs	5–8 pairs	(–7) 9–11 (–13) pairs
Leaf margin	entire or slightly undulate	undulate	dentate
Cupule scales	two kinds of cupule scales: upper ones subulate, lower spatulate bracts	scales of cupule uniform, subulate	scales of cupule uniform, subulate



Figure 2. (a) *Fagus x taurica* leaves (b) *Fagus orientalis* leaf, (c) *Fagus x taurica* cupule, (d) *Fagus orientalis* cupules

1. Leaves ovate, with 5–8 pairs of lateral veins, margin undulate; scales of cupule all alike, subulate.....*Fagus sylvatica*
1. Leaves ovate or obovate, with 8–13 pairs of lateral veins margin entire or dentate
2. Leaves obovate, margin entire or slightly undulate; scales of cupule two kinds, upper ones subulate, lower spatulate bracts.....*Fagus orientalis*
2. Leaves ovate or obovate, margin dentate; all scales of cupule subulate.....*Fagus x taurica*

Distribution: TÜRKİYE: A3–Bolu: Kökez Old Growth Fir Forest Nature Reserve Area, at elevation of 1400–1420 m, in the fir– beech forest, 10.07.2020, Leg.: N. Güneş Özkan (3610), T. Birtürk & A. Ayteğin (DUOF 9547), Det. N. Aksoy; A3–Bolu: Bolu Kale Fındığı Nature Reserve Area, at elevation of 1420 m, in the beech–fir and other deciduous-mixed forest, 16.07.2020, Leg.: N. Güneş Özkan (3863), T. Birtürk & A. Ayteğin (DUOF 9549), Det. N. Güneş Özkan; A3–Bolu: Yedigöller National Park, near Büyükgöl, at elevation of 790 m, in the fir–beech forest, 26.07.2020, Leg.: N. Güneş Özkan (4181), (DUOF 9550), Det. N. Güneş Özkan; A3–Bolu: Bolu Kale Fındığı Nature Reserve Area, at elevation of 1400 m, in the beech–fir forest, 16.07.2020, Leg.: N. Güneş Özkan (3730), T. Birtürk & A. Ayteğin (DUOF 9546), Det. N. Aksoy; A3–Bolu: Kökez Old Growth Fir Forest Nature Reserve Area,

at elevation of 1400 m, in the fir–beech forest, 12.11.2020, Leg.: N. Güneş Özkan (3782), N. Aksoy & A. Ayteğin (DUOF 9548), Det. N. Aksoy (Fig. 3 and 4).

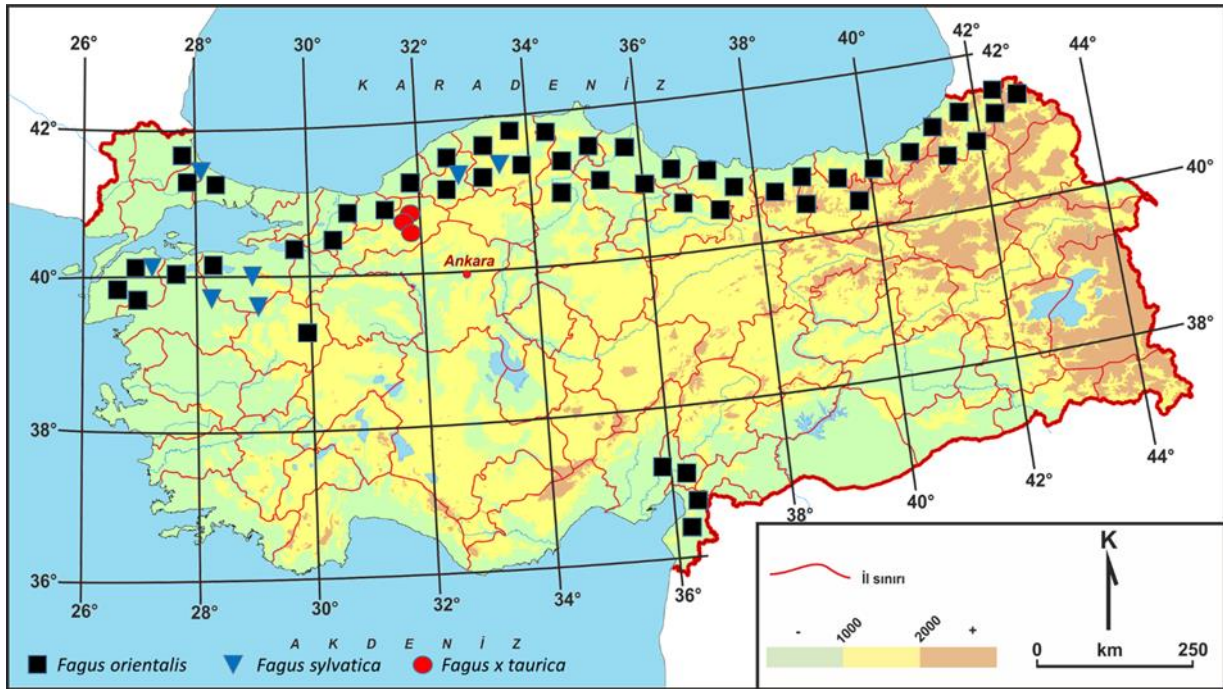


Figure 3. Distribution of *Fagus* sp. in Türkiye [22, 11, 12, 23, 24].

