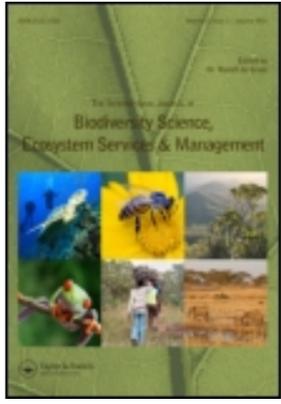


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***Centaurea* species in Turkey (A): *Centaurea odyssei* Wagenitz (Asteraceae) in Kazdagi (Mt. Ida) National Park**

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Key words: *Centaurea odyssei*, Kazdagi, morphology, anatomy, autoecology, palynology

SUMMARY

Kazdagi (Mt. Ida: 1774 m) is in northwestern Turkey. The rock type is mainly schist, and the soil is brown forest soil without lime. For these reasons, Kazdagi is one of the most important floristic areas in Turkey. With regard to genetic resources, this area is of major importance for in situ conservation of plant genetic diversity. *Centaurea odyssei* Wagenitz is a threatened very local endemic species, growing only in three small areas on Kazdagi. These populations are under heavy grazing stress. Morphological, anatomical and palynological studies are described and autecological and conservation aspects of the species are discussed.

INTRODUCTION

The impact of humans on natural ecosystems has resulted in the development of a new suite of rare species that were previously more abundant but are now rare because of human disturbances. Understanding the difference between natural and induced rarity is important for focusing conservation efforts (Rabinowitz *et al.* 1986; de Lange and Norton 1998). One of the most important criteria used in the identification of high-priority areas for conservation is endemism (Olson and Dinerstein 1998; Mittermeier *et al.* 1998; WWF and IUCN 1994–1997).

Turkey has an extremely rich flora due to its geographical location, ecological characteristics, paleogeography and vegetation history. Although Turkey has one fifteenth of Europe's land area, it has a disproportionate number of endemic species.

European countries other than Turkey possess 12,000 species, of which 2750 are endemic, while Turkey has an estimated 9000 species, of which 30% are endemic (Taskin 2000; Ekim *et al.* 2000).

The genus *Centaurea* is the third largest genus, after *Astragalus* and *Verbascum*, in Turkey, represented by 187 taxa, of which 114 are endemic (endemism ratio: 60.9%) (Wagenitz 1975; Davis *et al.* 1988; Wagenitz *et al.* 1988; Güner *et al.* 2000; Duran and Duman, 2002; Turkoglu *et al.* 2003). The high endemism ratio shows that Turkey is one of the gene centres of the genus. *C. odyssei* has a distribution in a very local area on Kazdagi (Kazdagi mountain: Mount Ida) in northwestern Anatolia. This mountain forms a natural border between the Marmara and Aegean regions of Turkey. These areas are also phytogeographically at the transition

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zone of the Euro-Siberian and Mediterranean regions (Gemici *et al.* 1998). The summit of Kazdagi is 1774 m high. It is part of a large massif to the north of the Edremit Gulf, on the borders of Balikesir and Canakkale in the southeast of the Biga Peninsula. Kazdagi National Park was established on 17 April 1993 as the 93/4243 decision of the Council of Ministers (Kelkit *et al.* 2004). It has an area of 21.643 ha of which the National Park is made up of 19.781 ha of forest and 1682 ha of open space. Approximately 800 vascular plant taxa belonging to 101 families have been found in Kazdagi National Park. Risk groups of endemic and rare species, determined according to IUCN (1994) have been published by Gemici *et al.* (1993).

According to Wagenitz (1975), this area is a special region in the Euxine province (Canakkale or Mysia.). Gemici *et al.* (1998) reported that the plant communities found in Kazdagi mountain are as follows: forest vegetation (*Pinus brutia* community, *Pinus nigra* ssp. *pallasiana* community, *Abies nordmanniana* ssp. *equi-trojani* community, *Fagus orientalis* community, *Carpinus betulus* community), shrub vegetation (*Phillyrea latifolia* community, *Quercus infectoria* ssp. *boissieri* community) and high mountain vegetation (*Juniperus communis* ssp. *nana* community, *Astragalus idea* community, *Saxifraga sancta* community and *Narduss stricta* community). The present study addresses the morphology, anatomy, palynology and seed structure of *C. odyssei* and its autoecological features and discusses conservation methods.

