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New record of two feather mites (Acari: Sarcoptiformes: Astigmata) from Korea

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Two feather mites, *Zachvatkinia larica* Mironov, 1989 and *Ardeacarus ardeae* (Canestrini, 1878) are reported for the first time in Korea. Specimens of *Z. larica* and *A. ardeae* were collected from the black-tailed gull *Larus crassirostris* and little egret *Egretta garzetta*, respectively. The genera *Zachvatkinia* Dubinin, 1949 and *Ardeacarus* Dubinin, 1951 are new to this country. Here, we provided morphological descriptions and illustrations of these two species. Additionally, we provide the partial sequences of the mitochondrial cytochrome *c* oxidase subunit I (*COI*) as DNA barcode markers.

Keywords: *Ardeacarus ardeae*, black-tailed gull, *COI*, feather mite, Korea, little egret, *Zachvatkinia larica*

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Introduction

Feather mites are bird ectoparasites and comprise three superfamilies: Analgoidea, Freyanoidea and Pterolichoidea (Gaud and Atyeo, 1996). Species of feather mites show variation in their morphological structures depending on the microhabitat and host specificity (Dabert and Mironov, 1999). About 2,500 species of feather mites have been recorded from all recent orders of Aves (Gaud and Atyeo, 1996; Proctor, 2003; Mironov and Proctor, 2008). So far, 21 species (12 genera in seven families) of feather mites have been reported from Korea (Atyeo and Gaud, 1971; Cho, 1980; Hwang *et al*., 1986; Noh and Sohn, 1992; Sohn and Noh, 1994a; 1994b; 1995).

The genus *Zachvatkinia* Dubinin, 1949 is one of 33 genera belonging to the family Avenzoariidae Oudemans, 1905 that comprise 15 species associated principally with birds in the Procellariiformes and Charadriiformes orders (Mironov, 1989; 1992; Gaud and Atyeo, 1996; Mironov and Stefa, 2013; Negm *et al*., 2013). This genus has the following diagnostic characteristics: (1) the subcapitulum is not gourd-shaped (the anterior part is not narrowed); (2) setae *mG* of genua I are filiform; (3) the lateral membrane of the opisthosomal lobe is present; (4) epimerites III and IV are closed in males; and (5) the anterior part of the hysteronotal shield is extended to a humeral shield in females (Mironov, 1989; Stefan *et al*., 2014).

The genus *Ardeacarus* Dubinin, 1951 is one of 112 genera that belong to the family Pterolichidae Trouessart and Mégnin, 1884 and contains only one species. This genus was mostly found in flight feathers on wings of birds of the family Ardeidae, and it has the following diagnostic characteristics: (1) the gnathosoma is subtriangular in shape; (2) the basis capitulum is very wide and heavily sclerotized laterally; (3) the anterior tarsi are longer than the conjoined lengths of the tibiae and genua; (4) one internal vertical seta in the prodorsal shield is present; (5) long hair-like setae of the opisthosomal lobe exist (four pairs in males and two in females) (Dubinin, 1951; 1956; Gaud, 1981; Gaud and Atyeo, 1996).

Here, we provide the descriptions and illustrations for *Z. larica* and *A. ardeae* based on their morphology. Additionally, we provide the partial sequences of the mitochondrial cytochrome c oxidase subunit I (*COI*) as DNA barcode markers.

Materials and Methods

Specimens of *Z. larica* and *A. ardeae* were collected from feathers of black-tailed gulls from Dokdo Island and little egrets from Eumseong-gun, respectively, using a vacuum machine. Collected mites were preserved directly in 95% ethyl alcohol. The mite specimens were cleared by lactic acid for 24 h 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 mites were photographed with a microscopic digital camera (Leica, Wetzlar, Germany). The terms and measurements follow Gaud and Atyeo (1996) and Norton (1998). All measurements are given in micrometers (μm). All examined specimens were deposited in the National Institute of Biological Resources (NIBR) and Inha University, Korea.

