

New record of two feather mites (Acari: Sarcoptiformes: Astigmata) isolated from *Actitis hypoleucos* in South Korea

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Two feather mites, *Bychovskiata hypoleuci* Mironov and Ddabert, 1997 and *Phyllochaeta interifolia* (Mégnin and Trouessart, 1884) are reported for the first time in South Korea. Specimens of these two species were collected from the common sandpiper *Actitis hypoleucos*. The genera *Bychovskiata* Dubinin, 1951 and *Phyllochaeta* Dubinin, 1951 are also new reports for South Korea. Here, we provide morphological descriptions and illustrations of these two species. Additionally, we provide partial sequences of the mitochondrial cytochrome *c* oxidase subunit I (*COI*) as DNA barcodes.

Keywords: *Bychovskiata hypoleuci*, *COI*, common sandpiper, feather mite, *Phyllochaeta interifolia*, South Korea

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INTRODUCTION

The common sandpiper *Actitis hypoleucos* (Linnaeus, 1758) is widespread across central and northern Eurasian continent, and migrates in the winter to Africa, the Middle East, India, and Southeast Asia (Iwajomo and Hedenström, 2011; Lee *et al.*, 2014; Park, 2014). In Korea, this bird is recorded as a passage migrant and a breeding, summer visitor (Lee *et al.*, 2014). Thus far, 10 species of feather mites have been recorded from the common sandpiper worldwide (Dubinin, 1956; Gaud and Mouchet, 1957; 1959a; 1959b; Gaud, 1958; 1972; Vasyukova and Mironov, 1991; Mironov and Dabert, 1997; Dabert and Ehrnsberger, 1999; Dabert, 2003). However, there are no studies of feather mites from the common sandpiper in Korea.

The feather mite genus *Bychovskiata* is one of the 19 genera that belong to the family Avenzoariidae Oudamans, 1905, and comprises 25 species associated with birds of order Charadriiformes (Gaud and Atyeo, 1996; Mironov and Dabert, 1997; Krantz and Walter, 2009; Stefan *et al.*, 2014). This genus has the following diagnostic characteristics: (1) epimerites I are free; (2) diameter of ambulacral disc is shorter than tarsus length; (3) opisthosomal lobe is usually short and variably shaped in males; and (4) adanal disc corolla has two teeth or bulges in males (Vasyukova and Mironov, 1991; Gaud and Atyeo, 1996; Mironov and Dabert, 1997).

The genus *Phyllochaeta* is one of 14 genera that belong to the family Syringobiidae Trouessart, 1897 and contains 17 species (Gaud and Atyeo, 1996; Dabert, 2003; Krantz and Walter, 2009). This genus has been found on quills of wing feather on birds in the order Charadriiformes. The genus *Phyllochaeta* has the following diagnostic characteristics: (1) setae *cG* of leg I and II are varied; (2) terminal membranes are serrated in males; (3) tarsus IV has single apico-ventral spine in males; and (4) epigynum is semicircle-shaped without strongly enlarged branches in females (Vasyukova and Mironov, 1991; Dabert, 2003).

In this study, we recovered *B. hypoleuci* and *P. interifolia* isolated from the common sandpiper, which are their first records in Korea. We provide descriptions and illustrations of these two feather mites based on morphology, as well as provide the partial sequences of the mitochondrial cytochrome *c* oxidase subunit I (*COI*) as DNA barcodes.

