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An ecological and syntaxonomical overview of *Castanea sativa* and a new association in Turkey

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Abstract: *Castanea sativa Mill. is thought to be originated from Turkey. It is an important deciduous angiosperm with edible fruits and valuable wood. It has a wide distribution from east Black sea to Marmara and Aegean Regions. Because of its wide distribution, C. sativa grows on different ecological, geological, climatic and edaphic condition and these results in different associations with different companion species evaluated in different upper units. In this paper, the status of Turkish C. sativa forests, their ecological and syntaxonomical characteristics were overviewed. The C. sativa associations described so far and a new one from Black Sea region were grouped in various alliances of two distinct classes, Querco-Fagetea and Quercetea pubescentis.*

Key words: *Castanea sativa, Ecology, Synecology*
PDF of full length paper is available online
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Introduction

Castanea sativa Mill. is the only natural species of the genus *Castanea* in Europe and Turkey. It is distributed over Western and Eastern Europe (Jalas and Suominen, 1989; Urbizs and Urbizs, 2007). In Turkey *C. sativa* has a distribution from East Black sea to Mediterranean region. There are striking climatic differences between these two main areas, particularly in precipitation. Gradual transition and vegetation intrusion between these regions is obvious in Western Black Sea region where it meets Mediterranean area forming an ecotone (Davis, 1965-1978).

The genus *Castanea* has been thought to have originated from Asia, in Tertiary period. Its eastward migration gave rise to the American chestnut *C. dentate* (Marsch.) Borkh, while westward migration resulted in the European chestnut *C. sativa* (Zohary and Hopf, 1988).

C. sativa was confined towards the southern parts of Europe where it survived as patches in glacial refugia in the Northern part of Mediterranean basin, like most other European tree species in the latest glacial era (Pitte, 1986; Bennet *et al.,* 1991; Aira-Rodriguez and Ramil Rego, 1995; Hewitt, 1996; Taberlet *et al*., 1998; Fineschi *et al*., 2000; Konstantinidis *et al*., 2008). These *C. sativa* patches formed the sources for the distribution of the species in central Europe and elsewhere during the years followed the glacial age (Dimoulas 1986). Krebs *et al.* (2004) distinguished six regions where *C. sativa* survived in refuges during glaciation; areas to the south of Black Sea, southern and middle Italy, north-eastern Italy, northern parts of Iberian Peninsula, southern Greece and north-western part of Syria.

The actual distribution of *C. sativa* is largely affected by human activities especially during the Roman times (Zoller, 1960; Zohary and Hopf, 1988; Martin *et al.,* 2007), but it has adapted well in most areas where it was introduced and it exhibited similar behaviour in terms of reproduction and it responsed to disturbance to the native species (Horvat *et al.,* 1974).

The contemporary European populations of *C. sativa* originated from the region of eastern Turkey. Also the region of western Turkey is considered to be the centre of domestication (Pigluicci *et al.,* 1990; Villani *et al.,* 1991,1994,1999; Oosterbaan, 1998; Seemann *et al.,* 2001). Because of its complex biogeographical position and the consideration of Turkey as a centre of origin, Turkey is drawn attention about *C. sativa.*

C. sativa is an important deciduous forest species in Mediterranean basin due to its edible fruits and the good quality timber. As a result of both ecological and socio-economical reasons, *C. sativa* forests in Europe are under the influence of human impact.

C. sativa is a monoecious and deciduous tree grows up to the length of 40 m and the diameter of 150 cm (Fernández-López and Alía, 2003). All the species of *Castanea* genus have the same somatic chromosome number; 2n=24 (Jaynes,1963). In general, it is distributed over the areas where the mean annual precipitation is higher than 600 mm without a drought season or with a drought season shorter than 3 months. It prefers the slightly acidic soils (pH 4.5-6.5) (Urbizs and Urbizs, 2007). If the ground water level is too high *C. sativa* does not grow well (Bourgeois, 1992, Oosterbaan 1998). Also this species does not prefer the areas where the risk of late spring frost is high (Oosterbaan, 1998; Konstantinidis *et al.,* 2008). *C. sativa* blooms most often in July. Fruits start ripening from September till October or November. It is an anemophilous species but sometimes can be pollinated by insects.

