
ABSTRACT

Folsomia najtae n. sp. is described from the southern part of Sikhote-Alin Range (Far East, Russia). It is characterized by 6 + 6 ommatidia, a full set of ms-chaetae on body tergites, long accp3 s-chaetae on the fifth abdominal segment, four posterior chaetae on dens, and dimorphism of juvenile specimens. The properties that define the ’mobile’ form are protruding cornea of ommatidia and tuberous long dens. The closely related species F. orientalis Martynova, 1977 and F. setula Christiansen & Tucker, 1977 are redescribed basing on the material from North-East of Asia and East of North America, respectively.

Mikhail B. POTAPAOV
Moscow Pedagogical State University, Moscow 129164, Kibalchicha St. 6 b. 3 (Russia)
mpnk-abroad@yandex.ru
(corresponding author)

Arne FJELLBERG
Mågerøveien 168, N-3145, Tjøme (Norway)
arneecoll@gmail.com

Anna BOKOVA
Moscow Pedagogical State University, Moscow 129164, Kibalchicha St. 6 b. 3 (Russia)
anbok.mpgu@gmail.com

Published on 31st March 2017

KEY WORDS
Sikhote-Alin Range, Russia, phenotypic plasticity, dimorphism, ommatidia, new species.

MOTS CLÉS
Monts Sikhote-Alin, Russie, plasticité phénotypique, dimorphisme, ommatidies, espèce nouvelle.
INTRODUCTION

Morphological plasticity of Collembola was repeatedly described by using terms like sex dimorphism, epitoky, ecomorphosis, and cyclomorphosis (Fjellberg 1976; Cassagnau 1990). Judith Najt made a large contribution to our knowledge on the morphological modifications related to unfavourable environmental condition, age instar and sex. Najt & Massoud (1976) and Najt & Dalens (1979) were the first to give special attention to morphological abnormalities in Collembola. It was concluded that some taxa were more vulnerable to the factors responsible for abnormal morphology. Anomalies of Collembola were classified, the epitoky and ecomorphosis were considered among distinguished groups. Subsequently these special kinds of modifications were given more attention since their functional value became more evident. Thereafter several ecomorphic forms were described (Najt 1979; 1980; 1981a, b), for example in *Folsomia nigromaculata* Najt, 1980, *Gnathisotoma bicolor* Cassagnau, 1957, *Gnatidionota* sp., *Desoria* sp. (studied as ‘*Isotoma olivacea’*), *D. gersi* Najt, 1981, *D. graeae* Najt, 1981, *D. propinqu* (Axelson, 1902), *Isotoma viridis* Boulet, 1839, *Proisotoma* (s.l.) *veca* (Wray, 1952), and *Cilifora aleghaniensis* (Wray, 1952). The published data on other ‘ecomorphic species’ of the family Isotomidae were summarized by Najt (1983). Four types of ecomorphic modifications were proposed to classify all known cases, based on morphological structures affected by ecomorphosis. These include chaetae, cuticle, shape of body, or a combination of these structures. Secondary sexual dimorphism and epitoky, other intriguing phenomena, were investigated, including male secondary sexual characters in several species of Brachystomellidae (Massoud & Najt 1974; Weiner & Najt 2001). The genera of Isotomidae with well developed secondary sex dimorphism were also discussed (Najt 1977). In her opinion, the characters of strong sex dimorphism were of great taxonomical value and indicated the generic status of sexually dimorphic forms.

In the genus *Folsomia* Willem, 1902, three species are known to date to be affected by ecomorphosis (Najt 1980; Takeda 1985; Culik & Najt 1986), which include *F. nigromaculata*, *F. elongata* (MacGillivray, 1896) and *F. octooculata* Handschin, 1925. In the present paper we describe a new species from the Far East of Russia displaying a phenotypic modification known in the family Isotomidae as the ‘mobile’ forms (Potapov & Bogomolov 2015). This type of modifications was not observed in the genus *Folsomia* until now.

MATERIAL AND METHODS

The material on which this paper is based is deposited in the Moscow State Pedagogical University, Russia (MSPU) and Muséum national d’Histoire naturelle in Paris, France (MNHN).

