



## ***Boerhavia erecta* L. (Nyctaginaceae): A new record to the flora of Türkiye**

Aysel ULUS<sup>1,\*</sup> Fatmagül BOLAT<sup>2</sup>

<sup>1)</sup> İstanbul University-Cerrahpaşa, Faculty of Forestry, Department of Landscape Architecture, 34473, İstanbul, Türkiye.

<sup>2)</sup> İstanbul University-Cerrahpaşa, Vocational School of Forestry, Irrigation Technique Prog. 34473, İstanbul, Türkiye.

Corresponding author: [ulusay@iuc.edu.tr](mailto:ulusay@iuc.edu.tr)

### **Abstract**

*Boerhavia erecta* L. (Nyctaginaceae) is reported as a new record for the flora of Türkiye. The plant was first observed and photographed on June 30, 2023, along Uğur Mumcu Street in the Şarkonak neighborhood of Karaağaç village, Arsuz district, Hatay. Samples from a population of approximately 30 plants were collected and documented on January 27, 2024 and June 23, 2024. The species was also detected in another nearby locality on June 23, 2024, where it is in the colonization stage. Identification was based on extensive botanical literature reviews and detailed herbarium studies utilizing a 60x binocular microscope and handheld loupes with 50x and 60x magnifications. Our research revealed that this species had not previously been recorded in publications on the flora of Türkiye. This observation indicates the first recorded presence of Genus *Boerhavia* in Türkiye, likely introduced to the region via bird migration. *Boerhavia* species are well known for their widespread use in alternative medicine. Further studies about *Boerhavia erecta* L. are recommended to explore both the potential applications and the ecological impact.

**Keywords:** new record, *Boerhavia*, Nyctaginaceae, Türkiye, Arsuz.

### **Introduction**

Nyctaginaceae family (known as the four o'clock family in English and Akşamsefasıgiller in Turkish) comprises woody trees, shrubs, thorny climbers, and annual to perennial herbaceous ground-covering genera (Yuan and Lan 2022). This family is represented by 33 genera and approximately 400 species worldwide (Neto et al. 2020). Nyctaginaceae species grows in a diverse array of habitats ranging from arid deserts to tropical rainforests across the Americas, Africa, and the Indo-Pacific regions (Haug et al. 2004, Hernandez-Ladesma et al. 2015, Douglas and Spellenberg 2010). This extensively distributed family is renowned for its ornamental value and pharmaceutical properties. In Türkiye, some species from this family, such as *Bougainvillea glabra* Choisy and *Mirabilis jalapa* L., are cultivated as exotic ornamental plants in temperate regions. However, no other genus from this family has been reported in Türkiye to date.

In the genera of this family, the stem is generally swollen at the nodes and sometimes spiny (Bittrich and Kühn 1993). The leaves are typically distinctly petiolate and simple, with leaf blades that are slightly fleshy to membranous and come in shapes including linear, cordate, ovate, or orbicular (Douglas and Spellenberg, 2010). The leaf arrangement can be opposite (as in *Boerhavia* and *Mirabilis*), alternate (as in *Bougainvillea*), or rarely whorled (Stemmerik, 1960). The leaves lack stipules. The margins of the leaves can be entire, crenate, undulate, or sinuate, and are sometimes glandular pubescent (Douglas and Spellenberg, 2010). The surfaces of the leaves may be glabrous or pubescent, often glandular.

Many genera in the family have flowers that bloom in the late afternoon or early evening, hence the name "four o'clock" in English (Levin et al. 2001). Similarly, in Turkish, the family is referred to as "Akşamsefasgiller," which translates to "Evening Joy family". The inflorescences are mostly terminal, occasionally axillary comprising cymes, umbels, or verticils. They can sometimes be single-flowered or fasciculate, often forming compound racemes (Dequan and Gilbert 2003). Bracts, and bracteoles are generally present, sometimes very small, caducous, sometimes large and bright colored.