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Table - 1: Characteristic species under Smilaco-castanetum association

Quadrate no.	132	120	119	193	160	118	123	192	195	116	117	191	66	115	113	162	65	114	194	126	
Altitude (m)	200	200	150	300	200	150	150	450	150	400	350	450	250	450	150	350	200	450	300	300	
Quadrate size (m^2)	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	Presence
Inclination (°)	20	30	20	20	30	20	20	10	30	20	20	10	30	20	20	20	30	20	20	30	
Exposition	SE	W	NW	E	NW	W	NW	E	W	NE	E	NE	NE	NW	NE	NE	S	E	E	NE	
Coverage (Trees) (%)	70	80	70	70	80	80	80	85	80	85	85	85	85	90	90	90	85	90	90	90	
Coverage (Shrub) (%)	50	30	50	50	50	40	50	30	30	50	30	30	30	30	40	50	50	30	50	50	
Coverage (herbs) (%)	20	20	20	20	20	15	20	20	20	15	20	20	20	20	15	15	10	20	10	10	
Mother rock (C: Calcareous, M: Marl)																					
Characteristic and differential species of the association																					
Castanea sativa	45	44	44	45	45	45	45	44	45	44	45	45	45	45	44	45	55	45	55	55	V
Smilax excelsa	11	11	21	11	.	21	11	23	21	23	11	.	21	11	11	11	23	21	23	23	V
Hedera colchica	.	.	.	.	+1	.	.	.	11	.	.	.	.	.	.	.	21	.	.	21	I
Characteristic species of Rhododendro-Fagetalia orientalis																					
Rhododendron ponticum	21	32	33	23	.	.	33	.	.	32	.	22	22	.	32	.	33	.	34	34	III
Trachystemon orientale	+1	+1	.	11	11	.	.	21	11	.	+1	+1	.	11	.	.	21	21	.	11	III
Ilex colchica	+1	+1	11	.	.	+1	+1	.	.	+1	.	.	11	.	+1	.	22	.	22	.	III
Rhododendron luteum	.	.	.	22	23	.	.	23	22	.	22	.	.	22	.	23	22	.	22	33	III
Vaccinium arctostophyllos	+	.	12	.	11	.	12	12	.	.	.	12	11	.	.	12	.	22	.	.	III
Rubus hirtus	+1	+	+1	.	.	+	.	.	+1	+	+1	.	.	.	11	.	.	.	.	.	II
Daphne pontica	.	12	.	11	.	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	I
Fagus orientalis	.	.	+	.	22	.	.	.	.	.	.	.	.	.	.	22	.	.	.	.	I
Ruscus hypoglossum	+1	.	.	.	.	.	.	.	.	.	.	12	.	.	.	.	.	.	.	.	I
Hypericum calycinum	.	.	.	.	+1	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Carpinus betulus	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Quercus petraea subsp. iberica	.	.	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Characteristic species of Querco-fagetea and fageralia sylvaticae																					
Sanicula europaea	+1	.	+1	.	.	.	.	.	.	.	+1	.	.	.	+	.	.	11	.	.	II
Veronica officinalis	.	+1	.	.	.	.	+1	.	.	.	.	.	+1	11	.	.	.	.	.	.	I
Mycelis muralis	.	.	11	+1	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
[X] *Neottia nidus-avis*	+	.	.	+	++	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Characteristics of Querco-carpinetalia and Carpino-acerion[X]																					
[X] *Cornus sanguinea subsp. australis*	+	.	+	.	.	.	+	.	.	12	+	+	.	.	12	+	.	.	.	.	II
[X] *Helleborus orientalis*	.	11	.	.	.	.	.	.	.	+1	.	.	.	+	.	.	.	.	11	.	I
Laurocerasus officinalis	22	.	.	.	.	22	.	.	.	.	.	.	.	23	.	.	.	.	.	.	I
Dorycnium pentaphyllum	+1	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

