

Research Article

A new invasive neophyte *Elodea nuttallii* (Planch.) H.St.John for the flora of TürkiyeNeval Güneş Özkan¹, Nihan Koçer² and Necmi Aksoy¹¹Düzce University, Faculty of Forestry & DUOF Herbarium Konuralp, 81620, Düzce/Türkiye²Düzce University, Forestry Vocational School, Department of Forestry, 81620, Düzce/TürkiyeCorresponding author: Neval Güneş Özkan (nevalgunes@duzce.edu.tr)

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Abstract

A new locality of *Elodea nuttallii* (Planch.) H.St.John (Hydrocharitaceae), native to North America, has been recorded for the first time in Göksu Nature Park (Bolu/Türkiye). *Elodea nuttallii* is a potentially invasive macrophyte and often confused with *Elodea canadensis* Michaux, whose existence was previously known in Türkiye. The description, distribution map, notes about the habitat of *Elodea nuttallii*, and the morphological differences between the two taxa are given in this article.

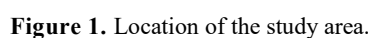
Key words: aquatic, Bolu, Göksu Nature Park, Hydrocharitaceae, neophyte plants, Northwest Türkiye

Introduction

The genus *Elodea* Michaux is one of the 14 genera of the Hydrocharitaceae family and is represented by 9 taxa in the world (COL 2022). It is known that any taxa of this genus do not naturally spread in Türkiye (Uotila 1984; GBIF 2001; Bizimbitkiler 2012; Uludağ et al. 2017; POWO 2017; İkinci 2023).

Elodea nuttallii which is naturally distributed in North America has been introduced into most of the European countries, Crimea, China, Japan, and the Philippines nowadays (Ciocârlan et al. 1998; Chorna et al. 2006; Sârbu et al. 2006; eFloras 2008; Duenas 2010; Kočić et al. 2014; Sato et al. 2014; POWO 2017; Poulis and Zervas 2017; Georgiev et al. 2019; Davydova et al. 2021; Buldrini et al. 2022;).

In Türkiye, the genus *Elodea* was first reported from Edirne in 1982 (Altınayar and Onursal 1982). It can be seen that it has spread to many provinces in the studies carried out until today. According to the records of the genus *Elodea* in Türkiye, only the existence of *Elodea canadensis* is mentioned in many studies (Altınayar and Onursal 1982; Uotila 1984; Altınayar 1988; Seçmen and Leblebici 1991; Akküz et al. 2000; Altınışıl and Altınışıl 2005; Kesici et al. 2009; Uludağ et al. 2017; Leblebici 2018; Ersoy and Turan 2019; Karataş 2019; İkinci 2023). However, it could be possible that this is due to the misidentification of *Elodea nuttallii* (Güneş



This paper gives the distribution map, a description of the taxon, and notes regarding the habitat where it was found. This study was carried out within the scope of the “Monitoring Plant Species and Identifying Threats in Yedigöller National Park, Kargalı Gölçük and Göksu Nature Parks in Bolu, Aquatic Ecosystem and Habitat Areas” project. The project, financed by Bolu Provincial Directorate of Nature Conservation and National Parks, aims to monitoring plant species and identify threats in aquatic ecosystem and habitats in these areas.

Materials and methods

In addition, *Elodea canadensis* specimens were also collected from the same area. Photographs of plant samples collected during fieldwork were taken and morphologically identified (St. John 1965; Uotila 1984; Simpson 1986; Larson 1993; eFloras 2008). Leaf, internode, and bud measurements were made on 20 individuals for each taxon and the specimens compared with the materials of digital herbaria (see section Examined Herbarium Specimens). Since there were no flowers and fruits in the collected samples, that characteristics were compiled from the literature. Measurements were made with Nikon SMZ 745T microscope and microscopic photographs of taxa were taken with Nikon DS-Fi1 camera. Three *Elodea nuttalli* specimens

were recorded in the Herbarium collection of Düzce University Faculty of Forestry (DUOF 10720, 10721, 10722).

