Acarina 21 (1): 27–37

REDESCRIPTION OF THE FEATHER MITE SPECIES, *ZACHVATKINIA PUFFINI* (BUCHHOLZ, 1869) (ACARIFORMES: AVENZOARIIDAE), FROM ITS TYPE HOST, THE GREY PETREL *PROCELLARIA CINEREA* (PROCELLARIIFORMES: PROCELLARIIDAE)

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ABSTRACT: The feather mite species, *Zachvatkinia puffini* (Buchholz, 1869) (Acariformes: Avenzoariidae), the type species of the genus *Zachvatkinia* Dubinin, 1949, is redescribed based on specimens collected from its type host, the Grey Petrel *Procellaria cinerea* Gmelin, 1789 (Procellariiformes: Procellariidae). *Zachvatkinia robusta* Mironov, 1991 syn. n. from *P. aequinoctialis* Linnaeus, 1758 is synonymized with *Z. puffini*.

KEY WORDS: Acariformes, feather mites, Avenzoariidae, *Zachvatkinia*, systematics

INTRODUCTION

Mites of the genus *Zachvatkinia* Dubinin, 1949 (Acariformes: Avenzoariidae) are large-sized feather mites (400–700 μm) associated with two bird orders, Procellariiformes (families Diomedeidae, Hydrobatidae and Procellariidae) and Charadriiformes (Dromadidae, Laridae, Stercorariidae, Sternidae) (Dubinin 1949; Gaud and Till 1961; Gaud 1976; Mironov 1989a, 1989b, 1991, 1992). These mites live on the flight feathers of the wings and tail feathers of their hosts, where they are commonly located in the channels of the ventral surface of vanes. This genus was ancestrally associated with procellariiform birds, and later in its evolutionary history shifted to charadriiform birds (Dabert and Mironov 1999).

The genus *Zachvatkinia* was originally established by Trouessart (1916) under the name *Giebelia* (preoccupied by Kellogg 1896, Insecta, Mallophaga). Dubinin (1949) proposed a replacement name, *Zachvatkinia* Dubinin, 1949. This author made the first revision of this genus where he considered three species associated with procellariiform birds (Dubinin 1949).

To date the genus *Zachvatkinia* includes 14 species (Mironov 1989a, 1992), of which 5 species are associated with procellariiforms, and 9 species live on charadriiforms. The subgenus *Rhinozachvatkinia* Mironov, 1989, with 3 species associated with procellariiform birds (Mironov 1989b), has been elevated to the generic rank (Mironov and Dabert 1999; Stefan et al. 2013).

The type species of the genus, *Dermaleichus puffini* Buchholz, 1869, was originally described by Buchholz (1869) from the Grey Petrel *Procellaria cinerea* Gmelin, 1789 (Procellariiformes: Procellariidae). This mite was a single species included by Trouessart (1916) in this genus. One more species of the genus *Zachvatkinia*, known to acarologists in the 19th century, *Dimorphus sternae* Canestrini et Fanzago, 1876 from the Black Tern *Chlidonias nigra* (Linnaeus, 1758) (Charadriiformes: Sternidae) (Canestrini and Fanzago 1876), was synonymized by Trouessart (1885) with *D. puffini* without giving any justification. This wrong synonymy was accepted by almost all subsequent investigators until the 1960s, who referred all *Zachvatkinia* mites found on charadriiform birds to *puffini* (Canestrini 1886; Canestrini and Kramer 1899; Gaud 1953; Radford 1958), leding to the wrong widespread opinion that this species is a "cosmopolite" distributed on procellariiform and charadriiform birds worldwide. Only Oudemans (1897) did not accept this synonymy.

In his revision of *Zachvatkinia*, Dubinin (1949) redescribed *Z. puffini* based on an abiundant material from 19 host species and subspecies of the family Procellariidae. It is necessary to note, there was only a single male from *Procellaria cinerea* in his material, while other samples were from other procellariform hosts, mainly from shearwaters of the genus *Puffinus* Brisson, 1760. Mironov (1989a) re-examined Dubinin's material and assigned nearly half of samples from hosts of the genera *Calonectris* Mathews et Iredale, 1915 and *Puffinus* Brisson, 1760 to a new species, *Z. ovata* Mironov, 1989, and treated the remaining specimens as the true *Z. puffini*. These two species were separated morphologically based on the shape of the terminal cleft and the size of the interlobar membranes in males.

In the course of the project carried out by the junior author (see: Stefan et al. 2013), a number of species of the genus *Zachvatkinia* have been collected in the field from live procellariiform hosts. An investigation of newly collected specimens from *Procellaria cinerea* showed that their male genital apparatus is distinct and does not correspond to either *Z. puffini* or *Z. ovata* from the Dubinin's collection. At the same time, males and females from *Pr. cinerea* by their general appearance and the shape of opisthosoma appeared very similar to the original illustrations of *D. puffini* by Buchholz (1869), but not to those of subsequent authors (Canestrini 1886; Dubinin 1949, 1951a, 1951b, 1952, 1953; Mironov 1989a).