Characteristics of Quercetea pubescentis																						
Coronilla varia	.	.	+1	.	.	.	.	.	.	.	.	+1	.	.	.	+1	.	.	.	.	I
Cornus mas	.	.	.	.	.	.	.	.	.	.	.	.	.	+1	.	.	.	.	.	.	I
Ligustrum vulgare	.	.	.	.	.	.	.	.	.	.	12	.	.	.	.	.	.	.	.	.	I
Characteristics of superclass Querco-fagea																						
Hedera helix	11	+1	.	+1	.	.	.	12	.	.	.	+1	11	12	.	.	.	+1	11	.	III
Euphorbia amygdaloides	+1	.	+1	.	.	+1	.	.	.	.	.	+1	.	+1	.	+1	.	.	.	.	II
Primula vulgaris subsp. *sibthorpii*	.	12	.	+1	.	+1	.	.	.	+1	.	.	+1	.	11	.	.	.	.	.	II
Fragaria vesca	.	+1	.	.	+1	+1	.	.	+1	.	+1	.	.	.	.	.	.	.	.	.	II
Tamus communis	21	.	11	.	11	.	.	12	.	.	.	.	.	.	.	.	.	21	.	.	I
Lapsana communis subsp. *intermedia*	.	.	.	.	.	.	+1	.	+1	.	+1	.	.	.	.	.	.	.	.	.	I
Geranium robertianum	.	+1	.	.	.	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	I
Corylus avellana	.	.	.	+1	.	.	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	I
Poa nemoralis	11	.	.	11	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Clinopodium vulgare	.	.	.	.	.	.	.	.	.	+1	.	.	.	.	.	.	.	.	.	.	I
Luzula forsteri	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Characteristics of Quercetea-ilicis																						
Asplenium adianthum-nigrum	.	11	.	.	.	.	.	.	.	11	.	.	.	.	.	.	.	.	.	.	I
Companions																						
Pteridium aquilinum	11	.	.	11	11	12	11	+1	11	11	+1	11	12	.	12	.	.	11	.	.	IV
Rubus discolor	.	+	.	.	+	+	12	+1	.	.	.	+	12	.	.	.	.	.	.	.	II
Rosa canina	.	.	.	.	.	+	+	+1	.	.	.	.	.	.	.	.	.	.	.	.	I
Hypericum perforatum	+1	+1	.	.	.	+1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I

The numbers given in table indicate the cover-abundance value for each species

Table - 2: Physical and chemical characteristics of soil under smilaco-castanetum association

Physical properties										
Depth (cm)	**$CaCO_3$ (%)**	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Texture**	**Humidity (%)**	**Saturation (%)**	**Field capacity (%) 1/3 atm**	**Wilting point (%) 1/5 atm**	**Available water (%)**
0-30	0.0	40.57	17.47	41.96	clay	5.06	72.31	39.71	27.63	12.08

Chemical properties													
pH	**EC (mmhos cm^{-1})**	**C/N**	**Organic matter (%)**	**Total Carbon (%)**	**Total Nitrogen (%)**	**Soluble cations (meq l^{-1})**			**Exchangeable cations (meq 100 g^{-1})**			**CEC (meq 100g^{-1})**	**NO_3 (ppm)**
						Na	**K**	**Ca+Mg**	**Na**	**K**	**Ca+Mg**		
5.4	0.363	6.97	6.21	3.611	0.518	0.07	0.167	2.60	0.236	0.498	12.27	49.68	3.5

Turkey has 21188 million ha of forest area in total. About 42% of this area is covered with coniferous, 53.3% is covered with broad leaved forests and 4.5% is covered with mix forests of both coniferous and broad-leaved species (Ministry of Environment and Forestry, General Directorate of Forestry, www.ogm.gov.tr). Chestnut forests comprise about 0.1% of this area (Mayer and Aksoy, 1986).

In this study, the ecological and phytosociological status of *C. sativa* forests in Turkey was revisited and a new syntax from Northwest of Turkey was described.