DNA sequencing

DNA was extracted from a leg of each specimen using a Tissue DNA Purification Kit (Cosmogenetech Inc., Seoul, Korea) according to the manufacturer's instructions. The partial *COI* gene of the mitochondrial DNA was amplified by polymerase chain reaction (PCR) with two primers: bcdF05 5′-TTTTCTACHAAYCATAAAG ATATTGC-3′ and bcdR04 5′-TATAAACYTCDGGAT GNCCAAAAAA-3′ (Dabert *et al*., 2008). PCR amplification was conducted under the following conditions: 3 min at 94°C, 45 cycles at 95°C for 10 s, 50°C for 30 s, and 72°C for 60 s, and a final extension at 72°C for 5 min. PCR products were purified using a PCR Purification Kit (Cosmogenetech) and were sequenced with an ABI3100 automated sequencer (Perkin Elmer, Foster City, CA, USA).

Results and Discussion

Order Sarcoptiformes Canestrini, 1891 옴진드기목
Family Avenzoariidae Oudemans, 1905 깃털진드기과
Genus *Zachvatkinia* Dubinin, 1949
바닷새날개깃진드기속 (신칭)

1. *Zachvatkinia larica* Mironov, 1989
갈매기날개깃진드기 (신칭) (Figs. 1-5)

Synonyms. *Zachvatkinia larica* Mironov, 1989: 91-115, figs. 2, 4 and 8.

Material examined. Korea: 5♂♂, 4♀♀, Dokdo Island, Ulleung-gun, Gyeongsangbuk-do, 37°14′N, 131°52′E, 16 April 2014, collected using vacuum machine from wings and tail feathers in the black-tailed gulls *Larus crassirostris* by Han Y.-D.

Diagnosis. *Male* (Fig. 1): Length 660-710 of idiosoma from anterior end to bases of setae *h3*. Width 370-420 at level of humeral shields. Length of hysterosoma from level of sejugal crease to bases of setae *h3* 450-520.

Gnathosoma (Fig. 2A): Subcapitulum not narrowed in anterior part, lateral margins with small ledge-like extensions. Length 85-125 including palps, width 75-85.

Prodorsal shield (Fig. 2B): Length 150-175 along midline, width 190-225, subtriangular shape, narrowed in anterior part, posterolateral part rounded, the posterior edge convex and with a pair of filiform setae *vi*.



Fig. 1. *Zachvatkinia larica*, male. Scale bar: 0.2 mm.

Hysteronotal shield (Figs. 1, 2C, D): Anterior part slightly concave, anterior angles acute, length 425-475 from anterior margin to bases of setae *h3*, width 260-300 at anterior margin. Terminal cleft extending after level of setae *e2*, length 215-250 from anterior end to bases of setae *h3*, width 70-100. Inner margins of opisthosomal lobes with ledge near bases of setae *h3*. Incision in interlobar membrane extending after level of setae *h1*, length 145-160 of incision from anterior end to apices of terminal membranes.

Sternum (Fig. 2E): Coxal setae *3a* locate in same level of setae *4b*. Genital shields square or diamond-shaped with rounded posterolateral margin, not fused. Genital setae *g* situated on the posterolateral edge of genital shield. The anterior end of adanal shields form an acute angle, setae *ps3* situated on adanal shields. The additional adanal sclerites oval-shaped, separated from adanal apodemes.

Legs (Fig. 5A-D): Tarsi I, II absent apical spine-like processes. Genua I and II with setae *mG* of filiform. Tarsi III with thick spine-like setae *s*. Setae *W* with thin