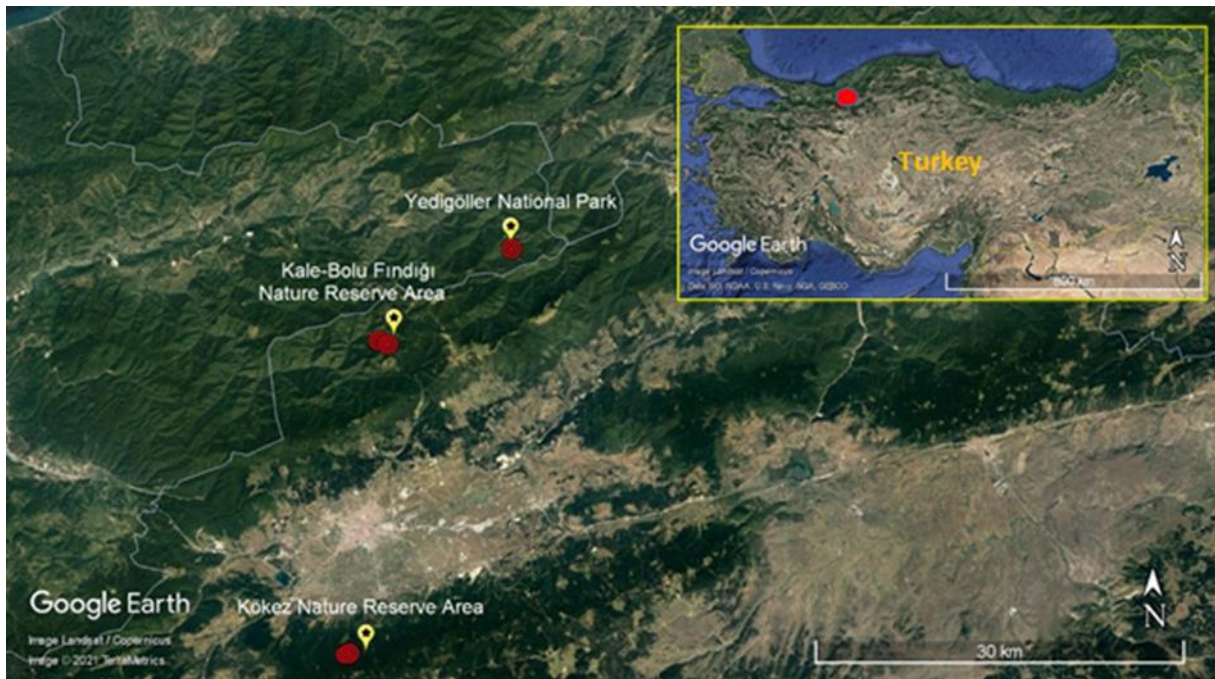


Figure 4. Distribution of *Fagus x taurica* in Bolu district.

Fagus x taurica which is the Euro–Siberian element, has been recorded in beech–fir mixed forest habitats. A large number of adult trees were found. At the same time, *F. orientalis* individuals in which hybridization is in the formation stage were also encountered.

In its habitat, this hybrid species is accompanied by species such as *Abies nordmanniana* (Steven) Spach subsp. *equi–trojani* (Asc. & Sint. ex Boiss.) Coode & Cullen, *Fagus orientalis*, *Rubus canescens* DC.

var. *canescens*, *Daphne pontica* L. subsp. *pontica*, *Ilex colchica* Pojark., *Pteridium aquilinum* (L.) Kuhn, *Cardamine impatiens* L. subsp. *impatiens*, *Helleborus orientalis* Lam., *Oxalis acetosella* L. in Kökez Old Growth Fir Forest Nature Reserve Area. *Carpinus betulus* L., *Corylus colurna* L., *Acer platanoides* L., *Quercus petraea* (Matt.) Liebl. subsp. *iberica* (Steven ex M.Bieb.) Krassiln., *Rhododendron ponticum* L., *Lonicera caucasica* Pall., *Euonymus europeaus* L., *Euonymus latifolius* Mill. subsp. *cauconis* Coode & Cullen, *Sedum pallidum* M.Bieb., *Cephalanthera rubra* (L.) Rich., *Calystegia sylvatica* (Kit.) Griseb., *Trachystemon orientalis* (L.) G. Don, *Hypericum perforatum* L. are found together with this species in Bolu Kale Fındığı Nature Reserve Area.

