



## Three new species of *Paronychia* (Caryophyllaceae) from Turkey

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### Abstract

On the basis of both morphological and molecular data, three new species belonging to the genus *Paronychia* were described from Turkey: *P. aksoyii* (from Tortum, Erzurum) which is related to *P. saxatilis*, *P. kocii* (from Kelkit, Erzincan) which is related to *P. turcica*, and *P. davrazensis* (from Isparta) which is related to *P. pontica*. Morphology, notes on ecology, conservation status and distribution maps are provided for each new species, as well as a morphological comparison with the related taxa is given.

**Keywords:** endemism, molecular data, morphology, new taxon, *Paronychia*.

### Introduction

The genus *Paronychia* Miller (1754: without pagination) comprises approximately 110 species, with a subcosmopolitan distribution (they do not occur in southern Africa, Southeast Asia), and centres of diversity in the Mediterranean basin, Turkey, SE-USA and Peru/Bolivia (Bittich 1993). The flora of Turkey includes 42 taxa belonging to *Paronychia* (31 species, 5 subspecies and 6 varieties; see Chaudhri, 1967–68; Davis *et al.* 1988).

As part of the ongoing taxonomical study of *Paronychia* in Turkey, we collected from different locations about 265 samples, and observed that some populations cannot be identified with any of the currently known *Paronychia* species. As a consequence we here propose to describe three new species for science, also providing a comparison with the related taxa.

### Materials and methods

The present work is based both on a review of the relevant literature, floristic surveys, and on the examination of material preserved at ANK, GAZI, and KTUB (acronyms according to Thiers 2016+).

Total genomic DNAs were extracted from fresh healthy leaves or herbarium material according to Doyle & Doyle (1987). ITS (Internal transcribed Spacer) regions were amplified with universal ITS4 and ITS5 primers (White *et al.* 1990) according to Gültepe *et al.* (2010). Sequencing of the PCR products were carried out with the aid of Macrogen Inc. (Seoul, Korea) by using primers ITS4 and ITS5. For the phylogenetic reconstruction, fourteen accessions belonging to *Paronychia* and 4 accessions belonging to the genera *Herniaria* Linnaeus (1753:218), *Gymnocarpus* Forsskål (1775: 65), *Stellaria* Linnaeus (1753: 401) and *Scleranthus* Linnaeus (1753: 406) were used. Sequence data for *Stellaria chinensis* Regel (1862: 283) (JN589133) and *Gymnocarpus rotundifolius* Petrusson & Thulin (1996: 19) (AJ310974), obtained from GenBank and sequence data for 16 accessions, are newly presented in this study (Table 1). All sequences were aligned with Bioedit v. 7.0 software (Hall 1999). Maximum Parsimony (MP) analysis was conducted by MEGA5 (Tamura *et al.* 2011) software. The topology of the tree was constructed and evaluated with 1000 bootstrap replications (Felsenstein 1985).