MATERIALS AND METHODS

A common sandpiper (CWARC no. CN14-588) was rescued in Cheongyang-gun by the Chungnam Wild Animal Rescue Center (CWARC). However, it died and was stored at -20°C freezer in CWARC. Specimens of *B. hypoleuci* and *P. interifolia* were collected from the vanes and quills of wing feather. The collected mites were di-

rectly preserved in 95% ethyl alcohol. The mite specimens were cleared using lactic acid for 24 hours and then mounted on micro slides using PVA (PVA stock solution 56%, lactic acid 22% and phenol 22%) as the mounting medium (Downs, 1943). The specimens were photographed using a microscopic digital camera (Leica, Wetzlar, Germany) and a scanning electron microscope (SEM) (Model Hitachi S-4300SE; Japan). Before to SEM imaging, we used TWEEN 20 (Model 036K00963; Sigma, USA) to remove debris on specimens. The mites were fixed for four hours at 4°C in 2.5% glutaraldehyde and 2% Paraformaldehyde in PBS and then post-fixed for four hours at 4°C in 2% osmium tetroxide solution in distilled water. The specimens were dehydrated using an ascending alcohol series (30%, 50%, 70%, 80%, 95%, and 100% ethyl alcohol; 10 min each), followed by using

hexamethyldisilazane (Sigma, St. Louis, USA) for 1 hour. The specimens were then dried in a sealed box with silica gel for 24 hours. The morphological terms and measurements follow Gaud and Atyeo (1996) and Norton (1998). All measurements are given in micrometers. All examined specimens were deposited in the National Institute of Biological Resources (NIBR) and Inha University, Korea.

DNA sequencing

DNA was extracted from a single leg of each specimens using a Tissue DNA Purification Kit (Cosmogentech Inc., Seoul, Korea) according to the manufacturer's instructions. PCR amplification, purification and sequencing were performed according to the methods described by Han *et al.* (2016).