All Dubinin's material was collected from dry museum skins, most of which were very old and dated by the 19th century. We believe that cross-contaminations in this material are quite possible. Mites of the genus *Zachvatkinia* are usually very abundant on their hosts and it is likely that a few individuals found on a museum skin represent an inadvertent cross-contamination rather than the actual association.

Therefore, we believe that Dubinin (1949) misidentified his material as "*Z. puffini"* because most of his samples were from *Calonectris* and *Puffinus*, but not from *Procellaria cinerea*. We also suggest now that the majority of well-preserved Dubinin's specimens represent *Z. ovata*. Below we redescribe *Z. puffini* based on the material collected from its type host, *P. cinerea*. Additionally, we synonymize *Z. robusta* Mironov, 1991 described from *P. aequnoctialis* Linnaeus 1758 from Antarctica (Mironov 1991) with *Z. puffini*.

MATERIAL AND METHODS

Feather mites from *Procellaria cinerea* were collected by Dr. J. González-Solís (Universidad de Barcelona, Spain), the supervisor of the junior author, in the field. Bird capturing, handling, and sampling for mites were made in accordance with the European Union legislation, and with a permit. Feather mites, sampled using the dust-ruffling method (Clayton and Moore 1997), were cleared in lactic acid for 24h and mounted on microscope slides in PVA medium (BioQuip Products, Rancho Dominguez, California). Mites specimens used for redescription will be deposited in the Zoological Institute of the Russian Academy of Sciences (Saint Petersburg, Russia).

The redescription of *Z. puffini* follows the standards used for bonnetelline mites (Mironov 1989a; 2000). Morphological terms and the leg chaetotaxy follow Gaud and Atyeo (1996); the idiosomal chaetotaxy also follows these authors with corrections for coxal setae as proposed by Norton (1998). All measurements are in micrometers (μm). Drawings were made using a Leica DM 5000B light microscope with DIC illumination and a camera lucida.

Family Avenzoariidae Oudemans, 1905

Subfamily Bonnetellinae Atyeo et Gaud, 1981

Genus *Zachvatkinia* Dubinin, 1949

Giebelia Trouessart, 1916: 217 (preoccupied by Kellogg 1896: Insecta, Mallophaga).
Buchholzia (non Trouessart, 1916): Bonnet 1924a: 192 (partim) (preoccupied by Michaelsen 1886: Oligochaeta, Enchytraeidae).
Zachvatkinia Dubinin, 1949: 216 (nom. n. pro *Giebelia* Trouessart, 1916); 1951b: 217; 1952: 254; Gaud 1976: 27; Gaud and Till 1961: 278 (partim); Atyeo and Peterson 1967: 100; 1970: 146; Atyeo and Gaud 1981: 342; Mironov 1989a: 92.
Pseudogiebelia Radford, 1950: 167 (nom. n. pro *Giebelia* Trouessart, 1916); 1953: 204.

Type species: *Dermaleichus puffini* Buchholz, 1869 by original designation (Trouessart 1916).

Trouessart (1916) established the genus *Giebelia* with a single species, *Dermaleichus puffini* Buchholz, 1869 from the type host *Procellaria cinerea* Gmelin, 1789 (Procellariiformes: Procellariidae). Bonnet (1924a) moved *D. puffini* to the genus *Buchholzia* Trouessart, 1916, because he considered *Giebelia* Trouessart a junior synonym of *Buchholzia* Trouessart. The latter genus was established by Trouessart in the same paper for a single species, *Analges fuscus* Nitzsch, 1818 from *Pandion haliaetus* Linnaeus, 1758 (Falconiformes: Pandionidae). Bonnet's synonymy was not accepted by subsequent authors and they treated the two Trouessart's taxa as separate genera. Besides, Bonnet (1924a) did not know that both generic names proposed by Trouessart were junior homonyms. Thus, *Giebelia* Trouessart was preoccupied by Kellogg (1896) in Mallophaga. Dubinin (1949) found out this homonymy and proposed a replacement name, *Zachvatkinia*, for *Giebelia* Trouessart. Radford (1950), not knowing about the work of Dubinin, also proposed a replacement name *Pseudogiebelia* Radford, 1950.

For *Buchholzia* Trouessart, 1916 (preoccupied by Michaelsen 1886 in Oligochaeta, Enchytraeidae), Trouessart (in Bonnet 1924b) proposed a new name, *Bonnetella* Trouessart, 1924. Not

knowing about this replacement, which was given in a footnote of the paper, Balogh (1937) proposed another replacement name, *Pandionacarus* Balogh, 1937. Since then, *Bonnetella* Trouessart, 1924 has been used as a valid name for nearly ninety years until it was discovered that it is also a junior homonym (preoccupied by Cossmann 1908 in Gastropoda) making *Pandionacarus* Balogh a valid name for this monotypic genus (Özdikmen 2008).

