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Research article

A new generic record for the flora of Turkey: *Notholirion koeiei* (Liliaceae: Lilioideae)

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Abstract: The genus *Notholirion* Wall. ex Boiss. (Liliaceae), is recorded for the first time from Turkey. Specimens collected from Derecik (Hakkari) province, east Anatolia, are reported here as the new record *Notholirion koeiei* Rech.f., which was first described from Iran and later determined in Iraq. Its detailed morphological features, vernacular name, pollen grain details and seed surface characteristics, photographs in its natural distribution area and the updated distribution map are given in present study.

Keywords: Hakkari, morphology, new record, *Notholirion*, palynology, Turkey.

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Introduction

The family Liliaceae is represented by about 15 genera and 705 species in the world. (Christenhusz & Byng, 2016). According to the latest comprehensive checklist and other studies conducted in Turkey, the Liliaceae family is represented by 106 taxa belonging to 5 genera in Turkey (Güner, 2012; Kayıkçı et al., 2014; Özhatay et al., 2015; Tekşen & Karaman Erkul, 2015; Yıldırım & Tekşen, 2021). In the Eastern Anatolia region of Turkey, the Liliaceae family is represented by 46 taxa belonging to 4 genera (Fırat et al., 2015).

The genus *Notholirion* Wall. ex Boiss. (1882: 190) is widely distributed from China to the Himalayas, Afghanistan and Southwest Asia (Al-Khayat, 1999; Tamura, 1998; Song-jun & Tamura, 2000). Although the genus is distributed in a wide geography, it is represented by 4 species according to WCSP data (Govaerts, 2022).

The genus *Notholirion* is morphologically similar to genus *Fritillaria* L. (1753: 303) and *Lilium* L. (1753: 302). It differs from the genus *Fritillaria* in that its lower leaves are dense and elongated, its perianth is more or less erect, its corms are covered with a tunic, and its anthers are medifixed (Wendelbo, 1985; 1990). The *Notholirion* differs from the genus *Lilium* by the absence of nectar pits on their tepals and the fact that their corms are covered with a tunic (Rechinger et al., 1990).

Considering the neighboring countries of Turkey, the genus *Notholirion* is represented by two species in Iran: *N. koeiei* Rech.f. (1955: 51) and *N. thomsonianum* (Royle) Stapf (1934: 95); and one species in Iraq: *N. koeiei* (Wendelbo, 1985; 1990). In the Flora Iranica, *N. koeiei* differs from *N. thomsonianum* in that its anthers are 4–6 mm long (not c. 10 mm) and its ± erect perigon (not deflexed to subascenders) (Rechinger et al., 1990).

The *N. koeiei* was first described in Iran and later found in eastern Iraq (Wendelbo, 1985; 1990). Later, in a study conducted in Iraq, it was determined that the species expanded its range to the northeast of Iraq, which is also very close to the Turkish border (Al-Khayat, 1999).

When the micromorphological studies on the genus *Notholirion* were examined, no study was found on the seed surfaces, but it was seen that the palynological characteristics of the *N. thomsonianum* and *N. bulbuliferum* (Lingelsh.) Stearn (1951: 421) species were determined (Kosenko, 1999; Hu et al., 2021).

Notholirion koeiei, which is distributed in Iran and Iraq, was recorded for the first time in Derecik (Hakkari) province for the Flora of Turkey. In addition, contributions were made to the morphological characteristics of the species, and pollen and seed surface characteristics were determined for the first time.

Material and Methods

In the field studies carried out around Derecik district of Hakkari province in 2020-2022 (Figure 1-2). Individuals of *Notholirion koeiei* populations in Turkey were photographed and some specimens collected in the field for herbarium specimens. Then, in 2022, our dear colleagues Dr. Muhabbet Kemal KOÇAK and PhD student Hanife Geçer, working in the field of Entomology, brought specimens of the genus to the article authors from Derecik district. The dried samples were tried to be identified with the literature in Turkey, but no result could be reached (Davis, 1984; Davis et al., 1988; Güner et al., 2000). In subsequent literature research and digital herbarium sample examinations, it was determined that the samples belonged to the species *Notholirion koeiei* (Wendelbo, 1985; 1990). The distribution area of the species was updated in the study (Figure 1). Specimens belonging to the species are kept in Van Flora Application and Research Center Herbarium (VANF) with the inventory number *M. Fırat 35466, 35467, M. Fırat 35612 & H. Eroğlu* and *M. Fırat 35613 & H. Eroğlu.* (VANF and Herb. M. Fırat) [Herbariumabbreviation given according to Thiers (2016)].

Morphological studies

The specimens photographed in their natural habitat during the fieldwork were collected and dried in accordance with the herbarium techniques, and then the necessary morphological examinations were made on these specimens. The description of the species was written according to the data obtained in this study.

