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Source: Systematic and Applied Acarology, 22(8) : 1091-1095

Published By: Systematic and Applied Acarology Society

URL: <https://doi.org/10.11158/saa.22.8.1>

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Eriophyoidea and allies: where do they belong?

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The eriophyoid mites are tiny but ancient and very diverse—over 5000 species have been named and described so far (Chetverikov *et al.* 2015; Bolton *et al.* 2017; Xue *et al.* 2017). They have received tremendous attention from acarologists over the last two decades or so. Major books—such as world catalogue (Amrine & Stasny 1994), key to genera (Amrine *et al.* 2003) and volumes of comprehensive review articles on its taxonomy, biology and control (Lindquist *et al.* 1996; Ueckermann 2010)—have facilitated the discovery and study of these mites in recent years. Surveys of new mite species described during 2007 to 2015 revealed that more new species of this superfamily have been described than any other mite superfamily (Liu *et al.* 2013; Lam and Zhang 2016; Li & Zhang 2016; Liu & Zhang 2016). This trend seems continuing; in 2016, *Systematic and Applied Acarology* alone published 14 papers on various aspects of eriophyoid mites with descriptions of 8 new genera and 17 new species (Azevedo *et al.* 2016; Chandrapatya *et al.* 2016; Chetverikov & Craemer 2016; Chetverikov & Kostin 2016; Chetverikov & Petanović 2016a,b; Chetverikov *et al.* 2016; Druciarek *et al.* 2016; Duarte *et al.* 2016; Han *et al.* 2016; Li *et al.* 2016; Lotfollahi *et al.* 2016; Tan *et al.* 2016; Vidović *et al.* 2016). This issue also has three papers on Eriophyoidea with 11 new species (Bolton *et al.* 2017; Han *et al.* 2017; Lotfollahi *et al.* 2017). The main purpose of this editorial, however, is to review the phylogenetic position of Eriophyoidea—the focus of Bolton *et al.* (2017) in this issue.

The studies on the relationships of the Eriophyoidea with other mites have a very long and troubled history (see Lindquist 1996b for a review). In the very early days of the classification of the Acarina (Murray 1877: p 94), there were only eight families and gall mites (then as Phytoptidae) were treated as a subfamily within Acaridae (=Astigmata, Sarcoptiformes). This is perhaps the first suggestion that these mites are in Sarcoptiformes. Kramer (1877) first recognized the importance of stigmata and associated structures in Acari and placed “*Phytoptus*” and “*Demodex*” along with Acaridae in Atracheata (=Astigmata). Berlese (1885) similarly placed “*Phytoptus*” and “*Demodex*” in Demodicidae. Canestrini (1891) classified mites in 6 orders; in Astigmata (=Atracheata of Kramer) he proposed Vermiformia for Demodicidae and Phytoptidae. Thor (1929) went as far as placing Vermiformia as sister to all other mites (“Protoacarina”). Trouessart (1892) further named the suborder Tetrapoda for Phytoptidae and Octopoda for Demodicidae. Oudemans (1902) classified 12 families of mites in seven groups and listed Eriophyidae as the seventh group. Later, Oudemans (1906) proposed Zemioptigmata for Eriophyidae (=Tetrapodili Bremsi 1872 but see Lindquist 1996a for nomenclatural notes on Bremsi and the lack of evidence for a paper by Bremsi in 1872). Reuter (1909) included Eriophyiformes as one of his five suborders of Acari. The artificial Vermiformia was rejected by both Oudemans (1906) and Reuter (1909). The supra-familial status of gall mites continued for many decades (e.g. Oudemans 1923, Vitzthum 1931, André 1949 as referred to in Lindquist & Amrine 1996) as late as Hughes (1959). In modern acarology, eriophyoid mites are placed in Trombidiformes (e.g. Baker & Wharton 1952), with close relationships to Tarsonemoidea, Tetranychoidae, and Raphignathae by various authors (see Lindquist 1996b for a review). Krantz

(1970) placed Eriophyoidea in Prostigmata and later Krantz (1978) placed it in Raphignathae. According to Lindquist and Amrine (1996), it is really the arguments presented in Lindquist (1976) and Lindquist & Krantz (1979) that there were wide later acceptance of this position of Eriophyoidea in Raphignathae (Kethley 1982; Woolly 1988) or Raphignathina (Evans 1992). Lindquist (1996b) argued for a sister relationship between Eriophyoidea and Tydeoidea—this has been widely followed since and accepted in recent classifications of Trombidiformes (Lindquist *et al.* 2009; Zhang *et al.* 2011). Recent discoveries of fossil mites in Triassic amber (Schmidt *et al.* 2012; Sidorchuk *et al.* 2015) lead to the establishment of Triasacaroida and revival of updated Tetrapodili for Triasacaroida + Eriophyoidea. Just last year, Xue *et al.* (2016) sequenced mitochondrial genomes of two eriophyid species and showed new evidence in a phylogenetic analysis that Eriophyoidea is sister to Sarcoptiformes + Trombidiformes excluding Eriophyoidea. A follow-up study using mitochondrial genomes and nuclear small subunit (18S) rRNA genes published this year (Xue *et al.* 2017) confirmed that the Eriophyoidea is outside Trombidiformes but within Acariformes, and they diverged from other mites in the Devonian (384 Mya). Using morphological data, Bolton *et al.* (2017) showed that the Eriophyoidea (E) is most closely related to Nematalycidae (N) and this EN clade falls outside of Trombidiformes, but within Sarcoptiformes. EN as a clade is not surprising as it may seem; Kiefer (1975) compared the two groups and Lindquist (1996b) provided a review of this possible sister relationship. Although the internal relationships within Sarcoptiformes is uncertain in Bolton *et al.* (1997), it is interesting to note that this new study brings us back to the early suggestion by Murray (1877) that gall mites belong to the Sarcoptiformes, but now with morphological support.

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Submitted: 14 Jul. 2017; accepted by Qing-Hai Fan: 14 Jul. 2017; published: 24 Jul. 2017