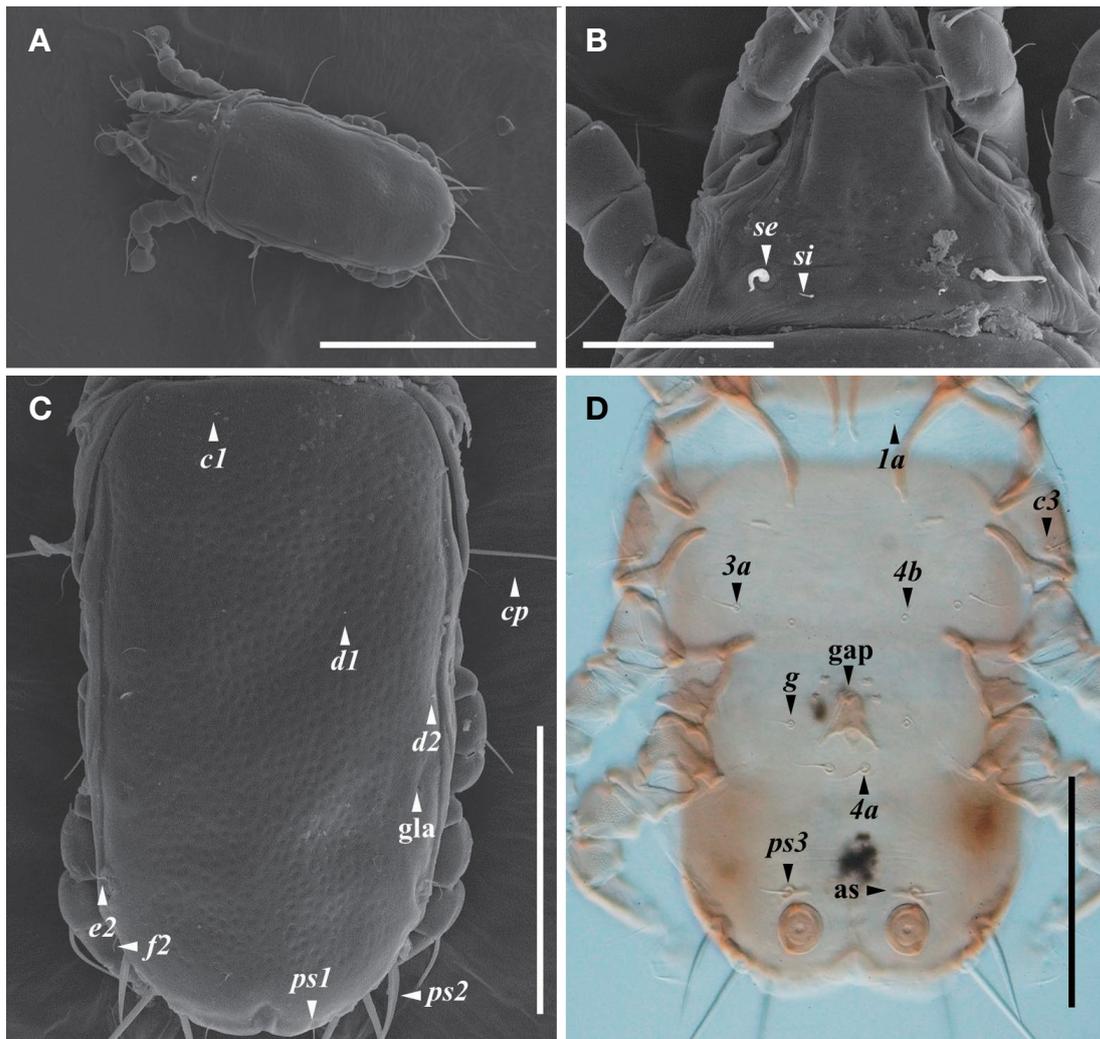


Fig. 1. *Bychovskiatia hypoleuci*, male; A, dorsal view; B, dorsal view of prodorsal shield; C, dorsal view of hysteronotal shield; D, ventral view of hysterosoma; as - adanal shield, gap - genital apparatus, gla - opening of dorsal hysteronotal glands. Scale bars: A, 0.2 mm; B, 0.05 mm; C, D, 0.1 mm.

RESULTS AND DISCUSSION

Order Sarcoptiformes Canestrini, 1891 **움진드기목**
 Family Avenzoariidae Oudemans, 1905
날개깃진드기과
 Genus *Bychovskiata* Dubinin, 1951
단엽날개깃진드기속 (신칭)

1. *Bychovskiata hypoleuci* Mironov and Dabert, 1997
꺾작도요단엽날개깃진드기 (신칭) (Figs. 1, 2)

Synonyms. *Bychovskiata hypoleuci*: Mironov and Dabert,

1997, p. 96, 100-102, figs. 9, 21-22, figs. 16-17, 19;
 Dabert, 2000, p. 306.

Material examined. Korea: 4♂♂, 3♀♀, Jeongsanmyeon, Cheongyang-gun, Chungcheongnam-do, 36°22'34"N, 126°56'38"E, 12 Sept 2014, collected using vacuum machine from flight feathers on the wings of the common sandpiper *Actitis hypoleucos* by Han Y.-D.

Diagnosis. Male: Length 330-345 of idiosoma from anterior end to bases of setae *h3*, width 185-220 at level of humeral shields, length to width ratio 1.6-1.8 (Fig. 1A). Prodorsal shield (Fig. 1B): Surface without striation, pos-