The flowers are hermaphroditic (bisexual), rarely unisexual or dioecious, (Nores et al. 2013) and actinomorphic or slightly to strongly zygomorphic (Douglas and Spellenberg 2010). The perianth is often tubular, campanulate, or funnel-shaped, either uniseriate or gamophyllous, with lobes that can be plicate or valvate in bud, and is typically persistent around the ovary, sometimes accreting in fruit (Stemmerik, 1960). In many genera, the flowers are apetalous with 5 sepals (Williamson and Bazeer 1997) and have an inconspicuous calyx. However, in species like *Mirabilis jalapa* L. and *Okenia* Schltld. & Cham. The calyx tube is large and colorful, mimicking a corolla, and several involucre bracts sometimes forming a calyx-like involucre (Bogle 1974). Flowers have developed various traits to attract pollinators, such as visual appeal, diurnal or nocturnal blooming, and distinct fragrances (Nores et al. 2013). The fruit is often encased in a persistent part of the perianth, forming an anthocarp (Westra and Stoffers 1980). The ovule is solitary and located at the base of the ovary, which is superior (inferior in the genus *Okenia*). The pseudocarps are radially symmetrical or dorsiventrally flattened anthocarps. The seed is single, with a membranous seed coat. The embryo is straight or curved, the cotyledons are leaf-like, the endosperm is minimal and the perisperm is abundant (WFO 2024a).

The genus *Boerhavia*, belonging to the Nyctaginaceae family, is commonly known as "spiderlings" in English. This name is due to the plant's long, sticky peduncles that resemble spider webs (Struwig and Sieberg 2013). According to Douglas and Spellenberg (2010), there are approximately forty species of *Boerhavia* distributed worldwide, primarily across tropical and subtropical regions. Notably, it exhibits significant diversity in the southwestern region of North America (Ezeabara and Nwiyi 2017). Generally, *Boerhavia* species are coastal plants that proliferate in dunes, gravel plains, or rocky slopes (Chen and Wu 2007).

*Boerhavia* species are predominantly herbaceous, displaying either annual or perennial life cycles and display erect, repent or ascending growth habit (Ezeabara and Nwiyi 2017; Westra and Stoffers 1980). Their stems are elongated with prominent nodes. Certain species have adapted to arid environments by developing a sticky, mucilaginous substance along their internodes (Struvik et al. 2011). This mucilage may facilitate seed dispersal by animals or enhance seed adherence to the soil, thereby improving germination success (Fosberg 1978).

*Boerhavia* species are characterized with opposite leaves. The flowers of *Boerhavia* are hermaphrodite and usually arranged in loose cymose inflorescences (Ezeabara and Nwiyi 2017) and in some cases, they form spike-like clusters with small, scale-like free bracts (Fosberg 1978). Filaments and style included or shortly exerted. The perianth is less than 1 cm long (Dequan and Gilbert 2003).

The fruits of *Boerhavia* species are narrowly obovate, with 3-5 prominent longitudinal ribs (Ezeabara and Nwiyi 2017). They may have a smooth surface or be densely glandular with minute, tightly packed glands (Ezeabara and Nwiyi 2017, Hutchinson and Dalziel 1954). Some researchers (Fosberg 1978, Mauseth 1988, Struwig et al. 2011) have noted the challenges in identifying *Boerhavia* species due to their significant morphological diversity or plasticity, which varies with environmental conditions and habitats (Azeez et al. 2020).

Many *Boerhavia* species are used medicinally worldwide, featuring prominently in various traditional medical systems including Indian Ayurveda, Siddha, and Unani, as well as Martinique, African, and traditional Chinese medicine, and are listed in the Indian and Brazilian pharmacopoeias (Patil and Bhalsing 2016, Ocvirk et al. 2013, Chopra et al. 1956).

This article proposes that *Boerhavia erecta* L. represents the first genus and species record for the flora of Türkiye.

## Materials and Methods

The research area is located in the district of Arsuz, within Hatay province, along the coast of the Gulf of Iskenderun (Figure 1). The region is characterized by a Mediterranean climate and is predominantly covered with maquis vegetation.