Zachvatkinia puffini (Buchholz, 1869)

Figs. 1–5, 6A–E

Dermaleichus puffini Buchholz, 1869: 37, fig. 23, 24.
Pteronyssus puffini (partim): Trouessart 1885: 50; Canestrini 1886: 274, taf. 2, fig. 1; Berlese 1887: Fasc. 38, N 3; Canestrini and Kramer 1899: 84; Bedford 1932: 257.
Giebelia puffini (partim): Trouessart 1916: 217; Bedford, 1936: 73.
Buchholzia puffini (partim): Bonnet 1924: 192; Gaud 1953: 216.
Zachvatkinia puffini (partim): Dubinin 1949: 217, fig. 9в, 10в; 1951a: 112, fig. 92 (*1*); 1952: 255, fig. 1 (*1*), 2 (*1*); 1953: 199, fig. 75B; Radford 1958: 132; Gaud and Till 1961: 278, fig. 172; Mironov 1989a: 105, figs. 4, 5, 7, 8.
Pseudogiebelia puffini (partim): Radford 1953: 204.
Zachvatkinia (Zachvatkinia) robusta Mironov, 1991: 70, fig. 1, **syn. n**.

Material examined. 7 males, 5 females (ZISP 5057–5059) from *Procellaria cinerea* Gmelin, 1789 (Procellariiformes: Procellariidae), Gough Island (British oversee territory), 40º20′43″ S, 9º53′10″ W, 25 September 2009, coll. J. González-Solís. Male holotype (ZISP 3722), 5 male and 6 female paratypes (*Z. robusta* Mironov, 1991) from *P. aequinoctialis* Linnaeus, 1758 (Procellariiformes: Procellriidae), South Georgia Island, 30 April 1987, coll. I.S. Smirnov.

Male (n = 5). Length of idiosoma from anterior end to bases of setae *h3* 680–718, greatest width at level of humeral shields 440–480. Gnathosoma: length including palps 108–110, greatest width 70–79, lateral margins of subcapitulum slightly convex, with a pair of ledge-like extensions (Fig. 6A). Prodorsal shield: pear-shaped, strongly narrowed in anterior part, with pair of small ovate unsclerotized patches in anterior one third, posterior margin straight, posterior angles rounded, lateral margins without incisions at bases of setae *se*, length along midline 195–198, greatest width 178–184 (Fig. 1). Setae *vi* minute filiform, about 5–8 long (Fig. 6C). Scapular setae *se* separated by 160–166, setae *si* situated slightly anterior to level of these setae. Length of hysterosoma from level of sejugal furrow to lobar apices 515–550. Setae *c3* narrowly lanceolate basally, with filiform apex, 53–62 long. Hysteronotal shield: anterior margin slightly concave, anterior angles rounded, connected by narrow transverse bridges to corresponding humeral shields, greatest length from level of anterior angles to bases of setae *h3* 510–520, width at anterior margin 315–322. Opisthosomal lobes long and relatively wide, approximately parallel each other; terminal membranes on lobar apices roughly rectangular, with oblique distal margin; width of opisthosoma at level of setae *f2* 245–255. Terminal cleft extending slightly beyond level of setae *e2*, length from anterior end to lobar apices 255–267, greatest width 120–125, lateral margins of cleft without ledge near bases of setae *h3*. Interlobar membrane wide, monotonously narrowed to lobar apices, incision in interlobar membrane extending beyond level of setae *h1*, length of incision from anterior end to distal margins of terminal membranes 180–195 (Fig, 1). Distance between dorsal setae: *c2:d2* 116–128, *d2:e2* 133–146, *e2:h2* 178–188, *h2:h3* 50–55, *c1:c1* 192–214, *d1:d1* 130–135, *e1:e1* 155–160, *h2:h2* 190–200, *h3:h3* 130–135. Setae *ps1* not extending beyond lobar apices, 50–60 long.

Sternum about half as long as total length of epimerites I. Coxal setae *3a* and *4b* situated at same transverse level. Genital apparatus small, branches of genital arch curved medially and fused forming closed ring- or stirrup-shaped stricture, 31–33 in length, 35–36 in width (Fig 2, 6D). Genital setae *g* situated on posterior margin of ring-shaped genital apparatus, very close to one another. Fused adanal shields with truncate or slightly concave median extension; setae *ps3* situated on adanal shields. Diameter of anal suckers 42–44. Adanal apodemes wide, additional adanal sclerites present, transverse, closely adjacent to inner ends of adanal apodemes. Distance between ventral setae: *4b:4a* 70–76, *4b:g* 89–100, *g:ps3* 44–50, *4b:4b* 53–70, *g:g* 10–11, *ps3:ps3* 72–80.