The differences between the two taxa are given in the dichotomous key (Ucjeps 1996).

1. Leaves linear, oblong to ovate, 2–5 mm wide, tip obtuse to abruptly pointed; staminate flowers deciduous in late bud or when flowers open, petals $\pm$ 5 mm; pistillate sepals $\pm$ 2–3 mm *E. canadensis*
- . Leaves linear to lanceolate, 0.3–2 mm wide, tip acute; staminate flowers deciduous in bud, petals generally 0 or $\pm$ 0.5 mm; pistillate sepals $\pm$ 1 mm *E. nuttallii*

Synonyms and combinations

Elodea nuttallii H.St.John, Rhodora 22: 29 (1920). (IPNI 2000)

Anacharis nuttallii Planch., Ann. Sci. Nat., Bot., sér. 3, 11: 74 (1849), *Udora verticillata* var. *minor* Engelm. ex Casp., Monatsber. Königl. Preuss. Akad. Wiss. Berlin (1857), *Philotria minor* (Engelm. ex Casp.) Small, Fl. S.E. U.S.: 47 (1903), *Philotria nuttallii* (Planch.) Rydb., Bull. Torrey Bot. Club 35: 461 (1908), *Elodea minor* (Engelm. ex Casp.) Farw., Rep. (Annual) Michigan Acad. Sci. 17: 181 (1915 publ. 1916), *Elodea columbiana* H.St.John, Res. Stud. Washington State Univ. 30: 37 (1962) (POWO 2017; COL 2022).

Examined herbarium specimens

Elodea canadensis

CANADA: environs de Montreal, Michaux, (Holotype: P00690054!). EDINBURGH: Scotland, Herb. Scottish Lake Survey, Duddingston Loch, Leg: G. T. West 07.10.1904 (E00698224!). BRITISH ISLES: v/c 95 Moray, grid 38/2845, Pool by river Spey between Danda leith & Gaigellachie, Leg. M. McCallum Webster, 20.8.1974 (E00698245!). BRITISH ISLES: v/c 94 Banff, grid 38/3132, Artificial loch, Glen Fiddich Lodge, introduced with trout, Leg. M. McCallum Webster, 6.7.1983 (E00698244!). TÜRKİYE: A3–Bolu: Göksu Nature Park, at an elevation of 1350 m, in the lake, 05.11.2022, Leg.: N. Aksoy (8594), Det. N. Aksoy, N. Güneş Özkan & N. Koçer (DUOF 10719).

Elodea nuttallii

OREGON: F Botany, Colombus, Leg. Drake & Dikson, May 1889 (Holotype: V0045882F!), (Herb. Mus. Par. Amer. Boreale, donné par sir. W. Hooker 1845, Det. C. D. Cook, 2000, P01754890!). WISCONSIN: Herbarium of Univ. Wis.- Stevens Point, Portage Co., Wis., Tp.: Plover, Sect.: 16, T 23 N, R 8 E, Village of Whiting, Marshy areas and wooded thickets bordering the Wisconsin River and small adjacent ponds, Leg. Robert W. Freckmann 12150, 16 August 1975 (WIS50529!). BRITISH ISLES: v/c 89 East Perth, grid 37/1 4, Small pool by R. Tay South 57 caputh with *Subularia*, *Limosella*, *Peplis*, *Apium inundatum*, *Polygonum minus*, etc, flowering. Leg. M. McCallum Webster, 16.8.1984 (E00698283!). SCOTLAND:

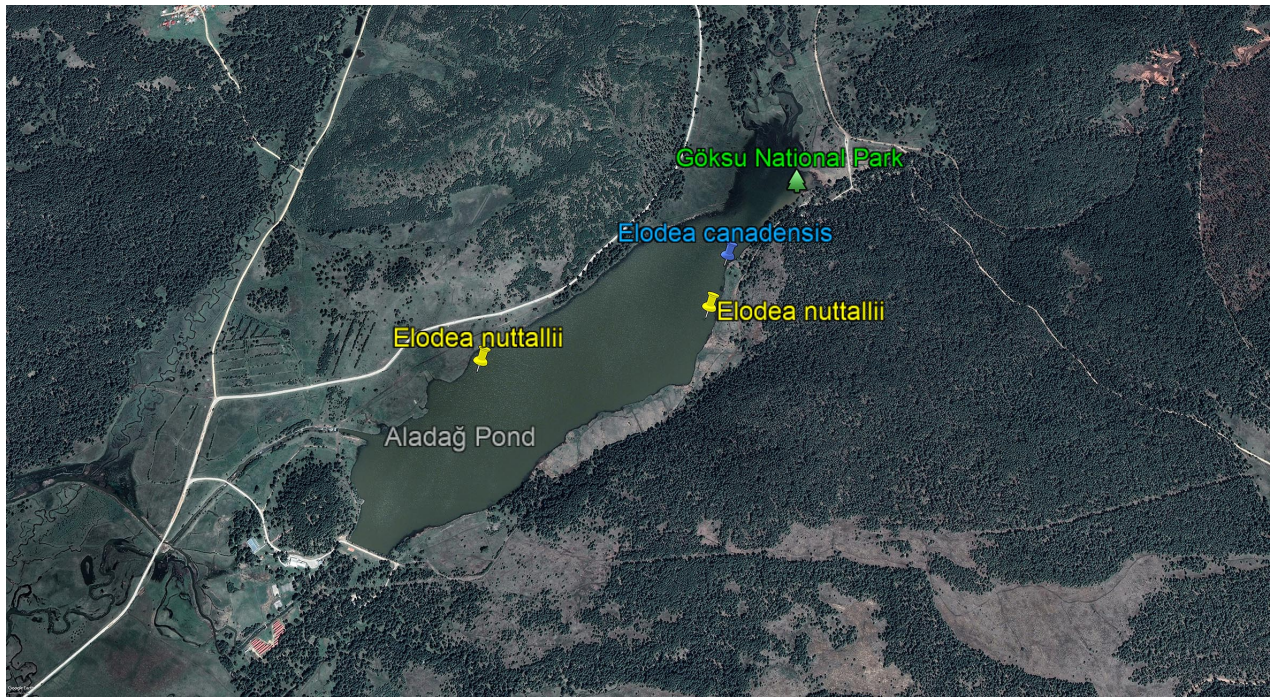


Figure 2. *Elodea nuttallii* and *Elodea canadensis* in the study area. (Photograph by Google Earth).

Kirkcudbrightshire. VC73. Near Parton, edge of Loch Ken, second record, Leg. O.M. Stewart, OS180/91, 22.8.1991. (E00698301!). SCOTLAND: Kirkcudbrightshire. VC73. Cailsfad Loch, Leg. O.M. & N.F Stewart, OS152/93, 3 August 1993. (E00698284!). TÜRKİYE: A3-Bolu: Göksu Nature Park, at an elevation of 1350 m, in the lake, 09.06.2022, Leg.: N. Aksoy (8499), N. Güneş Özkan & N. Koçer, Det. N. Aksoy, N. Güneş Özkan & N. Koçer (DUOF 10720). A3-Bolu: Göksu Nature Park, at an elevation of 1350 m, in the lake, 05.11.2022, Leg.: N. Aksoy (8593), Det. N. Aksoy, N. Güneş Özkan & N. Koçer (DUOF 10721). A3-Bolu: Göksu Nature Park, at an elevation of 1350 m, in the lake, 05.11.2022, Leg.: N. Aksoy (8595), Det. N. Aksoy, N. Güneş Özkan & N. Koçer (DUOF 10722).