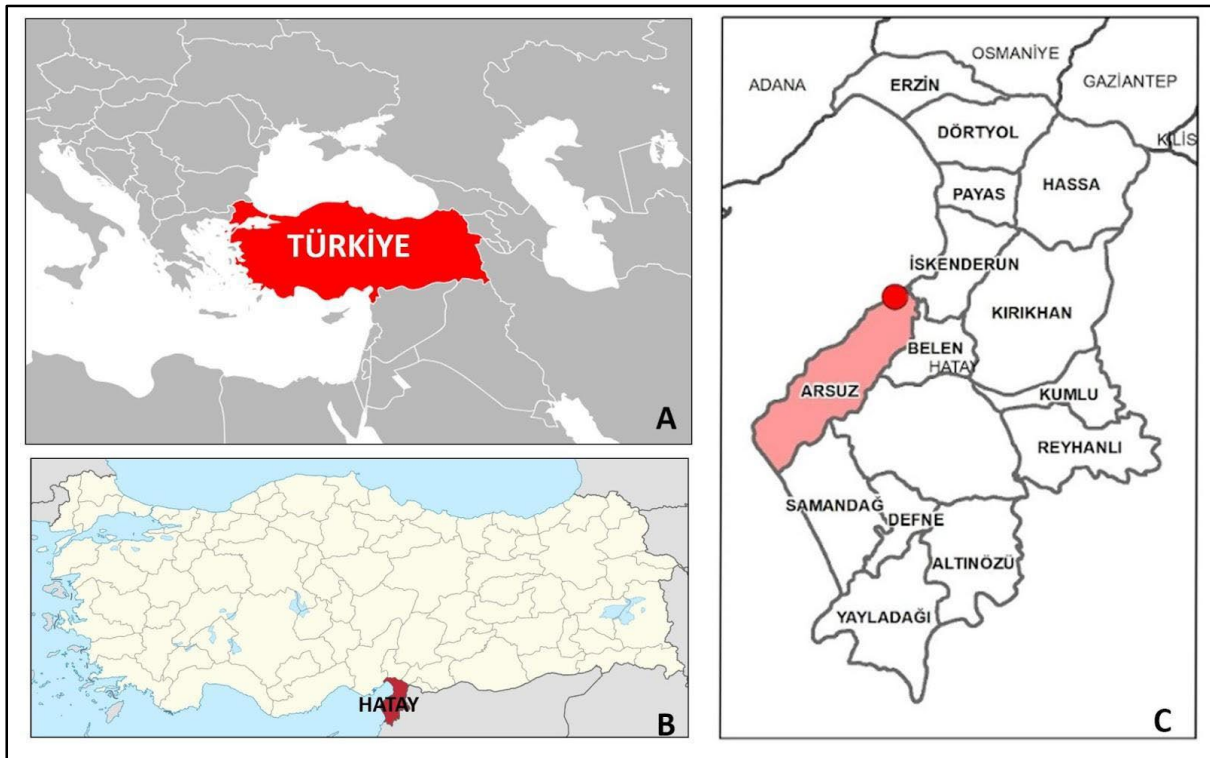


Figure 1. The location of the research area (A. Türkiye B. Hatay C. Arsuz).

The studied plant was first detected by Dr. Aysel Ulus on June 30, 2023, in the Şarkonak neighborhood, along Uğur Mumcu Street at the coordinates 36.557460° N, 36.101370° E (Figure 2). The initial location of the plant population was approximately 350 meters from the sea, on the edge of a vacant lot bordered by low-density, 2-3 story buildings.

