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Updates to Szeptycki's check-list of the Protura of the World

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SUMMARY

After 15 years from its publication, the Szeptycki's check-list of the Protura of the World has been updated. Five new genera and 98 new species since then were added. New taxonomical combinations have been adopted. Updates to the species distribution were also added. Globally, the new list shows 831 species belonging to 77 genera arranged in seven families and three orders.

INTRODUCTION

After the description of the first species (*Acerentomon doderoi* Silvestri, 1907) the first worldwide overview of Protura is due to the Tuxen's (1964) monograph where 143 valid species in 16 genera are reviewed. Then, one hundred years after their discovery, Szeptycki (2007) published his monumental Catalogue of the World Protura. Such a volume contains a list of 748 specific and subspecific names of Protura (including eight species inquirendae and four nomina nuda) belonging to 72 genera. Since that time, the world checklist of Protura has not been updated anymore and it still constitutes an unmissable reference point for the group's specialists. The only exception is the world synopsis on genera by Galli et al. (2018). Therefore, after 15 years, the recent description of new taxa and the taxonomic revision of some

genera/species make an update necessary. This paper lists in a systematic order the genera and species known to date in order to fill this gap.

MATERIALS AND METHODS

The checklist presented here (in the Supplementary Material) is based on the systematic arrangement proposed by Szeptycki (2007). The fauna and systematic papers on Protura published since 2007 were examined in order to update the world list of Protura and their distribution. All species for which there are no relevant updates in the most recent literature are simply listed together with the distribution available in Szeptycki's Catalogue. No further bibliographic information is provided on them, for which reference is made to Szeptycki (2007). For the species described later, or placed more

recently in other genera or for whose distribution updates are available in the post-Catalogue literature, the relative bibliographic indications and/or brief remarks are reported. For the new species the place of deposition of the type material is also indicated.

RESULTS AND DISCUSSION

The complete check-list of the world Protura is shown in the Supplementary Material. Totally, 831 valid species belonging to 77 genera are arranged in seven families and three orders. In Table 1 the distribution of each genus is summarized (for an overview on Protura distribution, see Galli & Rellini, 2020).

Table 1. Genera of Protura: number of species (ssp = subspecies) and distribution (? = doubtful).

Genus	Number of species	Distribution
ACERENTOMATA		
Hesperentomidae Price, 1960		
Hesperentominae Price, 1960		
<i>Hesperentomon</i> Price, 1960	20	North America, East and Central Asia
<i>Ionescuellum</i> Tuxen, 1960	8	Europe
Huhentominae Yin, 1983		
<i>Huhentomon</i> Yin, 1977	1 (+1 ssp)	China, Japan
Protentomidae Ewing, 1936		
Hinomotentominae Yin, 1999		
<i>Hinomotentomon</i> Imadaté, 1973	1	Japan
Condeellinae Tuxen & Yin, 1982		
<i>Condeellum</i> Tuxen, 1963	4 (+ 1 ssp)	Subtropical China, Pacific Islands, Tropical Asia, Reunion
<i>Neocondeellum</i> Tuxen & Yin, 1982	10	North America, Far East
<i>Paracondeellum</i> Yin, Xie & Zhang, 1994	2	China
Protentominae Ewing, 1936		
<i>Protentomon</i> Ewing, 1921	14	Cosmopolitan
<i>Proturentomon</i> Silvestri, 1909	13	Holarctic
Acerentomidae Silvestri, 1907		
Berberentulinae Yin, 1983		
<i>Acerentuloides</i> Ewing, 1921	2	North America
<i>Acerentulus</i> Berlese, 1908	47 (+ 2 ssp)	Cosmopolitan
<i>Amazonentulus</i> Yin, 1989	4	South America
<i>Amphientulus</i> Tuxen, 1981	10	South America, Madagascar (?), Far East, Australia, New Zealand
<i>Andinentulus</i> Tuxen, 1984	2	South America
<i>Australentulus</i> Tuxen, 1967	18	Tropical Asia, Madagascar, Australia, New Zealand,
<i>Baculentulus</i> Tuxen, 1977	41	Cosmopolitan
<i>Berberentulus</i> Tuxen, 1963	11	Cosmopolitan
<i>Bolivaridia</i> Bonet, 1942	6	Pantropical
<i>Brasilentulus</i> Nosek, 1973	2	Tropical America and Africa
<i>Brasilidia</i> Nosek, 1973	4	South America, India (?)
<i>Chosonentulus</i> Imadaté & Szeptycki, 1976	2	Northeastern China and Korea
<i>Delamarentulus</i> Tuxen, 1963	3	Tropical America and Africa
<i>Gracilentulus</i> Tuxen, 1963	21	Cosmopolitan