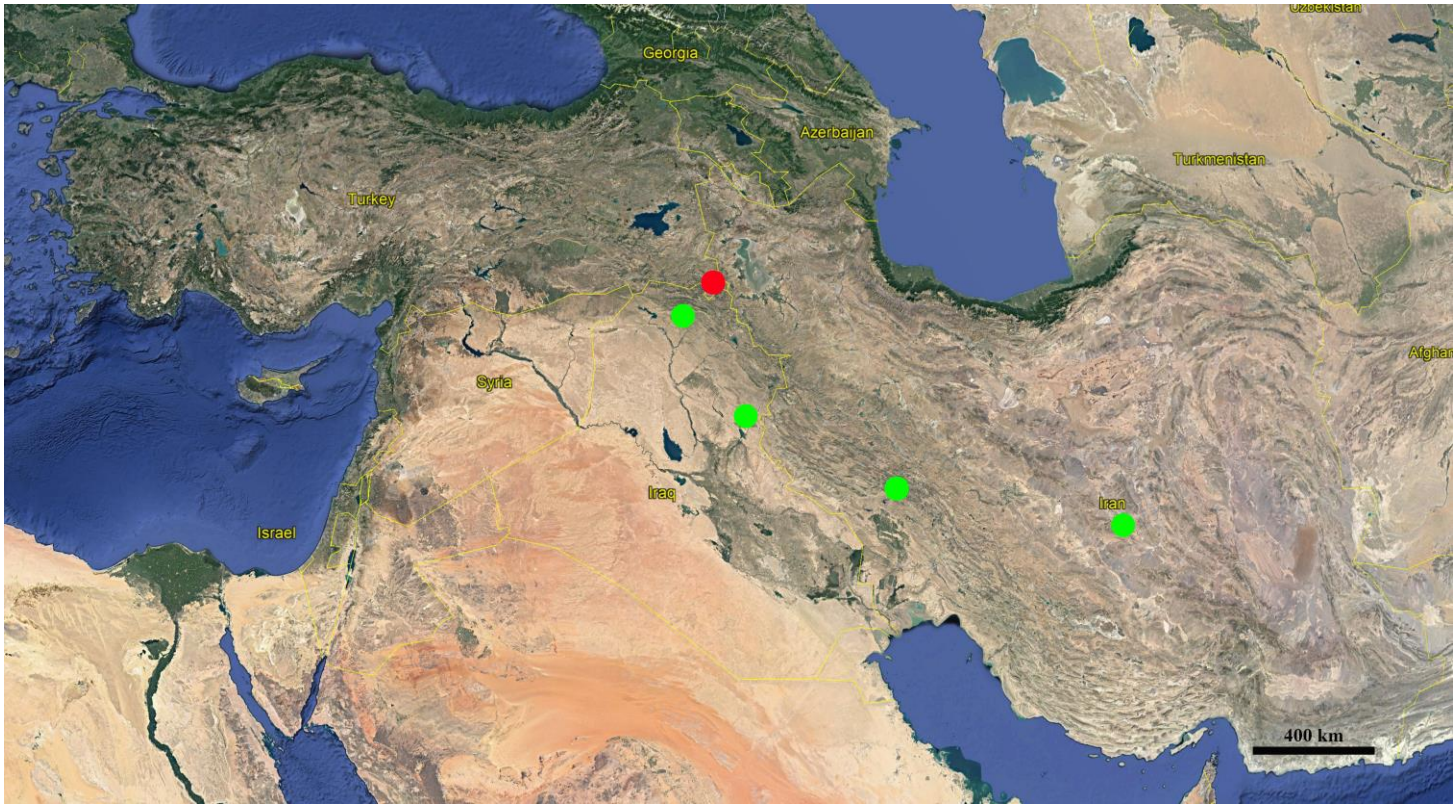

Figure 1. Map showing the distribution area of the *Notholirion koeiei*: (●)- in Turkey, (●)- previous location records in Iran and Iraq. (The map image is taken from the Google Earth software)