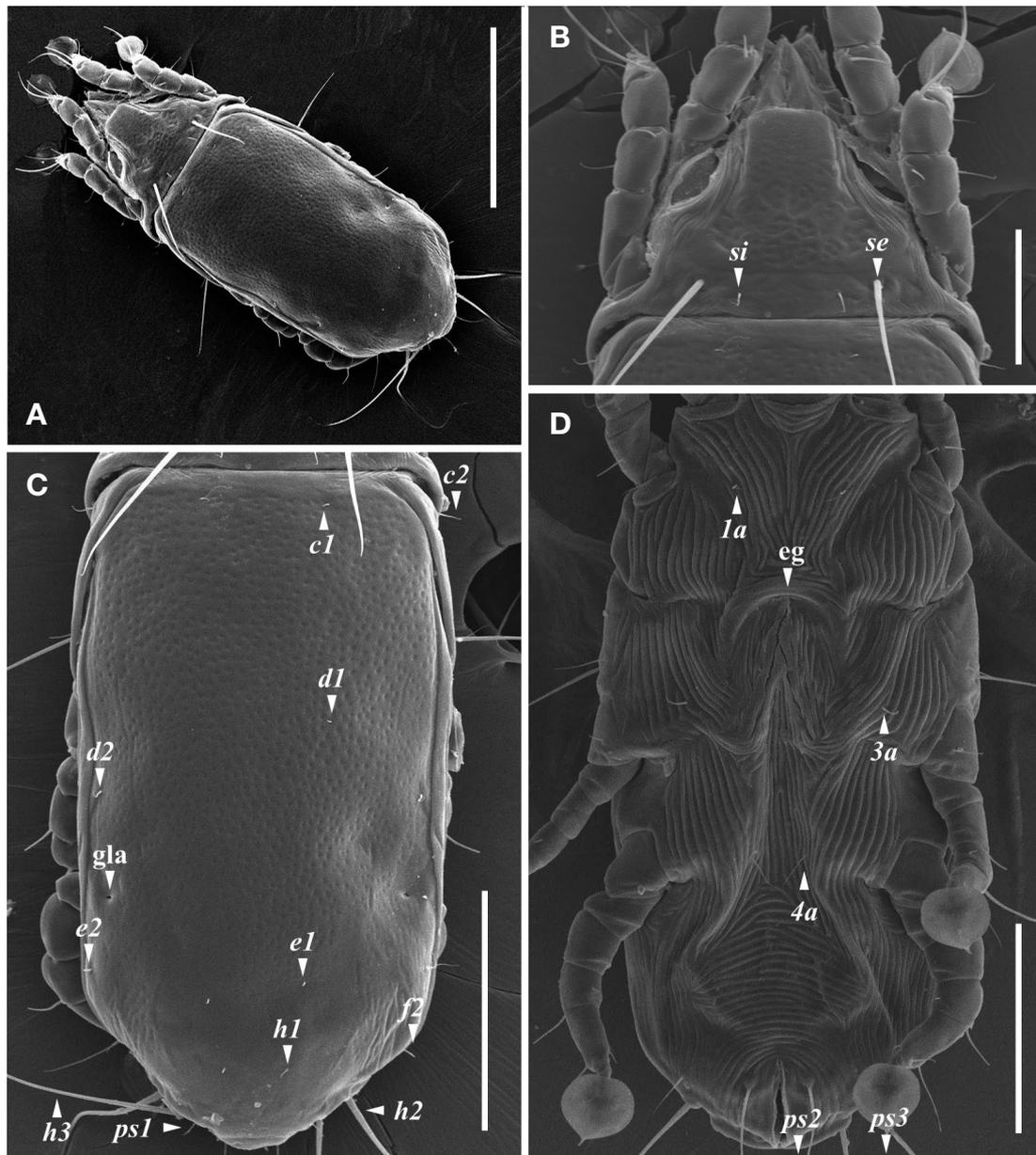


Fig. 2. *Bychovskiata hypoleuci*, female; A, dorsal view; B, dorsal view of prodorsal shield; C, dorsal view of hysteronotal shield; D, dorsal view of hysterosoma; eg - epigynum. Scale bars: A, 0.25 mm; B, 0.05 mm; C, D, 0.1 mm.

terior angles acute, posterior margin slightly convex as wide blunt angle, length 75-85 along midline, width 100-105 at posterior part. Hysteronotal shield (Fig. 1C): Anterior part straight, lateral margins with small rounded extensions at level of setae *cp*, length 240-243 from anterior margin to bases of setae *h3*, width 165-180 at level of setae *dl*. Opisthosomal lobes bluntly round-shaped and short. Terminal cleft broad V-shaped and short, anterior margin round-shaped. Interlobar membrane form narrow band along terminal apex of opisthosoma. Sternum (Fig. 1D): Epimerites I free, posterior ends not connected with epimerites II. Ventral margin of humeral shield with setae *c3*. Genital apparatus short and stiletto-shaped, situated between levels of trochanters IV. Posterior genital papillae situated at level of genital apparatus. Adanal shields irregularly transverse stick-shaped, setae *ps3* situated on this shield.