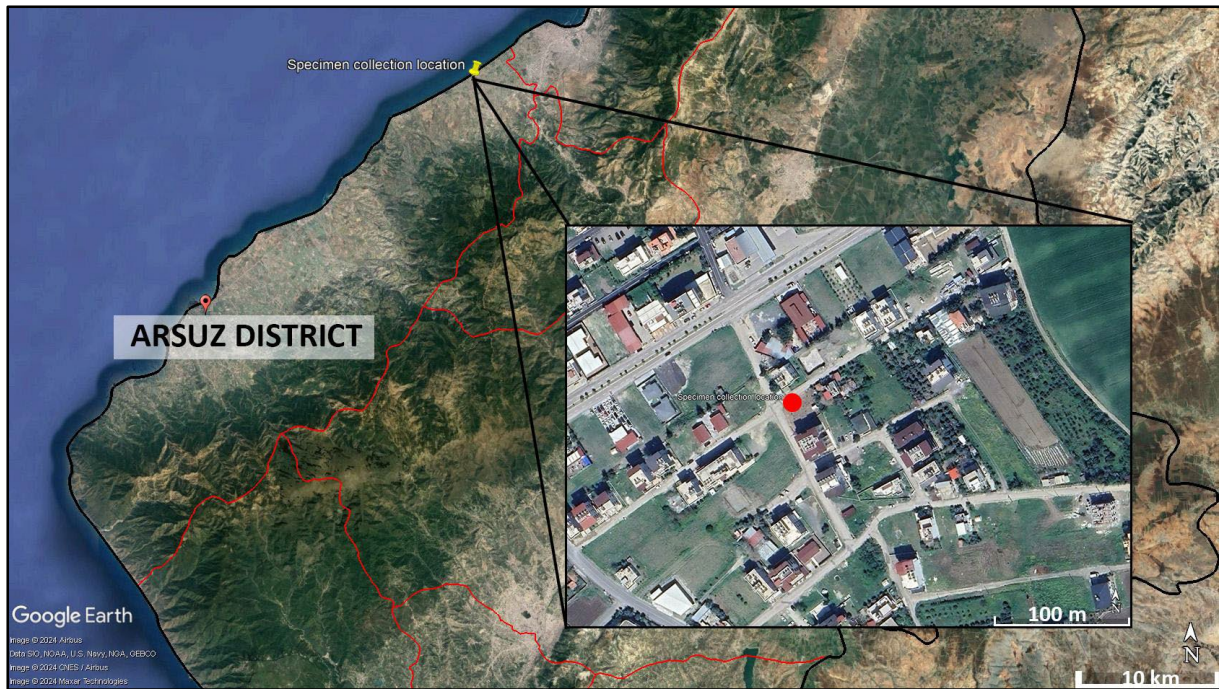


Figure 2. Location where the population was first observed (Google Earth, 2024) (Marked with a red dot).

Observations of the plant were conducted on June 30, 2023, January 27, 2024, and June 23, 2024. Measurements were taken and detailed information was gathered regarding the plant's habitat and habitus. The plant was observed in various stages of its lifecycle, including flowering, fruiting, and as a newly germinated seedling, and was photographed. Fresh stem, leaf and anthocarp material from the plant were collected on-site on January 27, 2024, during the winter season and the plant was photographed both individually and within its habitat. Additional samples were collected on June 23, 2024, with a particular focus on fruit specimens. During this survey, another population proximal to the original collection site was also observed.

The taxonomic studies of the species were conducted at the ISTO Herbarium (Located in İstanbul University-Cerrahpaşa Faculty of Forestry).

The identification of plant species was conducted through extensive review of literature including articles, books and key references that provide detailed descriptions and identification keys (Stemmerik 1960; Bogle 1974; Fosberg 1978; Westra and Stoffers 1980; Bittrich and Kühn 1993; Douglas and Spellenberg 2010; Struwig and Siebert 2013; Debasmita et al. 2015; Ravichandran 2020; Dequan and Gilbert 2023; Flora of North America 2024, WFO 2024b).

In addition to these published sources, digital herbaria were consulted for examining plant specimens. The digital herbaria references were the Royal Botanic Garden Edinburgh (1998), Flora of Peninsular India (Sankara Rao et al. 2019) and Atlas of Florida Plants (2024).

Following the literature review, plant specimens were analyzed in the herbarium environment. This analysis involved the use of handheld loupes with magnifications of 50x and 60x, as well as a 60x binocular microscope. The morphological characteristics of various plant organs, including shoots, leaves, flowers, and fruits, were measured and documented. High-resolution photographs were taken to aid in the accurate identification and documentation of the species.



## Results

The research revealed that *Boerhavia erecta* L. is not included in the Flora of Türkiye (Davis 1965-1985, Davis et al. 1988, Güner et al. 2000) or in other relevant previously published literature (Güner et al. 2012, Uludağ et al. 2017). The new record for Türkiye, *B. erecta*, was detected in the Arszuz district of Hatay province (C6) according to Davis's grid system in the C5-C6 square (Figure 3).



Figure 3. Grid system of Türkiye according to Davis, (1965-1985) and the exact location of *B. erecta*.

The plant has been observed along roadsides and field edges, on bare, rocky-sandy soils, either in association with other low-growing herbaceous plants or as solitary individuals. It is an annual or short-lived perennial. Within the observed population, both dry and living specimens were observed. Individuals in various stages, from seedlings to mature plants, were present in the population. According to samples from the research area, the plants exhibit a prostrate growth habit initially, but become erect with the development of inflorescences, reaching heights of approximately 60-65 cm and widths up to 170 cm (Figure 4).