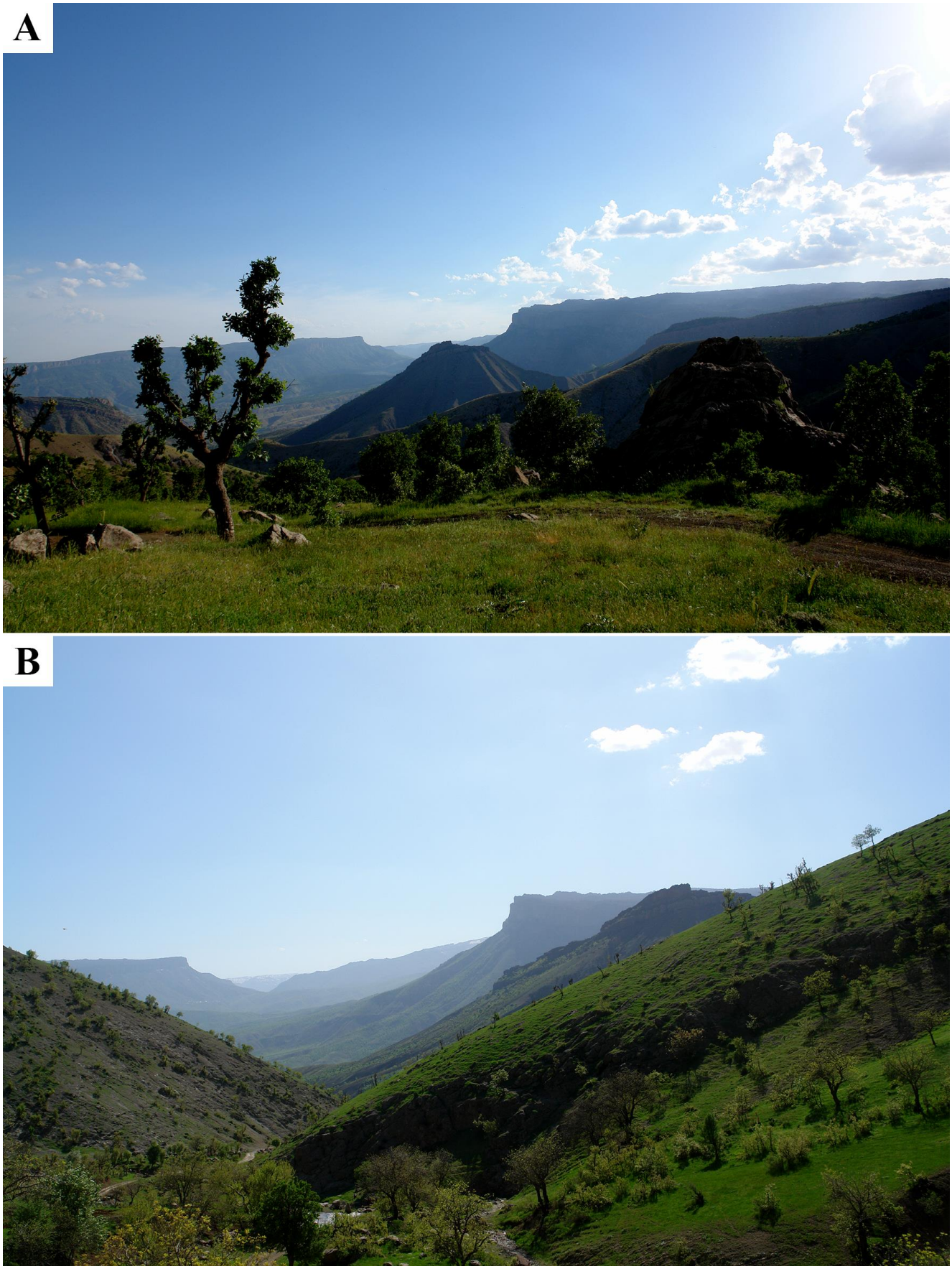

Figure 2. **A, B**- Habitat of *Notholirion koeiei* populations in Turkey.

Palynology and seed surface examinations

While the specimens belonging to the species were collected from the field, the flowers and seeds were taken into separate envelopes and brought to the laboratory for analysis. The pollens extracted from the anthers were taken on the slide and 1 drop of 70% ethyl alcohol was dripped onto them. Then, permanent preparations of pollen were prepared in gelatin-glycerin medium prepared with 1% safranine (Wodehouse, 1935). The preparations were photographed under a light microscope with a Leica DM500 model microscope equipped with a Leica ICC50HD camera, and micro-morphological measurements were made on 60 pollen grains from 3 different individuals with the Las EZ program. For electron microscopy investigations, pollen was fixed on aluminum stabs and coated with gold-palladium. The coated pollen was photographed with a Zeiss Leo 440 scanning electron microscope at the Central Laboratory of Van Yüzüncü Yıl University. Relevant literature was used to determine pollen characteristics (Walker, 1974a; 1974b, Erdtman, 1969, Faegri & Iversen, 1975, Punt et al., 2007), (Table 1, Figure 4). In order to determine the seed characteristics, the seeds brought to the laboratory were photographed in detail with a Leica Ez4d model camera stereo microscope and measured. Seed surface examinations were made on the photographs taken under the electron microscope, the samples were prepared with the same method as the pollen and photographed in the same place. The relevant literature was used to determine the seed surface characteristics (Stearn, 1983; Bojňanský & Fargašová, 2007).

Results

Notholirion koeiei Rech.f. (Figures 3–7)

Type: Persia: Lur.: Shah Bazan, 1000 m, KOEIE 1674 (holotype: W 1951-0010994 photo!) (Figure 7)

Description: *Bulb* ovoid, with many bulblets, 4–8 × 2–4 cm, with 2–3 coriaceous plicate tunics, outer tunica dark brown, inner tunica creamy brown, cataphylls elliptical, acuminate, plicate, creamy to dirty creamy. *Stem* erect, single, 0.7–1 cm diameter at the base, up to 100 cm, smooth, green or purplish spotted to purplish. *Leaves* linear. Lowermost leaves 2–4, 17–35 × 1–3 cm, (stemless leaves to 80 cm long), canaliculate and cucullate, upper surface smooth, lower surface plicate. Cauline leaves 9–13, alternate, 6–40 × 0.5–2 cm (decreases in size to upwards), gradually attenuate towards the tip, canaliculate and cucullate, upper surface smooth, lower surface striate. *Inflorescence* 20–37 flowered, 25–40 × 10–13 cm, conical. *Bracts* lanceolate, flat, to 8 cm × to 0.8 cm, acute, falcate. *Pedicels* incurved-erect, 1–1.5 cm long at anthesis, up to 3–3.5 cm long at fruiting time. *Flowers* erect in bud, green, at anthesis spreading. Perigon fragrant, tubular campanulate. Tepals free, sphatulate, 40–45 × 0.5–0.9 cm, curved backwards, lilac to pinkish, mid-bottom of inner sides phoeniceous stained, with prominent vein in the middle, in two rows, the outer ones cucullate at the top, with a green back, inner ones obtuse, without a green back. *Stamens* 6, free, filaments subequal, 3.5–4 cm. *Anthers* medifixed, 7–9 mm in immature, 3–5 mm in mature. *Stigma* 3 lobed, style filiform, 4–4.3 cm, curled upwards at the tip, caudocus in fruit. *Ovary* cylindrical 7–9 mm. Fruiting pedicels spreading-erect, 1.4–2.1 cm. *Capsule* 3 valved, opening longitudinally, obovoid to elliptical, 1.9–2.3 × 1.2–1.9 cm. *Seeds* brown or light brown, flat, ovoid to in the shape of a half-moon, 3–6.3 × 2.6–5.1 mm.

Material: Turkey. C10 Hakkari, Derecik (Rûbarok) district, Kırca (Bêgor) village, while descending from the Silo plateau (Zozana Silo) to Kırca (Bêgor) village, Rezok region, regionmoist stream banks, forest clearings around moist streams, 1304 m, 37°07′48″ N, 44°20′14″ E, coll. 24.04.2020, *M. Fırat 35466* [(VANF, Herb. M. Fırat), (in flower)]; ibid. 02.05.2021, *M. Fırat 35612 & H. Eroğlu* [(VANF, Herb. M. Fırat), (in flower)]; ibid. 01.06.2021, *M. Fırat 35621 & H. Eroğlu* [(VANF, Herb. M. Fırat) (in fruit mature)]; ibid. 19.06.2022, *M. Fırat 35946* [(VANF, Herb. M. Fırat) (in fruit ripe)]. Turkey. C10 Hakkari, Derecik (Rûbarok) district, Üçyan (Şerwêna) village, regionmoist stream banks, forest clearings around moist streams, 807 m, 37°05′36″ N, 44°18′22″ E, coll. 24.04.2020, *M. Fırat 35467* [(VANF, Herb. M. Fırat), (in flower)]; ibid. 02.05.2021, *M. Fırat 35613 & H. Eroğlu* [(VANF, Herb. M. Fırat), (in flower)]. North Iraq, Barzan region, Akrê, regionmoist stream banks**,** 569 m, 36°31′44″ N, 44°13′36″ E, coll. 20.04.2019, *M. Fırat 34785 & T. Saylaman* [Herb. M. Fırat), (in flower)].