MATERIAL AND METHODS

Plant specimens belonging to *C. odyssei* and neighbouring species were collected from three known localities on Kazdagi. The plant specimens were identified according to Wagenitz, (1975) and are kept in the Biology Department at Çanakkale Onsekiz Mart University. The morphological observations and biometric measurements were made on fresh as well as herbarium specimens. A total of 30 measurements were evaluated statistically. In conservation biology studies, the relationships between *C. odyssei* and the other species were evaluated.

For palynological studies, pollen grains were obtained from dried herbarium specimens. Several unopened buds (to make sure alien pollen grains were not present) were placed on a watch glass and

squashed, adding a few drops of wetting agent. The pollen grains were transferred to copper stubs, which were already prepared with double-sided adhesive tape, and then stubs were coated with gold for 5–6 minutes for studying and taking pictures with a scanning electron microscope (SEM). A jeol 100 × CXII scanning electron microscope was used in the study. The terminology used is mainly that of Punt *et al.* (1994).

In the present study of the anatomy of the root, stem and leaf, the wax-embedding procedure was followed. Plant parts were first fixed by using formalin/acetic alcohol (FAA) (Cutler 1978, Menemen and Jury 2001). The samples were passed through an alcohol and histoclear series for dehydration. Paraplast was added to the histoclear and the samples placed in an oven. Transverse sections of root, stem and leaf were taken with the help of a rotary microtome at 7 µm thickness and stained with safranin and crystal violet. Investigations were carried out under a light microscope and photographs taken with a microphotography apparatus (JENA).

Soil specimens (depth 0–30 cm) were collected from the area where the plant specimens were obtained and brought into the laboratory for analysis (Table 1). The analyses were carried out according to Walkley and Black (1934), Jackson (1962), Chapman and Pratt (1961), Bouyoucos (1962) and Olsen and Sommers (1982).

RESULTS

Morphological characteristics

Perennial, 8–25 cm, profusely branched woody rootstock with numerous sterile and fertile shoots forming a loose cushion, stems erect, simple, densely foliate. Leaves adpressed grey-tomentose, basal and lower entire or mostly pinnatifid with 2–3 pairs of short segments, median and upper similar or pinnatilobate to dentate, sessile and shortly decurrent, segments (lobes) ending in a yellow 2–10 mm spinule. Involucre 20–22 × c.13 mm, nearly cylindrical, arachnoid-floccose. Appendages a 10–20 mm spine, with (1-) 2–4 pairs of lateral 3–5 mm spinules near the base. Flowers yellow, marginal not radiant. Pappus 5–6 mm, inner row 1 mm. In addition to macromorphology of the species, micromorphology of the achene was studied. The SEM study showed that the achene

surface is strongly depressed, glabrous, and cells form a reticulate structure with thick wall on dorsal (Figure 1a and b).

Pollen grains

The pollen grain in *C. odyssei* is tricolporate. The detailed features of pollen are as follows: Polar axis (P) 31.81 μm , equatorial axis (E) 22.72 μm , P/E 1.40, prolate; colpi tapering at both ends; spinulose, spinules sparsely distributed, width of the spinules at base (W) 2.00 μm , height of the spinules (H) 1.25 μm , W/H 2.26, very large at base, apices sharp, with basal and subapical distinct perforations, pores irregularly distributed (Figure 2a and b).

Anatomical characteristics

Root anatomy

Centaurea odyssei is a perennial species. A transverse section of the root showed that a disintegrated

periderm is present on the outermost layer as a protective tissue. Below it lies a cortex tissue with flat and thick-walled cells. The cortex occupies a wide arcade up to the endodermis, that is not easily distinguished. Phloem takes up a small proportion of the bundle; xylem with trachea, tracheids and sclerenchymatic cells occupy most of the bundle and distributed all around the pith. Pith rays lie in the cortex with 4–6 cell layers (Figure 3a).