Tarsi I, II without apical spine-like processes (Figs. 5A, B). Setae *cG* of genua I, II narrow spine-like, slightly curved; setae *mG* of genua I, II filiform. Tarsus III: seta *s* thick spine-like, bidentate apically and with basal tooth-like extension; seta *w* with thin needle-like extension at midlevel (Fig. 5C). Tarsus IV with one dorsobasal spine-like extension and with small subapical spine-like extension at base of modified seta *e* (Fig. 5D). Length of

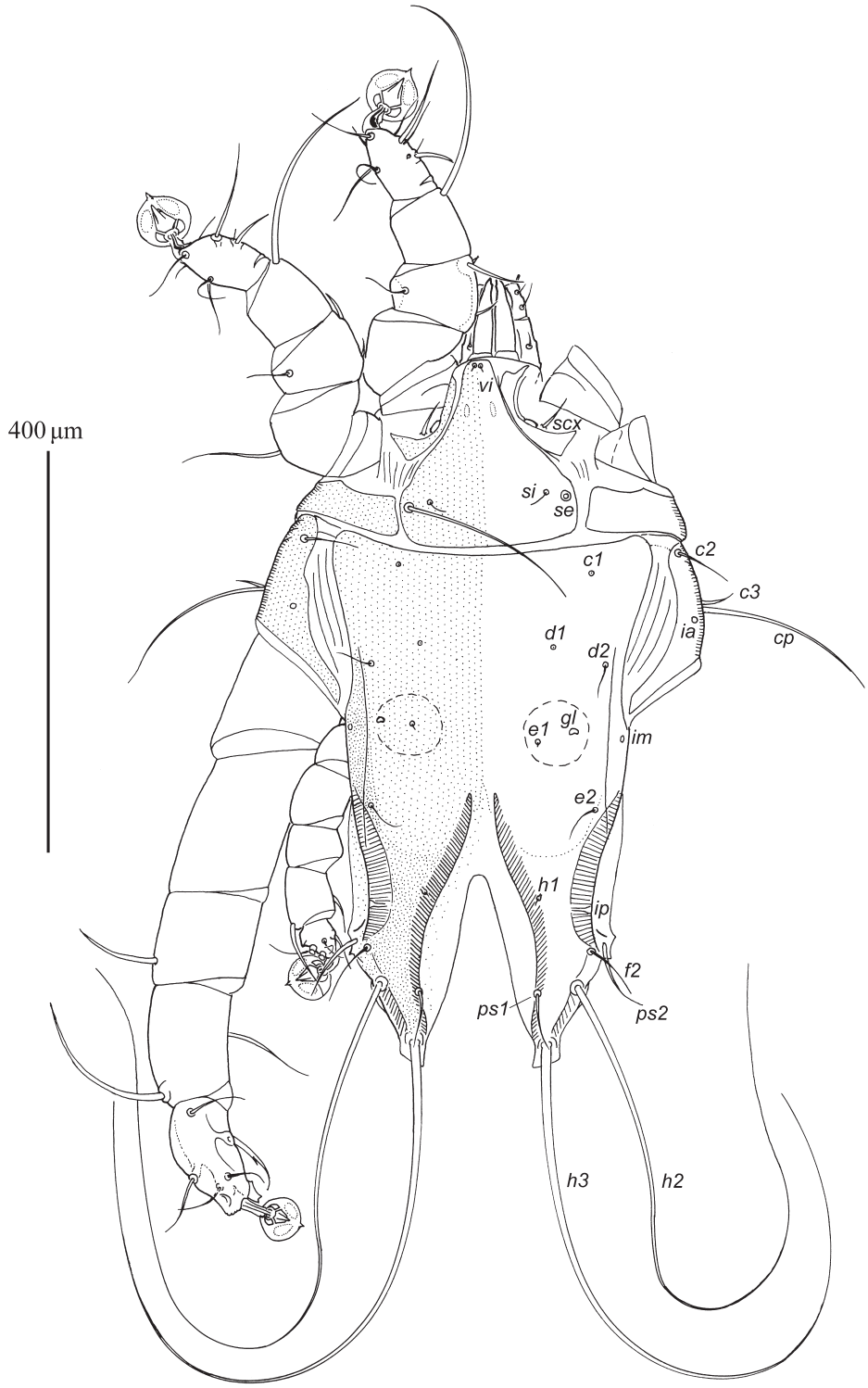

Fig. 1. *Zachvatkinia puffini*, dorsal view of male.

tarsi I–IV excluding pretarsus: I: 86–90, II: 90–96, III: 125–128, IV: 36–42.

Female (n = 3). Idiosoma, length × width, 530–550 × 370–405. Gnathosoma: generally shaped as in male, but basal part of subcapitulum wider, with blunt-angular lateral extensions, length including palps 98–110, greatest width 80–85 (Fig. 6B). Prodorsal shield: pear-shaped, strongly narrowed in anterior part, anterior part with pair of short unsclerotized grooves, posterior margin slightly convex, lateral margins with small incisions posterior to bases of setae *se*, length along midline 158–170, greatest width 146–188 (Fig. 3). Setae *vi* minute filiform as in male. Distance between setae *se* 160–165; setae *se*, *si* situated on same transverse level. Humeral shields large, oc-