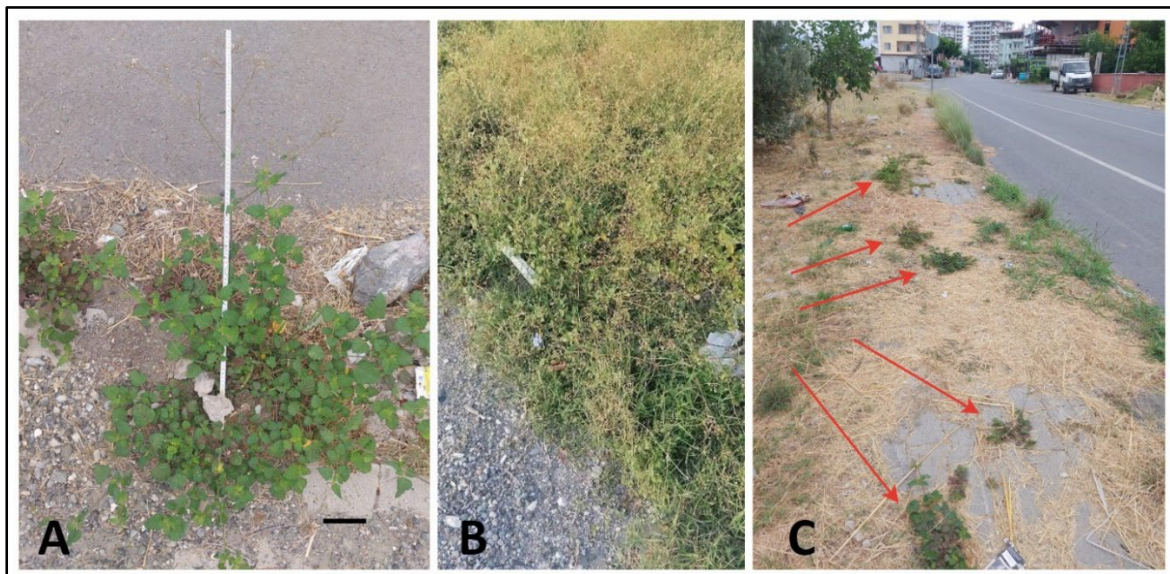


Figure 4. A. Top view of the plant (Scale bar 10 cm) (Photo taken on: 23.06.2024) B. Roadside population (Photo taken on: 30.06.2023) C. Roadside new colonization (red arrows showing *B. erecta* plants) (Photo taken on: 23.06.2024).



The shoots are smooth, round, and exhibit a purplish-red-green coloration, with swollen nodes. Both nodes and internodes possess short, sticky, septate hairs (Figure 5). The stems near the base become glabrous and woody.



Figure 5. A. Purplish-red-green shoots B. Swollen nodes (scale bar 1mm) C. Short, sticky, septate hairs D: Woody stem at the base.

In young seedlings, the leaves and petioles are bronze-colored (Figure 6). The leaves are slightly fleshy, arranged oppositely, and vary in size and form (Figure 6). The leaves are petiolate, with petioles measuring (17-) 22 (-25) mm in length. The leaf margins are entire and undulate. Mature leaf blades measure (32-) 38 (-45) mm in width and (33-) 40 (-47) mm in length. They range in form from rounded (rotund) to broadly lanceolate. The leaf base varies from rounded to cordate. Leaf apices are rotund, subacute, or obtuse, with veins prominent on both surfaces of the leaf. The lower surface of the round-shaped leaves at the base is reddish along the veins (Figure 6). The point of attachment of the leaf to the petiole is marked by soft septate hair bundles along the veins (Figure 7).



Figure 6. A. Young seedling and bronze-colored leaves (Photo taken on: 30.06.2023), B. C. D. Leaf shapes and sizes of *B. erecta*, E. Distinctive reddish veining on the upper surface of the leaf.