Stem anatomy

The stem has a thick outer cuticle layer, followed by a single layered epidermis which has papilla-like projections and amaryllis-type stomata. Chlorenchymatic tissue with 3–4 layers covers a small area under the epidermis, which has sparsely single aglandular hairs. There are collenchyma and parenchyma cells in the cortex tissue. Vascular bundles are scattered in a circular form, with parenchymatic tissue with phloem on the outer and xylem on the inner sides. The phloem takes up a small proportion of the vascular bundle; xylem with trachea,

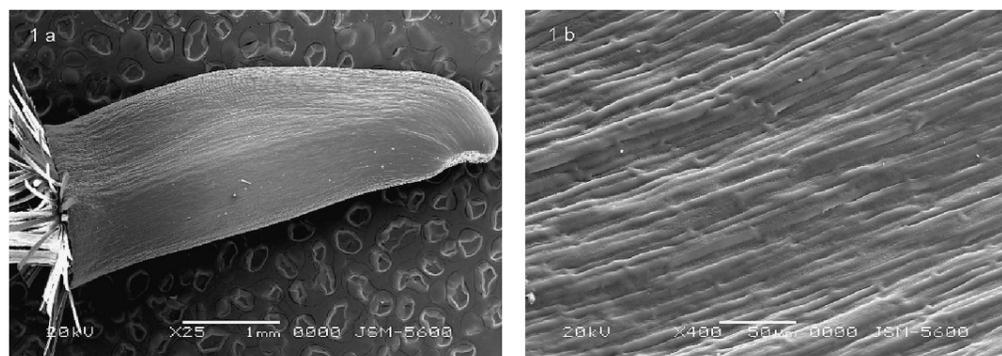


Figure 1 *Centaurea odyssei* achene photographed in SEM. a. General view, b. reticulate surface of the achene on dorsal

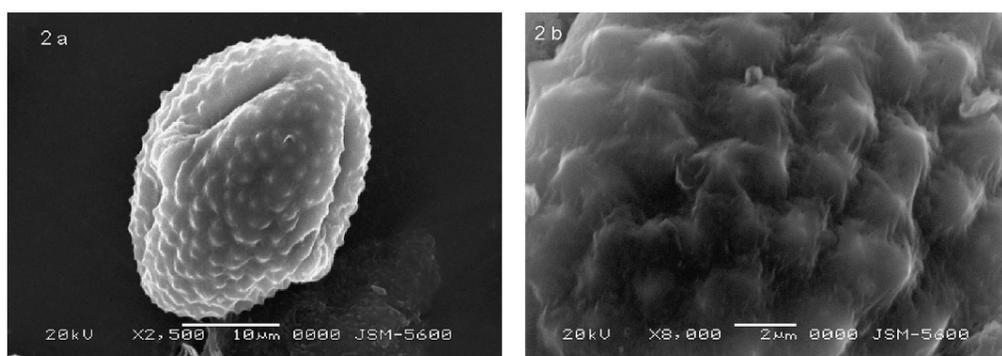


Figure 2 *Centaurea odyssei* pollen grain (SEM) a. General view b. Pollen surface

tracheids and sclerenchymatic cells occupy most of the bundles. Vascular bundles are surrounded by sclerenchymatic tissue. Cambium has 2–3 cell layers. Pith is parenchymatous (Figure 3b).

Leaf anatomy

The leaf is of an equifacial type, in which 2–3 layers of palisade parenchyma are found on both sides of the spongy parenchyma, occupying a small part in the centre. A waxy cuticle lies on the upper side, with a silicified epidermis. Spongy parenchyma occupies a small part and is highly reduced, as in other xerophytes. Mesophytic stomata are located on both upper and lower surfaces of the leaf. The largest bundle is present in the midvein. The bundle sheath has a single parenchymatic cell layer. The leaf is of an amphistomatic type and covered with adpressed grey-tomentose hairs (Figure 3c).