It is normal to see *Fagus x taurica* in our country, which is a hybrid of two taxa naturally spread in Türkiye and is known to hybridize, and its existence is proven by this article.

IV. CONCLUSION

Fagus x taurica is a new hybrid record for the vascular flora of Türkiye. With this new record, the number of *Fagus* L. sp. taxa in the flora of Türkiye has risen to 3. *Fagus x taurica* is a rare species for Türkiye with this narrow distribution. The conservation status of this species should be listed as Critically Endangered (CR) according to the IUCN categories [25].

Because the distribution area of this hybrid tree, whose existence has just been discovered, has the status of a protected area where its use is regulated by the relevant legislation, only scientific and educational studies are allowed. However, the population, health, and reproductive status of the individuals of these hybrid trees in their distribution areas should be determined and monitored.

Some of the examined *F. sylvatica* herbarium specimens; reflect *F. sylvatica* in terms of leaf characteristics and *F. orientalis* in terms of the cupula, or it creates a question mark when there is no cupula in the sample. Because there is a very high variation in leaf characteristics between these two taxa, due to the cupula's lack of some herbarium specimens identified as *F. orientalis*, we believe that these specimens may be *F. x taurica*.

For this reason, herbarium records should be examined comprehensively and local flora studies should be carried out to determine certainly the distribution areas of *F. x taurica* in Türkiye. We think that the species is distributed in more areas than expected due to the high probability of hybridization, especially in areas where the distributions of the two main species overlap.

SPECIMENS EXAMINED

Fagus x taurica: CRIMEA: Republic of Crimea, Beech Forests between Alushta and Bukovel, Tauria, Leg: Poplawska (3385), fl. 07.05.1926, fr. 25.09.1926 (MW0606919!). South slopes of Crimea, Nikita Village, alt. 1000 m., forest, 19.07.1953, Leg. B.S. Govorulin (MW0606917!). Crimea, 15.08.1955, 800 m., Leg. Sergei Nikolaevich Tyuremnov (MW0606923!). Col. J' Ang., Crimea (URSS), Leg. Leon Delvosalle, July, 1978, 400 m., (BR0000024645485!). GREECE: N side of Mt. Chortiatas, above Ajos Ioannis (Greece, Makedonia, Nomos & Eparchia Thessalonikis), 40° 35' 45''N 23° 06' 40'' E, alt. 900–1000 m, mixed *Fagus Castanea* forest with clearings rich in *Pteridium aquilinum*, on calcareous rocks, July 23rd, 1994, Leg. Th –Taus, M. Palm & Ch. Schiers no 20980, Det. Th.Raus (BR0000027282816V!). ROMANIA: Comm. Racova: in silva Runc dicta. Alt. cca 400 m s.m.–10. VI. 1973. Leg. et. det. N. Barabaş & D. Mititelu. (L1553853!). TÜRKİYE: A3–Bolu: Kökez Old Growth Fir Forest Nature Reserve Area, at elevation of 1400–1420 m, in the fir– beech forest, 10.07.2020, Leg.: N. Güneş Özkan (3610), T. Birtürk & A. Ayteğin (DUOF 9547), Det. N. Aksoy. A3–Bolu: Bolu Kale Fındığı Nature Reserve Area, at elevation of 1420 m, in the beech–fir and other deciduous–mixed forest, 16.07.2020, Leg.: N. Güneş Özkan (3863), T. Birtürk & A. Ayteğin (DUOF 9549), Det. N. Güneş Özkan. A3–Bolu: Yedigöller National Park, near Büyükgöl, at elevation of 790 m, in the fir– beech forest, 26.07.2020, Leg.: N. Güneş Özkan (4181), (DUOF 9550), Det. N. Güneş Özkan. A3–Bolu: Bolu Kale Fındığı Nature Reserve Area, at elevation of 1400 m, in the beech–fir forest, 16.07.2020, Leg.: N.

Güneş Özkan (3730), T. Birtürk & A. AYTEĞİN (DUOF 9546), Det. N. Aksoy. A3–Bolu: Kökez Old Growth Fir Forest Nature Reserve Area, at elevation of 1400 m, in the fir–beech forest, 12.11.2020, Leg.: N. Güneş Özkan (3782), N. Aksoy & A. AYTEĞİN (DUOF 9548), Det. N. Aksoy. A2(A)–Bursa: Uludağ, 7.1944, Leg. S. Kuntay, Det. N. Aksoy (ISTF4548!). A1–Kırklareli: Demirköy, Yeniceköy, Velika Köprüsü, Quercus ormanı, 500 m., 8.7.1958, Leg. H. Demiriz, Det. N. Aksoy (ISTF17407!). A3–Bolu: Bolu Dağları, Seymenler, ormanaltı, 19.05.1962, Leg. B. Tutel, Det. N. Aksoy (ISTF18534!).