Genus	Number of species	Distribution
<i>Kenyentulus</i> Tuxen, 1981	42	Far East and Tropical Asia; one species (<i>K. kenyanus</i>) pantropical
<i>Madagascaridia</i> Nosek, 1978	2	China, Madagascar
<i>Maderentulus</i> Tuxen, 1963	1	Iberian Peninsula, Macaronesia, Serbia (?)
<i>Najtentulus</i> Szeptycki & Weiner, 1997	1	West Europe
<i>Neobaculentulus</i> Yin, 1984	4	Far East
<i>Notentulus</i> Yin, 1989	2	Central America, China
<i>Podolinella</i> Szeptycki, 1995	2	Europe
<i>Polyadenum</i> Yin, 1980	1	Far East
<i>Proacerella</i> Bernard, 1975	2	North America, West Europe
<i>Silvestridia</i> Bonet, 1942	5	Pantropical
<i>Tasmanentulus</i> Tuxen, 1985	3	Australia, New Zealand
<i>Tuxenidia</i> Nosek & Cvijović, 1969	2	Balkans, Near East
<i>Vindobonella</i> Szeptycki & Christian, 2001	1	Austria
<i>Yinentulus</i> Tuxen, 1985	1	New Zealand
<i>Zangentulus</i> Yin, 1983	1	China
Acerentominae Silvestri, 1907		
<i>Acerentomon</i> Silvestri, 1907	40	West Palearctic
<i>Filientomon</i> Rusek, 1974	10	North America, Far East, Siberia
<i>Fjellbergella</i> Nosek, 1978	4	USA, Russian Far East, NE China
<i>Huashanentulus</i> Yin, 1980	2	China
<i>Liaoxientulus</i> Wu & Yin, 2011	1	Northeastern China
<i>Orinentomon</i> Yin & Xie, 1993	2	Alaska, China
<i>Sugaentulus</i> Imadaté, 1978	3	Alaska, Siberia, Japan
<i>Tuxenentulus</i> Imadaté, 1973	6	North America, Far East
<i>Wenyingia</i> Imadaté, 1986	1	Japan
<i>Yamatentomon</i> Imadaté, 1964	5	Far East
<i>Yichunentulus</i> Yin, 1980	3	Russian Far East, China
Nipponentominae Yin, 1983		
<i>Alaskaentomon</i> Nosek, 1977	2	Alaska
<i>Callientomon</i> Yin, 1980	1	China
<i>Imadateiella</i> Rusek, 1974	8 (+ 1 ssp)	North America, Central and East Asia
<i>Mastodonentomon</i> Sruhobovych, Smykla & Bernard, 2020	1	Alaska
<i>Nanshanentulus</i> Bu & Yin, 2007	1	China (Xinjiang)
<i>Nienna</i> Szeptycki, 1988	3	Central and Eastern Asia
<i>Nipponentomon</i> Imadaté & Yosii, 1959	15 (+ 1 ssp)	North America, Far East
<i>Noldo</i> Szeptycki, 1988	2	East Europe, Central Asia
<i>Nosekiella</i> Rusek, 1974	2	Palearctic
<i>Nosekientomon</i> Shrubovych, Rusek & Bernard, 2014	1	Alaska
<i>Paracerella</i> Imadaté, 1980	4	North America, Far East
<i>Verrucoentomon</i> Rusek, 1974	12	Holarctic
<i>Vesiculentomon</i> Rusek, 1974	2	North America
<i>Yavanna</i> Szeptycki, 1988	7	Alaska, Central Asia