Ecology and conservation

Kazdagi is one of Turkey's most important floristic areas and is of major importance for the in situ

conservation of plant genetic diversity. In the present study, information about the habitat, demography and biological relationships of the species are presented with the aim of building up effective conservation programmes.

C. odyssei populations are located at altitudes from 1530 m to 1700 m. Population I grows at 1583 m (39°42'46" N, 26°49'52"E) on the north slopes of 60° inclination with 60% coverage, over an area of 350 m². Population II is found at 1650 m (39°42'33"N, 26°49'59"E) on the southwest slopes of 60° inclination, with 30% coverage in a 500 m² area. Population III is on the same side as population II at 1716 m (39°42'24"N, 26°50'31"E) on a slope of 30° with 20% coverage over a 300 m² area (Braun-Blaunquet 1973; Akman *et al.* 2001) (Figure 4).

According to Esginler (2004), in three neighbouring areas, the annual average temperature is 14.8°C and the annual average rainfall is 1500 mm. The mountain has a mediterranean rainfall regime (Akman 1990). Koçman (1993) reported that it is in the Marmara transition rainfall regime. Although the main mass in the mountain is a paleozoic schist,

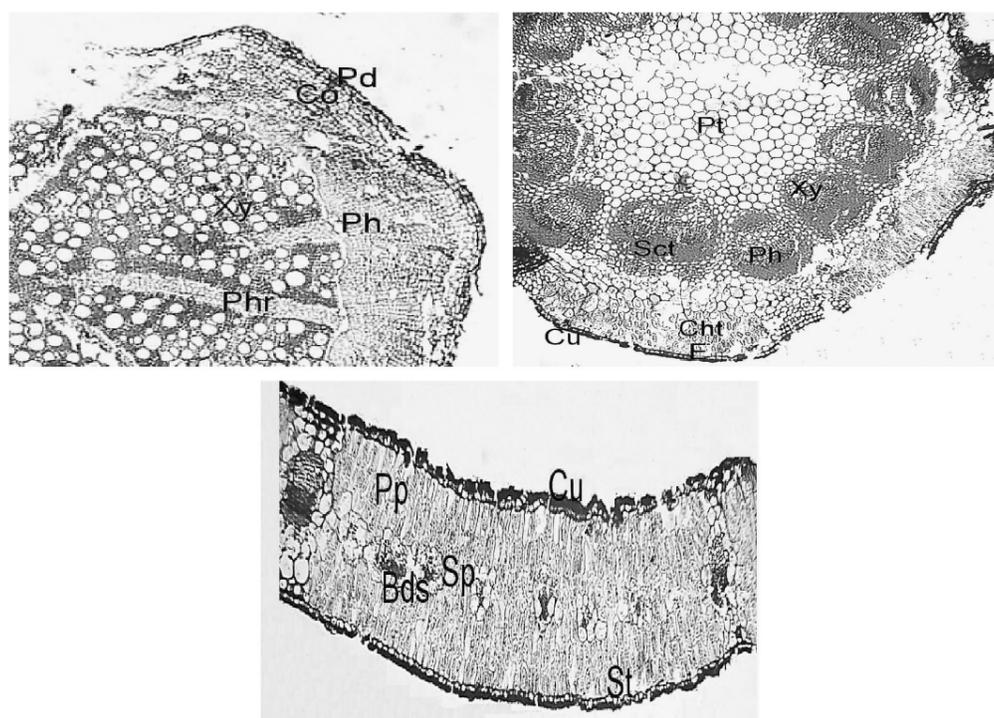


Figure 3 *Centaurea odyssei* a. Transverse section of root. (10 × 5). b. Transverse section of stem (10 × 5). c. Transverse section of leaf (10 × 6.3) (Bds: Bundle sheath Co: Cortex, Xy: Xylem, Ph: Phloem, Pd: Periderm, Pt: Pith Cu: Cuticle, Cl: Chlorenchyma, Cht: Chlorenchymatic tissue, E: Epidermis, Pp: Palisade parenchyma, Phr: Pith ray Sp: Spongy parenchyma, St: Stomata, Sct: Sclerenchymatic tissue)