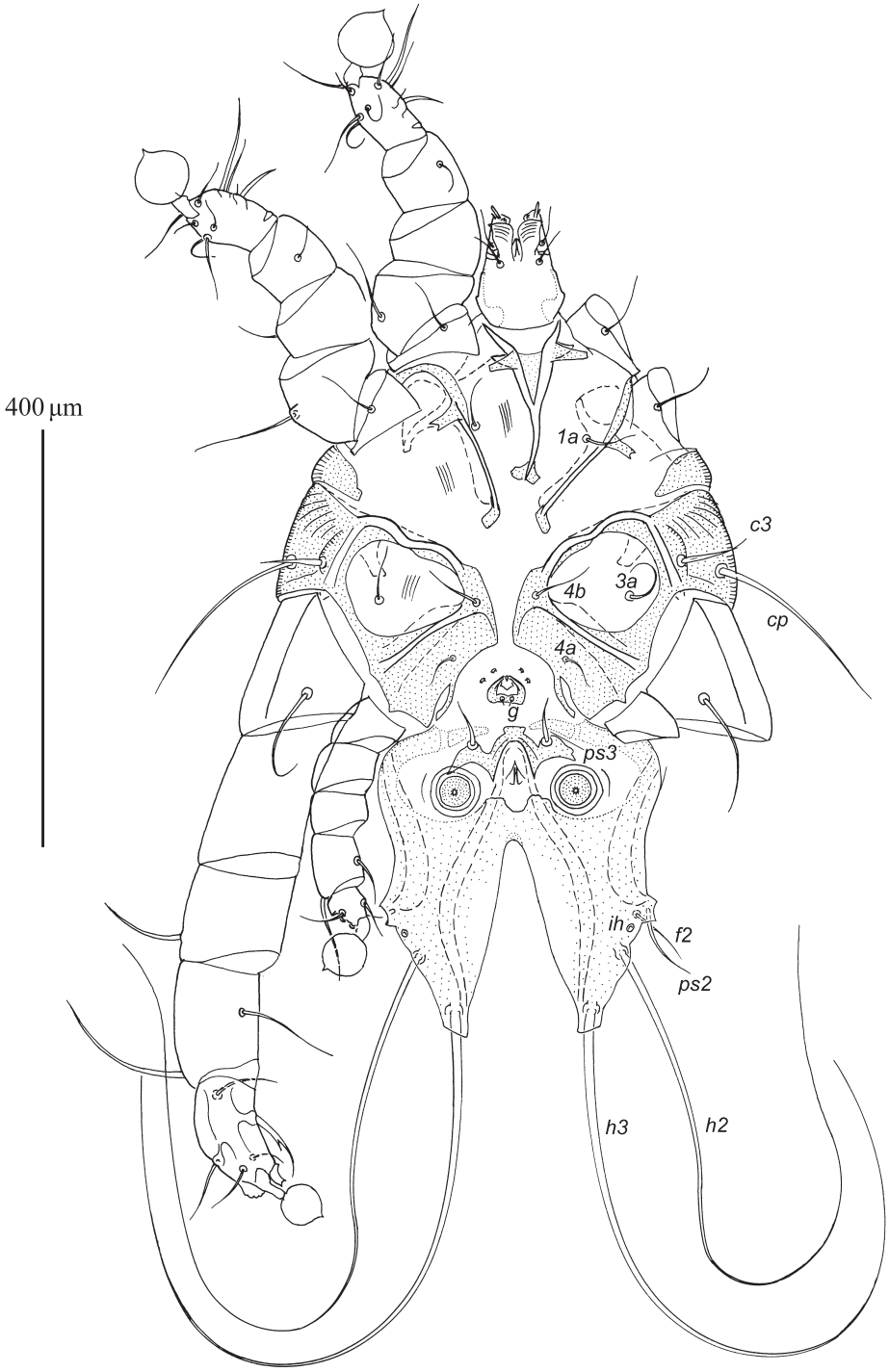

Fig. 2. *Zachvatkinia puffini*, ventral view of male.

cupying all lateral areas of idiosoma between corresponding scapular and hysteronotal shields, encompassing bases of setae *c2*. Setae *c3* narrowly lanceolate, with filiform apex, 42–44 long. Length of hysterosoma from sejugal furrow to posterior margin of opisthosoma 366–400. Hysteronotal shields 250–300 long, shortest distance between their inner margins (at level of setae *e1*) 90–106. Setae *c1*, *d1* situated on striated median tegument of hysterosoma, setae *e1* situated on inner margins of hysteronotal shields slightly posterior to level of gland openings *gl* (Fig. 3). Posterior margin of opisthosoma with short and blunt terminal extension, with poorly expressed lobes, posterior margin of this extension with narrow membrane (Fig. 6E). Pigydial shield short and wide, with slightly convex anterior margins, 48–54 long, 110–120 wide. Copulatory opening situated on small conical extension near anterior margin of pygidial shield. Distance between dorsal setae: *c2:d2* 150–160, *d2:e2*