Genus	Number of species	Distribution
Acerellinae Yin, 1983		
<i>Acerella</i> Berlese, 1909	3	West Palearctic
Acerentomata total spp.	457	
SINENTOMATA		
Fujientomidae Tuxen & Yin, 1982		
<i>Fujientomon</i> Imadaté, 1964	2	China, Japan
Sinentomidae Yin, 1965		
<i>Sinentomon</i> Yin, 1965	3	Far East
Sinentomata total spp.	5	
EOSENTOMATA		
Eosentomidae Berlese, 1909		
Isoentominae Yin, 1983		
<i>Isoentomon</i> Tuxen, 1975	11	Mexico, Brazil, Southwest Europe, Canary Island, Kenya, Australia, New Hebrides (“Warmer areas of the whole world” according to Szeptycki, 2007).
<i>Madagascarentomon</i> Nosek, 1978	1	Madagascar
<i>Orientomon</i> Nakamura, 2010	2	China, Japan
<i>Zhongguohentomon</i> Yin, 1979	2	China
Eosentominae Berlese, 1909		
<i>Eosentomon</i> Berlese, 1908	312	Cosmopolitan
<i>Styletoentomon</i> Copeland, 1978	2	North America
Anisentominae Yin, 1983		
<i>Anisentomon</i> Yin, 1977	5	Far East
<i>Neanisentomon</i> Zhang & Yin, 1984	4	China
<i>Paranisentomon</i> Zhang & Yin, 1984	3	Far East
<i>Pseudanisentomon</i> Zhang & Yin, 1984	24	Far East
Antelientomidae Yin, 1983		
<i>Antelientomon</i> Yin, 1974	3	China
Eosentomata total spp.	369	
Total number of species	831	

It is evident, especially deepening the approach to geographic distributions at the species level, that there is a clear preponderance of Chinese and Japanese taxa, followed by Russian ones from the Far East, East Europeans and finally Central and West Europeans, and North Americans. This could be partly related to the intrinsic distribution of Protura diversity, but it is more likely related to the distribution of specialists, as already discussed in Galli & Rellini (2020). In Figure 1 the increase in the number of genera and species known since Protura discovery (Silvestri, 1907) is outlined. In

particular, if compared to the Catalogue of Szeptycki (2007), five new genera and 98 new species have been described; moreover 12 species have been transferred to different genera (Table 2). Updates on the species distribution were obtained from Allen (2007), Bu & Yin (2007a), Bu & Yin (2008), Minor (2008), Szeptycki & Shrubovych (2008), Shrubovych (2009), Bu & Yin (2010a), Nakamura (2010), Shrubovych (2010a), Galli et al. (2011), Blesić & Mitrovski-Bogdanović (2012), Galli et al. (2012), Shrubovych & Bernard (2012), Shrubovych & Bernard (2013),

