1. Introduction

Saxifraga L., the most species-rich genus of Saxifragaceae, is dominantly distributed in montane to alpine vegetation belts in mountain ranges of the Northern Hemisphere (Soltis, 2007; Tkach et al., 2015). The genus comprises more than 440 species worldwide (Tkach et al., 2015) and 21 species in Turkey (Matthews, 1972; Aslan, 2012; Fırat, 2016). The Caucasus region is recognized as one of the world’s 35 biodiversity hotspots (Marchese, 2015), and the plant biodiversity of this region is facing significant threats (Solomon et al., 2013). The Turkish part of this hotspot holds approximately 3210 vascular plant taxa, of which 465 are endemic to Turkey (Terzioğlu et al., 2015). The mountainous part of the Caucasus, including the northeastern part of Turkey, is among the centers of biodiversity for Saxifraga (Tkach et al., 2015). The Altındere Valley National Park, in northeastern Turkey, is home to many endemic species. This national park was studied floristically by Anşin (1979) for the first time, after which 2 further surveys focused on the subalpine-alpine (Palabıı-Uzun and Anşin, 2006) and forest ecosystems of the valley (Uzun and Terzioğlu, 2008). In the latter study, concentrating on the type location of the present new taxon, 383 vascular taxa were reported, including 16 endemics, and 2 Saxifraga species: S. paniculata Mill. and S. rotundifolia L.

During an excursion in the Altındere Valley in April 2013, the authors found dwarf Saxifraga on a damp and shady rock below the Sumela Monastery in the valley (A7 Trabzon). Literature and herbarium surveys revealed that the plants did not belong to any of the taxa recorded from the national park; instead, they represented Saxifraga artvinensis V.A.Matthews, which is endemic to Turkey, and thus only known from the type location (A8 Artvin). Further comparisons showed that the specimens represented a new subspecies of S. artvinensis.

2. Materials and methods

Morphological characters were noted and measured from the authors’ collection from the type locality. To determine the morphological limits of the new and related taxa, additional plant material for morphological and molecular studies was also collected during the field trips (Table 1). All of the morphological measurements were done using at least 3 specimens. An identification key of the new subspecies and related species is therefore given, together with images of both the subspecies and line drawings of useful distinguishing characteristics. Specimens of 2 sub-
species of *S. artvinensis* were deposited in the Herbarium of the Karadeniz Technical University, Faculty of Forestry (KATO) and Department of Biology (KTUB).

The total genomic DNA was extracted from healthy leaves dried with silica gel or the herbarium materials following the modified cetyl trimethylammonium bromide extraction procedure of Doyle and Doyle (1987). Primers internal transcribed spacer ITS4 and ITS5 (White et al., 1990) were used to amplify the nrDNA ITS region. The polymerase chain reaction (PCR) protocol for the amplification of the region followed that of Gültepe et al. (2010). The PCR products were sequenced by Macrogen Inc. (Seoul, Korea) using the ITS4 and ITS5 primers. For the phylogenetic analysis, 9 sequences belonging to *Saxifraga* were newly generated (Table 1) and 15 more were downloaded from GenBank, comprising 13 of *Saxifraga* and 2 selected as outgroups (Table 1). *Chrysosplenium alternifolium* L. and *Micranthes nivalis* (L.) Small were the chosen outgroup for the phylogenetic reconstruction. All of the sequences (24 accessions) were aligned using Muscle v.3.8.31 (Edgar, 2004) and edited in PhyDE v.0.9971 (Müller et al., 2010). Indels were coded as informative characters according to the Simple Indel Coding method (Simmons and Ochoterena, 2000), as implemented in the program SeqState v.1.40 (Müller, 2005), and added at the end of the sequence data set before being subjected to the maximum parsimony (MP) analysis. The MP analysis was conducted using the parsimony ratchet (Nixon, 1999) with PRAP v.2.0 (Müller, 2004) in combination with PAUP v.4.0b10 (Swofford, 2002). Standard ratchet settings were used (200 ratchet iterations, with 25% of the positions randomly upweighted (weight = 2) during each replicate, and 10 random addition cycles). The generated command files, also including the nexus data matrix, were run in PAUP using the heuristic search option with the following parameters: all of the characters had equal