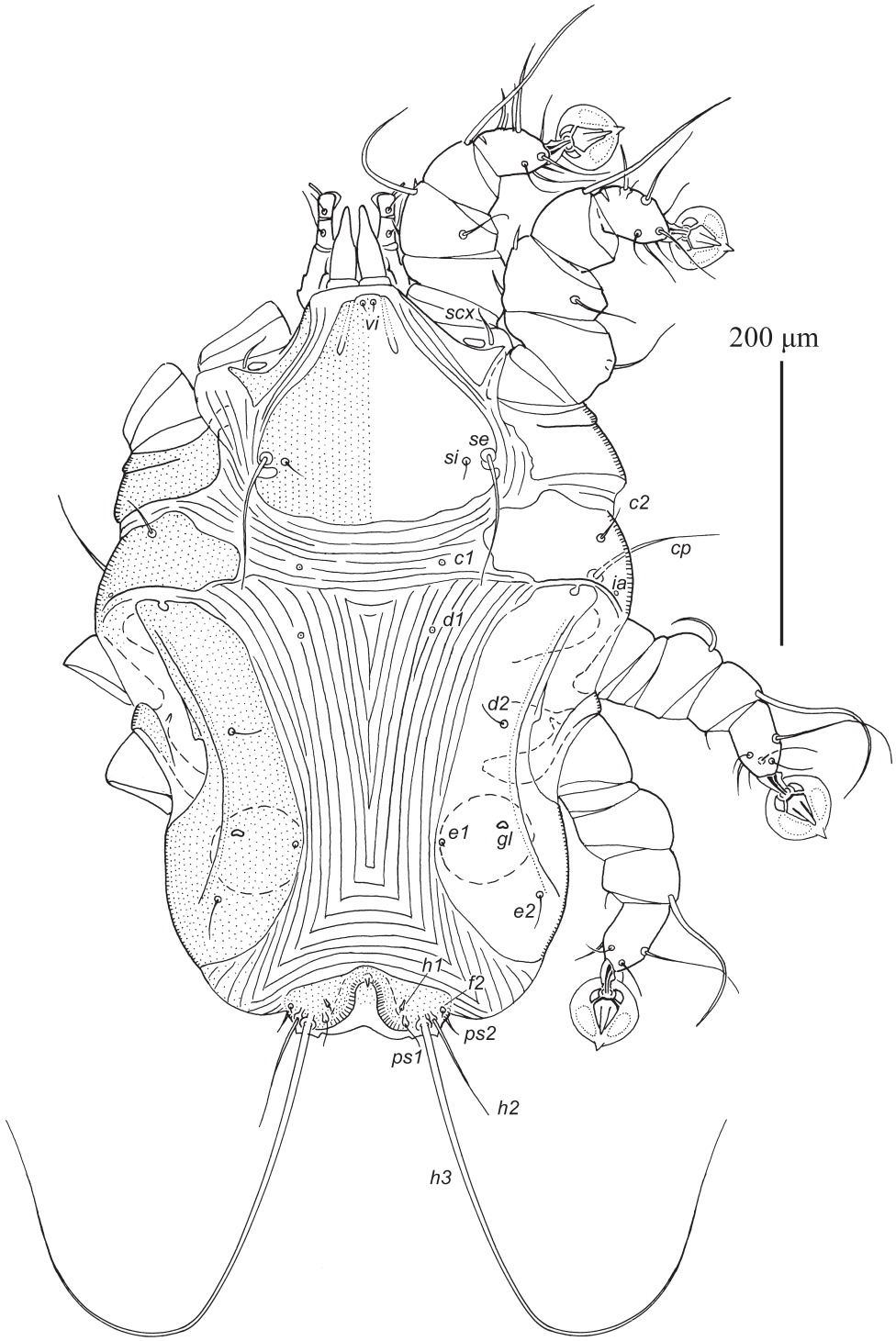

Fig. 3. *Zachvatkinia puffini*, dorsal view of female.

120–130, *e2:h3* 98–106, *c1:c1* 98–110, *d1–d1* 78–80, *e1–e1* 98–120, *h2:h2* 90–95, *h3:h3* 80–85.

Epimerites I fused into a Y, sternum about half as long as total length of epimerites. Bases of epimerites I, II not thickened. Humeral shields ventrally fused with epimerites IIa and III. Epimerites IIIa and IVa with wide subtegumental ridges. Transverse sclerites of coxal fields III situated posterior to tips of epimerites III. Epigynum semicircular, thick, extending to level of anterior genital papillae (Fig. 4), 50–64 long, 98–120 wide. Setae *g* situated posterior to level of setae *3a*.

Legs I–IV stumpy; femora, genua and tibia of all legs noticeably wider than long (Fig 4). Femora II with small extensions covering bases of setae *vF*II. Genual setae *cG*I, II and *mG*I, II as in male. Tarsi III, IV slightly longer than wide; tarsus IV 1.7–1.8 times longer than corresponding tibia

Fig. 4. *Zachvatkinia puffini*, dorsal view of male. ts — transverse sclerite.

(Figs. 5E, F). Leg IV slightly extending beyond posterior margin of the body. Length of tarsi I–IV excluding pretarsi: I: 51–55, II: 53–57, III: 46–49, IV: 53–57.