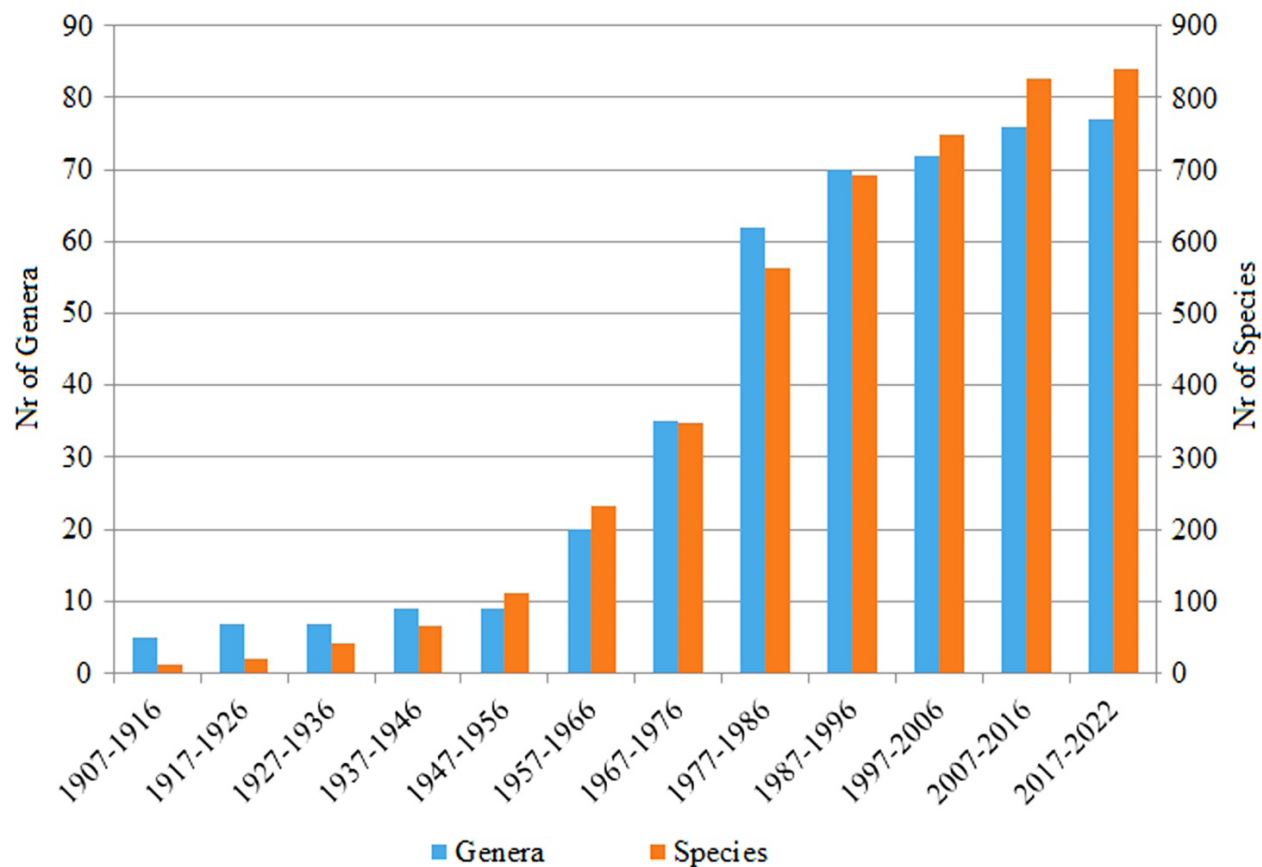


Figure 1. Trend of the numbers of described genera and species of Protura since their discovery in 1907.

Bu et al. (2014), Nakamura (2014), Shrubovych (2014), Shrubovych et al. (2014a,c), Shrubovych et al. (2015), Galli et al. (2016a,b), Shrubovych & Fiera (2016), Bu et al. (2017), Qian et al. (2018), Galli et al. (2019), Shrubovych & Georgiev (2020), Shrubovych et al. (2020), Sterzyńska et al. (2020), Bluhm et al. (2019), Bu et al. (2019), Galli et al. (2021a,b), Nakamura (2021a), Vahedi Moghadam et al. (2022). The increase in taxonomic knowledge on Protura is not particularly fast in relation to the modest number of specialists who studied and still study

this group (Pass & Szucsich, 2011; Bernard & Whittington, 2021; Thibaud et al., 2022). A confirmation of the lack of knowledge about this taxon comes from the observation that 324 species (39%) is currently known only from the type area.

This checklist hopefully represents an updated basis for specific studies on the systematics of Protura and their distribution, but could also be useful for more generic studies on biodiversity and its distribution.

Table 2. Novelties compared to Szeptycki's checklist (2007).

Authors/References	
New Genera	
<i>Liaoxientulus</i>	Wu & Yin, 2011
<i>Mastodonentomon</i>	Shrubovych, Smykla & Bernard, 2020
<i>Nanshanentulus</i>	Bu & Yin, 2007
<i>Nosekientomon</i>	Shrubovych, Rusek & Bernard, 2014
<i>Osientomon</i>	Nakamura, 2010