Female: Idiosoma length 390-405, width 215-225 (Fig. 2A). Prodorsal shield (Fig. 2B): Mostly shaped as in male, without transversal striation, length along middle line 85-88, width 105-115 at posterior part. Hysteronotal shield (Fig. 2C): Shaped as in male, lateral margins with small rounded extensions at level of setae *cp*, surface without dotted lacunae, length 295-300, width 180-190. Opisthosoma terminus round-shaped. Setae *el* and *hl* microchaetae. Heavy sclerotized membrane situated between posterior margin of opisthosoma and setae *h3*. Sternum (Fig. 2D): epimerites I shaped as in male. Epigynum simecircular-shaped, length 68-73, width 48-50 at posterior margins. Legs IV extending to posterior margin of opisthosoma.

Remarks. *Bychovskiata hypoleuci* was originally described by Mironov and Dabert, 1997 based on specimens collected from *Actitis hypoleucos* in Russia.

Bychovskiata hypoleuci is distinguishable from other species of the genus *Bychovskiata* by the presence of several characteristics: (1) transverse striation of prodorsal shield is absent; (2) idiosoma length is longer than 330 in males; and (3) small adanal shields are located at the bases of setae *ps3* in males; and (4) leg IV does not extend beyond the posterior end of opisthosoma in females (Mironov and Dabert, 1997).

Bychovskiata hypoleuci is very similar to *B. dubia* Mironov and Dabert, 1997 and *B. macularii* Mironov and Dabert, 1997 with regard to external traits. However, *B. hypoleuci* can be clearly distinguished from *B. dubia* and *B. macularii* by the following characteristics: length of idiosoma is more than 330 in males; small adanal shields are situated at the bases of setae *ps3* in males; and leg IV does not extend over the posterior margin of opisthosoma in females (Mironov and Dabert, 1997). The Korean specimens were morphologically consistent with the original descriptions and illustrations provided by Mironov and Dabert, 1997. However, the adanal shields of the four

Korean males are irregularly formed around of setae *ps3*. Nonetheless, these Korean males have the same partial *COI* sequences (654 bp). Therefore, we consider this difference to be intraspecific variation.

Host. This species was found on wing feathers in the common sandpiper *Actitis hypoleucos*.

Distribution. Kirghizia, Russia (Mironov and Dabert, 1997), Korea (this study).

Deposition. NIBR No. NIBRIV0000833401-NIBRIV0000833407.

Molecular characteristics. The *COI* sequences were obtained from four individuals and deposited in GenBank with accession numbers of No. MK031707-MK031710.

Family Syringobiidae Trouessart, 1896 깃촉진드기과 (신칭)

Genus *Phyllochaeta* Dubinin, 1951 톱니깃촉진드기속 (신칭)

2. *Phyllochaeta interifolia* (Méglin and Trouessart, 1884) 깃작도요톱니깃촉진드기 (신칭) (Figs. 3, 4)

Synonyms. *Pterolichus interifolia*: Méglin and Trouessart, 1884, p. 433, figs. 53b-c. *Thecarthra (Phyllochaeta) interifolia*: Oudemans, 1904, p. 192; Dubinin, 1951, p. 203, 205; 1956, p. 678-684, figs. 333-337.

Phyllochaeta interifolia: Gaud, 1972, p. 89; Vasyukova and Mironov, 1991, p. 150, 154, fig. 109; Dabert, 2000, p. 313; 2003, p. S59-63, figs. 98-103.

Material examined. Korea: 3♂♂, 2♀♀, Jeongsan-myeon, Cheongyang-gun, Chungcheongnam-do, 36°22'34"N, 126°56'38"E, 12 Sept 2014, collected from quills of flight feather on the wings of common sandpiper *Actitis hypoleucos* by Han Y.-D.