Remark. Among previously described species of the *puffini* species group, *Z. puffini* resembles *Z. ovata* Mironov, 1989 described from *Calonectris borealis* (Cory, 1881). *Zachvatkinia puffini* can be clearly distinguished from this species by the following features: in males, setae *vi* are minute filiform (less than 10 in length), the genital apparatus circle- or stirrup-shaped, genital setae *g* are situated on the posterior margin of the genital apparatus very close to each other, the fused part of the adanal shields forms a truncate or slightly concave median extension, the additional adanal sclerites form a continuation of the adanal apodemes (Figs. 6C, D); in females, the humeral

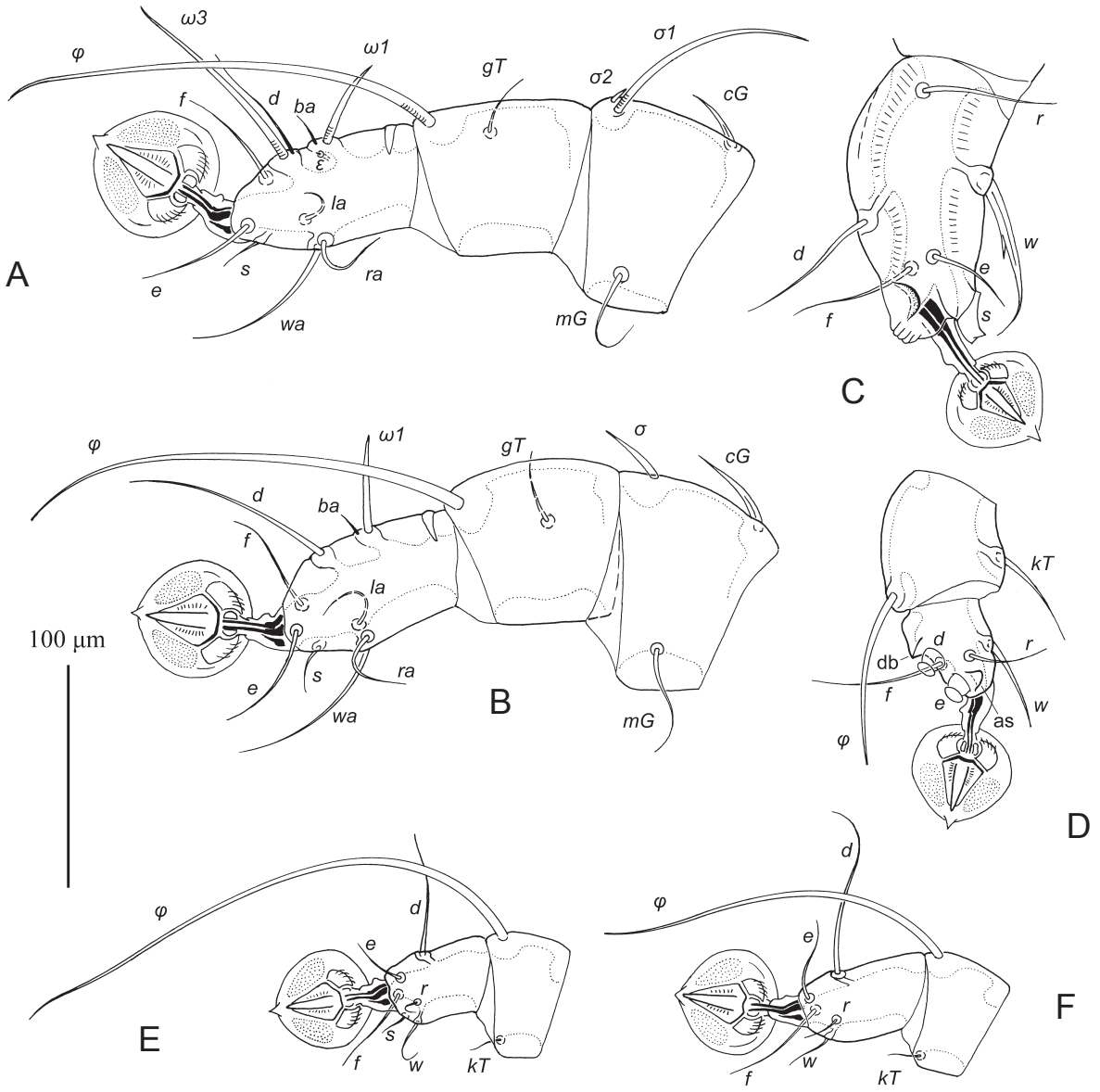

Fig. 5. *Zachvatkinia puffini*, legs. A — tarsus, tibia and genu I of male, B — tarsus, tibia and genus II of male, C — tarsus III of male, D — tarsus and tibia IV of male, E — tarsus and tibia III of female, F — tarsus and tibia IV of female. as —apical spine-like extension of tarsus IV, db — dorsobasal spine-like extension of tarsus IV.

shields are large and encompass the bases of setae *c2* (Fig. 2), cupules *ia* are situated on the humeral shields, tarsi IV are 1.7–1.8 times longer than corresponding tibiae (Fig. 5F). In males of *Z. ovata*, setae *vi* are spiculiform, about 20–25 long (Fig. 6F), branches of the genital arch are crescent-shaped and widely separated from each other, genital setae *g* are situated on the lateral margins of the branches of the genital arch and their bases are separated by 50–60, the fused branches of adanal shields form an acute angle, the additional adanal sclerites are situated between the adanal shields and the ends of the adanal apodemes (Fig. 6G); in females, the humeral shields do not encompass the bases of setae *c2*, cupules *ia* are situated on soft tegument, tarsi IV are 2 times longer than corresponding tibiae.