New Species

<i>Hesperentomon bolense</i>	Qian, Bu & Luan, 2018
<i>Hesperentomon dunhuaense</i>	Bu, Shrubovych, & Yin, 2011
<i>Hesperentomon fopingense</i>	Bu, Shrubovych, & Yin, 2011
<i>Hesperentomon liaoningensis</i>	Wu & Yin, 2008b
<i>Hesperentomon nanshanensis</i>	Bu & Yin, 2007b
<i>Hesperentomon septemseum</i>	Bu & Yin, 2007a
<i>Hesperentomon xiningense</i>	Bu & Yin, 2007b
<i>Hesperentomon yangi</i>	Bai & Bu, 2013b
<i>Neocondeellum chaoyangensis</i>	Wu & Yin, 2008b
<i>Paracondeellum paradisum</i>	Bu & Yin, 2019 (in Bu et al., 2019)
<i>Acerentuloides bernardi</i>	Shrubovych, 2017 (in Shrubovych et al., 2017)
<i>Acerentulus bulgaricus</i>	Shrubovych, 2019a
<i>Acerentulus charrieri</i>	Shrubovych, Schneider & D'Haese, 2012b
<i>Acerentulus iranicus</i>	Vahedi Moghadam, Shayanmehr, Mohammadi Sharif & Galli, 2022
<i>Acerentulus noeli</i>	Shrubovych, Schneider & D'Haese, 2014d
<i>Acerentulus pyreneicus</i>	Shrubovych, Schneider & D'Haese, 2014d
<i>Acerentulus shrubovychae</i>	Galli & Capurro, 2013
<i>Acerentulus sinensis</i>	Wu & Yin, 2007
<i>Acerentulus tortii</i>	Galli, Capurro, Lionetti & Zinni, 2017
<i>Amphientulus sinensis</i>	Xiong, Xie & Yin, 2005
<i>Baculentulus changchunensis</i>	Wu & Yin, 2008a
<i>Baculentulus Chiangmaiensis</i>	Nakamura & Likhitrakarn, 2009
<i>Baculentulus krabbensis</i>	Bu, Potapov & Yin, 2014
<i>Baculentulus kulsarinae</i>	Likhitrakarn, Nakamura, Wiroonrat & Suttiprapan, 2009
<i>Baculentulus pomorskii</i>	Shrubovych, 2010b
<i>Baculentulus potapovi</i>	Shrubovych, 2010b
<i>Baculentulus wenyngae</i>	Bu, Gao & Luan, 2020
<i>Baculentulus xizangensis</i>	Bai & Bu, 2013a
<i>Bolivaridia chamelana</i>	Bu & Palacios-Vargas, 2012
<i>Bolivaridia revillagigedo</i>	Bu & Palacios-Vargas, 2012
<i>Chosonentulus changbaiensis</i>	Wu & Yin, 2008c
<i>Gracilentulus macrotarsus</i>	Nakamura, 2021a
<i>Gracilentulus microtrichus</i>	Nakamura, 2021a
<i>Gracilentulus sarmaticus</i>	Shrubovych & Szeptycki, 2008b
<i>Kenyentulus louguanensis</i>	Bu & Yin, 2010b
<i>Kenyentulus shaanxiensis</i>	Bu & Yin, 2010b
<i>Kenyentulus suthepicus</i>	Nakamura & Likhitrakarn, 2009
<i>Acerentomon brozai</i>	Szeptycki & Shrubovych, 2008
<i>Acerentomon christiani</i>	Shrubovych & Resh, 2016 (in Shrubovych et al., 2016)
<i>Acerentomon szepteyckii</i>	Shrubovych, 2009
<i>Filientomon qianshanense</i>	Bu & Xie, 2007
<i>Fjellbergella jilinensis</i>	(Wu & Yin, 2007) [see new comb. part of the table]
<i>Fjellbergella lazovskiensis</i>	Bu, Potapov & Yin, 2014
<i>Fjellbergella uteorum</i>	Shrubovych & Bernard, 2013
<i>Huashanentulus liupanensis</i>	Bu & Yin, 2010a
<i>Liaoxientulus xingchengensis</i>	Wu & Yin, 2011
<i>Sugaentulus andrzejii</i>	Shrubovych & Rusek, 2010
<i>Tuxenentulus solncevae</i>	Shrubovych & Bernard, 2013
<i>Yamatentomon guoi</i>	Bu & Wu, 2012
<i>Yichunentulus alpatovi</i>	Bu, Potapov & Yin, 2014
<i>Nanshanentulus urumchiensis</i>	Bu & Yin, 2007a
<i>Nienna chukotka</i>	Shrubovych, 2019b
<i>Nienna qinghaiensis</i>	Bu & Yin, 2008
<i>Nipponentomon imadatei</i>	Bu, Wu & Yin, 2013 (in Bu et al., 2013)
<i>Nipponentomon jaceki</i>	Shrubovych, 2009
<i>Nipponentomon pembertonense</i>	Bernard & Nichele, 2008