ABBREVIATIONS

| accep | accessory p-row s-chaetae; |
| Abd. | abdominal segments; |
| alt. | altitude; |
New Folsomia with 'mobile' forms from Russia

Head
Ocelli 6 + 6, size of cornea strongly variable (see the dimorphism part below). PAO narrow, constricted, longer (1.1-1.3) than width of Ant.I and 1.3-1.6 as long as inner unguis length (Figs 2E-G; 3A). Its anterior and posterior edges often with chitinized wrinkles ('setulae' or 'denticles' in use, auct.): though the variation of the character is high, from factually smooth to wrinkled, even in our not so abundant material. Maxillary outer lobe with 4 sublobal hairs, maxillary palp bifurcate (few specimens found with simple palp at least on one side). Labral formula as 4/5,5,4. Labium with 5 papillae (A-E), guard e7 absent, with 3 proximal, 4 basomedian, and 5 basolateral chaetae. Ventral side of head with 4 + 4 postlabial chaetae. Ant.1 with 2 ventral s-chaetae (s) and 3 small basal ms-chaetae (bms), 2 dorsal and 1 ventral (Fig. 2E), normally with 13 chaetae. Ant.2 with 3 bms and a laterodistal s. Ant.3 without bms and with 6 distal s (including two lateral), without additional s-chaetae. Ant.4 with several tubular s-chaetae. Organite rather big and roundish, set together with subapical ms.

Body
S-formula 4,3/2,2,3,5 (s) and 1,1/1,1,1 (ms) (Fig. 3B, C). Tergal s-chaetae short, much shorter than common chaetae, longer on Abd.V. Medial s-chaetae on Th.II-Abd.III situated in mid-tergal position, on Abd.I-III between Mac1 and Mac2. Abd.V with 5 s-chaetae arranged as 3 dorsal ones (as, accp1, accp2), of middle size, almost as long as common chaetae, one dorso-lateral accp3, longer and thicker than in dorsal group, and one ventro-lateral short ('3+1+1' pattern) (Figs 1B; 3B). Common chaetae short. Macrochaetae rather short and smooth, 2,2/3,3,3 in number, medial pair hardly

---

Fig. 1. — Folsomia najtae n. sp.: A, appearance of subadult ♀ of normal form (1.4 mm); B, Abd. IV-VI. Abbreviations: see Material and methods. Scale bars: A, 0.3 mm; B, 0.1 mm.
visible on thorax, especially on Th.II. Medial macrochaetae on Abd.V shorter than dens (0.4-0.7, see also dimorphism) and 1.6-2.1 times longer than mucro. Foil chaetae at the tip of abdomen absent. Axial chaetotaxy abundant. Thoracic sternites without ventral chaetae. Unguis with lateral teeth (Fig. 3D). Empodial appendage about half as long as inner edge of unguis. Tibiotarsi normally with 1-2 additional chaetae on Leg 1 and 2, and with several additional chaetae on Leg 3. Tibiotarsal tenent chaetae pointed. VT with 4 + 4, more rarely 3 + 4 or 3 + 3 laterodistal and 6-7 posterior chaetae, anteriorly without chaetae. Tenaculum with 4 + 4 teeth and 1-2 chaetae. Anterior furcal subcoxae with 7-12, posterior one with 2-4 chaetae. Anterior side of manubrium with two pairs of chaetae, as 2 + 2 (rarely 1 + 2 or 3 + 2) (Fig. 2C). Posterior side of manubrium with 4 + 4 (4 + 5) laterobasal, 1 + 1 apical (a1), 2 + 2 distal chaetae (M1, L1, without ml1). Lateral chaetae (l2) present or absent (Fig. 2C). Dens with 8 anterior chaetae arranged as 1,1,1,2,3. Posterior side of dens with few distinct crenulations at the middle, with 3 chaetae on proximal half and 1 at the middle. Length of dens and crenulations on its posterior side affected by dimorphism (see below). Mucro bidentate. Ratio of manubrium: dens: mucro = 3.8-4.4 : 2.8-4.6 : 1 (considering both normal and ‘mobile’ forms).
REMARKS

*F. najtae* n. sp., *F. setula* (eastern areas of USA), and *F. orientalis* (North of Far East of Russia) form a compact group of species which is characterized by the presence of 6+6 ommatidia, full set of ms-chaetae on body tergites, long accp3 s-chaetae on the fifth abdominal segment (Figs 1B; 4A, B), short chaetae covering, two s-chaetae on Ant.1.