ACKNOWLEDGEMENT

We thank Dr. J. González-Solís (Universidad de Barcelona, Spain) for specimens. This research was supported by grants CGL2006-01315/BOS and CGL2009-11278/BOS from the MICINN (Spain) and Fondos FEDER for JGS and LS, and Grant 13-04-00608a from the Russian Foundation for Basic Research for SM. Comparative material used in the present study is deposited in the collection (UFC ZIN No 2–2.20) of the Zoological Institute of the Russian Academy of Sciences (Saint Petersburg, Russia).

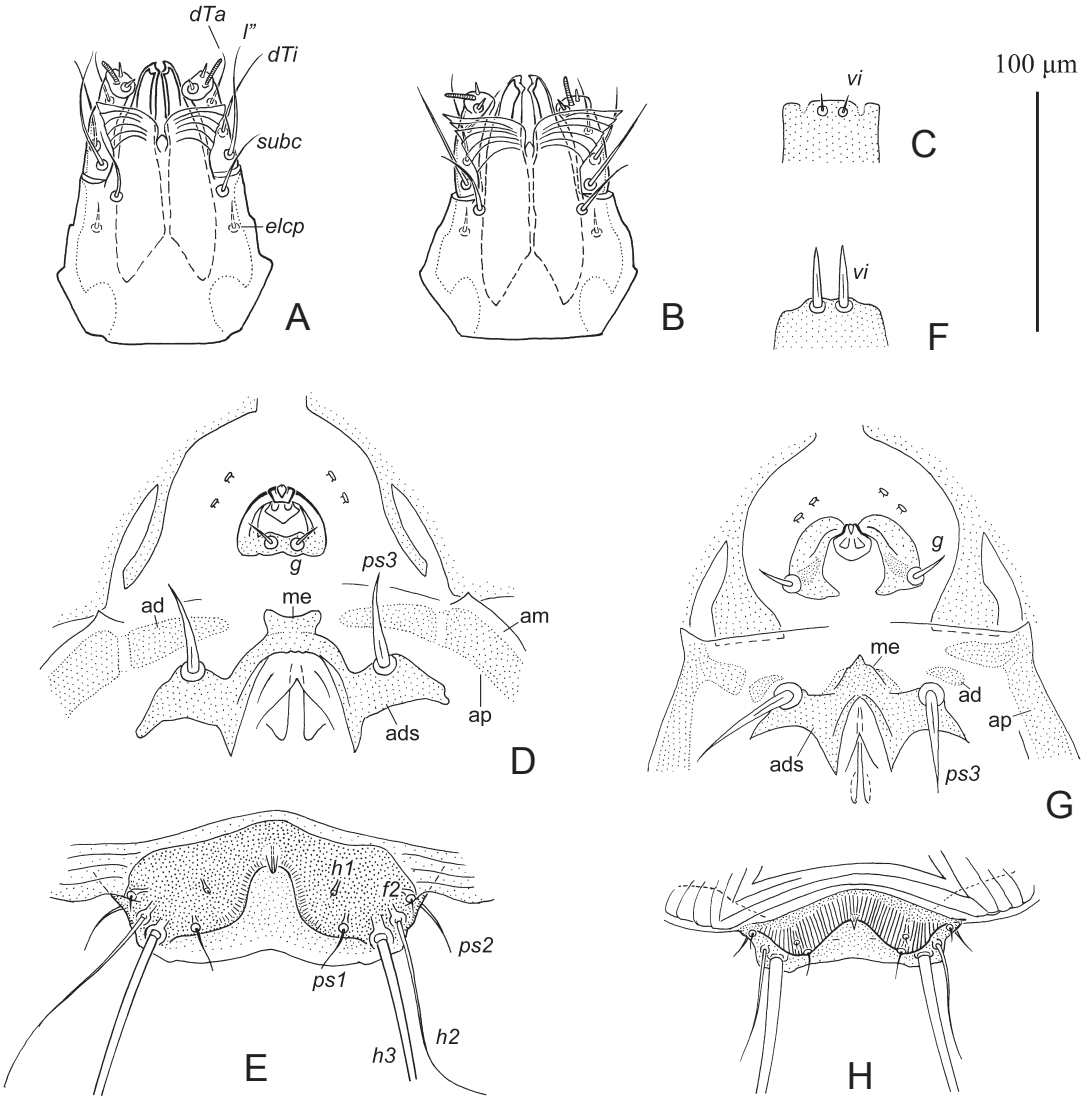

Fig. 6. *Zachvatkinia* species, details. A–E — *Zachvatkinia puffini*, F–H — *Z. ovata*. A — gnathosoma of male, ventral view; B — gnathosoma of female, ventral view; C — setae *vi* of male, D — male genital apparatus and surrounding sclerites, E — pygidial shield of female, F — setae *vi* of male, G — male genital apparatus and surrounding sclerites, H — pygidial shield of female. ad — additional adanal sclerite, ads — adanal shield, am — adanal membrane, ap — adanal apodeme, me — median extension of adanal shields.

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