**TABLE 1.** Voucher information used in the molecular study.

| Taxa                                    | Locality information                                                                                                                                                                                               |
|-----------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <i>P. pontica</i>                       | <b>B3</b> Eskişehir: between Eskişehir-Söğüt, near Oluklu village, sandy steppes, 1000–1040 m, 39°53'28"N, 030°14'29"E, 08.vii.2014, <i>Budak</i> 3137 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)    |
| <i>P. turcica</i>                       | <b>B9</b> Van: between Tatvan-Gevaş, above Koruklu village, calcareous rocky places, 1980–2000 m, 38°21'00"N, 042°40'39"E, 02.vii.2014, <i>Budak</i> 2991 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium) |
| <i>P. davrazensis</i>                   | <b>C3</b> Isparta: Davraz mountain, Kır yayla parting of the ways, 1936 m, 37° 36' 66" N, 031° 10' 06"E, 30.vii.2013, <i>E.Coşkunçelebi</i> 477b & M. Gültepe (KTUB)                                               |
| <i>P. saxatilis</i>                     | <b>C9</b> Van: Başkale, İspiriz mountain, calcareous rocky places, 3230–3260 m, 38°03'58"N, 043°57'21"E, 03.vii.2014, <i>Budak</i> 3010 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                   |
| <i>P. aksoyii</i>                       | <b>A8</b> Erzurum: Tortum, near Tortumkale village, 1580–1620 m, sandy steppes, 40°20'46"N, 041°29'36"E, 05.vii.2014, <i>Budak</i> 3060 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                   |
| <i>P. kocii</i>                         | <b>B7</b> Erzincan: between Pülümür and Erzincan, near pass, 1820–1880 m, steppes, 39°11'19"N, 039°52'27"E, 12.vii.2012, <i>Budak</i> 2685 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                |
| <i>P. boissieri</i>                     | <b>C6</b> Gaziantep: Above Dülük village, 37°09'22"N 037°21'33"E, 955 m, 19.05.2012, <i>Budak</i> 2541 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                                    |
| <i>P. kurdica</i> subsp. <i>kurdica</i> | <b>B4</b> Ankara: Şereflikoçhisar to Gölbaşı 25.km 39°07'16"N 33°21'24"E, 955 m, 22.06.2012, <i>Budak</i> 2630 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                            |
| <i>P. kurdica</i> subsp. <i>kurdica</i> | <b>B7</b> Erzincan: Erzincan to Kelkit ca. 8 km, 1900–1950 m, 12.07.2012, <i>Budak</i> 2684 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                                               |
| <i>P. echinulata</i>                    | <b>C1</b> Muğla: Bodrum, Yalıkavak coast, 37°07'47"N 027°16'55"E, 5 m, 21.05.2012, <i>Budak</i> 2555 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                                      |
| <i>P. argentea</i> var. <i>argentea</i> | Muğla: Marmaris, Hisarönü coast, 36°47'43"N 028°07'50"E, 1 m, 20.05.2012, <i>Budak</i> 2550 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                                               |
| <i>P. polygonifolia</i>                 | İzmir: Ödemiş-Bozdağ east of sky center, 26.06.2012, <i>Budak</i> 2644 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                                                                    |
| <i>P. euphratica</i>                    | <b>B7</b> Erzincan: Erzincan to Kelkit ca. 5 km, 1500–1600 m, 39°50'36"N 039°23'12"E, 27.07.2011, <i>Hamzaoglu</i> 6227 & <i>Budak</i> (Bozok Univ. Biology Dept. Herbarium)                                       |
| <i>P. euphratica</i>                    | <b>B7</b> Erzincan: Erzincan to Kelkit ca. 5 km, 1500–1600 m, 12.07.2012, <i>Budak</i> 2687 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                                               |
| <i>Scleranthus perennis</i>             | Edirne: near Lalapaşa, 41°50'48"N 26°44'37"E, 180 m, 15.05.2010, <i>Budak</i> 2389 & <i>Hamzaoglu</i> (Bozok Univ. Biology Dept. Herbarium)                                                                        |

## Taxonomic treatments

***Paronychia aksoyii*** Budak *sp. nov.* (Figures 1, 4).

**Type:**—TURKEY. Erzurum: Tortum, near Tortumkale village, 1580–1620 m, sandy steppes, 40°20'46"N, 041°29'36"E, 05 July 2014, *Budak* & *Hamzaoglu* 3060 (holotype GAZI!, isotypes KTUB!, ANK!, Bozok Univ. Biology Dept. Herbarium!).

**Diagnosis:**—*Paronychia aksoyii* is morphologically similar to *P. saxatilis*, from which differs by the stipules which are shorter than the leaves (not longer as in *P. saxatilis*), the sepals lanceolate, 2.00–2.25 mm long and acute at apex (not oblong, 2.25–2.75 mm long and obtuse at apex), the styles 0.9–1.0 mm long (not 0.7–0.8 mm long).

**Description:**—Caespitose perennial herb. Stems prostrate to ascending, much branched at the base, 3–7 cm long; nodes 6–9, internodes 2–5 mm long, glabrescent to sparsely retrorsely pubescent. Stipules lanceolate, 2.5–4.0 mm long, shorter than the leaves. Leaves elliptic-oblong, 3–6 × 1–2 mm, glabrescent to sparsely pubescent (hairs adpressed), margins ciliate, acute. Flowers arranged in terminal and subterminal glomerules, each one oblong-ovoid, 6–10 × 8–12 mm, 14–20-flowered; bracts ± broadly ovate, 4–4.5 × 3.5–4 mm, ± acuminate, concealing the flowers. Sepals equal, lanceolate, 2–2.25 × 1–1.25 mm, pubescent (hairs adpressed), acute, margins narrow scarious with 0.3–0.4 mm. Petals 0.7–0.8 mm long. Filaments 0.3–0.4 mm long, anthers 0.3–0.4 × 0.2–0.3 mm. Styles 0.9–1 mm long. Fruit pyriform, 1.2–1.5 × 1–1.2 mm, glabrous.