Habitat: Regionmoist stream banks, forest clearings around moist streams 500-1300 m.

Phenology: Flowering from late April to May, fruiting from June to July.

Distribution in Turkey: Hakkari Province.

General distribution: Iran, Iraq and Turkey.

Vernacular name: ***Notholirion koeiei*** is called “Qomele” in Kurdish (Kurmanci dialect) by the local people of Derecik (Rubarok) and is called “Gol helîn” in Kurdish

(Behdini dialect) by the local people of Akrê (Region of Barzan).

Figure 3. A, B- Natural habitat and habit of *Notholirion koeiei*

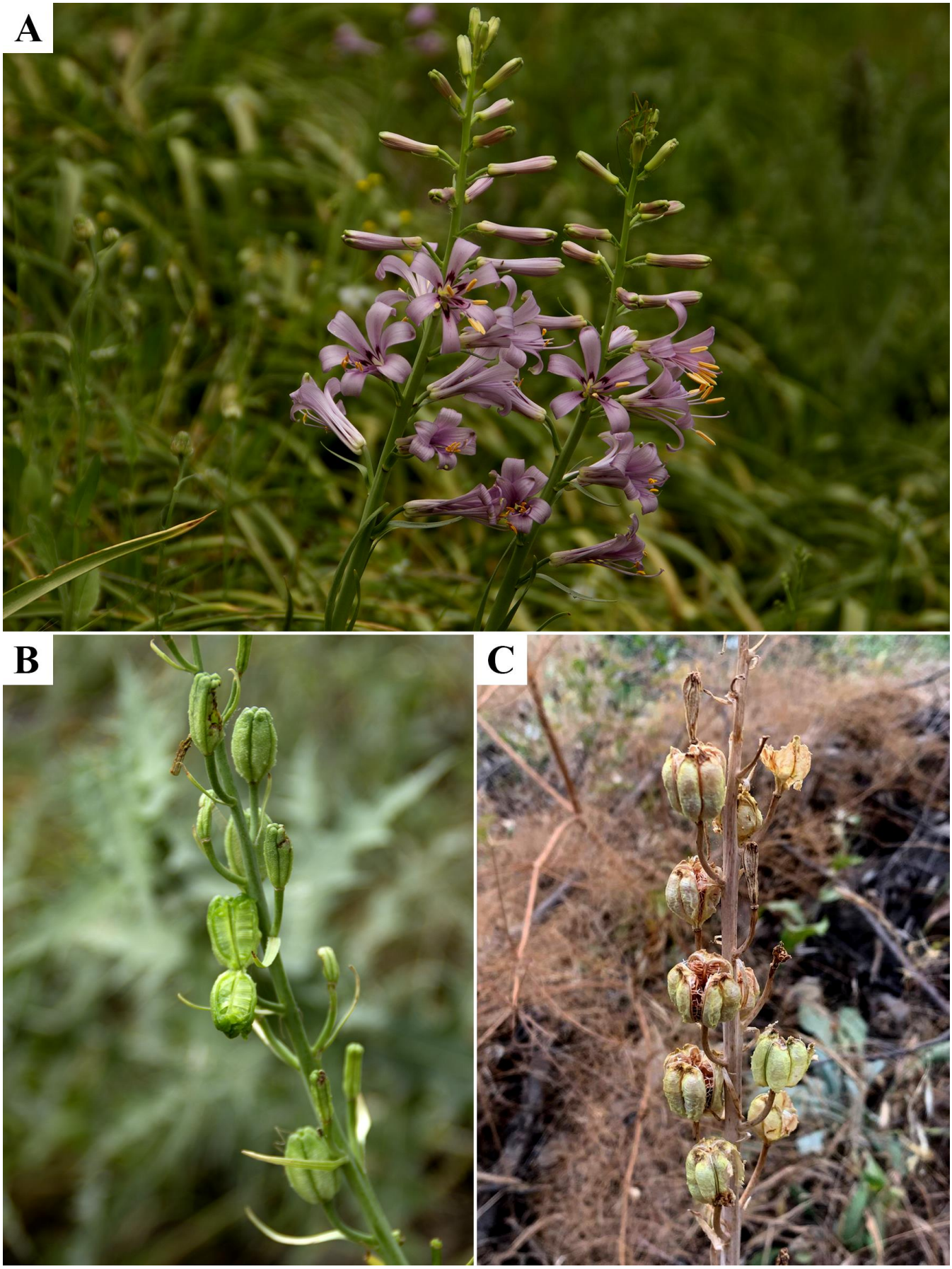

Figure 4. Flowering and fruiting inflorescences of *Notholirion koeiei*: **A**- flowering inflorescence, **B**- fruiting inflorescence in mature stage, **C**- fruiting inflorescence in ripe stage (capsule 3 valved, opening longitudinally)