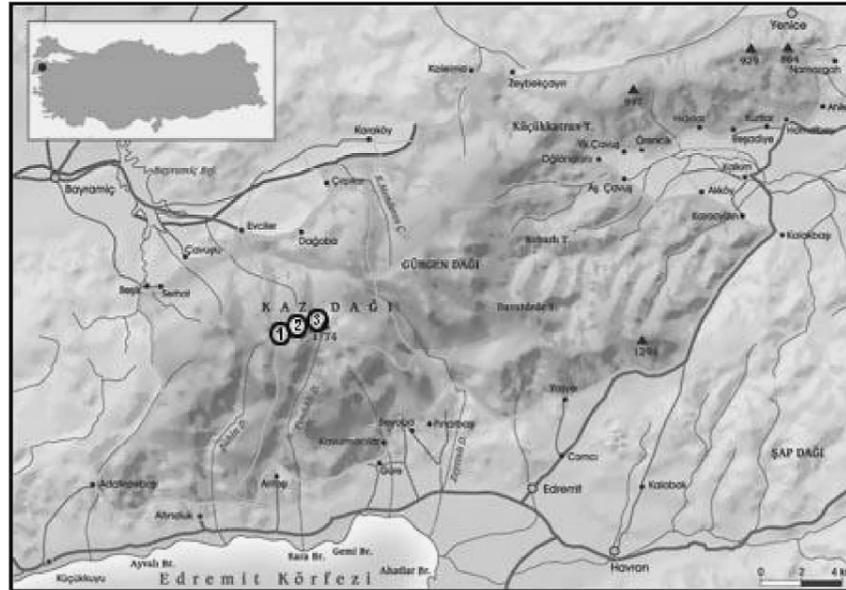


Figure 4 Areas of *Centaurea odyssei* populations (1,2,3)

there are crystalline calcareous regions around the summit and marble, gneiss and tufa structures at various locations (Gemici *et al.* 1998). *C. odyssei* grows on the calcareous main mass. The soil in calcareous areas is moderately basic. The soil in which *C. odyssei* grows is rich in CaCO_3 and organic matter, but poor in nitrogen (Table 1). In the distribution areas of *C. odyssei* Mg^{++} and K^+ ions are at normal levels, but Na^+ ions are below the limits.

The population of a plant, variations in its morphology, and number of seeds produced are mostly affected by genetic changes during time, existence of predators and ecological factors (Shamsi and Whitehead 1974; Weihe and Neely 1997; Stevens *et al.* 1997; Edwards *et al.* 1999; Corcket *et al.* 2002). *C. odyssei* is a semi-dominant species in the three areas and associated with endemic plants such as *Allium kurtzianum* Asch. & Sint. ex F. Kollmann, *Matthiola montana* Boiss., *Astragalus heldreichii* Boiss., *Astragalus idae* Sirjaev, *Muscari bourgaei* Baker, *Sideritis trojana* Bornm., *Linum boissieri* Asch. & Sint. Ex Bornm., *Asperula sintenisii* Asch. ex Bornm., *Veronica caespitosa* Boiss. var. *caespitosa*, *Veronica elmaliensis* M. A. Fischer. Non-endemic plants include *Aethionema iberideum* Boiss., *Alyssum minutum* Schlecht ex DC., *Aubrietia deltoidea* DC., *Draba brunifolia* Stev. ssp. *olympica* Sibth. ex DC.) Coode & Cullen, *Arenaria serpyllifolia* L., *Paronychia sintenisii* Chaudhri, *Sedum magellense* Ten., *Onobrychis montana* DC. ssp. *cadmea* Boiss.)