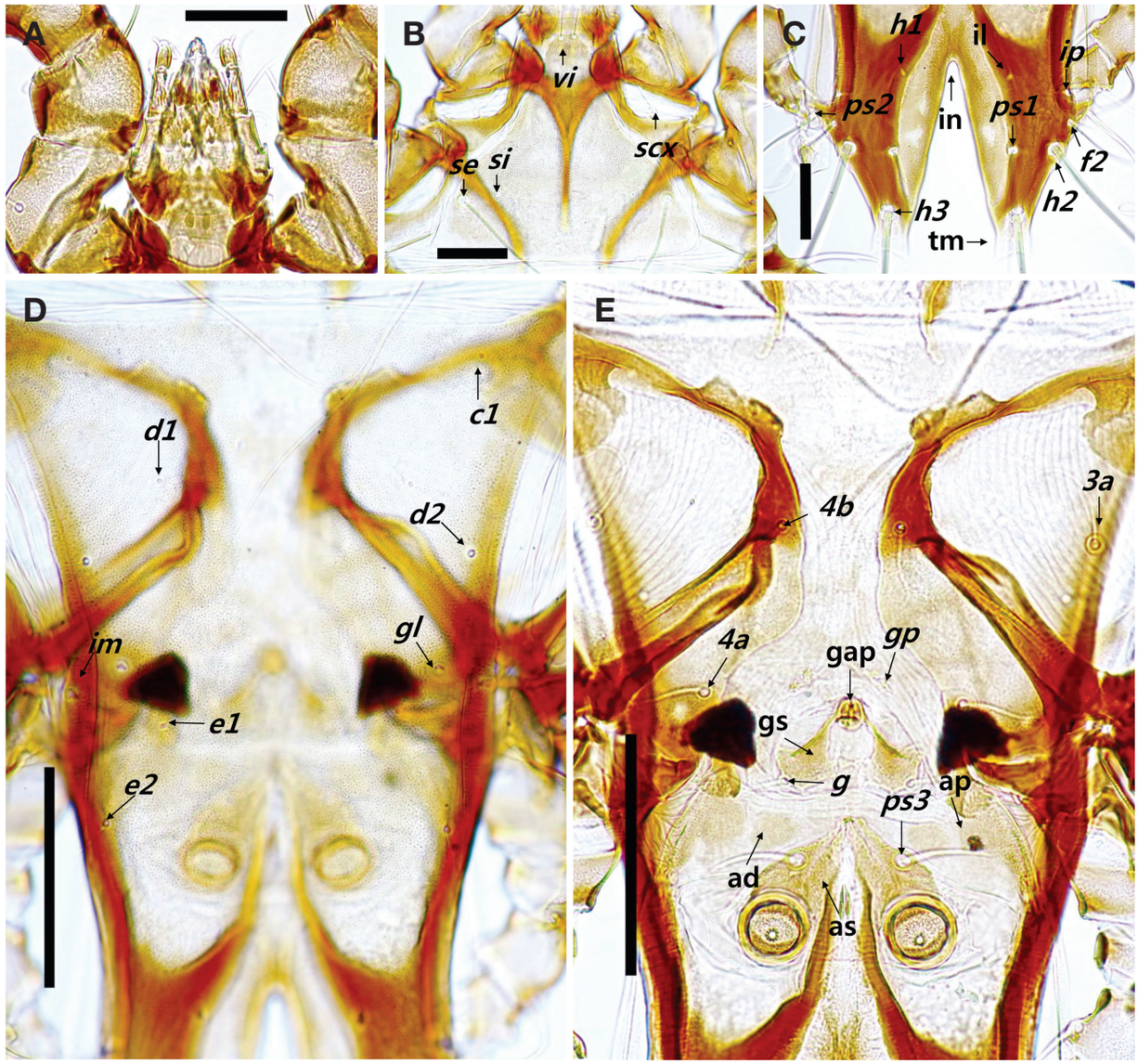

Fig. 2. *Zachvatkinia larica*, male. A, gnathosoma; B, prodorsal shield; C, opisthosomal lobes area view; D, dorsal view of hysteronontal shield; E, ventral viewe of sternum. ad-additional ananal sclerite, ap-adanal apodeme, as-adanl shield, gap-gentital apparatus, gp-genital papillae, gs-genital shield, il-interlobar membrane, in-incision in interlobar membrane, tm-terminal membrane. Scale bars: A-C = 0.05 mm, D, E = 0.1 mm.

needle-like extension at midlevel. Tarsi IV with 3-4 dorsobasal spines with one apical spine-like extension at base of modified setae *e*.

Female (Fig. 3): Idiosoma length 425-450, width 315-335. Length of hysterosoma from sejugal crease to posterior margin of opisthosoma 385-300.

Gnathosoma (Fig. 3): Shaped as in male, length 75-85 including palps, width 70-90.

Prodorsal shield (Fig. 4A): Mostly shaped as in male, with convex at the rear edge between the bases of setae *si*, length along center line 115-120, width 130-140. Setae *se* and *si* situated and lateral margins of prodorsal shield at same horizontal level.