<i>Nipponentomon taiga</i>	Shrubovych, 2013 (in Bu et al., 2013)
<i>Paracerella monterey</i>	Shrubovych, 2012 (in Shrubovych & Smykla, 2012)
<i>Paracerella sinensis</i>	Bu, Ma & Luan, 2016
<i>Verrucoentomon anatoli</i>	Shrubovych & Bernard, 2012
<i>Verrucoentomon louisanne</i>	Shrubovych & Bernard, 2012
<i>Yavanna babenkoi</i>	<i>Shrubovych</i> , Rusek & Bernard, 2012
<i>Yavanna baikalica</i>	Shrubovych, Rusek & Bernard, 2012
<i>Yavanna chimitovae</i>	Shrubovych, Rusek & Bernard, 2012
<i>Yavanna sinensis</i>	(Bu & Yin, 2008) [see new comb. part of the table]
<i>Yavanna stebaevae</i>	Shrubovych, Rusek & Bernard, 2012
<i>Osientomon japonicum</i>	Nakamura, 2010
<i>Eosentomon ateruii</i>	Nakamura, 2010
<i>Eosentomon brachychaetum</i>	Nakamura, 2010
<i>Eosentomon calvum</i>	Nakamura, 2010
<i>Eosentomon carolinae</i>	Allen, 2007
<i>Eosentomon Chiangmaiense</i>	Nakamura & Likhitrakarn, 2009
<i>Eosentomon dubium</i>	Nakamura, 2010
<i>Eosentomon furunoi</i>	Nakamura, 2010
<i>Eosentomon Hiroshianum</i>	Nakamura, 2010
<i>Eosentomon hitakami</i>	Nakamura, 2010
<i>Eosentomon impar</i>	Nakamura, 2010
<i>Eosentomon imperiale</i>	Nakamura, 2010
<i>Eosentomon inconditum</i>	Nakamura, 2010
<i>Eosentomon kantoense</i>	Nakamura, 2010
<i>Eosentomon kubotai</i>	Nakamura, 2010
<i>Eosentomon longispine</i>	Nakamura, 2010
<i>Eosentomon mizushimai</i>	Nakamura, 2010
<i>Eosentomon morei</i>	Nakamura, 2010
<i>Eosentomon ornatum</i>	Nakamura, 2010
<i>Eosentomon scytha</i>	Shrubovych & Szeptycki, 2008a
<i>Eosentomon simulans</i>	Nakamura, 2010
<i>Eosentomon spatulatum</i>	Nakamura, 2010
<i>Eosentomon villare</i>	Nakamura, 2021b
<i>Eosentomon xinjiangense</i>	Bu & Yin, 2007a
<i>Eosentomon yambaru</i>	Nakamura, 2010
<i>Anisentomon hainanense</i>	Xiong, Bu & Yin, 2008
<i>Neanisentomon shaanicum</i>	Bu & Yin, 2011
<i>Pseudanisentomon donan</i>	Nakamura, 2010
<i>Pseudanisentomon lishuiensis</i>	Bu, Gao & Luan, 2020
<i>Pseudanisentomon nasuense</i>	Nakamura, 2021b
<i>Pseudanisentomon parvum</i>	Nakamura, 2010
<i>Pseudanisentomon villaticum</i>	Nakamura, 2021b
New Combinations	
<i>Andinentulus rapoportii</i> (Condé, 1963)	Shrubovych et al. (2014c)
= <i>Acerentulus rapoportii</i>	
<i>Podolinella ruseki</i> (Nosek, 1967)	Galli et al. (2016b)
= <i>Acerentulus ruseki</i>	
<i>Fjellbergella jilinensis</i> (Wu & Yin, 2007)	Bu et al. (2014)
= <i>Brasilidia jilinensis</i>	
<i>Sugaentulus hoogstraali</i> (Nosek, 1980)	Shrubovych et al. (2014a)
= <i>Nosekiella hoogstraali</i>	
<i>Yichunentulus borealis</i> (Nakamura, 2004)	Bu et al. (2014).
= <i>Baculentulus borealis</i>	
<i>Imadateiella mixta</i> (Nosek, 1981)	Shrubovych et al. (2015)
= <i>Verrucoentomon mixtum</i> ,	
<i>Mastodonentomon macleani</i> (Nosek, 1977)	Shrubovych et al. (2020)
= <i>Nipponentomon macleani</i>	

<i>Nosekientomon ruseki</i> (Nosek, 1977) = <i>Vesiculentomon ruseki</i>	Shrubovych et al. (2014b)
<i>Verrucoentomon montanum</i> (Martynova, 1970) = <i>Acerella montana</i>	Shrubovych (2011)
<i>Vesiculentomon condei</i> (Tuxen, 1955) = <i>Nosekiella condei</i>	Shrubovych et al. (2014a)
<i>Yavanna sinensis</i> (Bu & Yin, 2008) = <i>Nosekiella sinensis</i>	Shrubovych et al., 2012a
<i>Orientomon linoculum</i> (Zhang & Yin, 1981) = <i>Isoentomon linoculum</i> = <i>Paranisentomon linoculum</i>	Nakamura, 2010

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