Diagnosis. Male: Length 480-500 of idiosoma from anterior end to base of the setae *h3*, width 240-270 at level of humeral shields (Fig. 3A). Prodorsal shield (Fig. 3B): Triangle-shaped, length 143-153 along midline, width 203-220 at posterior margins. Antero-medial delimitation covered by tubercles. Hysteronotal shield (Fig. 3C): Anterior margins straight, with some broken transverse striation at anterior part, length 335-350 from anterior margins to base of setae *h3*, width 215-235 at level of setae *dl*. Opisthosomal lobes short and triangle-shaped, with angled protuberance at medial margins. Interlobar cleft triangle-shaped. Postlobar membranes consist of small 3-4 teeth. Sternum (Fig. 3D): Epimerites I fused into a Y. Terminal shield located on sternum, rounded triangle-shaped, anterior margins with horn-shaped. Anterior parts of coxal field I and entirety of coxal field II sclerotized. Paragenital apodeme composed of two additional antero-lateral, two lateral narrow vertical and one rounded central sclerites. Paragenital sclerites not fused, anterior parts

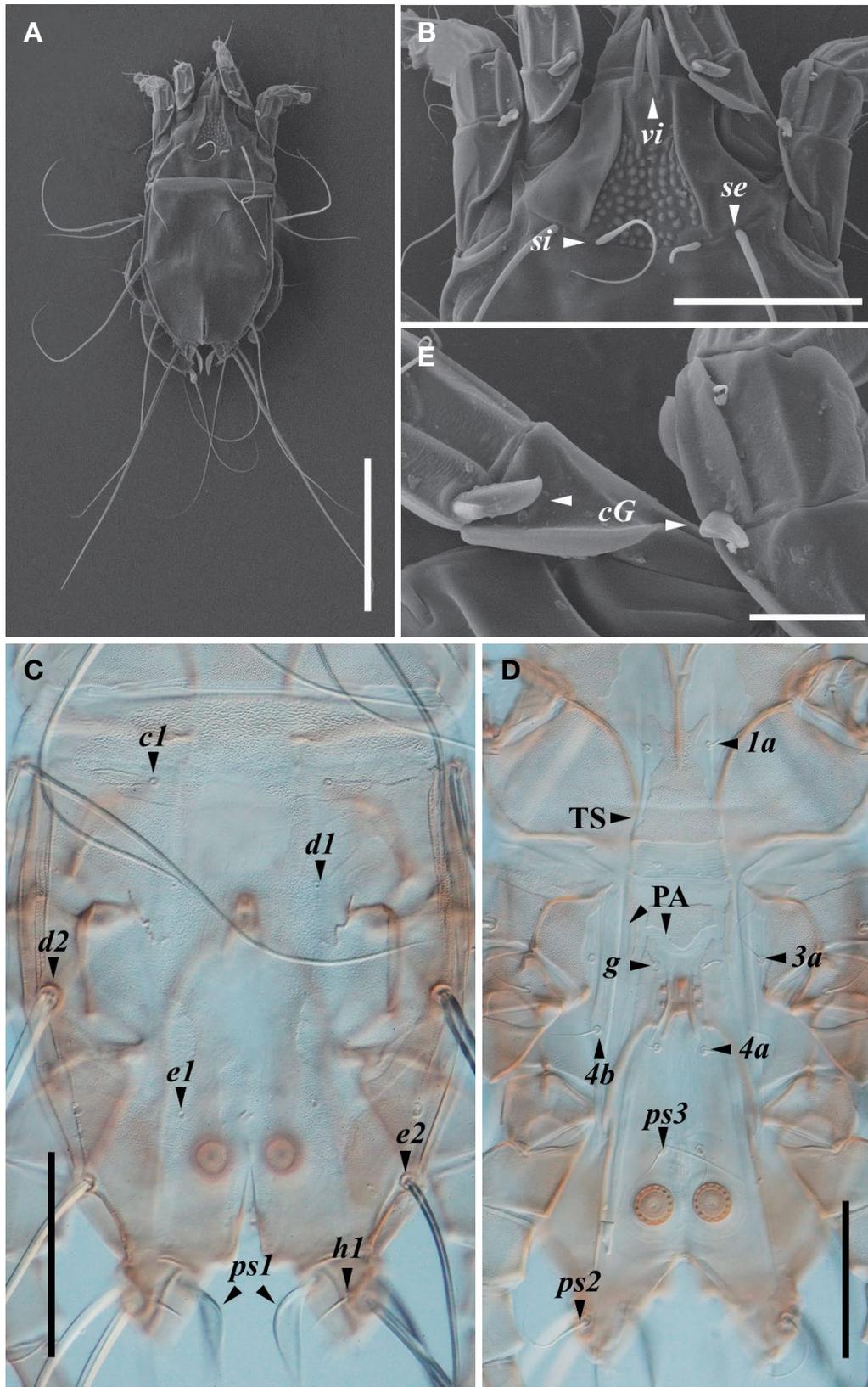


Fig. 3. *Phyllochaeta interifolia*, male; A, dorsal view; B, dorsal view of prodorsal shield; C, dorsal view of hysteronotal shield; D, ventral view of hysterosoma; E, setae *cG* of leg I and II; PA - pregenital apodeme, TS - terminal shield of sternum. Scale bars: A, 0.25 mm; B-D, 0.1 mm; E, 0.025 mm.