Hysteronotal shield (Fig. 4B): Length 185-205 from anterior margins to posterior ends of large longitudinal shields. Setae *d1* situated on lateral edge of hysteronotal shield.

Pygidial shield (Fig. 4C): With at anterior margin curved shape, length 30-38, width 75-85.

Sternum (Figs. 3, 4D): Epimerites I fused into a Y. Epigynum thin semicircular-shaped, widening to base of anterior genital papillae, length 50-60, width 88-100.



Fig. 3. *Zachvatkinia larica*, female. Scale bar: 0.2 mm.

Setae *g* situated posterior to level of setae *3a*.

Legs (Fig. 3): Tarsi III, IV slightly longer than wide (Fig. 5E-F). Legs IV extend beyond the rear margin of the body.

Remarks. *Zachvatkinia larica* was originally described by Mironov (1989) based on the specimens collected from *L. ridibundus* in the Volga delta, Russia.

Zachvatkinia larica is distinguishable from other species in the genus *Zachvatkinia* by several characteristics in male: (1) the inner margins of the opisthosomal lobes have ledges near the bases of setae *h3*; (2) three or four dorsobasal spines exist on the tarsi IV; and (3) wedded anterior margin of adanal shield absents protrusion (Mironov, 1989).

Zachvatkinia larica is very similar to *Z. issykkulica* (Chirov, 1978) in external traits. However, *Z. larica* can be clearly distinguished from *Z. issykkulica* with the following characteristics in males: the inner margins of opisthosomal lobes have ledges near the bases of setae *h3*; the additional adanal sclerites are an ovoid shape; setae *g* situated on the inside of the genital shield (Mironov, 1989). The morphology of Korean male specimens well agreed with the original descriptions and illustrations that described by Mironov (1989). However, one of five observed males was incompletely fused for the genital shields. We consider this difference to be an intraspecific variation.

Host. This species was found on the surface of wings and tail feathers in the black-tailed gulls *Larus crassirostris*.

Distribution. Russia (Mironov, 1989), Korea (This study).

Deposition. NIBR No. NIBRIV0000326276, NIBRIV 0000542813-0000542820.

Molecular characteristics. The *COI* sequences with 612 bp lengths were obtained from two individuals (GenBank accession numbers: KX610950 and KX610951). The sequence alignment did not contain any insertions or deletions. No frame shift was detected during amino acid conversion with the invertebrate mitochondrial genetic code.

Identifiers. Yeong-Deok Han and Gi-Sik Min.

Family Pterolichidae Trouessart and Mégnin, 1884
깃사이진드기과
Genus *Ardeacarus* Dubinin, 1951
백로날개깃진드기속 (신칭)

2. *Ardeacarus ardeae* (Canestrini, 1878)
백로날개깃진드기 (신칭) (Figs. 6-8)

Synonyms. *Dermaleichus ardeae* Canestrini, 1878: 51.
Ardeacarus ardeae: Dubinin, 1951: 125, fig. 1; 1956: 126-140, figs. 38 and 39; Gaud, 1981: 861, fig. 1; Gaud and Atyeo, 1996: Part II, 311, fig. 322.

Material examined. Korea: 3♂♂, 3♀♀, Eumseong-gun, Chungcheongbuk-do, 36°56′N, 127°41′E, April 26, 2015, collected using vacuum machine from flight feathers on the wings of little egret *Egretta garzetta* by Han Y.-D.

Diagnosis. *Male* (Fig. 6): Length 310-315 of idiosoma from anterior end to bases of setae *h3*. Width 215-235 at level of setae *c2*.

Gnathosoma (Figs. 6, 8A): Subtriangular-shaped, sclerotized posterolateral margin, length 75-85 together with palps, width 95-113.

Prodorsal shield (Fig. 8A): Rectangular-shaped, each angles rounded. Length at base of seta *vi* 60-70, width 58-68, with one internal vertical seta (*vi*) of filiform. Setae *si* situated under prodorsal shield, at same transverse level with setae *sc*.