Normally *F. najtae* n. sp. does not show such a prominent PAO as in *F. setula*, but its variability prevents (Fig. 3A) reliably separating the two species with this key character. After

---

**Fig. 3.** — A-D, *Folsomia najtae* n. sp.: variability of PAO (A); s-chaetae and macrochaetae on tergites of Abd.II-VI (B) and Th.II,III and Abd.I (C), apical part of leg 3 (D); E, F, *F. setula* Christiansen & Tucker, 1977, dens, lateral view (E), PAO (F); G, *F. orientalis* Martynova, 1977 furca, lateral view. Abbreviations: see Material and methods. Scale bars: A, D-F, 0.03 mm; B, C, 0.02 mm; G, 0.05 mm.
our study the only steady character is the number of chaetae on the posterior side of the dens: 4 (F. najtiae n. sp.) vs 3 (F. setula) (see Figs 2C; 3E). Apart from this, F. setula has 12 common chaetae on Ant.1 (vs 13 in F. najtiae n. sp.) but the character is not very stable in the new species. Folsomia orientalis has 8-10/5 chaetae on dens (Fig. 3G, vs 8/4 in F. najtiae n. sp. and 6-8-6-8 laterodistal chaetae on ventral tube (vs 4(3)+4(3) in F. najtiae n. sp.), labial palps with guard e7 present (vs absent in F. najtiae n. sp. and F. setula), chaetae ml1 present on the manubrium (Fig. 3G, vs absent in F. najtiae n. sp. and F. setula), and basal ms present on Ant.3 (vs absent in other two species).

ECOLOGY AND DISTRIBUTION
The new species is known from four localities within the southern spurs of the Sikhote-Alin Mt. Range (Far East of Russia). It often inhabits rotten wood that may explain its stout body shape, large head and short antennae being usual characteristics of xylophilous species of springtails.

Folsomia setula Christiansen & Tucker, 1977
(Figs 3E, F; 4A)

Folsomia setula Christiansen & Tucker, 1977: 376.


ECOLOGY AND DISTRIBUTION. — F. setula is probably distributed only in the East of USA.

REDESCRIPTION
Colouration from almost white (often in juveniles) to blue fumose. Body stout, antennae short. Cornes of ocelli hardly marked, their number (6 + 6) defined by form of eye pigment which often weakly developed in juveniles. PAO narrow, constricted, longer (c. 1. 3) than width of Ant.I and 1.8-1.9 as long as inner unguis length (Fig. 3F), its anterior and posterior edges with chitinized wrinkles. Outer mouth parts as in F. najtiae n. sp. Labial palp without guard e7 (present on one side of one individual). Ventral side of head with 4 + 4 postlabial chaetae. Ant.I with 2 ventral s and 3 small bms, 2 dorsal and 1 ventral, with 12 (rarily 11) common chaetae. Ant.2 with 3 bms and a latero-distal s. Ant.3 without bms and with 6 distal s (including two lateral), without additional s. Ant.4 with big and roundish organite. S- and ms-formula as in F. najtiae n. sp. Abd.V with 3 dorsal s (as, acp1, acp2) of middle size, one longer and thicker dorso-lateral acp3, and one short ventro-lateral acp4 (Fig. 4A). Common chaetae very short. Macrochaetae short and smooth, 2,2’/3,3,3 in number, medial pair rudimentary on Th.II. Medial macrochaetae on Abd.V shorter than dens (0.6-0.8) and 1.8-1.9 times longer than mucro. No foil chaetae. Axial chaetotaxy abundant (9,7/6,5,5 seen in one individual). Unguis with lateral teeth. Empodial appendage about half as long as inner edge of unguis (0.5-0.6). Tibiotarsi with few additional chaetae. VT with 3 +4 +3-4 laterodistal and 5-6 posterior chaetae. Tenaculum with 4 + 4 teeth and 1-2 chaetae. Anterior furcal subcoxae with 5-7, posterior one with 1-3 chaetae. Anterior side of manubrium with two pairs of chaetae (rarely 1 + 2). Posterior side of manubrium with 4 + 4 laterobasal, 1 + 1 apical (a1), 2 + 2 distal chaetae (M1, L1, without ml1), and 4 + 4 central chaetae. Lateral chaetae (l2) present. Dens with 7-8 anterior and 3 posterior chaetae, basal chaeta larger (Fig. 3E). Ratio of manubrium: dens: mucro = 3.5-3.7 : 2.6-3.0 : 1.