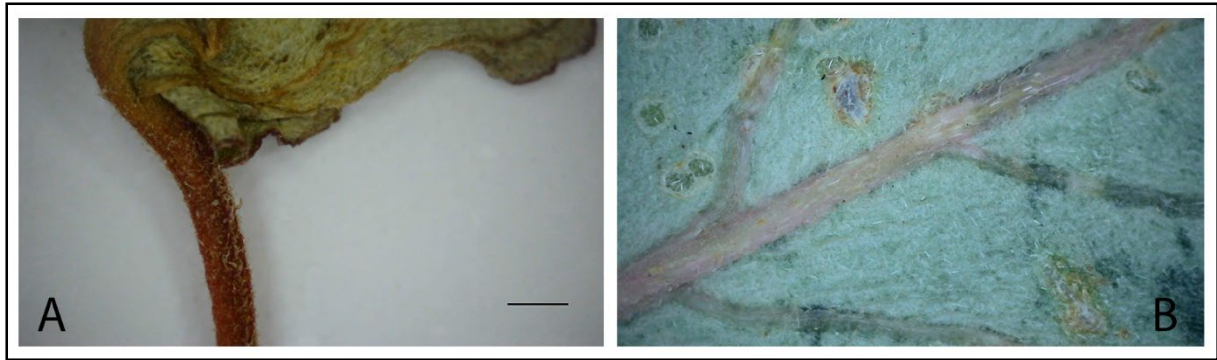


Figure 7. A. The point of attachment of the leaf to the petiole (Scale bar 1 mm) B. Soft septate hair bundles along the veins.

Flowers and anthocarp fruits were observed on three different dates, indicating that the plant's flowering period extends throughout the year. Most of the flowers cluster together to form racemes (Figure 8). The flowers emerge from leaf axils or the tips of shoots, positioned on the main floral axis, which bears secondary and sometimes tertiary peduncles. The main floral axis can extend up to 80 cm and branch 4-5 times. Secondary peduncles can reach lengths up to 50 cm. The terminal flower cluster consists of 2-6 flowers. The flowers are small with purple buds when in bud, when fully opened the perianth is white with a pink stripe outside of the outside of the perianth. The number of stamens varies, with some flowers having one, others two, and some having three stamens. An open flower is approximately 2.5-3 mm in width, and the pedicels are less than 1 mm in length (Figure 8).



Figure 8. A. Cymose inflorescence B. Flowers and anthocarp fruits on twig (Photo taken on: 30.06.2023) C. Flowers located at the end of the inflorescence, D. Flower buds with purple stripes E. Shortly exerted stamens and flower F. The purple stripes on the outer part of the perianth petals, the peduncle, and the lower floral covering (Scale bar 1 mm).

Anthocarp fruits are inverted conical (broad at the top, narrow at the base) in shape, distinctly 5-ribbed, with a flat-truncate apex. The ribs are wavy, the width is 1-1.2 mm, the length is 3 mm, and they are glabrous (Figure 9).

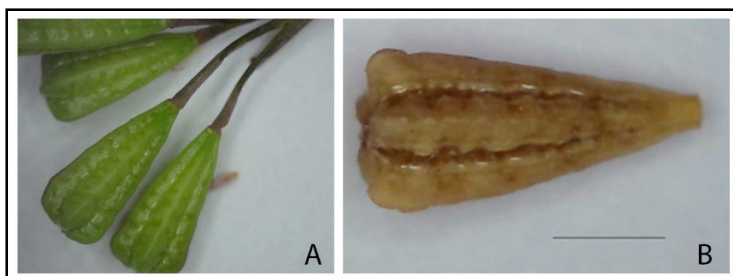


Figure 9. A. Young anthocarp fruits B. Mature anthocarp fruit (Scale bar 1 mm).



The identified specimens of the species were processed accordingly and registered in the ISTO herbarium under the accession number 39164 (Figure 10).