**FIGURE 1.** *Paronychia aksoyii*: A) habit, B) glomerule, C) fruit, D) bract, E) sepals, F) petals.

**Etymology:**—The species is named in honor of the eminent Turkish botanist Prof. Ahmet Aksoy (Akdeniz University, Antalya).

**Distribution and habitat:**—*Paronychia aksoyii* can be considered as a endemic Turkish species which is known only from the *locus classicus* in east Anatolia (Tortum/Erzurum). Where it grows at altitude of about 1600 m on stony sandy slopes in steppes.

**Phenology:**—Flowering time June–July; fruiting time July–August.

**Conservation status:**—The EOO of *Paronychia aksoyii* is about 30 km<sup>2</sup>. On the basis of the criterion B1a, the species is sesses as Critically Endangered (CR) (IUCN 2014).

**Other specimens examined:**—*Paronychia saxatilis*. TURKEY. Van: Başkale, İspiriz mountain, calcareous rocky places, 3230–3260 m, 38°03'58"N, 043°57'21"E, 03 July 2014, *Budak & Hamzaoglu 3010* (Bozok Univ. Biology Dept. Herbarium).

***Paronychia kocii* Budak sp. nov.** (Figs. 2, and 4).

**Type:**—TURKEY. Erzincan: between Pülümür and Erzincan, near pass, 1820–1880 m, steppes, 39°11'19"N, 039°52'27"E, 12 July 2012, *Budak & Hamzaoglu 2685* (holotype GAZI!, isotypes KTUB!, ANK!, Bozok Univ. Biology Dept. Herbarium!).

**Diagnosis:**—*Paronychia kocii* is morphologically similar to *P. turcica*, from which mainly differs by the stems glabrous-glabrescent (not glabrescent to sparsely retrorsely pubescent), the stipules 1.0–1.5(–2.0)mm long and shorter than the leaves (not 4–6 mm long and longer than), the sepals 2.00–2.25 mm long (not 2.25–2.75 mm long), the styles 0.3–0.4 mm long (not 0.7–0.9 mm long), and the fruits 1.00–1.25 mm long (not 1.6–1.8 mm long).

**Description:**—Caespitose perennial herb. Stems prostrate to ascending, much branched at the base, 7–14 cm long; nodes 6–9, internodes 4–10 mm long, glabrescent to sparsely retrorsely pubescent. Stipules ± lanceolate, 1.0–1.5 (–2.0) mm long, shorter than the leaves. Leaves linear-lanceolate, 3–4 × 0.7–1.5 mm, glabrescent, with margins ciliate, obtuse. Flowers arranged in terminal glomerules, each one oblong-ovoid, 4–7 × 6–9 mm, 5–8-flowered; bracts ± ovate, 5–6 × 2.5–5.0 mm, ± acuminate, concealing the flowers. Sepals equal, ± oblong, 2.0–2.25 × 1.0–1.25 mm, sparsely pubescent (hairs adpressed), obtuse, margins narrow scarious with 0.3–0.4 mm. Petals 0.4–0.6 mm long. Filaments 0.3–0.4 mm long; anthers 0.4–0.5 × 0.2–0.3 mm. Styles 0.3–0.4 mm long. Fruit pyriform, 1–1.25 × 0.7–0.8 mm, glabrous.

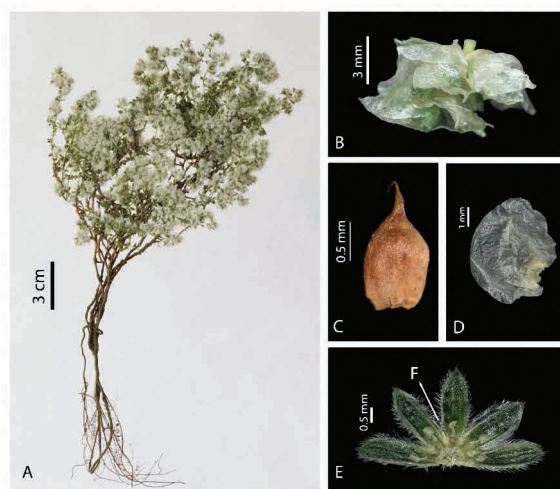
**Distribution and habitat:**—*Paronychia kocii* is an endemic species known only from the type locality (east Anatolia, Pülümür/Erzincan), where it grows at altitude of 1850 m on stony slopes in steppes.