REMARK
After Christiansen & Bellinger (1998), F. setula is recorded from Illinois and Kentucky and can be easily separated from the related species by a striking PAO with prominent inner ‘setulae’ (Fig. 3F). Our material from neighboring states (North Carolina and Tennessee) fits well to the available descriptions (Grow & Christiansen 1976; Christiansen & Tucker 1977) and therefore makes the detailed comparison between F. setula and F. najtiae n. sp. possible (see the Remark part to F. najtiae n. sp.).

Folsomia orientalis Martyanova, 1977
(Figs 3G; 4B)

Folsomia orientalis Martyanova, 1977: 121.


ECOLOGY AND DISTRIBUTION. — F. orientalis is recorded from Magadan region and Kamchatka (NE Asia).

REDESCRIPTION
Colouration bluish grey, irregular. Body of normal shape. 6 + 6 cornes of ocelli well visible, arranged in two groups (4 anterior and 2 posterior). PAO narrow, constricted, longer (1.5-1.6) than width of Ant.I and 1.6-1.9 as long as inner unguis length, without chitinized wrinkles. Outer mouth parts as in F. najtiae n. sp. while guard e7 present. Ventral side of head with 4-5+4-5 postlabial chaetae. Ant.1 with 2 ventral s and 3 small bms, with 13 common chaetae. Ant.2 with 3 bms and a latero-distal s. Ant.3 with bms and with 6 distal s (including two lateral), without additional s. Ant.4 with big and roundish organite. S- and ms-formula as in F. najtiae n. sp. Abd.V with 3 dorsal s (as, acp1, acp2) of middle size, one longer and thicker dorso-lateral acp3, and one short ventro-lateral acp4 (Fig. 4A). Common chaetae very short. Macrochaetae short and smooth, 2,2’/3,3,3 in number, medial pair rudimentary on Th.II. Medial macrochaetae on Abd.V shorter than dens (0.6-0.8) and 1.8-1.9 times longer than mucro. No foil chaetae. Axial chaetotaxy abundant (9,7/6,5,5 seen in one individual). Unguis with lateral teeth. Empodial appendage about half as long as inner edge of unguis (0.5-0.6). Tibiotarsi with few additional chaetae. VT with 3 +4 +3-4 laterodistal and 5-6 posterior chaetae. Tenaculum with 4 + 4 teeth and 1-2 chaetae. Anterior furcal subcoxae with 5-7, posterior one with 1-3 chaetae. Anterior side of manubrium with two pairs of chaetae (rarely 1 + 2). Posterior side of manubrium with 4 + 4 laterobasal, 1 + 1 apical (a1), 2 + 2 distal chaetae (M1, L1, without ml1), and 4 + 4 central chaetae. Lateral chaetae (l2) present. Dens with 7-8 anterior and 3 posterior chaetae, basal chaeta larger (Fig. 3E). Ratio of manubrium: dens: mucro = 3.5-3.7 : 2.6-3.0 : 1.
New Folsomia with ‘mobile’ forms from Russia