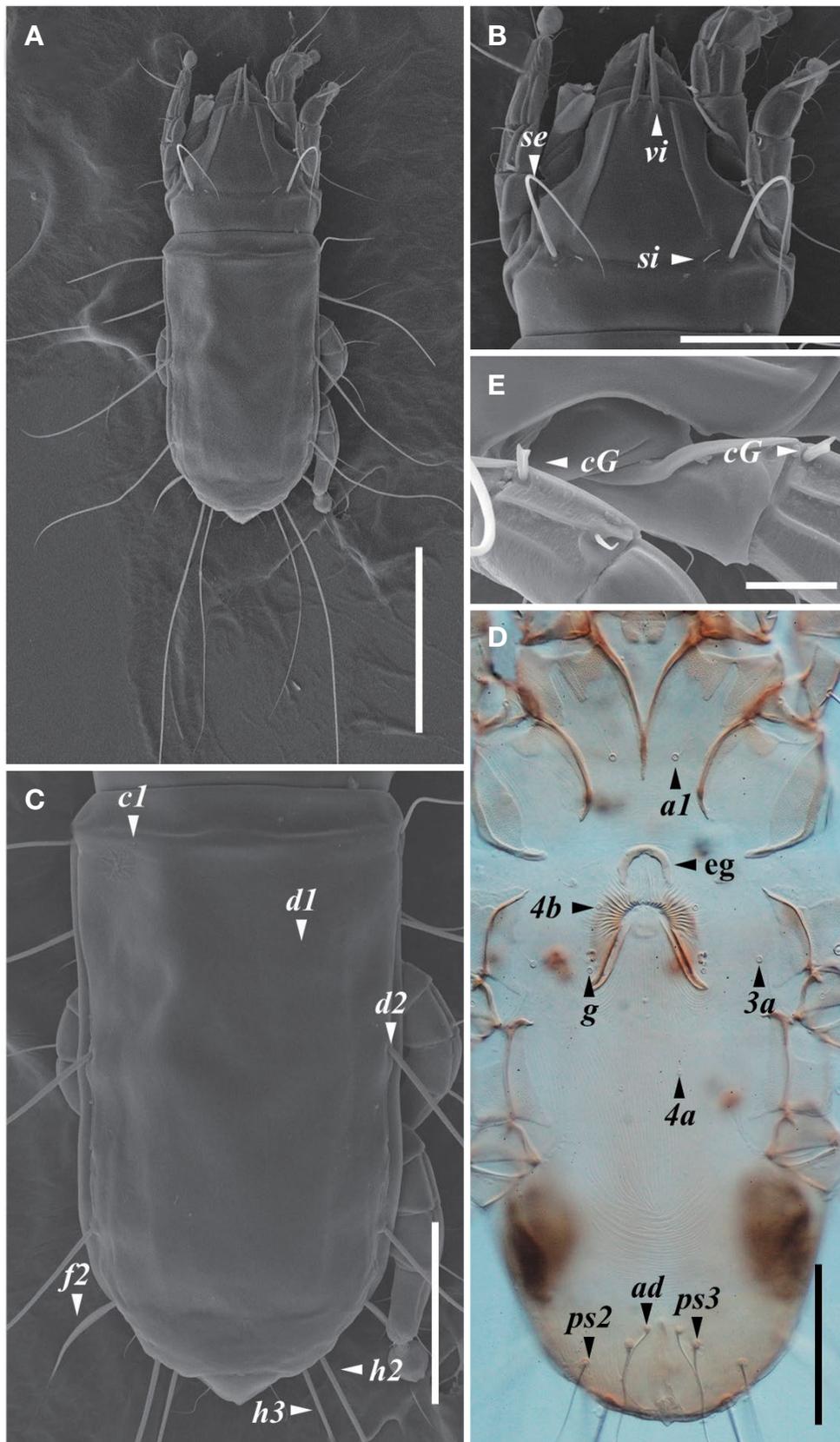


Fig. 4. *Phyllochaeta interifolia*, female; A, dorsal view; B, dorsal view of prodorsal shield; C, dorsal view of hysteronotal shield; D, ventral view of hysterosoma; E, setae *cG* of leg I and II; eg - epigynum. Scale bars: A, 0.2 mm; B-D, 0.1 mm; E, 0.02 mm.

expand to bases of setae *g*, posterior parts narrow, with genital papillae. Setae *cG* of leg I, II as massive Y (Fig. 3E).

Female: Length 530-550, width 250-260 (Fig. 4A). Prodorsal shield (Fig. 4B): Shaped as in male, with sinus posterior margin, length 163-165, width 215-220 at posterior part. Hysteronotal shield (Fig. 4C): length 310-320, width 200-205 at level of setae *d1*, without lateral incisions. The posterior part of opisthosoma round-shaped. Sternum (Fig. 4D): Epimerites I fused into a Y, posterior end without terminal shield. Epigynum crescent-shaped, with expanded ends, length 25-28, width 35-38. Setae *3a* situated at the level of posterior genital papillae. Setae *cG* of genua I and II thick Y (Fig. 4E).

Remarks. *Phyllochaeta interifolia* was originally described by Mégnin and Trouessart (1884) based on specimens collected from *Actitis hypoleucos* in Europe.