**Phenology:**—Flowering time June–July; fruiting time July–August.

**Conservation Status:**—On the basis of IUCN (2014), and the criterion B1a, the EOO is about 30 km<sup>2</sup>, and *Paronychia kocii* can be assessed as Critically Endangered (CR).

**Etymology:**—The species is named in honor of the eminent Turkish botanist Ass. Prof. Dr. Murat Koç (Bozok University, Yozgat).

**Other specimens examined:**—*Paronychia turcica*. TURKEY. Van: between Tatvan–Gevaş, above Koruklu village, calcareous rocky places, 1980–2000 m, 38°21'00"N, 042°40'39"E, 02 July 2014, *Budak & Hamzaoglu 2991* (Bozok Univ. Biology Dept. Herbarium).



**FIGURE 2.** *Paronychia kocii*: A) habit, B) glomerule, C) fruit, D) bract, E) sepals, F) petals.

***Paronychia davrazensis* Budak *sp. nov.*** (Figs. 3, and 4).

**Type:**—TURKEY. Isparta: above Davraz sky center, 1920–1960 m, calcareous rocky places, 37°46'22"N, 030°44'35"E, 10 July 2014, Budak 3193 & Hamzaoglu (holotype GAZI!, isotypes KTUB!, ANK!, Bozok Univ. Biology Dept. Herbarium!).

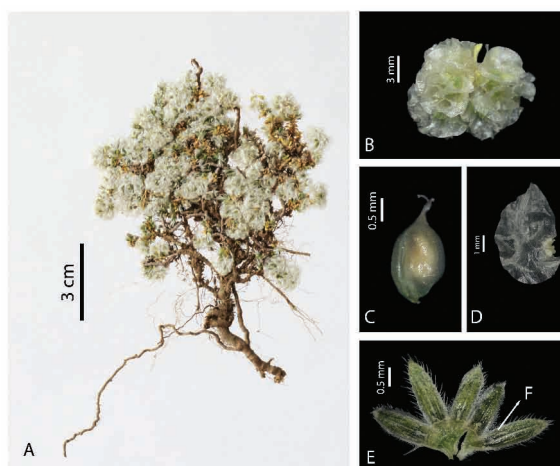
**Diagnosis:**—*Paronychia davrazensis* is morphologically similar to *P. pontica* from which differs by the stems 1–4 cm long and glabrous-glabrescent (not 2–7 cm long and glabrescent to sparsely retrorsely pubescent), the stipules longer than the leaves (not equaling the leaves), the sepals 1.8–2.1 mm long, acute with penicillate at apex and inflexed (not 2.25–2.5 mm long, acute at apex and not penicillate and erect), and the fruits 1.6–1.9 mm long (not 1.2–1.5 mm long).

**Description:**—Caespitose perennial herb. Stems prostrate to ascending, much branched at the base, 1–4 cm long; nodes 8–12, internodes 1–3 mm long, glabrous-glabrescent. Stipules ± lanceolate, 3.0–4.5 mm long, longer than the leaves. Leaves elliptic-obovate, 2–3.5 × 1.5–2.5 mm, glabrescent to sparsely adpressed pubescent, with margins ciliate, obtuse. Flowers arranged in terminal glomerules terminaly, each one ovoid, 8–12 × 8–11 mm, 15–22-flowered, bracts ± broadly ovate, 4–5 × 3–3.5 mm, ± acuminate, concealing the flowers. Sepals equal, elliptic-lanceolate, 1.8–2.1 × 0.8–1 mm, sparsely pubescent (hairs adpressed), acute, acute with penicillate at apex and inflexed, margin narrow scarious with 0.3–0.4 mm. Petals 0.8–0.9 mm long. Filaments 0.4–0.5 mm long; anthers 0.4–0.5 × 0.3–0.35 mm. Styles 0.5–0.6 mm long. Fruit pyriform, 1.6–1.9 × 1–1.2 mm, glabrous.