| Taxa                                      | Voucher/reference                  | Code/GenBank accession number in the MP tree |
|-------------------------------------------|------------------------------------|---------------------------------------------|
| *S. adscendens* L.                       | M. A. Chapman and John M. Burke, Evolution, 2007, 61-7: 1773–1780 | EF028688                                    |
| *S. artvinensis* subsp. *artvinensis*     | turkey, Coşkunçelebi 1278 (KTUB)  | C1278/MP059938                              |
| *S. artvinensis* subsp. *artvinensis*     | turkey, Coşkunçelebi 1279 (KTUB)  | C1279/MP059939                              |
| *S. artvinensis* subsp. *artvinensis*     | turkey, Coşkunçelebi 1280 (KTUB)  | C1280/MP059940                              |
| *S. artvinensis* subsp. *meryemii*        | turkey, Terzioğlu & Coşkunçelebi 1246 (KTUB) | T&C1246/MP059941 |
| *S. bulbifera* L.                        | Italy, Fiuminata, Conti (MA)       | AF261166                                    |
| *S. exarata* Vill.                       | Austria, Glockturmi, Plats D. Gomez 1994 (JACA) | AJ233861                                    |
| *S. cymbalaria* L.                       | Ferguson 1994-04                   | AF087599                                    |
| *S. flagellaris* Willd. subsp. *stenophylla* (Royle) Hulten | Tajikistan, B. Dickore, 18385 (MSB) | KU524187                                    |
| *S. gracca* Boiss. & Heldr.              | Greece, Olimbos, Stauros, Richards (RNG) | AF261179                                    |
| *S. hederacea* L.                        | Italy, Sicily, Trapani             | KU524139                                    |
| *S. hirculus* L.                         | Canada, Yukon Territory            | MG237161                                    |
| *S. juniperifolia* Adams                 | turkey, Coşkunçelebi 1284 (KTUB)  | C1284/MP059943                              |
| *S. juniperifolia* Adams                 | turkey, Coşkunçelebi 1244 (KTUB)  | C1244/MP059944                              |
| *S. moschata* Wulfen                     | turkey, Coşkunçelebi 1282 (KTUB)  | C1282/MP059942                              |
| *S. paniculata* Mill.                    | turkey, Coşkunçelebi 1281 (KTUB)  | C1281/MP059937                              |
| *S. rotundifolia* L.                     | turkey, Coşkunçelebi 1283 (KTUB)  | C1283/MP059936                              |
| *S. rotundifolia* L.                     | bbg 267-94-80-10                  | AF087598                                    |
| *S. sancta* Gris.                        | Greece: M. Roesser 2700 (HAL)      | LN812523                                    |
| *S. sempervivum* K.Koch                   | Kew 1984-3743                     | AF087590                                    |
| *S. tridactylites* L.                    | M. A. Chapman and John M. Burke, Evolution, 2007, 61-7: 1773–1780 | EF028687                                    |
| *S. yezhiensis* C.Y.Wu                   | China: C.H. Wang, 68389 (HUH)      | KU524203                                    |
| *Micranthes nivalis* (L.) Small           | Denmark, Groenland                | LM654384                                    |
| *Chrysosplenium alternifolium* L.        | Poland, PE: 01505547              | N375572                                     |
weight, simple addition of sequences, tree bisection and
reconnection branching swapping, maxtrees setting to
100 and autoincreased by 100, one nonbinary starting tree
arbitrarily dichotomized before branch swapping, and only
1 tree saved. A majority-rule consensus tree was calculated
from the most parsimonious trees. Jackknife (JK) support
values for the nodes found by the MP analysis were
calculated in PAUP by applying the optimal JK parameters
according to the method of Farris et al. (1996) with 10,000
JK replicates.

3. Results and discussion

Saxifraga artvinensis V.A.Matthews subsp. meryemii
Terzioğlu & Coşkunç. subsp. nov. (Figure 1)

S. artvinensis subsp. meryemii is easily distinguished
from subsp. artvinensis by its pilose flowering stems
(not glabrous), flowers 3–8 (not 3–5), pedicels subsessile
(not longer than flowers) and sepals hairy at base (not
glabrous), and its distribution at altitudes of 1100–1150 m
in forest (not in alpine zone higher than 2135 m) (Figures
2 and 3).

Type: —Turkey. A7 Trabzon: Altındere Vadisi National
Park, around the Sumela Monastery, 1126 m, 31.03.2013,
Terzioğlu & Coşkunçelebi 1246 (KATO 9843), holo:
KATO; iso: KTUB.

Description: —Perennial, caespitose forming
 cushions up to 10 cm in diameter. Cauline shoots erect,
imbricate-leaved, previous years’ dead leaves light brown
and remaining in dense rosettes. Leaves lanceolate to
linear-lanceolate, glabrous, not lime-encrusted, margin
ciliate in lower half only. Flowering stem 1–4 cm long,
pilose. Inflorescence racemose with 3–8 flowers, pedicel
pubescent, up to 2.5 mm long, shorter than flower. Sepals
2–3.5 mm long, oblong-oval, glabrous, ciliate-margined.
Petals 3–5 mm long, linear-spathulate or oblong-
spathulate, white, shorter than stamens. Fl. 3–4. Damp
rocks under oriental spruce forest, 1100–1150 m.

Distribution, habitat, and conservation status:
— S. artvinensis subsp. meryemii is endemic to Turkey. It
belongs to the Euxinian element, and grows on a damp
and shady rock in the Picea orientalis (L.) Peterm. forest
between 1100 and 1150 m, together with Pachyphyagma
macrophyllum (Hoffm.) Busch, Geranium robertianum
L., Impatiens noli-tangere L., Fragaria vesca L., Saxifraga
paniculata Mill., Sanicula europaea L., Telekia speciosa
(Schreb.) Baumg., Petasites albus (L.) Gaertn., Cyclamen
parviflorum Pobed., Brachypodium sylvaticum (Hudson) P.
Beauv. and Festuca drymeja Mert. & Koch.