Materials and Methods

In this study all the ecological and syntaxonomical studies of *C. sativa* were scanned and it was aimed to review the ecology and syntaxonomy of this species in Turkey. Also a new association from Inebolu-Cide area in the north-west part of Black Sea region of Turkey was defined by using the method of Braun-Blanquet (1964). The numbers given in Table 1 indicate the cover-abundance value for each species. The association was named after the International Code of Phytosociological Nomenclature (ICPN; Weber *et al.,* 2000). Vascular plants were identified using Flora of Turkey and East Aegean Islands (Davis, 1965-1978). The soil samples belonging to the distribution area of the association were physically and chemically analyzed. The physical analysis and their methods were as follows; texture-Bouyoucos hydrometer method; saturation according to Richards (1954); field capacity-universal centrifuge and wilting point-pressure membrane extractor; humidity (by calculation as percentage of stable weight of air dried soil at 105±1 ^{o}C). The chemical analyses were pH (determined by using Beckman expanded scale pH meter), $CaCO_3$ (measured with Scheibler calcimeter), total nitrogen amount (Kjeldahl method), organic matter and total carbon (Walkley-Black method), EC (conductivy meter), soluble cations and cation exchange capacity (Na acetate method with Beckman flame photometer) and exchangeable cations (ammonium acetate method with Beckman flame photometer), NO_3 (colorimertically with nitrophenoldisulphonite method).

The climatic data were obtained from Akman's work (1999). The temperatures of Cide station are enterpolated data due to the fact that there are only precipitation measurements for this station.

The newly described association from Inebolu-Cide region grows at the altitude from 10 to 64 m. The annual precipitation at Inebolu which is under the influence of Mediterranean climate is 976.3 mm and at Cide which is under the influence of Oceanic climate is 1176.9 mm. Annual mean temperature at Inebolu and Cide is 13.1^{o}C and 14.9^{o}C, respectively. The mean minimum and maximum temperatures of the stations Inebolu and Cide are 2.1^{o}C and 3.5^{o}C; 25.8^{o}C and 27.6^{o}C, respectively. Although these two close stations are in the same geographical region, Cide is under the influence of humid air mass because of its geographical position. For this reason, it rains throughout the year without an arid period and the precipitation regime type is oceanic.

Results and Discussion

Syntaxonomical overview of *C. sativa* in Turkey: *C. sativa* forests have a wide distribution from East Black sea to Marmara and Aegean regions in Turkey. As a result of these changing ecological, geological, geographical and climatic conditions, different species accompany *C. sativa* forests which lead to the formations of different associations. There are five associations. Most of them belong to order Rhododendro-Fagetalia orientalis (Quezel *et al.,* 1980) of the class Querco-Fagetea Br.-Bl and Vlieger, 1937 in Vlieger, 1937. Fago-Castanetum sativa (Kutbay and Kilinc 1995) described from Samsun is directly included in the order. Campanulo alliariifolia-Castanetum sativae (Quezel *et al.*, 1980) belongs to the alliance Castaneo sativa-Carpinion orientalis Quezel. The Campanulo alliariifolia-Castanetum sativae (Quezel *et al.* , 1980) association has a distribution between Unye and Trabzon and it is known as the most eastward chestnut forest in Turkey. The geographical distributions of the remaining associations are close. These and their distributions are the following: Castanea sativa-Sophora jaubertii (Quezel *et al.*, 1980) from Cide; Hedero-Castaneetum sativa (Yurdakulol *et al.*, 2002) from Abana and Smilaco-Castanetum sativae ass. nova from the region between Cide and Inebolu (Table 1). There is also an association belonging to the Querco cerridis-Carpinetalia orientalis (Quezel *et al.*, 1980) order of the class Quercetea pubescentis (Doing-Kraft, 1955) Scamoni and Passarge, 1959. But the alliance to which the Osmundo regali-Castanetum sativae (Ozel, 1999) was attached is not certain. It was not only attached to Quercion frainetto Horvat, 1954 but also Carpino betuli-Acerion hyrcani (Quezel *et al.,* 1980; Ozel, 1999) in the same text. Also an association of *C. sativa* with *Quercus pubescens*, which was named as Querco pubescenti-Castanetum sativae, was presented as a proceeding of a congress and can be evaluated in Querco-Fagetea (Kargioglu, 1988).