Results

In this study, *Elodea nuttallii* was found in Türkiye for the first time as a new neophyte record. The first specimens of *Elodea nuttallii* were detected by the authors in June 2022 in Türkiye. The distribution of the taxon is as follows: TÜRKİYE: A3-Bolu: Göksu Nature Park, at an elevation of 1350 m, in the lake, 09.06.2022, Leg. et Det.: N. Aksoy (8499), N. Güneş Özkan & N. Koçer (Figure 2).

Elodea nuttallii species description

Smaller and more slender than *Elodea canadensis*. Stems terete, often freely branched. Shoot diameter 7 mm, internodes ca. 5 mm. Buds narrowly, lanceolate, ca. 1.2 × 2.9 mm. Leaves whorls of 3, linear to linear-lanceolate, 6–12 mm long, 0.86–1.80 mm wide, apex narrowly acute to acuminate, margin

Table 1. Morphological differences between *Elodea nuttallii* and *Elodea canadensis*.

		<i>Elodea nuttallii</i>	<i>Elodea canadensis</i>
Habitus		slender	stout
Internodes		longer, (3–) 4,5–6,5 (–7,5) mm	shorter, (2,7–) 3–4 (–6) mm
Buds		narrowly, lanceolate, 0,94–1,73 × 2–3,98 mm	broadly, ovoid 1–1,91 × 2,5–4,72 mm
Leaf	shape	linear to linear-lanceolate, narrower	oblong to ovate, broader
	size	0,86–1,80 × 6–12 mm	2–3,26 × 4–7,33 m
	apex	narrowly acute to acuminate	broadly acute to obtuse
	margin	recurved, undulate	flat


Figure 3. Habitus of *Elodea nuttallii* (A) and *Elodea canadensis* (B). Photographs by Necmi Aksoy.

recurved, undulate (Table 1). Flowers unisexual; male flowers solitary and sessile in the spathe, sepals ovate, ca. 2 mm long, sometimes reddish; petals lacking or to 0.5 mm long, ovate-lanceolate; stamens 9. Spathes of female flowers borne in upper axils, narrowly cylindric, 9–25 mm long; sepals obovate, ca. 1 mm long; petals white, obovate, longer than the sepals; stigmas slender, shallowly bifid, slightly exceeding the sepals. Fruit narrowly ovoid to fusiform, 5–7 mm long; seeds cylindric or fusiform, 3.5–4.5 mm long. Flowering Jun–Aug (Larson 1993; eFloras 2008).

When compared morphologically with *Elodea canadensis*, there are obvious differences in the following features: habitus is slender, internodes are longer, buds are narrowly lanceolate, leaves linear to linear-lanceolate, narrower, apex narrowly acute to acuminate, margin recurved and undulate (Figures 3 and 4).

Habitat

Helophytic plants submerged in the stagnant water of the pond, close to riparian and muddy places vegetation, altitude is 1350 m. (Figure 5). In the habitat where *Elodea nuttallii* grows, the following species accompany it: *Elodea canadensis*, *Polygonum amphibium* L., *Lemna minor* L., *Equisetum arvense* L., *Alisma plantago-aquatica* L.