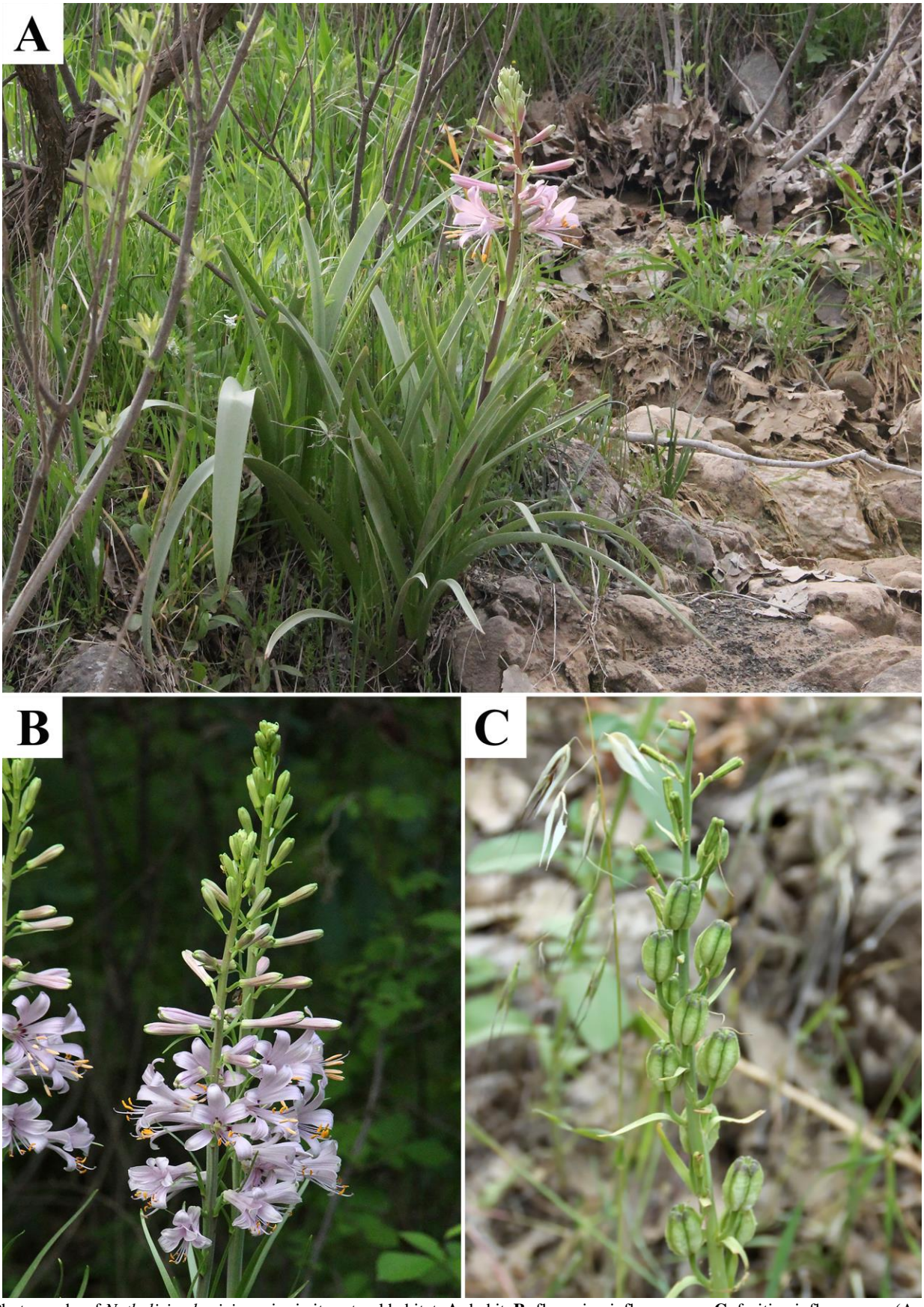

Figure 5. Photographs of *Notholirion koeiei* species in its natural habitat: **A**- habit, **B**- flowering inflorescence, **C**- fruiting inflorescence (A- photograph by Muhabbet Kemal Koçak and B- Hanife Geçer)