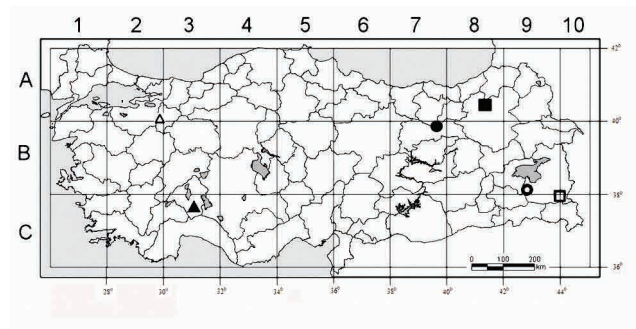
**Distribution and habitat:**—*Paronychia davrazensis* is an endemic species known only the type locality (SW-Anatolia, Davraz/Isparta), where it grows at altitude of 1940 m on rocky places in subalpine steppes.

**Phenology:**—Flowering from June to July, fruiting from July to August.

**Conservation Status:**—*Paronychia davrazensis* covers a EOO of about 30 km<sup>2</sup>. According to IUCN (2014) and the criterion B1a, it is assessed as Critically Endangered (CR).



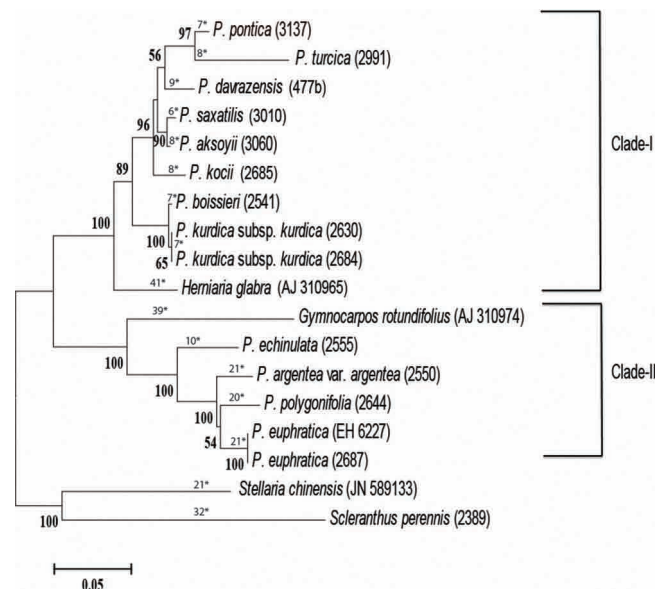
**FIGURE 3.** *Paronychia davrazensis*: A) habit, B) glomerule, C) fruit, D) bract, E) sepals, F) petals.



**FIGURE 4.** Distribution map of *Paronychia aksoyii* (■), *Paronychia saxatilis* (□), *Paronychia kocii* (●), *Paronychia turcica* (○), *Paronychia davrazensis* (▲) and *Paronychia pontica* (Δ) in Turkey.

**Vernacular name:**—The epithet was chosen from the locality “Davraz Dolamaotu” (Turkish).

**Other specimens examined:**—*Paronychia pontica*. TURKEY. Isparta: Davraz mountain, Kır yayla parting of the ways, 1936 m, 37° 36' 66" N, 031° 10' 06" E, 30 July 2013, *K. Coşkunçelebi* 477b & *M. Gültepe* (KTUB, paratype); Eskişehir: between Eskişehir-Söğüt, near Oluklu village, sandy steppes, 1000–1040 m, 39°53'28"N, 030°14'29"E, 08 July 2014, *Budak* 3137 & *Hamzaoğlu* (Bozok Univ. Biology Dept. Herbarium).



**FIGURE 5.** Most parsimonious phylogenetic tree based on the internal transcribed spacer. Numbers above branches are bootstrap values in percentages based on 1000 replicates and number with asterisk is the deletion numbers.

## Discussion

On the basis of the three new proposed species, the Flora of Turkey now includes 45 *Paronychia* species.

*Paronychia* is a polyphyletic genus based on molecular analyses (Oxelman et al 2002). The cladogram obtained by our study shows that the examined accessions are splitted in two major clades (Clade-I, and Clade-II), each one with 100 % of bootstrap value. This spitting clearly supports the polyphyletic structure of *Paronychia* as stated by Oxelman *et al.* (2002). The three new taxa, which was described in the present paper, are included in the Clade-I into a subclade together with *P. pontica*, *P. saxatilis*, and *P. turcica* (bootstrap value 96%). *P. davrazensis* is sister to the group *P. turcica*/*P. pontica* and these three taxa a separated from the other ones by a low bootstrap value (56%). *P. davrazensis* can be interpreted as a new species. *P. aksoyii*, which is grouped with *P. saxatilis* (bootstrap of 90%) grows in open forest between 1580 and 1620 m a.s.l., while *P. saxatilis* prefers rocky limestone slopes at above 3200 m a.s.l. *P. kocii* appears to be clearly separated being the basal taxa of the subclades *P. pontica*/*P. turcica*/*P. davrazensis*, and *P. saxatilis*/*P. aksoyii*.