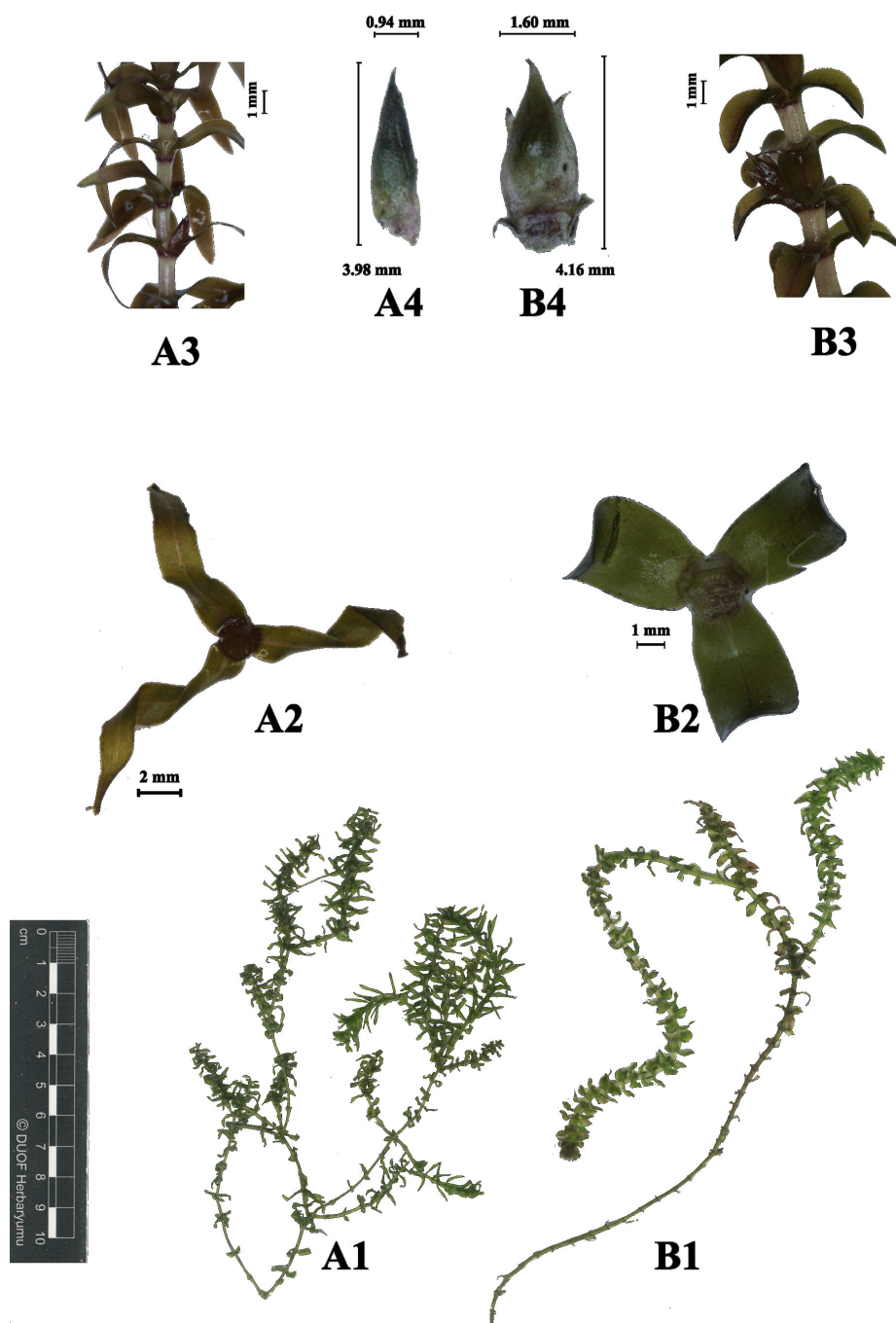


Figure 4. Morphological comparison of *Elodea nuttallii* (A1 – habitus, A2 – whorls of leaves, A3 – shoot, A4 – bud) and *Elodea canadensis* (B1 – habitus, B2 – whorls of leaves, B3 – shoot, B4 – bud). Photographs by Neval Güneş Özkan and Nihan Koçer.

Discussion

Biological invasions are major threats that reduce biodiversity and disrupt ecosystem functioning. Because most of the accessible freshwater in the world is used by humans, it is sensitive compared to terrestrial ecosystems. Thus for freshwater ecosystems, biotic interchange is much more important than terrestrial ecosystems. Some submerged plants, such as *Elodea canadensis* and *Elodea nuttallii*, may built-up a massive biomass, become highly invasive, and cause biotic interchange by replace native plants (Sala



Figure 5. *Elodea nuttallii* in its habitat. Photograph by Necmi Aksoy.

et al. 2000; OEPP/EPPO 2021). These features can create great pressure on the ecosystem. More efforts are needed to reduce the pressure of alien species on biodiversity and ecosystems. Globally integrated approaches are needed to prioritize, manage, and control them (Latombe et al. 2017). Therefore, first of all, the alien species must be correctly identified and recorded. After that, active monitoring is required.