Hysteronotal shield (Fig. 8A): Anterior part slightly concave or straight, anterior angles rounded. Length 180-185 from anterior margin to base of setae *h3*, width

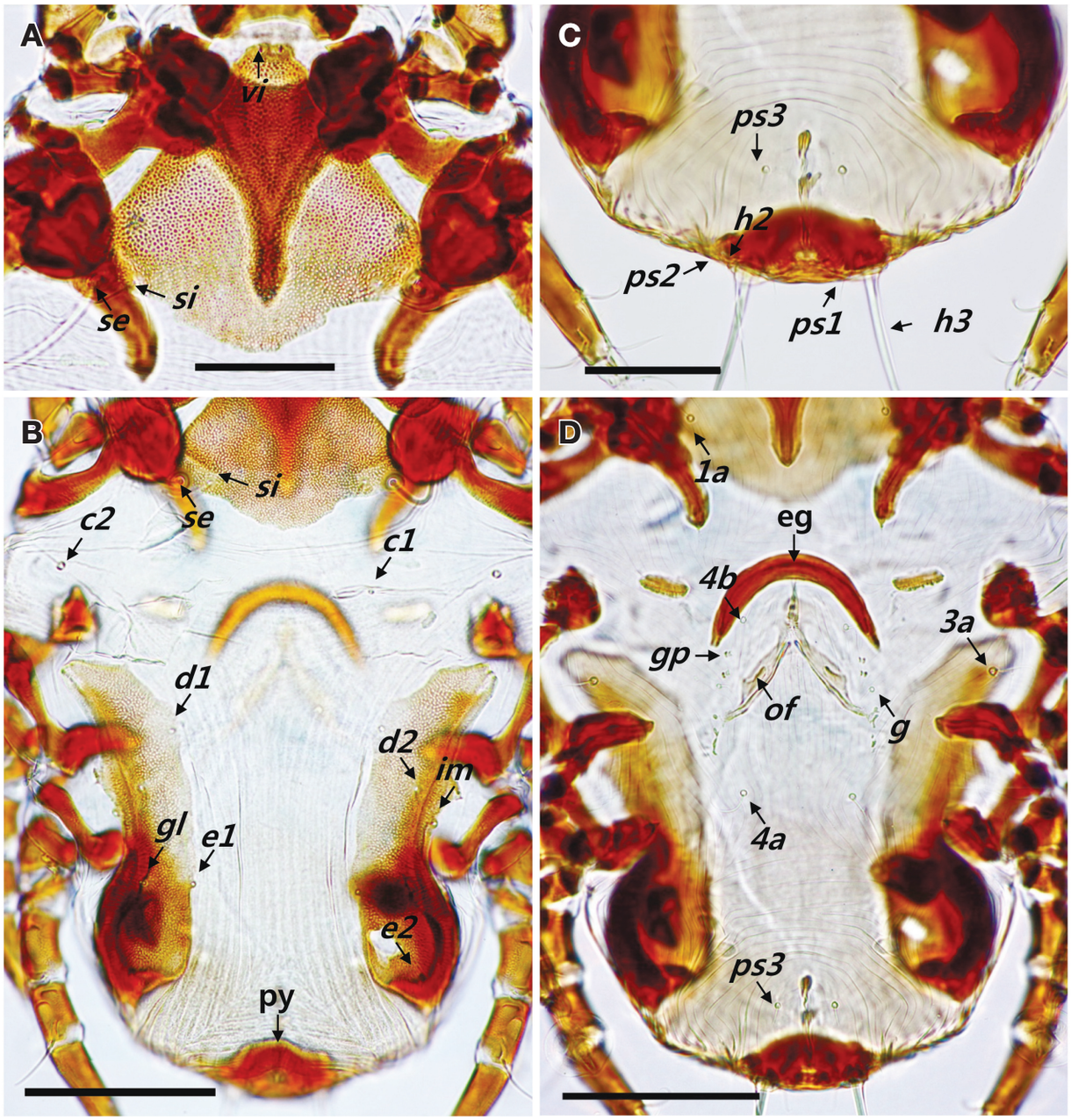

Fig. 4. *Zachvatkinia larica*, female. A, prodorsal shield; B, ventral view of pygidial shield area; C, dorsal view of hysteronontal shield; D, ventral viewe of sternum. py-pygidial shield, eg-epigynum, of-oviporus folds. Scale bars: A, B = 0.05 mm, C, D = 0.1 mm.