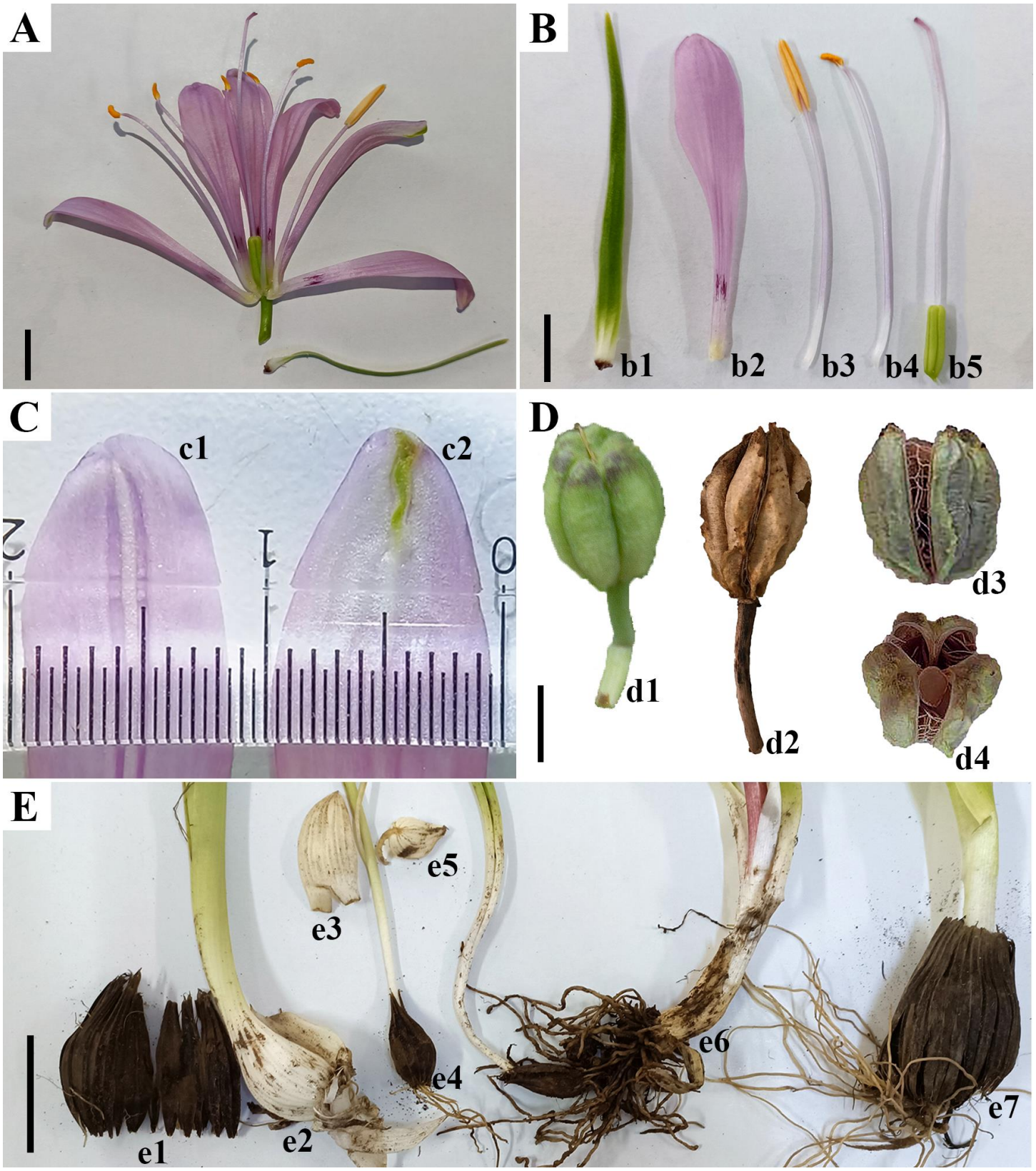

Figure 6. Detailed photos of *Notholirion koeiei*: **A**- flower (bar=1 cm); **B**- dissected flower (**b1**- bract, **b2**- inner tepal, **b3**- immature stamen, **b4**- mature stamen, **b5**- pistil) (bar=1 cm); **C**- upper wiev of tepals (**c1**- inner tepal, **c2**- outer tepal); **D**- stages of fruits (**d1**- mature fruit, **d2**, **d3**, **d4**- ripe fruits and capsule 3 valved, opening longitudinally) (bar=1 cm); **E**- bulbs and tunics (**e1**- outer tunica, **e2**- inner tunica, **e3**- cataphylls, **e4**-unflowered bulb , **e5**- bulblets, **e6**- center of bulb and roots, **e7**- flowered bulb) (bar=5 cm)

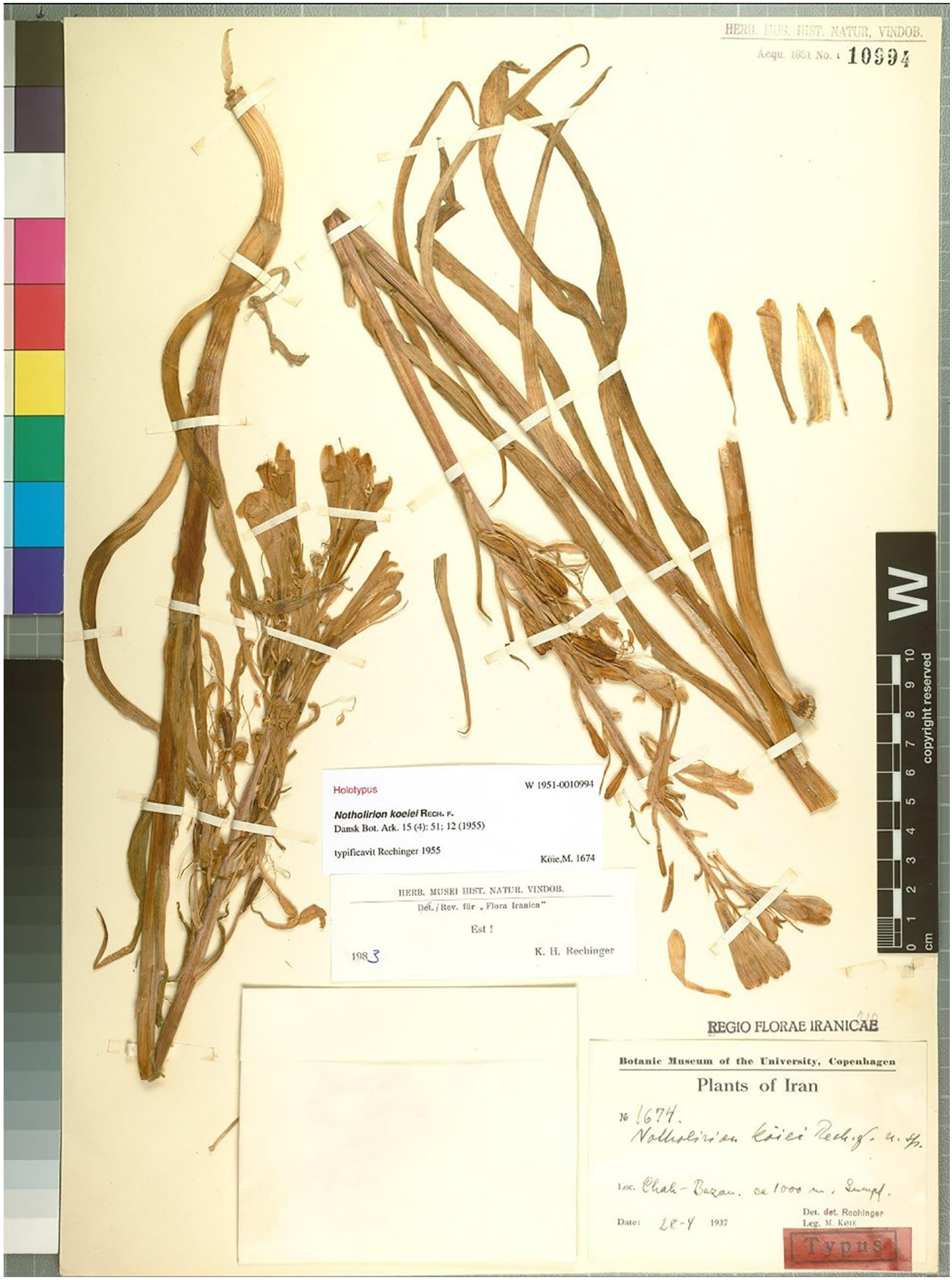

Figure 7. Holotype specimen of *Notholirion koeiei* (Naturhistorisches Museum Wien 1951-0010994)