**TABLE 2.** Morphological comparison among *Paronychia aksoyii*, *P. davrazensis*, *P. kocii*, *P. pontica*, *P. saxatilis* and *P. turcica*.

|                   | <i>Paronychia aksoyii</i>                                 | <i>Paronychia davrazensis</i>                                                     | <i>Paronychia kocii</i>                        | <i>Paronychia pontica</i>                                 | <i>Paronychia saxatilis</i>                               | <i>Paronychia turcica</i>                                  |
|-------------------|-----------------------------------------------------------|-----------------------------------------------------------------------------------|------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|
| <b>Stems</b>      | 3–7 cm long, glabrescent to sparsely retrorsely pubescent | 1–4 cm long, glabrous–glabrescent                                                 | 7–14 cm long, glabrous–glabrescent             | 2–7 cm long, glabrescent to sparsely retrorsely pubescent | 3–8 cm long, glabrescent to sparsely retrorsely pubescent | 3–11 cm long, glabrescent to sparsely retrorsely pubescent |
| <b>Stipules</b>   | 2.5–4.0 cm long, shorter than the leaves                  | 3.0–4.5 mm long, longer than the leaves                                           | 1.0–1.5(–2.0) mm long, shorter than the leaves | 2.5–4.0 mm long, equaling the leaves                      | 2.5–5.0 mm long, longer than the leaves                   | 4–6 mm long, longer than the leaves                        |
| <b>Leaves</b>     | elliptic–oblanceolate                                     | elliptic–obovate                                                                  | linear–lanceolate                              | elliptic–oblanceolate                                     | elliptic–obovate                                          | elliptic–obovate                                           |
| <b>Glomerules</b> | 8–12 mm in diameter                                       | 8–11 mm in diameter                                                               | 6–9 mm in diameter                             | 6–9 mm in diameter                                        | 9–15 mm in diameter                                       | 12–19 mm in diameter                                       |
| <b>Sepals</b>     | lanceolate, 2.00–2.25 mm long, acute at apex              | elliptic–lanceolate, 1.8–2.1 mm long, acute with penicillate at apex and inflexed | ± oblong, 2.00–2.25 mm long, obtuse at apex    | lanceolate, 2.25–2.50 mm long, acute at apex              | oblong, 2.25–2.75 mm long, obtuse at apex                 | oblong, 2.25–3.00 mm long, obtuse at apex                  |
| <b>Petals</b>     | 0.7–0.8 mm long                                           | 0.8–0.9 mm long                                                                   | 0.4–0.6 mm long                                | 1.1–1.4 mm long                                           | 0.6–0.7 mm long                                           | 0.6–0.7 mm long                                            |
| <b>Styles</b>     | 0.9–1.0 mm long                                           | 0.5–0.6 mm long                                                                   | 0.3–0.4 mm long                                | 0.4–0.6 mm long                                           | 0.7–0.8 mm long                                           | 0.7–0.9 mm long                                            |
| <b>Fruits</b>     | 1.2–1.5 mm long                                           | 1.6–1.9 mm long                                                                   | 1–1.25 mm long                                 | 1.2–1.5 mm long                                           | 1.4–1.8 mm long                                           | 1.6–1.8 mm long                                            |

Concerning the morphology of the three new taxa (see Table 2), *Paronychia aksoyii* is similar to *P. saxatilis* for characters of stipules which are shorter than the leaves (not longer as in *P. saxatilis*), the sepals lanceolate, and acute at apex (not oblong and obtuse at apex).

*P. kocii* is similar to *Paronychia turcica* from which mainly differs by the stems glabrous–glabrescent (not glabrescent to sparsely retrorsely pubescent), the stipules shorter than the leaves (not longer than). *P. davrazensis* is similar to *P. pontica* from which differs by the stems glabrous–glabrescent (not glabrescent to sparsely retrorsely pubescent), the stipules longer than the leaves (not equaling the leaves), the sepals acute with penicillate at apex and inflexed (not acute at apex and not penicillate and erect).

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