150-155 at level of setae *cp*. Setae *f2*, *h2* and *h3* long hair-like shaped. Setae *c3* situated at same transverse level with setae *cp*.

Sternum (Fig. 8B): Epimerites I not fused. Setae *4b* situated on slightly posterior to level of setae *3a*. Genital apparatus smooth crowns-shaped, situated at epimerites IV.

Legs (Fig. 6): Tarsi, tibiae, genua and femora of legs I-IV longer than wide. Each length of Tarsi I-IV as long as tibia and genu combined.

Female: length 375-400 of idiosoma from anterior end to bases of setae *h3*, width 250-285 at level of setae *c2* (Fig. 7).

Gnathosoma (Fig. 7): Shaped as in male, length 85-93 including palps. Width 103-113.

Prodorsal shield (Fig. 7): Shaped as in male. Length

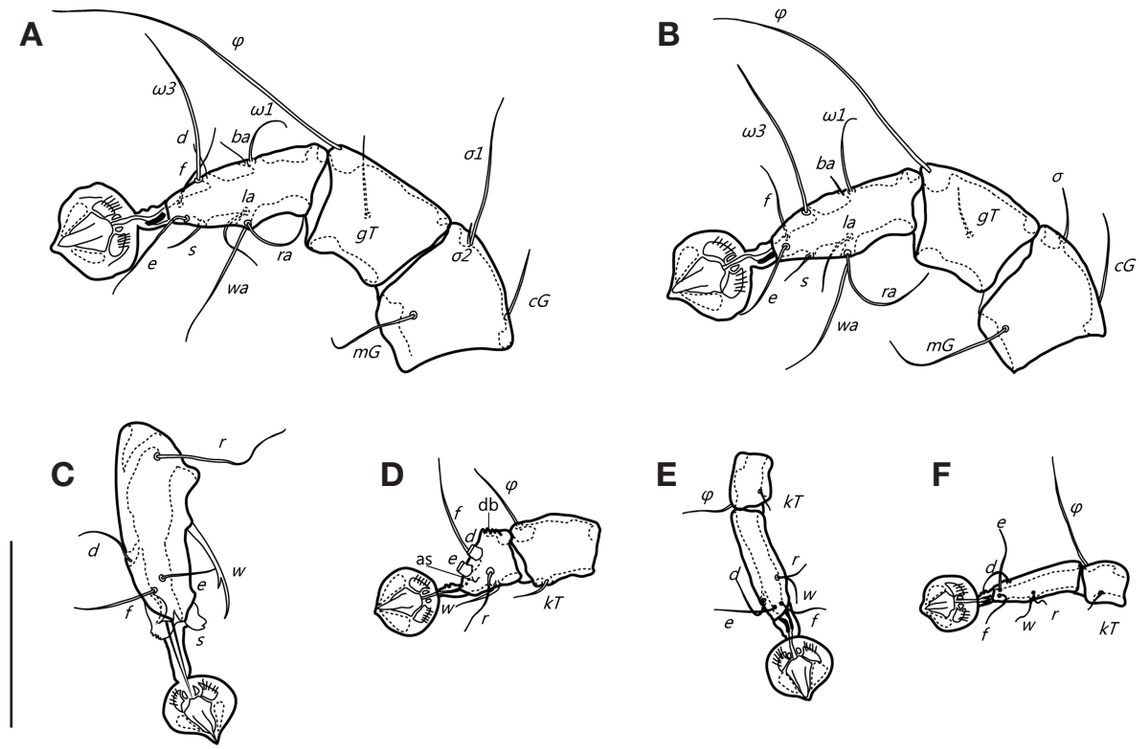

Fig. 5. *Zachvatkinia larica*, legs. A, tarsus, tibia and genu I of male; B, tarsus, tibia and genu II of male; C, tarsus III of male; D, tarsus and tibia IV of male; E, tarsus and tibia of female; F, tarsus and tibia IV of female. as-apical spine-like extension of tarsus IV; db-dorsobasal spine-like extension of tarsus IV. Scale bar: 0.1 mm.