Phyllochaeta interifolia is easily distinguished from other species in the genus *Phyllochaeta* by several characteristics: (1) anterior part of hysteronotal shield has a broken striation in males; (2) Postlobar membranes consist of 2-4 teeth in males; and (3) posterior part of epigynum is wider than its anterior part in females (Dabert, 2003).

Phyllochaeta interifolia is very similar to *P. maculariae* Dabert, 2003 in terms of appearance. However, *P. interifolia* can be clearly distinguished from *P. maculariae* by the following characteristics: pores *p1* is present; anterior half of hysteronotal shield has a broken transverse striae in males; and posterior part of epigynum is expanded than its anterior part in females (Dabert, 2003).

Korean specimens were morphologically consistent with the description and illustrations (Dabert, 2003).

Host. This species was found on quills of wing feather in the common sandpiper *Actitis hypoleucos*.

Distribution. Cameroon, Congo, Zambia, (Gaud, 1972), Europe (Mégnin and Trouessart, 1884), France, Poland, South Africa (Dabert, 2000; 2003), Russia (Dubinin, 1951; 1956; Vasyukova and Mironov, 1991), Korea (this study).

Deposition. NIBR No. NIBRIV0000833408-NIBRIV0000833412.

Molecular characteristics. The *COI* sequence were obtained from single individual and deposited in GenBank with accession number of MK031711.

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