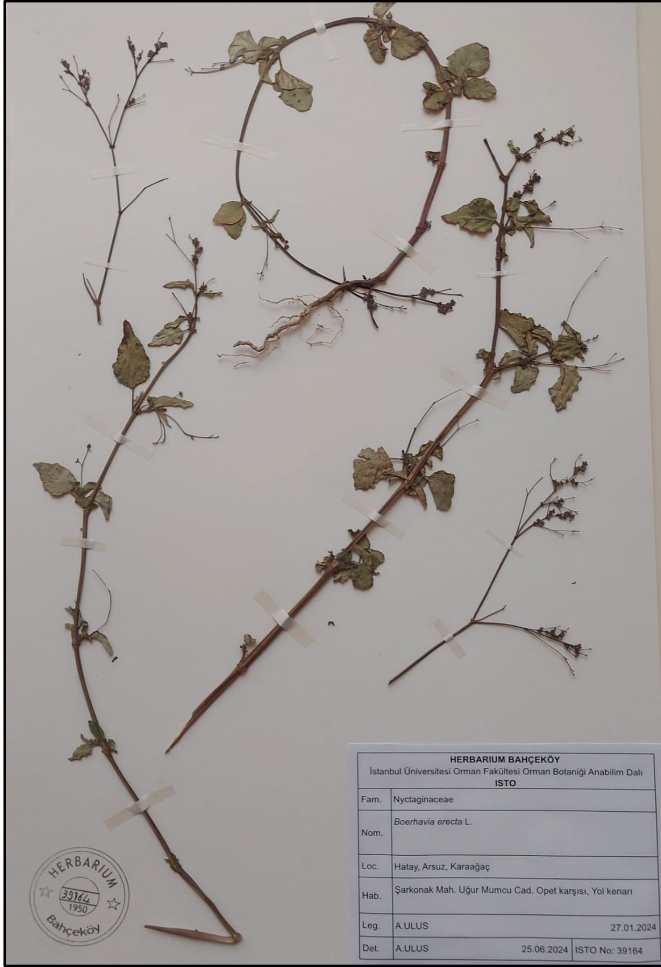


Figure 10. ISTO herbarium specimen.

## Discussion

In this study, it is proposed that the species *Boerhavia erecta* L. is recorded for the first time in the flora of Türkiye (registered in the ISTO herbarium with number 39164). *Boerhavia* L. from the Nyctaginaceae family comprises approximately 40 species widely distributed in the tropics and subtropics of both hemispheres (Douglas and Spellenberg, 2010; WFO 2024c).

*B. erecta* L. has a native distribution in the northern and southern parts of America and has been introduced to various regions, including temperate and tropical Asia, Africa, and Southern America. Until now, neither *B. erecta* L. nor any species from the genus *Boerhavia* have been recorded in Turkey.

Selveraj et al. (2012) noted that *Boerhavia erecta* can be confused with other species such as *B. diffusa*, *B. repanda*, *B. coccinea*, and *B. verticillata*, complicating its accurate identification. The distinguishing morphological characteristics of *B. erecta* L. include its erect habit (at least for the inflorescences), its relatively tall stature, the primary floral axis being longer than other parts, and most notably, the glabrous and truncate-topped anthocarp (Mochanla and Aluri, 2021; Struwig and Siebert, 2013; Choo et al. 2022).

Mochanla and Aluri (2021), in their study on the reproductive ecology of *B. erecta* and *B. diffusa*, noted that these species have a wide distribution globally. This extensive distribution is attributed to their continuous flowering and fruiting throughout the year, alternating cycles, and their flower structures,



which facilitate pollination by various insects (different species of bees, butterflies, and flies), alongside self-pollination and cross-pollination. Additionally, the mucilaginous nature of the single-seeded indehiscent anthocarp fruits facilitates their dispersal by birds, insects, water, and humans (zoochory, anthropochory, ornithochory, and hydrochory), allowing the plant to colonize new areas and maintain its genetic diversity. In line with this, a plant population observed in a single location in January 2023 was also found in a nearby location in June 2024. The immediate germination of seeds after dispersal, without dormancy, indicates that these species can become invasive in a short period.

*B. erecta* is known for its widespread use in alternative medicine worldwide. Further research on the active compounds and potential health benefits of this species is important. Such studies will help elucidate not only the pharmacological value of the species but also its ecological adaptations and survival strategies.

Al-Hawshabi (2015) documented the first record of *B. erecta* in Yemen in his study and noted that the plant was found along roadsides, alluvial plains, and field boundaries. Similarly, our observations of *B. erecta* were made in similar habitats, specifically along a roadside and at the edge of a field.

*B. erecta* is named "erect spiderling" in English due to its spider web-like appearance. Accordingly, the Turkish name "Dik Örümcek Ağı Otu" is proposed.

Monitoring and studying whether the species is invasive in its new habitat in Türkiye and its interactions with local species is also crucial. Alien species can exert dominant and detrimental effects on local ecosystems. Therefore, it is imperative to conduct detailed studies to determine the ecological impacts of *B. erecta*. These studies will provide necessary information for the management and conservation of the species, contributing to the maintenance of biological diversity.

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