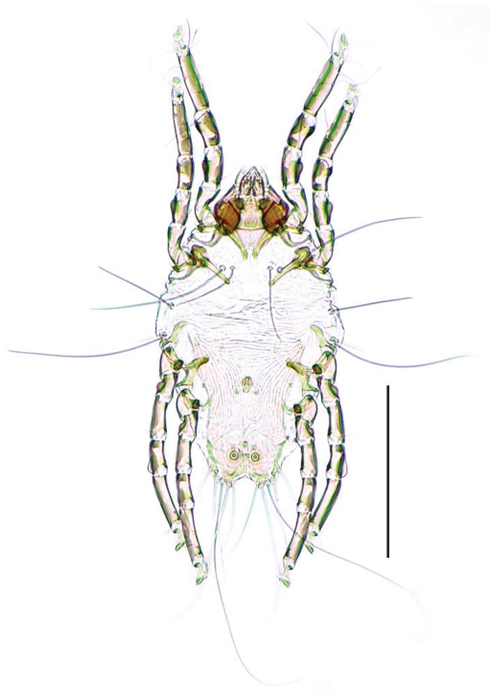

Fig. 6. *Ardeacarus ardeae*, male. Scale bar: 0.2 mm.

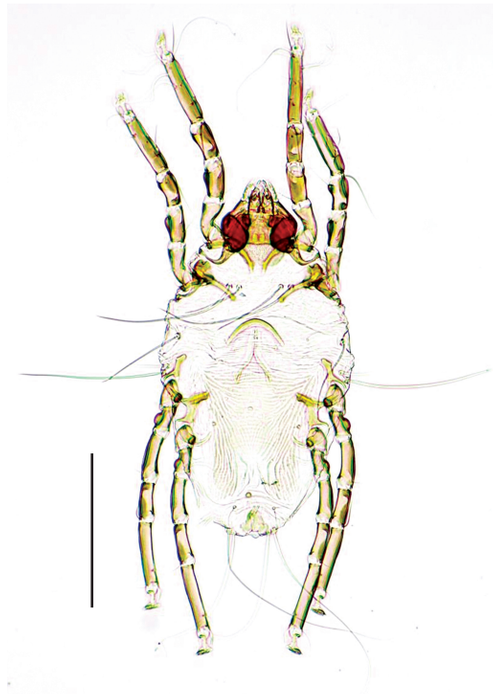

Fig. 7. *Ardeacarus ardeae*, female. Scale bar: 0.2 mm.