Palynological properties: The pollen grains of *N. koeiei* are monads, heteropolar, monosulcate, prolate [Polar axis length: 71.63 (± 3.41), Equatorial length: 45.58 (± 2.79), Polar length/Equatorial length: 1.53, Exine thickness: 2.37 (± 0.2), Intine thickness: 0.97 (± 0.15), Sulcus width: 23.71 (± 4.44)], ornamentation is reticulate; the murus is striate, continuous, forming tuberculae, the lumina is flat, irregular, uneven, having granulate process. Towards the sulcus, murus becomes irregular and the lumina narrows and eventually disappear so the ornamentation around the sulcus looks like verrucate. The sulcus extends from one pole to the other, it becomes atrophied towards the poles and its ends are folded. The surface of the sulcus membrane is rugose-granulate (Table 1, Figure 8).

Table 1. Palynological properties of *Notholirion koeiei*

Characters	
P (polar axis length) (µm)	71.63 (± 3.41)
E (equatorial axis length) (µm)	45.58 (± 2.79)
Pollen shape (P/E)	prolate (1.53)
Et (exine thickness) (µm)	2.37 (± 0.2)
It (intine thickness) (µm)	0.97 (± 0.15)
Sw (sulcus width) (µm)	23.71 (± 4.44)
Sulcus membrane ornamentation	rugose-granulate
Structure	tectate
Ornamentation	reticulate (The circumference of the sulcus is verruca-like)

Seed surface properties: Seed ornamentation type of the *N. koeiei* is reticulate. The structures of the anticlinal cell walls of the examined species is raised, the periclinal cell walls is in concave structure. Also, the shape of epidermal cells on the seed surface is polygonal structures (Table 2, Figure 9).

Other examined specimens: Turkey, C10 Hakkari: Derecik, Üçyan village, rocky and woody streamside, 870-960 m, 27.04.2022, M.Kemal & H.Geçer; Iran: Lorestan: Shah Bazan, 1000 m, 28.04.1937, Køie 1674 (isotypus: C10013964 photo!).

Discussion

With this study, a new genus has been added to the Liliaceae family in the Flora of Turkey. When the distribution area of the *Notholirion koeiei* is examined, it is quite natural that the species is on the Turkish side of the border, since the place where the species was last detected is a region very close to the Iraqi-Turkish border (Al-Khayat, 1999).

Table 2. Macro and micromorphological features of seeds of *Notholirion koeiei*

Characters	
Seed length (mm)	4.86 (± 0.71), (min: 3.05; max: 6.34)
Seed width (mm)	3.58 (± 0.56), (min: 2.64; max: 5.10)
Length/width	1.36
Seed shape	ovoid to half-moon shaped
Ornamentation	reticulate
Seed color	brown
Anticlinal cell walls	raised
Periclinal cell walls	concave

No photographs of the species taken in its natural habitat were found in the literature research. In this study, the photos of the species were taken from its natural habitat.

In previous studies, it was determined that the pollen grains of *N. thomsonianum* were 80.6–87.2 × 42.2–46.0 µm in size and the sulcus extended from one pole to the other pole (Kosenko, 1999); pollen grains of *N. bulbuliferum* were 59.40–59.58 × 26.56–27.0 µm in size and the sulcus did not completely extend from one pole to the other (Hu et al., 2021). In our study, the micromorphological features of pollen grains of *N. koeiei* were determined for the first time. It was determined that the pollen grains were 69.08–76.01 × 42.68–49.92 µm in size and the sulcus extended from one pole to the other. When pollen sizes are considered, it is seen that pollen grains of *N. koeiei* were smaller than pollen grains of *N. thomsonianum* and larger than pollen grains of *N. bulbuliferum*. In addition, pollen grains of *N. koeiei* were more similar to pollen grains of *N. thomsonianum* due to the feature of the sulcus extending from one pole to the other.

Anther length is used as the distinguishing character when diagnosing the two species belonging to the genus of Iranian flora. According to the diagnostic key in the flora, the anther length of the *N. thomsonianum* species is approximately 10 mm, and the anther length of the *N. koeiei* species is 4–6 mm (Wendelbo, 1990). In our study, it was determined that the anther length of the *N. koeiei* was 7–9 mm in the early period and 3–5 mm in the mature period. While diagnosing the species belonging to the genus, it was concluded that in order not to make any

mistakes, attention should be paid to the fact that the anthers measured are mature anthers.

Notholirion koeiei is a very showy, eye-pleasing plant. It has the potential to be an ornamental plant even as it is without being selected. The authors draw attention to the conservation, reproduction and commercialization of this fascinating species.