Fagus sylvatica: TÜRKİYE: A4–Karabük: Yenice Ormanları, Kavaklı Tabiatı Koruma Alanı, karışık yapraklı orman, 1070 m. 41° 10' 60''N 32° 24' 47'' E, Leg. A. AYTEĞİN 2592, Det. N. Aksoy (DUOF8349!). C6–Adana: Osmaniye, Gavur Dağı, *Abies cilicica* ile ve homojen buk, Exp. N., 1900 m., 7.1942, Leg. K. Mihçioğlu, Det. N. Aksoy (ISTF1985!). C6–Adana: Osmaniye, Gavur Dağı, *Abies cilicica* ile ve homojen buk, Exp. N., 1900 m., 7.1942, Leg. K. Mihçioğlu, Det. N. Aksoy (ISTF1985!). DEUTSCHLAND (DE), Niedersachsen, Bad Iburg, 52° 09' 34.20''N 8° 01' 19.42'' E, 2013–01–01, Leg. W. Bleeker WB–005, Det. W. Bleeker, (B 10 0553983!). SUISSE: Canton: Neuchâtel. District: Le Locle. Commune: Les Brenets. Localite: Forêt., 47° 04' 09,15 ''N 6° 42' 11.57'' E, 800 m, Forêt, W. McNeely & M. Hallal., (NEU000099977!).

Fagus orientalis: GEORGIA: Caucasus, Georgia, districtus Lagodekhi, in valle fluvii Lagodekhis–zkhali, alt. 1300 m. 19.06.1971, E. E. Gogina, (E00401536!). GREECE: Chalkidiki, NO Polygyros, 18.05.2019, Krautfluren in Eichenwald, 866 m, GK 17.05.77, 40° 24' 21''N 23° 29' 00'' E, Leg. E. & R. Willing, Det. E. Willing. (B 10 1086562!). IRAN: Mazanderan, Elburz Mts., Golban Forest Mixed deciduous forest of *Quercus*, *Fagus*, *Carpinus*, etc., 1200 m, Coll. David Walton, 31.08.1967, No. 242, (E00400275!). Caucasus magnus: Osetia Borealis, distr.bet", dictum 45 km ad australem et occidentem ab urbe ordzhonikidze, in meridie vici Karmadon. Alt. 2100 m.s.m. 31.07.1987, Det. J. Cuba, (E00401542!). TÜRKİYE: A4 Bartın: Ulus, Arıt yolu, Şahin Köyü üstü, 775 m., Leg. B. Tunçkol 4168, Det. B. Tunçkol, (DUOF7281!). A3 Düzce: Yığılca, Yığılca Bal Üretim Ormanı, 998 m, Leg. E.A. Yıldırım 1081, Det. E.A. Yıldırım, (DUOF9057!). A3 Düzce: Beçiyörükler, Düzce Üniversitesi Konuralp kampüsü, Orman Fakültesinin üst tarafı, 250 m., Leg. M. Bülbül 1172, Det. M. Bülbül, (DUOF5851!). A8 Artvin: Northeast Anatolia; above Murgul; above Damar. Ziyaretçi Dağ. 41° 14' 25.8''N 041° 35' 49.8'' E, 1491 m., Habitat: Degraded vegetation on steep mountain slopes above copper mine, with *Picea orientalis* and *Sorbus aucuparia* codominant species. 27. 09.2005., Leg. B. Güner, S. Knees, M. Gardner, P. Jones, D. Luscombe, S. Çelik, İ. Güner, G. Eksi, B. Kusoglu, (E00210447!). ENET Coll. No. 57, 25.09.2008, 40° 51' 59''N 40° 56' 34'' E, 1562 m, Kackar Mountains to ENET WP5 1 km north of Cat Village Margin of *Picea orientalis* woodland, (E00318857!). Kastamonu: Ilgaz Dag, 5000 ft., co–dom. With *Abies*, Davis 21724 A, 09.06.1954, Det. F. Yaltrık, 1964, (E00401501!). A6 Samsun: Borabay, 1000 m, Scrub, and pine. Bushy tree. 31.07.1967, Tobey 2292, 09.06.1954, (E00401543!). Adana distr., bahçe (Amanus), Dildil Dğ between Gökçayır & Atlık yayla, Ira with *Carpinus orientalis*, *Buxus sempervirens* & some *Abies cilicica*, Coll. P. H. Davis, 16443, 26.08.1949, Det. F. Yaltrık, 1964, (E00401552!). Türkiye, Eskişehir, Türkmenbaba dağ, Kalabak deresi, 12.06.1971, 1400–1600 m, Leg. T. Ekim 489, Det. T. Ekim, (E00401533!).

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