Table 1 Soil Analysis of *C. odyssei* Populations (0-30 cm)

	Pop. I	Pop. II	Pop. III
pH	7.60	7.80	7.90
CaCO_3 %total	5.75	5.82	5.15
Organic Mat. %	4.90	4.20	3.80
P_2O_5 %	75	45	29
N %	0.95	0.55	0.40
Ca^{++} ppm	9750	8500	7250
Mg^{++} ppm	1250	1110	950
K ⁺ ppm	7000	6000	4500
Na^+ ppm	35	40	20

P.W. Ball, *Bromus riparius* Rehm., *Dactylis glomerata* L. ssp. *hispanica* (Roth) Nym., *Festuca callieri* (Hackel) Margr. ssp. *callieri*, *Koeleria cristata* Pers., *Poa alpina* L. ssp. *fallax* F. Hermann, *Potentilla rupestris* L., *Saxifraga sibirica* L. ssp. *mollis* (Sm.) Matthews, *Daphne oleoides* Schreb. ssp. *oleoides*, *Cystopteris fragilis* (L.) Benth. and the very local non-endemic *Saxifraga sancta* Gris.

C. odyssei is included by Ekim *et al.* (2000) in the endangered (EN) category of IUCN (1994). This means that the species is at high risk and could be extinct in the near future. The greatest danger is heavy grazing. Ecotourism and forest roads are also becoming a serious danger for the populations. Small livestock are the only livelihood for local farmers because of the steep slopes, and many goats

graze in the area. Although the area has been officially declared as being a national park, the area belonging to Çanakkale province has not been included within the border of the park. It was estimated that the number of goats in the area is between 800 and 1500 m. These small animals feed especially on the basal leaves of *C. odyssei*, but while feeding they damage the young capitula and so decrease seed production.

DISCUSSION

Insular, mountains or isolated edaphic systems (ultrabasic rocks, gypsum, limestone, etc.) generally appear to be major endemic centres (Favarger 1972). The impact of humans on natural ecosystems has resulted in the formation of a new suite of rare species that were previously more abundant but are now rare because of human and animal disturbances. In many rare species classifications, including the Red Book listings of the IUCN (Ekim *et al.* 2000), *Centaurea odyssei* is a perennial endemic species, with anatomical features similar to *C. polyclada* (Uysal *et al.* 2005). The importance of leaf anatomy in *Centaurea derderifolia* and *Centaurea saligna* was reported by Kaya (1987).

The ecological characteristics of the species are in full agreement with its anatomical behaviour. Silica dominance in the soil of surrounding areas makes the habitat of *C. odyssei* very local. As a result of chemical analyses of the soil, it was found to be rich in CaCO₃ and organic matter content, but poor in nitrogen and sodium, and with a normal level of calcium. *C. odyssei* might be thought of as an indicator species for calcareous soils.

Observations showed that *C. odyssei* is very tolerant of cold temperatures, but very sensitive to drought. Another aspect which might affect the

survival of the species in the area is gene flow amongst the three populations. Ehrlich and Raven (1969) stated that, in insect-pollinated plants, the distance to isolate two populations of the same species varies from 15 m to a couple of kilometers. The distance between *C. odyssei* populations is about 500 m, which might have caused limited or complete isolation between the populations. Much more detailed studies on the effects of wind and ants in dispersal of the seeds of *C. odyssei* over a long period are needed.

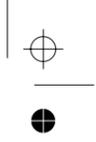
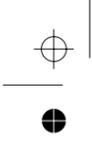
To complete *in situ* activities, a few seeds were collected from the three populations and preserved in the Biology Department of Çanakkale Onsekiz Mart University. Studies of the germination of the seeds and vegetative propagation are still going on. A technique for producing this species might help in saving other natural populations under a variety of stresses and in propagation of desired plants. During the flowering and fruiting season (June–August), the area is visited by groups of 40–50 people for trekking and ecotourism. Population I is only 50 m from a picnic area on one of the summits. Visitors collect the attractive flowers of the species without knowing its rarity.

C. odyssei is under a threat of becoming extinct because of its limited distribution area and small population size. Our prolonged observations have shown that this species is under very high threat and its populations are limited to 300–500 m² areas in three localities. Therefore it should be put in the critically endangered category (CR). In addition, conferences and meetings about this and the other rare species of Kazdagi must be organized by local authorities to inform the people. The farmers must be encouraged to feed their animals on the east and south slopes with abundant grass, rather than where the endemic rare plants grow.

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