Smilaco-Castanetum sativae ass. nova spreads on the schistous and some other type of soils derived from andezite main rocks. This association prefers sandy-loamy soils. The soil does not contain $CaCO_3$ and give an acidic reaction with the pH 5.4. The physical and chemical characteristics of the soils on which the association occurs are given in Table 2. The tree coverage varies between 70-90%. Its floristic composition is not so rich and its structure is composed of tree, shrub and herb layers. While the *C. sativa* is the dominant species in the community, in some sites *Fagus orientalis* accompanies as co-dominant species. The height of shrub layer reaches to 5 m. and the coverage rises to 50%, the major shrubs in this layer are; *Rhododendron ponticum, R. luteum, Cornus sanguinea* subsp. *australis, Vaccinium arctostophyllos, Carpinus betulus, Laurocerasus officinalis, Cornus mas, Rubus hirtus, R. discolor, Rosa canina, Corylus avellana and Quercus petrea* subsp. *iberica*. The height of herbs is 50 cm and the coverage is about 10-20%. *Smilax excelsa* and *Hedera colchica* are the regional diagnostic species of the association.

The association is considered in the alliance Castaneo sativa-Carpinion orientalis of the order Rhododendro-Fagetalia orientalis. Holotype releve no: 195. (Table 1).

Syntaxonomical synopsis:

Class: Ouerco-Fagetea Br.-Bl et Vlieger 1937 (Vlieger, 1937)
- Order: Rhododendro-Fagetalia orientalis Quezel *et al.,* 1980
  - Ass. Castanea sativa-Sophora jaubertii Quezel *et al.,*1980
  - Ass. Fago-Castanetum sativa Kutbay and Kilinc 1995
  - Alliance: Castaneo sativa-Carpinion orientalis Quezel *et al.,*1980
  - Ass. Campanulo alliariifolia-Castanetum sativae Quezel *et al.,*1980
  - Ass. Hedero-Castanetum sativa Yurdakulol *et al.,*2002
  - Ass. Smilaco-Castanetum sativae ass. nova

Class: Quercetea pubescentis (Doing-Kraft 1955) Scamoni et Passarge 1959
- Order: Querco cerridis-Carpinetalia orientalis Quezel *et al.,*1980
- Alliance: Carpino betuli-Acerion hyrcani Quezel *et al.,*1980

OR

- Alliance: Quercion frainetto Horvat, 1974
- Ass. Osmundo regali-Castanetum sativae Ozel, 1999

In this paper the ecological and phytosociological works on the chestnut forest are compiled and reviewed. In the taxonomical classification and denomination of *C. sativa* forests, the transition between semi-natural forest ecosystems and artificially managed woodland formations causes some difficulties because of the anthropogenic impact on them (Konstantinidis *et al.,* 2008). Due to the lack of management, *C. sativa* forests appear to be reverting towards other deciduous forest types (Horvat *et al.,* 1974). Due to this instability, some ecologists have suggested that *C. sativa* ecosystems should not be classified below the level of association (Raus, 1980; Bergmeier, 1990; Korakis and Athanasiadis, 2003). Furthermore Horvat *et al.* (1974) have suggested that *C. sativa* does not include other characteristic species, apart from those of the acidic soils in the areas of sites where the communities occur. Currently many researchers using modern techniques have advanced the classification of *C. sativa* at the level of association and subassociaiton, providing significant information on the ecology and distribution of its communities (Konstantinidis *et al.,* 2008).

In the absence of cultural inputs, chestnut woods tend to be invaded by other trees giving way to evolutionary dynamics toward climax forests as observed in European regions in recent decades (Arnaud *et al.,* 1997; Conedera *et al.,* 2000; Conedera *et al.,* 2001, 2004; Maltoni and Paci, 2001; Krebs *et al.*, 2004). Because the increasing of human impact and invasion of them with other species make the *C. sativa* forests more vulnerable and they need special management. These forests have an important situation in Turkey, because the genetic origin of the species in Turkey and these forests occupy wide areas in Turkey, but the studies on its ecology and syntaxonomy are very little.

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