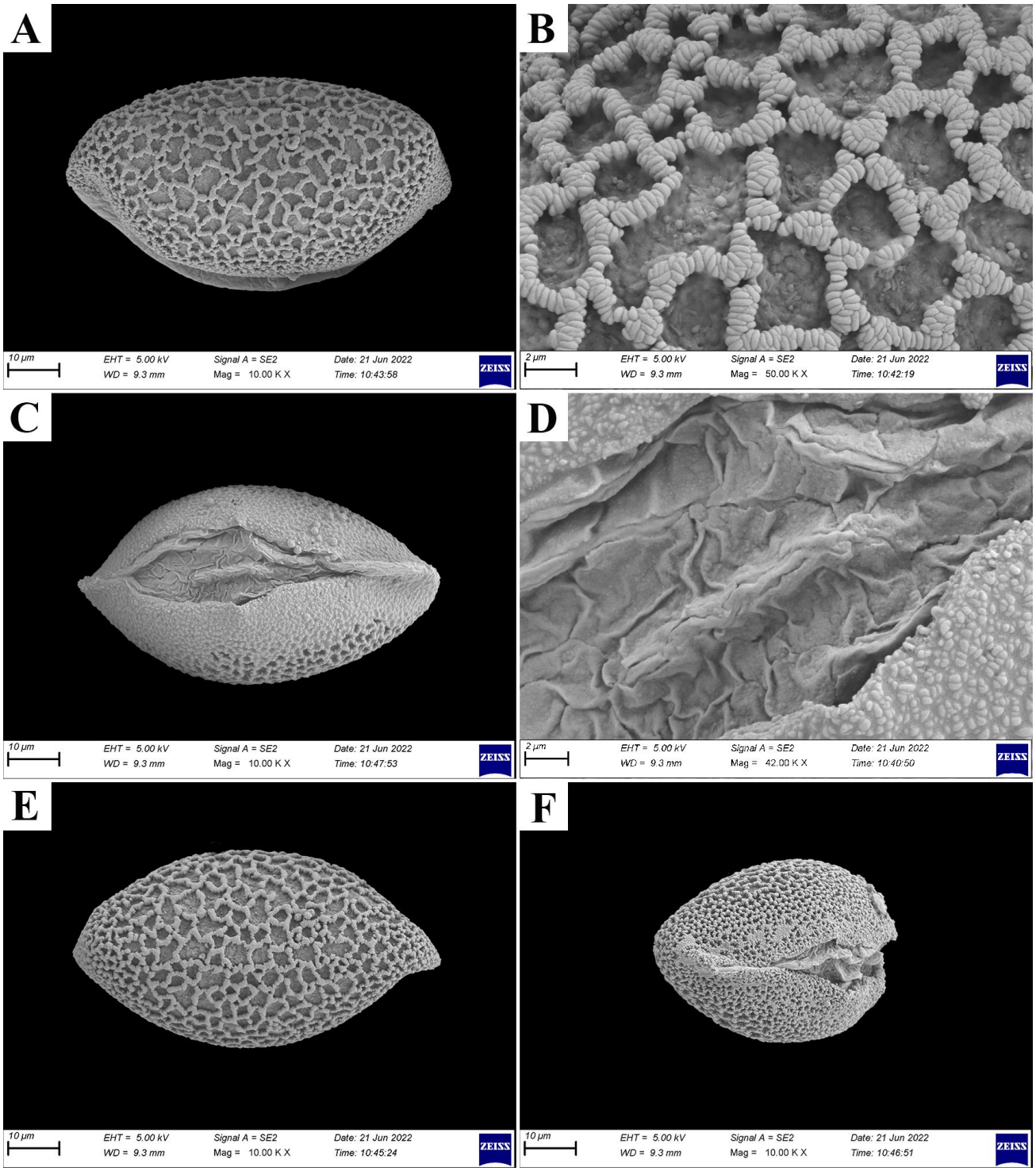

Figure 8. SEM photographs of pollen grains of *Notholirion koeiei*: **A**- equatorial view, **B**- ornamentation in equatoial view, **C**- polar-distal view, **D**- ornamentation in polar distal view, **E**- polar-proximal view, **F**- polar view

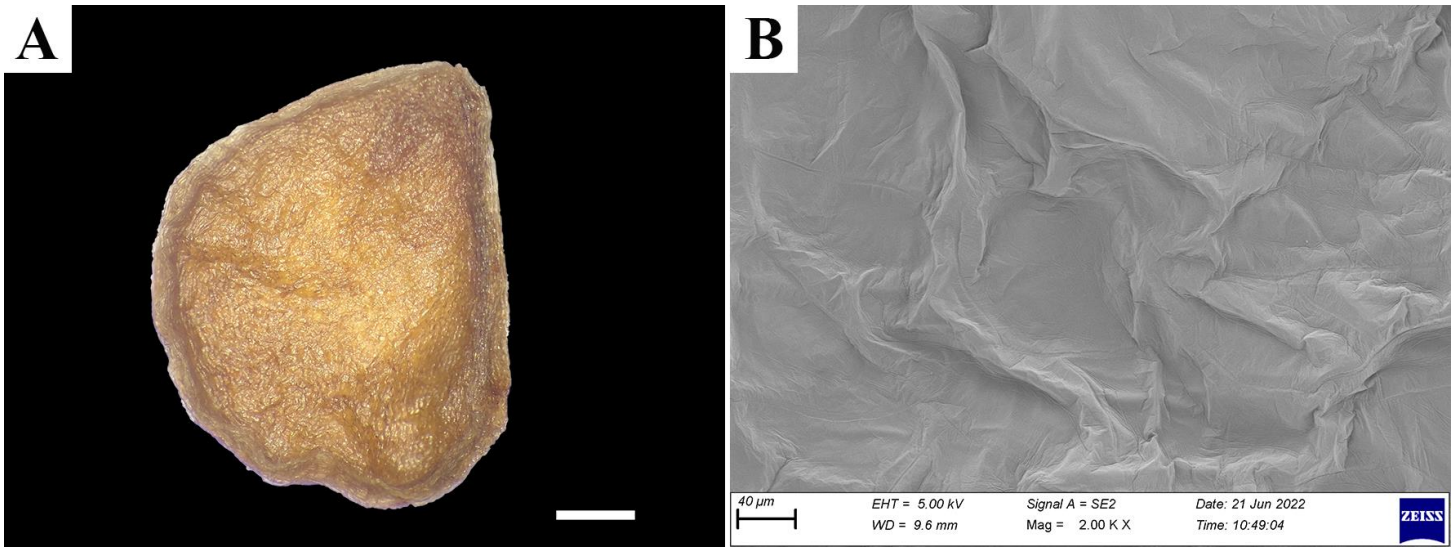

Figure 9. Seed photographs of *Notholirion koeiei*: **A**- general view of the seed under a stereo microscope (bar =1mm), **B**. surface view of seed under the SEM

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Conflicts of Interest

No potential conflict of interest was reported by the author.

Ethical approval

No need to ethical approval.

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