This is very different from the habitat of subsp.
artvinensis, which occurs at alpine elevations between
2135 and 2410 m (Figure 4). This new subspecies is a
narrow local endemic and is only known from the type
locality. There are approximately 175 km between the 2
subspecies of S. artvinensis. Currently, the habitat quality
is high, but it is under the negative effects of the religious
tourism related to the Sumela Monastery. The entire known
population comprises less than 20 individuals, covers a
single large rock, and has an area of occupancy smaller
than 100 m². Consequently, the threat category of this new
subspecies has been assessed as critically endangered [CR
B1ab(ii,iii,iv)+2ab(i,ii)] according to the International
Union for Conservation of Nature (2014).

Figure 1. Saxifraga artvinensis subsp. meryemii. a- General view (scale bar: 0.5 cm), b- flower (scale bar: 1 mm), c- leaf (scale bar: 1
mm), d- gynoecium (scale bar: 0.5 mm), e- stamen (scale bar: 0.5 mm), f- holotype (Terzioğlu & Coşkunçelebi 1246, KATO 9843).
Figure 2. Inflorescence and pedicels: a- *S. artvinensis* subsp. *meryemii*, b- *S. artvinensis* subsp. *artvinensis*, c- *S. juniperifolia*. Leaves: d- *S. artvinensis* subsp. *artvinensis*, e- *S. juniperifolia*, f- *S. artvinensis* subsp. *meryemii*.

Figure 3. Habitat and habits. a- *Saxifraga artvinensis* subsp. *meryemii*, b- *S. artvinensis* subsp. *artvinensis*. 
Additional specimens examined: — *S. artvinensis*: A8 Artvin (Çoruh): Tiryal Dağı, above Murgul, 2300 m, shady vertical igneous rocks, 23.06.1957, Davis & Hedge, D. 29957 (Holotype: E photo); Murgul, Tiryal Dağı, 2420 m, damp rocks, 19.06.2018, Terzioğlu & Coşkunçelebi 1278, 1279, 1280 (KTUB). *S. juniperifolia* Adams A8 Artvin (Çoruh): Şavval Tepe above Murgul, 2800 m, D.32290 (E photo). Trabzon: Çaykara, Uzungöl, Demirkapı Dağı, rocky places, nival zone, 3102 m, 19.09.2013, Coşkunçelebi 1244 (KTUB). A8 Trabzon: Demirkapı Dağı, above Aygr Gölü, 3208 m, cliffs, 20.06.2018, Coşkunçelebi 1284 (KTUB). *S. moschata* 1781: 128): A8 Trabzon: Demirkapı Dağı, above Aygr Gölü, 3000 m, cliffs, 20.06.2018, Coşkunçelebi 1282 (KTUB). *S. paniculata*: A8 Artvin: Murgul, Tiryal Dağı, 2306 m, 19.06.2018, Coşkunçelebi 1283 (KTUB). *S. rotundifolia*: A8 Artvin: Murgul, Tiryal Dağı, 2306 m, 19.06.2018, Coşkunçelebi 1283 (KTUB). *S. sancta*: B1 Balikesir: Edremit, Kazdağ, Sarıkız site, limestone, 1600 m, 08.05.2004, F. Satil 1316 (TTUB).

**Etymology:** —This new subspecies is named in honor of the first author’s mother, who died in 2008.

Key to the subspecies of *S. artvinensis*:
—Flowering stem and base of sepal glabrous, pedicels longer than flowers, flowers produced from June–July; alpine plant, at altitudes of 2135–2410 m.

**subsp. artvinensis** —Flowering stem and base of sepal pilose, pedicels as long as or shorter than flowers, flowers produced from March–April; forest plant, at altitudes of 1100–1150 m.

**subsp. meryemii**

**Relationship and molecular phylogeny:** The Saxifraga species distributed in Turkey were not divided into sections by Matthews (1972). However, according to Gornall (1987), *S. artvinensis* should be classified under the sect. *Porphyron* Tausch subsect. *Kabschia* (Engler) Rouy & Camus. Depending on both the morphological (Table 2) and molecular studies (Figure 5), this new subspecies clearly belongs to *S. artvinensis*. A comparison of the diagnostic morphological characters of the 2 subspecies of *S. artvinensis* is given in Table 2.

Alignment of the entire nrDNA ITS sequence, including the outgroups, resulted in 731 characters. Identical sequences were observed in the entire ITS regions of samples belonging to subsp. *artvinensis* (3) and subsp. *meryemii* (1). In the MP tree, these 4 accessions of *S. artvinensis* were grouped with a high JK support value (93%) (Figure 5). The MP tree also revealed that *S. juniperifolia* is sister to *S. artvinensis*, with maximum JK support (99%) among the studied taxa. Because *S. juniperifolia* was treated under the sect. *Porphyron* by Gornall (1987), our data supported placing *S. artvinensis* under this section.

**Figure 4.** The distribution in northeastern Turkey and habitat of *S. artvinensis* subsp. *meryemii*: a - Conifer forest at 1125 m in Trabzon. *S. artvinensis* subsp. *artvinensis*; b - Alpine rocky slopes at 2410 m in Artvin.
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