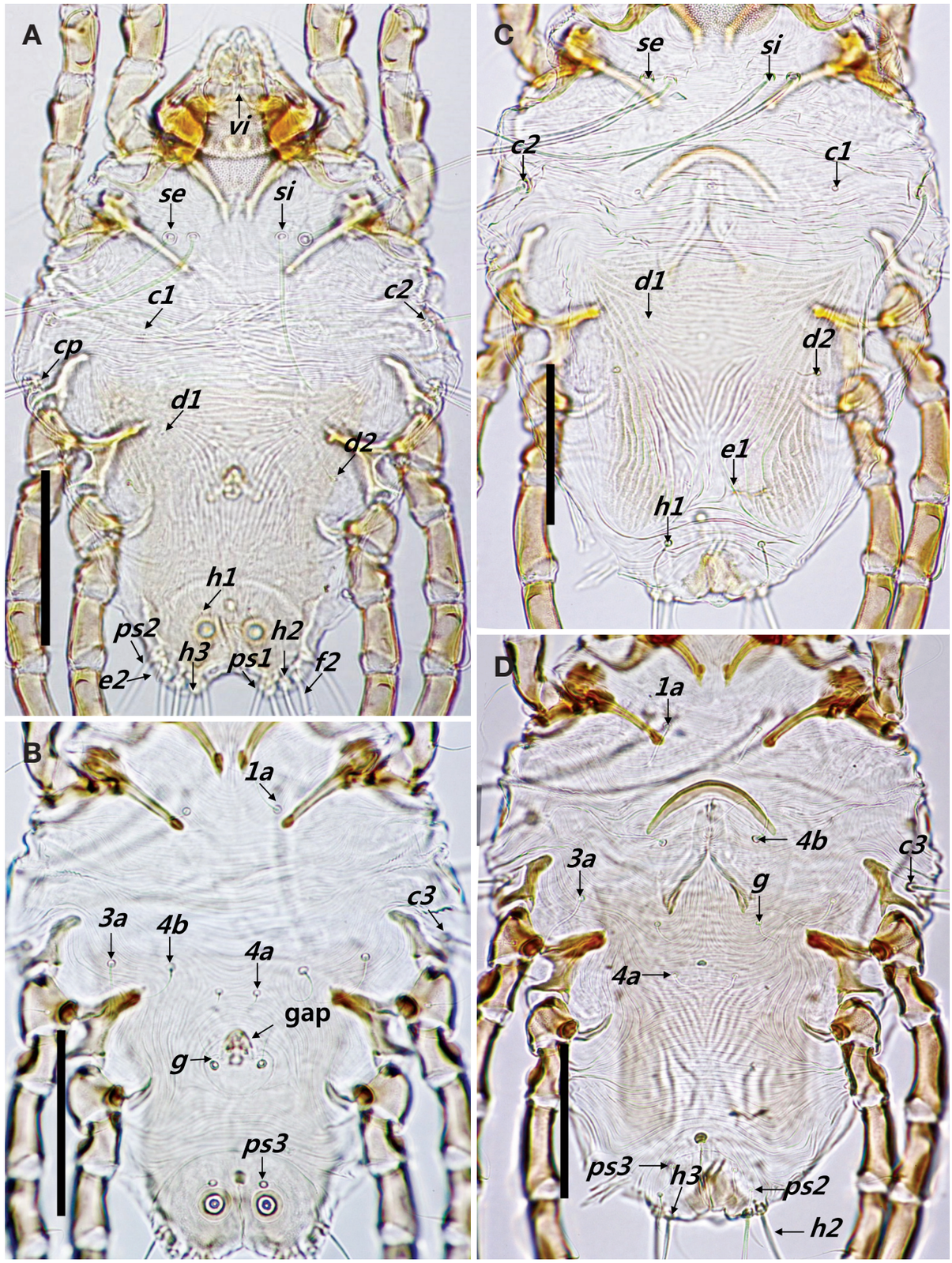

Fig. 8. *Ardeacarus ardeae*. A, dorsal idiosoma view of male; B, ventral idiosoma view of male; C, dorsal idiosoma view of female; D, ventral idiosoma view of female. Scale bars: A-D = 0.1 mm.

68-75 at based of setae *vi*. Width 68-73.

Hysteronotal shield (Fig. 8C): Anterior part slightly concave or straight, posterior margin concave. Length 175-178, width 175-185 at based of setae *d2*.

Sternum (Fig. 8D): Epigynum crescent-shaped, length 30-38, width 78-80. Setae *g* situated at posterior part of epigynum. Oviporus folds located between epimerites III and IV. Posterior margin of opisthosoma is rounded, with long hair-like setae *h2* and *h3*.

Remarks. *Ardeacarus ardeae* is the sole species in the genus *Ardeacarus* and was originally described without illustration by Canestrini (1878) based on the specimens collected from little bitterns *Ixobrychus minutus* in Europe. Thereafter, this species was redescribed by several mite taxonomists with detailed morphological descriptions and illustrations (Dubinin, 1951; 1956; Gaud, 1981; Gaud and Atyeo, 1996). Their descriptions and illustrations are very similar, except for some differences in the length of the setae *sci*, and the positions of the setae on the ventral part and hysteronotal shield. Korean specimens are well matched with those of Gaud (1981) and Gaud and Atyeo (1996), although some differences were found in the following characteristics: (1) setae *g* were situated on the anterior tips of epimerites III in males; and (2) setae *3a* were situated anterior to the level of setae *4b* in females.

Host. Specimens were collected from the surface of flight feathers on the wings of little egret *Egretta garzetta*.

Distribution. Worldwide (Dubinin, 1951; 1956; Gaud, 1981; 1996).

Deposition. NIBR No. NIBRIV0000542807-00005428 12.

Molecular characteristics. The *COI* sequences with 606 bp lengths were obtained from three individuals of *A. ardeae* (GenBank accession numbers: KX610952-54). The sequence alignment did not contain any insertions or deletions. No frame shift was detected during amino acid conversion with the invertebrate mitochondrial genetic code.

Identifiers. Yeong-Deok Han and Gi-Sik Min.

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