than dens (0.5-0.6) and 1.9-2.1 times longer than mucro. No foil chaetae. Axial chaetotaxy abundant. Unguis with lateral teeth. Empodial appendage about half as long as inner edge of unguis. Tibiotarsi with several additional chaetae. VT with 6-8+6-8 laterodistal and more than 10 posterior chaetae. In some specimens posterior side with an additional group of few chaetae at base of VT. Tenaculum with 4 + 4 teeth and normally 2-3 chaetae (4 in holotype). Anterior furcal subcoxae with 9-12, posterior one with 5-6 chaetae. Anterior side of manubrium with two pairs of chaetae. Posterior side of manubrium with 5-6+5-6 laterobasal, 1 + 1 apical (a1), 3 + 3 distal chaetae (M1, L1, m1), and 7 + 7 central chaetae. Lateral chaetae (l2) present. Dens with 9 (more rarely 8 or 10) anterior and 5 posterior chaetae (Fig. 3G). Ratio of manubrium: dens: mucro = 3.9-4.3 : 3.4-3.7 : 1.

REMARK
It is the largest and the most polychaetotic species among the three forms under consideration. For more detail comparison see the Remarks part to F. najiae n. sp.

DIMORPHISM

The new species displays dimorphism appearing in normal and ‘mobile’ forms (Fig. 2A, B). The latter forms were present only in autumn samples and only in two of the seven studied populations, occurring together with normal forms. Modified specimens have larger ocelli and longer dens armed with tubercles (Fig. 2F vs 2E, G; Fig. 2D vs 2C). The dens is 2.0-2.6 times longer than the macrochaetae on Abd.V in mobile forms compared with 1.5-2.0 in normal forms. Other characters, such as tenten hairs on tibiotarsi, skeleton of furcal apparatus and the length of chaetae on the body, are not affected. Along the whole age row of available specimens (from 0.5 to 1.4 mm), only specimens of the size ranging from 0.8 to 1.0 mm are affected by dimorphism. Mobile forms occur among both juvenile females and males. The size of the ocelli is probably age dependent even within normal specimens: younger individuals may have hardly developed cornea, which are almost invisible and marked only by pigmentation and weak swellings at the associated positions of the eye spot (Fig. 2G).

A similar dimorphism can also occur in populations of F. setula. According to Christiansen & Bellinger (1998) “specimens from Illinois had shorter setae and better developed eyes than those from Kentucky”, while the variability of the number of ocelli was also mentioned (4-6). Our material from the North America display only normal forms without clearly marked ocelli, so that their exact number was impossible to ascertain. The studied populations of F. orientalis also consisted of normal specimens only. A similar dimorphism was previously described in four species of Proisotoma s.str. (Potapov & Bogomolov 2015) in which more morphological characters are affected, while protruding eyes and tuberculated dens are shared by mobile forms of both groups. Colonization of temporary substrata (rotten wood and similar sites) is possibly a common trait of the species displaying ‘mobile’ dimorphism.
Acknowledgements
We would like to express our sincere thanks to V. Alpatov, A. Bedos, Y. Bu, L. Deharveng, C.-W. Huang, A. Korotkevich, N. Kuznetsova, L. Lobkova, A. Kuprin, A. Ptashinsky for kindly providing material on Collembola or field assistance in Russia. The authors are grateful to the management and staff of the State Reserve of Laso, Ussuriysky State Nature Reserve, and “Land of the Leopard” National park (Primorsky Krai), who provided the collecting permit and the favourable conditions to our field work in 2011 and 2016. Part of the material of the new species was collected during a joint French-Polish-Russian expedition headed by Louis Deharveng (Paris) in autumn 2004. We also thank Ernest Bernard (Knoxville) for laboratory facilities and practical support during field work in the Appalachian Mountains in 2007. We are also much indebted to Charlene Janion-Scheepers for having edited the English of a draft manuscript, Wanda M. Weiner and an anonymous reviewer for their corrections and suggestions. The study was supported by RFBR (Russia, research project n° 6.632.2014/K of the Ministry of Education and Science of the Russian Federation for the third author.

REFERENCES

Submitted on 12 July 2016; accepted on 12 December 2016; published on 31st March 2017.