Reports of this genus for most countries may be based on the misidentification of *Elodea canadensis* because these two species are often confused with each other (Larson 1993; Kočić et al. 2014). Some of the specimens identified as *Elodea canadensis* in some previous studies (Altınayar and Onursal 1982; Uotila 1984; Altınayar 1988; Seçmen and Leblebici 1991; Akköz et al. 2000; Altınışalı and Altınışalı 2005; Kesici et al. 2009; Leblebici 2018; Ersoy and Turan 2019; Karataş 2019; İkinci 2023) in Türkiye may be *Elodea nuttallii*. For this reason, wetlands with a flora record belonging to the genus *Elodea* may need to be reviewed. This taxon was not found in other lakes examined within the scope of the project “Monitoring Plant Species and Identifying Threats in Yedigöller National Park, Kargalı Gölçük and Göksu Nature Parks in Bolu, Aquatic Ecosystem and Habitat Areas”. For now, *Elodea nuttallii* seems to occur only in the Aladağ pond located in the Göksu Nature Park. It can be said that it is a neophyte until detailed studies are conducted on its invasiveness (Pyšek et al. 2004). It is stated that *Elodea nuttallii* is even more competitive than *Elodea canadensis* (Sârbu et al. 2006). Therefore, it will probably become invasive also in Türkiye in the future.

There are many introduction pathways for alien and invasive plants. Intensive angling can be one of the pathways these plants reach the study area. On the other hand, the study area is on the migration route of *Podiceps*



Figure 6. *Podiceps cristatus* L. in the Aladağ Pond. Photograph by Necmi Aksoy.

cristatus L. (1758) (Arslangündoğdu 2011; BOW 2022). According to our observations, this bird spends breeding periods in the Aladağ pond. The bird's behavior of taking a plant out of the water and presenting it to the female during the mating dance (Güleç 2020) or using this plant in the construction of a nest may be another dispersal means for this species (Figure 6).

Intensive recreational activities such as camping and angling in the area are risk factors for the distribution of native plants. Risk analysis studies should be carried out to determine these factors and their effects.

Dense *Elodea nuttallii* populations reduce water movement and light penetration, producing anaerobic conditions and trapping sediments. Decomposition of the amounts of biomass at the end of the growing season significantly contributes to the deterioration of water quality and intensification of secondary eutrophication altering the nutrient balance of the entire ecosystem. Further, the species affects local populations of aquatic plants and animals. Dense communities of *Elodea nuttallii* can displace native species and contribute to the reduction of the diversity of aquatic vegetation. For macrophytes, this effect is usually related to competition for space, light, and nutrients, which leads to the displacement of the native species by the invading species and contributes to the reduction of the diversity of aquatic vegetation (Kolada et al. 2022). It is stated that invasive plants like *Elodea nuttallii* and *Elodea canadensis* produce more vegetative propagules in areas with high eutrophication (Hrivnák 2002; Xie et al. 2010). For this reason, water quality should be assessed (Figure 7).

On the other hand, one study suggested that to restore native aquatic animal communities of *Procambarus clarkii* Girard (1852)-infested ecosystems,



Figure 7. Eutrophication in the pond. Photograph by Necmi Aksoy.

priority should be given to preserving aquatic vegetation, like *Elodea nuttallii*, which has more abundant macro-invertebrate communities than emerging and floating leafy vegetation (Sato et al. 2014). Therefore, the possible positive and negative effects of this invasive species on the natural flora and fauna of the pond should be evaluated and risks should be managed accordingly.

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